Lower Duwamish Waterway Group

Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Remedial Investigation

REMEDIAL INVESTIGATION REPORT

FINAL

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Region 10
Seattle, WA

The Washington State Department of Ecology
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Bellevue, WA

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Acronyms

Acronym	Definition
ac	acres
AET	apparent effects threshold
AOC	Administrative Order on Consent
AOC	area of concern
API	Asian and Pacific Islander
ARI	Analytical Resources, Inc.
aRPD	apparent redox potential discontinuity
AS/SVE	air sparging/soil vapor extraction
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substance and Disease Registry
AWQC	ambient water quality criteria
BACT	best available control technology
Battelle	Battelle Marine Research Laboratory
BAZ	biologically active zone
BBP	butyl benzyl phthalate
BCA	bias-corrected accelerated
BDC	Boeing Developmental Center
BEHP	bis(2-ethylhexyl) phthalate
bgs	below ground surface
BHC	benzene hexachloride
BMP	best management practice
BOD	biological oxygen demand
Boeing	The Boeing Company
BTEX	benzene, toluene, ethylbenzene, and xylene
CAA	Clean Air Act
CAS	Columbia Analytical Services, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
cfs	cubic feet per second
COC	chemical of concern
COPC	chemical of potential concern
CORRACTS	Corrective Action Site
cPAH	carcinogenic polycyclic aromatic hydrocarbon

Acronym	Definition
CPM	coarse particulate matter
^{137}Cs	cesium-137
CSCSL	Confirmed and Suspected Contaminated Sites List
CSL	cleanup screening level
CSM	conceptual site model
CSO	combined sewer overflow
CT	central tendency
CVAF	cold vapor atomic fluorescence
CWA	Clean Water Act
cy	cubic yard
DAIS	Dredged Analysis Information System
DARRP	Damage Assessment, Remediation, and Restoration Program
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DEA	David Evans and Associates, Inc.
DMMO	Dredged Material Management Office
DMMP	Dredged Material Management Program
DMMU	dredged material management unit
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DPD	Department of Planning and Development
DQO	data quality objective
DRCC	Duwamish River Cleanup Coalition
DSOA	Duwamish sediment other area
dw	dry weight
EAA	early action area
EBI	Elliott Bay Interceptor
Ecology	Washington State Department of Ecology
ECOSS	Environmental Commission of South Seattle
EDR	Environmental Data Resource, Inc.
EE/CA	engineering evaluation/cost analysis
EFDC	Environmental Fluid Dynamics Code
EIM	Environmental Information Management
EOF	emergency overflow
EPA	US Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment

Acronym	Definition
ERNS	Emergency Response Notification System
ERTS	Environmental Report Tracking System
ESA	Endangered Species Act
ESG	Environmental Solutions Group, Inc.
FPM	fine particulate matter
FR	Federal Register
FS	feasibility study
FWM	food web model
GC/ECD	gas chromatography with electron capture detection
GC/MS	gas chromatography/mass spectrometry
GIS	geographic information system
gpd	gallons per day
GPS	global positioning system
GSA	General Services Administration
GSD	grain size distribution
GWI	Great Western International
Herrera	Herrera Environmental Consultants
HHRA	human health risk assessment
HI	hazard index
HOC	hydrophobic organic compound
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
HpCDD	heptachlorodibenzo-*p*-dioxin
HpCDF	heptachlorodibenzofuran
HPLC/PDA	high-performance liquid chromatography/photodiode array detection
HQ	hazard quotient
HSD	honestly significant difference
HSL	Hazardous Sites List
HWMP	Hazardous Waste Management Program
HxCDD	hexachlorodibenzo-*p*-dioxin
HxCDF	hexachlorodibenzofuran
I-5	Interstate 5
ICP-MS	inductively coupled plasma-mass spectrometry
ID	identification
IDW	inverse distance weighting
IIT	Illinois Institute of Technology
IP	intraperitoneal
IQR	interquartile range

Acronym	Definition
IR	ingestion rate
IRA	independent remedial action
IWP	Industrial Waste Program
J-qualifier	estimated concentration
JN-qualifier	tentative identification of estimated concentration
KCDNR	King County Department of Natural Resources
KCIA	King County International Airport
K-M	Kaplan-Meier
LAET	lowest apparent effects threshold
2LAET	second lowest apparent effects threshold
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
LF	linear feet
LNAPL	light non-aqueous phase liquids
LOAEL	lowest-observed-adverse-effect level
LOEC	lowest-observed-effect concentration
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
LQG	large-quantity generator
LUST	leaking underground storage tank
M-qualifier	calculated concentration
MDL	method detection limit
mgd	million gallons per day
mgy	million gallons per year
ML	maximum level
MLLW	mean lower low water
MNR	monitored natural recovery
MT/yr	metric tons per year
MTCA	Model Toxics Control Act
N-qualifier	tentative identification
NAPL	non-aqueous phase liquid
NBF	North Boeing Field
NFA	No Further Action
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no-observed-adverse-effect level
NOEC	no-observed-effect concentration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List

Acronym	Definition
NTCRA	non-time-critical removal action
NTR	National Toxics Rule
NWR	National Wildlife Refuge
O&M	operation and maintenance
OC	organic carbon
OCDD	octachlorodibenzo-*p*-dioxin
OCDF	octachlorodibenzofuran
OIG	Office of the Inspector General
OSWER	Office of Solid Waste and Emergency Response
Pa	pascal
PAH	polycyclic aromatic hydrocarbon
^{210}Pb	lead-210
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
pcf	pounds per cubic foot
PCP	pentachlorophenol
PCT	polychlorinated terphenyl
PeCDD	pentachlorodibenzo-*p*-dioxin
PeCDF	pentachlorodibenzofuran
PEF	potency equivalency factor
PIE	Pacific International Engineering, PLLC
PM	particulate matter
PM_{10}	particulate matter less than 10 micrometers in diameter
$PM_{2.5}$	particulate matter less than 2.5 micrometers in diameter
ppb	parts per billion
ppt	parts per thousand
PRG	preliminary remediation goal
PSAMP	Puget Sound Ambient Monitoring Program
PSC	Phillip Services Corporation
PSCAA	Puget Sound Clean Air Agency
PSDDA	Puget Sound Dredged Disposal Analysis
PSEP	Puget Sound Estuary Program
PSMAF	Puget Sound Maritime Air Forum
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan

Acronym	Definition
QEA	Quantitative Environmental Analysis, LLC
R^2	regression coefficient
RAO	remedial action objective
RBC	risk-based concentration
RBTC	risk-based threshold concentration
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
RfD	reference dose
RFI	RCRA facility investigation
RI	remedial investigation
RL	reporting limit
RM	river mile
RME	reasonable maximum exposure
ROC	receptor of concern
ROD	Record of Decision
ROW	right-of-way
RPS	relative penis size
PSS	practical salinity scale
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act
SCA	source control area
SCAP	source control action plan
SCWG	Source Control Work Group
SD	storm drain
SEA	Striplin Environmental Associates, Inc.
SEPA	State Environmental Policy Act
SF	slope factor
SI	site inspection
SL	screening level
SMC	Seattle Municipal Code
SMS	Washington State Sediment Management Standards
SPCC	South Park Community Center
SPI	sediment profile imaging
SPMD	semipermeable membrane device
SPU	Seattle Public Utilities
SPWG	Sediment Phthalates Work Group
SQG	small-quantity generator
SQS	sediment quality standards

Acronym	Definition
SRI	supplemental remedial investigation
STAR	sediment transport analysis report
STM	sediment transport model
SU	standard unit
SVOC	semivolatile organic compound
SWAC	spatially weighted average concentration
SWF/LF	solid waste facility/landfill
SWMU	solid waste management unit
T-105	Terminal 105
T-106	Terminal 106
T-107	Terminal 107
T-108	Terminal 108
T-115	Terminal 115
T-117	Terminal 117
TBD	to be determined
TBT	tributyltin
TCDD	tetrachlorodibenzo-*p*-dioxin
TCDF	tetrachlorodibenzofuran
TCE	trichloroethene
TCRA	time-critical removal action
TE	trapping efficiency
TEF	toxic equivalency factor
TEQ	toxic equivalent
TOC	total organic carbon
TPH	total petroleum hydrocarbons
tpy	tons per year
TRIS	Toxics Release Inventory System
TRV	toxicity reference value
TSD	treatment, storage, and disposal
TSS	total suspended solids
U&A	Usual and Accustomed
U-qualifier	not detected at given concentration
U.S.C.	United States Code
UCL	upper confidence limit
USACE	US Army Corps of Engineers
USCG	United States Coast Guard
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey

Acronym	Definition
UST	underground storage tank
VCP	Voluntary Cleanup Program
VOC	volatile organic compound
WAC	Washington Administrative Code
WARM	Washington Ranking Method
WDFW	Washington State Department of Fish and Wildlife
WHO	World Health Organization
Windward	Windward Environmental LLC
WPCC	Washington State Pollution Control Commission
WQA	water quality assessment
WQC	water quality criteria
WQS	water quality standards
WRCC	Western Regional Climate Center
WRIA	Water Resource Inventory Area
WSDOH	Washington State Department of Health
WSDOT	Washington State Department of Transportation
ww	wet weight
WWTP	wastewater treatment plant

Executive Summary

This document presents the results of the remedial investigation (RI) for the Lower Duwamish Waterway (LDW), located in Seattle, Washington. The RI provides information on the extent of contamination and the risks to humans and the environment posed by the contamination. The RI will be used to help make decisions about necessary sediment cleanup actions and other actions to manage risks.

In 2000, the City of Seattle, King County, the Port of Seattle, and The Boeing Company, working collectively as the Lower Duwamish Waterway Group, agreed in an Administrative Order on Consent to conduct a remedial investigation/feasibility study (RI/FS) for the LDW with oversight by the US Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology). In September 2001, the LDW was formally listed as a Superfund site; and in February 2002, the LDW was formally listed as a Washington Model Toxics Control Act (MTCA) site.

This RI presents the results of many years of investigations conducted for the LDW study area, which extends from the southern tip of Harbor Island to just south of the Upper Turning Basin (Map ES-1). The RI data will support the analyses to be conducted in the FS to allow EPA and Ecology to make cleanup decisions for the LDW.

This RI describes what is known about the LDW, including:

- The history of the LDW as well as the environmental setting, habitat, and uses
- The deposition and transport of sediment within the LDW
- The distribution of contamination in the LDW, including concentrations of chemicals in sediment, water, and tissues
- Information regarding potential historical and ongoing sources of chemicals to the LDW as well as the source control and identification strategy
- The results of the baseline human health risk assessment (HHRA) and ecological risk assessment (ERA), which assess risks to people and ecological species from contamination within the LDW prior to remedial actions

The specific topics addressed in each section of the RI are summarized below. Details are provided in the RI, its appendices, and attachments.

ES.1 ENVIRONMENTAL SETTING

The LDW is an estuary that has been extensively modified over the past 100 years. Diversion of two major rivers (i.e., White River in 1906 and Black River in 1916) approximately 100 years ago reduced the flow volume and watershed area by

about 70%. Today, the Green River is the primary source of water for the Duwamish River.

Many of the natural curves of the estuary were eliminated when the navigation channel was created in the early 20th century. Prior to 1920, the King County Commercial Waterway District No. 1 had dredged the LDW to an Upper Turning Basin at River Mile (RM) 4.6. This Upper Turning Basin serves as a trap for most sediment being carried downstream by the Green/Duwamish River. Frequent dredging is still necessary to remove sediment from this area and thereby keep it from being transported into the lower reaches of the LDW. The construction of the Howard Hansen Dam, approximately 65 mi upstream of the LDW, in 1961 effectively decreased peak flows in the river system, which now rarely exceed 12,000 cubic feet per second.

Today, the LDW is maintained as a federal navigation channel by the US Army Corps of Engineers. The shoreline along the majority of the LDW has been developed for industrial and commercial operations. Common shoreline features include constructed bulkheads, piers, wharves, sheet piling walls, buildings that extend over the water, and steeply sloped banks armored with riprap or other fill material. Despite the highly modified river habitat, the LDW is home to diverse communities of fish, birds, mammals, and invertebrate species.

The LDW corridor is one of the City of Seattle's primary industrial areas. Current land use, zoning requirements, and land ownership within most of this corridor are consistent with the characteristics of an active industrial waterway. Two neighborhoods, South Park and Georgetown, are located to the west and east, respectively, of the LDW. These neighborhoods support a mixture of residential, recreational, commercial, and industrial uses. The LDW supports considerable commercial navigation and is also used for various recreational activities such as boating, kayaking, fishing, and beach play. Several public parks and publicly accessible shoreline areas exist. There are plans to create additional recreational and habitat opportunities in the LDW corridor. The LDW is also one of the locations of the Muckleshoot Tribe's commercial, ceremonial, and subsistence fishery for salmon. The Suquamish Tribe actively manages aquatic resources north of the Spokane Street Bridge, located just north of the LDW. The Duwamish Tribe uses Herring's House Park and other parks along the Duwamish for cultural gatherings.

Intertidal habitats are dispersed in relatively small patches downstream of RM 3.0, with the exception of Kellogg Island, which represents the largest contiguous area of intertidal habitat remaining in the LDW. There is great interest in restoring and improving the intertidal habitat in the LDW. Several restoration projects have already been completed, some of which included the creation of public parks.

ES.2 SEDIMENT DYNAMICS

Several studies of LDW sediment movement have been conducted since the 1970s, but the most extensive work has been done in the past 3 years as part of the RI. This type of analysis will be used in the FS to estimate the potential for contaminated surface sediment to be buried by sediment from upstream in the future and to estimate areas and depths of erosion. This work included the collection of new data to be used in conjunction with historical data to develop a sediment transport model (STM) for the LDW. This model, as well as other lines of evidence, was used to develop a physical conceptual site model (CSM) for the LDW. The key components of the CSM are:

- On annual time scales, more sediment is added (deposited) throughout the LDW than is removed (eroded).
- The rate at which sediment is deposited is generally higher in deeper areas, especially the navigation channel, than in shallower areas, such as intertidal benches.
- High-flow events that occur periodically (e.g., one event every 2 years or less frequently), generally as a result of high rainfall events, have the greatest influence on sediment erosion. Net erosion (when the amount of erosion exceeds that of deposition) occurs at 20% or less of the LDW during such events. During such high-flow events, approximately 6% of the LDW experiences net erosion of 10 cm or greater (maximum depth of 21 cm).[1] Over much of the LDW, erosion depths are much less, particularly between RM 0.0 and RM 2.0, where net erosion is predicted to be negligible.
- Tugboats in the navigation channel tend to mix a thin layer of sediment (i.e., 1 to 2 cm) repeatedly over certain areas where these boats travel. Tugboats have the potential to erode sediment to a greater depth while maneuvering over relatively small areas outside the navigation channel (e.g., docks and berthing areas).
- The STM developed for the RI/FS (QEA 2008) is an important tool for predicting the changes, both erosion and deposition, that occur on the sediment bed. Simulations were run for both short (days or weeks) and long (years) time periods. The STM was also used to estimate changes in the physical composition of the sediment surface layer over time as sediment from upstream and lateral sources (e.g., storm drains) becomes incorporated into the sediment bed. Based on the results of the modeling conducted to date, approximately

[1] These depths are similar to the 10-cm (3.9-in.) depth used to characterize surface sediment within the LDW and the 10-cm depth of the biologically active zone, which was based in part on the sediment profile imaging data (Ecology 2007n).

99% of the total external sediment particle load[2] to the LDW comes from the Green River, upstream of the LDW.

ES.3 NATURE AND EXTENT OF CONTAMINATION

The presence of chemical contamination in the LDW has been known for many years, prompting numerous environmental studies. From 1990 to 2001, approximately 1,200 surface sediment samples, 230 subsurface sediment samples, 90 fish and shellfish tissue samples, and 480 surface water samples, were collected and analyzed for metals and organic compounds. A Phase 1 RI (Windward 2003a) was initially produced based solely on information available at that time. Additional chemical data needs were subsequently identified (Windward 2003f), and a plan for filling those data needs was prepared (Windward 2004h) and approved by EPA and Ecology. Since 2003, approximately 900 additional samples were collected and analyzed as part of the RI to characterize chemical contamination in the following media:

- Juvenile chinook salmon tissue
- Fish, clam, and crab tissue
- Benthic invertebrate tissue
- Seep water (tidally fluctuating groundwater seeping from the banks along the river)
- Surface sediment (top 10 cm or 3.9 in.)
- Subsurface sediment (below the top 10 cm)
- Porewater (water in spaces between sediment particles)

In addition, samples of surface water[3] and source-tracing samples (e.g., sediments from catch basins and in-line sediment traps from stormwater and combined sewer overflow basins) have also been collected and analyzed.

Based on surface sediment data, the LDW can be characterized as having localized areas with relatively high chemical concentrations (hot spots) separated by relatively large areas with lower chemical concentrations (Table ES-1). Many of the highest concentrations of key chemicals are in areas that were identified as candidates for early action (known as early action areas [EAAs]) (Maps ES-2a, ES-2b, and ES-2c)

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[2] Particle loading should be distinguished from chemical loading. Chemical loads from lateral sources could have a significant influence on the sediment and water quality in the vicinity of a lateral source, even though the relative magnitude of particle loading from those sources is very small compared with particle loading from upstream sources.

[3] Surface water samples were collected by King County for analysis of PCB congeners in 2005. Samples representing potential sources to the LDW are discussed in Section 9 (samples from combined sewer overflows in Section 9.4.4.2; sediment samples from the storm drain and combined sewer overflow basins in Section 9.4.4.6; and groundwater samples in Section 9.4.6.1).

(Windward 2003e). Polychlorinated biphenyls (PCBs), various metals, polycyclic aromatic hydrocarbons (PAHs), and phthalates were frequently detected in surface sediments (Maps ES-3a, ES-3b, and ES-3c). Samples from a smaller number of locations in the LDW were analyzed for dioxins and furans; at least one dioxin or furan congener was detected in each sample. Many other organic chemicals, such as volatile organic compounds (VOCs), other semivolatile organic compounds, and pesticides, were less frequently or rarely detected.

Table ES-1. Summary statistics for key chemicals in surface sediment

Chemical	Unit	Detection Frequency	Concentration			
			Mean	Median	95TH Percentile	Maximum
Total PCBs	µg/kg dw	1,243/1,327	1,170	137	4,300	220,000
Arsenic	mg/kg dw	794/852	17	11	30	1,100
cPAHs[a]	µg/kg dw	780/828	460	260	1,500	11,000
Dioxin and furan TEQ	ng/kg dw	54/54	82.1	10.4	490	2,100
BEHP	µg/kg dw	674/832	590	230	2,400	14,000

Note: summary statistics were calculated assuming one-half the reporting limit for non-detect results.

[a] cPAH concentrations are expressed in terms of benzo(a)pyrene equivalents.

dw – dry weight

BEHP – bis(2-ethylhexyl) phthalate

cPAH – carcinogenic polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

TEQ – toxic equivalent

The distribution of chemicals within subsurface sediment has also been characterized. Chemicals frequently detected in subsurface sediment were similar to those detected in surface sediment (Table ES-2). In many areas, the highest chemical concentrations were buried under surface sediment with lower concentrations. These results are generally consistent with the STM results, which emphasize the importance of sediment transported from the Green River to the sediment dynamics within the LDW and the fact that concerted efforts to control sources have resulted in the concentrations of chemicals in current releases generally being lower than those in historical releases. There are many exceptions to this general trend, which could be the result of localized chemical sources or lower than predicted net sedimentation rates because of site-specific conditions the STM did not evaluate.

Table ES-2. Summary statistics for key chemicals in sediment cores

Chemical	Unit	Detection Frequency[a]	Concentration				Depth Interval of Maximum Concentration (ft)[b]
			Mean	Median	95th Percentile	Maximum	
Total PCBs	µg/kg dw	609/821	3,000	170	5,600	890,000	0.3 – 1.5
Arsenic	mg/kg dw	267/325	40	12	63	2,000	2 – 4
cPAHs[c]	µg/kg dw	252/304	400	190	1,500	7,000	1 – 2
Dioxin and furan TEQ	ng/kg dw	26/26	27.2	14.4	170	194.0 J	4 – 6
BEHP	µg/kg dw	216/306	500	230	1,800	5,100	0 – 3

Note: summary statistics were calculated assuming one-half the reported or calculated non-detect results.

[a] Total number of samples represents all samples collected from any subsurface interval at all locations. Statistics are calculated based on all samples.

[b] Depth interval with highest concentration for a given chemical within any single core within the LDW.

[c] cPAH concentrations are expressed in terms of benzo(a)pyrene equivalents.

dw – dry weight

BEHP – bis(2-ethylhexyl) phthalate

cPAH – carcinogenic polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

TEQ – toxic equivalent

Some areas have high chemical concentrations in both subsurface and surface sediment. This distribution of contamination generally is found in areas estimated to have low net sedimentation rates by the STM. In a few areas where higher sedimentation was predicted, the presence of high chemical concentrations near the surface could be the result of localized disturbance events or recent or ongoing sources of contamination.

Tissue samples of many different fish and invertebrate species have been collected and analyzed. Most of the tissue data represent English sole, shiner surfperch, Pacific staghorn sculpin, juvenile chinook salmon, Dungeness and slender crabs, soft-shell clams, and small invertebrates that live in the sediment, such as amphipods and marine worms. These species were selected because they were assumed to be representative of species that could be consumed by people, fish, or wildlife within the LDW. Their tissues were analyzed for a wide variety of chemicals.

Mean total PCB concentrations were highest for Dungeness crab hepatopancreas and English sole whole-body tissue, followed by shiner surfperch (Table ES-3). Mean total PCB concentrations were lowest for mussels. Inorganic arsenic concentrations in softshell clams were much higher than in fish and crabs collected in the LDW and in clams from Puget Sound. Carcinogenic PAH (cPAH) concentrations were highest in clams, mussels, and benthic invertebrates, and phthalates were frequently detected in clams and benthic invertebrates. Most other organic chemicals were infrequently detected.

Table ES-3. Summary statistics for key chemicals in tissue

Chemical and Tissue Type	Unit	Detection Frequency[a]	Concentration		
			Minimum	Mean	Maximum
Total PCBs					
Juvenile chinook salmon (whole body)	µg/kg ww	24/24	6.9	140	1,200
English sole (whole body)	µg/kg ww	67/67[b]	300	1,700	4,700
English sole (fillet with skin)	µg/kg ww	26/26	170	860	2,010
English sole (fillet without skin)	µg/kg ww	15/15	79	230	530
Shiner surfperch (whole body)	µg/kg ww	78/78	200 J	1,300	18,400 J
Pacific staghorn sculpin (whole body)	µg/kg ww	28/28	430	900	2,800
Starry flounder (whole body)	µg/kg ww	6/6	156	380	660
Starry flounder (fillet with skin)	µg/kg ww	2/2	63	260	450
Striped perch (fillet with skin)	µg/kg ww	3/3	164 J	320 J	630 J
Pile perch (fillet with skin)	µg/kg ww	1/1	300	300	300
Dungeness crab (edible meat)	µg/kg ww	14/17	15	130	300
Dungeness crab (hepatopancreas)	µg/kg ww	11/11	280	2,000	5,500
Dungeness crab (whole body)[c]	µg/kg ww	16/16	97 M	890	1,900 JM
Red rock crab (edible meat)	µg/kg ww	2/2	85 J	120	164 J
Red rock/Dungeness crab (edible meat)	µg/kg ww	1/1	60 J	60	60 J
Slender crab (edible meat)	µg/kg ww	19/19	27	150	390
Slender crab (hepatopancreas)	µg/kg ww	11/11	250	940	2,190 J
Slender crab (whole body)[c]	µg/kg ww	19/19	100 M	510	838 JM
Clams (non-depurated)	µg/kg ww	20/20	15 J	130	580 J
Clams (depurated)	µg/kg ww	6/6	14 J	98	270
Amphipods	µg/kg ww	4/4	106	230	410
Mussels (wild)	µg/kg ww	18/22	16	34	60
Mussels (transplanted)	µg/kg ww	13/32	25.9	27	73.1
Benthic invertebrates	µg/kg ww	19/20	60 J	270	1,400
Inorganic Arsenic					
English sole (whole body)	mg/kg ww	7/7	0.020	0.051	0.090
English sole (fillet with skin)	mg/kg ww	6/7	0.003	0.004	0.006

Chemical and Tissue Type	Unit	Detection Frequency[a]	Concentration		
			Minimum	Mean	Maximum
Shiner surfperch (whole body)	mg/kg ww	8/8	0.020	0.070	0.16
Starry flounder (whole body)	mg/kg ww	1/1	0.09	0.09	0.09
Starry flounder (fillet with skin)	mg/kg ww	1/1	nd	0.0015 U	nd
Striped perch (fillet with skin)	mg/kg ww	0/1	nd	0.005 U	nd
Pile perch (fillet with skin)	mg/kg ww	0/1	nd	0.005 U	nd
Dungeness crab (edible meat)	mg/kg ww	2/2	0.010 J	0.010	0.010
Dungeness crab (hepatopancreas)	mg/kg ww	2/2	0.050	0.070	0.090
Dungeness crab (whole body)[c]	µg/kg ww	2/2	0.022 JM	0.029	0.035 M
Slender crab (edible meat)	mg/kg ww	4/4	0.030	0.030	0.030
Slender crab (hepatopancreas)	mg/kg ww	4/4	0.080	0.24	0.33
Slender crab (whole body)[c]	µg/kg ww	4/4	0.046 M	0.098	0.123 M
Clams (non-depurated)	mg/kg ww	23/23	0.132	2.72	11.3
Clams (depurated)	mg/kg ww	15/15	0.720	3.37	9.300
cPAHs[e]					
English sole (whole body)	µg/kg ww	18/21	0.45 J	1.6	2.8
English sole (fillet with skin)	µg/kg ww	4/7	0.37 J	0.35[d]	0.53
English sole (fillet without skin)	µg/kg ww	0/6	nd	8.9 U	nd
Shiner surfperch (whole body)	µg/kg ww	24/27	0.37 J	3.1[d]	2.2
Pacific staghorn sculpin (whole body)	µg/kg ww	1/24	36 J	130[d]	36 J
Starry flounder (whole body)	µg/kg ww	3/3	0.47 J	0.59 J	0.66 J
Starry flounder (fillet with skin)	µg/kg ww	1/1	0.64 J	0.64 J	0.64 J
Striped perch (fillet with skin)	µg/kg ww	1/1	0.43 J	0.43 J	0.43 J
Pile perch (fillet with skin)	µg/kg ww	1/1	0.43 J	0.43 J	0.43 J
Dungeness crab (edible meat)	µg/kg ww	6/9	0.54 J	3.7 J	0.84 J
Dungeness crab (hepatopancreas)	µg/kg ww	2/4	0.73 J	6.5[d]	0.73 J
Dungeness crab (whole body)[c]	µg/kg ww	7/9	0.60 JM	2.6[d]	2.4 JM
Slender crab (edible meat)	µg/kg ww	2/12	0.33	0.35	0.63 J
Slender crab (hepatopancreas)	µg/kg ww	4/4	0.68 J	0.70	0.71

Chemical and Tissue Type	Unit	Detection Frequency[a]	Concentration		
			Minimum	Mean	Maximum
Slender crab (whole body)[c]	µg/kg ww	12/12	0.45 M	0.65	0.67 M
Clams	µg/kg ww	14/14	6.8	15	44
Amphipods	µg/kg ww	0/4	nd	22 U	nd
Benthic invertebrates	µg/kg ww	20/20	4.2 J	44	290 J
Mussels (wild)	µg/kg ww	11/22	30	23[d]	33
Mussels (transplanted)	µg/kg ww	16/34	28.9	24[d]	34.6
BEHP					
English sole (whole body)	µg/kg ww	1/27	170	600[d]	170
English sole (fillet with skin)	µg/kg ww	2/7	1,100	370[d]	1,300 J
English sole (fillet without skin)	µg/kg ww	0/6	nd	4.9 U	nd
Shiner surfperch (whole body)	µg/kg ww	5/34	280 J	650 J	2,100 J
Pacific staghorn sculpin (whole body)	µg/kg ww	0/24	nd	1,700 U	nd
Starry flounder (whole body)	µg/kg ww	0/3	nd	33 U	nd
Starry flounder (fillet with skin)	µg/kg ww	0/1	nd	34 U	nd
Striped perch (fillet with skin)	µg/kg ww	0/1	nd	34 U	nd
Pile perch (fillet with skin)	µg/kg ww	0/1	nd	34 U	nd
Dungeness crab (edible meat)	µg/kg ww	0/9	nd	31 U	nd
Dungeness crab (hepatopancreas)	µg/kg ww	0/4	nd	36 U	nd
Dungeness crab (whole body)[c]	µg/kg ww	0/9	nd	15.6 U	nd
Slender crab (edible meat)	µg/kg ww	0/12	nd	60 U	nd
Slender crab (hepatopancreas)	µg/kg ww	1/4	100 J	70[d]	100 J
Slender crab (whole body)[c]	µg/kg ww	3/12	80 JM	45[d]	80 JM
Benthic invertebrates	µg/kg ww	5/20	1,100 J	1,400	2,200 J
Amphipods	µg/kg ww	2/4	170	180	530
Clams	µg/kg ww	10/14	56 J	140	220 J
Mussels (wild)	µg/kg ww	2/22	28	17[d]	190
Mussels (transplanted)	µg/kg ww	0/34	nd	8.6 U	nd

Note: Mean concentrations were calculated assuming one-half the reported or calculated non-detect results.

[a] This table includes all tissue data in the RI dataset (collected between 1995 and 2007; see Table 4-8).

[b] Number of samples includes 32 whole-body samples and 10 calculated "whole-body" samples. Concentrations in "whole-body" samples were estimated using results from separate analyses of fillet and remainder composite samples (i.e., all remaining tissue and fluids after fillets were removed from the specimens). The estimated English sole "whole-body" concentrations were based on the relative weights and total PCB concentrations in skin-on fillet and remainder tissues collected in 2005.

[c] Data from hepatopancreas composite samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Whole-body (i.e., edible meat plus hepatopancreas) crab concentrations were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weight of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

[d] The mean concentration is generated with both detect and non-detect data. Non-detect data were included at half RL.

[e] cPAH concentrations are expressed in terms of benzo(a)pyrene equivalents.

BEHP – bis(2-ethylhexyl) phthalate
cPAH – carcinogenic polycyclic aromatic hydrocarbon
J – estimated concentration
M – calculated value
na – not applicable
nd – not detected
PCB – polychlorinated biphenyl
U – not detected
ww – wet weight

Tissue samples collected in 2004 were analyzed for PCB Aroclors by Columbia Analytical Services, Inc.; samples collected in 2005, 2006, and 2007 were analyzed by Analytical Resources, Inc. The PCB mixtures in samples collected from 2005 to 2007 appeared to have had a higher proportion of the more highly chlorinated PCB congeners than did those collected in 2004.

Aroclor wet-weight and lipid-normalized tissue data as a whole suggested that total PCB concentrations in 2004 were higher than those in more recent years; total PCB concentrations appear to be decreasing based on Aroclor data. Trends based on the limited PCB congener data are more uncertain. PCB congener data suggest that total PCB concentrations (wet weight) in English sole collected from Area T1 (RM 0.2 to RM 1.0) and possibly from Area T2 (RM 1.6 to RM 2.4) may be decreasing, although the sample sizes are small. Total PCB concentrations (PCB congener sums, wet weight) in crabs collected from Areas T1 and T3 (RM 2.9 to RM 3.7) were also consistently lower in 2007 than 2004. The wet-weight PCB congener data suggest that temporal trends in total PCB concentrations in shiner surfperch are uncertain. The lipid-normalized PCB congener data suggest potential downward trends in Area T3 for English sole, in Area T2 for shiner surfperch, and in Areas T1 and T3 for Dungeness crab. Trends in PCB congener data could not be evaluated for Area T4 (RM 4.2 to RM 5.0) because PCB congener analyses were conducted on tissue samples from that area only in 2004.

Relationships between total PCB concentrations in tissue and sediment were investigated using regression analyses. Co-located tissue and sediment samples collected in 2004 were used for the clam and benthic invertebrate analyses, and surface sediment spatially weighted average concentrations (SWACs) and tissue data collected in 2004 and 2005 were used for the fish and crab analyses. Total PCB concentrations (wet weight) in clams and benthic invertebrates were significantly correlated with total PCB concentrations (dry weight) in sediment. English sole and crabs, which were composited from larger sampling areas than those of Pacific staghorn sculpin and shiner surfperch, appear to have somewhat larger foraging ranges based on several lines of evidence. Concentrations of total PCBs in English sole and crab tissues were not correlated with total PCB concentrations in sediment on a sampling area scale (on

either a wet-weight or lipid-normalized basis). Both wet-weight and lipid-normalized total PCB concentrations in Pacific staghorn sculpin tissues were correlated with total PCB concentrations in sediment on a subarea scale (0.3 RM) and on an area scale (approximately 1 RM). Both wet-weight and lipid-normalized total PCB concentrations in shiner surfperch tissue were correlated with total PCB concentrations in sediment on a subarea scale but not on an area scale.

The relationships between arsenic concentrations in sediment and tissue were statistically evaluated only for benthic invertebrates and clams. For benthic invertebrates, the relationship was significant, but there was a high degree of uncertainty in the relationship for clams. Mean total arsenic concentrations in English sole and Pacific staghorn sculpin were similar among areas but were slightly higher in Area T1. Total arsenic concentrations in shiner surfperch tissue were similar among all areas. In crab tissue, the highest total arsenic concentration was in Area T4, but only one Dungeness crab sample was collected in this area. When this sample is excluded, the highest mean total arsenic concentrations in crabs were in samples from Area T1.

The relationships between cPAH concentrations in sediment and tissue were evaluated only for clams; no strong relationship was found between cPAH concentrations in clam tissue and co-located sediment. cPAH concentrations in whole-body English sole samples were much lower in Area T4 than in Areas T1 and T2. For shiner surfperch, mean concentrations were lower in Area T4 than in Area T3. In Dungeness crab samples, cPAH concentrations were similar among all areas, except for the single sample collected from Area T4, which had a higher concentration.

Relationships between bis(2-ethylhexyl) phthalate (BEHP) concentrations in sediment and tissue were not evaluated because BEHP was infrequently detected in tissue. Relationships between dioxin and furan concentrations in sediment and tissue were not evaluated because dioxins and furans were not analyzed in tissue samples from the LDW.

Chemical concentrations in surface water, seep water, and porewater were also summarized in the RI. A large number of surface water grab samples were collected by King County in 1996 and 1997 and analyzed for metals and SVOCs. More recently (2005), water samples were collected and analyzed for PCB congeners using methods that are more sensitive than those used previously. Total PCB concentrations in whole-water samples ranged from 0.13 to 3.2 ng/L, with the lowest concentrations detected during periods when the flows were highest.

Seep water and porewater data were collected in areas along the banks of the LDW where EPA and Ecology considered the likelihood of contamination to be the greatest. These data were collected instead of additional groundwater data because they are more directly relevant to animals using the LDW. The results of seep water sampling showed that arsenic, copper, and zinc were detected at concentrations greater than the Washington State acute marine water quality criteria in seep samples from at least one

location in the LDW. VOCs were detected in both seep water and porewater in a localized area near one facility with well-documented VOC contamination in groundwater (i.e., Great Western International). VOCs were also detected in some of the porewater samples collected near the boundary between Boeing Plant 2 and Jorgensen Forge.

ES.4 BASELINE ECOLOGICAL RISK ASSESSMENT

The baseline ERA presents risk estimates for benthic invertebrate, crabs, fish, and wildlife species that may be exposed to chemicals in the LDW. Chemicals of potential concern (COPCs) were first identified through a conservative risk-based screening process so that risk analyses could focus on chemicals more likely to be of concern.

There were 10 receptors of concern (ROCs)[4] evaluated in the ERA (i.e., the benthic invertebrate community, crabs, juvenile chinook salmon, Pacific staghorn sculpin, English sole, spotted sandpiper, great blue heron, osprey, river otter, and harbor seal). ROCs are species selected to represent larger groups of animals because not all species can be individually evaluated in the ERA. The risk estimates were based either on COPC concentrations in sediment, water, and aquatic biota from the LDW or on estimated dietary chemical doses, depending on the species and chemical.

For crabs, fish, and wildlife, the site-related chemical concentrations or doses were compared with concentrations or doses from the scientific literature that have been shown to cause specific harmful effects in the same or related species. The effects of primary concern are those that decrease survival, growth, or reproduction.

To evaluate risks to the benthic macroinvertebrate community, chemical concentrations in sediment were compared with the Washington State Sediment Management Standards (SMS), which provides for both chemical and biological standards. The goal of the SMS is to reduce and ultimately eliminate adverse effects on biological resources (Washington Administrative Code [WAC] 173-204-100). For benthic invertebrates living in intertidal and subtidal sediments, sediment chemistry and site-specific toxicity test results indicated that no adverse effects are expected in approximately 75% of the LDW area (345 ac), based on chemical concentrations in surface sediment that were less than the sediment quality standards (SQS) of the SMS and toxicity test results (Maps ES-3a, ES-3b, ES-3c, and ES-4). There is a higher likelihood for adverse effects in approximately 7% of the LDW area (34 ac), which was found to have chemical concentrations or biological effects in excess of the cleanup screening levels (CSLs) of the SMS. The remaining 18% of the LDW area (82 ac) had chemical concentrations or biological effects between the SQS and CSL, indicating that

[4] Key considerations for selecting ROCs include the potential for direct or indirect (e.g., ingestion of fish or invertebrates) exposure to sediment-associated chemicals, human and ecological significance, site usage, sensitivity to COPCs at the site, susceptibility to biomagnification of COPCs (i.e., higher-trophic-level species), and data availability.

risks to benthic invertebrate communities are less certain in these areas than in areas with concentrations greater than one or more CSL values.

Forty-one chemicals exceeded the SQS in one or more surface sediment samples. Concentrations of total PCBs, BEHP, and butyl benzyl phthalate exceeded SMS chemical criteria more frequently than any other chemicals. No other chemicals exceeded the SQS in more than 5% of the surface sediment samples, although the ratio of the maximum detected concentration to the SQS was greater than 10 for some chemicals (e.g., lead, acenaphthene, and 1,4-dichlorobenzene).

Of the 48 sediment samples tested for toxicity during the RI, 11 exceeded the SQS biological effects criteria, 19 exceeded the CSL biological effects criteria, and 18 did not exceed either the SQS or CSL biological effects criteria.

VOCs were analyzed in sediment porewater at two locations in areas where VOCs were known to be present at high concentrations in groundwater on upland properties adjacent to the LDW. One VOC (cis-1,2-dichloroethene) was detected at a concentration higher than the no-observed-effect concentration for marine invertebrates in porewater samples collected from high intertidal areas at one of the two locations (Great Western International at RM 2.4); the maximum concentration was lower than the lowest-observed-effect concentration. Thus, it is uncertain whether the cis-1,2-dichloroethene concentration is sufficiently high within this area of the LDW to result in adverse effects. Because this area was considered to be a worst-case exposure area with respect to the potential for adverse effects on benthic invertebrates from VOCs, and because other areas with groundwater data had lower VOC concentrations, it was concluded that there was a low likelihood of appreciable risks from VOCs in sediment porewater elsewhere in the LDW.

Risks to benthic invertebrates from tributyltin (TBT) were considered to be low based on an evaluation of imposex in field-collected gastropods, as well as a comparison of TBT concentrations in benthic invertebrate tissue samples to tissue effect concentrations from the scientific literature. There was a significant regression relationship between TBT concentrations in benthic invertebrates and co-located surface sediment samples. This regression was used to estimate an LDW-wide exposure point concentration (EPC) of TBT in benthic invertebrate tissue for comparison to the effect concentrations from the literature. TBT concentrations in benthic invertebrate tissue were less than no-observed-effect concentrations in all samples analyzed and as estimated using the regression.

Total PCB concentrations in benthic invertebrate tissue were significantly correlated with total PCB concentrations in co-located sediment. Total PCB concentrations in benthic invertebrate tissues were compared with available toxicity data in the uncertainty assessment; use of this alternative method for risk evaluation did not identify additional locations with the potential for adverse effects resulting from PCBs.

The relationship between metal concentrations in benthic invertebrates and co-located sediment was evaluated and the only significant regression relationship was for

arsenic. This relationship was used to estimate an LDW-wide EPC of arsenic in benthic invertebrate tissue for use in evaluating risk to fish from ingestion of benthic invertebrates.

For the other receptors evaluated as ROCs, hazard quotients (HQs) were calculated based on a range of effects data, including no-observed-adverse-effect levels (NOAELs) and lowest-observed-adverse-effect levels (LOAELs). The highest LOAEL-based HQ for fish, crabs, and wildlife species was 5.5 (for lead in spotted sandpiper) (Table ES-4).

Table ES-4. Summary of ecological risks for fish and wildlife species

CHEMICAL	RECEPTOR OF CONCERN	NOAEL-BASED HQ	LOAEL-BASED HQ
COCs with LOAEL-Based HQs ≥ 1.0[a]			
Total PCBs	crab	**10**	**1.0**
	English sole	**4.9 – 25**	0.98 – **5.0**
	Pacific staghorn sculpin	**1.5 – 19**	0.30 – **3.8**
	river otter	**5.8**	**2.9**
PCB TEQs	spotted sandpiper	**1.9 – 15**	0.18 – **1.5**
Cadmium	juvenile chinook salmon	**5.0**	**1.0**
	English sole	**6.1**	**1.2**
	Pacific staghorn sculpin	**3.0 – 5.2**	0.60 – **1.0**
Chromium	spotted sandpiper	**1.3 – 8.8**	0.26 – **1.8**
Copper	spotted sandpiper	0.62 – **1.5**	0.45 – **1.1**
Lead	spotted sandpiper	0.58 – **19**	0.17 – **5.5**
Mercury	spotted sandpiper	**1.1 – 5.3**	0.21 – **1.0**
Vanadium	English sole	**5.9**	**1.2**
	Pacific staghorn sculpin	**3.2 – 5.9**	0.65 **– 1.2**
	spotted sandpiper	**2.0 – 2.7**	**1.0 – 1.4**
COPCs with NOAEL-Based HQs ≥ 1.0 and LOAEL-Based HQs < 1.0[b]			
Total PCBs	spotted sandpiper	0.51 – **2.0**	0.18 – 0.71
PCB TEQs	osprey	**1.6**	0.16
	river otter	**4.5**	0.59
Arsenic	juvenile chinook salmon	**1.1**	0.73
	English sole	**1.2**	0.80
	crab	**3.9**	na
Benzoic acid	English sole	**1.5**	na
	Pacific staghorn sculpin	**2.1**	na
Cadmium	Pacific staghorn sculpin	**3.0 – 4.9**	0.60 – 0.98
Chromium	juvenile chinook salmon	**2.1**	na
	English sole	**1.1**	na

CHEMICAL	RECEPTOR OF CONCERN	NOAEL-BASED HQ	LOAEL-BASED HQ
Copper	Juvenile chinook salmon	**1.9**	0.93
	English sole	**1.9**	0.93
	Pacific staghorn sculpin	0.9 – **1.5**	0.45 – 0.77
Mercury	river otter	**2.8**	0.57
TBT	Pacific staghorn sculpin	**1.6 – 2.9**	0.18 – 0.33
Vanadium	juvenile chinook salmon	**4.0**	0.79
Zinc	crab	**2.5**	0.91

Note: HQs for fish are the highest HQs in cases where more than one approach was used. **Bold** identifies NOAEL-based HQs greater than 1.0 or LOAEL-based HQs greater than or equal to 1.0.

[a] The LOAEL-based HQs for endrin were 1.2 and 3.1 for English sole and Pacific staghorn sculpin, respectively, based on risk calculations discussed in the uncertainty section. These calculations were presented only in the uncertainty section because of analytical interferences from PCB Aroclors in the pesticide analyses of LDW tissue samples, resulting in uncertainties in pesticide identification and a high bias in pesticide concentrations.

[b] The NOAEL-based HQs were ≥1 for the following COPC/ROC pairs based on risk calculations discussed in the uncertainty section: 1) total DDTs and spotted sandpiper (2.6 to 4.3), 2) endrin and juvenile chinook salmon (3.6), 3) alpha-endosulfan and English sole (6.8) and Pacific staghorn sculpin (2.3), 4) beta-endosulfan and English sole (29) and Pacific staghorn sculpin (6.6), 5) endrin and juvenile chinook salmon (3.6), and 6) methoxychlor and crab (3.6). These calculations were presented in the uncertainty section because of analytical interferences from PCB Aroclors in the pesticide analyses, resulting in uncertainties in pesticide identification and a high bias in pesticide concentrations.

COPC – chemical of potential concern
DDT -dichlorodiphenyltrichloroethane
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
na – not available
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
TBT – tributyltin
TEQ – toxic equivalent

Chemicals of concern (COCs) were defined as chemicals with LOAEL-based HQs greater than or equal to 1, which indicates a potential for adverse effects. Seven chemicals were identified as COCs (PCBs, cadmium, chromium, copper, lead, mercury, and vanadium) for at least one fish and wildlife species (Table ES-4).

No quantitative ecological risk estimates were calculated for dioxins and furans; tissue samples were not analyzed for dioxins and furans because of the difficulties associated with assessing risks from dioxins and furans, the need for a large background dataset with which to compare site-specific data, and the paucity of background tissue data in the Puget Sound area. Remedial decisions to address dioxin and furan contamination in sediment will be based on MTCA and CERCLA regulations, including those specifically related to background (Ecology 2001a; EPA 2002d).

Based on the risk estimates, uncertainties discussed in the ERA, preliminary natural background concentrations, and COC concentrations in EAAs, chemicals were identified as risk drivers for ecological receptors in accordance with EPA (1998) and Ecology (WAC 173-340-703) guidance. The risk drivers from both the ERA and the HHRA will be the focus of remedial analyses in the FS. In consultation with EPA and Ecology, PCBs were identified as a risk driver for river otter because estimated exposure concentrations for river otter were greater than the LOAEL by a factor of 2.9 and uncertainties in the risk estimate were relatively low. In addition, 41 chemicals were selected as risk drivers for the benthic invertebrate community because

concentrations of these 41 chemicals exceeded the SQS at one or more locations. COCs not selected as risk drivers will be addressed through focused evaluation in the FS; these chemicals may also be considered in remedial design for specific areas in or near the LDW and in the post-remedial monitoring program that is part of the 5-year review that EPA conducts at all Superfund sites where hazardous substances, pollutants, or contaminants remain in place after cleanup is completed.

ES.5 BASELINE HUMAN HEALTH RISK ASSESSMENT

The baseline HHRA estimated the risks people could face from exposure to chemicals in LDW sediments and seafood (exposure pathways). Direct contact with sediments during commercial netfishing, clamming, or beach play in the LDW and consumption of seafood from the LDW were identified as primary exposure scenarios. Quantitative risk estimates for other exposure scenarios, such as swimming, were also included in the HHRA but were calculated in a previous risk assessment, which suggested that risks from those scenarios were insignificant.

Reasonable maximum exposure (RME) estimates were calculated for all exposure scenarios to avoid underestimating risks. Consequently, risk estimates may be overestimated for many individuals. This approach is consistent with EPA's policy of "RME," which uses high-end, but plausible, estimates of exposure for assessing risks.

There are limited data available on the amount of resident seafood organisms currently being harvested and consumed from the LDW. A creel survey conducted by King County in the mid-1990s indicated that far less seafood was being harvested in the LDW compared with Elliott Bay and the Spokane Street Bridge just north of the LDW site boundary. More recently, the Washington State Department of Health (WSDOH) has issued health advisories for resident fish and shellfish in the LDW, warning the public that any level of seafood consumption from the LDW is unsafe because of elevated total PCB concentrations in these species (WSDOH 2005). WSDOH (Office of Food Safety and Shellfish) and Public Health—Seattle and King County also advise against the consumption of bivalves (i.e., clams, mussels, and oysters) from all of King County, including the LDW, because of pollution concerns (WSDOH 2005). There are no recent data on seafood consumption rates specific to the LDW, but such data should not be used to estimate potential future risks because current consumption rates may be suppressed. There are several possible explanations for such suppression, including the current advisory against the consumption of resident fish and shellfish, media coverage of the published risks from seafood consumption in the LDW, and the close proximity of more desirable fishing locations outside the LDW. Therefore, EPA and Ecology required the application of seafood consumption rates that have been developed for adult and child consumers based on seafood harvest from King County or Puget Sound. The tribal seafood consumption rates represent relatively high rates that might occur for harvest from the LDW at some time in the future, and were identified by EPA as the most appropriate RME seafood consumption scenarios for tribal members, although they likely overestimate the

current consumption of resident seafood organisms from the LDW. An additional RME scenario required by EPA and Ecology was based on seafood consumption by adult Asian and Pacific Islanders (APIs). There is considerable uncertainty about the applicability of some of the seafood consumption rates to this HHRA, as discussed in Section 6.4.

Although salmon are a highly preferred and consumed fish from the LDW and tissue data were available for salmon, human health risks were not calculated for the consumption of adult salmon. PCBs accumulated in juvenile salmon during the time they spend in the LDW constitute only a very small fraction of the PCBs in adult salmon. Most of the PCBs in adult salmon result from foraging activities in Puget Sound or the Pacific Ocean.

Other scenarios with exposure assumptions higher or lower than those of the RME scenarios were also evaluated to characterize the range of risk estimates. For seafood consumption, these other scenarios included consumption rates estimated for the Suquamish Tribe, "average exposure" scenarios using central tendency consumption rate estimates, and a "unit risk" scenario based on an assumed one seafood meal per month. RME risks are generally used to evaluate remedial actions at a site. Risks estimated using Suquamish Tribe consumption rates represent an upper bound on tribal seafood consumption risks. Risks estimated using average consumption rates are a measure of the most likely risks posed by chemicals in seafood. The one-meal-per-month exposure scenario is not meant to actually describe seafood consumption that is occurring on the LDW (there are limited data[5] on current recreational seafood consumption rates for the LDW). Instead, it is intended to allow individuals to evaluate their own exposure depending on how many meals of seafood of different types collected from the LDW are consumed per month. For example, if an individual consumed two meals per month, then the risk for this individual would be two times the one-meal-per-month risk estimate.

There are no LDW-specific data to estimate the degree to which humans may currently be directly exposed to sediments via beach play or clamming activities. The exposure scenarios assumed for these activities were intended to represent exposures for a health-protective estimation of risks. The tribal netfishing scenario, on the other hand, reflects exposure conditions that could occur under current tribal fishing activities within the LDW.

Once the exposure scenarios were selected, chemistry data for each COPC were compiled over the assumed exposure area (e.g., intertidal sediments for clamming). For the seafood consumption scenarios, data for several different species (e.g., English

[5] In 1997, King County conducted a survey on seafood collection and consumption that included locations in the LDW.

sole, perch, crab, clams, mussels) were used to represent a typical seafood consumer's diet.

Based on health-protective exposure assumptions, estimated cancer risks in the LDW were determined to be highest for the seafood consumption scenarios (Table ES-5). The cumulative risk for all carcinogenic chemicals ranged from 7 in 10,000 (7×10^{-4}) to 3 in 1,000 (3×10^{-3}) for the RME seafood consumption scenarios (adult tribal RME based on Tulalip Tribes' data, child tribal RME based on Tulalip Tribes' data, and adult API RME), with the primary contributors being PCBs, arsenic, and carcinogenic PAHs (cPAHs). Seafood samples from the LDW were not analyzed for dioxins and furans, so risks from these chemicals are not included in seafood consumption risk estimates but were assumed to be unacceptable. The evaluation of non-cancer HQs indicates the potential for adverse effects other than cancer associated with seafood consumption, particularly for arsenic and PCBs (Table ES-5).

Table ES-5. Summary of risks associated with seafood ingestion scenarios

Scenario	Ingestion Rate (g/day)[a]	Meals per Month[b]	Exposure Duration (years)	Excess Cancer Risk	Non-Cancer HI[c]
Adult tribal RME (Tulalip data)	97.5	13.1	70	3×10^{-3}	47
Adult tribal CT (Tulalip data)	15	2.0	30	1×10^{-4}	5
Adult tribal (Suquamish data)	597.7	80	70	3×10^{-2}	348
Child tribal RME (Tulalip data)	39.0	5.2	6	7×10^{-4}	104
Child tribal CT (Tulalip data)	6.0	0.8	6	7×10^{-5}	10
Adult API RME	51.5	6.9	30	1×10^{-3}	35
Adult API CT	5.3	0.7	9	2×10^{-5}	2
One meal per month – benthic	7.5	1.0	30	1×10^{-4}	6
One meal per month – crab	7.5	1.0	30	4×10^{-5}	1
One meal per month – clam	7.5	1.0	30	2×10^{-4}	4
One meal per month – pelagic fish	7.5	1.0	30	2×10^{-4}	10

[a] Rates do not include consumption of adult salmon because these fish acquire most of their chemical body burden from outside the LDW.

[b] It is assumed that one meal is equal to 227 g (8 ounces).

[c] Total across all chemicals. This total is not directly interpretable for risk assessment because it includes hazard quotients across multiple endpoints. The values indicate that the HI may exceed 1 for individual endpoints.

API – Asian and Pacific Islander

CT – central tendency

HI – hazard index (a sum of the HQs for individual chemicals)

RME – reasonable maximum exposure

Cancer risks for direct sediment contact RME scenarios for netfishing, clamming, and beach play were much lower (Table ES-6). Risk estimates ranged from 5 in 1,000,000 (5×10^{-6}) to 1 in 10,000 (1×10^{-4}). COCs for these pathways included PCBs, arsenic, cPAHs, and dioxins and furans. None of the direct sediment contact RME scenarios

had HQs greater than 1 for non-cancer effect, and therefore, non-cancer effects are not expected from direct contact with sediments.

Table ES-6. Summary of risks associated with direct sediment contact scenarios

Scenario	Exposure Area	Incidental Sediment Ingestion Rate (g/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Excess Cancer Risk
Netfishing RME	all subtidal and intertidal	0.050	119	44	3×10^{-5}
Netfishing CT	all subtidal and intertidal	0.050	63	29	5×10^{-6}
Beach play RME	Area 1	0.20	65	6	2×10^{-5}
	Area 2				5×10^{-5}
	Area 3				3×10^{-5}
	Area 4				3×10^{-5}
	Area 5				8×10^{-6}
	Area 6				9×10^{-6}
	Area 7				5×10^{-6}
	Area 8				7×10^{-6}
Clamming 7 days per year	intertidal area accessible from the shore	0.1	7	30	1×10^{-6}
Tribal clamming RME scenario	intertidal area accessible from the shore or from a boat	0.1	120	64	1×10^{-4}
Tribal clamming 183 days per year	intertidal area accessible from the shore or from a boat	0.1	183	70	2×10^{-4}

Note: Non-cancer hazard quotients did not exceed 1 for any chemical and are therefore not shown in this table.
CT – central tendency
RME – reasonable maximum exposure

Nineteen chemicals were identified as COCs (a COC has a cancer risk estimate greater than 1 in 1,000,000 [1×10^{-6}] or an HQ greater than 1 for an RME scenario) for at least one RME seafood consumption scenario.[6] Five chemicals were also identified as COCs based on a cancer risk estimate greater than 1 in 1,000,000 (1×10^{-6}) for at least one direct sediment contact RME scenario.[7] Four of these COCs were identified as risk

[6] The COCs based on seafood consumption scenarios were PCBs, arsenic, cPAHs, dioxins and furans, aldrin, BEHP, alpha-benzene hexachloride (BHC), beta-BHC, carbazole, total chlordane, total DDTs, dieldrin, gamma-BHC, heptachlor, heptachlor epoxide, hexachlorobenzene, pentachlorophenol, TBT, and vanadium. Dioxins and furans were included as a COC for seafood consumption, even though no quantitative risk estimates were made. It was assumed that dioxin and furan excess cancer risk estimates for RME seafood consumption scenarios would have been greater than 1×10^{-6}.

[7] The COCs based on direct sediment exposure were PCBs, arsenic, cPAHs, dioxins and furans, and toxaphene.

drivers based on the magnitude of their risk estimates and the relative percentage of their contributions to total human health risk. PCBs, arsenic, cPAHs, and dioxins and furans were identified as risk drivers for both seafood consumption and direct sediment exposure scenarios. COCs not selected as risk drivers in the baseline HHRA will be addressed through focused evaluation in the FS; these chemicals may also be considered in remedial design for specific areas in or near the LDW, and included in the post-remedial monitoring program that is part of the 5-year review that EPA conducts at all Superfund sites where hazardous substances, pollutants, or contaminants remain in place after cleanup is completed.

These findings do not constitute a definitive characterization of human health risks. There are many uncertainties associated with the site-specific risk estimates for each exposure scenario. In spite of these uncertainties, the baseline risk characterization for the LDW site is considered to be health-protective and sufficient to support risk management decisions.

ES.6 PRELIMINARY BACKGROUND CONCENTRATIONS

Both EPA and Ecology recognize two types of background, natural and anthropogenic (also referred to as area), although their definitions and uses differ. The most important difference is in the potential application of anthropogenic background concentrations in making risk management decisions. EPA generally does not require cleanup to concentrations below anthropogenic background concentrations because of the potential for recontamination from sources unrelated to the site, cost effectiveness, and technical practicability (EPA 2002d). Under MTCA, natural background concentrations[8] are used in the evaluation of sediment cleanup levels as a lower limit below which cleanup levels cannot be achieved (WAC 173-340-705(6)).

Background information presented in the RI is intended to provide initial information and a preliminary context for the site characterization data and risk-based threshold concentrations (RBTCs) presented herein. This compilation is not exhaustive. Additional studies are underway and will provide new datasets relevant to LDW background determinations. Additional evaluation of background concentrations will be documented in the FS or in a separate technical memorandum before a ROD is completed.

Concentrations in surface sediment for four risk driver chemicals (total PCBs, arsenic, cPAHs, and dioxins and furans) were calculated using from data from Puget Sound reference areas (Table ES-7). These areas were designated as Puget Sound reference areas in various studies sponsored by federal and state agencies because they are in relatively undeveloped areas and represent areas outside the influence of urban bays

[8] According to MTCA (WAC 173-340-200), natural background concentrations are concentrations of hazardous substances that are consistently present in an environment that has not been influenced by localized human activities.

and known point sources. The application of these Puget Sound reference area data to remedial decisions will be determined by EPA and Ecology.

Table ES-7. Concentrations of risk driver chemicals in samples collected from Puget Sound reference areas, upstream of the LDW, urban bays and lakes, and the Upper Turning Basin

Risk Driver Chemical	Unit	Surface Sediment Data			Subsurface Sediment Data	Upstream Water Data
		Puget Sound Reference Areas[a]	Upstream[b]	Urban Bays and Lakes[c]	Upper Turning Basin[d]	Suspended Solids[e]
Total PCBs	µg/kg dw	0.2 – 19.9	40	64 – 217	86	107
Arsenic	mg/kg dw	2.3 – 15.9	11	9.8 – 38	13	73
cPAHs[f]	µg/kg dw	14.7 – 244.7	135	185 – 904	201	354
Dioxin and furan TEQ	ng/kg dw	0.141 – 2.3	2.0[g]	16.3[h]	no data	no data

[a] Information relevant to preliminary natural background concentrations in sediment is presented in Section 7.1. The concentration ranges presented in this table (for informational purposes only) represent the ranges of 90th percentile concentrations in Puget Sound reference areas.

[b] Information relevant to upstream concentrations in sediment is presented in Section 7.2.2. The concentrations presented in this table (for informational purposes only) represent the 90th percentile concentrations in the upstream dataset.

[c] Information on concentrations from urban bays and lakes (excluding cleanup and disposal sites) is presented in Section 7.3 to provide additional context to the concentrations summarized in Sections 7.1 and 7.2. The concentration ranges presented in this table (for informational purposes only) represent the ranges of 90th percentile concentrations from the various datasets considered. Inner Elliott Bay data have been excluded from this summary because the bay receives discharge from the LDW and may be influenced by other known point sources of contamination.

[d] Information relevant to concentrations in subsurface sediment from the Upper Turning Basin is presented in Section 7.2.3. The concentrations presented in this table (for informational purposes only) represent the 90th percentile concentrations in sediment cores collected between RM 4.0 and RM 4.75.

[e] Information relevant to concentrations in suspended solids is presented in Section 7.2.4. For PCBs and cPAHs, suspended solids concentrations were estimated by normalizing whole-water concentrations in upstream samples to the sample-specific TSS concentrations. For arsenic, sample-specific total and dissolved concentrations and TSS in upstream water samples were used to estimate suspended solids concentrations. The concentrations presented in this table (for informational purposes only) represent the 90th percentile concentrations.

[f] cPAH concentrations are expressed in terms of benzo(a)pyrene equivalents.

[g] The TEQ presented for dioxins and furans represents the mean concentration of four upstream surface sediment samples.

[h] The TEQ presented for dioxins and furans represents the 90th percentile of the dataset collected near storm drains and other areas receiving surface runoff within the greater Seattle metropolitan area (Section 7.3).

cPAH – carcinogenic polycyclic aromatic hydrocarbon
dw – dry weight
LDW – Lower Duwamish Waterway
MTCA – Model Toxics Control Act
PCB – polychlorinated biphenyl
RM – river mile
TEQ – toxic equivalent
TSS – total suspended solids
Washington Administrative Code

The RI also presents surface sediment data from other areas outside of the LDW (e.g., Green River data upstream of the LDW and sediment data from urban bays and lakes), subsurface sediment data from the Upper Turning Basin, and suspended solids data from upstream of the LDW for the risk driver chemicals (Table ES-7). The RI does

not recommend natural or anthropogenic background concentrations, which will be developed as part of the FS in consultation with EPA and Ecology.

ES.7 RISK-BASED THRESHOLD CONCENTRATIONS

Sediment RBTCs, which are defined as concentrations of risk driver chemicals in sediment that are associated with specific risks, are helpful in risk management decisions. If sediment were remediated to meet a sediment RBTC, for example, then the exposure conditions following that cleanup action would be associated with a reduction of risk down to the target risk level for that RBTC. RBTCs were estimated for each of the risk driver chemicals identified in the risk assessments. Sediment RBTCs were calculated for risks associated with direct sediment contact by people, seafood consumption, and protection of the benthic invertebrate community.

For each of the direct sediment contact RME scenarios (beach play, tribal clamming, and tribal netfishing), sediment RBTCs were calculated using the risk equation for three different excess cancer risk levels (Table ES-8). Other RBTCs were also calculated for informational purposes. For example, RBTCs associated with the central tendency scenarios were also calculated. Sediment RBTCs derived for human health direct-contact scenarios should be applied as SWACs over the exposure areas identified in the HHRA. For the netfishing scenario, the exposure area is the entire LDW. For the clamming and beach play scenarios, the exposure areas include intertidal areas where such activities may occur.

Table ES-8. Summary of sediment RBTCs for human health risk drivers for RME direct sediment exposure scenarios

Risk Driver Chemical	Unit	Exposure Scenario	Sediment RBTCs		
			1 in 1,000,000 Risk Level[a]	1 in 100,000 Risk Level[a]	1 in 10,000 Risk Level[a]
Arsenic	mg/kg dw	tribal clamming	1.3	13	130
		beach play	2.8	28	280
		netfishing	3.7	37	370
cPAHs[b]	µg/kg dw	tribal clamming	150	1,500	15,000
		beach play	90	900	9,000
		netfishing	380	3,800	38,000
Dioxin and furan TEQ	ng/kg dw	tribal clamming	13	130	1,300
		beach play	28	280	2,800
		netfishing	37	370	3,700
Total PCBs	µg/kg dw	tribal clamming	500	5,000	50,000
		beach play	1,700	17,000	170,000
		netfishing	1,300	13,000	130,000

Note: RBTCs were not calculated for non-cancer endpoints because estimated HQs were all < 1.

[a] Tribal clamming (120 days/yr).

[b] cPAH concentrations are expressed in terms of benzo(a)pyrene equivalents.

cPAH – carcinogenic polycyclic aromatic hydrocarbon RBTC – risk-based threshold concentration

dw – dry weight
HQ – hazard quotient
PCB – polychlorinated biphenyl
RME – reasonable maximum exposure
TEQ – toxic equivalent

For seafood consumption, sediment RBTCs for total PCBs were estimated using a food web model. A range of RBTCs was calculated. Sediment RBTCs at the 1 in a million (1×10^{-6}) and 1 in 100,000 (1×10^{-5}) risk levels for the tribal RME (adult and child) scenario could not be calculated; the contribution of total PCBs from water alone was high enough to result excess cancer risks above those risk levels even in the absence of any contribution from sediment (the sediment RBTCs for these scenarios are expressed as < 1 µg/kg dw in Table ES-9). Sediment RBTCs for total PCBs for the non-RME scenarios ranged from < 1 µg/kg dw for the adult tribal scenario based on Suquamish data to > 380 µg/kg dw for a number of scenarios at the 1×10^{-4} target risk level (Table ES-10). A sediment RBTC of > 380 µg/kg dw indicates that even under current conditions in the LDW (i.e., the current LDW-wide SWAC is 380 µg/kg dw), excess cancer risks are estimated to be less than the target risk level.

Table ES-9. Sediment RBTCs for total PCBs based on excess cancer risks in HHRA RME seafood consumption scenarios

Scenario	Risk Level	Sediment RBTC (µg/kg dw)[a]		
		Lower Bound	Best Fit	Upper Bound
Adult tribal RME (Tulalip data)	1×10^{-4}	< 1[b]	7.3	25
Child tribal RME (Tulalip data)		109	185	301
API RME		67	100	167
Adult tribal RME (Tulalip data)	1×10^{-5}	< 1	< 1	< 1
Child tribal RME (Tulalip data)		< 1	< 1	< 1
API RME		< 1	< 1	< 1
Adult tribal RME (Tulalip data)	1×10^{-6}	< 1	< 1	< 1
Child tribal RME (Tulalip data)		< 1	< 1	< 1
API RME		< 1	< 1	< 1

[a] The best-fit RBTC was derived using the food web model parameter set that resulted in the closest match between empirical data and model estimates for all species. The lower and upper bounds represent RBTCs derived from the model based on the range of estimates from other parameter sets that passed the performance criterion (i.e., all model estimates within a factor of 2 of empirical data).

[b] RBTC could not be calculated because contribution from water alone resulted in estimated tissue concentrations greater than the applicable risk level, even in the absence of any contribution from sediment.

API – Asian and Pacific Islander
dw – dry weight
HHRA – human health risk assessment
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration
RME – reasonable maximum exposure

Table ES-10. Sediment RBTCs for total PCBs based on excess cancer risks in the non-RME HHRA seafood consumption scenarios

Scenario	Risk Level	Sediment RBTC (µg/kg dw)[a]		
		Lower Bound	Best Fit	Upper Bound
Adult tribal CT (Tulalip data)	1×10^{-4}	370	> 380	> 380
Child tribal CT (Tulalip data)		> 380	> 380	> 380
API CT		> 380	> 380	> 380
Adult tribal (Suquamish data)		< 1[b]	< 1	< 1
Adult one meal per month of benthic fish		220	320	> 380
Adult one meal per month of pelagic fish		170	250	> 380
Adult one meal per month of crabs		> 380	> 380	> 380
Adult one meal per month of clams		> 380	> 380	> 380
Adult tribal CT (Tulalip data)	1×10^{-5}	13	29	62
Child tribal CT (Tulalip data)		68	100	181
API CT		260	> 380	> 380
Adult tribal (Suquamish data)		< 1	< 1	< 1
Adult one meal per month of benthic fish		9	13	23
Adult one meal per month of pelagic fish		< 1	< 1	< 1
Adult one meal per month of crabs		100	220	> 380
Adult one meal per month of clams		270	350	> 380
Adult tribal CT (Tulalip data)	1×10^{-6}	< 1	< 1	< 1
Child tribal CT (Tulalip data)		< 1	< 1	< 1
API CT		0.2	10	28
Adult tribal (Suquamish data)		< 1	< 1	< 1
Adult one meal per month of benthic fish		< 1	< 1	< 1
Adult one meal per month of pelagic fish		< 1	< 1	< 1
Adult one meal per month of crabs		< 1	< 1	< 1
Adult one meal per month of clams		< 1	2	8

[a] The best-fit RBTC was derived using the food web model parameter set that resulted in the closest match between empirical data and model estimates for all species. The lower and upper bounds represent RBTCs derived from the model based on the range of estimates from other parameter sets that passed the performance criterion (i.e., all model estimates within a factor of 2 of empirical data).

[b] RBTC could not be calculated because contribution from water alone resulted in estimated tissue concentrations greater than the applicable risk level, even in the absence of any contribution from sediment.

API – Asian and Pacific Islander
CT – central tendency
dw – dry weight
HHRA – human health risk assessment
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration
RME – reasonable maximum exposure

At the 1 in 10,000 (1×10^{-4}) risk level, sediment RBTCs for total PCBs ranged from 7.3 to 185 µg/kg dw for the three RME scenarios (Table ES-9), which are lower than the sediment RBTCs at the 1 in a million (1×10^{-6}) risk level for the direct sediment exposure scenarios (500 to 1,700 µg/kg dw) (Table ES-8). The sediment RBTCs for total

PCBs calculated for river otter ranged from 128 to 159 µg/kg dw. These sediment RBTCs for total PCBs are lower than the current SWAC of total PCBs in the LDW (approximately 380 µg/kg dw).[9]

Sediment RBTCs were not calculated for arsenic, cPAHs, or dioxins and furans for the human seafood consumption pathway because either data were not available or the relationship between sediment and tissue for these chemicals is not sufficiently understood (Section 8.3). Sediment RBTCs for the protection of benthic invertebrates were the SQS and CSL from the SMS.

A comparison of sediment RBTCs to background concentrations will be important in risk management decisions made by EPA and Ecology because cleanup to concentrations below background concentrations is not practicable. The comparison of RBTCs with preliminary background datasets presented here uses the 90th percentile of each of the background datasets. Sediment RBTCs at the 1×10^{-6} risk level for direct sediment contact are higher than the range of Puget Sound reference area concentrations for total PCBs and dioxins and furans (Table ES-11). The cPAH sediment RBTC for netfishing at the 1×10^{-6} risk level is also greater than the range of Puget Sound reference area concentrations. The cPAH direct-contact sediment RBTCs at the 1×10^{-6} risk level for beach play and clamming are within the range of Puget Sound reference area concentrations. For arsenic, the direct sediment contact RBTCs at the 1×10^{-6} risk level are toward the lower end or below the range of the Puget Sound reference area concentrations.[10] At higher risk levels, direct-contact sediment RBTCs are above the concentration ranges of samples collected from Puget Sound reference areas, upstream, and the Upper Turning Basin, except for arsenic. The direct-contact sediment RBTCs for tribal clamming for arsenic at the 1×10^{-5} risk level is within the range of these concentrations.

[9] Using the inverse distance weighting (IDW) interpolation method documented in ENSR (2008), the SWAC of total PCBs for the LDW from RM 0.0 to 5.25 was 350 µg/kg dw. Based on an earlier IDW interpolation used in the food web model (FWM), the SWAC was 380 µg/kg dw for the LDW from RM 0.0 to RM 5.25. The sensitivity of the FWM to this difference in SWAC was evaluated as part of the sensitivity and uncertainty analysis of the model (Appendix D), and was found to be low.

[10] Of the 10 Puget Sound reference areas, one area (Rich Passage) had a 90th percentile arsenic concentration of 2.3 mg/kg dw; the remaining nine areas had 90th percentile arsenic concentrations ranging from 6.3 to 15.9 mg/kg dw.

Table ES-11. Comparison of sediment RBTCs and concentrations for selected risk driver chemicals in samples collected from Puget Sound reference areas, upstream of the LDW, and the Upper Turning Basin

Risk Driver Chemical	Unit	Risk Level	Sediment RBTCs for RME Direct-Contact Scenarios (Tribal Clamming, Beach Play, Netfishing)	Sediment RBTCs for RME Seafood Consumption Scenarios	Surface Sediment Data		Subsurface Sediment Data	Water Data
					Puget Sound Reference Areas[a]	Upstream[b]	Upper Turning Basin[c]	Upstream Suspended Solids[d]
Arsenic	mg/kg dw	1×10^{-6}	1.3, 2.8 ,3.7[e]	nc[f]	2.3 – 15.9	11	13	73
		1×10^{-5}	13 ,28, 37[e]	nc[f]				
		1×10^{-4}	130, 280, 370[e]	nc[f]				
		HQ = 1	na	na				
		SQS	57	na				
		CSL	93	na				
cPAHs[g]	µg/kg dw	1×10^{-6}	150, 90, 380[e]	nc[h]	14.7 – 244.7	135	201	354
		1×10^{-5}	1,500, 900, 3,800[e]	nc[h]				
		1×10^{-4}	15,000, 9,000, 38,000[e]	nc[h]				
		HQ = 1	na	na				
Dioxin and furan TEQ	ng/kg dw	1×10^{-6}	13, 28, 37[e]	nc[i]	0.141 – 2.3	2.0[j]	nd	nd
		1×10^{-5}	130, 280, 370[e]	nc[j]				
		1×10^{-4}	1,300, 2,800, 3,700[e]	nc[j]				
		HQ = 1	na	na				
Total PCBs	µg/kg dw	1×10^{-6}	500, 1,700, 1,300[e]	< 1[k]	0.2 – 19.9	40	86	107
		1×10^{-5}	5,000, 17,000, 13,000[e]	< 1[k]				
		1×10^{-4}	50,000, 170,000, 130,000[e]	7.3 – 185[l]				
		HQ = 1	nc[m]	128 – 159[n]				
		SQS	130[o]	na				
		CSL	1,000[p]	na				

[a] Information relevant to calculating preliminary natural background concentrations in sediment is presented in Section 7.1. The concentration ranges presented in this table (for informational purposes only) represent the ranges of 90th percentile concentrations calculated for multiple Puget Sound reference areas.

[b] Information relevant to upstream concentrations in sediment is presented in Section 7.2. The concentrations presented in this table (for informational purposes only) represent the 90th percentile concentrations in the upstream and Upper Turning Basin datasets. Other anthropogenic inputs from the surrounding urban area are likely due to atmospheric deposition and stormwater runoff but were not quantified as part of the RI studies. Concentrations in urban bays and lakes are discussed in Section 7.3.

[c] Information relevant to concentrations in subsurface sediment from the Upper Turning Basin is presented in Section 7.2.3. The concentrations presented in this table (for informational purposes only) represent the 90th percentile concentrations in sediment cores collected between RM 4.0 and RM 4.75.

[d] Information relevant to concentrations in suspended solids is presented in Section 7.2.4. For PCBs and cPAHs, suspended solids concentrations were estimated by normalizing whole-water concentrations in upstream samples to the sample-specific total TSS concentrations. For arsenic, sample-specific total and dissolved concentrations and TSS in upstream water samples were used to estimate suspended solids concentrations. The concentrations presented in this table (for informational purposes only) represent the 90th percentile concentrations.

[e] Sediment RBTCs developed from the human health direct-contact RME scenarios (i.e., tribal clamming/beach play/netfishing).

[f] Although identified as a COC for seafood consumption, sediment RBTCs were not calculated for arsenic for seafood consumption scenarios because a clear relationship has not been established between arsenic concentrations in surface sediment and clam tissues, but would be needed to develop an RBTC.

[g] cPAH concentrations are expressed in terms of benzo(a)pyrene equivalents.

[h] Although identified as a COC for seafood consumption, sediment RBTCs were not calculated for cPAHs for seafood consumption scenarios because a clear relationship has not been established between cPAH concentrations in surface sediment and clam tissues, but would be needed to develop an RBTC.

[i] Although identified as a COC for seafood consumption, sediment RBTCs were not calculated for dioxins and furans for seafood consumption scenarios because no tissue data were available from the LDW at the time of the risk assessments.

[j] Because of the small dataset, 90th percentiles were not calculated for dioxin and furan TEQs. The dioxin and furan TEQ represents the mean TEQ in upstream surface sediment samples.

[k] A sediment RBTC could not be calculated; even if the total PCB concentration in sediment was set equal to 0 µg/kg dw, FWM-estimated total PCB concentrations in tissue would be greater than the tissue RBTC for the applicable risk level because of the contribution of PCBs from water alone.

[l] Sediment RBTCs developed from the human health seafood consumption RME scenarios.

[m] Sediment RBTCs were not estimated for non-cancer hazards for direct-contact scenarios because none of the RME scenarios had HQs for an individual chemical greater than 1 or generated endpoint-specific HIs in excess of 1 (Appendix B, Section B.5.6).

[n] RBTCs developed from the otter prey ingestion scenario, estimated through the FWM.

[o] Reported value is lowest AET, which is functionally equivalent to the SQS, but in dry weight units.

[p] Reported value is second lowest AET, which is functionally equivalent to the CSL but in dry weight units.

AET – apparent effects threshold
COC – chemical of concern
cPAH – carcinogenic polycyclic aromatic hydrocarbon
CSL – cleanup screening level
dw – dry weight
FWM – food web model
HI – non-cancer hazard index
HQ – non-cancer hazard quotient
LDW – Lower Duwamish Waterway
na – not available or applicable
nc – not calculated
nd – no data
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration
RI – remedial investigation
RM – river mile
RME – reasonable maximum exposure
SQS – sediment quality standard
TEQ – toxicity equivalent quotient
TSS – total suspended solids

Tissue RBTCs for total PCBs were also calculated for a given risk threshold and seafood consumption rate. For example, the total PCB concentration in seafood that would be necessary to achieve an excess cancer risk of 1×10^{-5} would be 4.2 µg/kg ww for the adult tribal RME scenario and 14 µg/kg ww for the API RME scenario. Just as it is important to put sediment RBTCs in the context of sediment background levels, it is important to put tissue RBTCs in the context of the PCB concentrations in other common dietary food items. As described in Section 7.4.1 and in WSDOH (2006), PCBs are frequently detected in many different seafood species throughout Puget Sound at concentrations similar to these tissue RBTCs (Table ES-12). Mean concentrations in Puget Sound seafood ranged from 4.5 to 32.3 µg/kg ww in rock fish, 2.8 to 11.6 µg/kg ww in English sole fillet, 0.62 to 25 µg/kg ww in crab edible meat and hepatopancreas, and 0.12 to 2.8 µg/kg ww in bivalves (WSDOH 2006). In addition, these tissue RBTCs are lower than the PCB concentrations that have been detected in some common food items from a typical diet (WSDOH 2006). Consumption of many of these common food items at the rates assumed under these RME scenarios would subject the consumer to unacceptable risks.

Table ES-12. Total PCB concentrations in LDW and greater Puget Sound tissue compared with tissue RBTCs

EPC or RBTC	Total PCB Concentration (µg/kg ww)		
	English Sole	Clam	Dungeness and Slender Crab
LDW-wide 95% UCL	1,200	600	200
LDW-wide mean	700	140	170
Greater Puget Sound (range of mean values)[a]	2.8 – 11.6[b]	0.12 – 2.8[c]	0.62 – 8.44[d]
1×10^{-4} RBTC (Tulalip RME)	42	42	42
1×10^{-5} RBTC (Tulalip RME)	4.2	4.2	4.2
1×10^{-6} RBTC (Tulalip RME)	0.42	0.42	0.42

[a] Range of mean total PCB concentrations from various studies and non-urban sampling areas in the greater Puget Sound area, as presented in Table 7-19.

[b] Total PCB concentrations in English sole fillet tissue.

[c] Total PCB concentrations in clam soft tissue.

[d] Total PCB concentrations in crab edible meat or calculated whole-body tissue.

EPC – exposure point concentration
LDW – Lower Duwamish Waterway
PCB – polychlorinated biphenyl
RME – reasonable maximum exposure
RBTC – risk-based threshold concentration
UCL – upper confidence limit on the mean
ww – wet weight

ES.8 POTENTIAL CHEMICAL SOURCES AND ONGOING SOURCE CONTROL EFFORTS

Much of the sediment contamination in the LDW is believed to be the result of historical sources. Many of these historical sources, including direct discharges of municipal and industrial wastewater, have largely been controlled through compliance with modern regulatory requirements, improved business practices, elimination of product use, or cleanups of industrial property. Many of the historical direct discharges have been diverted to the sanitary sewer system and are now treated at the West Point wastewater treatment plant. Inspection and compliance programs are in place to monitor and control the handling and disposal of manufacturing wastes produced by industrial operations along the LDW. In addition, the chemical loading from stormwater and combined sewer overflows (CSOs) has been greatly reduced by permit programs that require the monitoring and control of discharges that could otherwise enter the LDW.

Although sources of chemicals to the LDW are much reduced in number and magnitude compared with the past, as chemical profiles in sediment cores demonstrate, sources that could lead to sediment contamination, or recontamination of sediment following cleanup, still exist in some areas of the LDW. Ecology, in its lead role in the Source Control Work Group (SCWG), is responsible for investigating these potential ongoing sources and evaluating whether they have been controlled sufficiently for sediment cleanup to begin.

Potential ongoing sources include stormwater runoff, CSOs, industrial wastewater discharges, deposition from uncontrolled or partially controlled air emissions (from motor vehicles and the burning of wood and fossil fuels), illicit discharges and spills, erosion of contaminated bank material, groundwater, and upstream contributions from the Green River. Ongoing investigations are being conducted at several facilities near the LDW.

The characterization of potential chemical sources to the LDW began in the 1980s. In recent years, considerable effort has been expended in sampling potential upland sources. The chemicals most often detected in these samples are PCBs, TPH, phthalates, and metals (i.e., copper, mercury, and zinc).

Source control efforts will continue until all areas with significant potential to contaminate the LDW have been addressed. Ecology and the SCWG have identified 23 nearly contiguous areas within the LDW as an organizational tool to prioritize source investigations. Seven of these areas were previously identified as candidate EAAs based on sediment contamination (Windward 2003e). Removal actions have been implemented at two of these seven locations (i.e., Duwamish/Diagonal and Norfolk) and are currently in the planning stages for three more (Slip 4, Boeing Plant 2/Jorgensen Forge, and Terminal 117).

Initial source control efforts have been focused on source identification at the five EAAs where removal actions have occurred or are being planned. Current and future source control efforts include compiling summaries of existing information,

identifying data gaps, and preparing source control action plans for the identified source control areas. These efforts help direct future investigation and remediation efforts while assessing potential sources of contamination to LDW sediments.

ES.9 KEY OBSERVATIONS AND FINDINGS

Key observations and findings for the RI are summarized below.

- Over the past 100 years, the LDW has been highly modified from its natural configuration to support urban and industrial development. Changes have included reductions and control of water flow, significant shoreline modifications, loss of intertidal habitat, and installation of riprap, pier aprons and sheet pile walls. Some limited areas of natural shoreline still exist within the LDW.
- Industrial and commercial facilities occupy most of the shoreline; one residential community is also located along the shoreline with another community nearby.
- The LDW is currently used as an industrial navigational corridor. It also supports recreational uses such as boating, kayaking, fishing, and beach play. The LDW is also one of the locations of the Muckleshoot Tribe's commercial, ceremonial, and subsistence fishery for salmon, and the Suquamish Tribe actively manages aquatic resources north of the Spokane Street Bridge, located just north of the LDW. The Duwamish Tribe uses Herring's House Park and other parks along the Duwamish for cultural gatherings.
- Despite significant alterations in habitat and areas with elevated chemical concentrations, the LDW contains a diverse assemblage of aquatic and wildlife species and a robust food web that includes top predators.
- The majority of the high arsenic and total PCB concentrations in surface sediment were located within fairly well-defined areas. The locations of the highest arsenic and total PCB concentrations were generally not in the same areas, indicating that sources likely differ for these two chemicals. Areas with the highest cPAH concentrations were located in many of the same areas identified for arsenic and total PCBs, but were also more dispersed. There are several areas with high dioxin and furan TEQs in surface sediments.
- Most of the human health risk is from PCBs, arsenic, cPAHs, and dioxins and furans.
- The highest risks to people are associated with consumption of fish, crabs, and clams, with lower risks associated with activities that involve direct contact with sediment, such as clamming, beach play, and netfishing.
- Ecological risks to fish and wildlife were relatively low, with the exception of risks to river otter from PCBs.

- Based on sediment chemistry and toxicity test results, sediment contamination in approximately 75% of the LDW (345 ac) is estimated to have no effect on the benthic invertebrate community; approximately 7% (34 ac) of the surface sediment has chemical concentrations exceeding the higher of the two state standards, and is therefore expected to have adverse effects on the benthic invertebrate community (see WAC 173-204-310[b]). The remaining 18% of the LDW (82 ac) has chemical concentrations exceeding the lower of the two state standards and these areas are considered to have minor adverse effects on the benthic invertebrate community. Most of the exceedances of SMS criteria were for PCBs and phthalates, although 41 different chemicals had at least one exceedance.
- Sediment is continually depositing within the LDW, with almost all new sediment (99%) originating from the Green River. The STM estimates that over 200,000 metric tons of sediment per year enter the LDW. Approximately 50% of this load deposits in the LDW. STM modeling runs indicate that approximately 90% of the total bed area in the LDW receives 10 cm of new sediment (from the combined Green River and lateral sources) within 10 years or less. This sediment is mixed with the existing bedded sediment through various processes, including bioturbation and propeller wash.
- A few areas in the LDW will be scoured during high-flow events. Based on the STM, the maximum scour depth is relatively shallow and is generally limited to sediment in the top 20 cm; thus, deeper sediments would not be exposed as a result of high-flow events. Scour to these relatively shallow depths is expected to occur in relatively small areas of the LDW. The STM did not account for scour from localized activities, such as discharges from outfalls, tugboat maneuvering, or anchor dragging, that could have caused localized erosional environments. Routine boat traffic is expected to mix the top few cm of sediment, which is part of the biologically active zone mixed by benthic invertebrates, whereas tugboat maneuvering is a potential source of localized erosion that could disturb sediment at greater depths in small areas. In addition, in some areas, ships may have caused localized erosion from physical forces (i.e., anchor dragging) unrelated to propeller-driven scour. Site-specific information, in addition to the results of the STM, will be evaluated in any future remedial designs.
- The physical conceptual site model of a net depositional environment is supported by both physical and chemical lines of evidence, including lithology and chemistry profiles in sediment, where these data were collected. Empirically derived net sedimentation rates from chemical and physical markers were within 1 cm/yr of the modeled sedimentation rates for 40 of

63 core locations. Most (70%)[11] of the 157 core locations evaluated had depths of peak PCB concentrations that were consistent with those predicted by the STM, with peak PCB concentrations as deep or deeper than those estimated by the STM. The remaining 30% of the cores had peak concentrations that were shallower than expected, assuming net sedimentation rates from the STM, peak PCB usage and release in the 1960s and 1970s, and minimal localized disturbances.

- Based on the STM, LDW surface sediment is generally expected to become more similar in character over time to the sediment being transported by the Green River on an LDW-wide scale; localized areas may continue to be influenced by inputs from sources in those areas.
- A comparison of background concentrations with risk-based goals in sediment (represented by sediment RBTCs) will be important in risk management decisions by EPA and Ecology. Puget Sound sediment data will be considered in the derivation of natural background concentrations, and data from other lines of evidence will be considered in the derivation of anthropogenic background concentrations.
- For total PCBs, all sediment RBTCs for direct-contact scenarios are above the concentration range of samples collected from Puget Sound reference areas, upstream of the LDW, and from the Upper Turning Basin (subsurface sediment). All sediment RBTCs for RME seafood consumption scenarios are below the range of Puget Sound reference area concentrations across the risk range of 1×10^{-6} to 1×10^{-4}, except for three sediment RBTCs. Sediment RBTCs for the child Tribal RME and the API RME scenarios (at 1×10^{-4} risk level) and for the protection of river otters are within the range or higher than the concentration range of samples collected from upstream of the LDW and from the Upper Turning Basin (subsurface sediment).
- No sediment RBTCs were derived for seafood consumption scenarios for arsenic, cPAHs, and dioxins and furans. Sediment RBTCs for arsenic and cPAHs for seafood consumption could not be estimated because the relationships between concentrations in clam tissue and sediment are not well understood and are highly uncertain. Sediment RBTCs for dioxins and furans for seafood consumption could not be estimated because there were no tissue data from the LDW when the risk assessments were conducted.
- For arsenic, sediment RBTCs for direct-contact scenarios at the 1×10^{-6} risk level are below the concentration range of samples collected from upstream of the

[11] The percent of cores with peak concentrations as deep or deeper than expected is 65% when 24 cores were excluded from the analysis because they had samples composited over intervals ≥ 3 ft in the portion of the core where the peak PCB concentrations were estimated or detected.

LDW and from the Upper Turning Basin (subsurface sediment) and are just below or within the wider range of concentrations in Puget Sound reference area samples. The tribal clamming direct-contact sediment RBTC at the 1×10^{-5} risk level is above the upstream concentration and the same as from the Upper Turning Basin (subsurface sediment) concentration but within the range of concentrations in Puget Sound reference area samples. The beach play and netfishing direct-contact sediment RBTCs at the 1×10^{-5} risk level are above concentrations found in Puget Sound reference areas, upstream of the LDW, and the Upper Turning Basin. Direct-contact sediment RBTCs at the 1×10^{-4} risk level are above all of these concentrations.

- Sediment RBTCs for cPAHs for the tribal clamming and beach play direct-contact scenarios at the 1×10^{-6} risk level are within the concentration ranges of samples collected from Puget Sound reference areas, upstream of the LDW, and from the Upper Turning Basin (subsurface sediment). The netfishing sediment RBTC for cPAHs at the 1×10^{-6} risk level is above all of the aforementioned concentration ranges as are all direct-contact sediment RBTCs at the 1×10^{-5} and 1×10^{-4} risk levels.
- Sediment RBTCs for dioxins and furans for direct-contact scenarios across the excess cancer risk range of 1×10^{-6} to 1×10^{-4} are above the concentration ranges of samples collected from Puget Sound reference areas and upstream of the LDW.

1 Introduction

This document presents the results of the remedial investigation (RI) for the Lower Duwamish Waterway (LDW). Located in Seattle, Washington, the LDW consists of the downstream portion of the Duwamish River, excluding the East and West Waterways around Harbor Island, and has served as the City of Seattle's major industrial corridor since about 1911. The area sampled as part of the RI extends from River Mile (RM) 0.0, near the southern tip of Harbor Island, to upstream of the Upper Turning Basin to approximately RM 6.0 (Map 1-1).

The LDW has been the subject of numerous environmental investigations and characterization studies completed under the auspices of various governmental and private entities, including the US Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), The Boeing Company (Boeing), King County, the Port of Seattle, the Elliott Bay/Duwamish River Restoration Program, and the US Army Corps of Engineers (USACE). The LDW was evaluated and proposed for inclusion on the National Priorities List (NPL) pursuant to Section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund), 42 US Code 9605, by EPA; and on September 13, 2001, the LDW was formally listed as a Superfund site. In February 2002, the Washington State Department of Ecology (Ecology) listed the LDW under the authority of the Washington State Model Toxics Control Act (MTCA).

Superfund and MTCA regulations require that an RI and a feasibility study (FS) be conducted for all listed sites. In 2000, the City of Seattle, King County, the Port of Seattle, and Boeing, working collectively as the Lower Duwamish Waterway Group (LDWG), agreed in an Administrative Order on Consent (AOC) to conduct an RI/FS for the LDW. Oversight of the LDW RI/FS is being provided by EPA and Ecology. As part of the RI, existing data were synthesized and new data were analyzed to determine the nature and extent of contamination, assess sources of contamination to the LDW, and conduct baseline risk assessments. Information collected during the RI will be used to help identify areas requiring cleanup. The purpose of the FS is to analyze and compare alternatives or approaches to remediate those areas that need cleanup to reduce risks.

1.1 LDW RI PROGRAM OVERVIEW

To maximize the effective use of existing data, the LDW RI was completed in two phases (Windward 2000). For the Phase 1 RI (Windward 2003a), LDWG compiled and analyzed existing data to support an understanding of the nature and extent of contamination in the sediments of the LDW and presented preliminary risk estimates based on those chemical distributions. Information evaluated during the Phase 1 RI was used to support the identification of candidate early remedial action sites also known as early action areas (EAAs). EAAs were selected using a risk-based approach

to identify high-priority areas for which remedial actions could be initiated prior to completion of the RI/FS process, as described in a technical memorandum submitted to EPA and Ecology in July 2003 (Windward 2003e). The Phase 1 RI also served as the basis for identifying additional data needed to complete the RI and the baseline ecological risk assessment (ERA) and human health risk assessment (HHRA) (Windward 2003f).

The principal objective of Phase 2 of the RI process was to collect and evaluate data necessary to support the RI/FS and future risk management decision making for the site. Phase 2 tasks included:

- Further characterize the physical and biological nature of the LDW area, including human use
- Further characterize the nature and extent of contamination within the LDW area
- Summarize available source information and the status of source control activities
- Estimate risks to both human health and the environment under baseline conditions (prior to early action) and identify risk driver chemicals
- Determine risk-based threshold chemical concentrations in sediment for these risk drivers

To complete these tasks, additional studies and investigations were conducted as follows:

- Tissue studies
  - Juvenile chinook salmon tissue sampling and chemical analyses
  - Fish, clam, and crab tissue sampling and chemical analyses
  - Benthic invertebrate community characterization, including co-located tissue and sediment sampling and chemical analyses
- Clam, crab, and shrimp surveys
- Groundwater/porewater studies
  - Groundwater seep survey and chemical analyses
  - Sediment porewater sampling and chemical analyses
- Sediment studies
  - Sediment transport studies
  - Surface sediment sampling, chemical analyses, and toxicity testing
  - Subsurface sediment sampling and chemical analyses

- Other supporting studies
  - Reconnaissance studies to assess site use by sandpiper
  - Reconnaissance studies to assess potential human use of the LDW shoreline by means of various public access points
  - Gastropod study to assess imposex
  - Bathymetry study

The protocols and study design of these investigations were developed in consultation with EPA and Ecology. Results have been discussed in various documents and technical memoranda and reviewed by various public stakeholders; all results are available at www.ldwg.org/rifs_docs.htm.The results of these investigations, along with acceptable Phase 1 RI data and other new data of acceptable quality, have been used in the development of the baseline ERA and HHRA and are incorporated in this RI report.

1.2 DOCUMENT ORGANIZATION

This document is organized as follows:

- Section 1 – Introduction
- Section 2 – Environmental Setting
- Section 3 – Sediment Dynamics
- Section 4 – Nature and Extent of Contamination
- Section 5 – Summary of the Baseline Ecological Risk Assessment
- Section 6 – Summary of the Baseline Human Health Risk Assessment
- Section 7 – Preliminary Background Concentrations of Risk Driver Chemicals
- Section 8 – Risk-Based Threshold Concentrations
- Section 9 – Potential Pathways, Source Identification, and Source Control Efforts
- Section 10 – Key Findings
- Section 11 – References

These sections are supported by the following appendices:

- Appendix A – Baseline Ecological Risk Assessment
- Appendix B – Baseline Human Health Risk Assessment
- Appendix C – Implications of Incorporating Round 3 Surface Sediment Data in Risk Assessments
- Appendix D – Food Web Model

- Appendix E – Data Selection for the RI Baseline Surface Sediment Dataset, Data Quality Review Summaries, Data Management Rules, Additional Statistical Information, Summary Data Tables, and Arsenic and cPAH Concentrations in Sediment Associated with Tissue RBTCs
- Appendix F – Subsurface Core Analysis
- Appendix G – Listed Properties and Source Control Documentation
- Appendix H – LDW Outfall Locations
- Appendix I – Source Control Area-Related Facility Information
- Appendix J –Boring Logs Used for the LDW Hydrostratigraphy Evaluation

In addition, oversized maps are bound in a separate map folio. A CD containing the complete dataset used in this RI is attached to the back cover. In addition, a separate dataset is included on the CD that contains all of the trumped surface sediment data.

2 Environmental Setting

This section describes the LDW, its history, and its environmental setting, including physiography, physical characteristics, hydrogeology, ecological habitats, biological communities, and land use.

2.1 SITE DESCRIPTION

The Duwamish River originates at the confluence of the Green and Black Rivers (Map 2-1), and flows northwest for approximately 19 km (12 mi), splitting at the southern end of Harbor Island to form the East and West Waterways, prior to discharging into Elliott Bay. The LDW study area consists of the downstream portion of the Duwamish River, excluding the East and West Waterways (Map 2-1).[12]

The LDW serves as a major shipping route for bulk and containerized cargo, and the shoreline along the majority of the LDW has been developed for industrial and commercial operations. Common shoreline features include constructed bulkheads, piers, wharves, sheet piling walls, buildings that extend over the water, and steeply sloped banks armored with riprap or other fill material (Weston 1999a). A portion of the LDW (i.e., the reach downstream of the Upper Turning Basin) is maintained as a federal navigation channel by USACE (Weston 1999a). Authorized navigation channel depths are -30 ft mean lower low water (MLLW) from Harbor Island to the 1st Avenue S Bridge to -20 ft MLLW from the 1st Avenue S Bridge to Slip 4 and –15 ft MLLW from Slip 4 to the Upper Turning Basin (NOAA 2009b). Intermittent, shallow benches exist in the nearshore, intertidal, and shallow subtidal zones of the LDW, outside the navigation channel. These benches are of various dimensions and elevations, with minimum elevations of less than 3 ft MLLW (Windward and QEA 2008). A shallow sill is present at the southern end of the East Waterway, and a deeper sill is present at the southern end of the West Waterway, where the LDW splits around Harbor Island (Weston 1999b).

Intertidal habitats are dispersed in relatively small patches (i.e., generally less than 1 acre [ac] in size), with the exception of Kellogg Island, which represents the largest contiguous area of intertidal habitat remaining in the Duwamish River (Tanner 1991). Areas of low intertidal mudflats are present below upper bank riprap in the reaches upstream of the 1st Avenue S Bridge.

The LDW is used as an industrial and commercial corridor, consistent with the land use, zoning, and land ownership in the LDW. The LDW is also part of Tribal Usual and Accustomed (U&A) fishing areas. The Muckleshoot Indian Tribe currently conducts seasonal netfishing operations in the LDW for commercial, ceremonial, and

[12] The East and West Waterways are part of the Harbor Island Superfund site.

subsistence purposes. The Suquamish Tribe actively manages resources north (downstream) of the Spokane Street Bridge, located just north of the LDW. The Duwamish Tribe uses Herring's House Park and other parks along the Duwamish for cultural gatherings.

Two City of Seattle neighborhoods, South Park and Georgetown, are located near the LDW. Both neighborhoods include a mixture of residential, recreational, commercial, and industrial land uses. The South Park neighborhood is located on the west side of the LDW, near the southern border of the City of Seattle's city limits. A portion of the South Park residential area abuts the LDW, and several houses are located along the shoreline. The Georgetown neighborhood is located east of the LDW and E Marginal Way S. The LDW also supports various recreational activities, including boating, kayaking, fishing, and beach play.

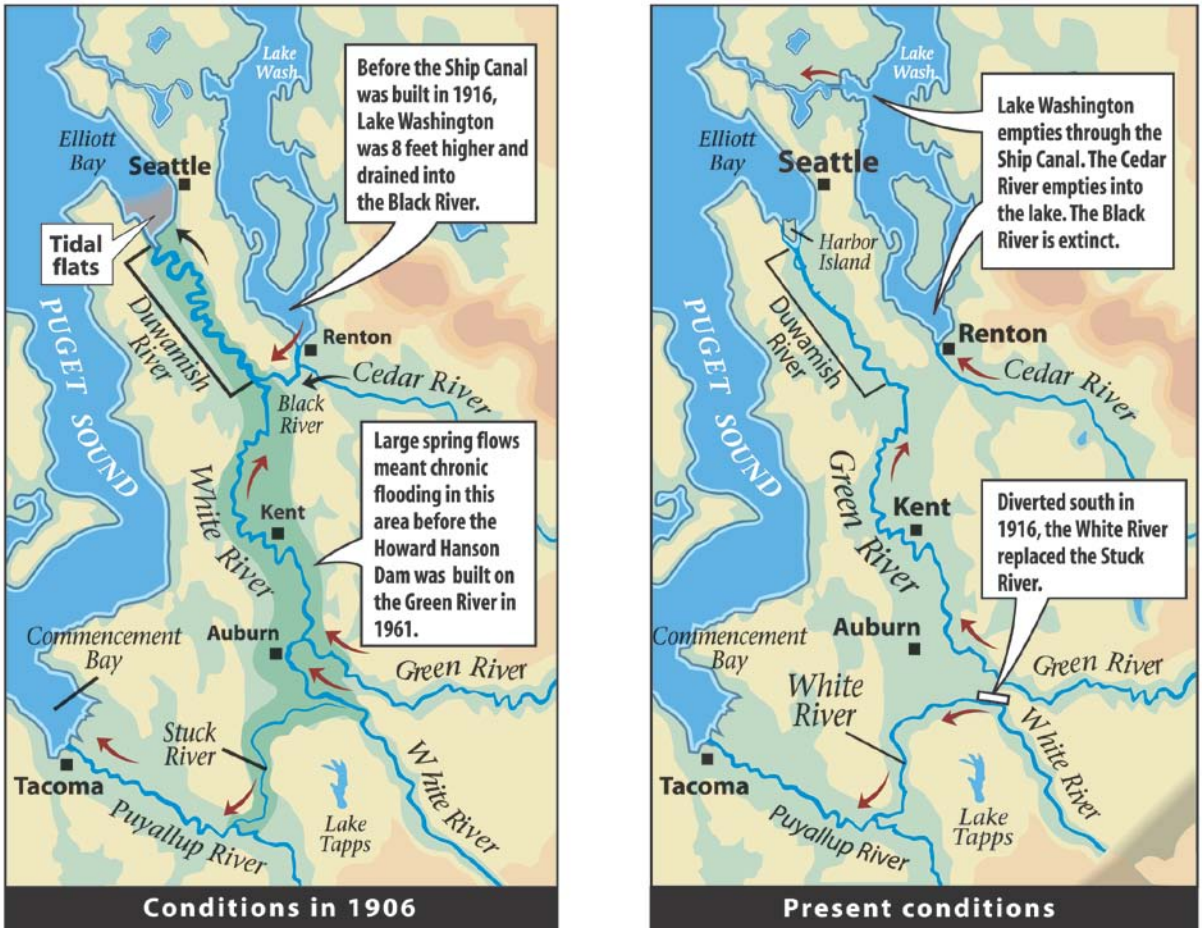
Interest in restoring and improving the intertidal habitat and other uses has led to several restoration projects, including the creation of public parks. Many restoration projects have been completed, and efforts are expected to continue over time (see Sections 2.8.1 and 2.9.3.4). Efforts to improve street ends and access points have also taken place (DRCC and ECOSS 2008; NOAA 2007b; Port of Seattle 1985, 1992). A more detailed description of site use is presented in Section 2.8.

2.2 SITE HISTORY

Prior to the 20th century, the Duwamish River was fed by the Green, Black, and White Rivers, with a combined drainage area of approximately 4,250 km^2 (1,640 mi^2) (Blomberg et al. 1988). The river meandered through a valley of floodplains, freshwater wetlands, and tidal marshes before emptying into Elliott Bay (Map 2-1). Flooding was a common occurrence in the river valley. Prior to the 1850s, the Duwamish River area was occupied by Native American tribal communities. The primary activities of these native peoples included fishing, hunting, gathering, and some limited farming, and some of the activities, notably fishing, continue to the present day. People of European origin began to settle in the area around the 1850s, clearing the Duwamish shorelines and draining wetlands for logging and agricultural purposes. In the early 1900s, continued issues with flooding in the area precipitated the installation of levees and dams, and the subsequent channelization of the river. As the quality of transportation and roads improved, commercial, industrial, and residential developments were constructed in the cleared lowland forest and farmland areas.

Throughout the 1900s, the watershed area and flow volumes to the Duwamish River were reduced by about 70% as a result of the diversion of the river's tributaries (Kerwin and Nelson 2000) (Figure 2-1). In 1906, the White River was diverted to the Puyallup River to help control flooding (Harper-Owes 1983). In 1916, the Black River, which was fed by the Cedar River and Lake Washington, was reduced to a minor stream when the level of Lake Washington was lowered through the construction of the Lake Washington Ship Canal, and the Cedar River was subsequently diverted to

Lake Washington (Harper-Owes 1983). Today, the Green River is the primary source of water for the Duwamish River.



Source: Original artwork by Ben Garrison. Image provided courtesy of WRIA 9 Forum of Local Governments and King Conservation District.

Figure 2-1. Historical changes to the Duwamish River system

To facilitate navigation and economic development, the LDW was straightened and dredged in many areas by Commercial Waterway District No. 1 (Washington Statute Revised Code of Washington [RCW] 91.04). Dredging between 1903 and 1905 created the East and West Waterways, and dredged material from the river was used to create Harbor Island (Weston 1993a). The river has been dredged and channelized from just upstream of the Upper Turning Basin to the southern tip of Harbor Island since about 1916. Upstream of the Upper Turning Basin, the river is contained by dikes.

Most of the upland areas adjacent to the LDW have been heavily industrialized for many decades. Historical and current commercial and industrial operations include cargo handling and storage, marine construction, boat manufacturing, marina operations, concrete manufacturing, paper and metals fabrication, food processing, and airplane parts manufacturing. Two mixed commercial and residential communities, Georgetown and South Park, are also located near the waterway (Wilma 2001a).

The arrival of Seattle's first railroad in 1874 attracted numerous industrial activities. All major rail connections to Seattle from the south ran through Georgetown. Early tracks crossed the mudflats on pilings; and, in later years, railroad yards were built on fill dredged from the river. Industrial development increased as the mudflats were filled with soil from Seattle's former hills. In 1928, Seattle's first municipal airport, Boeing Field, was opened. Seven years later, Boeing opened its Plant 2 on the west side of Boeing Field (Wilma 2001a).

The neighborhood of South Park is located on the west bank of the LDW. Established as a farming community, South Park grew by more than 66 ac when the Duwamish was straightened, and the new land was claimed by farmers. In the 1920s, Boeing, located just north of South Park, built airplanes for the military. During World War II, South Park changed rapidly as industry from neighboring Georgetown attracted workers, creating a critical housing shortage in the farming community (Wilma 2001b).

2.3 PHYSIOGRAPHY

The LDW is located at the downstream end of the 1,466-km^2 (566-mi^2) Green/Duwamish River watershed (referred to as Water Resource Inventory Area [WRIA] 9), which includes portions of the Cities of Seattle, Tukwila, SeaTac, Renton, Kent, Federal Way, Auburn, Black Diamond, and Enumclaw, plus forested areas in unincorporated south-central King County (Map 2-2).

From the south end of Harbor Island to just south of the Upper Turning Basin, the LDW is approximately 8.8 km (5.5 mi) in length. The depth of the LDW varies from approximately -56 ft MLLW near the mouth to -10 ft MLLW near the head of the navigation channel (RETEC 2006). The average width of the LDW is 134 m (440 ft), widening downstream of the 1st Avenue S Bridge. The width of the navigation channel is 45.7 m (150 ft) (RETEC 2006).

2.3.1 LDW bathymetry

Numerous bathymetric surveys have been conducted in the LDW, but the most comprehensive survey was conducted in 2003 as part of the LDW RI (Windward and DEA 2004). The objective of the 2003 high-resolution, multibeam, bathymetric survey was to produce a bank-to-bank (where possible) bathymetric dataset for the LDW study area. The multibeam data were used to create a digital model of the riverbed morphology from which hillshade images and contours were generated. The survey was conducted from RM 0.0 (the southern end of Harbor Island) to the bridge at RM 4.8 (Map 2-3). The procedures used to conduct the survey were described in detail in the quality assurance project plan (QAPP) (Windward 2003d) and are briefly summarized below.

A boat equipped with Reson SeaBat® 8101 multibeam bathymetric sonar ran multiple lines parallel to the shoreline to achieve full bathymetric coverage. Several perpendicular cross-tie lines were also surveyed to confirm system calibration and document accuracy. A preliminary coverage plot was generated in real-time to show multibeam swath coverage.

Survey coverage met most of the requirements specified in the QAPP, with a few expected data gaps. Because of low clearance, the survey boat was not able to navigate under the bridge at S 102nd Street, which excluded the area from RM 4.8 to RM 5.0 from the survey. The survey was conducted in August, during a spring tide, so that it could be completed before the beginning of the Muckleshoot netfishing season. As a result, there were low tides during survey hours, even though shoreline surveying was timed so that data could be collected during the highest possible tide stage. The tidal cycle limited the ability of the survey crew to collect all shoreline data during a tide stage above the targeted 5 ft MLLW (as stated in the QAPP).

Other expected data gaps included areas where obstructions, such as docks, vessels, or pilings, restricted safe vessel operation. With the exception of these data gaps, the LDW multibeam bathymetric dataset was considered to provide a complete and accurate picture of the LDW bathymetry (Windward and DEA 2004).

2.3.2 LDW dredging history

As discussed in Section 2.2, the LDW has a long history of dredging, with events aimed at supporting general navigation needs as well as reworking the shoreline to accommodate new and updated infrastructure and berthing areas. USACE is responsible for continued maintenance dredging of the LDW navigation channel. Table 2-1 summarizes maintenance dredging events completed by USACE since 1986.

Table 2-1. LDW navigation channel maintenance dredging events since 1986

Location (RM)	Dredging Date		Volume Dredged (cy)	Paydepth/ Overdepth (ft MLLW)[a]	Authorized Navigation Channel Depth (ft MLLW)	Dredging Distance		Reference
	Start	End				Station Start	Station End	
3.34 to 4.65	2/6/1992	3/21/1992	199,361	-15/-17	-15	205+00	275+56	USACE (1992)
3.43 to 4.65	3/11/1999	6/29/1999	165,116	-15/-16	-15	210+00	275+56	USACE (1999)
3.97 to 4.65	2/28/1990	3/30/1990	127,619	-17	-15	238+00	275+56	USACE (1990)
4.02 to 4.48	2/22/1996	3/30/1996	90,057	-15/-16	-15	241+00	265+00	USACE (1996)
4.19 to 4.38	3/11/1986	3/29/1986	33,637	-16/-18	-15	250+00	260+00	USACE (1986b)
4.26 to 4.65	2/5/1997	3/31/1997	89,011	-15/-16	-15	253+31	275+56	USACE (1997a)

Location (RM)	Dredging Date		Volume Dredged (cy)	Paydepth/ Overdepth (ft MLLW)[a]	Authorized Navigation Channel Depth (ft MLLW)	Dredging Distance		Reference
	Start	End				Station Start	Station End	
4.27 to 4.65	1/14/2002	2/9/2002	96,523	-15/-16	-15	254+00	275+56	USACE (2002a)
4.27 to 4.65	12/22/2007	1/10/2008	140,608	-15/-16	-15	254+00	275+56	Manson Construction (2008a)
4.33 to 4.65	3/7/1994	3/28/1994	57,243	-15/-17	-15	257+35	275+56	USACE (1994)
4.33 to 4.65	1/15/2004	2/16/2004	75,770	-15/-17	-15	257+00	275+56	USACE (2004)
4.38 to 4.65	6/19/1986	07/15/1986	126,470	-16/-18	-15	260+00	275+56	USACE (1986a)
4.38 to 4.65	2/24/1987	3/24/1987	80,160	-18/-20	-15	260+00	275+56	USACE (1987)

Note: Dredging information provided by AECOM (formerly ENSR).

[a] Paydepth is the planned design depth of the dredging event; overdepth is maximum allowed dredging depth.

cy – cubic yards

LDW – Lower Duwamish Waterway

MLLW – mean lower low water

RM – river mile

USACE – US Army Corps of Engineers

In addition, numerous dredging events have been completed in isolated areas of the LDW by private entities. Table 2-2 lists the private dredging events that have been conducted in the LDW since 1986. The approximate locations of these dredging events are shown on Map 2-4. For the most part, these were maintenance dredging events or were associated with infrastructure improvements. In addition, sediment remediation and capping events were recently completed in the vicinity of the Duwamish/Diagonal and Norfolk combined sewer overflow (CSO) and storm drain outfalls (in 2004 and 2003, respectively), and a thin layer of sand was placed next to the southwestern part of the Duwamish/Diagonal area in 2005. A sediment remediation effort was also completed adjacent to the south storm drain at the Boeing Developmental Center (BDC) in the vicinity of the Norfolk outfall in 2003.

Table 2-2. History of private dredging events in the LDW since 1986

Location	Project or Site Name	River Side	Year	Volume Dredged (cy)	Paydepth/ Overdepth (ft MLLW)[a]	Purpose	Suitable for Open Water Disposal?	Permit	Reference
RM 1.02 to RM 1.09	Lehigh Northwest	east	2004	9,000	-20/-21	maintenance dredging	DMMUs 1 and 3 (6,000 cy) suitable; DMMU 2 (3,000 cy) not suitable	USACE DAIS No. LEHIG-1-B-F-196	MCS (2004d), USACE et al. (2004)
RM 1.39 to RM 1.42	Duwamish Shipyard	west	multiple	unknown	-15 to -25/ unknown	maintain depth of basin behind dolphins	unknown	unknown	USACE (2002b)
RM 1.42 to RM 1.54	Glacier NW	west	2005	9,920	-34/authorized to -35	maintenance dredging and thin-layer cap	DMMU 1 (3,250 cy) suitable; DMMUs 2 and 3 (6,670 cy) not suitable	USACE Permit No. 92-2-00452 and USACE DAIS No. GLANW-1-B-F-183	PIE (2002), Anchor (2005), USACE et al. (2003)
RM 1.43 to RM 1.52	Lone Star Northwest – West Terminal	east	1986	unknown	unknown	maintenance dredging	not suitable (taken to upland site)	USACE Permit No. 92-2-00452	Hartman (1992), PIE (2002)
RM 1.43 to RM 1.52	Lone Star Northwest – West Terminal	west	1993	3,900	-35/-36	maintenance dredging	suitable	USACE Permit No. 92-2-00452	Hartman (1992), PIE (2002)
RM 1.56 to RM 1.75	James Hardie Gypsum	east	1999	10,000	-31/ unknown	maintenance dredging	4,540 cy (of 7,042 cy) suitable	Permit 95-2-00837	Spearman (1999)
RM 1.55 to RM 1.75	Lone Star – Hardie/Kaiser	east	1996	18,000	-30/-31	maintenance dredging and dock upgrade	DMMUs 1 to 3 (9,375 cy) not suitable; DMMUs 4 and 5 (8,625 cy) suitable	Permit 95-2-00837	Hartman (1995), USACE et al. (1995)
Slip 2	Glacier Ready Mix	east	2001	4,900	-15/-16	maintenance dredging	suitable	USACE Permit No. 2001-02-00528	USACE et al. (2001), PIE (2001)
RM 1.78 to RM 1.95 (two areas)	Terminal 115	west	1993	3,000	-15/ unknown	maintenance dredging, dolphin construction	suitable	Dredging Project No. 92-2-01363	USACE et al. (1993)
RM 2.39 to RM 2.49	Boyer	west	1998	8,000	-10/unknown	maintenance dredging	DMMUs 5 and 6 suitable; DMMUs 1 to 4 at Hurlen site	USACE Permit No. 98-2-00477	Hart Crowser (1998), WR Consulting (2004)

Table 2-2, cont. History of private dredging events in the LDW since 1986

LOCATION	PROJECT OR SITE NAME	RIVER SIDE	YEAR	VOLUME DREDGED (cy)	PAYDEPTH/ OVERDEPTH (ft MLLW)[a]	PURPOSE	SUITABLE FOR OPEN WATER DISPOSAL?	PERMIT	REFERENCE
RM 2.45 to RM 2.47	Boyer	west	2004	unknown	unknown	dock replacement	unknown	USACE Nationwide Permit No. 3, Reference No. 200200607	WR Consulting (2004)
RM 2.64 to RM 2.77	Hurlen	west	1998	15,000	-10/unknown	maintenance dredging	DMMUs 1 and 4 suitable; DMMUs 2 and 3 not suitable	USACE Permit No. 98-2-00476	Hart Crowser (1998)
RM 2.79 to RM 2.85	Crowley	Slip 4	1996	13,000	-15/unknown	maintenance dredging	DMMU 2 (3,250 cy) suitable; DMMUs 1, 3, and 4 (9,750 cy) not suitable	USACE Permit OYB 95-2-00537	PTI (1995a, b), USACE et al. (1996)
RM 2.86 to RM 2.97	Morton	west	1992	7,980	-18/unknown	maintenance dredging	suitable	OYB-2-013054, City of Seattle Shoreline Permit No. 8903261-1991	Spearman (1991a), USACE et al. (1991)
RM 3.36 to RM 3.44	South Park Marina	west	1993	15,500	-8/-9	maintenance dredging	8,000 cy suitable	USACE Permit OYB-2-012574	Spearman (1991b; 2003)
RM 4.03 to RM 4.15	Duwamish Yacht Club	west	1999	24,000	-8/unknown	maintenance dredging	suitable	071-OYB-2-008104 and 071-OYB-2-012184	Hart Crowser (1999), USACE (1999)
RM 4.17 to RM 4.24	Delta Marine	west	2004	7,000	-10/-11 in one area; -15/-17 in another area	maintenance dredging	suitable	USACE Permit No. 2002-2-00175; DAIS No. DELTA-1-B-F-171.	USACE et al. (2002)
RM 4.17 to RM 4.24	Delta Marine	west	2008	3,550	-10/-11 to -15/-17, three areas	maintenance dredging	11,905 cy suitable	USACE Permit 200200175; DE Permit NWS-2008-0320-NO, DAIS No. DELTA-1-A-F-244	King County (2007a); Manson Construction (2008b);USACE et al. (2007); USACE (2008); USACE and Ecology (2008)

Note: Dredging information provided by AECOM (formerly ENSR).

[a] Paydepth is the planned design depth of the dredging event; overdepth is the maximum allowed dredging depth.

cy – cubic yards
DAIS – Dredge Analysis Information System
DMMO – Dredged Material Management Office
DMMU – dredge material management unit
MLLW – mean lower low water
PIE – Pacific International Engineering, PLLC
RM – river mile
SEPA – State Environmental Policy Act
USACE – US Army Corps of Engineers

2.4 METEOROLOGY

The climate of the Puget Sound area is characterized as "Pacific marine." The prevailing winds move moist air inland from the Pacific Ocean, moderating both winter and summer temperatures. According to the Western Regional Climate Center (WRCC), which has compiled meteorological data from 1931 to 2007 (WRCC 2007), monthly average winter temperatures at Sea-Tac International Airport (December through February) range from 4 to 6°C (40 to 43°F), and monthly average summer temperatures (June through August) range from 16 to 18°C (60 to 65°F). Over 50% of the annual precipitation in the region falls between the months of October and January. Annual monthly average precipitation at Sea-Tac International Airport ranges from 2 to 15 cm (0.8 to 6.0 in.), with an annual average precipitation of 97 cm (38 in.) (WRCC 2007). Winds in the Duwamish Valley are typically from the south and southwest in the late fall, winter, and spring and from the north in the summer and early fall (PSCAA 2007c; Battelle et al. 2001). Annual monthly average wind speeds at Sea-Tac International Airport range from 11 to 14 km/hr (7 to 9 mi/hr) (WRCC 2007).

2.5 HYDROGEOLOGY

The hydrogeology of the Duwamish River basin, including the nature of subsurface materials and geologic units, is complex and influences both surface water and groundwater flow systems within the basin. Regional recharge and discharge patterns also play a significant role in defining the groundwater flow system of the Duwamish basin. The following subsections provide an overview of the relevant geologic features that influence the groundwater flow pathways to the LDW.

2.5.1 Geologic history

The Greater Duwamish Valley was formed by the carving action of glaciers that last advanced into this area from British Columbia approximately 15,000 years ago. When the ice sheets began to retreat approximately 5,700 years ago, the waters of Puget Sound extended up the Duwamish Valley as far south as Auburn, about 32 km (19 mi) upstream of the present mouth of the LDW at Elliott Bay. Around that same time, the Osceola Mudflow descended from Mount Rainier, depositing a massive layer of sediment into the then marine waters near present-day Auburn and Kent. The mudflow diverted the historical course of the White River, at that time a tributary of the Puyallup River, to the Green River (Booth and Herman 1998).

The alluvial fill within the Duwamish Valley deepened over time from the deposition of upstream fluvial sediments of the White, Green, and Black Rivers, advancing the mouth of the Duwamish River farther to the north. The fill included beds of fine silts and sands deposited as riverine and floodplain deposits, with coarser sands and gravels deposited near the water's edge. These sediments eventually buried the post-glacial form of the valley so that only a few outcroppings of bedrock remain exposed at the ground surface. As the river flooded and migrated back and forth across the floodplain, these

sediments were redeposited by the river and continually intermixed with additional riverine and floodplain deposits (Booth and Herman 1998).

In the late 1800s and early 1900s, the river was extensively modified. Tide flats and floodplains were filled to straighten the river channel, resulting in the abandonment of almost 6 km (3.7 mi) of the original meandering river bed. Current side slips in the LDW are remnants of these old river meanders (Map 2-1).

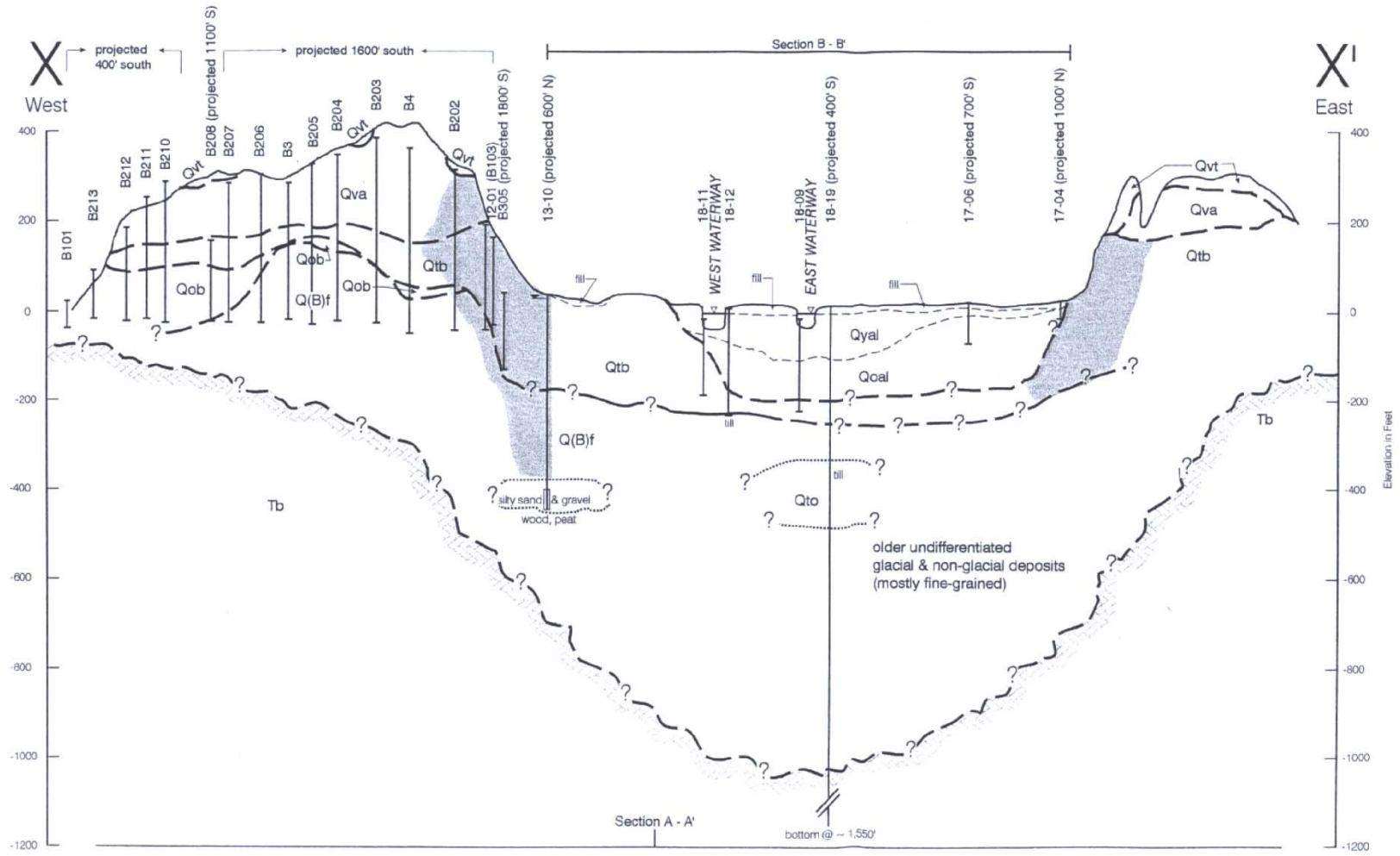
The channel has been frequently dredged for navigational purposes, and the excavated material was used to fill the old channel areas and the lowlands to bring them above flood levels. Subsequent filling of the lowlands for continued development resulted in a surficial layer of fill over most of the lower Duwamish Valley. Although the sediment types encountered in the LDW are variable (either from changing regional or local hydrodynamics or anthropogenic disturbances), basic sedimentary patterns of interbedded silts and sands are evident in the LDW. These patterns are controlled by Duwamish drainage basin morphology, precipitation, and flow rates. Both the regional and local aspects of these patterns are discussed in the following subsections.

2.5.2 Regional stratigraphy

The three principal geologic assemblages within the Greater Duwamish Valley that establish the hydrogeologic system, from oldest to youngest, are:

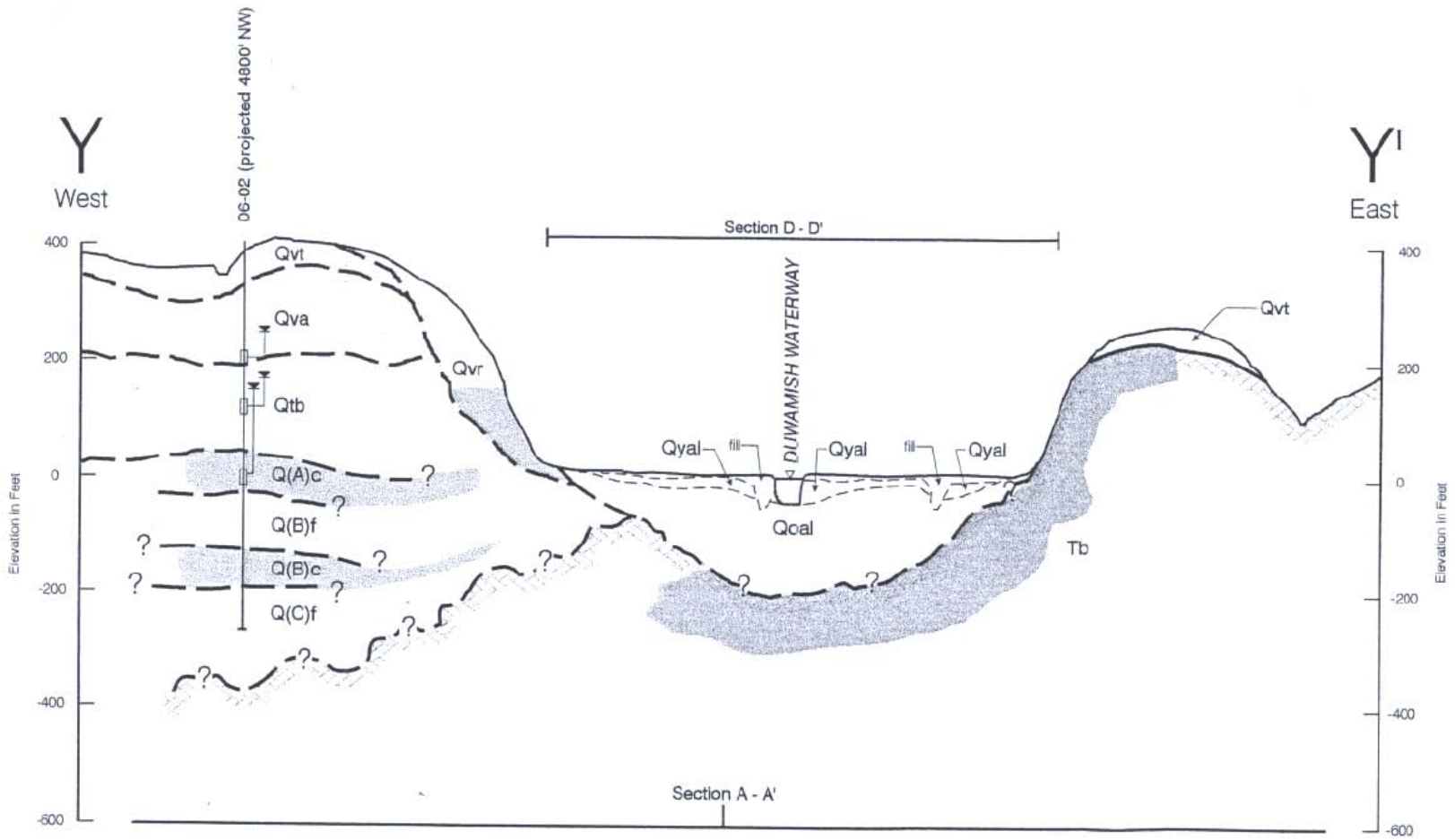
- Bedrock
- Glacial and non-glacial sedimentary units (glacially overridden and dense units that make up the plateaus to the east and west of the Duwamish Valley)
- Undifferentiated quaternary alluvial deposits (principal aquifer and groundwater pathway for the Duwamish basin)

Map 2-5 presents the surficial geology of the Greater Duwamish Valley basin and provides definitions of the surficial geologic units. Figures 2-2 and 2-3 are schematic cross sections of the regional stratigraphy at two locations in the Duwamish Valley as identified on Map 2-5 (cross sections X-X′ and Y-Y′, respectively); the additional cross sections identified on Map 2-5 are not included or discussed in this document. Figure 2-2 is a cross section of the LDW near Harbor Island, and Figure 2-3 presents the regional stratigraphy at approximately RM 3.0. Table 2-3 provides subsurface geologic unit nomenclature used in Figures 2-2 and 2-3 and discussed in this text (Booth and Herman 1998; 2005). The following subsections describe the assemblages and their influence on groundwater flow patterns in the Greater Duwamish Valley.



Source: Booth and Herman (1998)

Figure 2-2. Cross section of Greater Duwamish Valley stratigraphy at southern end of Harbor Island



Source: Booth and Herman (1998)

Figure 2-3. Cross section of Greater Duwamish Valley stratigraphy near LDW RM 3.0

Table 2-3. Definitions of subsurface geologic nomenclature

GEOLOGIC NOMENCLATURE	DEFINITION
Q(A)c	coarse-grained deposits, presumably immediately underlying Olympia-age (approximately 17,000 to 40,000 years ago) deposits (correlation is speculative)
Q(B)c	coarse-grained deposits, immediately underlying unit Q(B)f
Q(B)f	fine-grained deposits, immediately underlying the Q(A)c unit; speculative correlation would imply an age of at least 100,000 years old
Q(C)f	older undifferentiated, unconsolidated fine-grained deposits
Qoal	older alluvium
Qob	Olympia beds
Qtb	transitional beds, formed as the ice first advanced and laminated silt and clay were deposited; unit is a regionally significant aquitard, allowing very little movement of groundwater
Qva	coarser outwash, deposited by streams derived from the advancing ice sheet, initiated by the Vashon Advance Outwash (approximately 15,000 years ago); primary shallow aquifer in the upland areas throughout the region
Qvt	lodgment till, deposited by the melt-out of debris at the base of the glacier; composed of heterogeneous, compact sediment (glacial deposit)
Qyal	younger alluvium
Tb	the Blakely Formation, which includes marine sandstone, some conglomerate, and minor amounts of siltstone (bedrock)

Source: Booth and Herman (1998) and USGS (2005)

2.5.2.1 Bedrock

Bedrock in the Greater Duwamish Valley provides the lower boundary of the aquifer system and limits groundwater flow in the basin. At the northern end of the Duwamish Valley, the elevation of the bedrock unit ranges from roughly 60 m (200 ft) to over 500 m (1,640 ft) below ground surface (bgs). Exposed bedrock in the eastern and southern areas of the Greater Duwamish Valley (see Figures 2-2 and 2-3) is predominantly marine and continental sedimentary rocks intermixed with isolated areas of igneous rock deposited during the Tertiary period. Sedimentary rock units within the Greater Duwamish Valley are not an important source of groundwater because the predominantly cemented, fine-grained nature of the material precludes rapid groundwater movement. However, igneous rock layers are extensive in the area and can store and move water much more readily (Booth and Herman 1998).

2.5.2.2 Glacial and non-glacial sedimentary deposits

The glacial and non-glacial sedimentary units within the Duwamish basin are complex sequences of interbedded and unconsolidated deposits. In areas where bedrock occurs at significant depths below the river valley, these glacial sedimentary deposits serve as the lower boundary of the alluvial deposits in the Greater Duwamish Valley. The upland plateau areas to the east and west of the valley are formed predominantly of these glacially deposited sedimentary units (see Figures 2-2 and 2-3).

Little information is available on the glacially overridden sedimentary units within the LDW study area. These overridden deposits are mainly fine-grained materials; their maximum depth is unknown (Booth and Herman 1998). Although these deposits provide a geologic boundary to the alluvial deposits, they also provide a potential hydraulic pathway for the flow of upland groundwater to the Duwamish Valley alluvial sediments.

Thick sequences or silt beds (transitional beds) could potentially limit the upland inflow of groundwater where these deposits occur. The presence of saline water in the deeper alluvial sediments outside of current tidal influence areas suggests that there is little influx of fresh water into the original marine delta deposits. The lack of fresh groundwater in these deep alluvial sediments may indicate that the inflow of upland groundwater in this layer is limited (Figures 2-2 and 2-3).

2.5.2.3 Duwamish Valley alluvial deposits

The near-surface alluvial deposits in the Duwamish Valley extend to depths of roughly 60 m (200 ft) bgs within a trough bounded and underlain by either the bedrock unit or the dense glacial deposits and non-glacial sedimentary deposits. The geologic history of this valley suggests that the alluvial deposit sequences include estuarine deposits, typically fine sands and silts (often including shell fragments), which progress upward into more complex, interbedded river-dominated sequences of sand, silt, and gravel. These layers of alluvial deposits delineate the areas of advancing river delta sedimentation that increase in thickness from south to north (Booth and Herman 1998). Channel fill materials, which were deposited during settlement and when the river was straightened, are included in this category because fill material has properties similar to alluvium, as described below.

On a regional scale, the fill and alluvial deposits can be separated into various generalized units as illustrated in Figures 2-2 and 2-3. Geologic unit definitions and nomenclature are provided in Table 2-3. These regional units (from younger to older) include:

- **Fill –** The lower Duwamish River was straightened in the early 1900s into a navigation channel, using fill materials derived mostly from local sources. Much of the fill placed in the old river channels was dredged material, which is similar in hydraulic conductivity to the native younger alluvium. In the vicinity of the LDW, various depths of fill are present, ranging in thickness from 1 to 6 m (3 to 20 ft). Locally, the shallowest aquifer occurs within the lower portion of this fill material, especially in the northern sections of the LDW where upland was created during the last century. The depth of fill varied greatly and generally consisted of sand and silty sand in the saturated zone.

- **Younger alluvium (Qyal) –** This younger alluvium has been identified at the bottom of filled Duwamish River channels. Younger alluvium deposits are composed predominantly of sand, silt, gravel, and cobbles deposited by streams and running water (USGS 2005). In the central Duwamish Valley, roughly between RM 2.0 and RM 5.2, younger alluvial deposits are of relatively constant thickness and depth, based generally within 1.5 to 3 m (5 to 10 ft) of present-day mean sea level. These deposits are thicker in the south than in the north within the LDW; the thickest deposits on the northern end are estimated to occur at a depth of roughly 30 m (100 ft) bgs. The younger alluvium consists of sands, silts, and clays and includes abundant natural organic material. This layer is often distinguished from the overlying fill by abundant fibrous organic material typical of tide marsh deposits.
- **Older alluvium (Qoal**) – The older alluvium is characterized by estuarine deposits, often including shells at its lower depths, and composed of silts and clays with sandy interbeds (USGS 2005). This unit is commonly identified at depth between 15 and 30 m (50 and 100 ft) bgs in the central Duwamish Valley, increasing in depth toward the mouth of the LDW to between 45 and 60 m (150 and 200 ft) bgs. This unit has been best characterized at the Boeing properties in the central valley, where the older alluvium becomes finer-grained with increasing depth. In this area, the upper two-thirds of the older alluvium typically consist of sand and silty sand, and the lower third consists of sandy silt. The older alluvium also becomes significantly finer toward the north, with the sand almost completely absent near the mouth of the LDW. At this location, the layer is composed almost entirely of silt and clay, representing the farthest extent of the delta deposits into the marine waters and displaying the finest-grained material of the Duwamish Valley alluvial sequence.

2.5.3 LDW sediment stratigraphy

This section provides an overview of the stratigraphy of sediments identified in the LDW. Stratigraphy is the identification of individual sediment layers or groups of layers differentiated above or below by unity of color, texture, or gross appearance (Krumbein and Sloss 1963). The core logs provided in the subsurface sediment data report (Windward and RETEC 2007) characterize the stratigraphy of the units identified in the cores collected from within the LDW during the 2006 study.

The core logs provide the following stratigraphic information:

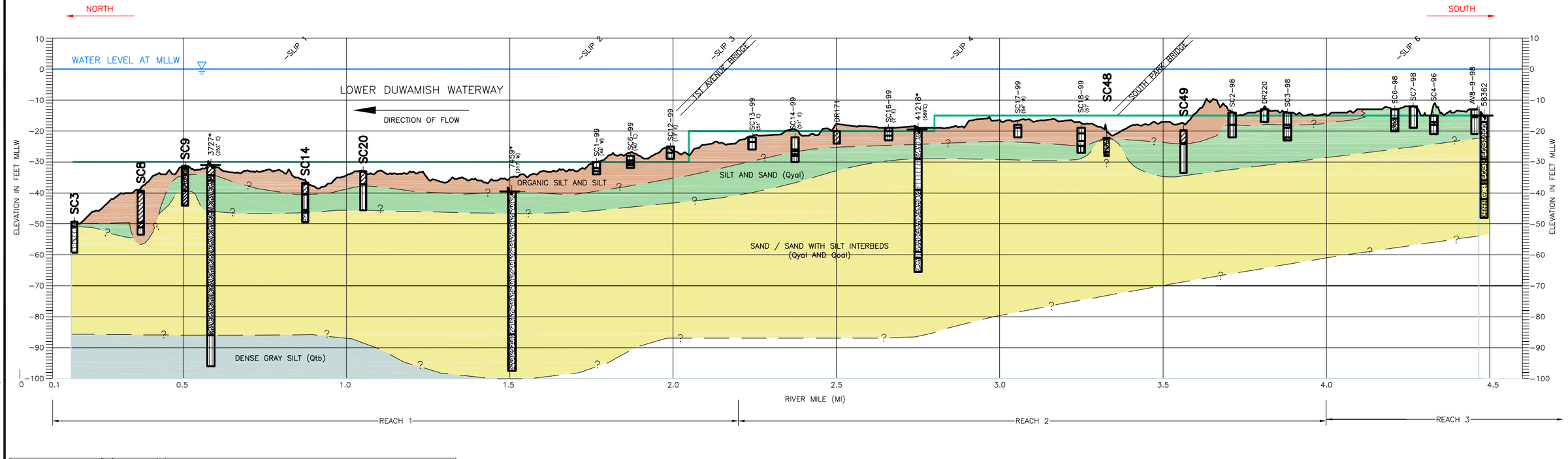
- A stratigraphic profile based on recovered depths, using description categories consistent with American Society for Testing and Materials (ASTM) nomenclature
- Detailed LDW sediment descriptions and comments
- A combined lithologic and stratigraphic profile based on *in situ* depths

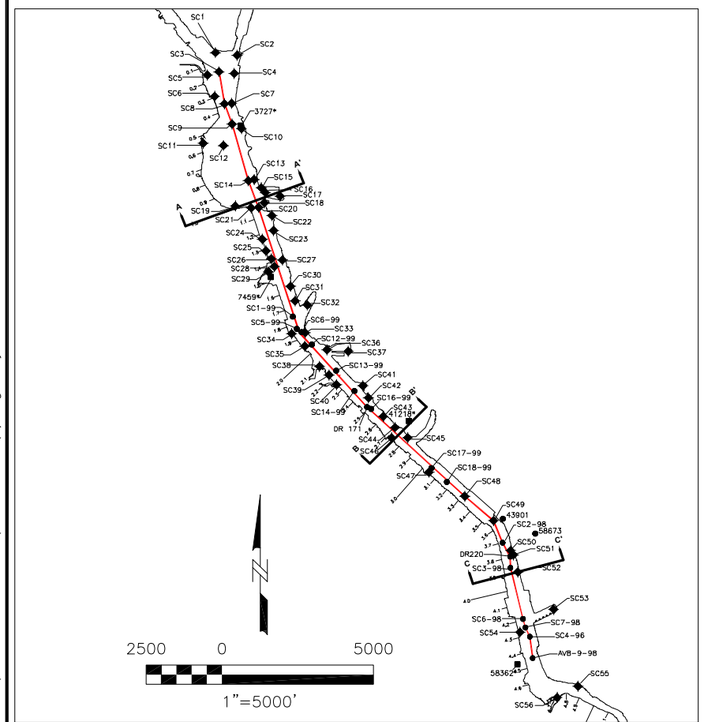
Based on field observations, the LDW sediments were grouped into three stratigraphic units. These units were delineated primarily based on density, color, sediment type, texture, and marker bed horizons; although other information, including the presence of anthropogenic matter, depth in the waterway, and available information on historical dredging events, was also considered.

Vertical sediment stratigraphic profiles were created for the LDW by comparing and evaluating sediment stratigraphy information from the LDW subsurface sampling event (Windward and RETEC 2007) and from other cores collected near the LDW shoreline. The core logs evaluated to prepare this presentation are provided in Appendix J. The locations of these cores are presented on maps included in Section 4.

The detailed stratigraphic information available from the cores collected in 2006, along with historical data from adjacent upland sites and other in-water boring data, was used to differentiate sedimentary units in the LDW from the larger undifferentiated Quaternary Alluvium unit of the Greater Duwamish Valley as described in Section 2.5.2.3.

To illustrate the distribution of these alluvial units in the LDW, a longitudinal cross section along the navigation channel centerline and three stratigraphic cross sections (A-A′, B-B′, and C-C′) at RM 1.0, RM 2.75, and RM 3.9 were prepared (Figures 2-4 through 2-7, respectively). The cross sections show the LDW at different river widths and together illustrate the change in sediment depositional patterns associated with the change in river morphology. The nomenclature used to describe the sediment units in these figures relates to the stratigraphy identified in the LDW and is not meant to correlate directly with the larger sedimentary units identified in the discussion of the Greater Duwamish Valley structure in Section 2.5.2.3.





800 0 1600
HORIZONTAL SCALE IN FEET
VERTICAL EXAGGERATION = 50:1

LEGEND

- DR-171 ● Historical Subsurface Core
  - SC4-96 = PSSDA96 study
  - SC2-98 = PSDDA98 study
  - SC6-99 = PSDDA99 study
  - DR171 = EPASI study
- 3727* ■ Upland Core
  - 7459 = Hart Crowser 1979 study
  - 41218 = Yonemitsu Geological Services 1979 study
  - 3727 = Dames and Moore 1988 study
  - 58362 = Seattle Public Utilities (CPT-D77_01) 1985 study
- SC48 ◆ 2006 Subsurface Core
- Authorized Navigation Depth (ft MLLW)
- Mid-channel mudline elevation (based on 2003 bathymetry survey, ft MLLW)
- Water level at MLLW (ft)

KEY

SC14-99 (51 ft)
- Core Name (Distance from section to Core)
- Top of Core
- Observed Contacts
- Bottom of Core

STRATIGRAPHY**

- RECENT
- UPPER ALLUVIUM/TRANSITION
- LOWER ALLUVIUM
- DENSE POST-GLACIAL AND GLACIAL UNIT

Qtb = TRANSITIONAL SILTS
Qyal = YOUNGER ALLUVIUM
Qoal = OLDER ALLUVIUM

LITHOLOGY

- Clay/Silt
- Organic silt
- Silt
- Sand with silt
- Sand with silt interbeds
- Sand
- Gravel, sandy gravel

NOTES

1) MLLW – mean lower low water
2) 2006 Phase 2 cores (SC3, SC8, SC9, SC14, SC20, SC48, SC49) are labeled with bold font in cross section.
3) AV8-9-98 is an average of Core 8 and 9 from PSDDA (1998).
4) Upland cores from GeoMap NW, Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
5) Cross sections represent regional geology. See core logs in the subsurface sediment data report (Windward 2007) for detailed stratigraphy.

* Upland cores projected into Navigation Channel. Lower portions of upland cores used to bound deeper sediment units.

** Stratigraphy terminology is used in subsurface data report (Windward and Retec 2007) and sediment transport analysis report (Windward and QEA 2008).

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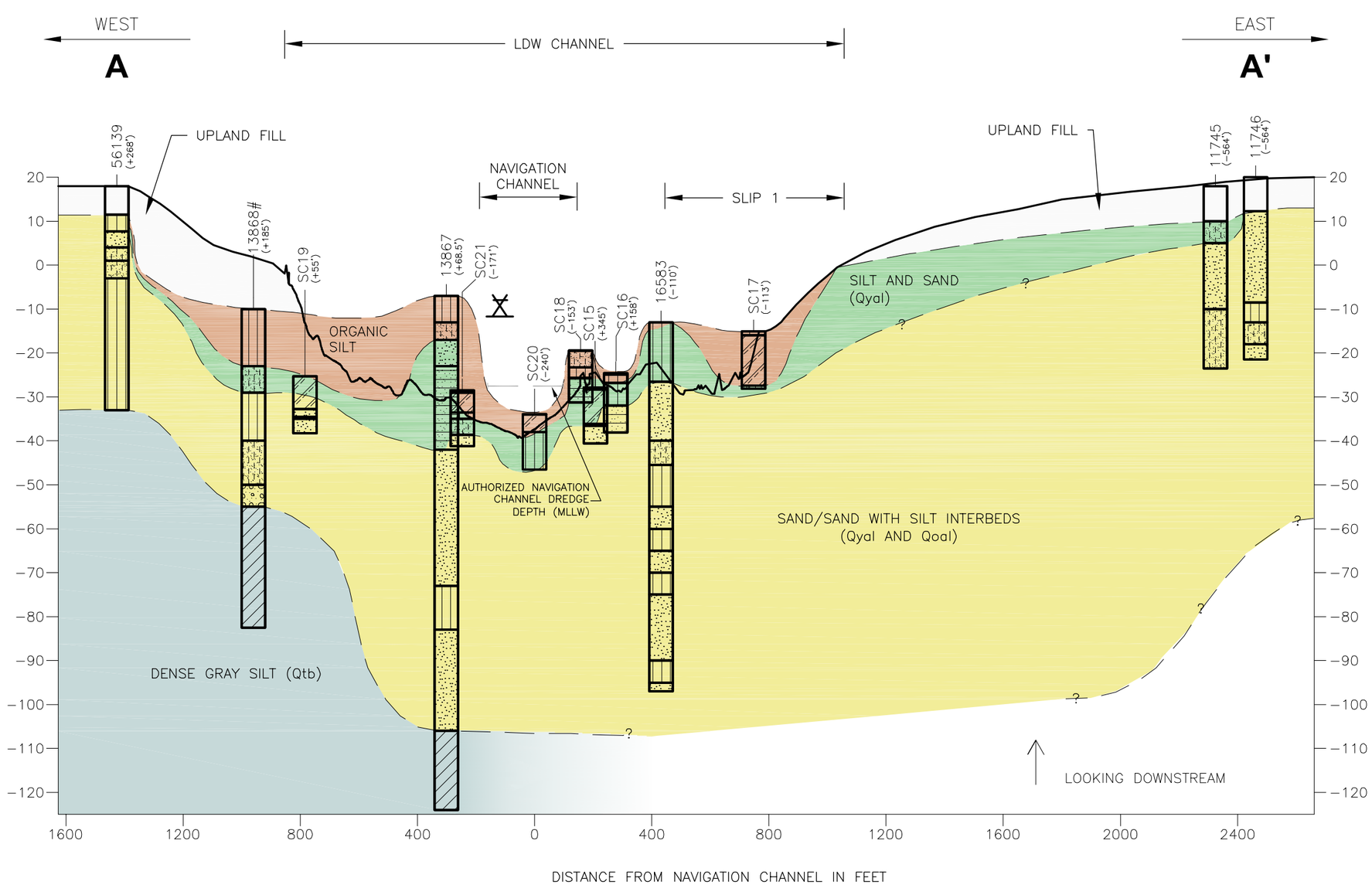
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

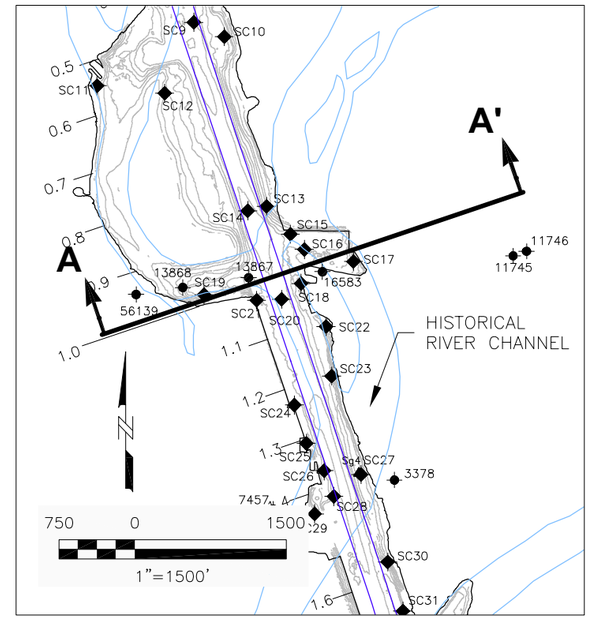
LOWER DUWAMISH WATERWAY
PHASE 2 RI REPORT
05482-015-514

NAVIGATIONAL CHANNEL LONGITUDINAL CROSS SECTION

DATE: 6/17/08 | DRWN: E.M./SEA | **FIGURE 2-4**

File: L:\Lower Duwamish\X-SECTS 6-17-08\18220-LONG(c).dwg Layout: FIG 2-3 User: emarshall Plotted: Jun 17, 2008 - 4:24pm Xref's:





NOTES:

1) Boring and core logs shown as in-situ depth. Actual contacts may vary.
2) Upland cores from GeoMap NW, Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3) Cross sections represent regional geology. See core logs in the subsurface sediment data report (Windward 2007) for detailed stratigraphy.

* Stratigraphy terminology is used in subsurface data report (Windward 2007) and sediment transport analysis report (Windward and QEA 2007).

\# In water core (13868) projected onto upland portion of cross section. Top of core at −10ft MLLW. Mudline elevation line extended to top of upland core to west (56139).

200 0 400
SCALE IN FEET
VERTICAL EXAGGERATION = 15:1

LITHOLOGY
- Fill
- Clay/silt
- Organic silt
- Silt
- Sand with silt
- Sand with silt interbeds
- Sand
- Gravel, sandy gravel

STRATIGRAPHY*
- UPLAND FILL
- RECENT SEDIMENT
- UPPER ALLUVIUM/TRANSITION
- LOWER ALLUVIUM
- DENSE POST-GLACIAL AND GLACIAL UNIT

LEGEND

INTERTIDAL OR SUBTIDAL CORES:
- SC52 – RI SUBSURFACE CORE (2006)

UPLAND BORINGS:
- 13867, 13868 – TWELKER, 1970
- 11745, 11746 – TERRA ASSOC., 1999
- 56139 – GEORESOURCE INC., 1985
- 16583 – GEOENGINEERS, 1995

Approximate mudline surface elevation in ft MLLW (2003 Bathymetry)

Approximate mudline surface elevation (1900 ACOE soundings)

KEY

SC19 (214') – Core Name – (Dist. from section to core in feet)
- Top of Core
- Observed Contacts
- Bottom of Core

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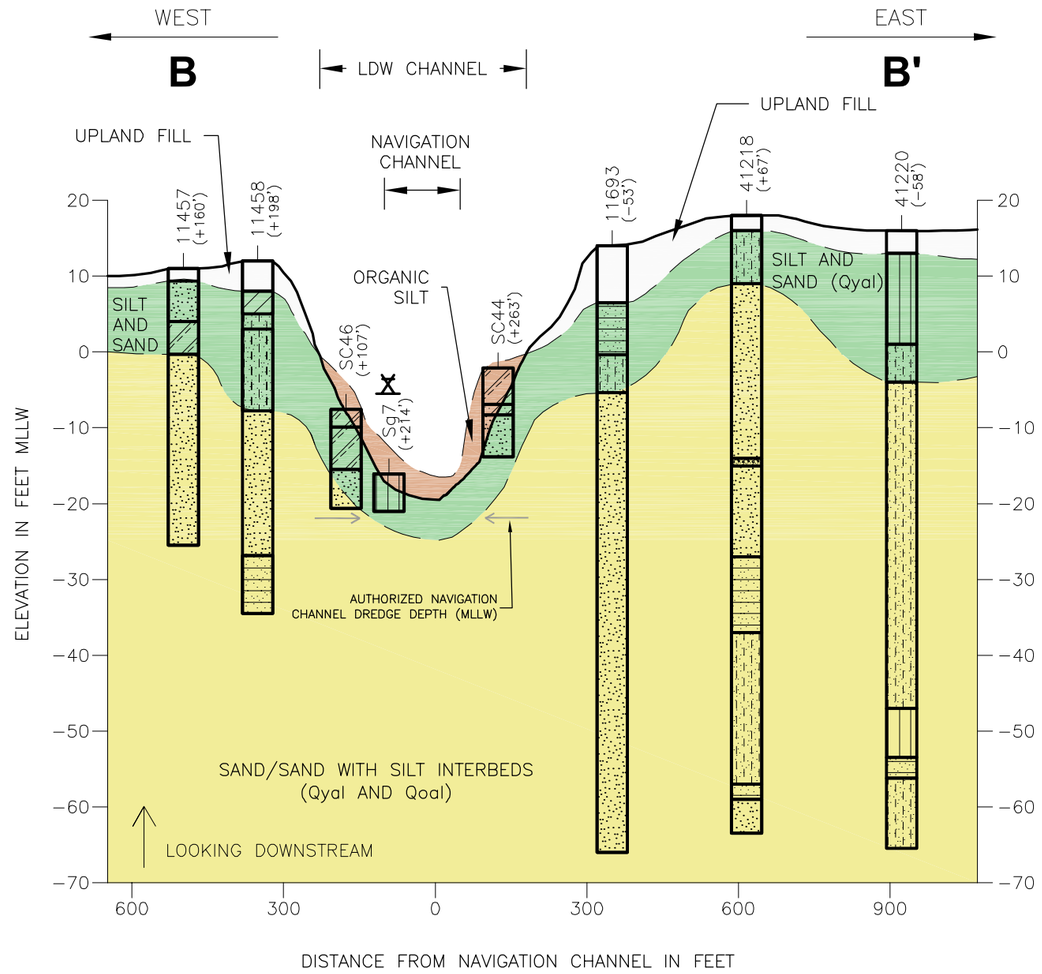
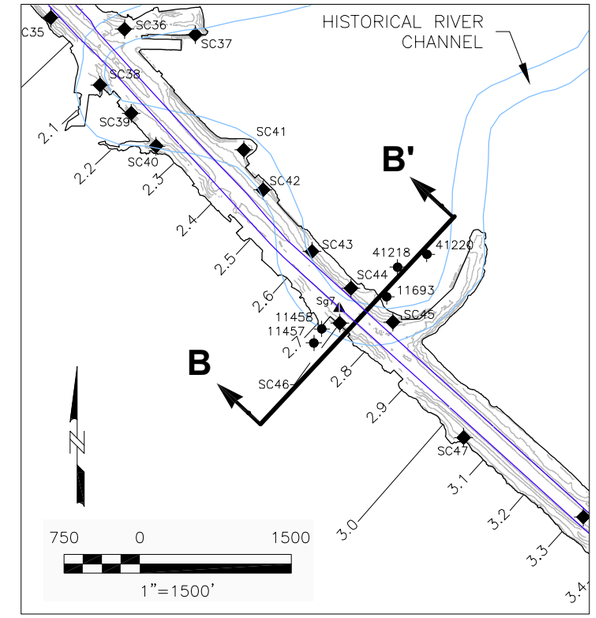
LOWER DUWAMISH WATERWAY PHASE 2 RI
05482-015-514

GENERALIZED CROSS SECTION A-A' RIVER MILE 1.0

DATE: 06/17/08 | DRWN: E.M./SEA | **FIGURE 2-5**

File: L:\Lower Duwamish\X-SECTS 6-17-08\CROSS-SEC_A-A'.dwg Layout: fig 2-4 User: emarshall Plotted: Jun 18, 2008 - 8:57am Xref's:





NOTES:

1) Boring and core logs shown as in-situ depth. Actual contacts may vary.

2) Upland cores from GeoMap NW, Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php

3) Cross sections represent regional geology. See core logs in the subsurface sediment data report (Windward 2007) for detailed stratigraphy.

* Stratigraphy terminology is used in subsurface data report (Windward 2007) and sediment transport analysis report (Windward and QEA 2007).

150 0 300

SCALE IN FEET

VERTICAL EXAGGERATION = 15:1

LITHOLOGY

- Fill
- Clay/silt
- Organic silt
- Silt
- Sand with silt
- Sand with silt interbeds
- Sand
- Gravel, sandy gravel

STRATIGRAPHY*

- UPLAND FILL
- RECENT SEDIMENT
- UPPER ALLUVIUM/TRANSITION
- LOWER ALLUVIUM

LEGEND

INTERTIDAL OR SUBTIDAL CORES:

- SC44, SC46 – RI SUBSURFACE CORE (2006)
- Sg7 – GEOCHRONOLOGY CORE (2004)

UPLAND BORINGS:

- 11457, 11458 – CONVERSE CONSULTANTS 1988
- 11693 – GOLDER ASSOCIATES, 1997
- 41218, 41220 – YONEMITSU, 1979

Approximate mudline surface elevation in ft MLLW (2003 Bathymetry)

Approximate mudline surface elevation (1900 ACOE soundings)

KEY

SC19 (214') – Core Name – (Dist. from section to core in feet)

- Top of Core
- Observed Contacts
- Bottom of Core

ENSR | AECOM

Lower Duwamish Waterway Group

Port of Seattle / City of Seattle / King County / The Boeing Company

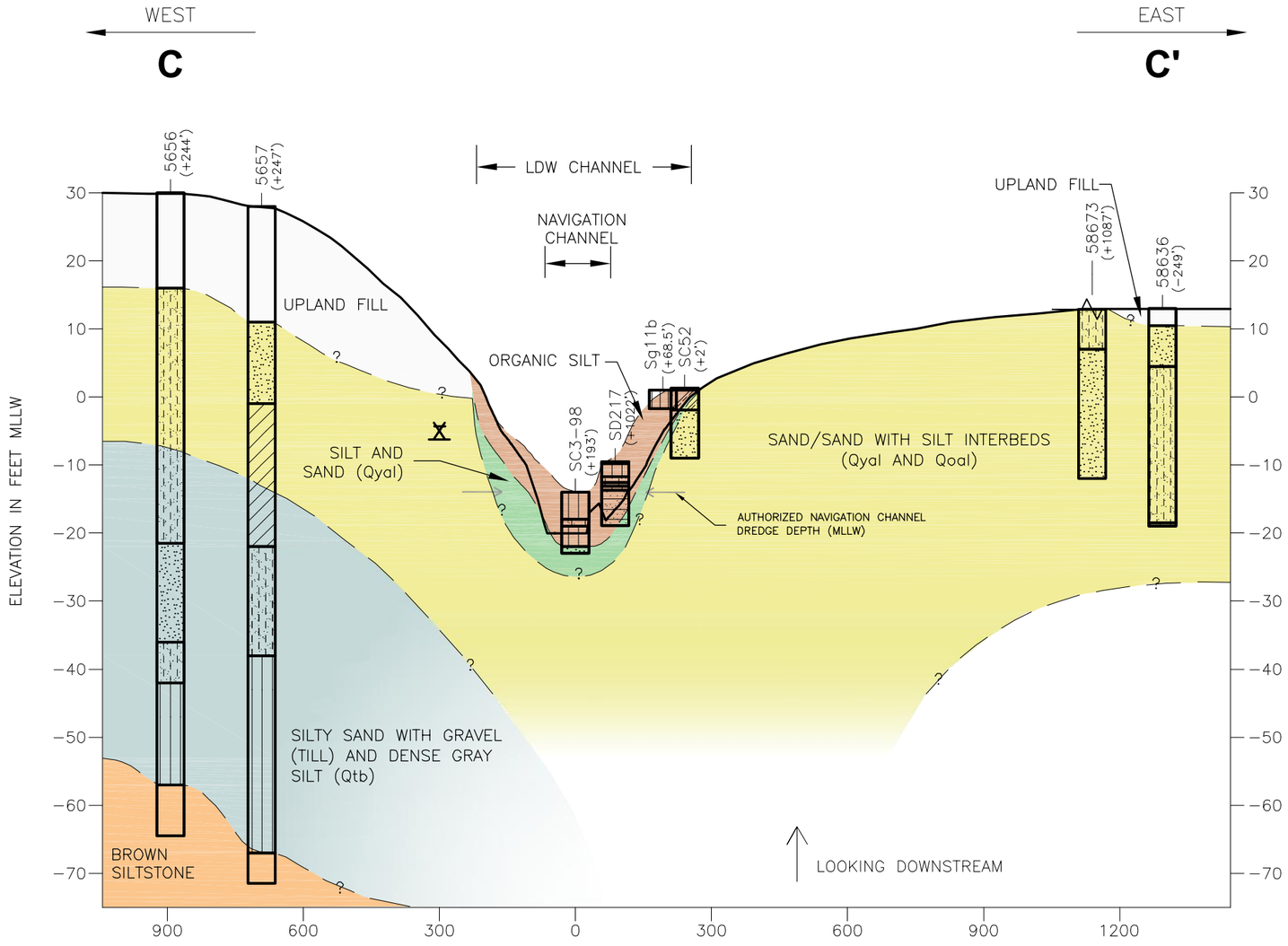
LOWER DUWAMISH WATERWAY PHASE 2 RI

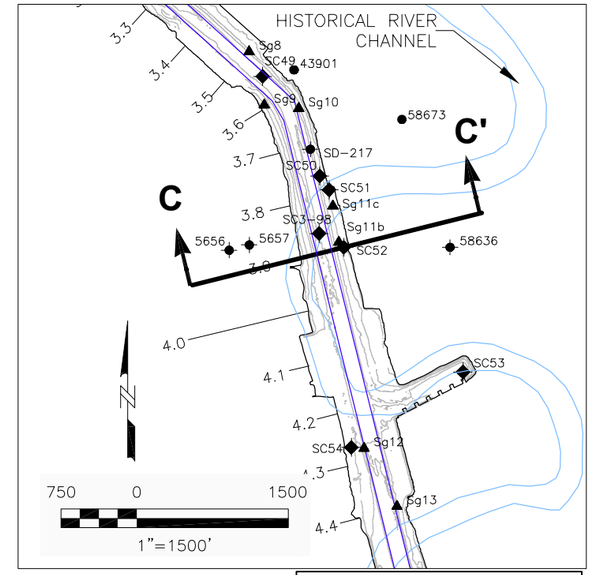
05482-015-514

GENERALIZED CROSS SECTION B-B' RIVER MILE 2.75

DATE: 06/17/08 | DRWN: E.M./SEA | **FIGURE 2-6**

File: L:\Lower Duwamish\X-SECTS 6-17-08\CROSS-SEC_B-B'.dwg Layout: fig 2-5 User: emarshall Plotted: Jun 17, 2008 - 4:20pm Xref's:





NOTES:

1) Boring and core logs shown as in-situ depth. Actual contacts may vary.

2) Upland cores from GeoMap NW, Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php

3) Cross sections represent regional geology. See core logs in the subsurface sediment data report (Windward 2007) for detailed stratigraphy.

* Stratigraphy terminology is used in subsurface data report (Windward 2007) and sediment transport analysis report (Windward and QEA 2007).

150 0 300

SCALE IN FEET

VERTICAL EXAGGERATION = 15:1

LITHOLOGY

- Fill
- Clay/silt
- Organic silt
- Silt
- Sand with silt
- Sand with silt interbeds
- Sand
- Gravel, sandy gravel

STRATIGRAPHY*

- UPLAND FILL
- RECENT SEDIMENT
- UPPER ALLUVIUM/TRANSITION
- LOWER ALLUVIUM
- DENSE POST-GLACIAL AND GLACIAL UNIT
- BEDROCK

LEGEND

INTERTIDAL OR SUBTIDAL CORES:

- SC52 – RI SUBSURFACE CORE (2006)
- Sg11b – GEOCHRONOLOGY CORE (2004)

UPLAND BORINGS:

- 5656, 5657 – DAMES & MOORE, 1984
- 58636 – GEOENGINEERS, 1988

Approximate mudline surface elevation in ft MLLW (2003 Bathymetry)

Approximate mudline surface elevation (1900 ACOE soundings)

KEY

SC19 (214')
- Core Name –(Dist. from section to core in feet)
- Top of Core
- Observed Contacts
- Bottom of Core

ENSR | AECOM

Lower Duwamish Waterway Group

Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY PHASE 2 RI

05482-015-514

GENERALIZED CROSS SECTION C-C'
RIVER MILE 3.9

DATE: 06/17/08 | DRWN: E.M./SEA | **FIGURE 2-7**

File: L:\Lower Duwamish\X-SECTS 6-17-08\CROSS-SEC_C-C'.dwg Layout: fig 2-6 User: emarshall Plotted: Jun 17, 2008 - 4:22pm Xref's:

Figure 2-8 provides a visual summary of sediment lithology in the LDW over the past 120 yrs relative to physical events and urban development.

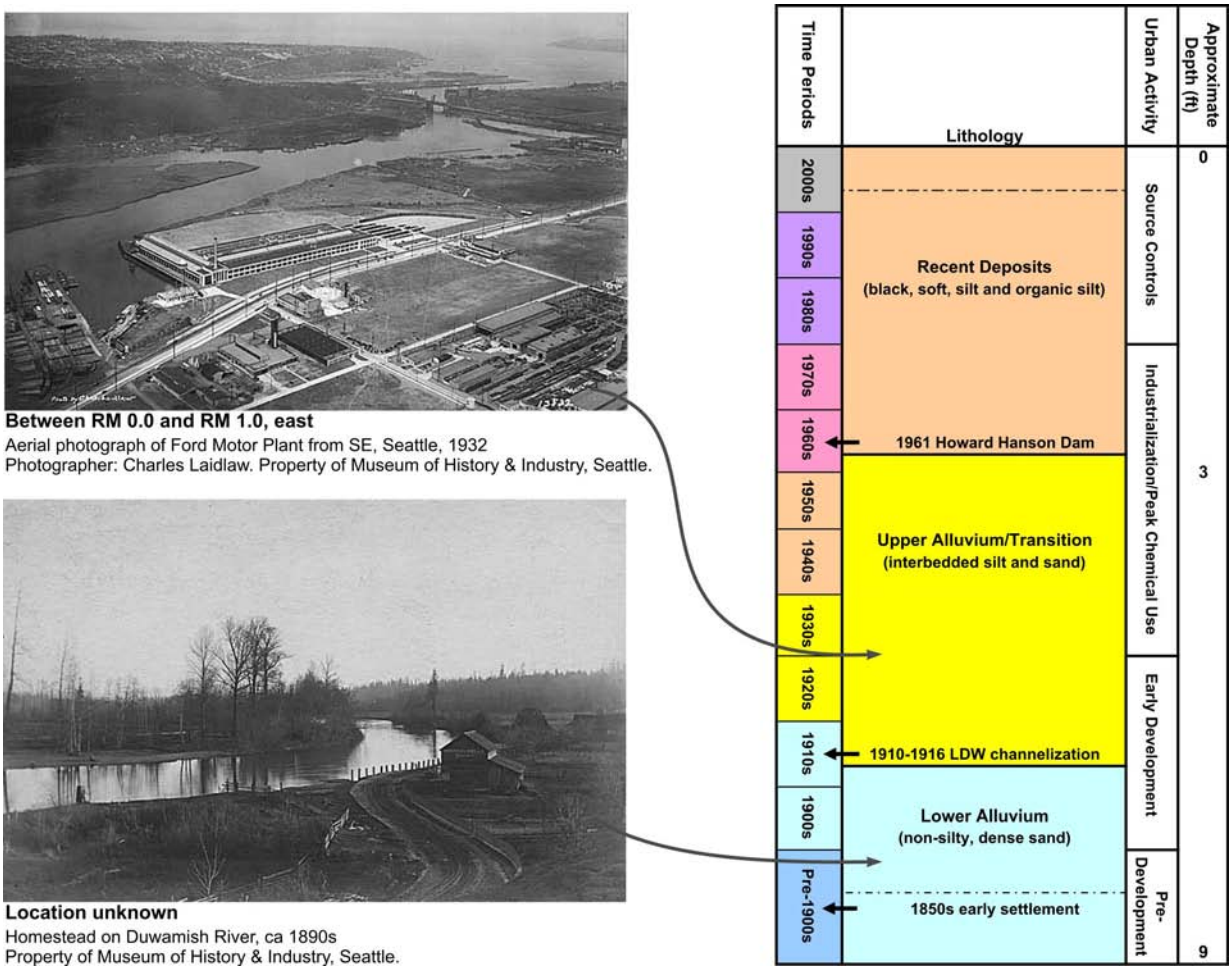


Figure courtesy of AECOM

Figure 2-8. Summary of sediment lithology in the LDW relative to physical events and human development

As shown in the cross sections (Figures 2-4 to 2-7), the LDW sediment typically consists of softer, recent sediments overlying transitional or upper alluvial sediments. In turn, these layers overlie a lower alluvial unit that represents deposition prior to the industrialization of the area.

In addition to the primary stratigraphic units presented in the cross sections, two other upland layers, fill and glacially–overridden sedimentary units, also have been identified in the study area. LDW sediments were classified as "other" when the sediment matrix was composed of over 50% fill, woody debris, or anthropogenic materials (Windward and RETEC 2007).

Three of the subsurface cores collected for the RI contained sediments classified as "other." Core SC2, located just north of RM 0.1 on the east side of the LDW, contained over 80% anthropogenic material between 4.3 and 10.5 ft bgs; the material was described as seams of silt and rock flour and chunky balls of hard silt (Windward and RETEC 2007). Traces of wood, a sheen, black streaks, and minor sand seams were also observed in core SC2 in the same sediment interval. Cores SC26 and SC28, located near one another at RM 1.4 on the west side of the LDW, also contained sediment intervals classified as "other." The sediment in the 7.7-to-9.1-ft (bgs) interval of core SC26 was described as "gravel with a hydrocarbon-like sheen and scattered debris, including possible paint chips and glass." Sediment from 5.8 to 12.8 ft bgs in core SC28 consisted of approximately 80% sand blast grit with a metallic shiny surface. Scattered debris, including possible paint chips and asphalt-like conglomerates, was associated with the sand blast grit in core SC28 (Windward and RETEC 2007).

2.5.4 Sediment lithology in the LDW

During the subsurface sediment investigations conducted for the RI, the lithology of the sediment cores collected was recorded in the field according to nomenclature established in ASTM D-2488, and a core log field key was used to ensure nomenclature consistency (Windward and RETEC 2007). Lithology is defined as the physical characteristics of the material described in terms of the dominant soil type (e.g., sand or silt), grain size percentages, texture (e.g., fine or medium grain), sorting (e.g., well sorted or poorly sorted), shape, and the color and mineralogy of particles (Krumbein and Sloss 1963).

Geotechnical parameter tests were also performed on a subset of subsurface sediment cores collected in 2006 within the upper 4 ft of the cores (Windward and RETEC 2007). These parameters included moisture content, specific gravity, Atterberg limits (i.e., liquid limit, plastic limit, plastic index), bulk density (dry and wet), and porosity.

Specific gravity, porosity, and wet density sample results did not vary notably with depth, indicating that sediment texture in the upper 4 ft was relatively uniform. The mean specific gravity of all subsurface sediment samples across similar core intervals ranged from 2.64 grams per cubic centimeter (g/cc) to 2.66 g/cc. The mean sediment porosity ranged from 0.59 standard unit (SU) to 0.64 SU, and the mean wet bulk density ranged from 102 pounds per cubic foot (pcf) to 104.4 pcf.

Other geotechnical properties varied with depth. The mean moisture content of all samples was 75% dry weight (dw) at the surface, decreasing to 63% dw below the 2-ft interval, consistent with the decrease in water content with depth as noted on the core logs. The mean dry bulk density across similar core intervals increased with depth from 60.4 to 67.2 pcf.

Atterberg limits testing was performed on fine-grained silt/clay sediments to determine the relationship between moisture content and LDW sediment type. The testing interprets the liquid limit of the sample (when sediment changes from a

viscous fluid to a plastic state) and the plastic limit (where sediment behaves as a solid). The plasticity index is the difference between the liquid limit and the plastic limit. The mean liquid limit of all subsurface sediment samples ranged from 61.2% to 70.7% dw, and the mean plastic limit ranged from 35.0% to 39.3% dw. Sediment samples exhibited medium to high plasticity, with the mean plasticity index varying from 26.2% to 32.5% dw (Windward and RETEC 2007).

2.5.5 Sediment physical properties

Sediment composition varies greatly throughout the LDW, ranging from sands to mud (fine-grained silt and clays), depending on the source of the sediments and the local current velocity. LDW sediment typically consists of slightly sandy to sandy silt with varying amounts of organic material. Finer-grained sediments have typically been reported in remnant mudflats, along channel sideslopes, and within portions of the navigation channel. Sediments in the navigation channel near the Upper Turning Basin have been predominantly sands, whereas sediments toward the mouth of the river have been predominantly fine-grained silts.

Coarse sediments were present at the surface in nearshore areas adjacent to CSO and storm drain (SD) discharges (Weston 1999a). Only nine of the subsurface sediment cores collected as part of the RI contained intervals dominated by gravel; four of the cores were collected downstream of RM 0.6. The gravel interval was present in the upper alluvium/transition stratigraphic layer in three of those cores (i.e., near RM 0.1 on the east side and near RM 0.1 and RM 0.5 on the west side of the LDW) and in the recent stratigraphic layer of the fourth core (i.e., near RM 0.5 on the east side). Upstream of RM 0.6, gravel was identified in five additional cores. The gravel in one core collected from the west side of the LDW at RM 1.4 was associated with anthropogenic sources. Gravel was present in the upper alluvium/transition stratigraphic layer in two cores (i.e., near RM 1.4 and RM 4.7 on the west side) and in the recent stratigraphic layer in the other two cores (i.e., near Slip 2 and RM 2.2 west).

Overall, the percent fines (also referred to as silt+clay) content of surface sediment in the LDW has been reported to be highly variable, with an average content of 53% (Map 2-6). The average silt+clay content in the navigation channel was 62%; the 10th and 90th percentile silt+clay contents were 29 and 82%, respectively. Silt+clay content was more variable outside of the navigation channel (excluding the slips), with 10th and 90th percentile contents of 13 and 87%, respectively, and an average content of 53%. Average silt+clay contents have been calculated using point-based averages.

Three of the five slips along the LDW had high silt+clay contents relative to the overall LDW average. Slips 1, 3, and 6 had average silt+clay contents of 79, 71, and 87%, respectively. The silt+clay contents of Slips 2 and 4 were lower, with average values of 41% and 57%, respectively. The area above RM 5.0 had a relatively low average silt+clay content (approximately 11.5%).

Total organic carbon (TOC) content in surface sediment did not vary widely (Map 2-7). Outside the navigation channel, the 10th and 90th percentiles were 0.80 and 2.9%, respectively. The TOC content in the navigation channel was less variable than the TOC content outside the navigation channel, with 10th and 90th percentiles of 1.2 and 2.6%, respectively. The average TOC content (1.9%) was the same within and outside the navigation channel. The TOC content in Slips 1, 3, 4, and 6 was slightly higher than the LDW-wide average, with average TOC contents of 2.3, 2.2, 2.6, and 2.7%, respectively. In Slip 2, the average TOC content (1.5%) was lower than the LDW-wide average. Average TOC content was calculated using point-based averages. The areas upstream of RM 5.0 had a lower average TOC content (0.84%) and lower average silt+clay content (11.5%).

Woody debris has been observed in sediment throughout the LDW study area. A review of sediment characteristic data collected during the three rounds of surface sediment sampling conducted as part of the RI revealed that woody debris was observed in at least one surface sediment sample within almost every tenth of a river mile interval between RM 0.0 and RM 4.8. Woody debris was not observed in any of the six surface sediment samples collected within the LDW upstream of RM 4.9. Woody debris and wood fragments were also observed at various depth intervals in subsurface sediment cores collected throughout the LDW. One core, collected upstream of RM 4.8, had wood fragments within the 5-to-6-ft-interval below the mudline of this core. The prevalence of woody debris in the LDW is consistent with the waterway's history of being used for timber storage and transport.

2.5.6 Groundwater systems, transport, and processes

The previous sections characterized the geologic and stratigraphic composition of the soils and sediments in the Greater Duwamish Valley and the LDW study area. These geological features help define the framework for the aquifer systems and influence the flow and transport of groundwater within the Duwamish basin.

This section provides an overview of the regional and local groundwater systems within the Duwamish Valley, including the spatial flow patterns and characteristics of groundwater within the LDW study area. Various physical and biochemical processes that can affect the transport of chemicals in groundwater are also discussed in general. Section 9.4.6 provides more site-specific information on the groundwater characteristics and investigation efforts ongoing in the LDW.

2.5.6.1 Valley aquifer and groundwater flow system

Aquifer Characteristics in the Duwamish Valley

In general, groundwater within the Duwamish Valley is unconfined at depths up to 3 m (10 ft) bgs (Booth and Herman 1998). Regionally, the valley alluvium is a single, large aquifer system. The maximum depth of the alluvial aquifer in the study area extends to roughly 30 m (98 ft) bgs, although deeper areas are present in the central portion of the Duwamish Valley. The thickness of the alluvial aquifer lessens to the

north of the valley, where finer-grained silts and clays dominate. The aquifer's thickness also lessens to between 10 and 12 m (33 and 39 ft) bgs toward the eastern and western margins of the valley (Booth and Herman 1998).

Site-specific studies in the LDW basin often subdivide the alluvial aquifer into shallow, intermediate, and deep zones. The shallow zone is generally located within the fill and/or younger alluvium (Qyal), and the deep zone is generally located within the older alluvium (Qoal). Shallow aquifer zones in the LDW are predominantly located in silty layers within interbedded sandier aquifer soils. In many areas, these shallow aquifers contain large amounts of organic material associated with the original river delta.

The separation of these shallow and deep zones is based partly on the presence of silt layers (aquitards), the presence of localized upward groundwater gradients, and the occurrence of pockets of saline/brackish groundwater. The silt layers are rarely continuous throughout the valley and often constrain local groundwater flow. The discontinuous nature of these silt layers allows for areas of hydraulic connection between the shallower and deeper alluvium zones.

General Characteristics of Groundwater Flow in the LDW Basin

The aquifer's flow characteristics vary depending on the nature of the materials that make up the local alluvium, the proximity to the river, and local tidal fluctuations. The elevation gradient between the glacially overridden deposits in the uplands and the LDW sediments creates a regional flow system with significant hydraulic potential for the transport of groundwater from the upland areas to the LDW. Groundwater elevations in the uplands were between 30 and 60 m (98 and 197 ft), while elevations in the valley aquifer were between 3 and 6 m (10 and 20 ft) relative to mean sea level. Appendix G of the Phase 1 RI (Windward 2003a) included a detailed groundwater pathways assessment for select properties along the LDW and presented groundwater flow patterns obtained from relevant site-specific investigations for these facilities. The groundwater elevation data presented in the appendix were for the shallowest aquifer system for which reliable data were available.

Few hydraulic conductivity data are available for the LDW; most of the available data are from investigations completed at properties on the east side of the waterway. Available data indicate that hydraulic conductivity varies greatly from site to site. Estimated hydraulic conductivity in the vicinity of the BDC ranged from 3.8×10^{-2} to 4.5×10^{-2} cm/sec, whereas the average hydraulic conductivity was 2.3×10^{-2} cm/sec at the Rhône-Poulenc facility to the north of the BDC (Windward 2003a). At the Kenworth Trucking/PACCAR facility, north of Rhône-Poulenc, hydraulic conductivity ranged from 1.5×10^{-3} to 4.9×10^{-3} cm/sec. Further north, on the Boeing Isaacson property, hydraulic conductivity ranged from 10×10^{-3} to 10×10^{-4} cm/sec.

Within the greater LDW basin, groundwater flow rates and gradients vary greatly. Examples of various site-specific horizontal gradients and flow rates are presented in Table 2-4.

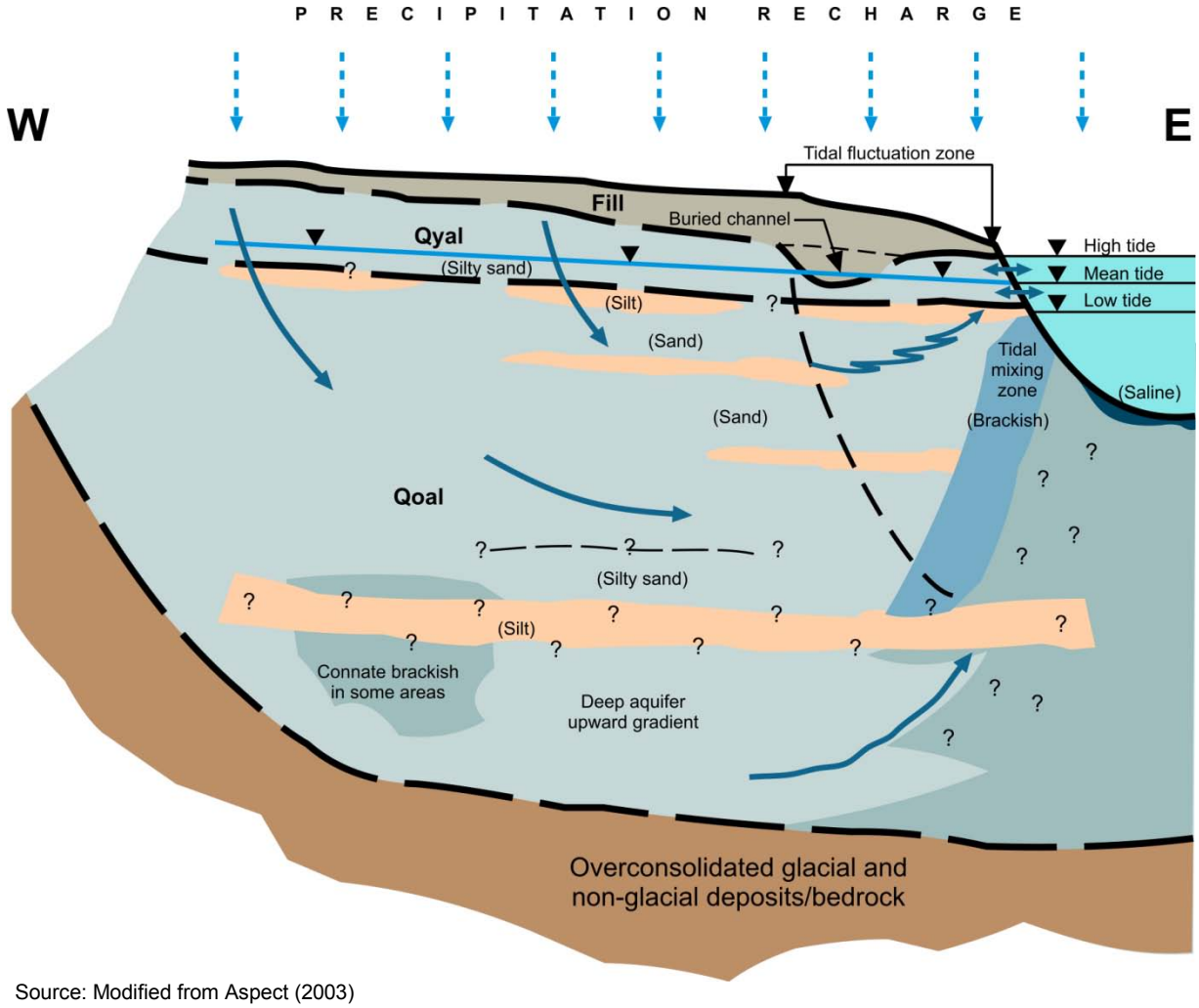
Table 2-4. Site-specific flow rates and gradients

LDW FACILITY	HORIZONTAL GRADIENTS (ft/ft)	FLOW RATES (ft/yr)
Boeing Developmental Center	0.0004 to 0.0008	65 to 150
Boeing Plant 2	0.0002 to 0.0029 (average 0.002)	25 to 26
Kenworth Trucking (PACCAR)	0.0017 (average)	12 to 24
Philips Services (Burlington Environmental)	0.0015 (average)	190
Rhône-Poulenc	0.002 (average)	25 to 30

LDW – Lower Duwamish Waterway

Groundwater flow within the LDW study area is generally toward the LDW. However, high tides in the LDW can cause temporary groundwater flow reversals. Tidal influences are greatest in wells installed in the sandiest alluvium in the central portion of the valley. Areas with tidal influence are generally within 100 to 150 m (328 to 492 ft) of the LDW shoreline (Booth and Herman 1998).

Tidal action can cause a continuous oscillation of groundwater within the effective zone of influence (Figure 2-9). At low tide, the hydraulic gradient between the groundwater system and the LDW is typically at its highest, causing the flow of local groundwater into the LDW. At high tide, the hydraulic gradient can reverse direction, causing LDW surface waters to flow into the adjacent LDW sediments and soil. The amount of LDW water intrusion into and out of the local aquifer depends on tidal patterns, site-specific aquifer conditions, soil stratigraphy (i.e., permeability), and rainfall recharge within the groundwater system.



Source: Modified from Aspect (2003)

Figure 2-9. Example of aquifer tidal mixing in the LDW

Recent tidal studies near the Boeing Isaacson property reported that tidal influences were noted in wells approximately 400 ft from the LDW; similar studies at the Boeing Plant 2 facility reported that tidal influences were noted between 300 and 600 ft from the LDW (Windward 2003a).

Tidal influence studies have also been conducted at Great Western International (GWI), located approximately 400 ft from the LDW shoreline. GWI has wells set in both the shallow and intermediate aquifer zones within the river valley. During high tide conditions, the flow gradient was toward the facility in both the upper and intermediate aquifer zones (Windward 2003a). During low-tide conditions, the flow gradient was toward the LDW (Table 2-5).

Table 2-5. Results of tidal influence study at GWI

Tide Condition	Aquifer Zone	Groundwater Flow Rate (ft/day)	
		Facility Wells	Tidal Zone Wells
High	shallow	0.80 (toward LDW)	0.93 (away from LDW)
	intermediate	0.75 (toward LDW)	0.25 (away from LDW)
Low	shallow	0.47 (toward LDW)	1.25 (toward LDW)
	intermediate	0.75 (toward LDW)	0.32 (toward LDW)

Source: Windward (2003a)
LDW – Lower Duwamish Waterway

Vertical Flow Gradients

Information on vertical flow gradients (both upward and downward) provided in the Duwamish groundwater pathways study (Booth and Herman 1998) indicated that downward flow gradients occur predominantly in the shallower alluvium layer, which extends roughly 10 to 15 m (33 to 49 ft) bgs, in part because of effects of local rainwater infiltration and groundwater recharge. The downward gradients are dependent on the volume of rainwater that infiltrates into the system (much of the LDW basin is classified as impervious), the presence of interbedded silt and sand layers (the greater the interbedding, the higher the downward gradient), and the distance from the waterway. Upward flow gradients are typically observed in groundwater wells installed in the deeper aquifer zone (Booth and Herman 1998).

Site-specific information, though limited, indicates that upward flow gradients have been identified in the vicinity of the Boeing Plant 2 facility, King County International Airport (KCIA), the South Park community, the BDC, and near Slip 6; these upward flow gradients were determined based on information from wells installed in the deeper aquifer zone (screen intervals between 40 and 80 ft bgs). Upward flow rates were lowest (between 0.002 and 0.07 m/day) beneath the eastern side of the Duwamish Valley (roughly between RM 2.0 and RM 5.2), where inflow from the adjacent uplands is limited by layers of bedrock and silt deposits. Higher upward flow rates, ranging from 0.02 to 0.3 m/day, generally occurred in the upland areas to the west of the LDW (Windward 2003a).

Where downward gradients intersect with upward gradients, the interaction has the potential to cause shallower groundwater to flow toward the LDW, often discharging as seeps in the intertidal zone (Figure 2-9). In addition, the presence of brackish and saline water tends to concentrate the outflow of the surficial aquifer into the intertidal areas because the less-dense, fresh groundwater tends to migrate above the higher-density saline water. This density variance minimizes the potential for shallower groundwater to mix with the more brackish or saline zones. Brackish and saline water areas have been primarily identified in the eastern portion of the Duwamish Valley as a result of extensive areas of impervious surface and limited freshwater recharge (Booth and Herman 1998).

2.5.6.2 Processes and conditions that can affect chemical transport in groundwater

The processes and conditions that can influence the movement of chemicals through the subsurface are complex. Determining whether a chemical in groundwater may or may not reach nearby surface water or sediment requires an analysis of site-specific conditions, flow patterns and rates, and chemical-specific attributes, such as the partitioning affinity and persistence of the chemical. The following sections provide an overview of the processes that could potentially affect the movement of chemicals in groundwater. Appendix G of the Phase 1 RI, as summarized in Section 9, provided a preliminary analysis of the potential for groundwater chemicals to reach the LDW at 12 sites judged by EPA and Ecology in 2002 to be the areas with the highest potential groundwater contamination. Site-specific seep, porewater, [13] and sediment testing in the vicinity of these areas was conducted and evaluated with respect to the potential for chemicals in groundwater to contaminate sediment (see Section 9.4.6).

Several processes can influence chemical concentrations in groundwater downgradient of a contaminated area, as well as concentrations in waters that discharge to the LDW. These processes include:

- **Advection –** Advective flow rates and patterns can transport dissolved chemicals and chemicals sorbed to small particles through groundwater to surface waters. Advection, the movement of groundwater through soil pores, is primarily dependent on the specific characteristics of the aquifer, such as porosity, hydraulic conductivity, and discontinuities within the aquifer system.
- **Partitioning –** The migration rate of dissolved chemicals in groundwater can be affected by chemical partitioning to the solid materials within the aquifer. The rate at which chemical transport is slowed (the retardation factor) is a function of the dry bulk density and porosity of the aquifer and the soil-water partitioning coefficient of the chemical (Fetter 1993). A soil-water partitioning coefficient for most organic compounds can be estimated as the product of the organic carbon (OC) content of the aquifer unit and the specific chemical's water-OC partitioning coefficient. For polar substances (e.g., pentachlorophenol), the water-OC coefficient is also dependent on groundwater pH, with the coefficient decreasing with increasing pH.
- **Volatilization –** The transition of a chemical from an aqueous phase into a vapor phase in unsaturated soil above the groundwater table that can occur when low-molecular-weight compounds migrate in groundwater.

[13] Porewater is the interstitial water in sediment. Chemical concentrations in porewater reflect the state of chemical partitioning between sediment and interstitial water; the concentrations can also be affected by groundwater discharge if a porewater sample is collected from within a groundwater discharge zone.

- **Diffusion –** The movement of molecules along chemical concentration gradients; generally more significant at low groundwater velocities (e.g., through silt and clay layers).
- **Dispersion –** A small-scale mixing process that results from the various paths that individual chemical molecules take while traversing through porous soil or sediment. A substantial amount of dispersion can occur in fine silty sand sediment from constant tidal oscillation.
- **Dilution –** The decrease in concentration that occurs along the groundwater pathway from an area with elevated groundwater chemical concentrations as a result of recharge from precipitation. Dilution also occurs at the point of discharge into a tidally influenced water body as a result of water exchange between the surface water body and the discharging aquifer. Tidal monitoring studies have indicated that water intrudes from a surface water body into the adjacent aquifer during high tides and that groundwater discharges to surface water at low tides. This exchange can reduce the dissolved chemical concentrations discharging into the LDW (Yim and Mohsen 1992).
- **Biological degradation –** The degradation of non-chlorinated hydrocarbon compounds, including total petroleum hydrocarbons (TPH), low-molecular-weight polycyclic aromatic hydrocarbons (LPAHs), and benzene, toluene, ethylbenzene, and xylene (BTEX) compounds, under aerobic conditions (Wiedemeir et al. 1994). Hydrocarbon compounds can also be degraded by sulfate- and nitrate-reducing bacteria, although this process is slower than aerobic degradation (Wiedemeir et al. 1994). In general, organic compounds must come into contact with the cell membranes of micro-organisms to be degraded, so degradation rates are generally higher for more soluble compounds (Mackay et al. 1992). Because micro-organisms can also influence the reduction-oxidation potential in the groundwater environment (e.g., through microbial oxidation of organic matter) (Moore et al. 1988), they can also alter the speciation and mobility of metals. Reducing conditions can mobilize iron, manganese, arsenic, and other metals present in or sorbed onto sediment particles. Under aerobic conditions, the mobility of these metals is decreased as a result of sorption to or co-precipitation with iron and manganese (hydr)oxides (Moore et al. 1988). The combination of these processes can produce a transition zone between the deeper anaerobic sediment layers and the surface aerobic sediment layers.
- **Facilitated transport –** A process that can potentially accelerate the migration of a chemical beyond what would normally be expected. One example of facilitated transport involves co-solvent effects, in which high concentrations of organic or solvent compounds can mobilize hydrophobic compounds in groundwater. Colloidal processes can also facilitate transport whereby the

presence of large organic macromolecules can increase the mobility of hydrophobic chemicals (Huling 1989).

The net result of these processes on chemical transport is a function of numerous factors, including, but not limited to, the salinity, pH, reduction-oxidation potential, duration of contact between groundwater and contaminated soil, and the chemical properties of the contaminant.

Conditions within LDW groundwater are dependent on a range of factors, including (but not limited to) proximity to the LDW, depth, geology, tidal fluctuations, groundwater quality parameters (e.g., dissolved oxygen [DO], pH), and the specific attributes of chemicals that may be present in the groundwater. These various factors affect organic chemicals and metals in different ways.

Tidal intrusion during high-tide events can greatly influence nearshore groundwater quality. Tidal fluctuations in the LDW create a dynamic mixture of fresh and saline waters, which contain high concentrations of chloride, carbonate, and sulfide in downstream portions of the waterway. Furthermore, the infusion of LDW water into local groundwater can affect chemical mobility and persistence in a number of ways. For example, high DO levels can cause organic compounds (i.e., petroleum hydrocarbons) to biodegrade and can increase the extent to which dissolved metals precipitate out of solution or sorb to particles within the aquifer. Tidal intrusion can also dilute the concentrations of chemicals in groundwater prior to groundwater discharge into the LDW. Specific conductivity, often used to interpret levels of salinity in groundwater, was high (> 10,000 µmhos/cm) in the vicinity of the Boeing Plant 2 facility and KCIA (Booth and Herman 1998).

Groundwater pH can be affected by several factors, including the residence time or age of the groundwater (with older groundwater typically having higher pH), the mineralogy of the geologic materials surrounding the aquifer, the geochemistry of the aquifer system, and microbial activity (Ayotte et al. 2003; USGS 2007a). The pH of groundwater can be increased as a result of ion exchange in aquifers formerly inundated by seawater. Anthropogenic activities, including industrial operations, impacts from the use of underground storage tanks, and land disposal of wastes can also affect the groundwater pH. For example, the use of fertilizers has been found to reduce groundwater pH (Robinson 2003), and organic matter in groundwater can act as a pH buffer (Robinson 2003). The pH of groundwater can affect the solubility of metals and other ions and thus plays a role in groundwater quality.

Numerous groundwater studies that have been completed at facilities near the LDW show that pH and DO levels vary greatly by location and distance from the waterway (Table 2-6).

Table 2-6. Groundwater pH and dissolved oxygen data from a subset of the wells along the LDW

LDW Facility	Facility Location[a]	Well Location[b]	Aquifer Zone[c]	pH	Dissolved Oxygen (mg/L)
Terminal 108	RM 0.5, east side of LDW	site-wide (range)	shallow	5.92 – 7.10	0.36 – 2.32
		150 ft from LDW shoreline	shallow	6.14 – 7.10	0.47 – 1.73
		400 ft from LDW shoreline	shallow	6.03, 6.34	0.53, 1.36
		950 ft from LDW shoreline	shallow	6.36	2.32
Duwamish Shipyard	RM 1.3, west side of LDW	500 ft from LDW shoreline	shallow	6.45 – 6.49	1.00 – 1.19
Trotsky property	RM 2.2, west side of LDW	275 ft from LDW shoreline[d]	shallow	5.9	na
		475 ft from LDW shoreline[d]	shallow	8.0	na
Boeing Plant 2	RM 2.9 – RM 3.6, east side of LDW	shoreline wells (throughout property shoreline)	various depths	6.22 – 7.63	0.45 – 10.98[e]
		shoreline	shallow	6.30 – 7.56	0.45 – 10.98
		shoreline	intermediate	6.35 – 6.80	0.68 – 1.05
		shoreline	deep	6.22 – 7.63	0.47 – 5.12[e]
Long Painting	RM 3.0, west side of LDW	75 ft from LDW shoreline	shallow	6.06[f]	3.60[f]
Terminal 117	RM 3.6, west side of LDW	shoreline wells (throughout property shoreline)	shallow	6.12 – 8.35	0.38 – 9.9
		40 ft from LDW shoreline	shallow	5.84	4.52
Rhône-Poulenc	RM 4.1, east side of LDW	shoreline	shallow	6.37	1.89
		shoreline	intermediate	6.64	0.02, 0.05
		shoreline	deep[g]	6.37 – 9.73	na
		275 ft from shoreline	shallow	6.38, 6.41	4.21, 6.63
		600 ft from shoreline	na	5.61 – 6.57[h]	na
South Park Landfill	approximately 2,000 ft southwest of the LDW	na[i]	deep	6.7[j]	na

Sources: Windward (2003c),Windward et al. (2005a), Ecology and Environment (2008b), Pacific Groundwater Group (2006), Pacific Groundwater Group (2007), Anchor (2006), SAIC (2007b), Environmental Partners (2008)

[a] River mile designations are approximate.

[b] Distances from the LDW shoreline are approximate.

[c] In the case of T-108 and Rhône-Poulenc, the aquifer zone was specified in the source report; in other cases, the aquifer zone was estimated based on well completion and screening depths and information on the aquifer characteristics of the Duwamish River Valley (Section 2.5.6.1).

[d] Distance reported is from the monitoring well location to the navigation channel of the LDW, rather than from the monitoring well to the RM 2.2 inlet.

[e] An anomalous DO value of 25.99 mg/L was reported but was excluded from this summary.

[f] Only one measurement was available for this property.

[g] The aquifer zone information available for these data indicated that the pH measurements were taken from wells located in the "lower" aquifer zone; this designation was interpreted as the deep aquifer zone.

[h] One pH reading for this well was not included in the range because it was noted in the source document to be lower than expected and the pH meter was recalibrated after this measurement was taken.

[i] The South Park Landfill is located approximately 2,000 ft southwest of the LDW.

[j] Represents a laboratory pH measurement rather than a measurement in the field.

DO – dissolved oxygen

LDW – Lower Duwamish Waterway

na – not available

RM – river mile

T-108 – Terminal 108

The mobility of organic compounds in groundwater is generally characterized by a retardation factor, which indicates the compounds' mobility relative to groundwater flow. Low-molecular-weight organic compounds (e.g., tetrachloroethene, 1,1,1-trichloroethane, BTEX) are the most mobile (retardation factors near 1), implying that chemicals with low soil-to-water partitioning coefficients travel close to the same rate as the groundwater. High-molecular-weight organic compounds, such as polychlorinated biphenyls (PCBs), have low mobility in groundwater and generally have retardation factors over 6,000 times slower than the movement of groundwater (Montgomery 1996). Conversely, in locations with high solvent concentrations, facilitated transport can decrease the retardation factor for hydrophobic chemicals.

The presence of dense non-aqueous phase liquid (DNAPL) can also affect groundwater quality. Upon release to the soil surface, free-phase DNAPL can move downward (via gravity) or laterally along the surface of soil layers. The DNAPL can become trapped in pores and fractures, leaving residual concentrations that may persist in the subsurface for many years. These residuals may slowly release chemicals into groundwater (EPA 1992a). No evidence of DNAPL was found in the LDW.

Light non-aqueous phase liquids (LNAPL) can also potentially affect groundwater quality, especially when soluble components of the LNAPL dissolve and create an aqueous phase plume (Newell et al. 1995). High groundwater flow rates and large contact areas between the LNAPL plume and the groundwater table may induce high dissolution rates of the plume. The LNAPL components may also undergo biodegradation within the subsurface and increase the formation of degradation products. While the soluble components of the LNAPL may dissolve and be transported in the aqueous phase in the subsurface, the less soluble components may be subject to volatilization and sorption. Parameters such as solubility, polarity, ionic charge, pH, and reduction-oxidation potential can all affect LNAPL sorption in the subsurface (Newell et al. 1995).

The mobility of dissolved metals in groundwater is influenced by their respective solubility, which is a function of pH, salinity, reduction-oxidation potential, and the presence of hydroxides and sulfide minerals in aquifer solids. In reducing environments, most metals are generally more mobile (USGS 1999), although their solubility can be decreased through precipitation reactions with groundwater anions (e.g., sulfate, hydroxides) if present in sufficiently high concentrations.

Metals in groundwater, such as copper and zinc, may have low mobility in the tidal mixing zone because of precipitation or sorption to oxides and clays, depending on the location of the reduction-oxidation boundary. Mixing of oxygenated estuarine water with groundwater within the aquifer results in higher concentrations of chlorides, sulfates, and carbonates in groundwater near the LDW. Reactions with these anions can lower the mobility of some metals (such as lead). Aerobic conditions in the tidally influenced zone also result in the formation of iron and manganese oxides (Boatman and Hotchkiss 1997), which provide an effective surface for sorption and

co-precipitation with other metals in groundwater, thus limiting their discharge into estuarine systems (Moore et al. 1988).

The solubility and mobility of arsenic in groundwater is influenced by adsorption and desorption reactions, the presence of competing ions, and solid-phase precipitation and dissolution reactions (USGS 1996), which are a function of reduction-oxidation conditions and pH. An increase in dissolved arsenic concentrations might occur in areas natural organic matter has created a reducing environment, such as in shallow aquifers with high organic matter. Releases of organic chemicals such as TPH also cause reducing conditions as biodegradation processes consume available oxygen and cause the dissolution of arsenic (Moore et al. 1988). As groundwater becomes more aerobic (i.e., in the tidal mixing zone), arsenic may be oxidized to arsenate, which tends to sorb onto iron oxide coatings and clay minerals (USGS 1996). Increased oxygen concentrations in the tidal mixing zone can further attenuate arsenic.

2.6 SURFACE WATER HYDROLOGY

The Green River, which is the main freshwater source for the LDW, originates in the Cascade Mountains near Stampede Pass and flows by the Howard Hanson Dam at RM 65.0 and the Tacoma Headworks Dam at RM 61.0 (Culhane et al. 1995). Major tributaries to the Green River include Sunday Creek, Smay Creek, and the North Fork upstream of the Howard Hanson Dam and Newaukum Creek, Soos Creek, and Mill Creek downstream of the Howard Hanson Dam. In addition, the Black River discharges fresh water to the Duwamish River in Tukwila, several km upstream of the LDW. Flow from the Black River is normally minimal (approximately 2.6 m^3/s [92 cubic feet per second (cfs)]) but increases substantially during storm runoff events.

The lower 10 km (6.2 mi) of the river originally opened into a tidal marsh and a broad expanse of intertidal mudflats. In the mid-1800s, estimated annual average discharge from the Duwamish River ranged between 70 and 250 m^3/s (2,500 to 9,000 cfs) (Blomberg et al. 1988), although large floods, between 424.8 m^3/s and 849.6 m^3/s (15,000 and 30,000 cfs), used to down trees along the river's edge, deposit sediment throughout the river basin, and move river channels (Fuerstenberg et al. [1996], as cited in USACE 1997b). The Howard Hanson Dam was installed in 1961 in the upper part of the Green River primarily for flood control and low-flow augmentation to preserve fish life when river flows were naturally low (Sato 1997). The dam effectively decreased peak flows, which now rarely exceed 340 m^3/s (12,000 cfs) but increased moderate flows from 85 to 140 m^3/s (3,920 to 6,460 cfs) because of the periodic metered release of water stored behind the dam (King County 2000b).

Flow has decreased 78% from historical levels, mostly as a result of the diversion of the White River to the Puyallup River basin and the diversion of the Cedar River into southern Lake Washington in 1912. The former diversion was natural; the latter diversion was man-made in support of the construction of the Ballard Locks and the Lake Washington Ship Canal. These changes lowered Lake Washington by over 6 ft and caused increased drainage through the locks rather than through the Black River

channel. Collectively, these irreversible changes have resulted in the present LDW hydrologic landscape.

The average downstream flow rate for the Duwamish River as measured at the Tukwila gaging station was 43.4 m^3/s (1,533 cfs) during 2003-2004 and ranged from 9.3 m^3/s (327 cfs) in August to 93.2 m^3/s (3,290 cfs) in June (Clemens 2007). Flow at the Auburn gaging station ranged from 4.3 to 329 m^3/s (152 to 11,600 cfs [the highest recorded flow rate since the construction of the Howard Hanson Dam]) between 1962 and 2004 (Clemens 2007). Average flow rates are based on mean daily values that were averages for the month (Clemens 2007). Between 2000 and 2006, the annual average flow rate measured at the Auburn gaging station was 33.7 m^3/s (1,190 cfs) (ranging between 24.1 m^3/s and 44 m^3/s [850.6 and 1,549 cfs]) (USGS 2007b). Approximately 80% of the water in the Duwamish River eventually flows through the West Waterway because of a sill at the south end of the East Waterway, which deters flow (Weston 1999a). Flow rates are greatest during the winter months because of seasonal precipitation and lowest throughout the late summer dry season.

Surface water runoff within the LDW area also contributes to flow within the LDW, from sources such as SDs, tributary creeks, CSOs, and non-point inputs; these sources are expected to be less than 1% of the total discharge, even during peak flow events. During the 1980s, SD discharges to the LDW were estimated at 1,868 million gallons per year (mgy) (0.2 m^3/s) (Tetra Tech 1988c). Annual CSO outflow to the LDW, derived from monitoring data collected between 2000 and 2005, averaged 75.7 mgy (0.008 m^3/s) (King County 2006a). The recent average SD inputs are small (approximately 0.02%) relative to the average flow of 43.4 m^3/s at the Tukwila gaging station during the 2003-2004 season.

Stream flow in the LDW is also influenced by water diversion, particularly by the City of Tacoma's Headworks Dam, which daily diverts at least 3.2 m^3/s (110 cfs) of fresh water for municipal use. Discharge of treated effluent from the King County South Wastewater Treatment Plant in Renton to the Duwamish River was eliminated in 1986, decreasing summer flows by as much as 25% (~1.6 m^3/s [56 cfs]) (Harper-Owes 1981).

EPA, the US Geological Survey (USGS), USACE, King County, Metro (now part of the King County Department of Natural Resources and Parks), the University of Washington, and other organizations have measured current velocities within the LDW as part of numerous environmental investigations (Harper-Owes 1983; King County 1999b; Prych et al. 1976; Santos and Stoner 1972; Stevens Thompson & Runyan 1972; Weston 1993b). The most extensive measurements within the LDW have been collected by King County. In 1996, King County deployed current velocity meters at two locations in the LDW (RM 1.1 and RM 3.5) for a 3-month period beginning in August, and recorded currents at 15-minute intervals along a vertical profile (King County 1999b). The two deployment stations were selected to represent the LDW study area with respect to channel width. The LDW is widest at RM 1.1 and is at its

narrowest at RM 3.5. Measured current velocities within the LDW during this study rarely exceeded 40 cm/s (1.3 ft/s) (Lavelle et al. 1985).

In the winter of 2003-2004, King County conducted another study of current velocities, deploying two current velocity meters at RM 1.1 for two 4-week periods (King County 2005a). During both monitoring periods, one meter was placed near the center of the navigation channel, while the other was placed on a shallower channel side slope. Reported mean net current speeds for meters placed in the center of the channel ranged from 2.5 cm/s (at 25% channel depth) to 18 cm/s (at 10% channel depth). Mean net current speeds for meters placed at channel side slope locations ranged from 1.3 cm/s (at 25% depth) to 8.9 cm/s (at 10% depth). Currents were predominantly oriented along the channel, and velocities were generally slower along the side slopes. Current patterns corresponded to the semi-diurnal tide.

2.7 ESTUARINE FEATURES

Water circulation within the LDW, a well-stratified estuary, is driven by tidal actions and river flow; the relative influence of each is highly dependent on seasonal river discharge volumes. Fresh water moving downstream overlies the tidally influenced salt water entering the system. Typical of tidally influenced estuaries, the LDW has a relatively sharp interface between the freshwater outflow at the surface and saltwater inflow at depth.

Santos and Stoner (1972) characterized the circulation patterns within the tidally influenced water (or salt wedge) area of the LDW, which typically extends from Harbor Island to near the head of the navigation channel. When freshwater inflow from the Green/Duwamish River is greater than 28.3 m^3/sec (1,000 cfs), the saltwater wedge does not extend upstream beyond the E Marginal Way S Bridge (RM 6.3), regardless of the tide height (Stoner 1967). During high-tide stages and periods of low freshwater inflow from the Green/Duwamish River, the saltwater wedge has been documented as extending as far upstream as the Foster Bridge (RM 8.7) (Stoner 1967). At the river's mouth at the northern end of Harbor Island, a salinity of 25 parts per thousand (ppt) is typical for the entire water column; salinity decreases toward the upriver portion of the estuary. The thickness of the freshwater layer increases throughout the LDW as the river flow rate increases.

Dye studies indicate that downward vertical mixing over the length of the saltwater wedge is almost non-existent (Schock et al. 1998). Santos (1972) described how the upstream location or "toe" of the saltwater wedge, typically located between Slip 4 and the head of the navigation channel, is determined by both tidal elevation and freshwater inflow from the Green/Duwamish River. Fluctuations in tidal elevation also influence flow in the upper freshwater layer, which varies over the tidal cycle.

USGS measured the average net upstream transport of saltwater below the Spokane Street Bridge and reported it as approximately 5.4 m^3/s (190 cfs) (Clemens 2007). This average net upstream flow was about 12% of the average downstream flow measured

at the Tukwila gaging station as noted in Section 2.6. During seasonal low-flow conditions, saltwater inputs from the West Waterway were more than one-third of the total discharge from the LDW (Harper-Owes 1983).

2.8 ECOLOGICAL HABITATS AND BIOLOGICAL COMMUNITIES

This section briefly summarizes the types of ecological habitats in the LDW, as well as the species that use these habitats, including benthic invertebrates, fish, wildlife, and plants. Additional information on the ecological habitats and biological communities of the LDW study area is provided in the ERA (Appendix A, Sections A.2.1 and A.2.2).

2.8.1 Ecological habitats and restoration activities

Ecological habitats of the LDW have been modified extensively since the late 1800s through hydraulic changes, channel dredging, the filling of surrounding floodplains, and the construction of overwater structures, levees, dikes, and other bank stabilization structures. The remnants of natural meanders along the LDW, several of which are now used as slips, and the area west of Kellogg Island are the only evidence of the river's original winding course.

The dominant natural habitat types in the LDW are intertidal mudflats, tidal marshes, and subtidal areas (Table 2-7). Most (around 98%) of the approximately 510 hectares (1,270 ac) of tidal marsh, 590 hectares (1,450 ac) of mudflats and shallows, and all of approximately 500 hectares (1,230 ac) of tidal wetland historically present in the LDW have been either filled or dredged (Blomberg et al. 1988). Remnant tidal marsh areas account for only 2 hectares (5 ac) of the LDW, while mudflats account for only 22 hectares (54 ac) (Leon 1980).

Table 2-7. Ecological habitat types represented in the LDW

HABITAT TYPE	DESCRIPTION	INFLUENTIAL PHYSICAL PARAMETERS	EXTENT AND CONDITION IN LDW
Intertidal marshes	Intertidal areas between -4 and +14 ft MLLW; exposed at low tides; marsh soils generally fine-textured and nutrient-rich, supporting grasses, sedges, rushes, and various other plants	salinity gradients, tidal variation, freshwater stream flow, wave action, water temperature, sediment characteristics, and oxygen content	limited extent; various marsh habitat classifications: emergent marsh (e.g., Herring's House, Hamm Creek, and Upper Turning Basin restoration areas), tidal marsh (5 ac in LDW); high and low marsh on Kellogg Island (Blomberg et al. 1988)
Intertidal mudflats	Intertidal areas roughly between -4 and +14 ft MLLW, remnant mudflats isolated from upland riparian vegetation, exposed at low tides, sometimes shaded by overwater structures	salinity gradients, wave action, water temperature, sediment characteristics, and oxygen content	flats and shallows (approximately 30 to 50 ac in LDW) (Blomberg et al. 1988); approximately 8.6 miles of exposed sand/mud substrate (Battelle et al. 2001); largest remnant on Kellogg Island
Intertidal riprap	Armored shoreline consisting of large rocks and rubble (riprap) or vertical wood or metal structures (sheet pile); can be anywhere from -4 to +14 ft MLLW.	salinity gradients, wave action, water temperature, and oxygen content	riprap-covered areas comprise approximately 17% of intertidal areas in the LDW (USFWS 2000b)

Habitat Type	Description	Influential Physical Parameters	Extent and Condition in LDW
Subtidal areas	Area deeper than -4 ft MLLW, never exposed by low tide; includes navigation channel and transition areas; sediment composition ranges from sand to mud	salinity, sediment composition, grain size, OC content, water depth, and temperature	throughout LDW, including navigation channel

LDW – Lower Duwamish Waterway
MLLW – mean lower low water
OC – organic carbon
USFWS – US Fish and Wildlife Service

The majority of the LDW shoreline consists of riprap, pier aprons, or sheet piling (Tanner 1991). Shoreline armoring is usually present at the top of the intertidal zone; areas of sloping mud, mudflats, and hard surfaces exist in the lower intertidal zone (Battelle et al. 2001). These hard surfaces support populations of encrusting organisms, such as barnacles, and burrowing organisms, such as shipworms (Leon 1980). Because of the shoreline armoring, the intertidal mudflats are partially isolated from inputs of sediment, nutrients, and organic matter (i.e., woody debris) from upland riparian vegetation zones; this isolation degrades the habitat quality of these mudflats (Battelle et al. 2001). In addition, overwater structures, which are common throughout the LDW, often shade shallow and intertidal habitats, alter microclimates, and inhibit growth of aquatic plant communities, further degrading the value of nearshore habitats for native fauna (Battelle et al. 2001).

Intertidal marshes are characterized by emergent aquatic plants and low shrubs, are tidally inundated, and occupy regional areas of the floodplain from approximately -4 to +14 ft MLLW (Blomberg et al. 1988; Bravo et al., undated draft). Marsh soils are generally fine-textured and nutrient-rich, supporting grasses, sedges, rushes, and various other plants. Intertidal marshes remain in the LDW to a limited extent, with some emergent marsh present at the Herring's House, Hamm Creek, and Upper Turning Basin restoration areas; approximately 5 ac of tidal marsh remain in the LDW, much of it on Kellogg Island (Blomberg et al. 1988). The shallow water and dense vegetation of intertidal marshes provide refuge as well as foraging and rearing habitat for benthic invertebrates and fish, including juvenile salmonids (Battelle et al. 2001). In addition, intertidal marshes provide important foraging and rearing habitat for many bird species, including great blue heron, killdeer, and marsh wrens. Taller vegetation, such as shrubs growing in intertidal marshes, can also provide nesting habitat for some bird species. In estuaries, intertidal marshes can also serve as wave buffers and provide flood attenuation (Battelle et al. 2001).

Intertidal mudflats are generally defined as the gently sloping areas from MLLW up to the edge of intertidal marsh vegetation (Blomberg et al. 1988). Intertidal mudflats in the LDW study area are located between -4 ft and +14 ft MLLW. These habitats can include mudflats consisting of unconsolidated silts and clays and sand flats consisting of unconsolidated sandy sediments (Simenstad et al. 1991). Approximately 30 to 50 ac

of remnant intertidal mudflats and shallows (Blomberg et al. 1988), and approximately 8.6 miles of exposed sand/mud substrate exist in the LDW (Battelle et al. 2001). These areas occur on the northern portion of Kellogg Island and in occasional patches throughout the LDW, where they are exposed at low tides and sometimes shaded by overwater structures. Intertidal mudflats serve as sources of nutrients for primary producers, and provide food and habitat for benthic invertebrates, fish, shorebirds, and aquatic mammals. Intertidal mudflats also attenuate boat wakes for up-slope tidal marshes (Battelle et al. 2001).

Subtidal sediment composition ranges from sand to mud, depending on the sediment source and local current velocity (Windward 2003b). The sediments in the upstream portion of the LDW, near the head of the main channel at the Upper Turning Basin, are predominantly sand. The sediments in the subtidal habitat further downstream (e.g., near Kellogg Island) are characterized as brown or brown-gray sandy mud overlying darker, more clayey mud.

Kellogg Island, located to the south of Harbor Island, is the largest original habitat area remaining in the LDW and is currently designated as a wildlife refuge. Habitat associated with the island comprises high and low marshes, intertidal mudflats, and filled uplands. Kellogg Island is highly altered from its historical size, shape, and function as the result of dredge, fill, and diking activities that occurred from the late 1940s or early 1950s through the 1970s, which greatly altered its interior (Canning et al. 1979). The upland portion of Kellogg Island was created in 1974, when the Port of Seattle deposited 1,700 m^3 (2,200 cubic yards) of dredged material on the island (Sato 1997). Both introduced and native plant species rapidly colonized the 7-hectare (17-ac) island. Remnants of natural intertidal habitat occur on the northern portion of Kellogg Island and in occasional patches throughout the LDW.

Small intertidal areas of marsh and unvegetated marsh habitat in the LDW have become the focus of habitat restoration activities. The Hamm Creek restoration area, located on the western shoreline at RM 4.3, restored 1 ac of emergent salt marsh, 2 ac of freshwater wetlands, and nearly 2,000 ft of the Hamm Creek stream bed in order to provide suitable habitat for salmon and other fish and wildlife species (EPA 2006e). Habitat restoration projects are also located on Port property at Terminal 107 (T-107) (RM 0.4 west) and Terminal 105 (T-105) (RM 0.1 W) (Port of Seattle 2007b). At the Coastal America site in the Upper Turning Basin (RM 4.7 W), 5 ac of intertidal habitat was restored. At Herring's House Park, located on the west side of the LDW near Kellogg Island (RM 0.3 to RM 0.5 W), intertidal habitat has been restored at a former lumberyard.

Additional restoration activities are also taking place at the General Services Administration (GSA) marsh area (RM 0.8 E), the Diagonal Avenue S/Terminal 108 (T-108) restoration area (RM 0.6 E), the 8th Avenue S street end park/Gateway North restoration area (RM 2.7 E), the S Portland Street street end park (RM 2.8 W), the Muckleshoot Tribe restoration area at Kenco Marine near the Upper Turning Basin

(RM 4.6 W), the S 112th Street mitigation site (RM 5.7 E), and King County's Cecil B. Moses Park (North Winds Weir, RM 5.7 W). These restoration areas are presented on Map 2-8. Information on several additional restoration sites within the LDW is available through NOAA's Damage Assessment, Remediation, and Restoration Program (DARRP) (NOAA 2007b). The objectives of these projects include the removal of rock riprap and over-water wharf structures, restoration of natural tidal flows, and natural re-colonization by native wetland plants (Cordell et al. 1996).

2.8.2 Benthic invertebrates

Benthic invertebrate species are important components of the LDW ecosystem because they serve as a major food resource for commercially and recreationally important fish and wildlife and play a critical role in the overall nutrient cycling of the system. This section briefly describes studies that have investigated site use by benthic invertebrates. Additional details are presented in Appendix A, Section A.2.2.2.

2.8.2.1 Summary of LDW studies

Numerous studies have investigated site use of the LDW by benthic invertebrates. Over the course of several years, Cordell et al. (1996; 1997; 1999) conducted studies of the benthic community at several restoration sites throughout the LDW. Other studies of the benthic community were primarily conducted near Kellogg Island (NOAA and Ecology 2000; King County 1999a; Leon 1980; West et al. 2001; Williams 1990). Surveys of larger benthic invertebrates were conducted throughout the LDW in 2003 and 2004, including a survey of crabs and shrimp (Windward 2004a) and a survey of clams (Windward 2004c). In addition, sampling of the benthic community was conducted at both intertidal and subtidal locations throughout the LDW in 2004 as part of the RI (Windward 2005e). In 2006, Ecology conducted a sediment profile imaging (SPI) survey (Ecology 2007n) to identify relationships between SPI survey data and direct measurements of sediment quality. Metrics collected as part of the SPI survey were used to estimate the depth of the biologically active zone (BAZ) that was used in the RI. A detailed list of the taxa identified in these studies is included in Appendix A, Attachment A1.

2.8.2.2 Summary of site use

Benthic invertebrates in the LDW form two distinct communities. The infaunal community is typified by burrowing polychaetes and bivalves. King County (1999e) noted that at most sampling locations, the infaunal community was dominated by surface detrital/surface-deposit feeding organisms. The epibenthic community (invertebrates living on top of the sediment), consisted mainly of larger crustaceans and mussels, and was dominated by surface detrital and surface filter-feeding organisms.

Benthic invertebrate communities observed in the LDW consisted of 670 taxa, representing 178 families in 13 phyla. Typical of estuarine environments, the benthic invertebrate community was dominated by annelid worms (polychaetes and

oligochaetes), mollusks, and crustaceans. Crustaceans were the most diverse of these three groups in the LDW, including more than 250 taxa. Mollusks included various bivalves and snails. The most abundant large epibenthic invertebrates included slender crabs, crangon shrimp, and coonstripe shrimp. Dungeness crabs were also common, although their distribution was generally limited to the portions of the LDW with higher salinity. Although the vast majority of benthic invertebrate species in the LDW are typical inhabitants of estuarine environments, a few organisms more typical of freshwater environments were found. For example, one chironomid larva was collected in intertidal habitat at RM 0.6, two chironomid larvae were collected in intertidal habitat at RM 1.4, and one chironomid larva was collected in the subtidal habitat at RM 1.6.

Key physical factors that may influence the distribution and abundance of benthic invertebrates in the LDW are salinity, water depth (intertidal versus subtidal), sediment grain size, and OC content. The LDW is a stratified estuary influenced by river flow and tidal effects. The daily salinity fluctuations favor species that are tolerant of such variability. A salinity range of approximately 5 to 8 ppt has been identified as the critical transition range that corresponds to a pronounced reduction of benthic invertebrate species richness (Levinton 1982). In general, benthic species richness diminishes steadily in an estuary until it reaches a minimum at the critical salinity level (Levinton 1982). A more diverse benthic invertebrate community generally exists in the downstream, more saline portion of the LDW (RM 0.0 to RM 2.0) (Windward 2005e). The benthic invertebrate community in the subtidal habitat is usually more diverse than the community in the intertidal habitat (Windward 2005e).

Common benthic communities in estuarine intertidal and subtidal channel habitats with mixed fines and muddy substrates are described in the classification system for marine and estuarine habitat types in Washington State (Dethier 1990). Benthic invertebrates typically present in intertidal habitats include the amphipods *Corophium salmonis*, *Paramoera columbiana*, and *Eogammerus* spp.; the polychaetes *Hobsonia florida* and *Manayunkia aestuarina;* the clam *Macoma baltica;* the shore crab *Hemigrapsus oregonensis;* tanaids; and mysids. In subtidal habitats, common invertebrates include a wide variety of polychaetes such as *Magelona* spp., *Capitella capitata*, P*araonella platybranchia*, *Eteone* spp., *Hobsonia florida*, and numerous spionids. Common subtidal crustaceans and bivalves are similar to the common species in intertidal habitats, with the inclusion of Dungeness crabs (*Cancer magister)* and shrimp (*Crangon* spp). The majority of these invertebrates or species within the same genus have been identified in the intertidal and subtidal habitats of the LDW.

Intertidal Community

Surveys of the intertidal benthic invertebrate communities (including infauna and smaller epibenthic species) were conducted at 12 locations throughout the LDW in 2004 (Windward 2005e). The total number of organisms ranged from 500 to 16,233 per

0.1 m² (Table 2-8). A total of 61 invertebrate taxa were identified in the sediment core and transect frame samples. The most abundant organisms were annelids and crustaceans. Numerous physical factors such as salinity, temperature fluctuation, desiccation, and wave action present physiological challenges to benthic invertebrates in the intertidal areas (Levinton 1982) and are thus contributing factors to the relatively low number of species in these areas. Some of these factors vary over the length of the LDW (e.g., salinity). Figure 2-10 presents the composition of major benthic invertebrate taxonomic groups at the intertidal locations as a function of river mile.

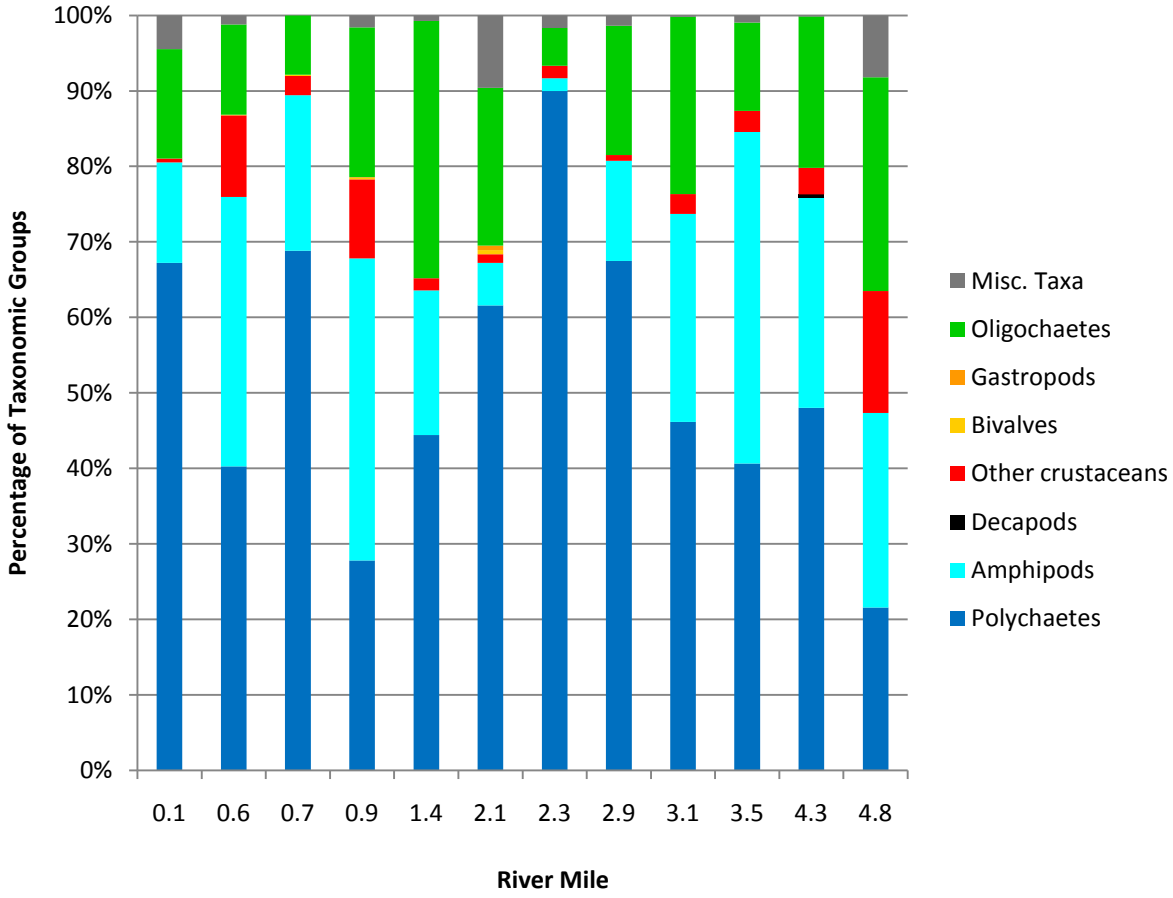


Figure 2-10. Composition of major benthic invertebrate taxonomic groups in intertidal areas of the LDW

Amphipods and polychaetes together represented more than 65% of the organisms identified at locations between RM 0.1 and RM 4.3. At the location in the Upper Turning Basin (RM 4.8), the benthic community was still estuarine; however, the composition had changed with amphipods and polychaetes together representing 48% of the organisms identified and three other groups (oligochaetes, other crustaceans, and miscellaneous taxa) representing the majority (51%) of the organisms identified. There are a few differences in the species composition in the intertidal community in the downstream versus the upstream end of the LDW. For example, species of

Cnidaria, including sea anemones, were only present in the intertidal areas from RM 0.0 to 1.0, and gastropods were present only at or downstream of RM 2.1. A Swartz's Dominance Index was calculated for each location. The Swartz's Dominance Index is defined as the minimum number of taxa that make up 75% of the total abundance (Swartz et al. 1985; as cited in PTI 1993). A higher number of taxa indicates a more diverse community; values of 5.0 or less are generally indicators of stressed communities (PTI 1993). In addition to the samples collected to assess the benthic community, separate samples were collected at each location and analyzed for biomass. Total biomass ranged from 0.1 g ww at location B5a-2 to 2.7 g ww at location B6a. Average biomass for intertidal locations was 1.4 g ww (Windward 2005e). Total weights at each location represented the biomass collected from an area of 0.012 m^2.

Cordell et al. (2001) conducted both epibenthic and infaunal surveys at seven restoration sites throughout the LDW from 1993 through 1999. The surveys demonstrated that the diversity and abundance of intertidal organisms varied both seasonally and among locations in the LDW. The greatest diversity of organisms (i.e., species richness) occurred in the downstream portion of the LDW; diversity was lower in the area of the Upper Turning Basin.

Two other benthic invertebrate surveys were conducted in the LDW by Williams (1990) and Leon (1980). Williams (1990) identified 80 invertebrate taxa inhabiting intertidal habitats at Kellogg Island. Nematodes, oligochaetes, small harpacticoid copepods, ostracods, and sabellid polychaetes were the dominant invertebrates. Leon (1980) found 43 different benthic taxa in sediment cores from the intertidal mudflats at Kellogg Island. Most taxa occurred infrequently; nine taxa accounted for 97% of all individuals. Small marine worms of the genus *Manayunkia*, oligochaetes, and harpacticoid copepods made up nearly 80% of all individuals (Leon 1980). In comparison, there were very few organisms at a mudflat site with anoxic sediments near the Duwamish Shipyard, (RM 1.35 W) and there was a greater degree of seasonal variability in the benthic community at a mudflat site at the Riverside Marina, then located near RM 0.2 W (Leon 1980).

In 2003, a clam survey was conducted at 11 intertidal locations between RM 0.0 and RM 4.0 (Windward 2004c). A random sampling design, based on Washington State Department of Fish and Wildlife (WDFW) guidance (Campbell 1996), was employed to survey each of the 11 locations for clam abundance. The mean density of clams at those 11 locations ranged from 0.18 to 0.94 per ft^2. The majority of clams collected were identified as *Macoma balthica* (60%), followed by *Mya arenaria* (20%) and *Macoma nasuta* (18%). *M. balthica* were the smallest clams collected on all beaches with a mean individual wet weight of 0.7 g (range of < 0.1 g to 3.4 g), and *M. arenaria* were the largest clams collected (mean individual wet weight of 15.2 g); however, this species also had the widest range in weight (0.3 g to 54 g) (Windward 2004c).

Table 2-8. Results of the intertidal benthic invertebrate community survey conducted for the RI

River Mile	Location ID[a]	Total Abundance[b]	Taxa Richness[c]	Swartz's Dominance Index	Taxa Richness by Major Taxonomic Group[d]				
					Annelida	Crustacea	Insecta	Mollusca	Misc. Taxa[e]
0.2	B1a	4,842	13	3	4	6	1	0	2
0.6	BCA-1[f]	11,667	22	6	7	9	2	1	3
0.8	B3a	11,958	25	4	9	13	0	2	1
0.9	B2a	16,233	30	8	8	12	2	3	5
1.4	B4a	8,858	23	4	6	13	2	0	2
2.1	B6a	1,475	19	5	8	5	0	2	4
2.3	B5a-2	500	10	3	6	2	0	0	2
2.9	BCA-3	9,050	16	2	8	6	0	0	2
3.1	B7a	8,600	20	4	6	11	1	0	2
3.5	B8a	14,100	21	6	7	11	0	0	3
4.5	B9a	5,875	24	5	8	13	1	0	2
4.8	B10a	6,600	20	6	7	10	0	0	3

[a] Sampling locations are shown on Map A.2-1 in Appendix A. BCA locations were sampled only for the benthic invertebrate community analysis.

[b] Total number of individual organisms in a standard 0.1-m^2 area determined by extrapolating the number in the composite samples, representing a total area of 0.012 m^2, to the number expected in the larger area (0.1 m^2) by multiplying by 8.33.

[c] Total number of taxa in a composite of five core samples, representing a total area of 0.012 m^2, at each location.

[d] Total number of taxa in each major taxonomic group in a composite of five core samples, representing a total area of 0.012 m^2, at each location.

[e] Miscellaneous taxa include Nemertea, Nematoda, Cnidaria, and Platyhelminthes.

ID – identification

RI – remedial investigation

Potential clam catch rates by people were assessed during the clam survey conducted in 2003 (Windward 2004c). Catch rate exercises were conducted at four beaches identified during the intertidal survey as having high clam abundance. The catch rate exercise used visible signs of clam presence such as holes or siphons to target where to dig, and also focused on collecting larger clams to simulate clamming behaviors that would most likely be conducted by harvesters. *M. arenaria* was the most common clam collected during the assessment of potential catch rates, comprising more than 98% of the total biomass.[14] Catch rates (i.e., total number of clams caught per hour) for all beaches combined were 652 for *M. arenaria* and 189 for all other species.

Subtidal Community

Surveys of the subtidal benthic communities (including infauna and smaller epibenthic species) were conducted at 14 locations throughout the LDW in 2004 (Windward 2005e). The total number of organisms ranged from 72 to 2,300 per 0.1 m^2 (Table 2-9). A total of 246 invertebrate taxa were identified in the van Veen grab samples. In general, annelids, crustaceans, and mollusks were the most abundant organisms at the subtidal locations. Benthic species richness in the subtidal habitats generally diminished with distance from the mouth of the river as the habitat changed from predominantly marine to estuarine. The largest decrease in species richness occurred between RM 0 and RM 3.0. Figure 2-11 presents the composition of major benthic invertebrate taxonomic groups at the subtidal locations as a function of river mile.

[14] The results of the catch rate exercise indicated that although *M. balthica* was the most abundant clam found in the quantitative survey, *M. arenaria* was the clam most likely to be harvested because of their larger size and presence of shows.

Table 2-9. Results of the subtidal benthic invertebrate community survey conducted for the RI

River Mile	Location ID[a]	Total Abundance[b]	Taxa Richness[c]	Swartz's Dominance Index	Taxa Richness by Major Taxonomic Group[d]				
					Annelida	Crustacea	Echinodermata	Mollusca	Misc. Taxa[e]
0.1	B1b	326	107	15	43	22	4	28	10
0.6	BCA-4	937	107	13	62	12	2	25	6
0.9	B2b	537	92	7	43	17	1	23	8
1.0	B3b	559	93	12	54	14	2	22	1
1.4	B4b	521	78	8	39	11	3	19	6
1.5	B5b	643	60	8	34	11	0	11	4
1.5	BCA-5	72	50	15	27	7 (1)[f]	0	12	3
1.7	BCA-2	328	54	6	29	12	1	11	1
2.2	B6b	1,137	83	3	41	17	0	21	4
2.7	B7b	497	75	5	38	16	1	18	2
3.9	B9b	935	36	6	17	12	0	6	1
4.2	B8b	2,300	27	4	14	12	0	1	0
4.3	B10b	1,541	16	2	9	7	0	0	0
4.6	BCA-6	1,689	14	3	7	7	0	0	0

[a] Sampling locations are shown on Map A.2-1 in Appendix A. BCA locations were sampled only for the benthic invertebrate community analysis.

[b] Total number of individual organisms retained on a 1-mm sieve in a standard 0.1-m^2 area determined by extrapolating what was enumerated in three composite van Veen grab samples, representing a total area of 0.3 m^2, to the smaller area (0.1 m^2) by dividing by 3.

[c] Total number of taxa in a composite of three van Veen grab samples, representing a total area of 0.3 m^2, at each location.

[d] Total number of taxa in each major taxonomic group in a composite of three van Veen grab samples, representing a total area of 0.3 m^2, at each location.

[e] Miscellaneous taxa include Nemertea, Nematoda, Cnidaria, and Platyhelminthes.

[f] One insect specimen was also collected at this location.

ID – identification

RI – remedial investigation

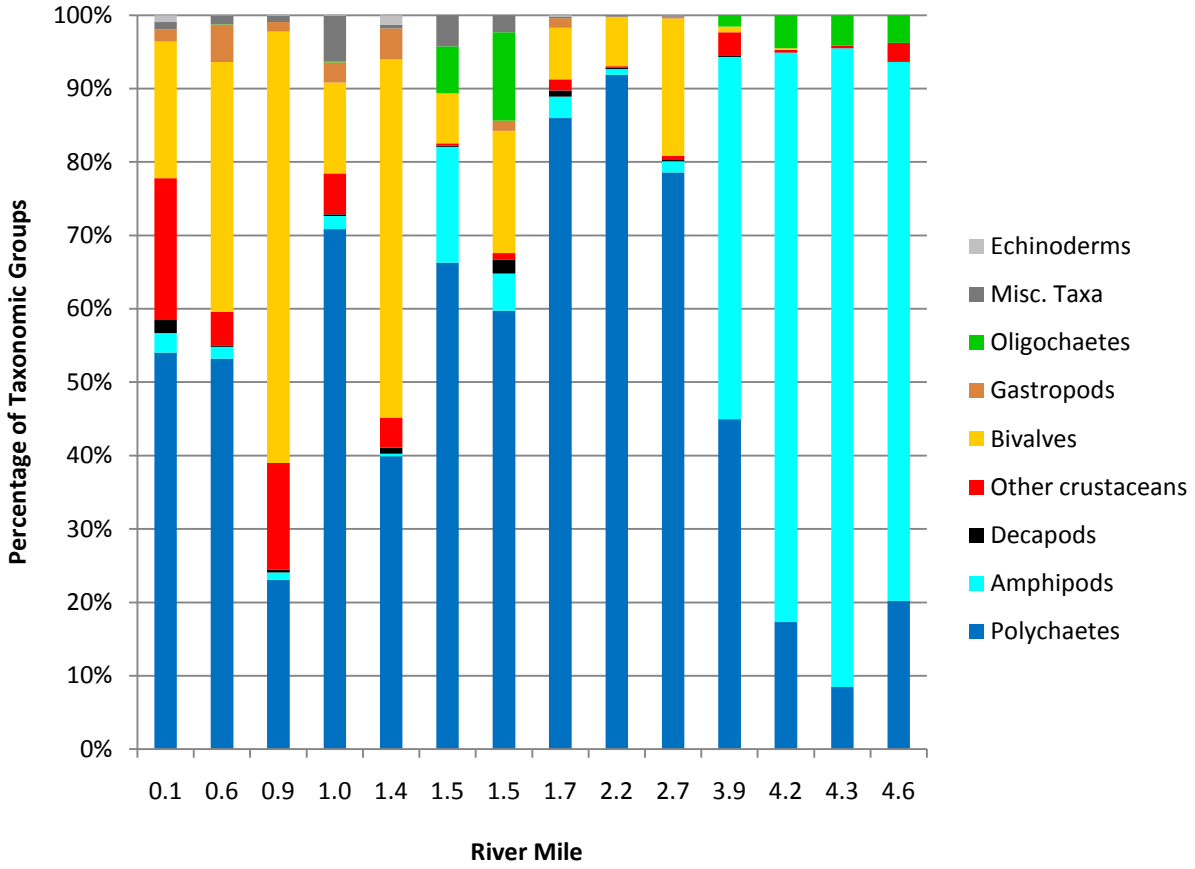


Figure 2-11. Composition of major benthic invertebrate taxonomic groups in subtidal areas of the LDW

Bivalves and polychaetes together represented more than 70% of the organisms identified at locations between RM 0.1 and RM 2.7. A clear shift in species composition occurred between RM 2.7 and RM 3.9. Bivalves were absent from the benthic community at the upstream locations (RM 3.9 to RM 4.6), and polychaete abundances at the three upper-most locations (RM 4.2 to RM 4.6) were reduced to 20% or less of the organisms identified. Amphipods were a dominant taxonomic group, accounting for 49 to 87% of the organisms at each upstream location (RM 3.9 through RM 4.6); whereas at downstream locations, amphipods accounted for a maximum of 16% of the organisms identified. Some of the main differences at the species level at upstream locations (relative to downstream locations) were: 1) the absence of butterclams, littlenecks, and cockles (these bivalves were relatively small in size and primarily found in the subtidal areas); 2) the absence of some marine polychaete genera, such as *Nephtys* and *Phyllodoce;* and 3) an increase in the abundance of some species, such as the amphipods *Americorophium salmonis* and *A. spinicorne* and the polychaete *Hobsonia florida*. These species are common in estuarine habitats with large salinity fluctuations. Additional differences in species composition at upstream locations (relative to downstream locations) were: 1) a reduction in the number of decapod species to one

(*Crangon franciscorum*, a species known for its tolerance of low salinity (Jensen 1995)); 2) the disappearance of gastropods, echinoderms, and miscellaneous taxa at locations at or above RM 3.9; and 3) a more consistent presence of oligochaetes at and above RM 3.9. The Swartz's Dominance Index calculated for each location supported this trend of diminishing numbers of taxa in upstream locations. Similar to the intertidal locations, samples were also collected and analyzed for biomass. Total biomass ranged from < 0.1 g ww at locations B7b, BCA-4, and BCA-5 to 1.7 g ww at location B4b. Average biomass for subtidal locations was approximately 0.34 g ww (Windward 2005e). Total weights at each location represented the biomass collected from an area of 0.0072 m^2.

Ecology (2000) evaluated the benthic community at three subtidal locations in the LDW as part of a sediment quality reconnaissance study for central Puget Sound. The benthic communities at the three locations were dominated by annelids. Mollusks were also common, whereas crustaceans and echinoderms were present in low abundances.

King County evaluated abundance of benthic infauna and epibenthos as a component of their assessment of CSO discharges to the LDW and Elliott Bay (King County 1999e). Subtidal sampling sites included transects located at Kellogg Island as well as downgradient from the Diagonal Avenue S CSO/SD and Duwamish CSO. Polychaetes were abundant in all samples and were the dominant organisms at all locations except at two locations downstream of the Diagonal Avenue S CSO/SD and Duwamish CSO, where oligochaetes and mollusks were dominant. A Kellogg Island location also had relatively abundant mollusks. Arthropods tended to be more abundant in deeper waters (King County 1999e).

Williams (1990) sampled epibenthic biota to a depth of –8 ft MLLW near Kellogg Island and reported that nematodes, oligochaetes, small harpacticoids, and cumaceans dominated the subtidal epibenthos. As with the intertidal benthos, stations with finer sediments generally had a greater abundance of epibenthic biota (Williams 1990).

Leon (1980) used van Veen grab samplers to characterize the subtidal epibenthic and infaunal sediment biota at five locations downstream of RM 1.5. The study identified more than 60 different taxa, greater than the number found in the intertidal habitat from the same survey. Most subtidal species were deposit-feeding polychaete worms characteristic of deeper, turbid waters of the LDW. Small deposit-feeding clams (*Macoma* sp., *Axinopsida* sp., and *Psephidia* sp.) and the amphipod *Anisogammarus* sp., which feeds on diatoms and green algae, were also present.

Larger Epibenthic Invertebrates

Larger epibenthic invertebrates identified in the LDW include crabs, shrimp, sea stars, anemones, and mussels. Numerous larger epibenthic invertebrate species were caught during two fish and crab surveys conducted throughout the LDW for the RI (Windward 2005b, 2006c). The most abundant epibenthic invertebrates were slender crabs, crangon shrimp, and coonstripe shrimp. Dungeness crabs were also caught in

both surveys, although their distribution was generally limited to the portions of the LDW with greater salinity.

A pilot survey and three quarterly surveys were performed in 2003 and 2004 to estimate the abundance of crabs and shrimp within the LDW (Windward 2004a). Three crab species and one shrimp species were caught during the surveys. Slender crabs and Dungeness crabs were the most abundant species, with red rock crabs and dock shrimp being less abundant (Windward 2004a). The majority of these crabs were caught in the downstream, more saline part of the LDW. Red rock crabs and dock shrimp were also caught, primarily in the downstream portion of the LDW, with a few adults caught between RM 1.6 and RM 2.2. During a reconnaissance study conducted by Environmental Solutions Group, Inc. (ESG) (1999), Dungeness crabs and red rock crabs were found at multiple locations near Kellogg Island; no adults were collected upstream of this point, whereas juveniles were found up to the 1st Avenue S Bridge.

During the Puget Sound Ambient Monitoring Program (PSAMP) (1989 to 1999), invertebrates were collected throughout Puget Sound, including locations in the LDW (West et al. 2001). Epibenthic invertebrate species, similar to those caught in the surveys conducted for the RI, were collected with otter trawls. The most common invertebrates were slender crabs and crangon shrimp. Other species caught during the PSAMP survey, but not in the RI surveys, included porcelain crabs (family Porcellanidae), chitons (class Polyplacophora), and several sea stars.

In September of 2006, King County collected fish for tissue analyses using a high-rise otter trawl in the downstream portion of the LDW (Anchor and King County 2007). Non-target invertebrate species were recorded and released. Coonstripe shrimp was the most common invertebrate species, followed by graceful crab and crangon shrimp. Other crab species included kelp crab, decorator crab, red rock crab, black-clawed crab and pygmy rock crab. Sea star species include short-spined sea star, sunflower sea star, and false ochre star. Plumose anemone was also found during this study.

Biologically Active Zone

The BAZ refers to the surface sediment layer where sediments are mixed by the feeding and burrowing behaviors of benthic invertebrates. This layer is often the focus of ERAs for benthic invertebrates and fish and is the point of compliance for surface sediments under the Washington State Sediment Management Standards (SMS). According to Ecology's sampling and analysis guidance (Ecology 2008c), "Past studies in Puget Sound have demonstrated that the majority of benthic macroinvertebrates are generally found within the uppermost 10 cm of the sediments. While some species may be found at deeper depths below the sediment surface, 10 cm is generally assumed to represent a reasonable estimate of the biologically active zone." This section provides a discussion of site-specific data collected during an Ecology-led investigation of SPI techniques for assessment of benthic communities in the LDW and elsewhere (Ecology 2007n) and a King County-led study of the Duwamish/Diagonal dredging residuals area prior to the placement of a thin sand layer (Anchor 2007) to

determine the appropriateness of the assumption that 10 cm represent the BAZ in the LDW RI/FS.

Background

Benthic organisms usually inhabit the oxygenated layer[15] of the sediment near the sediment-water interface. The depth that organisms occur within the sediment column is related to the habitat characteristics (grain size, hydrologic/sediment transport regime, amount and quality of food) and degree of perturbation that a given location experiences (e.g., periodic erosion from high currents or propeller scour; predation by larger organisms such as fish or crabs; exposure to chemical contamination in water, sediment, or food). Benthic communities in stable environments with adequate food and sediment quality typically include larger, less abundant, longer-lived organisms (e.g., deposit-feeding polychaetes) that burrow and feed up to 20 cm below the sediment surface (Germano & Associates 2007).[16] This burrowing depth is often below the oxygenated layer at the sediment surface; however, these mature (Stage 3) communities employ physical or biological adaptations that give them access to the oxygenated water at the sediment surface and retard the influx of anoxic porewater into their burrows or tubes. In stable, depositional areas of the LDW where Stage 3 communities would be expected to be common, it is likely that organisms occasionally burrow and/or feed in the 10–to-20-cm stratum of the sediment.

Benthic communities that undergo periodic or chronic disturbances (physical or chemical) are more likely to be characterized by very small, abundant organisms (typically opportunistic polychaetes and bivalves) that take advantage of the short-term availability of a habitat or a resource. These early colonizers (Stage 1 assemblages) live within a few millimeters of the sediment-water interface, reflecting both their small size and the depth to which oxidized sediment occurs, primarily through the molecular diffusion of oxygen from the overlying water column. Disturbed communities that have undergone some type of recovery will have infaunal members (e.g., tubicolous polychaetes, amphipods, small bivalves) that may burrow to shallow (within a few centimeters) depths in the sediment column. These transitional communities (Stage 2 assemblages) are the first to rework subsurface sediment and extend the oxygenated sediment layer to several centimeters or more. Regardless of the successional stage, the oxygenated sediment layer seldom extends deeper than about 10 cm.

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[15] Depth of the oxygenated layer is primarily a function of advection, diffusion, biological activity, and physical energy. Diffusion is the least effective, on the order of a few mm. Organisms, through feeding and burrowing, open up spaces and can actively ventilate oxygenated water down into the sediment. Physical energy (e.g., intertidal swash zones) can drive oxygenated water into the sediment. The depth varies depending on the type of organisms present, among other factors.

[16] There are individual organisms (e.g., various bivalves, ghost shrimp, nemerteans, polychaetes) in specific environments (e.g., quiescent environments) that can occur at deeper sediment depths.

SPI can be used to estimate the depths of the oxygenated layer and document depths of macroinvertebrate tubes or feeding voids. The SPI camera is deployed multiple times at a location and collects three replicate images of the sediment column approximately 15 cm wide and up to 20 cm deep. Each image is evaluated using image analysis software, with visual confirmation of the results. In many SPI surveys, plan view photos are also collected and are used to characterize the physical regime and other biological characteristics associated with the profile images.

Results

SPI data were collected at 87 stations in the LDW as part of an Ecology-led study in July 2006. The purpose of this study was to assess the relationships between SPI metrics and direct measures of sediment quality (sediment chemistry, sediment toxicity, and benthic community assemblages, as defined by the SMS). The study targeted communities in fine-grained sediments in areas with a range of chemical contamination between RM 0 (located at the southern end of Harbor Island) and RM 3.4. The SPI sampling was limited to highly saline subtidal areas with a minimum depth of 8 ft below MLLW. As part of the Ecology study, 23 different attributes were quantified for each image, including the following key attributes related to the assessment of the BAZ and distribution of community types that strongly influence the BAZ depth: the apparent redox potential discontinuity (aRPD) depth that indicates the *approximate* depth of the oxygenated layer; apparent grain size (based on phi classification); number and depth of observable subsurface voids; boundary roughness[17] and type (biological or physical); small-scale bed dynamics (depositional, erosional, or static); and successional stage of the benthic community (Germano & Associates 2007).

King County conducted a similar investigation of baseline conditions prior to the placement of a thin layer of sand in areas with residual contamination following dredging in the vicinity of the Duwamish/Diagonal CSO/SD in 2005 (Anchor 2007). SPI images were collected from 28 stations and images were minimally processed; only the average aRPD and void depth were reported. Results of these two studies are discussed in the following sections, by SPI metric.

Oxygenated Layer Depth — The apparent depth of the oxygenated layer (i.e., aRPD) is a good indication of where Stage 1 and the majority of Stage 2 organisms may be found in the sediment column. The aRPD was reported as the minimum and maximum depths measured in each replicate image, along with an average depth for each image. The depth of this feature across all images from the Ecology study ranged from 0.2 to 9.6 cm below mudline and averaged 2.6 cm (the 95% upper confidence

[17] Boundary roughness is the vertical distance between the highest and lowest points of the sediment-water interface over the width of a single image. This small-scale surface relief ranged from 0.2 to 9.1 cm in the LDW and was related to either physical sediment structures (e.g., ripples) or biogenic features (burrow openings, fecal mounds, foraging depressions).

limit on the mean [UCL] was 2.8 cm). The average aRPD (i.e., the average of three replicate image averages) at all Ecology sampling locations is presented on Map 2-9. The aRPD in the vicinity of the Duwamish/Diagonal CSO/SD was similar to that reported in the Ecology study, averaging 2.4 cm (with a 95% UCL of 2.7 cm).

Voids — Voids are subsurface oxygenated spaces in the sediment column created by organisms burrowing or ingesting sediment. These activities mix the surface sediments with subsurface sediment and are the major contributor to the process known as bioturbation. Void depth can be used as an indication of the maximum depth of the sediment column in which benthic invertebrates exist and may be exposed to sediment chemicals.[18]

Evidence of voids was found in half of the replicate images (119 out of 238 profile images) evaluated in the Ecology study. Where present, only a few (1 to 3) voids were typically noted per image, although in a dozen cases the number ranged from 4 (n = 7) to a maximum of 8 (n = 1) voids.[19] Void depths were reported as an interval (minimum/maximum) in the sediment within which voids occurred (if only one void was present, then the interval represented the top and bottom of that void). Depths of voids ranged from 0.5 to 19.5 cm below the sediment surface among all of the replicate images with voids, indicating that some benthic organisms in the LDW actively burrow or feed at depths of 10 to 20 cm in the sediment column. The average void depth per replicate was 10.3 cm (the 95% UCL was 11 cm) in fine-grained sediments, with about half of the void bottoms occurring at depths between 10 and 20 cm below the sediment surface. The minimum and maximum void depths at each station (three replicates combined) are provided on Map 2-10. These findings were similar to those reported in King County's study, which reported the average depth of bioturbation as ranging from 1.8 cm to 15.3 cm (the overall average was 8.4 cm; the 95% UCL was 9.4 cm).

Where voids were present, the maximum void depth was greater than the maximum aRPD in almost all cases. Voids below the oxygenated sediment layer were distributed throughout the study area (i.e., RM 0 to RM 3.4); no particular spatial pattern was found other than an association with fine-grained sediment.

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[18] Tube-building organisms and those that construct permanent (or semi-permanent) burrows limit their exposure by sealing tubes or lining burrows with mucous.

[19] The proportion of the cross-sectional area that is void space can be estimated for each image. However, without other measures made over time, the proportion is not a good estimator of absolute exposure or bioturbation; but it may be useful for indicating a relative rate of biological activity among locations. The cross-sectional areas of the voids were estimated to be between 0.1 and 20 cm^2 (based on a sampling of 25% of the replicate images with a single void). As a proportion of the surface area of the sediment in the profile image, the areal extent of sediment disturbed by void-producing activities ranged from < 1 to about 10% of a given image. Areal extent was calculated as the product of the number of voids and the estimated average void area divided by the area of the profile image reported by Ecology (2007n).

Boundary Roughness (Physical Feature) — Roughness was measured as the vertical distance (or amplitude) between the highest and lowest mudline elevations within a profile image. The maximum roughness was about 9 cm and averaged 1.1 cm. A higher measure is indicative of physical disturbance, such as current-induced ripples on the sediment bed; a lower measure (generally less than 3 cm) indicates mostly biological disturbance of the sediment bed. This information can be used to help characterize the physical regime to which the benthic communities are exposed and the likely community assemblages that may occur in response to the physical environment.

Small-Scale Sediment Bed Dynamics — Information about small-scale sediment bed dynamics can be used to predict, in part, the benthic community structure that may be found in different areas of the LDW. Features in both the plan and profile images that were indicative of various physical and biological processes were noted in Ecology's report. These features included, but were not limited to, sediment sorting and fabric and the presence of bedforms, faunal structures, and debris. From combinations of such features, Ecology inferred the extent to which a station is likely erosional or depositional at small spatial scales (profile images were about 15 cm wide; plan view images were about 50 cm wide). Over 70% of the stations examined were classified as depositional; 18% were classified as erosional; 8% were static (i.e., no net loss or accumulation of sediment); and 2% of the stations were not classified because their classification could not be determined based on the SPI metrics. One caveat is that no temporal scales were evaluated so these classifications may not be indicative of long-term conditions.

Community Successional Stages — An examination of successional stage classifications provided in Ecology's report showed that 60% of the replicate images evaluated were indicative of mature (Stage 3) communities, 28% of the images were indicative of a transitional community (Stage 2), and 4% of the images were indicative of early colonizing communities (Stage 1); the community stage could not be determined in 8% of the images.[20] At the stations where Stage 3 communities were present, there was often a mixture of Stage 1 or 2 communities as well; this was interpreted as evidence of recruitment/growth in a mature community or very small-scale perturbations. Community stage also varied among replicates at 40% of the sampling locations (e.g., one image showed a Stage 2 community, and two images showed Stage 3 communities); this variability is likely indicative of the small spatial-scale heterogeneity that benthic communities tend to exhibit in response to the biological and physical features of their environment. Map 2-11 displays the typical (based on two or more replicates) successional stage at each sampling station.

[20] Indeterminate classification was usually the result of insufficient penetration of the camera (substrate was compacted coarse-grained material), or when algae or wood that was entrained by the camera into the sediment obscured the camera's view.

The distribution of successional stages appeared to be strongly linked to sediment grain size and small-scale sediment bed dynamics (Table 2-10). In quiescent or depositional areas, sediments tend to be fine-grained and can support deeper burrowing, more mature communities. In general, Stage 3 communities (whose members are responsible for the deeper voids) are expected to dominate depositional areas. Conversely, early colonizers (Stage 1) or transitional communities (Stage 2) are expected to populate areas where sediments (typically sands) are being actively transported because of the instability of the habitat. As shown in Table 2-10, over 90% of the Stage 3 communities were found in fine-grained depositional areas (as expected), and about 40% of the early colonizing or transitional communities were found in areas noted in Ecology's report as having evidence of erosion or sediment transport at this small scale.[21] Based on the location of the transitional communities that were present in fine-grained areas (i.e., where mature communities would be expected), ship traffic (along pier faces, areas of tug activity, etc.) or other factors (e.g., located within or on the slope of the navigation channel; presence of sediment chemical contamination) may be contributing to small-scale or periodic perturbations that are affecting community succession. Table 2-10 presents the distribution of benthic community successional stages by physical regime, as defined by the Ecology SPI study (2007n).

Conclusions

The default assumption of 10 cm can be reasonably applied as the BAZ in the LDW based on the following factors:

- **Representativeness of the entire benthic invertebrate community –** Overall, the SPI data indicate that although individual benthic invertebrates may be utilizing depths between 10 and 20 cm below the sediment surface, the benthic invertebrate community primarily utilizes shallower sediment based on the limited number of voids below 10 cm, the limited areal extent of deeper sediment disturbed by feeding or burrowing activities, and the prevalence of Stage 1 and 2 organisms that co-occur with the Stage 3 communities.
- **Relationship between voids and depth in sediment –** The number of voids drops off dramatically with distance from the sediment surface. Specifically, where voids were observed, 49% were contained in the 0–to-10-cm interval, 38% of the voids were contained in the 10–to-15-cm interval, and only 13% of the voids extended to depths greater than 15 cm.
- **Central tendency of void depth –** The mean of the maximum void depths observed in individual profile images was approximately 10 cm (with a

[21] Erosion/transport classification is based on evidence of layering, sorting, and/or bedding in SPI images.

95%UCL of 11 cm), which was corroborated by the King County study (Anchor 2007).

- **Location –** Other than an association with fine-grained sediment, there were no apparent clusters of areas with deeper voids; voids seem to be distributed throughout the study area and not related to presence or absence of contamination.

Table 2-10. Distribution of benthic invertebrate community successional stages by physical regime in sediment profile images from the LDW

Community Stage	Replicate Distribution by SPI Grain Size and Physical Regime[a]					Exposure	
	Fine-Grained Depositional	Coarse-Grained Erosional or Transport	Mixed Grain Size/Static	Unknown[b]	Total	Maximum Void Depth (cm)	Mean Depth of Bottom of Void (cm)
Early colonizers (Stage 1)[c]	0	6	0	0	6	0	0
Transitional (Stage 2)[c]	33	28	12	1	74	13.3[d]	10.6[d]
Mature (Stage 3)	143	3	9	3	158	19.5	10.3[e]
Indeterminate	11	11	0	0	22	na	na
Total	**187**	**48**	**21**	**4**	**260**	na	na

[a] SPI classification of physical regime is conceptually similar to the sediment dynamics discussed in Section 3; however, the SPI analysis represents a much smaller scale of assessment and does not reflect long-term trends. For example, an area identified as being potentially subject to erosion in the discussion of sediment dynamics in Section 3 might experience erosion infrequently (e.g., during episodic periods of high flows); in between such periods of erosion, the area may be subject to net sediment deposition. Hence, there may not be a direct correspondence between the physical regimes identified in the one-time SPI study and the physical regimes identified in Section 3 based on long-term conditions.

[b] Unknown physical regime was a sampling artifact (e.g., camera and/or frame disturbed the sediment surface or entrained debris into the sediment, precluding assessment of the sediment characteristics related to physical regime).

[c] This classification refers to samples where only this stage was present. Stage 1 and 2 organisms co-occurred with Stage 3 organisms throughout the study area and were considered evidence of recruitment or very small scale (< 1 cm) disturbance at that location.

[d] Voids were observed in only two replicate samples (one void per replicate); voids were absent in all other Stage 2 locations.

[e] Mean of the reported bottom void depth, where Stage 3 communities were present.

LDW – Lower Duwamish Waterway

na – not applicable

SPI – sediment profile imaging

SPI images in the LDW indicate that benthic invertebrates in Stage 3 communities actively burrow and feed between 0 and 20 cm below the sediment surface. Benthic invertebrates may occasionally exist below 10 cm in Stage 2 transitional communities.[22] Successional Stage 3 communities were the most abundant community type in the Ecology study area (RM 0 to RM 3.4) and typically co-occurred with Stage 1 and Stage 2 organisms. Communities in these earlier stages generally utilize the top 10 cm, as evidenced by the depth of the aRPD and the depths of voids where only Stage 1 or Stage 2 communities are present.

2.8.3 Fish

A diverse fish community inhabits the LDW. This section briefly summarizes what is known about the LDW fish community. Further details regarding life history characteristics and dietary preferences are presented in Appendix A, Section A.2.2.3.

2.8.3.1 Summary of LDW fish studies

Data on site use by fish are available from 14 studies that have been conducted or are ongoing in the LDW (see Appendix A, Table A.2-8, for a complete list of these studies). In combination, these studies have used various capture techniques to assess the diversity and abundance of fish in the LDW.

2.8.3.2 Summary of site use by fish

The LDW is inhabited by numerous anadromous and resident fish species (see Appendix A, Attachment A2, for a complete list of identified species). Fifty-three resident and non-resident fish species were captured in the LDW during sampling events conducted for the RI (Windward 2004d, 2005b, 2006c). During previous sampling events, Warner and Fritz (1995) recorded 33 resident and seasonal species of fish in the LDW, Miller et al. (1977a) observed 29 species, and Matsuda et al. (1968) recorded 28 species.

Simenstad (1983) identified 43 species of demersal fish commonly found in estuaries throughout the Pacific Northwest, Puget Sound, and the Pacific Ocean. Of the 43 species listed, 24 have been reported in the LDW. Species listed in Simenstad (1983) but not identified in the LDW include Pacific lamprey, green sturgeon, white sturgeon, common carp, leopard dace, white crappie, black crappie, yellow perch, redtail surfperch, walleye surfperch, spotfin surfperch, silver surfperch, kelp greenling, rock greenling, lingcod, cabezon, pricklebreast poacher, showy snailfish, and ringtail snailfish. Differences in the fish community structure between the LDW and other Pacific Northwest estuaries are likely a function of differences in salinity profiles, availability of specific habitat types, and sampling methods and seasons.

[22] Two replicates categorized as transitional (i.e., with a Stage 2 community) each had a single void; voids were absent in all other Stage 1 and Stage 2 locations.

Based on the LDW fish studies reviewed in the ERA, shiner surfperch, snake prickleback, Pacific sandlance, Pacific staghorn sculpin, longfin smelt, English sole, juvenile Pacific tomcod, pile perch, rock sole, surf smelt, three-spine stickleback, Pacific herring, and starry flounder were identified as abundant at the time of the sampling events, as were chinook, chum, and coho salmon (see Appendix A, Attachment A2). Fish abundance in the LDW reaches its maximum in late summer to early fall and is generally lowest in winter (Dexter et al. 1981; Miller et al. 1977a). Based on 2004, 2005, and 2007 trawl data (Windward 2004d, 2005b, 2006c), differences between the fish community structure in the downstream (RM 0.0 to RM 2.4) and upstream (RM 2.9 to RM 5.0) segments of the LDW were apparent. Species diversity in the downstream segment was greater than in the upstream segment, with some species being rare or absent from the most upstream segment (RM 4.2 to RM 5.0) sampled for the RI. For example, English sole and rock sole were more abundant downstream, and starry flounder and shiner surfperch were more abundant upstream (Table 2-11). The salinity of the upstream portion of the river is lower than the salinity in the downstream portion, which may contribute to some of these differences in abundance.

Table 2-11. Catch per unit effort for fish species in the four fish sampling areas in the LDW

Species	Average Number of Fish per Trawl			
	Area T1 (RM 0.2 to RM 1.0)	Area T2 (RM 1.6 to RM 2.4)	Area T3 (RM 2.9 to RM 3.7)	Area T4 (RM 4.2 to RM 5.0)
English sole	4.7	17.6	4.9	2.3
Longfin smelt	0.7	< 0.5	2	2.9
Pacific herring	< 0.5	1	< 0.5	< 0.5
Pacific staghorn sculpin	2.8	8.2	5.2	11
Pacific tomcod	0.9	2.4	2.5	2.1
Pile perch	1	3.3	3.8	< 0.5
Prickly sculpin	< 0.5	< 0.5	1.3	< 0.5
Rock sole	2.7	0.9	< 0.5	< 0.5
Roughback sculpin	0.8	< 0.5	< 0.5	< 0.5
Sand sole	< 0.5	0.8	< 0.5	< 0.5
Shiner surfperch	5.1	19.7	34	103
Snake prickleback	1.3	< 0.5	0.9	< 0.5
Starry flounder	1.1	7.8	10.3	72
Striped perch	< 0.5	0.8	< 0.5	< 0.5
Surf smelt	< 0.5	2	< 0.5	< 0.5
Unknown sculpin	0.8	< 0.5	< 0.5	< 0.5

LDW – Lower Duwamish Waterway
RM – river mile

Anadromous Salmonids—Pacific Salmon

Five species of Pacific salmon (i.e., coho, chinook, chum, sockeye, and pink) have been identified in the LDW study area (Kerwin and Nelson 2000). These anadromous fish use the estuary for rearing and as a migration corridor for adults and juveniles. Among the numerous beneficial uses identified for the LDW study area, use as habitat for outmigrating juvenile salmonids was listed as the most important (Harper-Owes 1983).

Salmonid residence time in the LDW study area is limited and species-specific. Juvenile chinook and chum salmon have been shown to be present from several days to up to 2 months within the LDW, whereas coho salmon pass through the LDW in a few days (Grette and Salo 1986). Sockeye salmon are rare in the LDW. Salmon found in the LDW spawn mainly in the middle reaches of the Green River and its tributaries (Grette and Salo 1986). The juvenile outmigration of all five species generally commences during the high-flow months of March to June. Outmigration usually lasts through mid-July to early August (Nelson et al. 2004; Warner and Fritz 1995). During these months, salmonids use the estuary to feed and begin their physiological adaptation to higher salinity waters.

Of the salmonid species, chinook salmon have been studied the most extensively in the Green-Duwamish system. Puget Sound chinook salmon were listed as threatened under the federal Endangered Species Act (ESA) on March 24, 1999. The decline of chinook salmon has been attributed primarily to habitat degradation and fragmentation, blockage of migratory corridors, impact from hatchery fish, and commercial and local harvesting practices (Myers et al. 1998a).

Other Salmonids

The coastal Puget Sound bull trout population was listed as threatened under the federal ESA on November 1, 1999. Bull trout were historically found in the LDW because it originally included a much larger upper elevation drainage area, including the White River, which still maintains a bull trout run. Current stock status in the Green-Duwamish system is unknown (WDFW 2000). The decline of bull trout has been primarily attributed to habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, historical fisheries practices, and the introduction of non-native species (64 FR 210: 58910-58933).

Bull trout typically spawn in the upper headwaters of a river system, generally requiring high oxygen concentrations and water colder than 10 ˚C. Although sub-adult bull trout have been captured in the LDW (Shannon 2001; Warner and Fritz 1995), there is no evidence that bull trout are spawned or reared within the LDW.

Both winter- and summer-run steelhead trout, federally listed threatened species, have been observed in the Duwamish/Green River system (Washington Department of Fisheries et al. 1993; WDFW 2007b). Although they were not target species for fish collection, steelhead have been caught during studies conducted as part of the RI.

Summer steelhead (*Oncorhynchus mykiss*) is a non-native stock sustained by wild production of hatchery origin fish (Washington Department of Fisheries et al. 1993). The run size is unknown but approximated to be a few hundred fish. Winter steelhead consist of both wild and hatchery fish with annual returns ranging from 944 to 2,378 fish. Grette and Salo (1986) reported that repeat spawners make up approximately 19% or fewer of returning wild adults in the Green River system. Both winter and summer runs migrate quickly through the LDW (Grette and Salo 1986).

Sea-run cutthroat trout exist in the LDW, but very little is known about this population or its use of the system. Only 11 cutthroat trout were captured in beach seines at nine stations sampled approximately 30 times each throughout the LDW from February through June 1994 (Warner and Fritz 1995).

Non-Salmonid Fish

Based upon the LDW fish studies reviewed in the ERA, the most abundant non-salmonid fish in the LDW are shiner surfperch, snake prickleback, starry flounder, English sole, Pacific staghorn sculpin, Pacific sandlance, juvenile Pacific tomcod, pile perch, rock sole, surf smelt, three-spine stickleback, Pacific herring and longfin smelt (see Appendix A, Attachment A2). In 2006, King County also found tubesnout to be relatively abundant in the downstream portion of the LDW (Anchor and King County 2007). Shiner surfperch, longfin smelt, and Pacific herring are seasonally abundant in the LDW. Pacific sandlance and longfin smelt, though known to be abundant in the LDW, were encountered infrequently in recent beach seine and trawling efforts, as were Pacific herring and surf smelt. Though these species were not encountered frequently during recent sampling, they are occasionally found in large numbers in the LDW (Shannon 2006; Windward 2005b, 2006c). In all previous studies, Pacific staghorn sculpin were consistently one of the most abundant fish captured in the LDW, particularly during the fall months. Pacific staghorn sculpin are opportunistic feeders, and the adults feed at a higher trophic level than other common resident fish species.

Shiner surfperch abundance in the LDW peaks in summer during spawning (Miller et al. 1975). English sole are common in the LDW over all seasons, with peak abundance in spring (Miller et al. 1977b). Adult English sole migrate seasonally to their spawning grounds in Puget Sound in winter (Forrester 1969) and typically spawn in Puget Sound during February and March (Smith 1936). In central Puget Sound, adult populations of English sole spawn in Elliott Bay and Port Gardner but disperse quickly after spawning (Pallson 2001). Starry flounder are also noted to migrate seasonally between very shallow water and in estuaries during the summer, moving into deeper waters in the winter (Morrow 1980).

2.8.4 Wildlife

The aquatic and semi-aquatic habitats of the LDW support a diversity of wildlife species. Formal studies, field observations, and anecdotal reports indicate that up to 87 species of birds and 6 species of mammals use the LDW at least part of the year to feed, rest, or reproduce. This section provides a brief overview of these bird and mammal species. Additional information, including summaries of what is known about how these species use LDW habitats, is provided in Appendix A, Section A.2.2.4.

2.8.4.1 Birds

Many birds have been identified in the LDW area including: passerine/upland birds, raptors, shorebirds/waders, waterfowl, and seabirds; the species are listed in Appendix A (Table A.2-9). Canning et al. (1979) conducted extensive surveys of Kellogg Island, as well as occasional surveys of the entire LDW, from September 1977 to July 1978. They recorded a total of 70 species, including 26 passerines/upland birds, 3 raptors, 11 shorebirds/waders, 17 waterfowl, and 13 seabirds. The study showed that Kellogg Island had a much greater diversity of birds than did the rest of the LDW study area because of its seclusion and greater variety of habitats. Cordell et al. (2001) reported 75 species of birds, including 32 passerine/upland birds, 7 raptors, 8 shorebirds/waders, 16 waterfowl, and 12 seabirds. Diversity and abundance were highest at the Kellogg Island site, but other areas of the LDW were also consistently used by a wide variety of birds. Birds were most abundant in the spring and least abundant in the summer. During the sandpiper presence and habitat survey conducted for the RI in 2004 over the period of four days, 21 bird species were observed while assessing preferred spotted sandpiper habitat areas (Windward 2004j).

Passerines/Upland Birds

Thirty-two species of passerine/upland birds have been documented along the LDW (Canning et al. 1979; Cordell et al. 1999) (see Appendix A, Table A.2-9). Although generally associated with upland habitats, these birds occasionally forage in the exposed mudflats or use intertidal habitats along the LDW for bathing (Canning et al. 1979). During the sandpiper presence and habitat survey, 10 passerine species (starlings; crows; violet green, barn, and tree swallows; house, song, and white-crowned sparrows; rock pigeons, and American robins) were frequently observed in the LDW area (Windward 2004j).

Raptors

Eight species of raptors have been reported to use the LDW: bald eagle, osprey, peregrine falcon, merlin, and four species of hawks (Cordell et al. 1999). During the sandpiper presence and habitat survey bald eagles were frequently observed in the LDW area (Windward 2004j). The bald eagle is listed under ESA as a threatened species but is currently under review for delisting. In Washington, the bald eagle is also listed as a state threatened species (WDFW 2006a, b, 2007a). Five bald eagle nests

were occupied within 8 km (5 mi) of the LDW study area in 1999 (King County 1999e). One or two pairs of resident eagles can be found in the LDW vicinity during the summer (King County 1999e), and overwintering migrant eagles are routinely observed from the beginning of October through late March.

In 2006, WDFW reported 10 osprey nest sites located along the LDW or nearby, with nests also observed on Harbor Island and along the Duwamish and Green Rivers within about 6.4 km (4 mi) of the Upper Turning Basin (Thompson 2006). Four osprey nest platforms were identified throughout the LDW during the sandpiper presence and habitat survey, with young observed in each nest (Windward 2004j). Adult ospreys were also frequently observed on tall structures near the nest platforms during this survey.

Two pairs of peregrine falcons currently nest along the LDW. Two peregrine falcons were observed in the LDW area during the sandpiper presence and habitat survey (Windward 2004j). The peregrine falcon is listed as a species of concern under ESA and was downlisted from a state endangered species to a state sensitive species in April 2002 (WDFW 2007a).

Cooper's hawks and sharp-shinned hawks have been observed overwintering in the vicinity of the LDW. Red-tailed hawks are a resident species and are commonly observed along grassland/woodland margins of the LDW. These species are not heavily reliant on the LDW for food; they prey on songbirds and rodents but will also eat waterfowl. Swainson's hawks and merlin are rare in the LDW area (Canning et al. 1979; Cordell et al. 1999).

Shorebirds/Waders

Ten species of shorebirds and wading birds have been documented in the LDW: great blue heron, green heron, three species of sandpipers, dowitcher, dunlin, killdeer, sanderling, and lesser yellowlegs (Cordell et al. 1999). Of these species, great blue heron are year-round residents and comprise the only sizeable and consistent population recorded by Cordell et al. (1996) on the Duwamish River. During the sandpiper presence and habitat survey, great blue heron were frequently observed throughout the LDW (Windward 2004j). One nesting great blue heron colony is located 11 km (6.8 mi) to the northwest of the LDW (Kiwanis Ravine colony); another colony is located 12 km (7.5 mi) to the southeast, in Renton (Black River colony) (Butler 1997). A former blue heron colony of up to 37 nests was located a few hundred meters to the west of Kellogg Island. The colony was likely abandoned in 2000 because of local disturbances or predation (Norman 2006).

The two most common shorebirds observed in the LDW are killdeer and various species of sandpipers. The spotted, least, and western sandpipers are reported to use the LDW, and spotted sandpipers have been observed nesting on Kellogg Island (Canning et al. 1979). Spotted sandpipers are present in the Northwest region year-round; whereas least and Western sandpipers are present during the winter

(Sibley 2003). During the sandpiper presence and habitat survey, small numbers of spotted sandpipers were observed in the LDW area, particularly on and in the vicinity of Kellogg Island and Herring's House Park (Windward 2004j). Killdeer were also observed during the survey in the same areas as spotted sandpiper, but in larger numbers. Though no spotted sandpiper nests were observed during the survey, a killdeer nest was observed on Kellogg Island. Least and western sandpipers occur in mixed flocks and are difficult to distinguish. These species nest primarily in northern Canada and Alaska in the summer months but are reported to frequent Kellogg Island from September through May. Most are thought to be migrants, though some may reside in the LDW area throughout the winter.

Waterfowl

Seventeen species of waterfowl, including 13 species of ducks, 3 species of geese, and the American coot, use the LDW (Cordell et al. 1999). During the sandpiper presence and habitat survey, Canada geese and mallard ducks were commonly observed, and gadwall and common mergansers were also observed though less frequently (Windward 2004j). In general, these migratory birds overwinter in the Puget Sound area (and further south) and migrate north in the summer. A small resident population of mallards lives year-round in the LDW area, and as many as 290 migratory mallards have been reported to move through the LDW.

Canvasback, greater scaup, gadwalls, bufflehead, and both common and Barrow's goldeneye are reported to use the LDW. Feeding by all diving duck species is centered around Kellogg Island (Canning et al. 1979).

All three species of North American mergansers use the LDW study area. Approximately 30 red-breasted mergansers reportedly overwinter in the LDW area between December and March.

A population of approximately 1,000 Canada geese resides in the vicinity of Lake Washington and includes the LDW population (Canning et al. 1979).

Seabirds

Fourteen species of seabirds were recorded in the LDW during surveys completed in 1979 and 1999 (Canning et al. 1979; Cordell et al. 1997; 1999), including two species of cormorants, three species of grebes, three species of gulls, three species of loons, pigeon guillemot, common murre, and Caspian tern. Wintering cormorants (pelagic and double-crested) use the LDW study area between November and May, with large numbers present between December and April. During the sandpiper presence and habitat survey, double-crested cormorants and gull species were commonly observed in the LDW area (Windward 2004j).

Glaucous-winged gulls and mew gulls are the only gull species reported to use the LDW study area in large numbers. Glaucous-winged gulls are reported to use the area year-round; mew gulls frequent the area from September through May (Canning et al.

1979). Caspian terns have been seen on Kellogg Island (Luxon 2004). Pigeon guillemots and common murres have also been reported in the LDW; however, their use of the LDW is infrequent. The common loon is a state sensitive species; they are reported to be rare in the LDW area (Canning et al. 1979). Three species of grebe have been reported in the LDW area. The Western Grebe is present in the Northwest region during the winter (Sibley 2003). Grebes and other marine bird species have been declining throughout the greater Puget Sound region in recent years (Nysewander et al. 2001).

2.8.4.2 Mammals

Three species of terrestrial mammals use the LDW (i.e., raccoons, muskrats, and river otters), and three marine mammal species may enter the LDW (i.e., harbor seal, California sea lion, and harbor porpoise) (Dexter et al. 1981; Tanner 1991; WDFW 1999).

Anecdotal information indicates that a river otter family lives year-round on Kellogg Island in the LDW, although otters have not been observed during wildlife surveys (Cordell et al. 2001). Raccoons are reported to be common along the forested ridge slopes to the west of the LDW. Muskrat populations are reported to exist at T-107 and the Upper Turning Basin (Canning et al. 1979).

Harbor seals and sea lions are commonly seen in Elliott Bay and have occasionally been observed in the LDW. During a survey conducted by WDFW from December 1998 to June 1999, sea lions were observed in the LDW on 16 occasions and seals on 17 occasions (WDFW 1999), with most observations of both species occurring below the 1st Avenue S Bridge. Harbor seals have been shown to forage over large distances ranging from 5 km (3.1 mi) (Stewart et al. 1989) to 55 km (34.2 mi) (Beach et al. 1985). Recent information on use of the LDW by harbor porpoises was not available, although it has been noted that they occasionally enter the LDW (Dexter et al. 1981).

2.8.5 Plants

Few studies have investigated the plant communities present in the LDW (Canning et al. 1979; Cordell et al. 2001; Tanner 1991; USFWS 2000a). The methods used to assess plant communities have ranged from analysis of aerial photos to field surveys. Most recently, Cordell et al. (2001) monitored the vegetation of wetland restoration and reference sites in the LDW by conducting surveys during the growing season at six restoration and six reference sites throughout the LDW from 1993 to 1999.

In the LDW, there is a total of 0.0175 km^2 (0.0068 mi^2) of habitat with estuarine macrophytes, primarily limited to portions of Kellogg Island and other small intertidal areas with vegetated intertidal habitat (USFWS 2000b, c). *Carex* (sedges) and *Scirpus* (bulrushes) are the predominant marsh vegetation types between the Upper Turning Basin and Kellogg Island. Downstream from Kellogg Island are more marine plants such as *Salicornia* (grassworts), *Distichlis* (salt grass), and *Atriplex* (salt bush). The interior high marsh plant community of Kellogg Island, which is flooded only by

higher spring tides, includes *Carex lyngbyei*, *Distichlis spicata*, *Juncus balticus* (Baltic rush), and *Phragmites* sp., a non-native species (Battelle et al. 2001). The naturally occurring *Carex* patches surveyed in 1993 occurred between elevations of 1.6 and 3.0 m (5.2 and 9.8 ft) above MLLW, and the single patch of naturally occurring *Scirpus* was at 3.7 m (12 ft) above MLLW, indicating that these plants are seldom underwater (Cordell et al. 2001).

2.8.6 Threatened and endangered species

Fifteen species identified in the LDW study area are listed under either the ESA or by WDFW, as candidate species, threatened species, or species of concern (see Table 2-12). Information on the presence and observed frequency of these species in the LDW area is provided in the ERA (Appendix A).

Table 2-12. LDW species listed under ESA or by the Washington State Department of Fish and Wildlife

COMMON NAME	SCIENTIFIC NAME	STATUS
Chinook salmon	*Oncorhynchus tshawytscha*	federal threatened species, state candidate species
Coho salmon	*Oncorhynchus kisutch*	federal candidate species
Puget Sound steelhead	*Oncorhynchus mykiss*	federal threatened species
River lamprey	*Lampetra ayresi*	federal species of concern, state candidate species
Bull trout	*Salvelinus confluentes*	federal threatened species, state candidate species
Pacific herring	*Clupea herengus pallasi*	federal candidate species, state candidate species
Pacific cod	*Gadus macrocephalus*	federal species of concern, state candidate species
Walleye pollock	*Theragra chalcogrammus*	federal candidate species, state candidate species
Rockfish species	*Sebastes* spp.	state candidate species
Bald eagle	*Haliaeetus leucocephalus*	federal threatened species,[a] state threatened species
Peregrine falcon	*Falco peregrinus*	federal species of concern, state sensitive species[b]
Merlin	*Falco columbarius*	state candidate species
Common murre	*Uria aalge*	state candidate species
Common loon	*Gavia immer*	state sensitive species
Western grebe	*Aechmophorus occidentalis*	state candidate species

Source: (WDFW 2007a)

Note: The Puget Sound southern resident orca distinct population segment is listed on both the federal and Washington State endangered species lists. Orca do not use the LDW but are occasionally present in Elliott Bay and may be exposed to chemicals from the LDW through the consumption of prey (such as chum salmon) that spend part of their time in the LDW.

[a] Listing currently under review for removal.

[b] Downlisted from state endangered to state sensitive on April 2002 (WDFW 2002).

ESA – Endangered Species Act

LDW – Lower Duwamish Waterway

2.9 HUMAN USE

This section provides a brief overview of the demography, land use, and site use in the LDW area.

2.9.1 Demography

Although the area surrounding the LDW is often regarded as an industrial corridor, residential neighborhoods (i.e., South Park and Georgetown) are present in the LDW area. The racial diversity of the residential population in the immediate vicinity of the LDW is greater than the racial diversity of residents within the City of Seattle overall or the nearby City of Tukwila (Table 2-13).

Table 2-13. Population data for Duwamish neighborhoods, City of Seattle, and City of Tukwila

RACE[a]	POPULATION		
	DUWAMISH NEIGHBORHOODS[b]	CITY OF SEATTLE[c]	CITY OF TUKWILA[d]
Caucasian	11,871 (53.5%)	394,889 (70.1%)	10,032 (58.3%)
African-American	2,143 (9.7%)	47,541 (8.4%)	2,310 (13.5%)
Native American and Alaska Native	397 (1.8%)	5,659 (1.0%)	196 (1.1%)
Asian	4,221 (19.0%)	73,910 (13.1%)	1,788 (10.5%)
Native Hawaiian and other Pacific Islander	333 (1.5%)	2,804 (0.5%)	332 (1.9%)
Other single race	1,868 (8.4%)	13,423 (2.4%)	1,348 (7.8%)
Two or more races	1,359 (6.1%)	25,148 (4.5%)	1,198 (6.9%)
Total	**22,192 (100%)**	**563,374 (100%)**	**17,204 (100%)**

Note: Percentage of total population is given in parentheses.

[a] The US Census Bureau does not consider Hispanic or Latino to be a race but rather an ethnicity (2001). Thus, individuals who identify themselves as being Hispanic or Latino may be of any race. As a result, the Hispanic/Latino population was not included in the total population or percentage calculations as a separate group. Approximately 3,039 people in the Duwamish neighborhoods, 29,719 people in the City of Seattle, and 2,353 people in the City of Tukwila identified themselves as being of Hispanic or Latino origin.

[b] Population estimates from Seattle LDW neighborhoods, including Tract 93, Duwamish/SODO; Tract 99, North Delridge; Tract 108, Riverview; Tract 109, Georgetown; Tract 112, South Park; and Tracts 113, 264, and 265, Highland Park (City of Seattle 2006).

[c] Data from Census 2000 (City of Seattle 2006).

[d] Data from Washington State Office of Financial Management (2002).

2.9.2 Land use and ownership

The LDW study area is part of WRIA 9 (Map 2-2). WRIA 9 extends from the headwaters of the Green River in the Cascade Mountains to the mouth of the Duwamish River at Elliott Bay. Map 2-12 presents current land ownership of properties adjacent to the LDW. Tables 2-14 and 2-15 provide information on land ownership and land use, respectively, within WRIA 9. Over 77% of the land in WRIA 9 is under private ownership, with approximately 8% owned by the federal government and 8% owned by the State of Washington. Approximately 6% of land in

WRIA 9 is owned by local jurisdictions, and a very small percentage of the river basin is owned by tribal entities.

Table 2-14. Land ownership in the Duwamish and Green River Basin (WRIA 9)

Owner	No. of Acres	Proportion
Federal	30,634	8.2%
State	29,512	8.0%
Local	23,980	6.4%
Tribal	319	0.1%
Private	287,911	77.3%
Total	**372,356**	**100.0%**

Source: Ecology (2006c)

Table 2-15. Land use in the Duwamish and Green River Basin (WRIA 9)

Land Use Category	Proportion
Forested	54%
Rangeland	5%
Agricultural	5%
Urban	18%
Barren	10%
Open water	8%
Total	**100.0%**

Source: Ecology (2006c)

Land use within the greater Duwamish drainage basin has changed considerably since the construction of Harbor Island and the LDW nearly 100 years ago. Table 2-16 identifies the changes in land use in the lower 11 miles of the Duwamish River watershed since that time.

Table 2-16. Historical and current land cover from RM 0.0 to RM 11.0

Land Cover Type	Historical Coverage (ac)	Current Coverage (ac)
Forested floodplain	3,385	51.9
Forest terrace	885	na
Shrub	na	27.2
Upland bedrock	72	na
Bare earth and mudflats	na	39.5
Herbaceous vegetation	1.5	157.9
Wetlands	3,252	51.4
Built/developed	0	6,315.9
Open water	699.8	766.5

Land Cover Type	Historical Coverage (ac)	Current Coverage (ac)
Lakes/ponds	12.4	0.5
Mainstream river channel	687.4	766

Source: King County (2005k)
ac – acres
na – not available
RM – river mile

The LDW shoreline is zoned predominantly for recreation, conservancy preservation, and urban industrial land use (ATSDR 2003). A small area on the west side of the LDW between RM 3.1 and RM 3.3 is zoned for single-family residential use (SPU 2007). A shoreline survey of the LDW was completed for the WRIA 9 Steering Committee and SPU in 2004 (Terralogic and Landau 2004). The survey assessed shoreline conditions from RM 6.0 to the northern tip of Harbor Island (including both the East and West Waterway shoreline), and survey results are presented in Table 2-17.

Table 2-17. Results of the shoreline survey conducted for the LDW and the East and West Waterways

Designation	% of Shoreline Surveyed	Total Miles
Shoreline/Bank Structures		
Shoreline armoring – bulkheads	31.93%	7.04
Shoreline armoring – riprap	56.05%	12.36
Concrete boat ramps	0.68%	0.15
Unarmored bank area	11.34%	2.50
Total	**100%**	**22.05**

Source: WRIA 9 Subcommittee and SPU (Terralogic and Landau 2004)
Note: The Lower Duwamish study area for the shoreline survey was defined as the LDW from RM 0.0 to RM 6.0 and the East and West Waterways to the northern tip of Harbor Island. Therefore, this study area includes more than the LDW Superfund site, which extends only to the southern tip of Harbor Island.
LDW – Lower Duwamish Waterway
RM – river mile

Over 85% of the shoreline in the surveyed area was armored (with either bulkheads or riprap). Just over 10% of the shoreline was not armored, and a very small portion (less than 1%) was covered by concrete boat ramps.

2.9.3 Site use

Approximately 43% of the Duwamish estuary subwatershed (extending from RM 11.0 to Elliott Bay [Map 2-2]) is used for commercial/industrial purposes, and approximately 39% is residential (King County 2005k).

2.9.3.1 Commercial and industrial site use

The LDW serves as a navigational corridor for the movement of raw materials and products used by local industries. Many of the industrial and commercial facilities on the LDW operate year-round. In 2005, the City of Seattle studied the industrial land zoning and usage in Seattle (City of Seattle 2005). This study identified 3,980 ac of industrial land surrounding the LDW, which equals approximately 77% of the land zoned for industrial use in Seattle. According to the study (City of Seattle 2005), the four types of zoning within the Duwamish industrial area are Industrial General 1 (IG1), Industrial General 2 (IG2), Industrial Buffer (IB), and Industrial Commercial (IC). IG1 (with 54% of the 3,980 ac) allows for the heaviest of manufacturing. IG2 (42%) is similar to IG1 but allows for more office and retail development. IB (3%) allows for light and general manufacturing and more office and retail development. IC (1%) allows for the most office development.

2.9.3.2 Tribal use

The LDW is frequently used by tribes as a resource and for cultural purposes. The Muckleshoot Indian Tribe and Suquamish Tribe are both federally recognized tribes and are natural resource trustees for the Duwamish River. The Muckleshoot Indian Tribe currently conducts seasonal commercial, ceremonial, and subsistence netfishing operations in the LDW. The Suquamish Tribe actively manages resources north (downstream) of the Spokane Street Bridge, located just north of the LDW.

Other tribal activities include the Duwamish Tribe's use of Herring's House Park to launch canoes and for various cultural events (Windward 2005j). The Duwamish Tribe also uses T-107 for monthly gatherings, children's dance group practices, and large annual cultural gatherings. The Duwamish Tribe has recently completed construction of a longhouse and cultural center near T-107 and Herring's House Park, which will likely increase their use of these two areas along the LDW.

2.9.3.3 Recreational site use

The LDW is not a major area for recreational use compared with other water bodies in and around the City of Seattle (King County 1999e). However, several public access points from which people may enter the LDW for recreational purposes exist. In the human access survey conducted along the LDW shoreline in 2005 (Windward 2005j), 93 commercial/industrial, residential, and public properties along the LDW were surveyed for human access and use potential. Of these 93 properties, 27 sites were identified as potential human access sites: 7 on the eastern shore of the LDW, 18 on the western shore, and 2 at the southern end of Harbor Island (see Map B.3-1). Most of these access points were on King County or City of Seattle public access grounds or located at the ends of streets. Many of the access points were elevated above the water surface and separated from the sediment by steep banks covered by riprap or blackberry bushes.

Street end parks and restoration sites such as Gateway Park, Herring's House Park, Duwamish River Park, and the Duwamish Diagonal Way access point provide easy access to the LDW shoreline and waterway (NOAA 2007b; DRCC and ECOSS 2008; Windward 2005j). Many of these access points serve as boat launches and sites for recreational activity on the LDW. In addition, residents living adjacent to the waterway have easy access to the LDW. Residents use the shore in front of their or their neighbors' property to launch boats or as a site for bird watching, swimming, walking, or picnicking (Windward 2005j). Public kayaking tours of the LDW are also offered on a regular basis by Alki Kayak Tours (2008).

Three marinas are located in the LDW study area. The human access survey (Windward 2005j) identified 17 additional locations used for the launching or pullout of hand-powered boats or motorboats. In addition, 8 sites along the LDW have been used for swimming, and 10 have been used for picnicking. The frequency of recreational activities at these sites may increase in the future as ongoing remedial efforts and habitat restoration projects are completed, but such activities are likely to remain limited as a result of the active industrial and commercial use of the LDW and the availability of other, nearby areas that provide superior recreational opportunities.

Fishing, crabbing, and shellfishing activities have been reported at 34 sites along the LDW shoreline, and individuals have also been observed fishing off the sides of barges moored in the LDW (Windward 2005j). The access survey (Windward 2005j) and a clam abundance survey (Windward 2004c) also discussed the potential for fishing and clamming activities to occur throughout the LDW study area (see Map B.3-2). However, the clam survey did not assess areas farther upstream than RM 3.5; the potential for clamming (and the relative abundance of clams) is currently unknown upstream of this point (Windward 2004c). Through treaty rights, tribal members have access to both public and private property and can harvest clams and other shellfish along the entire shoreline of the LDW (Windward 2007b). In addition, the navigable waters of the LDW are generally owned by the Port of Seattle, as successor to the King County Commercial Waterway District, and are accessible to the public by boat.

Several surveys have documented relatively high seafood consumption among several Asian and Pacific Islander (EPA 1999a) and Native American (Suquamish Tribe 2000; Toy et al. 1996) populations within the Puget Sound region, some of whom may fish within the LDW for recreational or subsistence purposes. A review of seafood consumption surveys for the Elliott Bay/Duwamish and larger Puget Sound area was conducted by ESG (1999). The review indicated that the potentially exposed population of fish consumers in the LDW study area consists of a diverse group of people that fish both from shore and boat. In 1997, a fishing survey was also completed by King County (1999c). This intensive survey was conducted for 2 months in the summer of 1997, the period of highest use, and showed that use in the LDW was significantly lower than in other Puget Sound sites. However, people fish seasonally for salmon in the LDW, and a relatively high number of individuals fished/crabbed from the Spokane Street Bridge, just north of the LDW. Specifically, seafood has been harvested from T-105 within the

LDW and from the Spokane Street Bridge just north of the LDW adjacent to Harbor Island. Seafood consumption rates are discussed in greater detail in the baseline HHRA (Appendix B).

The Washington State Department of Health (WSDOH) issued a seafood consumption advisory for the LDW in July 2002, recommending that people limit their consumption of resident fish and shellfish from the LDW. In 2005, WSDOH updated the advisory with the recommendation that no resident fish or shellfish be consumed from the LDW (WSDOH 2005), and this advisory is still in effect. WDFW is responsible for educating anglers and others who harvest seafood from the LDW of the advisory; however, WDFW does not enforce the advisory with citations or penalties (Windward 2007b). WSDOH and Public Health – Seattle & King County also recommend that resident fish and shellfish from any urban shorelines along Elliott Bay should not be consumed; commercial shellfish harvesting is restricted because of high counts of fecal coliform bacteria (King County 1999d; WSDOH 2008a).

2.9.3.4 Residential site use

Two mixed residential/commercial neighborhoods are located adjacent to the LDW (see Appendix B, Map B.1-1). The South Park neighborhood, within and adjacent to the southern edge of the Seattle city limit, borders the west bank of the LDW and encompasses approximately 300 m (984 ft) of residential shoreline (Green-Duwamish Watershed Alliance 1998). The Georgetown neighborhood, located east of the LDW and E Marginal Way S, is separated from the LDW by several commercial facilities, although access to the LDW by foot from this neighborhood is possible. Based on data from the 2000 census, the combined residential population of the South Park and Georgetown neighborhoods is 4,900 (US Census Bureau 2002; ATSDR 2003). During the 15 years prior to 2003, the population of the Georgetown neighborhood decreased slightly, while the population of the South Park neighborhood increased by over 30% (ATSDR 2003).

2.9.3.5 Restoration activities

At least 12 habitat restoration projects are ongoing along the LDW, with several more planned for the near future (Windward 2005j; NOAA 2007a; EPA 2006e; WRIA 9 Steering Committee 2002). These activities include efforts to restore salmon habitat and efforts to develop street end parks and improve recreational access. Restoration efforts are expected to continue over time. Examples of restoration projects that include human use or public access components along the waterway include Herring's House Park, T-107, T-105, three sites on the southwest side of the Upper Turning Basin, including the Coastal America restoration site, the Diagonal Avenue S/T-108 public shoreline access area, Cecil B. Moses Park, and the 8th Avenue S street end park/Gateway North restoration area (DRCC and ECOSS 2008). Map 2-8 provides the locations of these restoration areas and street end parks. Map 2-8 also provides the locations of restoration areas that do not include human use or public access.

2.10 SUMMARY

The LDW study area consists of the downstream portion of the Duwamish River, excluding the East and West Waterways. The LDW is a well-stratified estuary that has been extensively modified over the last 100 years.

The LDW serves as a major shipping route for bulk and containerized cargo, and the shoreline along the majority of the LDW has been developed for industrial and commercial operations. Common shoreline features include constructed bulkheads, piers, wharves, sheet piling walls, buildings that extend over the water, and steeply sloped banks armored with riprap or other fill material.

To facilitate navigation and economic development, the LDW was straightened and has been frequently dredged in many areas. The excavated material was used to fill the old channel areas and the lowlands to bring them above flood levels. Subsequent filling of the lowlands for continued development resulted in a surficial layer of fill over most of the lower Duwamish Valley. Most of the upland areas adjacent to the LDW have been heavily industrialized for many decades.

Throughout the 1900s, the watershed area and flow volumes to the Duwamish River were reduced by about 70% as a result of the diversion of the river's tributaries. Today, the Green River is the primary source of water for the Duwamish River. Surface water runoff within the LDW area also contributes to flow within the LDW, from sources such as SDs, tributary creeks, CSOs, and non-point inputs; these sources are expected to be less than 1% of the total discharge, even during peak flow events. Annual average downstream flow for the Duwamish River, measured at the Auburn gaging station, ranged from 4.3 to 329 m^3/s (152 to 11,600 cfs [the record high]) between 1962 and 2004.

Water circulation within the LDW is driven by tidal actions and river flow. Fresher water moving downstream overlies the tidally influenced saltwater entering the system. Typical of tidally influenced estuaries, the LDW has a relatively sharp interface between the low-salinity water outflow at the surface and saltwater inflow at depth.

Tidal action in the LDW greatly affects groundwater flow direction, flow rate, and overall water quality. Under typical conditions, the hydraulic gradient is toward the LDW. At low tide, the hydraulic gradient between the groundwater system and the LDW is typically at its highest, causing the flow of local groundwater into the LDW. At high tide, the hydraulic gradient can reverse. Tidal action causes a continuous oscillation of groundwater within the effective zone of influence. The periodic reversal in flow direction caused by tidal influences can decrease the migration of dissolved chemicals in groundwater.

Sediment composition varies greatly throughout the LDW, ranging from sands to mud (fine-grained silt and clays), depending on the source of the sediments and the local current velocity. Sediments in the navigation channel near the Upper Turning Basin are predominantly sands, whereas sediments toward the mouth of the river are predominantly fine-grained silts.

Ecological habitats of the LDW have been modified extensively since the late 1800s through hydraulic changes, channel dredging, the filling of surrounding floodplains, and the construction of overwater structures, levees, dikes, and other bank stabilization structures. The remnants of natural meanders along the LDW, several of which are now used as slips, and the area west of Kellogg Island are the only evidence of the river's original winding course. Small intertidal areas of marsh and unvegetated marsh habitat in the LDW have become the focus of habitat restoration activities.

Benthic invertebrate communities observed in the LDW consisted of 670 taxa, representing 178 families in 13 phyla. Typical of estuarine environments, the benthic invertebrate community was dominated by annelid worms, mollusks, and crustaceans. The most abundant large epibenthic invertebrates are crabs and shrimp. Based on SPI information, 10 cm is an appropriate estimate of the BAZ in the LDW. The LDW is inhabited by numerous anadromous and resident fish species. Fifty-three resident and non-resident fish species were captured in the LDW during sampling events conducted for the RI. The aquatic and semi-aquatic habitats of the LDW support a diversity of wildlife species. Formal studies, field observations, and anecdotal reports indicate that up to 87 species of birds and 6 species of mammals use the LDW at least part of the year to feed, rest, or reproduce (i.e., raccoons, muskrats, and river otters, harbor seal, California sea lion, and harbor porpoise). Fifteen species identified in the LDW study area are listed under either the ESA or by WDFW, as candidate species, threatened species, or species of concern (see Table 2-12).

Approximately 43% of the Duwamish estuary subwatershed is used for commercial/ industrial purposes, and approximately 39% is residential. Two residential neighborhoods, South Park and Georgetown, are located adjacent to the LDW. The Muckleshoot Tribe currently conducts seasonal commercial, ceremonial, and subsistence netfishing operations on the LDW, which is part of their U&A fishing grounds; and the Suquamish Tribe actively manages resources that depend on the LDW for at least part of their life cycle, north (downstream) of the Spokane Street Bridge, located just north of the LDW. The Duwamish Tribe also uses several areas for gatherings and cultural events.

The LDW is not a major area for recreational use compared with other water bodies in and around Seattle. However, several public access points from which people may enter the LDW for recreational purposes exist. Although recreational use may increase at some point in the future, this area is anticipated to remain primarily commercial, industrial, and residential in use.

In 2005, WSDOH recommended that no resident fish or shellfish be consumed from the LDW (WSDOH 2005); this advisory is still in effect.

3 Sediment Dynamics

The Phase 1 RI (Windward 2003a) summarized existing information on sediment dynamics in the LDW and yielded a basic understanding of the stability of bedded sediments and sediment transport in the system, which was used to develop a preliminary conceptual site model (CSM). This CSM was considered to be preliminary because sufficient site-specific information and data were not available during the Phase 1 RI to confirm it. Based on the data available at the time of the Phase 1 RI, the preliminary CSM postulated:

- The LDW is net depositional[23] on a site-wide scale.
- On a local scale, the sediment bed is either aggrading (i.e., sediment bed elevation is increasing as a result of sediment deposition) or in dynamic equilibrium[24] (i.e., sediment bed elevation is neither increasing nor decreasing).
- Bed erosion occurs only episodically and over small spatial scales.

As described in the Phase 2 work plan (Windward 2004h) and the sediment transport data report (Windward and QEA 2005), additional data were collected in 2004 and 2005, consistent with EPA (2005b) guidance, to support development of a concise description of LDW sediment transport processes that affect sediment stability in the system and to refine the Phase 1 CSM. These additional data and supporting analyses are summarized in Section 3.1 and presented in detail in the sediment transport analysis report (STAR) (Windward and QEA 2008).

Based on information presented in the STAR (Windward and QEA 2008), LDWG, EPA, and Ecology concluded that additional sediment transport modeling (STM) was warranted because some of the key questions about sediment dynamics could not be satisfactorily answered by the empirical approach described in Section 3.1. This modeling has been completed and is summarized in Section 3.2 and presented in detail in the STM report (QEA 2008).

The analyses conducted during the STM, in conjunction with empirical and ship-induced bed scour analyses from the STAR, have resulted in an improved

[23] The term net depositional refers to a condition in which a portion of the sediment bed, or a reach of the river or waterway, experiences more deposition (i.e., settling of sediment from the water column onto the bed) than erosion (i.e., scour from the bed to the water column) over periods of about 1 year or longer (i.e., annual time scales). The net sedimentation rate is the rate at which net deposition occurs.

[24] The term dynamic equilibrium refers to a condition in which the sediment bed is neither net erosional nor net depositional, with minimal changes in bed elevation occurring over annual time scales. The bed may experience episodic erosion as a result of high-flow events or ship-induced bed scour, or net deposition over short time scales.

understanding of sediment transport processes in the LDW. Results and findings from the major components of these analyses were integrated and synthesized to produce a clear and concise picture of sediment transport over the scale of the entire LDW, as summarized in Section 3.3. This information was also used to update the CSM, as summarized in Section 3.4, and will be used in conjunction with site-specific characteristics (e.g., berthing areas, presence of outfalls) to assess the effectiveness of various remedial alternatives in the FS.

3.1 EVALUATION OF SEDIMENT DYNAMICS

Several types of empirical data were evaluated in the STAR (Windward and QEA 2008) to assess sediment dynamics using a weight-of-evidence approach. Those data are discussed in the sections that follow:

- Sediment physical properties (e.g., sediment particle size) (Section 3.1.1)
- Sediment cores used for age dating (Section 3.1.2)
- Bathymetry (Section 3.1.3)
- Physical and chemical markers in sediment cores for estimating net sedimentation rates (Section 3.1.4)
- Sediment cores used to evaluate erosion properties (Section 3.1.5)

The sediment cores discussed in Sections 3.1.2 and 3.1.5 were collected specifically for the evaluation of sediment dynamics in the RI; the data described in the other sections were collected for other purposes. These data were used in modeling analyses that are described in Sections 3.1.6 (hydrodynamic model) and 3.1.7 (ship-induced bed scour model). These modeling analyses are not the same as the STM application discussed in Section 3.2.

3.1.1 Sediment physical properties

The physical characteristics of bedded sediment affect sediment transport processes that occur in a given area. A large amount of historical data exists on the physical properties of sediment in the LDW (i.e., sediment particle size, TOC). Additional physical property data were derived from the sediment cores collected as part of the STAR (Windward and QEA 2008).

In the STAR (Windward and QEA 2008), historical surface sediment particle size data, which were available from approximately 1,250 locations sampled since 1990, were evaluated for spatial trends. The data were variable in the bench areas and navigation channel, with no apparent spatial structure (e.g., downstream fining). Sediment in the navigation channel had a higher silt+clay content than did other sediment, with an average silt+clay content of 62% (10^{th} and 90^{th} percentiles were 29 and 82%, respectively). Silt+clay content was more variable outside of the navigation channel, including the Upper Turning Basin, with 10^{th} and 90^{th} percentiles of 13 and 87%,

respectively, and an average value of 53%. The area above RM 5.0 had a relatively low average silt+clay content (approximately 11.5%).

Additional sediment particle size data were collected in December 2004 as part of the STAR (Windward and QEA 2008). These data were generated using a laser particle size counter, in contrast to the sieve and pipette method used to generate the historical data. The laser particle size counter generates an almost continuous particle size distribution, using approximately 100 different particle size categories, rather than the 15 particle size categories generated from the sieve and pipette method. Consequently, the data from the 19 sediment cores collected in December 2004 are discussed separately from the historical data because different summary statistics can be generated from the much larger number of particle size categories.

The particle size distributions in the top 5 cm of the Sedflume[25] cores collected at 19 locations in the LDW (Map 3-1) are summarized in Table 3-1. Eighteen cores were classified as sandy silt, and one core (Sf-5) was classified as silty sand (Windward and QEA 2005, 2006). A statistical analysis of the 18 sandy silt cores indicated that the median particle diameter (D_{50}) averaged 30 μm, and the clay, silt, and sand contents averaged 6%, 69%, and 28%, respectively (Table 3-1). In general, variability in particle size in these cores was relatively low. For example, about 90% of the D_{50} values for individual samples varied between 10 and 50 μm (silt). The single core classified as silty sand (Sf-5) had a D_{50} of 329 μm and a sand content of 79%.

Table 3-1. Particle size data for surface layer (0 to 5 cm) of Sedflume cores

Sediment Core ID	D_{10} (μm)[a]	D_{50} (μm)[a]	D_{90} (μm)[a]	Clay Content (%)	Silt Content (%)	Sand Content (%)
Sf-1	2	12	60	9	82	9
Sf-2	3	24	115	6	72	22
Sf-3	3	19	117	7	75	18
Sf-4	3	19	223	7	71	22
Sf-5	11	329	739	2	19	79
Sf-6-R1	3	21	122	7	73	20
Sf-6-R2	4	39	184	5	60	35
Sf-7	4	41	1,112	5	55	40
Sf-8	3	28	235	6	68	26
Sf-9	5	79	402	4	43	53
Sf-10	3	23	89	6	78	16
Sf-11	4	94	653	5	41	54

[25] The particle size data discussed in this section were collected as supporting data from cores tested in a device called a Sedflume, which was used to measure gross erosion rates over a range of shear stresses, as discussed in greater detail in Section 3.1.5.

Sediment Core ID	D_{10} (µm)[a]	D_{50} (µm)[a]	D_{90} (µm)[a]	Clay Content (%)	Silt Content (%)	Sand Content (%)
Sf-12	4	24	139	5	73	22
Sf-13	3	21	97	7	76	17
Sf-14	3	22	161	7	70	23
Sf-15	2	16	73	8	81	11
Sf-16-R1	3	20	93	7	76	17
Sf-16-R2	2	18	82	8	78	14
Sf-17	3	19	88	7	78	15
Average[b]	3	30	225	6	69	25
Standard deviation[b]	0.8	22	265	1.3	12	13
95% confidence interval[b]	2 – 4	19 – 41	93 – 357	5 – 7	63 – 75	17 – 31
Minimum[b]	2	12	60	4	43	9
Maximum[b]	5	94	112	9	82	54

Source: Windward and QEA (2005, 2006)

[a] D_{10}, D_{50}, and D_{90} values are the 10th, 50th (median), and 90th percentiles of the particle diameter data for that core.

[b] Statistics exclude data for Sf-5, which was classified as silty sand; the other 18 cores were classified as sandy silt.

ID – identification

In general, the 18 sandy silt cores had more silt and less sand than surface sediment samples contained in the surface sediment dataset, which averaged approximately 41% silt and 41% sand. These differences reflect one of the specific objectives of the Sedflume data collection, which was to target bench areas expected to be depositional. The LDW-wide surface sediment grain size dataset is much more comprehensive and larger than the Sedflume dataset and reflects many different types of sediments in the LDW.

Wet density data do not exist in the historical baseline surface sediment dataset, but this parameter was analyzed in the Sedflume cores. Wet densities of the 18 sandy silt cores (excluding Sf-5) ranged from about 1.2 to 1.7 g/cm^3. The single silty sand core (Sf-5) had a higher wet density (1.8 to 1.9 g/cm^3). In general, wet density increased with depth within a core because of consolidation effects. Similar to the particle size distributions, wet densities in the Sedflume cores were relatively uniform throughout the LDW for a given depth. A correlation analysis was conducted between wet density and particle size. The analysis indicated that minimal correlation existed between these two bulk bed properties for the 18 sandy silt cores. For example, the correlation coefficient (r) between wet density and D_{50} values for the 18 sandy silt cores was 0.42.

TOC content has been analyzed in over 1,300 surface sediment samples collected throughout the LDW since 1990. In general, TOC content in surface sediment did not vary widely. Outside the navigation channel, the 10th and 90th percentiles were 0.80 and 2.9%, respectively. The TOC content in the navigation channel was less variable

than the TOC content outside the navigation channel, with 10th and 90th percentiles of 1.2 and 2.6%, respectively. The average TOC content (1.9%) was the same within and outside the navigation channel. The area above RM 5.0 had a lower average TOC content (0.84%).

3.1.2 Geochronology analysis

To facilitate a better understanding of how net sedimentation rates in bench areas compared with rates previously estimated for the navigation channel, a geochronology study was conducted as part of the STAR (Windward and QEA 2008). This study consisted of an age-dating analysis of sediment cores collected from the LDW in December 2004 using the radioisotopes cesium-137 (^{137}Cs) and lead-210 (^{210}Pb).

Fourteen sediment cores were collected from bench areas within the LDW in 2005 (Map 3-2). Each core was segmented in 1-cm intervals, and every fifth segment within the top 81 cm (i.e., 0 to 1 cm, 5 to 6 cm, etc., to 80 to 81 cm) was submitted for ^{137}Cs, ^{210}Pb, TOC, and total solids content analyses; remaining segments were archived. After the initial results were reviewed, additional intervals, some as deep as 111 cm, were analyzed in four cores (Sg-3, Sg-6, Sg-7, and Sg-13) in an attempt to detect a ^{137}Cs peak at a depth greater than 81 cm.

Estimated net sedimentation rates based on the geochronology analysis are presented in Table 3-2. A detailed explanation of the calculation methods is provided in Windward and QEA (2008). Direct comparisons of the net sedimentation rates generated from the two different radioisotopes were possible for four cores: Sg-2, Sg-5a, Sg-7, and Sg-10. For two of the four cores (Sg-2 and Sg-5a), the ^{137}Cs net sedimentation rate fell within the range of the ^{210}Pb net sedimentation rate. In the other two cores (Sg-7 and Sg-10), net sedimentation rates determined from the ^{210}Pb data were lower than those estimated using the ^{137}Cs data. The fact that sedimentation rates could not be estimated for some cores suggests the possibility of localized disturbances.

Table 3-2. Comparison of net sedimentation rates from ^{137}Cs and ^{210}Pb analyses

Sediment Core ID	Mud Line Elevation (ft MLLW)	Range of Estimated Net Sedimentation Rates from ^{137}Cs Analysis (cm/yr)		Range of Estimated Net Sedimentation Rates from ^{210}Pb Analysis (cm/yr)
		Via ^{137}Cs Peak	Via First Presence of Detectable ^{137}Cs	
Sg-1a	-17.7	0.9 – 1.1	1.2 – 1.3	ne
Sg-2	-3.5	ne	0.5 – 0.6	0.4 – 1.1
Sg-3	-21.4	1.9 – 2.1	nd	ne
Sg-4	-12.8	1.6 – 2.0	nd	ne
Sg-5a[a]	-16.5	1.4 – 1.6	nd	0.7 – 9.3
Sg-6	-17.9	2.5 – 2.7	nd	ne

Sediment Core ID	Mud Line Elevation (ft MLLW)	Range of Estimated Net Sedimentation Rates from ^{137}Cs Analysis (cm/yr)		Range of Estimated Net Sedimentation Rates from ^{210}Pb Analysis (cm/yr)
		Via ^{137}Cs Peak	Via First Presence of Detectable ^{137}Cs	
Sg-7[a]	-16.1	1.9 – 2.1	nd	0.5 – 1.1
Sg-8	-10.3	ne	ne	ne
Sg-9	+0.4	0.3 – 0.5	0.8 – 0.9	ne
Sg-10	-11.0	1.6 – 1.8	nd	0.2 – 1.0
Sg-11c	-1.3	ne	ne	ne
Sg-11b	+0.6	ne	0.6 – 0.7	ne
Sg-12	-11.1	> 2.0	nd	ne
Sg-13	-8.3	2.3 – 2.6	nd	ne

[a] These cores were located relatively close to maintenance dredging areas in the 1990s. Consequently, the uncertainty surrounding the estimated net sedimentation rates for these cores is greater than the uncertainty surrounding estimated net sedimentation rates for cores not located near historical dredged areas.

Cs – cesium
ID – identification
MLLW – mean lower low water
nd – not detected
ne – not estimated
Pb – lead
yr – year

Net sedimentation rates in the bench areas were estimated to range from 0.2 to > 2.0 cm/yr. In general, net sedimentation rates were greater than 1 cm/year in the subtidal bench areas and less than 1 cm/year in the intertidal areas. Thus, net sedimentation rates in the subtidal bench and intertidal areas were lower than those previously estimated for the LDW navigation channel (i.e., 1 to 15 cm/year between RM 0.0 and RM 1.7, 10 to 25 cm/year between RM 1.7 and RM 3.4, and 20 to 110 cm/year between RM 3.4 and RM 4.7) (Windward 2003a). No other consistent spatial trend was apparent in the estimated net sedimentation rates calculated from radioisotope age-dating methods, likely because the data were too sparse to develop spatial relationships.

Several physical, chemical, and biological factors introduce uncertainty into the net sedimentation rates estimated from the radioisotope profiles. These factors include: 1) natural variability in the radioisotope data, 2) variations in sediment physical characteristics, 3) physical disturbances of the sediments (e.g., erosion, historical dredging), 4) compression and/or mixing of sediments during core collection/extrusion, and 5) poor sediment recovery rates in core samples. The first three factors are likely the greatest contributors to uncertainty in net sedimentation rates estimated during the geochronology study, primarily because of uncertainty in the extent and magnitude to which these factors vary in the LDW.

The geochronology analysis was one of two independent empirical lines of evidence used to derive net sedimentation rate data, the other being an analysis of multiple time markers in subsurface sediment cores (see Section 3.1.4). Because estimates based on time markers were available for many locations, the uncertainties discussed above for

the geochronology analysis do not greatly affect the LDW-wide interpretation of net sedimentation characteristics. Consequently, the net sedimentation rate was selected as the model calibration target, as described in Section 3.2.3.

3.1.3 Bathymetric analysis

The results of bathymetric surveys conducted in different years were also compared in the STAR (Windward and QEA 2008) to evaluate sediment dynamics. Sediment bed (i.e., mud line) elevations at specific locations were compared to identify areas of potential scour or deposition. A similar analysis was conducted for the Phase 1 RI (Windward 2003a), but additional bathymetric data had been collected since that time.

The bathymetric analysis conducted for the STAR consisted of a comparison of two existing bathymetric datasets collected from a portion of the LDW (between RM 2.6 and RM 4.7) in 2000 and from the entire LDW in 2003, resulting in a qualitative assessment of potential scour and depositional areas. Sediment surface elevations in 2000 were defined using a combination of bathymetric measurements from surveys conducted for USACE[26] and Boeing (Pentec et al. 2001). Sediment surface elevations in 2003 were defined using the acoustic multi-beam bathymetric data collected by David Evans and Associates (Windward and DEA 2004). Because of the higher density of measurements in 2003 (relative to 2000), each measurement from 2000 was paired with the nearest measurement from 2003 and a change in sediment elevation at each paired location was computed. The maximum distance allowed between pairs was 10 ft. Approximately 49,000 paired locations were evaluated. Linear interpolation was performed between measurement locations to estimate areas of scour and deposition. The largest differences measured (approximately 3 ft) represent potential scour (i.e., more recent measurements up to 3 ft lower than older measurements), deposition (i.e., more recent measurements up to 3 ft higher than older measurements), or a combination of both.

There were several uncertainties associated with positioning and measurement accuracy for the bathymetric surveys (Windward 2003a). The imprecision associated with these uncertainties has the greatest potential effect on estimates for the steep sloped areas of the LDW or at the outermost limits of the survey transects. These uncertainties are further compounded by the fact that the three surveys were performed by different contractors, using different equipment and different methods. Moreover, sediment elevation measurements from the USACE and Boeing surveys in 2000, which were used to define year 2000 conditions in the LDW, were collected along transects spaced at approximately 200-ft intervals, making it difficult to find matching points in the 2003 survey. Based on the uncertainties summarized above, any change in elevation less than 12 in. (30 cm) at a particular point was not considered significant.

[26] Bathymetry charts as contained in USACE file number E-12-2.1-12.3, dated September 15, 2000.

Measurement inaccuracies and other uncertainties described above made it difficult to make reliable conclusions regarding fine-scale sediment transport based on this analysis. Nonetheless, very small areas of scour and deposition in excess of 12 in. (30 cm) were noted in these comparisons. However, most of these areas were located immediately adjacent to the navigation channel (which has been routinely dredged), in the Upper Turning Basin, or at the outermost limits of the survey data; these areas are likely associated with measurement inaccuracies that are in excess of the criterion used in this analysis (i.e., 12 in. [30 cm]).

3.1.4 Additional analysis of net sedimentation rates

In the STAR (Windward and QEA 2008), net sedimentation rates were estimated from the geochronology cores, as described in Section 3.1.2, and evaluated along with several independent chemical and physical lines of evidence including historical information and sediment chemistry cores collected in 2006. The purpose of these additional analyses was to estimate net sedimentation rates for areas other than those where geochronology cores were collected and to validate the net sedimentation rates calculated from the geochronology study.

The site data used in the additional analyses included chemistry and stratigraphy data from 56 subsurface sediment cores collected in 2006 and from historical subsurface sediment cores; grain size distribution data; dredging records; chemical spill, industrial, and regional discharge records; and bathymetric data. These data provided a set of time markers that were found at different depths in the sediment bed at various locations in the LDW. After assigning a date or time period and specific depth for a particular marker, the net sedimentation rate was estimated from that marker. This estimate represented the average rate of net deposition for the time period between the time marker and core collection.

Nine different physical and chemical time markers were evaluated, although not all markers could be evaluated for a given core (Table 3-3). The conclusion of this time marker analysis was that net sedimentation rates were spatially variable, with the highest rates in the navigation channel (greater than 2 cm/yr), moderate rates in the subtidal bench areas (less than 2 cm/yr), and the lowest rates in the intertidal bench areas (less than 0.5 cm/yr). These results are generalized trends; there are several specific net sedimentation rate estimates greater than 2 cm/year outside of the navigation channel, as shown on Map 3-3. Net sedimentation rates were not calculated for the Duwamish/Diagonal, Slip 4, Boeing Plant 2/Jorgensen Forge, and Terminal 117 (T-117) EAAs because those areas are being evaluated separately by parties responsible for those removal actions. Net sedimentation rates calculated by the STM, in conjunction with other lines of evidence (e.g., empirical data), will be incorporated into the natural recovery analyses, which could potentially include the EAAs, to be conducted in the FS.

There are some uncertainties associated with the analysis of physical and chemical time markers, and the estimated net sedimentation rates may be underestimated or overestimated as a result of the following factors:

- Other, unaccounted-for physical events or disturbances
- Differences between measured and in situ core depths
- Variability in net sedimentation rates estimated among different time markers in the same core
- Lag time associated with the chemical or physical age dates
- Lack of spatial coverage in some areas

Additional details on how each marker was evaluated are provided in Attachment F of the STAR (Windward and QEA 2008), which was prepared by RETEC (now AECOM).

Although geochronology cores, as summarized in Section 3.1.2, were not co-located with the sediment cores for which the empirical sedimentation rates were estimated, the geochronology-based estimates generally agreed with the rates estimated from the physical and chemical markers, particularly at locations where the two core locations were close together. Because of the consistency in the findings of the analysis of geochronology cores and the evaluation of other empirical lines of evidence, it was possible to combine the net sedimentation rates estimated from the two methods to develop a large-scale view of LDW net sedimentation, including a map showing the spatial distribution of estimated net sedimentation rates in the LDW (Map 3-3). This map depicts five categories of net sedimentation rates: < 0.5 cm/yr, 0.5 to 1.0 cm/yr, 1.0 to 1.5 cm/yr, 1.5 to 2.0 cm/yr, and > 2.0 cm/year (the specific rate estimates for each core are also provided). Results of the analysis provided a consistent picture of large-scale net sedimentation processes in the LDW.

Table 3-3. Net sedimentation rates in the LDW estimated from physical and chemical time markers

Subsurface Core ID	Approx. River Mile	Estimated Net Sedimentation Rates (cm/yr) Determined from Time Markers and Event Horizons[a]								
		Physical[b]			Chemical (1-ft, 2-ft Intervals)			Chemical (6-in. Intervals) from a Subset of 2006 Cores		
		Lower (Native) Alluvium[c]	Hanson Dam Const.[d]	Dredge Horizon[e]	Lead/ PCB/ Phthalate Introduction	PCB Peak Usage/ Spill	Source Control Efforts	PCB Introduction	PCB Peak Usage/ Spill	Source Control Efforts
		1916	1961	Variable	1920/1935/ 1950	1960/1974	1980	1935	1960/1974	1980
RI 2006 Cores										
SC-1	0.0	0.9			1.7			1.1	0.9	0.9
SC-2	**0.1**									
SC-3	0.1	0.4								
SC-4	0.2	1.1			1.7		1.2			
SC-5	0.2	0.7	0.5		0.5, 0.9					
SC-6	0.3	2.6	3.0		2.3		2.3	2.6	2.3	2.7
SC-7	0.3				0.7					
SC-8	0.4					3.3	1.2			
SC-9	0.5		1.8	1.5						
SC-10	0.5	2.4	2.7	2.4		2.9				
SC-11	0.5		0.5		0.4					
SC-12	0.6	2.3	1.8		2.9	2.0	2.3, 1.2	2.6	2.0	2.1
SC-13	0.9				1.1			1.1 to 2.1		
SC-14	0.9	2.9			4.0					
SC-15	0.9	2.5	1.4		3.0	4.8				
SC-16	0.9	2.4			3.8	2.9	2.3, 1.2			
SC-17	1.0					2.9				
SC-18	1.0	1.9		1.5, 1.9	0.7, 0.9, 1.1					
SC-19	1.0	3.0	4.7		3.4	4.3				
SC-20	**1.0**									
SC-21	1.0	3.3	3.4		2.7	4.9	2.3			
SC-22	**1.1**									

Table 3-3, cont. Net sedimentation rates in the LDW estimated from physical and chemical time markers

Subsurface Core ID	Approx. River Mile	Estimated Net Sedimentation Rates (cm/yr) Determined from Time Markers and Event Horizons[a]								
		Physical[b]			Chemical (1-ft, 2-ft Intervals)			Chemical (6-in. Intervals) from a Subset of 2006 Cores		
		Lower (Native) Alluvium[c]	Hanson Dam Const.[d]	Dredge Horizon[e]	Lead/ PCB/ Phthalate Introduction	PCB Peak Usage/ Spill	Source Control Efforts	PCB Introduction	PCB Peak Usage/ Spill	Source Control Efforts
		1916	1961	Variable	1920/1935/ 1950	1960/1974	1980	1935	1960/1974	1980
SC-23	1.3		3.3		4.3	4.8	4.7	3.4	4.8	3.3
SC-24	1.2	1.1	0.7		0.7, 0.9					
SC-25	1.3	2.0 to 2.5			2.5, 3.0		1.2			
SC-26	**1.4**									
SC-27	1.4	1.5 to 2.6						1.4	1.2	0.9
SC-28	**1.4**									
SC-29	1.4	0.6	0.4							
SC-30	1.6	1.1								
SC-31	1.7			12.2	1.0, 1.2, 1.5					
SC-32	1.7	1.7 to 2.4	1.9		2.0, 2.5					
SC-33	1.9	2.9			3.0, 3.8			2.6	0.8 to 1.7	0.9, 1.4
SC-34	1.9		2.2							
SC-35	2.0		3.5	2.8, 3.7						
SC-36	2.1	2.8	2.2							
SC-37	2.1	1.8	1.8		2.0, 2.6	1.0	2.3			
SC-38	**2.1**									
SC-39	2.2	2.9								
SC-40	2.2	0.7								
SC-41	2.4	2.6								
SC-42	2.5		2.7							
SC-43	2.6	3.0	0.5							
SC-44	2.7				1.4, 1.1			1.3	0.5	0.3
SC-45	**2.8**									
SC-46	2.7	2.3		7.6, 1.8						

Table 3-3, cont. Net sedimentation rates in the LDW estimated from physical and chemical time markers

Subsurface Core ID	Approx. River Mile	Estimated Net Sedimentation Rates (cm/yr) Determined from Time Markers and Event Horizons[a]								
		Physical[b]			Chemical (1-ft, 2-ft Intervals)			Chemical (6-in. Intervals) from a Subset of 2006 Cores		
		Lower (Native) Alluvium[c]	Hanson Dam Const.[d]	Dredge Horizon[e]	Lead/ PCB/ Phthalate Introduction	PCB Peak Usage/ Spill	Source Control Efforts	PCB Introduction	PCB Peak Usage/ Spill	Source Control Efforts
		1916	1961	Variable	1920/1935/ 1950	1960/1974	1980	1935	1960/1974	1980
SC-47	3.1	1.0			1.3, 1.4, 2.2	1.0	1.2			
SC-48	3.3				0.4 to 0.5					
SC-49	3.5		2.4		4.3					
SC-50	3.8	0.9			1.0, 1.2, 1.5					
SC-51	3.8									0.6
SC-52	3.9				0.5, 0.7, 0.9					
SC-53	4.2	3.1	3.3							
SC-54	4.3	1.8	2.7							
SC-55	4.9	1.0	0.3							
SC-56	4.7				0.8 to 1.0					
Historical Cores										
B3 (T105 1985)	0.2	4.9	5.1							
DUD006 (D/D 1994)	0.5					1.9, 3.1	2.7			
DR18 (PSDDA99)	1.8	2.2	3.2							
DR39 (PSDDA99)	2.2	1.5								
SC11 (Slip 4 2004)	2.8	1.5	2.2							
S3 (PSDDA98)	3.8	3.0	3.3							
HI-NR-01	< 0						1.4			
HI-NR-02	< 0						1.3			
HI-NR-03	< 0						2.5			
HI-NR-04	< 0						1.3			

Source: Analysis conducted by RETEC (now AECOM), as reported in Windward and QEA (2008), Appendix F.

Notes: See subsurface data report (Windward and RETEC 2007) for core logs. Ranges or multiple estimates are given in some table cells where chemical markers for different chemicals could be observed.

[a] All net sedimentation rate estimates are based on recovered core depths and do not include uncertainty.

Table 3-3, cont. Net sedimentation rates in the LDW estimated from physical and chemical time markers

[b] Sediments were grouped into three stratigraphic units identified for the LDW, primarily based on density, color, sediment type, texture, and marker bed horizons. The three sediment stratigraphy units were identified as follows: Recent, Upper Alluvium, Lower (Native) Alluvium.

[c] Lower (Native) Alluvium is defined by top of dense sand unit.

[d] Hanson Dam construction is defined by the presence of organic silt.

[e] Dredge event rates show rate for event to top of core and intra-marker rate from stratigraphic marker to dredge effects marker.

ID – identification

LDW – Lower Duwamish Waterway

PCB – polychlorinated biphenyl

Blank cells indicate that markers were not present or core was not clearly indicative of a strong time marker.

Bold text, gray shading indicate no strong marker; therefore, no calculation was made for the core.

3.1.5 Site-specific erosion properties

Erosion rates as a function of shear stress and depth in the sediment bed were evaluated using 19 sediment cores collected from 17 locations in the LDW (Map 3-1) in December 2004 as part of the STAR (Windward and QEA 2004, 2005). Fourteen of these cores were collected from bench areas, and five cores were collected from the navigation channel. Many of the cores collected from the bench areas for erosion property analysis were located relatively close to the geochronology cores discussed in Section 3.1.2. Duplicate cores were collected at two locations (Sf-6 and Sf-16), one from a bench area and one from the navigation channel.

Erosion rates as a function of depth in the bed and shear stress were measured in the laboratory over the top 30 cm of each core using a Sedflume (Windward and QEA 2004), which has proven useful for measuring the erosion properties of sediments at many other sites (McNeil et al. 1996). The principal purpose of the Sedflume is to measure gross erosion rates (E_{gross}) over a range of applied shear stresses (τ)[27] at various depths in a sediment core.

Erosion rate data, collected from at least 15 different aquatic systems, clearly show that a log-linear relationship exists between gross erosion rate (E_{gross}) and bed shear stress (τ). Equation 3-1 portrays this relationship as a power-law equation (2000):

$$E_{gross} = A\,\tau^{n} \text{ when } \tau > \tau_{cr}$$
$$E_{gross} = 0 \text{ when } \tau \leq \tau_{cr} \qquad \textbf{Equation 3-1}$$

Where:

E_{gross}	=	gross erosion rate (cm/s)
A	=	site-specific erosion rate parameter that may be dependent on the sediment dry density (ρ), as well as on other sediment bed properties (units vary, as discussed below)
τ	=	bottom shear stress (Pa)
n	=	site-specific erosion rate exponent (unitless)
τ_{cr}	=	critical shear stress (Pa)

The conversion of Equation 3-1 to log space shows the log-linear characteristics of this equation.

$$\log(E_{gross}) = n \log(\tau + \log(A) \qquad \textbf{Equation 3-2}$$

[27] Shear stress is the force that acts parallel to a plane. In this application, the force is hydrodynamic (from moving water) and the plane is the sediment bed surface.

To determine the values of A and *n*, a log-linear correlation analysis was conducted using the erosion rate (i.e., Sedflume) data for a specific core (or from a particular interval within a core), where E_{gross} was plotted as a function of τ. The units of the coefficient A vary, depending on the value of the exponent *n*.

The critical shear stress (τ_{cr}), defined as the shear stress at which a small but measurable rate of erosion is observed, was estimated from Sedflume erosion rate data. For Sedflume studies performed at other sites (Jepsen et al. 2001; Jones 2000; McNeil et al. 1996), the critical erosion rate was set at 10^{-4} cm/s, a value that consistently corresponded to the initiation of erosion. Thus, a critical erosion rate of 10^{-4} cm/s was used in this study (Windward and QEA 2008). The critical shear stress was calculated by rearranging Equation 3-1:

$$\tau_{cr} = \left(\frac{E_{gross}}{A} \right)^{\frac{1}{n}} \qquad \textbf{Equation 3-3}$$

where E_{gross} was set equal to 10^{-4} cm/s.

The data generated from the Sedflume analysis was used to assess the spatial variability (i.e., horizontal and vertical) of the erosion rate parameters (A, *n*, and τ_{cr}). The equations given above for these erosion rate parameters do not explicitly account for physical mixing processes such as bioturbation. Sediment-dwelling invertebrates (e.g., clams, worms, amphipods) can alter sediment properties, which may affect the erosion and transport of surface sediments. However, the effects of physical mixing processes are implicitly included in the calculation of erosion rate parameters because the characteristics of the Sedflume cores reflect the net effect of all physical processes that have occurred in the past at the specific locations where the cores were collected. Seasonal differences in biological activity may exist within the sediment layers evaluated in the Sedflume device (i.e., top 30 cm). The Sedflume cores were collected in December; many studies of benthic invertebrate communities were conducted in the spring, summer, or fall.

SPI data were collected from within the LDW in the summer of 2006 (Ecology 2007n) (Section 2.8.2.2). The SPI study documented the widespread presence of Stage 3 communities, which represent larger, longer-lived organisms that typically burrow and feed deeper in the sediment column and occur in relatively stable, undisturbed habitats. It is likely that these communities would be present in the LDW regardless of the season, because of their longevity. Many organisms in benthic invertebrate communities are sedentary and construct tubes or mucus-lined burrows; these structures along with biological activity increase the roughness of the sediment surface. Increased surface roughness tends to decrease flow velocities at the sediment-water interface (i.e., boundary layer) by introducing turbulence; mucus acts as a binding agent. Given the results of the SPI survey, the Sedflume data collected in December are considered representative of the effects from benthic invertebrates over

a large spatial scale within the LDW, even though seasonal differences in boundary roughness and erosion have not been characterized.

The erosion rate relationship (i.e., Equation 3-1) was similar among various cores within a specific 5-cm depth layer (Windward and QEA 2008), as presented in Table 3-4. This similarity suggested that 5-cm subsections of cores could be separated into different groups for a given depth layer, as defined by similarities in the erosion rate parameters A and *n*. This grouping was conducted in an attempt to evaluate whether LDW-wide generalizations could be made using these data. Sixteen core groups were created, each consisting of two to nine core segments. Upon visual inspection, two core segments were considered to be outliers and were not included in any core group.

The results for the individual cores within a group were combined to determine average erosion parameter values for that group. The average exponent (n) value for a group was the arithmetic average of the *n* values for the cores within the group. The average proportionality constant (A_{ave}) was determined by calculating the log-average value:

$$\log(A_{ave}) = (1/K) \sum \log(A_k) \qquad \textbf{Equation 3-4}$$

where K was the total number of cores in the group. Equation 3-2, which is based on standard statistical theory for linear equations, was used to determine the average erosion rate parameters for a group of core intervals. This approach resulted in calculations of the arithmetic average of the exponent *n* values and the log-average of the A values (see Equation 3-4) to determine the appropriate average erosion rate parameters for the group.

The vertical distribution of τ_{cr} values for all of the core groups is shown in Figure 3-1. In general, critical shear stress increased with depth in the sediment bed, as expected because of bed consolidation. It would take more energy or higher water flows to erode sediments at depth compared with unconsolidated surface sediments. The group-averaged A, *n*, and τ_{cr} values determined from this analysis were used in developing the horizontal and vertical spatial distributions of these parameters for input to the LDW STM (Section 3.2).

Table 3-4. Values for erosion rate parameter (A) and erosion rate exponent (*n*) for each Sedflume core interval

Sediment Core ID	0-to-5-cm Interval		5-to-10-cm Interval		10-to-15-cm Interval		15-to-20-cm Interval		20-to-25-cm Interval	
	A ($\times 10^{-4}$)	*n*	A ($\times 10^{-4}$)	*n*	A ($\times 10^{-4}$)	*n*	A ($\times 10^{-4}$)	*n*	A ($\times 10^{-4}$)	*n*
Sf-1	3.8	3.0	0.29	3.5	5.3	0.3	3.8	3.0	0.13	2.7
Sf-2	8.8	1.7	1.9	2.0	0.19	2.9	9.2	1.3	0.51	3.1
Sf-3	89	2.2	24	3.3	12	2.7	16	2.2	29	1.8
Sf-4	23	2.1	3.7	2.6	0.74	3.3	0.55	3.1	0.03	5.0
Sf-6-R1	24	2.8	3.8	3.1	0.7	3.2	2.9	2.1	1.4	2.5
Sf-6-R2	35	2.2	6.3	2.6	4.3	3.0	0.27	3.7	0.62	3.1
Sf-7	19	1.5	6.0	1.8	11	2.0	1.8	3.0	0.35	3.6
Sf-8	21	1.5	5.9	2.8	8.2	2.1	0.14	3.0	0.023	4.2
Sf-9	15	0.96	0.055	3.4	24	2.3	0.029	3.2	0.0	6.7
Sf-10	22	1.5	5.9	2.8	8.3	3.7	0.083	3.5	0.0083	4.7
Sf-11	19	1.4	3.9	3.1	0.51	3.5	9.4	1.4	0.097	3.2
Sf-12	6.5	3.9	8.3	3.0	6.1	2.1	7.5	3.4	8.0	3.3
Sf-13	11	1.3	0.7	2.9	0.43	5.2	0.095	3.7	0.96	3.1
Sf-14	80	2.3	6.9	1.6	0.35	2.8	1.6	2.2	2.5	1.8
Sf-15	9.4	1.7	6.0	2.5	0.097	3.5	0.88	2.1	240	-0.53
Sf-16-R1	43	2.7	3.3	2.9	15	2.6	5.1	3.5	3.7	1.6
Sf-16-R2	29	2.6	4.7	2.6	5.3	0.3	3.8	3.0	0.016	4.0
Sf-17	21	3.0	25	2.6	0.19	2.9	9.2	1.3	2.8	2.3

ID – identification

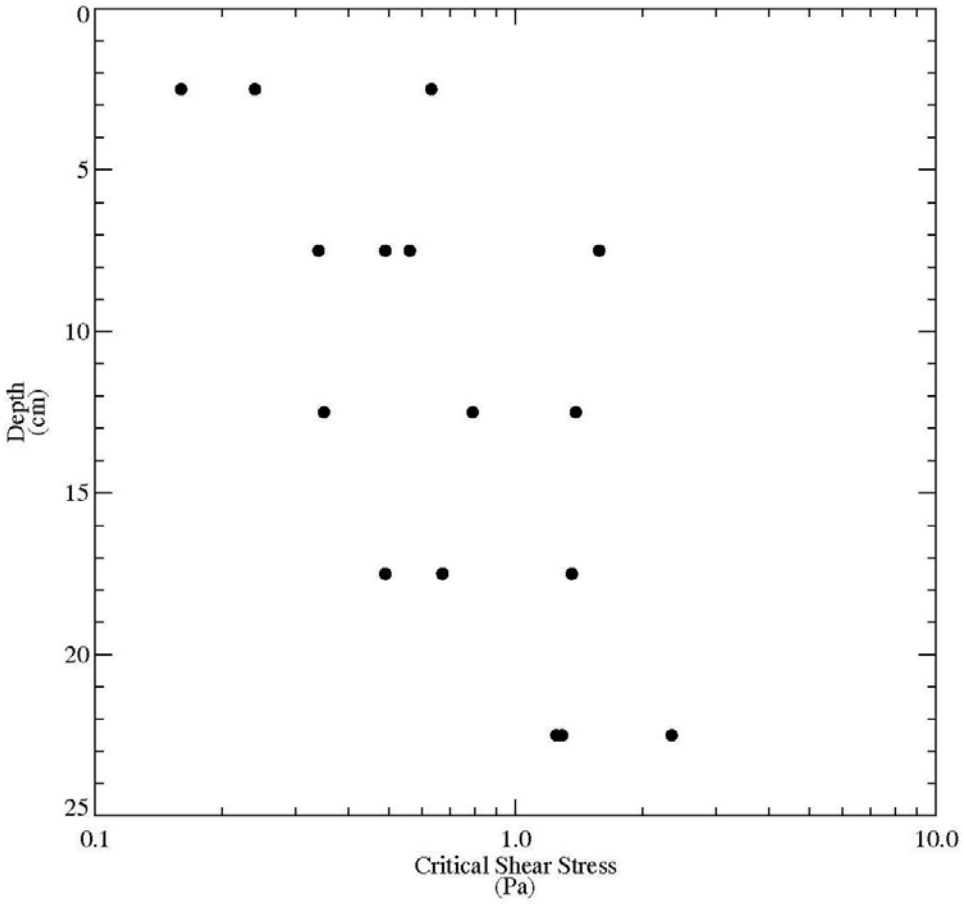

Figure 3-1. Vertical distribution of group-averaged critical shear stress values

3.1.6 Potential effects of natural events

The potential effects of an episodic high-flow event on bed stability in the LDW were evaluated through the use of a hydrodynamic model in the STAR (Windward and QEA 2008). The hydrodynamic model was used to simulate circulation in the LDW for a range of high-flow events (e.g., events with return periods of 2, 10, and 100 yrs) and a range of tidal conditions (i.e., spring and neap tides). Results of the hydrodynamic simulations were used to develop inferences and hypotheses about bed scour in the LDW during high-flow events and the spatial distribution of excess shear stress (i.e., bed shear stress minus critical shear stress).

High-flow events in the LDW are episodic in nature, with typical durations of hours to days. These episodic events may cause bed scour or deposition to occur at specific locations in the LDW. Although it is possible that a particular high-flow event may have measurable effects on bed elevation (i.e., either net deposition or erosion) at some

locations, the long-term effects of such an event on the depositional or erosional environment[28] at those locations may be relatively minor.

Sediment transport during an episodic high-flow event in the LDW is affected by a range of factors, including hydrodynamic circulation, spatial and temporal variations in bed shear stress, deposition, erosion (including bed armoring and consolidation effects), and sediment loads from upstream sources. These factors are the primary determinants of the effects of a high-flow event on bed stability and sediment transport in the LDW. Thus, a quantitative evaluation of sediment transport during a high-flow event requires the application of hydrodynamic and sediment transport models that incorporate all of the processes discussed above.

A three-dimensional hydrodynamic model of the LDW and Elliott Bay was developed during a water quality study of Elliott Bay, the East and West Waterways, and the LDW (King County 1999e). This model was created using the Environmental Fluid Dynamics Code (EFDC). Calibration and validation results indicated that the model simulated hydrodynamic processes in the LDW and Elliott Bay with reasonable accuracy. Dr. Earl Hayter of EPA increased the resolution of the King County model by developing a finer grid structure (Arega and Hayter 2004). The modified model was re-calibrated, as presented in Attachment B of the STAR (Windward and QEA 2008).

The LDW is a saltwater wedge estuary, and its hydrography has been studied as part of various investigations (Harper-Owes 1981; Santos and Stoner 1972). The location of the toe of the saltwater wedge varies depending on the rate of freshwater inflow from the Green/Duwamish River and the stage and magnitude of the saltwater tidal flow entering the LDW from Elliott Bay. The location of the saltwater wedge not only affects circulation in the LDW but also has an effect on bed shear stress distributions and bed scour during high-flow events. Results from hydrodynamic simulations of various high-flow events have suggested that the LDW may be broadly separated into three hydrodynamic reaches during high-flow conditions (Windward and QEA 2008).[29]

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[28] Depositional environment refers to an area in which the sediment bed is net depositional (i.e., bed elevation increases) over annual time scales. The bed may experience episodic erosion as a result of high-flow events or ship-induced bed scour. Erosional environment refers to an area in which the sediment bed is net erosional (i.e., bed elevation decreases) over annual time scales. The bed may experience net deposition over time scales of less than a year.

[29] In the STAR, reaches were designated 1 (most downstream), 2 (middle reach), and 3 (most upstream reach), but those designations are not used here so as to avoid confusion with the same reach designations used in Section 3.2 to describe the STM model-derived reaches. The boundaries between the STAR reaches were RM 2.0 (between Reach 1 and Reach 2) and RM 3.0 (between Reach 2 and Reach 3).

Various modeling analyses were conducted in the STAR (Windward and QEA 2008) to evaluate potential bed scour in the LDW during high-flow events (i.e., discharge greater than or equal to the 2-year high-flow event). The results of these analyses are presented in the STAR and summarized below.

- Over all flow conditions, bed shear stress tended to be higher in the navigation channel than in the bench areas.
- During high-flow events in the most downstream reach, negligible bed scour was estimated to occur in most of the area downstream of RM 1.8. Between RM 1.8 and RM 2.0, excess shear stress values of 0.4 pascal (Pa) or less were estimated to occur during high-flow events.
- During high-flow events in the middle and most upstream reaches (i.e., upstream of the saltwater wedge):
  - Minor differences were estimated in the general spatial pattern of excess shear stress during ebb and flood tides. Higher bed shear stresses were estimated during spring tide than during neap tides.
  - In general, lower excess shear stresses were estimated in the bench areas than in the navigation channel for a given high-flow event and tidal condition.
  - Within the portions of the bench areas where erosion was estimated to occur, the potential for erosion tended to be highest near the navigation channel and tended to decrease toward the shoreline.
  - The most upstream reach was estimated to have higher excess shear stress values than the middle reach.
- The hydrodynamic energy regime (represented by excess shear stress) during high-flow events was not estimated to have a significant effect on the erosion rate properties or geochronology at a particular location within the bench areas of the LDW. No correlation was apparent between the structure (i.e., vertical distribution of erosion rate or physical properties) of either a Sedflume core or a geochronology core and the hydrodynamic energy regime at the core location.

Although areas of potential erosion were identified through this analysis, the depth of bed scour in those areas during a specific high-flow event could not be reliably estimated without the application of an STM (see Section 3.2).

3.1.7 Potential effects of ship-induced bed scour

The gross bed scour that could potentially result from ship traffic was also analyzed in the STAR using a numerical model (Windward and QEA 2008). The focus of this analysis was on the upstream and downstream movements of ships within the navigation channel. This analysis was necessarily limited to estimating gross bed scour depth because sediment transport and deposition processes were not explicitly

accounted for in the model. Consequently, bed scour results, expressed on a per ship passage basis, were considered to be upper-bound estimates, with the actual bed erosion resulting from ship traffic in the navigation channel likely to be less than that estimated because in a typical event, sediment is suspended for a brief period of time but is then re-deposited shortly thereafter once the propeller-driven forces are no longer present. This analysis was considered to be a screening-level evaluation, with order-of-magnitude accuracy at best. The model was not designed to assess cumulative effects of ship traffic. Furthermore, the model did not address effects from vessel maneuvering outside of the navigation channel, which could result in localized scour and will be considered in the FS. Detailed ship-induced bed scour studies will be required during the design of future sediment cleanup actions. The STM discussed in Section 3.2 describes long-term simulations that incorporate cumulative effects of all ship traffic.

Results of this modeling analysis included:

- Within the navigation channel, ship movement was estimated to result in an average bed scour depth of less than 1 cm per ship passage in the most downstream reach, and less than 0.1 cm per ship passage in the middle and upstream reaches. Within the bench areas, average bed scour depths of about 1 to 2 cm per ship passage were estimated in the most downstream reach, and less than 1 cm per ship passage was estimated in the middle and upstream reaches.
- A sensitivity analysis indicated that reducing ship speed from the LDW speed limit of 5 knots to a speed of 2.5 knots would likely significantly reduce bed scour, with estimated bed scour of less than 1 cm throughout the LDW for all conditions. Doubling the applied ship power (i.e., horsepower) had minimal effect on estimated scour depth.
- The reworked (i.e., mixed) sediment layer was equated with the depth of gross bed scour, based on the assumption that the same layer is continually reworked. The most downstream reach was estimated to have an upper-bound average scour thickness of less than about 1 cm in the navigation channel and about 1 to 2 cm in bench areas. In the middle and upstream reaches, the reworked sediment layer was estimated to have an upper-bound average thickness of less than 0.1 cm in the navigation channel and less than 1 cm in bench areas. The frequency of mixing is about 100 to 250 events per year.
- Ship-induced bed scour depths were not found to be significantly related to erosion rate properties or geochronology results at any particular location in the bench areas or navigation channel of the LDW. No correlation was apparent between the structure of a geochronology or Sedflume core and the amount of ship-induced bed scour at the core location.

- The present-day structure of the LDW sediment bed reflects the effects of ship-induced bed scour that has occurred for at least 40 years.[30] The general lack of evidence in the bathymetric record of large depressions in areas with frequent ship traffic validates the assumption that the upper sediment layer is continually reworked and suggests that ship activity is not a major cause of sediment transport in the LDW. In some areas, ships may have caused localized erosion from physical forces unrelated to propeller-driven scour (i.e., anchors dragging), but the model did not account for such activities.

3.2 SEDIMENT TRANSPORT MODELING

The analyses presented in the STAR (Windward and QEA 2008) produced a significant amount of information on LDW sediment characteristics. However, a limitation of those analyses is the inability to predict erosion, deposition, and net sedimentation throughout the LDW during high-flow events and over multi-year periods. It was recognized by LDWG, Ecology, and EPA that development of an STM could potentially enhance the efficacy of various analyses during the FS process, including monitored natural recovery (MNR) analyses.

Discussions and meetings among LDWG, Ecology, and EPA during July and August 2006 concerning an STM resulted in the formation of an STM group,[31] which worked collaboratively and provided advice on the development, calibration, and application of the model. The STM group held meetings, conference calls, and informal discussions among members at various times between August 2006 and May 2007 to review model status and discuss the next steps to be taken in model development, calibration, and application. This collaborative effort was instrumental in producing a consensus modeling framework and in achieving the study objectives described in Section 3.2.1, which summarizes the results of the STM effort (QEA 2008).

3.2.1 Modeling objectives

The overall objectives of the STM effort were to:

- Develop a quantitative tool to evaluate short- and long-term sediment transport processes in the LDW
- Refine the CSM for the LDW that was developed in the STAR

[30] Many of the businesses that rely on barge or tug traffic, or their predecessors, have existed for at least 40 years.

[31] The members of this group have included: Shane Cherry (Cherry Creek Environmental), Karl Eriksen (USACE), Joe Gailani (USACE), Earl Hayter (EPA), Brad Helland (Ecology), Bruce Nairn (King County), Mike Riley (S.S. Papadopulos & Associates), Peter Rude (City of Seattle), Beth Schmoyer (City of Seattle), David Schuchardt (City of Seattle), Jeff Stern (King County), Kym Takasaki (USACE), and Kirk Ziegler (QEA).

- Provide information to support FS analyses and inform remedial decision-making

Multi-year simulations were conducted to predict long-term changes in bed elevation (i.e., net sedimentation rate) as well as changes in surface layer sediment composition. These results will be used in the FS to help evaluate remedial alternatives and estimate the rate of natural recovery in the LDW attributable to sediment transport processes. Through the use of long-term (e.g., 30-yr) simulations, the STM answered specific questions, including:

- What areas in the LDW are net depositional, net erosional, or in dynamic equilibrium?
- How does the composition of the surface layer sediment change over time as external sediment loads (from upstream and lateral sources, such as SDs) become incorporated into the sediment bed?
- What is the effect of high-flow events on episodic scour?
- What is the potential depth of scour during high-flow events?

In addition, the effects of high-flow events on bed scour and the potential for re-exposing buried sediments were evaluated with the STM. The high-flow event simulations were short-term, covering several-day periods equivalent to the storm length and the time necessary for flows to return to normal. For episodic high-flow events, questions of interest included:

- What areas experience erosion during a high-flow event?
- In the areas that experience erosion during high-flow events, what is the potential depth of scour?
- What is the potential for re-exposing buried sediments?

Note that the STM models the movement and fate of suspended and bed load sediment (as physical particles) but does not address chemical transport and fate.

3.2.2 Development of sediment transport model inputs

Input parameters for the STM were separated into three broad categories: 1) sediment characteristics, 2) bed characteristics, and 3) boundary conditions. Sediment characteristics include physical parameters, such as effective particle diameter and settling speed. Bed characteristics include physical parameters of the bulk sediment bed, such as dry density and sediment particle size, and calculated parameters such as erosion rates. Boundary conditions refer to characteristics at the edge of the modeling area (e.g., sediment loads at different inflow locations adjacent to the LDW).

Sediment particles in the LDW have a range of sizes, from less than 1 μm for clays to greater than 2,000 μm for gravel. Simulation of the entire particle size spectrum was impractical. Therefore, particles were separated into four size classes: 1) clay and fine

silt (less than 10 μm), 2) medium and coarse silt (10 to 62 μm), 3) fine sand (62 to 250 μm), and 4) medium and coarse sand (250 to 2,000 μm) (Table 3-5). Each sediment size class was represented as an effective particle diameter. The particle size distributions in the sediment bed and incoming loads were evaluated to select the appropriate average effective particle diameters in each general size class to represent particle transport throughout the LDW. Note that effective particle diameters for Classes 1A and 1B were treated as adjustable calibration parameters (Section 3.2.2).

Table 3-5. Characteristics of sediment particle size classes

Sediment Size Class	Particle Size Range (μm)	Effective Particle Diameter (μm)	Effective Settling Speed (m/day)
1A. clay, fine silt	< 10	5	1.3
1B. medium, coarse silt	10 – 62	20	21
2. fine sand	62 – 250	130	770
3. medium, coarse sand	250 – 2,000	540	5,500

The settling speeds of sediment particles are related to the effective particle diameter, with settling speed increasing as effective diameter increases. The effective settling speeds for the four sediment size classes had a large range, from about 1 m/day for Class 1A to about 5,500 m/day for Class 3 (Table 3-5). This large range (i.e., factor of approximately 5,000) had a significant effect on the transport characteristics of the different sediment size classes.

The specification of bed properties within the LDW began with the separation of the sediment bed into two distinct types of sediment: cohesive and non-cohesive. Cohesive sediment corresponded to a muddy bed composed of a mixture of clay, silt, sand, and organic matter. Non-cohesive sediment corresponded to a sandy bed with a relatively low amount of clay, silt, and organic matter. The STM required specification of the following bed property inputs within the cohesive and non-cohesive bed areas: 1) dry (bulk) density; 2) initial sediment particle size composition (i.e., relative amounts of Classes 1A, 1B, 2, 3), and 3) effective bed roughness. The median diameter (D_{50}) of particles in the non-cohesive bed areas needed to be specified. The spatial distribution of erosion rate parameters, both horizontally and vertically, for the cohesive bed areas also had to be determined and was derived from an analysis of the Sedflume core data (Section 3.1.5). A summary of model input parameters is presented in Table 3-6, which includes the data sources and an estimate of the level of uncertainty for each input.

Table 3-6. STM input parameters and data sources

MODEL INPUT PARAMETER	Data Source	Level of Uncertainty
Bathymetry and geometry	2003 multi-beam survey of the LDW (Windward and DEA 2004); USACE (bathymetry charts as contained in USACE file number E-12-2.1-12.3, dated September 15, 2000) and Boeing bathymetry data (Pentec et al. 2001)	Measurement uncertainty in vertical bed elevation is: ± 0.5 ft in LDW; ± 2 ft upstream of RM 4.7; ± 1 ft downstream of RM 0.0.
Green River flow rate	USGS gaging station at Auburn (USGS 2007b)	USGS rates discharge data at this station as good (i.e., 10% accuracy).
Tidal elevation in Elliott Bay	NOAA gaging station at Colman Dock (ferry terminal)	Accuracy of tidal elevation measurements is 0.3 cm.
Sediment bed – erosion parameters	Sedflume study conducted during December 2006 (18 cores) (Windward and QEA 2008)	Uncertainty/accuracy of Sedflume core data cannot be assessed. Potential uncertainties related to spatial variability were addressed through a sensitivity analysis.
Sediment bed – dry density	2006 subsurface core data (16 samples) (Windward and RETEC 2007)	The 95% confidence interval, with respect to average value, is 0.14 g/cm^3.
Sediment bed – non-cohesive bed D_{50}	1991 to 2006 core data (875 samples) (see Section 4)	The 95% confidence interval, with respect to average value, is 170 μm.
Sediment bed – effective bed roughness (D_{90})	1991 to 2006 core data (875 samples) (see Section 4)	The 95% confidence interval, with respect to average value, is 110 μm.
Upstream sediment load – magnitude	USGS sediment load studies conducted during 1965-1966 (Harper-Owes 1981) and 1995-1996 (Embrey and Frans 2003)	Annual sediment load estimates have an approximate factor-of-2 level of uncertainty.
Upstream sediment load – composition	USGS sediment load studies conducted during 1965-1966 (Harper-Owes 1981) and 1995-1996 (Embrey and Frans 2003) (composition was adjusted during calibration)	Available data were used to constrain the calibration value to within a realistic range.
Lateral source sediment load – magnitude	CSOs: Approximately 100 TSS samples collected from 1995 to 1997 from five major outfalls (i.e., Brandon, Chelan, Hanford, Connecticut, and King) (King County 1999e).Monthly CSO discharge volumes from June 1999 to May 2006 for nine locations within the LDW were obtained from annual CSO reports and summarized (Nairn 2007). Wet seasons from 1999-2000 and 2005-2006 were included. Storm Drains: Data from over 500 stormwater samples collected at 24 different locations across the US to determine representative TSS concentrations in urban stormwater (SPU 2007). Precipitation data (1986 to 2005) collected at E Marginal Way S pump station were used in watershed model to estimate monthly average volume discharge at each storm drain location (SPU 2007).	The 95% confidence interval, with respect to average value, is 150 mg/L for King County CSOs. Raw data for storm drains were not available, so no confidence interval could be calculated.

Model Input Parameter	Data Source	Level of Uncertainty
Lateral source sediment load – composition	CSOs: GSD estimated from settling analysis results at four CSOs: Denny, Henderson, M.L. King, and Norfolk (Nairn 2007). Storm Drains: GSD data collected from stormwater samples at 16 sites across the US (SPU 2007)	Available data were used to constrain the calibration value to a realistic range.

CSO – combined sewer overflow
GSD – grain size distribution
LDW – Lower Duwamish Waterway
NOAA – National Oceanic and Atmospheric Administration
RM – river mile
TSS – total suspended solids
USACE – US Army Corps of Engineers
USGS – US Geological Survey

Sediment loads from upstream (i.e., Green River) and lateral sources (i.e., SDs, CSOs, streams), including both the magnitude and composition of the loads (i.e., relative amounts of Classes 1A, 1B, 2, 3), were needed to establish boundary conditions for the STM. Loads from the lateral sources were not included during the calibration period simulation (see Section 3.2.3) because the annual average load from lateral sources totaled 0.6% of the upstream load (QEA 2008).

3.2.3 Model calibration and validation

The hydrodynamic model[32] that was originally refined and calibrated during the sediment transport analysis (Windward and QEA 2008), as described in Section 3.1.6, was re-calibrated because modifications were made to the numerical grid.[33] These modifications were necessary so that long-term, multi-year simulations could be completed in a timely manner. In addition, grid cells were added for the LDW slips.

The re-calibration results showed that the hydrodynamic model realistically simulated all of the major characteristics of estuarine circulation in the LDW. The vertical structure of tidal current velocity was realistically simulated, and the STM was able to reproduce the two-layer flow in the region occupied by the saltwater wedge. Strong vertical stratification of salinity has been documented and the model was able to simulate that stratification with acceptable accuracy. In addition, the model realistically simulated the dynamic nature of the saltwater wedge and the location of the toe of the wedge as it varies over the course of a tidal cycle, as well as variations that result from changes in freshwater inflow and the phase of the tidal cycle (i.e., spring and neap tide conditions). Overall, re-calibration of the hydrodynamic model

[32] This hydrodynamic model (EFDC) was an important component of the STM. The STM differs from EFDC in that it includes sophisticated algorithms for tracking sediment particles, whereas the hydrodynamic portion of EFDC includes only water movement.

[33] As summarized in Section 3.1.6, additional model cells were added to the hydrodynamic model originally constructed by King County to improve the resolution. Because model results are created independently for each grid cell, smaller grid cells allow the evaluation of smaller scale variability in model results.

demonstrated that the model is sufficiently accurate and reliable for the objectives of the STM study.

The STM was built on a foundation of mechanistic formulations that are used to simulate the erosion and deposition of cohesive and non-cohesive sediment. The erosion and deposition formulations used in the model were based on results from a large number of laboratory and field studies. Site-specific data were used to determine model input parameters, with robust datasets used to specify the two major inputs: sediment loading from the Green River and erosion properties of LDW sediments. The significant amount of site-specific data, in conjunction with the mechanistic nature of the model formulations, provided an opportunity to develop and calibrate a reliable STM.

Calibration and validation of the STM was a process that involved comparing model estimates to LDW data. These comparisons provided a "reality check" for the STM and were used to evaluate the accuracy and reliability of the model. The first step in the process was calibration of the STM, which involved adjusting model input parameters to optimize the agreement between model results and empirical data. The second step in the process was model validation, which involved a comparison of model predictions to an independent dataset (i.e., data not used to calibrate the model), with no adjustment of calibration input parameters. Taken together, the results of the model calibration and validation results provided an objective method for "ground-truthing" the STM and determining its reliability as a diagnostic tool to evaluate sediment transport processes in the LDW.

The STM was calibrated and validated over a 21-year period (1960 through 1980) to evaluate the accuracy and reliability of a model. This time period tested the model's capabilities because of the wide range of tidal and river flow conditions during that period, including several high flow events. This time period was selected because the data were readily available in a format that was compatible with the STM. Flows in the Green River during the 1960-to-1980 time period were very similar to flows during 1981-to-2006 time period, based on a comparison of flow duration curves for the two periods. Thus, using the 1960-to-1980 period for model calibration provided results that were consistent with current conditions. For the STM, the calibration targets (i.e., the parameters used to assess model accuracy or agreement) were net sedimentation rates in the navigation channel and bench areas of the LDW (QEA 2008). Four model parameters were adjusted to achieve the optimum agreement between estimated and empirically derived estimates of net sedimentation rates in the navigation channel and bench areas (Table 3-7) (QEA 2008).

Table 3-7. STM calibration parameter values

ADJUSTED PARAMETER	CALIBRATION VALUE
Effective particle diameter of Class 1A sediment	5 µm
Effective particle diameter of Class 1B sediment	20 µm
Average percentage of Class 1A sediment in incoming suspended load[a]	70%
Average percentage of Class 1B sediment in incoming suspended load[a]	18%

[a] The other 12% of the incoming suspended load consisted of Class 2 and 3 sediments.
STM – sediment transport model

In addition to the parameters listed in Table 3-7, two additional adjustments were made to the STM during calibration. First, a particle-shielding factor was incorporated into the calculation of bed erosion flux. This factor was used to reduce the erosion flux of smaller particles that can be sheltered by larger particles within a graded bed (i.e., a bed with a wide range of particle sizes) (QEA 2008). The second adjustment to the model was to specify that the sediment bed upstream of RM 4.8 be treated as a "hard bottom," which means that the bed in that region (i.e., in the river upstream of the Upper Turning Basin) was assumed to not experience erosion or deposition. Bed load transport of sediment was allowed in that region (QEA 2008).

Validation of the model was achieved through comparison of the estimated composition of sediment deposited in the LDW to the observed composition of surface-layer sediment. The relative amounts of the four size classes (i.e., Classes 1A, 1B, 2, 3) in the sediment estimated to be deposited between RM 0.0 and RM 4.3 (i.e., region downstream of the Upper Turning Basin) during the 21-yr calibration period were compared with the relative amounts of the four sediment size classes measured in the Sedflume cores, which represent the upper 30 cm of the sediment bed. No model input parameters were adjusted to optimize the agreement between observed and estimated composition. The satisfactory model results provided additional support for the capability of the model to realistically and accurately simulate erosion and deposition processes in the LDW.

Results of the calibration and validation exercises indicated that the STM is able to realistically and accurately simulate erosion and deposition processes in the navigation channel and bench areas of the LDW. The calibration and validation results, coupled with constraints on the model by mechanistic formulations and site-specific data, indicated that the model is a reliable tool for evaluating sediment transport processes in the LDW over a wide range of spatial and temporal scales. Quantitative uncertainty estimates have been made for STM predictions, providing additional data to assess the degree to which the model output is considered valid at various scales. Over small spatial scales, the STM can typically be used as one line of evidence, along with other information and data, to guide decision-making. In addition, the STM provides a reliable framework to extrapolate conditions for areas without erosion and/or empirical net sedimentation rate data.

The calibration and validation of the STM resulted in a revised definition of reach boundaries from those presented in the STAR. The reach designations discussed in this section, and in the STM, represent a refinement, based on an improved understanding of LDW sediment transport processes, from the modeling conducted for the STAR. The revised reach definitions were:

- **Reach 1.** Located downstream of RM 2.2 and includes the saltwater wedge during all flow and tidal conditions.
- **Reach 2.** Extends from RM 2.2 to RM 4.0 and includes the saltwater wedge toe.
- **Reach 3.** Located from RM 4.0 to RM 4.8, with flow in the uppermost portions of this reach corresponding to a freshwater tidal river under most flow conditions. This reach is occupied by the saltwater wedge only during low- and average-flow conditions; under high-flow conditions, the entire reach may behave as a freshwater tidal river.

3.2.4 Sediment bed stability results

The STM was used to evaluate the effects of high-flow events on bed stability in the LDW (QEA 2008). High-flow events with return periods of 2, 10, and 100 years were simulated. Boundary conditions for the high-flow simulations were developed using the hydrograph of a high-flow event that occurred during November-December 1975. During this high flow event, spring tide conditions occurred during peak flow conditions. Thus, the high-flow simulations produced conservative results that represented upper-bound estimates of bed scour depths during high-flow events.

Two quantities related to bed scour were derived from the simulation results: net erosion and maximum bed scour depth (QEA 2008). Net erosion at a specific location is the total decrease in bed elevation over the course of a high-flow event (i.e., difference in bed elevation between start and end of 26-day simulation). Net erosion thus incorporates the effects of erosion and deposition during the entire event. Maximum bed scour depth is the maximum depth of erosion that occurs at a specific location during the high-flow event. Typically, maximum bed scour occurs near the time of the peak flow rate, with deposition occurring after the peak flow rate, as river discharge declines.

Spatial distributions of estimated net erosion at the end of high-flow events with return periods of 2, 10, and 100 yrs are presented on Maps 3-4, 3-5, and 3-6, respectively. The spatial distribution of maximum bed scour during the 100-year high-flow event is shown on Map 3-7. The locations of the maximum net erosion depths of bed scour in cohesive and non-cohesive bed areas are denoted on these maps. Net erosion, where it was predicted to occur (i.e., above RM 2.0), was generally estimated to be higher in the navigation channel than on the benches.

Net erosion was estimated to occur over approximately 15 to 20% of the area of the LDW sediment bed during a high-flow event. Net erosion of 10 cm or greater was estimated to occur over about 6% (22 ac) of the bed area in the LDW during the 100-year high-flow event. Maximum net erosion depths during a 100-year event were estimated to be about 21 cm. Maximum bed scour depths were about 1 cm greater than net erosion depths. Thus, based on the model, scour was estimated to be limited to approximately the upper 20-cm layer of the sediment bed within a few small areas during the 100-year high-flow event upper-bound estimate. In most areas, the maximum scour depth was estimated to be far less. Even during a 100-year high-flow event, negligible bed scour was estimated to occur over large areas of the LDW, including nearly all of Reach 1 (Map 3-7).

The model results showed that net erosion primarily occurred between RM 2.2 and RM 4.0 during the high-flow event simulations in the LDW, including the 100-year event (QEA 2008). Most of the net erosion occurred in this reach of the LDW because most of the region upstream of approximately RM 2.2 behaved as a freshwater tidal river during high-flow events, with the saltwater wedge toe located downstream of approximately RM 2.2 during ebb tides. This is consistent with the hydrodynamic model simulation, which showed that relatively high bed shear stresses occurred upstream of the saltwater wedge (Windward and QEA 2008). Less net erosion was estimated to occur in the reach upstream of RM 4.0 than in the reach from RM 2.2 to RM 4.0 for two reasons. First, bed shear stresses were generally lower upstream of RM 4.0 than in the reach from RM 2.2 to RM 4.0, which is mainly the result of differences in cross-sectional area between the two reaches (i.e., larger cross-sectional area upstream of RM 4.0). Second, more deposition and less net erosion were estimated to occur upstream of RM 4.0 because a large of portion of sand (i.e., sediment Classes 2 and 3) transported from the Green River to the LDW was estimated to be deposited in this reach; the Upper Turning Basin was designed to be an effective sediment trap.

Net erosion was estimated to occur in only a few relatively small areas in the reach downstream of RM 2.2, even during a 100-year event, with typical net erosion depths of 2 cm or less (Map 3-6). The cause for the significant difference in estimated erosion depths between the reaches upstream and downstream of RM 2.2 is the presence of the saltwater wedge downstream of RM 2.2 during high-flow events, which resulted in relatively low bed shear stresses and a small amount of erosion in that reach.

The effects of deposition on net erosion after the peak flow rate, as river discharge declines, are illustrated by a comparison of the spatial distributions shown on Maps 3-6 and 3-7. These two maps show that: 1) the areal extent of maximum bed scour was estimated to be larger than the areal extent of net erosion at the end of the 100-year event, 2) net erosion was estimated to be less than maximum bed scour at most locations, and 3) net deposition over the course of the event was estimated to occur at some locations that experienced bed scour at some time during the event. In

areas that experienced deposition after the maximum bed scour occurred (i.e., after the peak flow during the event), the amount of deposition was typically relatively small.

The relative amounts of sediment eroded from surface (0 to 10 cm) and subsurface (deeper than 10 cm) layers during the 100-year event were evaluated by "tagging" sediments within those two layers at the start of the simulation and tracking the sediment from those two bed sources separately (QEA 2008). Results of a mass balance analysis for the 100-year event indicated that 20% of the mass of sediment eroded from the sediment bed in the LDW was from the subsurface layer (i.e., deeper than 10 cm), with the remaining 80% of eroded sediment originating from the surface layer (0 to 10 cm). The mass balance analysis also showed that about 4 and 2% of the total sediment transported downstream of RM 0.0 during the 100-year event was eroded from the surface and subsurface layers, respectively (the remainder coming from the Green River). These results indicated that subsurface contamination (i.e., >10 cm depth) is unlikely to be significantly eroded and transported within and outside the LDW during a high-flow event.

A sensitivity analysis was conducted to evaluate uncertainty in model predictions that may have resulted from uncertainty in model input parameters. The model was most sensitive to the parameters that control erosion rates, which were specified using Sedflume core data collected from the LDW. Based on model input uncertainty, uncertainty in the extent of areas estimated to have erosion was less than ± 50% within RM 0.0 to RM 4.3, relative to the base-case simulation. Uncertainty in predicted sediment mass eroded ranged from about -50 to +75% within RM 0.0 to RM 4.3 as well as in the east bench and navigation channel. The predicted sediment mass eroded in the west bench zone is more uncertain; the uncertainty range in the west bench was about -40 to +130%.

3.2.5 External sediment load analysis, net sedimentation rate analysis, and changes in bed composition

A 30-year simulation was conducted so that the effects of external sediment loads on surface layer bed composition over long-term, multi-year periods could be evaluated (QEA 2008). In addition, net sedimentation rates that account for all sources of sediment were estimated. Boundary conditions for the model were specified using river flow rate and tidal elevation data collected during the 30-year period from 1960 through 1979. External sediment loads were specified from two sources: 1) upstream loads (i.e., Green River), and 2) lateral loads (i.e., SDs, CSOs, and streams). Original bed sediment (i.e., sediment at the beginning of the 30-year simulation) was treated as a third source of sediment. The effects of the external loads on the relative amounts of sediment from the three sources (i.e., bed, upstream, and lateral) in the surface layer of the sediment bed over the 30-year period were estimated by the STM. The surface layer was defined as the top 10 cm of the bed.

Sediment from each of the three sources was separated into four particle size classes (i.e., Classes 1A, 1B, 2, 3), with the sediment transport characteristics of the four

particle size classes being the same for all three sediment sources (QEA 2008). For example, the erosion, deposition, and transport of Class 1A sediment was treated the same way for sediment originating from the bed, upstream, and lateral sources. Thus, the model simulated the erosion, deposition, and transport of 12 sediment classes (i.e., four particle size classes from each of the three sediment sources) during the 30-year period.

Changes in the composition of the 10-cm layer at the surface of the sediment bed were of particular importance in this analysis. At beginning of the 30-year simulation, the composition of the 10-cm surface layer was 100% bed-source sediment, with no sediment from upstream and lateral sources. As the 30-year simulation progressed, upstream- and lateral-source sediments were transported in the LDW and deposited on the 10-cm surface layer, which reduced the relative amount of bed-source sediment in that layer. The model tracked spatial and temporal changes in the relative amounts of sediment from the three sources over the course of the 30-year period that resulted from erosion, deposition, and transport processes in the LDW.

3.2.5.1 Sediment load and mass balance

Sediment loads from lateral sources (i.e., SDs, CSOs, and streams) were estimated using an approach that combined watershed modeling and empirically derived estimates (QEA 2008; SPU 2007; Nairn 2007). SDs, streams, and CSOs discharge sediment into the LDW at over 200 locations; incorporating each individual discharge location into the model was not practical. Thus, the lateral sources were aggregated and represented by 21 point sources that discharged into the LDW at 16 representative locations (Map 3-8). The total average annual load from lateral sources was estimated to be approximately 1,200 metric tons per year (MT/yr), with 76%, 3%, and 21% of the total lateral load from SDs, CSOs, and streams, respectively (QEA 2008). The total sediment load from lateral sources over a 30-year period (32,600 MT) was 0.5% of the total load from the upstream (river) source (6,266,400 MT) [34] (Figure 3-2).

[34] Note that the values on Figure 3-2 are totals for the 30-yr modeling period, not annual averages.

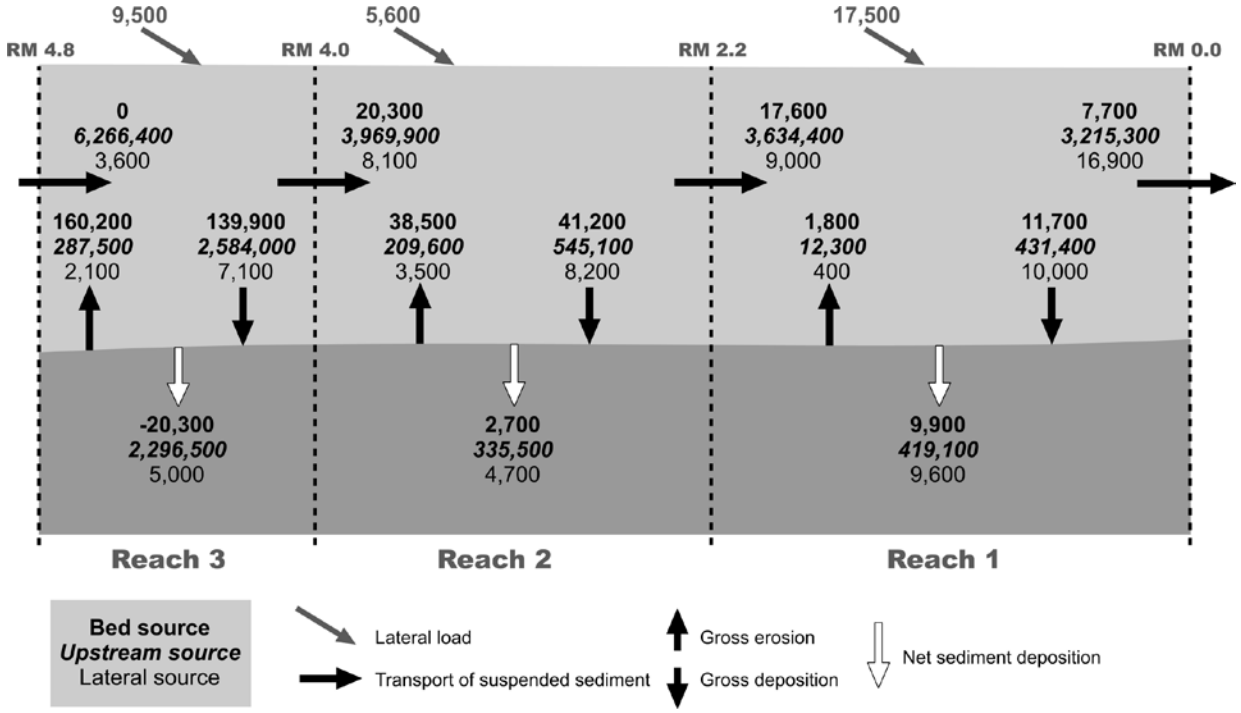

Figure 3-2. Sediment mass balances (in metric tons) for bed-, upstream-, and lateral-source sediment in the LDW (RM 0.0 to RM 4.8) for a 30-year period

3.2.5.2 Net sedimentation rates

The spatial distribution of average net sedimentation rates estimated for the 30-year period is presented on Map 3-9. These model results illustrate several characteristics of sediment transport processes in the LDW (QEA 2008). Reach 1 (RM 0.0 to RM 2.2) was estimated to be net depositional over multi-year periods with net sedimentation occurring everywhere. Within Reach 1, relatively high net sedimentation rates (i.e., greater than 2 cm/yr) were estimated between RM 1.4 and RM 2.2, with lower rates (i.e., typically 0.5 to 2 cm/yr) estimated downstream of RM 1.4. The model estimated a relatively low net sedimentation rate (i.e., less than 0.1 cm/yr) in a small area near RM 0.8 to RM 0.9 over the 30-year period, with net erosion during high-flow events (Section 3.2.4). Within Reach 2 (RM 2.2 to RM 4.0), net sedimentation rates were estimated to be generally lower than those in Reaches 1 and 3 (RM 4.0 to RM 4.8). Net erosion was predicted for three Reach 2 grid cells in the STM. This small area of net erosion over the 30-year period appeared to be in a state of approximate dynamic equilibrium. Relatively high variability in net sedimentation rates, from less than 0.5 cm/year to greater than 3 cm/yr, in Reach 2 reflected the dynamic nature of this reach, which was estimated to experience episodic bed scour during high-flow events (Section 3.2.4). Reach 3 was estimated to be net depositional and had the highest net sedimentation rates within the LDW, which is not surprising because the Upper Turning Basin, which is designed to function as a sediment trap, is located in this

reach. The maximum net sedimentation rate estimated by the model (approximately 140 cm/yr) was for several grid cells in the Upper Turning Basin.

Large-scale comparisons of net sedimentation rates among the three reaches were made by calculating reach-averaged values (Table 3-8). Reach 2 was separated into two sub-reaches to reflect significant spatial variations in net sedimentation rates within that reach (QEA 2008). Sedimentation rate averages for each reach reflect model results for both benches and the navigation channel. In Reaches 1 and 2, the average net sedimentation rates estimated for the benches and navigation channel were similar (1.8 to 3.7 cm/yr). For Reach 3, the 30-year net sedimentation rate for the navigation channel was more than double the rate for either the west or east bench. The value for Reach 3 corresponds to the average in the area excluding the Upper Turning Basin; average net sedimentation in the Upper Turning Basin was over 40 cm/yr.

Table 3-8. Reach-average sedimentation rates and composition at end of 30-year period

Reach	Net Sedimentation Rate (cm/yr)	Bed-Source Content (%)	Upstream-Source Content (%)	Lateral-Source Content (%)
1 (RM 0.0 to RM 2.2)	1.8	3	94	3
2 (RM 2.2 to RM 4.0)	2.8	13	85	2
2A (RM 2.2 to RM 2.6)	3.7	3	96	1
2B (RM 2.6 to RM 4.0)	2.4	17	81	2
3 (RM 4.0 to RM 4.8, excluding the Upper Turning Basin)	15	3	95	2

RM – river mile

For the navigation channel, the estimated net sedimentation rate decreased from the Upper Turning Basin (near RM 4.5) to downstream areas, primarily because less sand is transported to the downstream reaches than to the upstream reach. The Upper Turning Basin acts as a sink for sand from upstream sources, but silt and clay remain in suspension longer and generally settle farther downstream compared with sand. A similar phenomenon occurs for lateral inflows to the LDW. Based on model results, approximately one-quarter of the silt and almost all the clay is discharged to Elliott Bay, regardless of the source.

Net sedimentation rates can be used to estimate the time necessary to add to the existing surface sediment layer to a specified thickness. For example, the time needed to add 10 cm of new sediment to the existing surface sediment layer (which is defined as 0 to 10 cm) is estimated as:

$$T = 10/\text{net sedimentation rate} \qquad \textbf{Equation 3-5}$$

where T is time measured in years, and the net sedimentation rate is measured in cm/yr. This simplified approach does not account for the physical mixing of sediment

from different sources during deposition and erosion processes, nor for consolidation with time.

In general, net sedimentation rates estimated using the empirical approach (see Section 3.1.4) agreed reasonably well with the model estimates, considering the different methods used to derive the estimates. Of the 63 locations where a comparison between empirical (Map 3-3) and estimated (Map 3-9) net sedimentation rates was possible, 40 locations had a difference of 1.0 cm/year or less (Table 3-9). The model tended to over-estimate net sedimentation rates in the bench regions upstream of RM 4.0. Between RM 2.0 and RM 4.0, model results were generally within the range of the empirically derived estimates in the east bench area, with a tendency to be above empirical estimates in the vicinity of RM 2.5 to RM 2.8. Within the west bench area, between RM 2.0 and RM 4.0, the model tended to over-predict empirically derived estimates of net sedimentation rates. Downstream of RM 2.0 in both bench areas, the model results were less variable than the empirically derived estimates, but the model results were in agreement with the general trend of the empirically derived estimates.

Table 3-9. Comparison of net sedimentation rates derived using empirical data and the STM

Core ID[a]	River Mile	Net Sedimentation Rate (cm/yr)		Were Rates Within 1 cm/yr of Each Other?
		Empirical Estimate[b]	Model Estimate[b]	
SC1	0.0	0.9 – 1.7	1.3	yes
SC3	0.1	0.4	1.2	yes
SC5	0.1	0.5 – 0.9	1.3	yes
Sg1a	0.2	0.9 – 1.3	1.2	yes
SC4	0.2	1.1 – 1.7	0.76	yes
B3	0.2	4.9 – 5.1	1.3	no
SC6	0.3	2.3 – 3.0	1.1	no
SC8	0.4	1.2 – 3.3	1.1	yes
SC7	0.4	0.7	1.1	yes
DUD006	0.5	1.9 – 3.1	4.0	yes
SC9	0.5	1.8	1.2	yes
SC10	0.5	2.4 – 2.9	1.5	yes
SC11	0.5	0.4 – 0.5	1.3	yes
SC12	0.6	1.2 – 2.9	1.7	yes
Sg2	0.7	0.5 – 0.6	1.1	yes
SC13	0.9	1.1 – 2.1	1.6	yes
SC14	0.9	2.9 – 4.0	0.0	no
SC15	0.9	1.4 – 4.8	1.7	yes
SC16	1.0	1.2 – 3.8	1.9	yes
SC17	1.0	2.9	1.9	yes
SC18	1.0	0.7 – 1.9	2.1	yes

Core ID[a]	River Mile	Net Sedimentation Rate (cm/yr)		Were Rates Within 1 cm/yr of Each Other?
		Empirical Estimate[b]	Model Estimate[b]	
SC19	1.0	3.0 – 4.7	1.5	no
SC21	1.0	2.3 – 4.9	1.5	yes
Sg3	1.2	1.9 – 2.1	2.3	yes
SC23	1.2	3.3 – 4.8	2.5	yes
SC24	1.2	0.7 – 1.1	1.8	yes
SC25	1.3	1.2 – 3.0	2.0	yes
Sg4	1.4	1.6 – 2.0	2.5	yes
SC27	1.4	0.9 – 2.6	2.6	yes
SC29	1.4	0.4 – 0.6	2.5	no
SC30	1.6	1.1	2.5	no
SC31	1.7	1.0 – 1.5	2.5	yes
SC32	1.7	1.7 – 2.5	2.5	yes
S6	1.8	2.2 – 3.2	4.7	no
SC34	1.9	2.2	0.26	no
SC33	1.9	2.9 – 3.8	2.6	yes
Sg5a	1.9	1.4 – 1.6	0.45	yes
SC35	2.0	2.8 – 3.7	3.1	yes
SC36	2.1	2.2 – 2.8	2.3	yes
SC37	2.2	1.0 – 2.6	1.8	yes
SC39	2.2	2.9	3.3	yes
S13	2.2	1.5	3.4	no
SC40	2.3	0.7	2.8	no
Sg6	2.3	2.5 – 2.7	1.5	yes
SC41	2.4	2.6	2.0	yes
SC42	2.5	2.7	4.7	no
SC43	2.6	0.5 – 3.0	5.2	no
SC44	2.7	0.3 – 1.4	0.21	yes
Sg7	2.7	1.9 – 2.1	0.17	no
SC46	2.7	1.8 – 2.3	5.6	no
SC-11	2.9	1.5 – 2.2	2.5	yes
SC47	3.0	1.0 – 2.2	0.02	yes
SC48	3.3	0.4 – 0.5	2.1	no
SC49	3.5	2.4 – 4.3	2.3	yes
Sg9	3.6	0.3 – 0.9	6.9	no
Sg10	3.6	1.6 – 1.8	3.7	no
SC50	3.8	0.9 – 1.5	0.06	yes
S3	3.8	3.0 – 3.3	3.5	yes
SC51	3.8	0.6	2.3	no
Sg11b	3.9	0.6 – 0.7	1.7	yes
SC52	3.9	0.5 – 0.9	1.7	yes

Core ID[a]	River Mile	Net Sedimentation Rate (cm/yr)		Were Rates Within 1 cm/yr of Each Other?
		Empirical Estimate[b]	Model Estimate[b]	
SC53	4.2	3.1 – 3.3	2.2	yes
SC54	4.3	1.8 – 2.7	11	no
Sg12	4.3	> 2.0	11	no
Sg13	4.4	2.3 – 2.6	61	no
SC56	4.7	0.8 – 1.0	24	no
SC55	4.9	0.3 – 1.0	34	no

[a] Core IDs are shown on Map 3-3.

[b] Net sedimentation rates (both empirical and modeled) are shown on Map 3-3. This map shows the modeled rates as ranges, but single values were obtained from the STM output for use in this table.

ID – identification

STM – sediment transport model

3.2.5.3 Bed composition

A primary objective of this analysis was to evaluate the effects of external sediment loads on the composition of the surface layer (0 to 10 cm) sediment. This type of analysis will be used in the FS to estimate the rate and magnitude of sediment quality improvements in the future. Large-scale comparisons of the three reaches provided an assessment of the relative effects of upstream and lateral sediment loads on surface layer composition over the course of the 30-year period (Table 3-8). As shown in Table 3-8, the sediment bed will be composed mostly of upstream solids from the Green River (81 to 96% composition) over time, with less than 2% of the load coming from lateral sources.

The spatial distribution of bed-source content in the surface layer at the end of the 30-year simulation period is shown on Map 3-10. The relatively high net sedimentation rates estimated in Reaches 1 and 3 resulted in significant estimates of decreases in bed-source content (QEA 2008). The spatial distribution of upstream-source content in surface layer sediment at the end of the 30-year period was a mirror image of the bed-source content; upstream-source content was high at locations where bed-source content was low and vice versa (Map 3-11). In general, the estimated effects of sediment loads from lateral sources were greatest in the immediate vicinity of the discharge points of creeks, SDs or CSOs (Map 3-12). However, it is important to note that over 200 SDs and CSOs were represented by only 21 point sources that discharged into the LDW at 16 discrete locations in the model. Therefore, the true lateral-source content in the surficial bed layer is expected to be more widely distributed.

In Reaches 2 and 3, lateral-source contributions were greater than 1% in surface layer sediment in the slips near the SD/CSO discharge points. This effect was seen in Slips 4 and 6, located at approximately RM 2.9 and RM 4.2, as well as in the bench areas that extend downstream of near-shore discharge locations. The effects of lateral sources on surface layer composition were more widely distributed in Reach 1, with lateral-

source contributions greater than 1% in a large portion of this reach. Tidal effects within this reach were estimated to spread lateral-source sediment upstream and downstream of the discharge locations. Relatively high lateral-source content values (i.e., greater than 5%) were estimated in the grid cells where the lateral-load discharges were specified. These contributions are likely lower than the estimates because of the aggregation of inputs.

The spatial distributions of surface layer composition shown on Maps 3-10 through 3-12 represent conditions at the end of the 30-year simulation. Temporal variations in surface layer composition over the entire 30-year period indicated that bed-source content is estimated to generally decrease at an approximately exponential rate (QEA 2008).

Sediment mass balances were constructed for the 30-year period to gain additional insights about the movement within the LDW of sediment from bed, upstream, and lateral sources. The details of the mass balance calculations were presented in QEA (2008) and are summarized briefly here. The overall trapping efficiency (TE) for the LDW (RM 0.0 to RM 4.8) was 49% (Figure 3-3). TE is the portion of the incoming sediment load that is deposited within a particular region. TE varied among the three reaches because of differences in the hydrodynamic and sediment transport characteristics of those reaches. The TE of Reach 3 was 36%, which was higher than TE values of 12% and 9% for Reaches 1 and 2, respectively (Figure 3-3). The high TE value for Reach 3 was attributable to the presence of the Upper Turning Basin, which is designed to be an efficient sediment trap to capture a large portion of the sand that is transported from the river into Reach 3. The lowest TE value was in Reach 2 because of the hydrodynamic characteristics of this reach during high-flow events. Reach 1 had a higher TE (12%) than did Reach 2 because of minimal erosion during high-flow events. Reach 1 had a substantially lower TE than did Reach 3 because of the relatively small amount of sand transported into Reach 1 compared with the amount of sand transported into and deposited within Reach 3. Overall, about 50% of the sediment load coming into the LDW from upstream (6,270,000 metric tons over 30 years) settles in the LDW; and the remaining load, composed mostly of finer silt-clay particles, stays suspended in the water column and is transported out of the LDW (3,223,900 metric tons) (Figure 3-3). Approximately 10% of the fine silt-clay particles (Class 1a) that enter the LDW system, either from upstream or lateral sources, are deposited in the LDW. In contrast, 76%, 96%, and >99% of the other particle size classes (medium-coarse silt, fine sand, and medium-coarse sand, respectively) from upstream or lateral sources are deposited in the LDW. Figure 3-3 shows the LDW solids mass balance, illustrating the net depositional environment of the LDW.

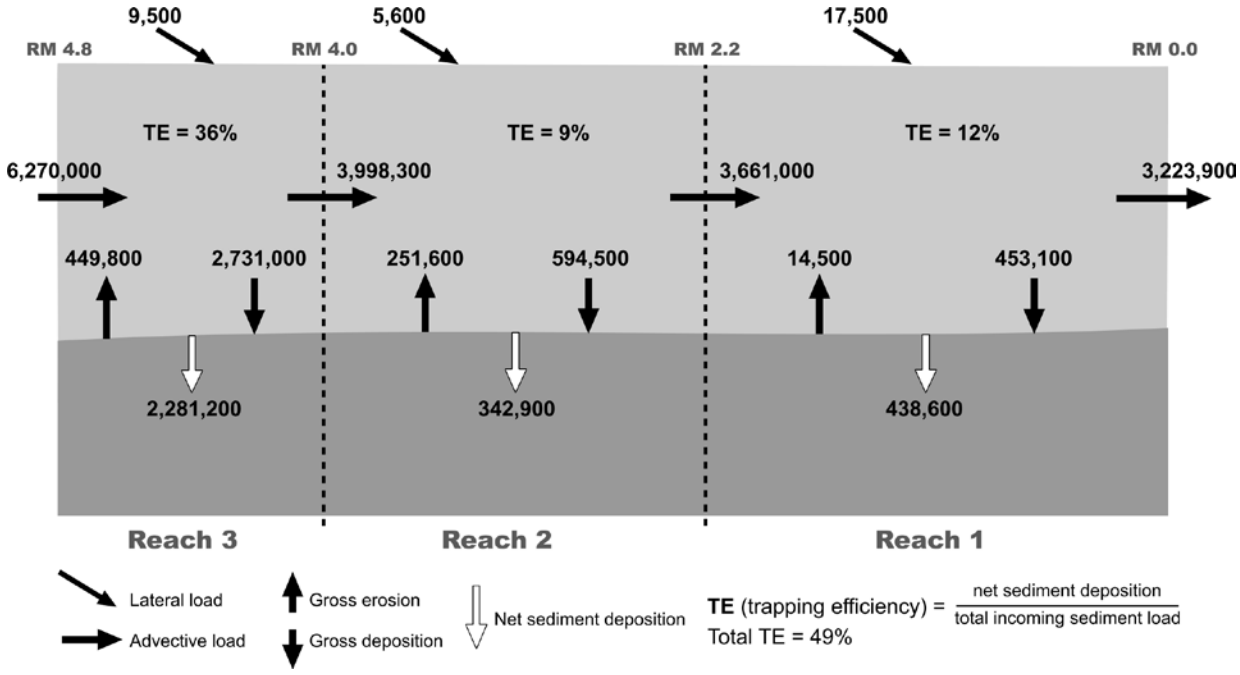

Figure 3-3. Sediment mass balance (in metric tons) in the LDW (RM 0.0 to RM 4.8) for a 30-yr period

A sensitivity analysis was used to evaluate uncertainty in model predictions. The sensitivity of the model to changes in the magnitude and composition of external sediment loads was investigated (see Section 4.4 of the STM report, QEA 2008). The results of the analysis showed that uncertainty in the lateral-source content was about ±40% with respect to the base-case value. The bed-source content varied non-linearly with respect to changes in the upstream-source load magnitude (e.g., doubling the upstream load caused the bed-source content to decrease by about 50%; decreasing the upstream load by 50% caused the bed-source content to increase by about 50%). Changes in the particle size composition of the upstream load resulted in variations that were within 10% of the base-case value. Thus, uncertainty in specifying the magnitude and composition of the upstream- and lateral-source loads produces uncertainty levels of about + 40% and + 50% in the predicted lateral-source and bed-source contents, respectively, in the mixing-zone layer.

3.2.6 Uncertainty analysis

The objective of the uncertainty analysis was to evaluate the effect of uncertainty on model predictions by varying key model input parameters that appeared sensitive to change. Based on the sensitivity analysis results, five model input parameters were selected to quantitatively evaluate model prediction uncertainty: 1) upstream sediment load, 2) settling speeds of Class 1A/1B sediment particles, 3) erosion rate parameters, 4) effective bed roughness, and 5) Class 2/3 particle diameter. Lower- and upper-bound limits for each of these five input parameters were determined, and a factorial analysis was conducted, which resulted in 32 simulations to account for all of the possible combinations of the bounding limits of the five input parameters. Details

of the technical approach for conducting the uncertainty analysis are provided in Appendix D of the STM report (QEA 2008).

The uncertainty analysis demonstrated that upstream sediment load and the settling speed of Class 1A/1B sediment particles were the primary controlling factors of predicted net sedimentation rates over multi-year periods in the LDW. The other three input parameters (i.e., erosion rate parameters, effective bed roughness, and Class 2/3 particle diameter) had only minor effects on multi-year model predictions. The upstream sediment load was specified using the results of two USGS studies, one for 1965-1966 (Harper-Owes 1981) and another for 1995-1996 (Embrey and Frans 2003), which provided good estimates of the magnitude of the Green River load. Class 1A/1B settling speeds were treated as adjustable parameters during model calibration; the model was relatively sensitive to these parameters. The settling speed values were estimated as a result of the calibration process and consequently should be relatively accurate. Therefore, the two primary input parameters controlling predicted net sedimentation rates over multi-year periods were reliably defined by site-specific data and model calibration. Additional results from the STM uncertainty analysis are provided in Appendix D of the STM report (QEA 2008).

The results of the uncertainty analysis summarized here were used to generate realistic lower- and upper-bound uncertainty limits on the model calibration results. Comparisons of the realistic bounding limits with the original calibration results for the navigation channel, east bench, and west bench were made in the STM report (QEA 2008). The uncertainty analysis demonstrated that uncertainty in model input parameters does not change the overall STM conclusions or CSM.

3.3 INTEGRATION AND SYNTHESIS OF SEDIMENT TRANSPORT ANALYSIS RESULTS

The analyses conducted for the STM, in conjunction with empirical and ship-induced bed scour analyses, have resulted in an improved understanding of sediment transport processes in the LDW. A large amount of information on LDW hydrodynamics and sediment transport is presented in the STAR (Windward and QEA 2008) and the STM report (QEA 2008), respectively. Results and findings from the major components of the analyses are integrated and synthesized in this section to produce a clear and concise picture of sediment transport in the LDW. Additional integration of sediment transport analysis results is provided in Section 4.3, where temporal trends in chemical concentrations are discussed, and in Section 10.2.2, where sediment chemistry data are discussed in the context of a chemical CSM.

The first step in understanding sediment transport in the LDW was to understand the hydrodynamics of this saltwater wedge estuary. During low-flow conditions in the Green River, the saltwater wedge extends up to or beyond the upstream portion of Reach 3 (i.e., RM 4.5 to RM 4.8), see Figure 3-4. The saltwater wedge is dominated by two-layer estuarine circulation, with saltier and denser water transported upstream in the lower layer of the water column and fresher water transported downstream in the upper layer. Near-bed velocities and bed shear stresses within the saltwater wedge are

tidally driven and relatively low, which results in minimal bed scour within the saltwater wedge during low-flow conditions. During a high-flow event in the Green River, the toe of the saltwater wedge is pushed downstream to the vicinity of the boundary between Reaches 1 and 2 (i.e., RM 2.0 to RM 2.5). Two-layer estuarine circulation exists in Reach 1 during high-flow events (Figure 3-5). High freshwater inflow from the Green/Duwamish River causes the hydrodynamic characteristics of Reaches 2 and 3 to change from two-layer estuarine circulation (low-flow conditions) to a freshwater tidal river. This change in the hydrodynamic characteristics of these two reaches results in significant increases in near-bed current velocities and bed shear stresses in Reaches 2 and 3 during a high-flow event.

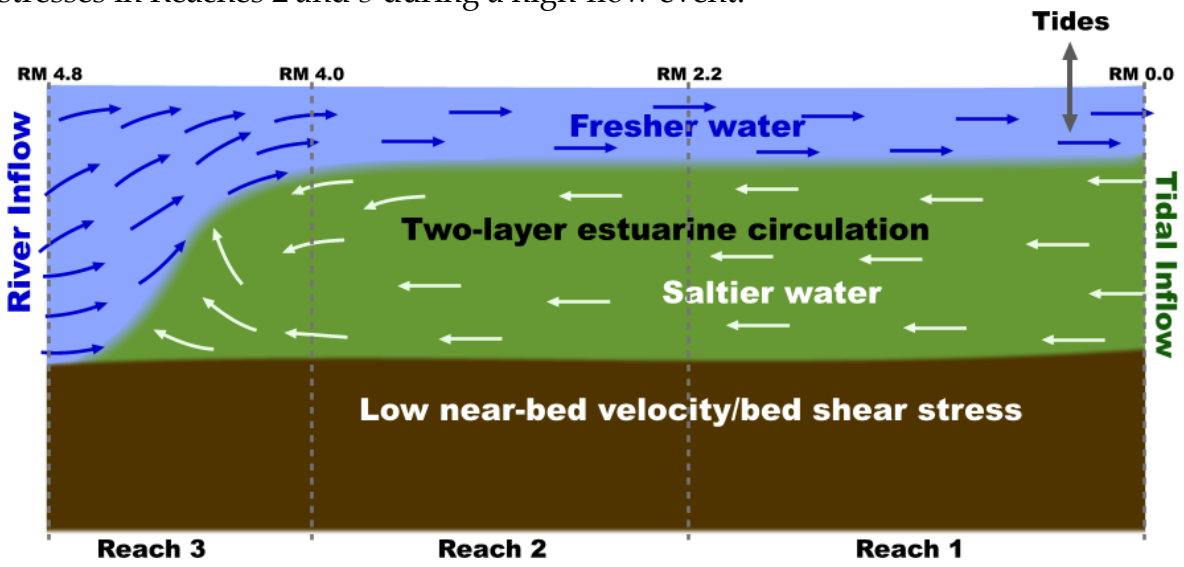

Figure 3-4. Schematic of LDW hydrodynamics during low-flow conditions

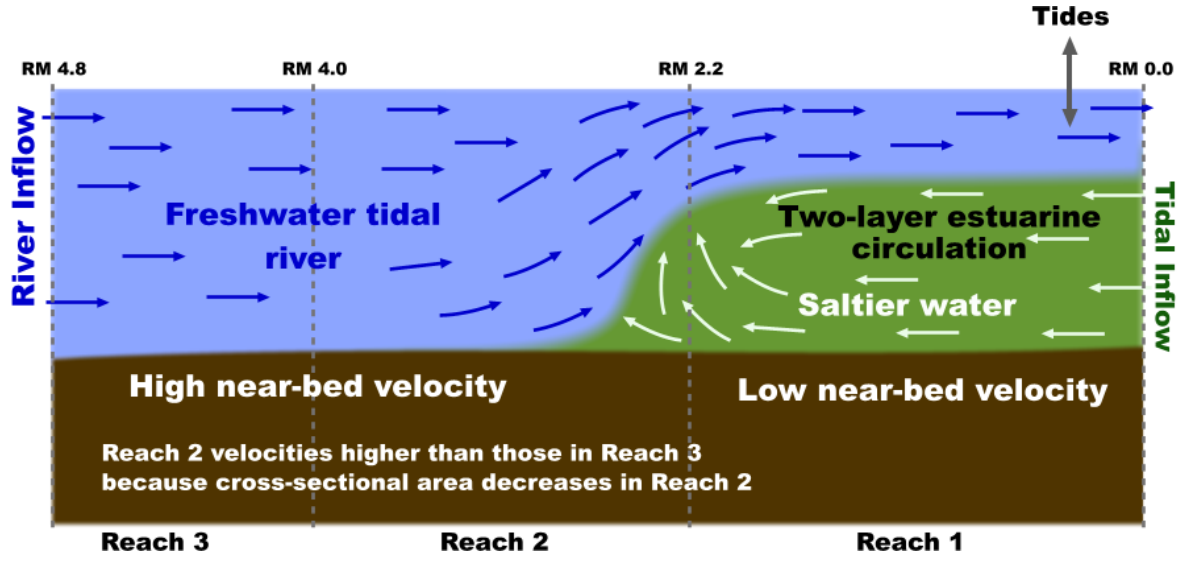

Figure 3-5. Schematic of LDW hydrodynamics during high-flow conditions

3.3.1 Sediment bed stability

Sediment bed stability analyses conducted to date included evaluations of high-flow events, with durations on the order of days to weeks, and long-term simulations over 30 yrs. Overall, model results from both high-flow event and long-term simulations suggested that Reaches 1, 2, and 3 have different sediment transport characteristics, primarily as a result of differences in the hydrodynamic characteristics of each reach. Reach 1 was estimated to have relatively high net sedimentation rate estimates, but these estimates were generally lower than the estimates in Reach 3 because less sand is transported into this portion of the LDW than into the upstream reach. Reach 2 was estimated to have spatially variable net sedimentation rates, with areas of relatively low net sedimentation. This reach experiences the most erosion during a high-flow event as a result of relatively high bed shear stresses caused by changes in hydrodynamics during an event (i.e., transition from estuarine circulation with a saltwater wedge during low-flow conditions to a freshwater tidal river during high-flow conditions). Reach 3 has the highest net sedimentation rate estimates in the LDW, because of the presence of the Upper Turning Basin, which acts as a sediment "sink" and captures a large portion of the load of sand from the Green River.

During a high-flow event, most of the bed scour is estimated to occur in Reach 2, with Reach 1 having minimal erosion, except in a small area near RM 0.8 to RM 0.9. Limited net erosion is estimated in Reach 3. During a high-flow event with a return period of 100 yrs, the model estimated that only about 18% of the total bed area in the LDW (i.e., about 70 ac) was net erosional, with most of the bed scour occurring in Reach 2. The remaining 82% of the total bed area in the LDW was estimated to be net depositional during a 100-year high-flow event (Figure 3-6). A large majority of the net erosion was estimated for the surface layer (i.e., 0 to 10 cm) of the bed, with only about 6% of the total bed area (about 22 ac) having net erosion greater than about 10 cm. The maximum depth of bed scour during a 100-year high-flow event was estimated to be about 21 cm, although this depth of bed scour was estimated for very small areas. Approximately 78% of the sediment mass eroded from the bed during a 100-year high-flow event was estimated to be redeposited within the LDW, with the remaining 22% transported out of the LDW.

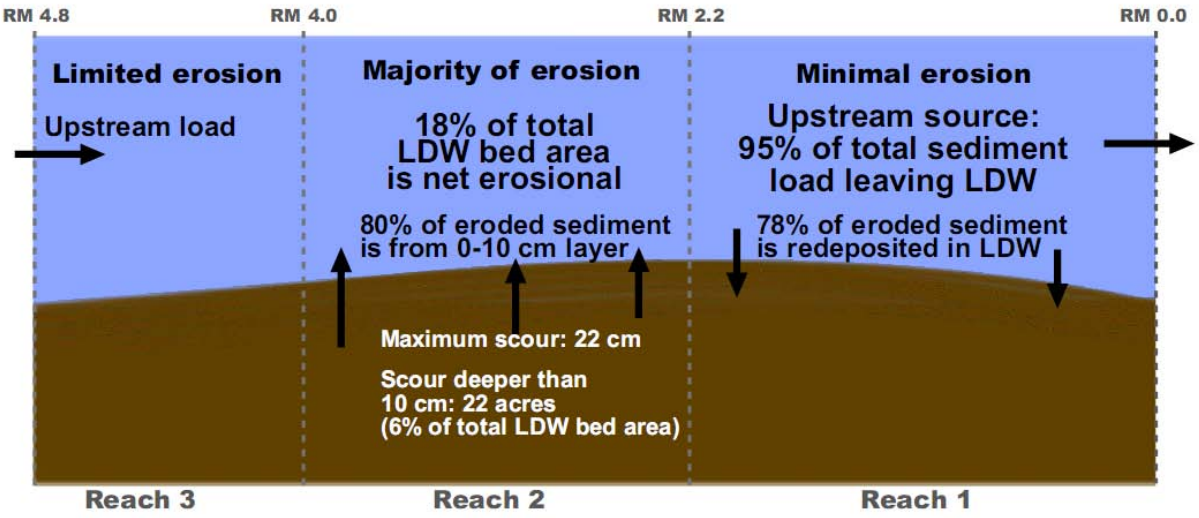

Figure 3-6. Schematic of LDW sediment transport processes during a 100-year high-flow event

Reaches 1, 2, and 3, and thus the entire LDW, were estimated to be net depositional on annual time scales.[35] The general effect of erosion during high-flow events was to reduce the net sedimentation rate in locations where bed scour occurs. Net sedimentation rates on a reach-average basis varied from about 2 cm/year in Reaches 1 and 2 to over 15 cm/year in Reach 3 (not including the Upper Turning Basin). Reach 2 was separated into two sub-reaches based on differences in net sedimentation rates, with the spatially averaged rate in Reach 2A (RM 2.2 to RM 2.6) about 50% higher than the spatially averaged rate in Reach 2B (RM 2.6 to RM 4.0) (Figure 3-7). In general, spatially averaged net sedimentation rates were similar in the navigation channel and bench areas, with differences between the zones being less than a factor of 2 in a particular reach.

[35] Annual time scales refer to time periods of 1 to 10 years, focusing on average or "typical" conditions for the sediment transport processes examined or discussed. Temporal variability in the processes exists, but conclusions or observations generally relate to long-term average conditions.

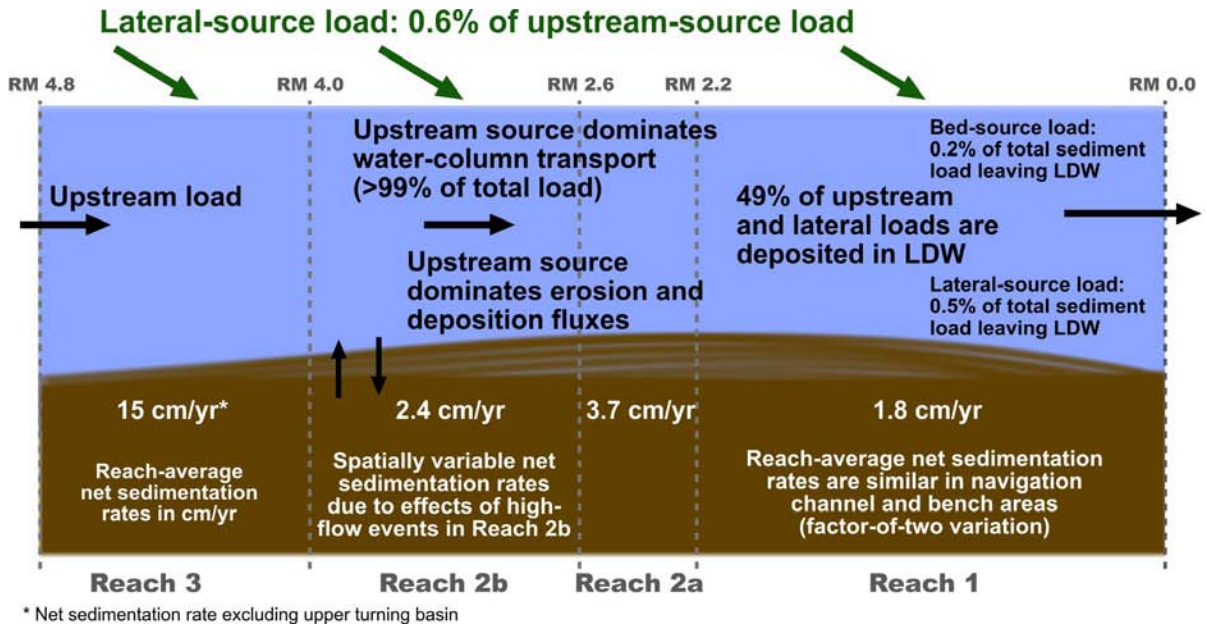

Figure 3-7. Schematic of net LDW sediment transport processes over a 30-year period

Three of the four questions that were established for the STM (see Section 3.2.1) were related to sediment bed stability. The questions and answers are provided below. The answers are based on STM results that represent LDW-wide conditions. Implications for specific areas with respect to remedial decisions will be considered in the FS using several lines of evidence.

- **What areas in the LDW are net depositional, net erosional, or in dynamic equilibrium?** Over the 30-year period, three grid cells in Reach 2 were estimated to be net erosional, but these locations should be considered to be in a state of approximate dynamic equilibrium because the total net erosion over the 30-yr period was estimated to be less than 1 cm. Other than these three locations, the sediment bed in the rest of the LDW was net depositional over the 30-year period, with average net sedimentation rates ranging from less than 0.1 cm/year to greater than 3 cm/yr.
- **What is the effect of high-flow events on episodic scour in otherwise net depositional areas?** Within Reach 1, negligible scour was estimated to occur during high-flow events in most of this reach, with only a minor effect on long-term deposition. A small area near RM 0.8 to RM 0.9 was estimated to experience bed scour during high-flow events, which tended to reduce long-term deposition and resulted in a relatively slow reduction in bed-source content. A small, localized area near RM 0.1 may also experience bed scour during high-flow events. Bed scour estimates were spatially variable in Reach 2,

and episodic erosion[36] during rare events tended to cause relatively low long-term net sedimentation rates at some locations. The relatively high net sedimentation rate estimates in Reach 3 (i.e., greater than 3 cm/yr) minimized the effects of bed scour during high-flow events over multi-year periods.

- What is the potential depth of scour during high-flow events in areas that are net depositional, net erosional, or in dynamic equilibrium? The depth of bed scour was dependent on river flow and tidal conditions during the high-flow event, as well as on the location in the LDW. For a 100-year high-flow event, approximately 20% of the LDW bed area was estimated to experience net erosion, with most of the erosion occurring in Reach 2. A large portion of the net erosion was estimated for the surface layer (i.e., 0 to 10 cm), with about 6% of the LDW bed area having net erosion depths greater than 10 cm. Maximum net erosion depth estimates during a 100-year high-flow event were about 21 cm, although such high net erosion occurred over only very small areas.

3.3.2 Changes in sediment bed composition

Based on the modeling, approximately 99% of the total external sediment particle load (by weight)[37] to the LDW comes from the upstream Green River (Figures 3-2 and 3-7). The annual average sediment load from lateral sources combined was estimated to be 0.6% of the annual average load from the Green River. Approximately 50% of the external sediment load, from upstream and lateral sources, was estimated to be deposited (or trapped) in the LDW (Figure 3-7). Of these deposited particles, approximately 50% are estimated to be medium-coarse sand; the other 50% of the deposited particles consist of fine sand (18% of the total deposited), medium-coarse silt (21% of the total deposited), and fine silt-clay (11% of the total deposited). The characteristics of the deposited particles vary by reach. Approximately 85% of the deposited particles in Reach 3 were estimated to be sand, whereas only 10% and 26% of the deposited particles were estimated to be sand in Reaches 1 and 2, respectively. TE (i.e., portion of incoming sediment load to each reach that is deposited within each reach) also varied among the three reaches as a result of differences in the hydrodynamic and sediment transport characteristics of these reaches. TE was highest for Reach 3 (36%) and lowest for Reach 2 (9%) (Figure 3-3).

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[36] Episodic erosion is bed scour that occurs during an episodic high-flow event or as a result of ship movement. The occurrence of episodic erosion at a particular location does not necessarily mean that an erosional environment exists at that location; a depositional or dynamic equilibrium environment can experience episodic erosion. During these events, current velocities are sufficiently fast to erode the bed at some locations. Generally, episodic erosion occurs over periods of hours to days.

[37] Particle loading should be distinguished from chemical loading, which may differ significantly, depending on the location. For example, chemical loads from lateral sources could have a significant influence on the sediment and water quality in localized areas, even though the relative magnitude of particle loading from those sources is very small compared with particle loading from upstream sources.

Of the sediment load leaving the LDW, sediment originating from the upstream source also represents over 99% of the total suspended solids (TSS) load transported downstream of the LDW (i.e., past RM 0.0), with sediment originating from lateral and bed sources composing about 0.5% and less than 0.2% of the TSS load exiting the LDW at RM 0.0, respectively (Figure 3-2). The contribution from lateral sources to the TSS load exiting the LDW at RM 0.0 was estimated to be about two to three times greater than the contribution from the bed-source sediment.

The bed-source content of the surface layer (0 to 10 cm) was estimated to decrease with time at an approximately exponential rate, primarily because of the deposition of upstream source sediment. The rate of decrease was spatially variable within the LDW as a result of variations in net sedimentation rate. According to net sedimentation rate calculations from the STM (Map 3-9) and Equation 3-5, approximately 90% of the total bed area in the LDW receives 10 cm of new sediment within 10 years or less. In other words, 90% of the LDW has estimated net sedimentation rates of at least 1.0 cm/year (i.e., 1.0 cm/year over a 10-year period equals an additional 10 cm of sediment) (Table 3-10). This sediment is mixed with the existing bedded sediment through various processes, including bioturbation and prop wash. In Reaches 2 and 3, elevated lateral-source contents (i.e., greater than 1%) in surface layer sediment were estimated to generally occur near the SD, CSO, and/or stream discharge points. The effects of lateral sources on surface layer composition were more widely distributed in Reach 1, with elevated lateral-source content values (greater than 1%) occurring over a large portion of this reach. At the end of a 30-year period, reach average values of lateral-source content in the surface layer of the bed were about 1 to 2% (Figure 3-8).

Table 3-10. Cumulative areal percentage of estimated net sedimentation rates

Estimated Net Sedimentation Rate (cm/yr)	Percentage (%)	Cumulative Percentage (%)
≤ 0.5	4.7	4.7
> 0.5 and ≤ 1.0	5.9	10.6
> 1.0 and ≤ 1.5	23.5	34.1
> 1.5 and ≤ 2.0	16.1	50.2
> 2.0 and ≤ 2.5	12.4	62.6
> 2.5 and ≤ 3.0	7.0	69.6
> 3.0 and ≤ 4.0	7.6	77.2
> 4.0 and ≤ 6.0	9.3	86.5
> 6.0 and ≤ 10.0	4.3	90.8
> 10.0	9.2	100

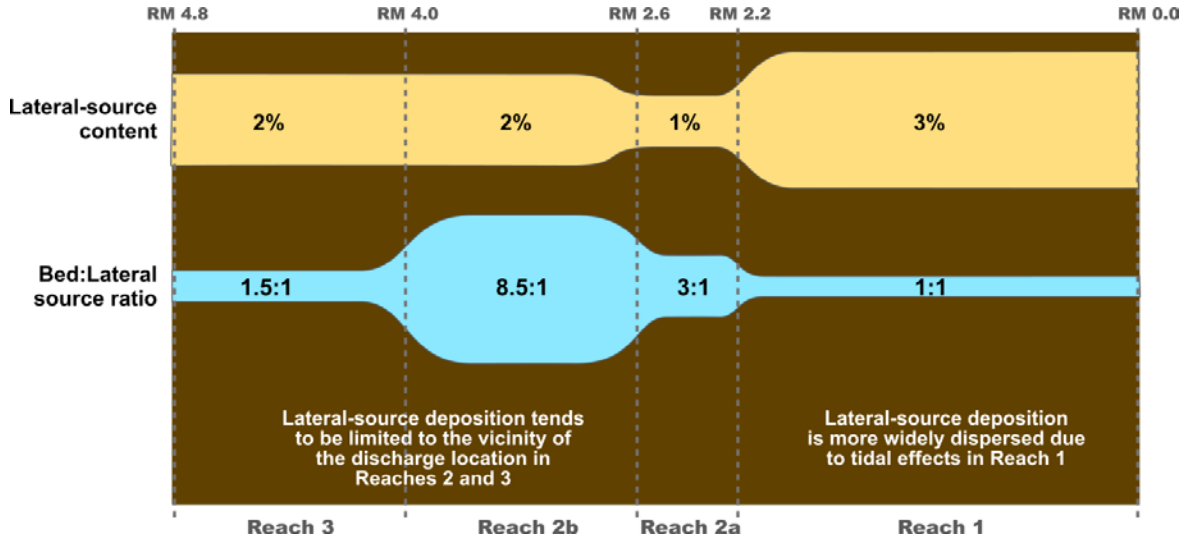

Figure 3-8. Estimated lateral-source content in surface layer (0 to 10 cm)

The fourth question that was established for the STM (see Section 3.2.1) concerns the change in the composition of the surface sediment layer over time as external sediment loads become incorporated into the sediment bed. The average bed-source content of the surface layer (i.e., 0 to 10 cm deep) sediment decreased by 97, 87, and 97% in Reaches 1, 2, and 3, respectively, during the 30-year period. In Reaches 2A and 2B, bed-source content decreased by 97 and 83%, respectively. For areas with net sedimentation rates less than about 0.2 to 0.3 cm/yr, bed-source content in the surface layer decreased at a relatively low rate. There are localized areas with little change in estimated original bed composition, where surface sediment concentrations exceeded the sediment quality standards (SQS) of the SMS, and net burial by sediment from the Green River is not occurring at significant rates. Many of these areas coincide with designated EAAs.

3.3.3 Model predictive capability and reliability

Calibration and validation of the STM, in conjunction with the spatial-scale and uncertainty analyses described in the STM report (QEA 2008), were used to evaluate the accuracy and reliability of the model. The 21-year simulation period used to calibrate and validate the STM was a strong test of the model's capabilities because of the wide range of tidal and river flow conditions during that period. Results of the calibration and validation exercises, as well as the spatial-scale and uncertainty analyses, indicate that the STM is able to adequately predict net sedimentation rates and bed composition in the navigation channel and bench areas at various spatial scales, which indicates that the model effectively simulates sediment transport processes in the LDW. Based on these results, the following conclusions concerning model reliability were developed:

- The STM may be used to refine, confirm, and validate the CSM.

- The analysis provides quantitative uncertainty estimates for STM predictions and CSM components.
- The STM provides a framework to support the evaluation of physical processes that could influence sediment and the effects of potential remedial actions in the LDW.
- Over small spatial-scales, on the order of a grid cell or several grid cells (94% of the grid cells are 1 ac or less), the STM provides one line of evidence, useful in conjunction with other information and data, to guide decision-making.
- The STM provides a reliable framework to extrapolate conditions in areas where no erosion and/or net sedimentation rate data are available.

The reliability of the STM makes it possible to use model results to support FS analyses at multiple spatial scales. The model provides a reliable framework for use as a diagnostic and prognostic tool to extrapolate information to areas in the LDW where no or minimal data are available for FS evaluation. However, the STM provides only one line of evidence for the FS analysis, which will rely on multiple lines of evidence to reach conclusions about the efficacy of one or more remedial alternative.

3.4 SUMMARY OF CONCEPTUAL SITE MODEL FOR SEDIMENT TRANSPORT

A range of empirical and modeling analyses was conducted by Windward and QEA (2008) and QEA (2008), with each analysis focusing on a specific component of sediment transport and bed stability in the LDW. The models developed in the STAR and STM provided several lines of evidence with similar conclusions; however, the uncertainty associated with the results and limitations in the models must be acknowledged. The qualitative conclusions derived from these analyses have a relatively low level of uncertainty, whereas the quantitative results have a higher level of uncertainty. The sensitivity analyses demonstrated that model results have an uncertainty level of a factor of 2 or less that is associated with uncertainty in model input parameters. This level of uncertainty is acceptable for the intended uses of the STM.

The results of the empirical analyses and modeling presented in Section 3.1 and the STM presented in Section 3.2 were used to refine the CSM presented in the STAR (in which the CSM was primarily based on the hydrodynamics and geomorphology), and even earlier versions presented in the Phase 1 RI (in which the CSM was primarily based on sediment properties). There have been step-wise refinements in the CSM developed over the past 4 yrs based on additional studies and modeling analyses that have been conducted for the RI/FS; the CSM may continue to be refined throughout the FS. The key concepts that define the revised CSM include the hydrodynamics of the saltwater estuary, sediment transport characteristics, erosion properties, and bed composition changes, each of which is summarized below.

3.4.1 Waterway-wide characteristics

- The entire LDW was estimated to be net depositional over an annual time scale.
- Net sedimentation rates were generally higher in the navigation channel than in the bench areas. For the navigation channel, the estimated net sedimentation rate decreased from the Upper Turning Basin (near RM 4.5) to downstream areas. For the bench areas, estimated net sedimentation rates were higher in Reaches 1, 2A, and 3 than in Reach 2B. Net sedimentation rate estimates tended to be lower in the intertidal areas than in the subtidal areas. Bed erosion is an episodic process that can be expected to be most pronounced during high-flow events. Episodic bed scour was estimated to occur to the greatest extent in Reach 2, was lower in Reach 3 than in Reach 2, and was minimal in Reach 1.[38] Net erosion is estimated to occur over about 20% or less of the LDW bed area during high-flow events, with most of the net erosion depth estimates being less than 10 cm (maximum of 21 cm or less).
- Ship-induced bed scour tends to behave as a mixing process for surficial sediment. In the scour model, the reworked surficial layer had an upper-bound average thickness of less than about 1 cm in the navigation channel and less than about 1 to 2 cm in the bench areas, with the frequency of such mixing being about 100 to 250 events per year. The scour model does not address localized scour around piers and berthing areas. The extent of this localized scour is unknown.

The CSM states that the LDW is net depositional over annual time scales, with a variable rate of net deposition (i.e., net sedimentation rate). The best estimate of the spatial distribution of net sedimentation rates in the LDW is presented on Map 3-9. Net depositional areas can be categorized as follows:

- **Lower net depositional areas**: areas with net sedimentation rates less than 0.5 cm/yr. In small, isolated areas within this category, the net sedimentation rate is minimal (e.g., less than 0.1 cm/yr) and the bed may approach a state of dynamic equilibrium (i.e., minimal changes in bed elevation over annual time scales).
- **Intermediate net depositional areas**: areas with net sedimentation rates ranging from 0.5 to 2.0 cm/yr.
- **Higher net depositional areas**: areas with net sedimentation rates greater than 2.0 cm/year and up to 140 cm/year in Reach 3.

[38] Similar conclusions were presented in the STAR, but the reach designations were different in the STAR compared with the current CSM. For example, Reach 3 was defined as upstream of RM 3.0; it is now defined as upstream of RM 4.0.

The CSM is discussed below for each of the three LDW reaches separately, based on results of the various modeling exercises. Viewing these three reaches separately provides a more comprehensive understanding of sediment dynamics and bed stability within the LDW.

3.4.2 Reach 1: RM 0.0 to RM 2.2

Reach 1 is net depositional on annual time scales in both the navigation channel and the adjacent bench areas. Based on net sedimentation rates estimated by the model, the navigation channel is classified as intermediate and higher net depositional, with a small area near RM 0.8 to RM 0.9 with lower net deposition. The bench areas range from intermediate to higher net depositional, with two small areas classified as lower net depositional. With respect to episodic erosion, this reach is always within the saltwater wedge, even during a 100-year high-flow event. The permanent presence of the saltwater wedge serves as a protective barrier for the bed within this reach. Consequently, bed shear stresses (i.e., near-bed current velocities) are dominated by tidally driven flows, which are relatively low for all flow conditions. As a result, relatively low bed scour (less than 2 cm) is limited to a small area near RM 0.8 to RM 0.9. The potential for re-exposing buried sediments as a result of scour during high-flow events is minimal in this reach. Ship-induced mixing of the surficial bed layer potentially extends to average depths of about 1 to 2 cm in the bench areas and less than 1 cm in the navigation channel.

3.4.3 Reach 2: RM 2.2 to RM 4.0

Reach 2 is net depositional on annual time scales; however, estimated net sedimentation is spatially variable in this reach, ranging from lower to higher net depositional. Reach 2 includes the saltwater wedge toe during high-flow events; the saltwater wedge extends even farther upstream during average-flow conditions. More net erosion is estimated for this reach during high-flow events than for Reaches 1 and 3, but erosion is generally limited to the upper 10 cm of the sediment bed with maximum net erosion depths of approximately 21 cm or less in small areas. Ship-induced mixing of the surficial bed layer potentially extends to average depths of less than 1 cm in the bench areas and less than 0.1 cm in the navigation channel.

3.4.4 Reach 3: RM 4.0 to RM 4.8

Reach 3 is net depositional on annual time scales. The relatively high net sedimentation rates in this reach indicate that the navigation channel and bench areas are classified as higher net depositional. Modeling results indicate that episodic erosion may occur during high-flow events in Reach 3, but the areal extent of net erosion is significantly less than the areal extent of net erosion in Reach 2. Bed scour during high-flow events (i.e., return period of 2 yrs or greater) is generally limited to the upper 15 cm of the sediment bed, with maximum scour depths of 20 cm. Ship-induced mixing of the surficial bed layer potentially extends to average depths of less than 1 cm in the bench areas and less than 0.1 cm in the navigation channel.

4 Nature and Extent of Contamination

This section discusses the nature and extent of contamination in the LDW based on available data for sediment, tissue, and water. Section 4.1 discusses how data were selected for use in the RI. Section 4.2 presents summaries of chemical distributions in sediment, tissue, and water, with a focus on five chemicals or chemical groups (PCBs, arsenic, carcinogenic PAHs [cPAHs], dioxins and furans, and bis(2-ethylhexyl) phthalate [BEHP]),[39] which are discussed in separate subsections. Section 4.3 discusses total PCB concentrations in subsurface sediment in combination with information on sediment transport to determine whether vertical patterns of PCBs are consistent with the predictions of the STM and the CSM.

4.1 DATA SELECTION, SUITABILITY, AND REDUCTION

This section presents the data quality objectives (DQOs) for available tissue, sediment and water chemistry data for the LDW and describes how data were selected for use in the RI. It also describes how raw data from the laboratories were managed for use in the evaluation of the nature and extent of contamination.

4.1.1 Data quality objectives

DQOs were established to determine whether chemistry data were acceptable for all uses in the RI/FS. The DQO process used to identify acceptable datasets was reviewed and approved by EPA and Ecology (Windward 2001, 2005k). Table 4-1 lists the DQOs that must be satisfied for chemistry data to be considered acceptable for all uses in the RI/FS, categorizing them according to the level at which each DQO would be applied: event, station, sample, or result. A DQO applied at the result level could cause a result record to be qualified for a particular chemical but not for other chemicals analyzed during the same study.

[39] PCBs, arsenic, cPAHs, and dioxins and furans were selected because they are risk driver chemicals for ecological receptors and/or humans, as described in Sections 5.5 and 6.5, respectively. BEHP was selected because it is a risk driver chemical for the benthic invertebrate community with the second highest number of SQS or CSL exceedances (after PCBs).

Table 4-1. Data quality objectives for chemistry data to be considered acceptable for all uses in the RI/FS

LEVEL	DATA QUALITY OBJECTIVE
Event	Hard copy or original electronic copy of data report must be available.
	Field coordinates must be available.
	Data must have been collected since 1990.
	Data must have been collected using appropriate sampling methods.
	Existence and location of supporting documentation (i.e., analytical raw data, chain-of-custody forms, and sample handling descriptions) must be known.[a]
Station	Stations located within dredge prisms or remediated areas should be identified.
Sample	Sediment sample depth must be identified.
	Sample type must be clearly identified.
Result	Data validation qualifiers must be present, or derivable from laboratory qualifiers or QA information, and must be applied in a manner consistent with EPA functional guidelines (EPA 1999c, 2002e).[a]
	Each result must have a laboratory-generated form (usually referred to as a Form 1).[a]
	For non-detects, reporting limits and appropriate qualifiers must be given.
	Calculated values must be recalculated.
	Analytical methods must be identified.

[a] The existence of supporting documentation, the availability of Form 1s, and a review of the presence and application of data validation qualifiers were not considered necessary if the data were previously approved by EPA for all uses in the RCRA or CERCLA programs.

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act

EPA – US Environmental Protection Agency

FS – feasibility study

RCRA – Resource Conservation and Recovery Act

RI – remedial investigation

EPA has not established definitive guidelines specifying the level of data validation required for Superfund investigations. However, EPA Order 5360.1 and Office of Solid Waste and Emergency Response (OSWER) Directive 9355.9-01 (EPA 1993a) requires that environmental measurements be of known quality, verifiable, and defensible. The Office of the Inspector General (OIG) concluded in an audit of Region 9 Superfund sites (EPA 1995) that data used for cleanup decision-making should be validated using EPA functional guidelines (EPA 1999c, 2002e). According to these guidelines, two different levels of data validation are generally recognized for chemistry data. A summary data validation, referred to as QA1, represents a lower level of effort compared with a full validation, referred to as QA2. The elements of summary and full data validations for environmental chemistry data are presented in Table 4-2 (EPA 1999c, 2002e).

Table 4-2. Elements of summary and full data validations for environmental chemistry data

Element	Applicable Analyses	Summary Data Validation (QA1)	Full Data Validation (QA2)
Quality control analysis frequencies	all	X	X
Analysis holding times	all	X	X
Instrument performance check	organic compounds, ICP-MS metals		X
Initial instrument calibration	all		X
Continuing instrument calibration	all		X
Laboratory blanks	all	X	X
ICP interference check sample	metals		X
System monitoring compounds (surrogates)	organic compounds	X	X
Matrix spikes/matrix spike duplicates	all	X	X
Laboratory control samples	all	X	X
ICP serial dilution	metals		X
Field QA/QC (field blanks, field duplicates)	all	X	X
Internal standards	VOCs, SVOCs, ICP-MS metals		X
Pesticide cleanup checks	pesticides/PCBs		X
Target compound identification and quantitation (requires verification of reported results with raw data)	organic compounds		X
RLs	all	X	X

ICP-MS – inductively coupled plasma-mass spectrometry
PCB – polychlorinated biphenyl
QA/QC – quality assurance/quality control
RL – reporting limit
SVOC – semivolatile organic compound
VOC – volatile organic compound

Data of acceptable quality may still be associated with uncertainty in the RI. For example, a chemical not detected in a sample may actually be present, but its concentration below the reporting limit (RL) is unknown. This uncertainty applies to all cases in which chemicals are reported as undetected; the magnitude of this uncertainty increases with increasing RLs. None of the sampling events evaluated for inclusion in the RI were excluded in their entirety because of elevated RLs. The uncertainties associated with data quality and that are relevant to conclusions of the risk assessments are discussed in both the ERA (Appendix A) and HHRA (Appendix B).

4.1.2 Data selection

Many environmental investigations conducted within the LDW have included the collection of samples of surface sediment, subsurface sediment, fish or shellfish tissue,

surface water, sediment porewater, or seep water for chemical analysis. This section describes the datasets selected for defining the nature and extent of contamination.

4.1.2.1 Surface sediment

Surface sediment samples have been collected during numerous sampling events since 1990 (Table 4-3). A baseline surface sediment chemistry dataset was compiled to characterize sediment from the LDW prior to any cleanup actions that occurred after the start of the RI in 2001 (i.e., excluding data collected after cleanup actions at the Duwamish/Diagonal EAA in 2003/2004 and 2005 and at the BDC south storm drain outfall at the Norfolk EAA in 2003[40]). This baseline dataset, which was used in the ERA and HHRA, included surface sediment data collected during the first two rounds of sampling conducted for the RI. A third round of surface sediment data was collected in 2006; these data were combined with the baseline dataset used in the ERA and HHRA to characterize the nature and extent of contamination. This combined baseline/Round 3 dataset is referred to in the remainder of this document as the RI baseline dataset. The criteria for including or excluding surface sediment data in the RI baseline dataset were determined in agreement with EPA and Ecology, as follows (Windward 2006d):

- Surface sediment data were excluded if they were collected before 1991 or after 2005 if they were not sampled as part of the RI. Surface sediment data collected as part of the RI in 2006 were included in the baseline dataset.
- Surface sediment data were excluded if they did not meet the DQOs, as described in Section 4.1.1.
- Surface sediment samples were excluded if the sampled areas were dredged as part of maintenance activities after the sample had been collected.
- Older data were excluded if a sediment sampling location was resampled at a later date within 10 ft of the original location, either as part of a monitoring program or to characterize temporal trends.[41]
- Surface sediment samples were excluded if they were collected after removal actions at two EAAs (i.e., Duwamish/Diagonal and BDC south storm drain outfall near RM 3.9, so that the dataset would represent baseline (pre-early action) conditions.[42]

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[40] Data for these areas following these actions are presented in Sections 4.2.2.1 and Appendix I.4.

[41] If data for an older sample were trumped by a newer sample, data for the older sample were not retained in the RI baseline dataset. Appendix E contains a summary of the data that were omitted as a result of this process (see Table E.1-4). The FS surface sediment dataset will include data for chemicals analyzed in older samples that were not analyzed in newer samples; these data will be included in FS analyses and maps.

[42] There is no EPA policy or guidance on whether baseline risk assessments should take into account the risk reduction achieved by removal actions that occur during the RI/FS. The risk reduction achieved

- Post-cleanup sediment samples near the Duwamish/Diagonal EAA were included only if they had been collected outside of a 200-ft perimeter of the EAA after the removal action (completed in 2004) because samples within 200 ft could have been influenced by the action.
- Sediment samples were categorized as surface sediment samples if they were collected to a depth of 15 cm or less. At 24 locations in the Norfolk EAA, samples were collected from the 0-to-2-cm depth in addition to the 0-to-10-cm depth on either the same date or at a later date. Only data from the 0-to-10-cm depth were included in the RI baseline dataset.

Table 4-3. Selection of surface sediment samples for the RI baseline dataset

FINAL DETERMINATION	NUMBER OF SAMPLES
Included in RI baseline surface sediment dataset.	1,484[a]
Excluded because of subsequent dredging of those sediments.	58
Excluded because of more recent sampling outside of monitoring program.	95
Excluded because of more recent sampling as part of monitoring program.	30
Excluded because of data quality considerations.	23
Excluded because 0-to-10-cm samples were preferred over 0-to-2-cm samples at these locations.	24
Excluded because post-removal sampling was not appropriate for the RI baseline surface sediment dataset at this location (Duwamish/Diagonal).	50
Total number of surface sediment samples	**1,764**

[a] Samples were collected from 1,365 discrete locations.

RI – remedial investigation

Both intertidal and subtidal sediment chemistry data were represented in the RI baseline dataset. The boundary used to differentiate between intertidal and subtidal areas was delineated by the US Fish and Wildlife Service (USFWS) as the shoreline (i.e., land/water interface) at low tide (estimated water level of -2 ft MLLW) using aerial photographs taken in 1999 (2000c). The 1,484 surface sediment samples in the RI baseline dataset were collected from 1,365 discrete locations; 593 of these locations are intertidal and 772 are subtidal (Maps 4-1 and 4-2).

Data quality reviews were conducted on each dataset that met the above criteria and was thus considered for use in the RI/FS. These reviews culminated in a determination of whether an individual dataset was considered suitable for all uses in the RI/FS (Windward 2005k, l, 2007a, e). Summaries of these data quality reviews are presented in Appendix E, Section E.2.

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at these two areas will be evaluated in the FS. Surface sediment data collected after dredging or other remedial activities at the Duwamish/Diagonal and BDC south storm drain areas are described in Sections 4.2.2.1, 10.3.1, and 10.3.15.

Appendix E, Section E.1, presents a more detailed description of the process for selecting data collected from dredged areas, from resampled locations less than 10 ft apart, and from the Duwamish/Diagonal EAA and the BDC south storm drain area. Table E.2-3 in Appendix E, Section E.2, identifies the surface sediment samples that were excluded from the RI baseline surface sediment dataset and the rationale for their exclusion. Approximately 85% of the surface sediment samples (1,484 of 1,764) were included in the RI baseline dataset, as presented in Table 4-3.

The surface sediment sampling events included in the RI baseline dataset are listed in Table 4-4. Additional surface sediment sampling events conducted in the LDW since 1990, but not included in the baseline dataset for one of the reasons presented in Table 4-3, are listed in Table 4-5. These data are discussed from a temporal perspective in Sections 4.2.3.1 (Duwamish/Diagonal) and Appendix I, Sections I.4.1 and I.4.8 (Duwamish/Diagonal and Norfolk). The locations of the RI baseline surface sediment samples collected during site-specific or LDW-wide studies are shown on Maps 4-1 and 4-2, respectively, and sampling locations with their sample identifications (IDs) are shown on Maps 4-3 and 4-4a through 4-4j.

Table 4-4. Summary of sampling events included in the RI baseline surface sediment dataset

Sampling Event	Event Code	Year of Sampling	Chemicals	Number of Sampling Locations[a]	Source
LDW RI: surface sediment sampling for chemical analyses	LDWRI-SurfaceSediment Round3	2006	metals, SVOCs, PCB Aroclors, dioxins and furans on subset of samples, butyltins, conventionals[b]	44	Windward (2007c)
LDW RI: chemical analyses of benthic invertebrate and clam tissue samples and co-located sediment samples	LDWRI-Benthic	2005	metals, SVOCs, PCB Aroclors, selected PCB congeners on subset of samples, butyltins, conventionals[b]	35	Windward (2005a)
LDW RI: surface sediment sampling for chemical analyses and toxicity testing	LDWRI-SurfaceSediment Round1 & Round2	2005	metals, SVOCs, PCB Aroclors, selected PCB congeners and dioxins and furans on subset of samples, butyltins, conventionals[b]	160	Windward (2005c, d)
Boyer Towing dock replacement	Boyer Towing	2004	metals, SVOCs, PCB Aroclors, TBT, conventionals[b]	3	WR Consulting (2004)
Slip 4 EAA site characterization	Slip4-EarlyAction	2004	PCB Aroclors, mercury	30	Integral (2004)
Rhône-Poulenc surface/subsurface sampling	RhônePoulenc 2004	2004	metals, organochlorine pesticides, SVOCs, conventionals[b]	21	EPA (2005d)
Triad approach to characterize PCB in a Washington riverine sediment site (USACE)	Jorgensen August 2004	2004	metals, PCB Aroclors, SVOCs, conventionals[b]	43	Wakeman (2005)
Duwamish/Diagonal perimeter monitoring – pre-dredge	DuwDiag-October2003	2003	metals, PCB Aroclors, organochlorine pesticides, SVOCs, conventionals[b]	12	King County et al. (2005b)

Sampling Event	Event Code	Year of Sampling	Chemicals	Number of Sampling Locations[a]	Source
Terminal 117 EAA site characterization	T117 Boundary Definition	2003-2004	PCB Aroclors; metals, TBT and SVOCs on selected samples, conventionals[b]	54	Windward et al. (2004a, b)
Boeing Plant 2 transformer investigation – Phase 1	Plant 2-Trans-former Phase1	2003	PCB Aroclors, conventionals[b]	6[c]	Floyd Snider McCarthy (2004)
Norfolk CSO (Duwamish River) sediment cap recontamination – Phase I investigation	Ecology-Norfolk	2002	PCB Aroclors, conventionals[b]	17	Ecology (2003)
Norfolk CSO sediment remediation project 5-year monitoring program: Annual monitoring report – year 3, April 2002	Norfolk-monit5	2002	metals, PCB Aroclors, SVOCs, conventionals[b]	1	King County (2002a)
Norfolk CSO 5-year monitoring program, year 2, April 2001	Norfolk-monit4	2001	metals, PCB Aroclors, SVOCs, conventionals[b]	1	King County (2001a)
Norfolk CSO 5-year monitoring program – 12-month post-construction	Norfolk-monit3	2000	metals, PCB Aroclors, SVOCs, conventionals[b]	1	King County (2000c)
Norfolk CSO 5-year monitoring program – supplemental nearshore sampling	Norfolk-monit2b	2000	metals, PCB Aroclors, SVOCs, conventionals[b]	3	King County (2000b)
Outfall and nearshore sediment sampling report, Duwamish facility	James Hardie Outfall	2000	metals, PCB Aroclors, SVOCs, conventionals[b]	9	Weston (2000)
Norfolk CSO 5-year monitoring program – 6-month post-construction	Norfolk-monit2a	1999	metals, PCB Aroclors, SVOCs, conventionals[b]	2	King County (2000d)
Norfolk CSO 5-year monitoring program – post-backfill	Norfolk-monit1	1999	metals, PCB Aroclors, SVOCs, conventionals[b]	2	King County (1999f)
EPA site inspection: Lower Duwamish River	EPA SI	1998	metals, PCB Aroclors, selected PCB congeners, and SVOCs; organochlorine pesticides, dioxins and furans, TBT, and VOCs on subset of samples; conventionals[b]	251	Weston (1999a)
King County CSO water quality assessment for the Duwamish River and Elliott Bay	KC WQA	1997	metals, PCB Aroclors, SVOCs, tetrabutyltin, conventionals[b]	14	King County (1999e)
Duwamish Waterway Phase 1 site characterization	Boeing SiteChar	1997	metals, PCB Aroclors, SVOCs, conventionals[b]	79[d]	Exponent (1998)
Duwamish Waterway sediment characterization study	NOAA SiteChar	1997	total PCBs, selected PCB congeners, total polychlorinated terphenyls, conventionals[b]	299	NOAA (1997, 1998)
Seaboard Lumber Phase 2 site investigation	Seaboard-Ph2	1996	metals, PCB Aroclors, SVOCs, conventionals[b]	20	Herrera (1997)
Rhône-Poulenc seep sampling	Rhône-Poulenc RFI-3	1996	metals, phenols	14	Rhône-Poulenc (1996)

Sampling Event	Event Code	Year of Sampling	Chemicals	Number of Sampling Locations[a]	Source
RCRA facility investigation Duwamish Waterway sediment investigation, Plant 2 – Phase 2b	Plant 2 RFI-2b	1996	metals, PCB Aroclors, phthalates, conventionals[b]	36	Weston (1998)
Duwamish/Diagonal cleanup study – Phase 2	Duw/Diag-2	1996	metals, PCB Aroclors, SVOCs, conventionals[b]	10	King County (2000a)
Duwamish/Diagonal cleanup study – Phase 1.5	Duw/Diag-1.5	1995	metals, PCB Aroclors, SVOCs, conventionals[b]	9	King County (2000a)
Norfolk CSO sediment cleanup study – Phase 3	Norfolk-cleanup3	1995	PCB Aroclors, SVOCs, conventionals[b]	12	King County (1996)
Norfolk CSO sediment cleanup study – Phase 2	Norfolk-cleanup2	1995	metals, organochlorine pesticides, PCB Aroclors, selected PCB congeners, SVOCs, conventionals[b]	2	King County (1996)
RCRA facility investigation, Duwamish Waterway sediment investigation, Plant 2 – Phase 2a	Plant 2 RFI-2a	1995	metals, PCB Aroclors SVOCs, conventionals[b]	54	Weston (1998)
RCRA facility investigation, Duwamish Waterway sediment investigation, Plant 2 – Phase 1	Plant 2 RFI-1	1995	metals, PCB Aroclors, TPH, SVOCs, VOCs, conventionals[b]	66	Weston (1998)
Duwamish/Diagonal cleanup study – Phase 1	Duw/Diag-1	1994	metals, organochlorine pesticides, PCB Aroclors, SVOCs, conventionals[b]	31	King County (2005a)
Norfolk CSO sediment cleanup study – Phase 1	Norfolk-cleanup1	1994	metals, organochlorine pesticides, SVOCs, PCB Aroclors, conventionals[b]	13	King County (1996)
Rhône-Poulenc RCRA facility investigation for the Marginal Way facility – Round 2	Rhône-Poulenc RFI-2	1994	SVOCs, conventionals[b]	6	Rhône-Poulenc (1995)
Results of sampling and analysis, sediment monitoring plan, Duwamish Shipyard, Inc.	Duwamish Shipyard	1993	metals, SVOCs, TBT, conventionals[b]	1	Hart Crowser (1993)
Harbor Island remedial investigation	Harbor Island RI	1991	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs, TPH, TBT, conventionals[b]	9	Weston (1993b)

[a] Samples are surface sediment grab samples from 0 to 15 cm unless otherwise noted.

[b] Conventionals may include all or some of the following parameters: grain size, pH, total organic carbon, and total solids.

[c] Five samples were collected from 0 to 5 cm. The top interval of 0 to 15 cm from a subsurface sediment core was also included in the RI baseline surface sediment chemistry dataset.

[d] Sample total does not include three reference samples that were collected upstream of the study area.

CSO – combined sewer overflow
EAA – early action area
EPA – US Environmental Protection Agency
LDW – Lower Duwamish Waterway
NOAA – National Oceanic and Atmospheric Administration
PCB – polychlorinated biphenyl
RCRA – Resource Conservation and Recovery Act
RFI – RCRA facility investigation
RI – remedial investigation
SI – site inspection
SVOC – semivolatile organic compound
TBT – tributyltin
TPH – total petroleum hydrocarbon
USACE – US Army Corps of Engineers
VOC – volatile organic compound
WQA – water quality assessment

Table 4-5. Summary of sampling events not included in the RI baseline surface sediment dataset

Sampling Event	Event Code	Year	Chemicals	Number of Sampling Locations[a]	Reference
BDC 2006 annual sampling of south storm drain system – year 3	Boeing Developmental Center-2007	2007	PCB Aroclors, conventionals[b]	3	CALIBRE (2007)
Duwamish Diagonal March 2007 cap monitoring – year 3	DuwDiagonal April2007	2007	metals, SVOCs, PCB Aroclors, organochlorine pesticides, conventionals[b]	23	King County (2007c, d, e)
Duwamish Diagonal March 2006 cap monitoring – year 2, perimeter sediment characterization and enhanced natural recovery cap sediment characterization – year 1	DuwDiagMarch 2006	2006	metals, SVOCs, PCB Aroclors, organochlorine pesticides, conventionals[b]	23	King County (2006d, e, 2007b)
Duwamish Diagonal January-February 2005 post-dredge perimeter – before thin-layer cap placement	DuwDiagJan 2005	2005	metals, SVOCs, PCB Aroclors, organochlorine pesticides, conventionals[b]	20	King County (2005g)
Duwamish Diagonal March 2005 post-dredge perimeter – after thin-layer cap placement	DuwDiagMarch 2005	2005	metals, SVOCs, PCB Aroclors, organochlorine pesticides, conventionals[b]	7	King County (2005f)
Duwamish Diagonal April 2005 baseline cap monitoring – year 1	DuwDiagApril 2005	2005	metals, SVOCs, PCB Aroclors, organochlorine pesticides, conventionals[b]	6	King County (2005e)
Duwamish Diagonal August 2005 baseline cap monitoring – year 1	DuwDiagonal August 2005	2005	metals, SVOCs, PCB Aroclors, organochlorine pesticides, conventionals[b]	1	King County (2005h)
Boeing Developmental Center 2005 annual sampling of south storm drain system – year 2	Boeing Developmental Center-2005	2005	PCB Aroclors, conventionals[b]	3	CALIBRE (2006)
Boeing Developmental Center 2004 annual sampling of south storm drain system – year 1	Boeing Developmental Center-2004	2004	PCB Aroclors, conventionals[b]	3	Calibre (2005)
Duwamish Diagonal June 2004 baseline cap monitoring – year 0 (post-cap placement)	DuwDiagJune 2004	2004	metals, PCB Aroclors, SVOCs, conventionals[b]	7	King County (2005i)
Duwamish Diagonal March 2004 post-dredge perimeter sediment characterization	DuwDiagonal-March2004	2004	metals, SVOCs, PCB Aroclors, organochlorine pesticides, conventionals[b]	12	King County (2004b)
Norfolk CSO sediment remediation project 5-year monitoring program; annual monitoring report – year 5, April 2004	Norfolk-monit7	2004	metals, PCB Aroclors, SVOCs, conventionals[b]	4[c]	King County (2005d)

Sampling Event	Event Code	Year	Chemicals	Number of Sampling Locations[a]	Reference
Norfolk CSO sediment remediation project five-year monitoring program: Annual monitoring report – year 4, April 2003.	Norfolk-monit6	2003	metals, PCB Aroclors, SVOCs, conventionals[b]	4[c]	King County (2003)

[a] Samples are surface sediment grab samples from 0 to 15 cm unless otherwise noted.

[b] Conventionals may include all or some of the following parameters: grain size, pH, total organic carbon, and total solids.

[c] These locations were resampled during the Round 3 RI surface sediment sampling in 2006; thus the data from 2003 and 2004 were superseded by the more recent data from 2006.

BDC – Boeing Developmental Center
EAA – early action area
PCB – polychlorinated biphenyl
RI – remedial investigation
SVOC – semivolatile organic compound
TOC – total organic carbon
VOC – volatile organic compound

The baseline surface sediment dataset used in both the ERA (Appendix A) and HHRA (Appendix B) did not include data collected during the Round 3 RI sampling event, and therefore contained fewer data. Round 3 sampling was conducted in October 2006, and results were not available for inclusion in the draft ERA or the draft HHRA, which were submitted to EPA and Ecology in August 2006 and September 2006, respectively. Prior to Round 3, the baseline dataset included a total of 1,446 surface sediment samples collected from 1,329 discrete locations throughout the LDW. Round 3 included the collection of 47 additional surface sediment samples from 44 discrete locations. Appendix C presents an evaluation of whether the risk assessment conclusions would have been different if Round 3 surface sediment data had been included.

4.1.2.2 Subsurface sediment

Numerous subsurface sediment sampling events have been conducted since 1990.[43] All subsurface sediment sampling events included in the RI dataset are summarized in Table 4-6 (for areas that have been dredged) and in Table 4-7 (for areas that have not been dredged) and the locations of subsurface samples collected during site-specific and LDW-wide studies are shown on Maps 4-5 and 4-6, respectively. Sampling locations, including the sample IDs, are presented on Maps 4-7a through 4-7d. Sampling locations with data for specific 2-ft core intervals are shown on Maps 4-8a through 4-8c.

[43] Since 1990, no subsurface sediment datasets have been excluded from the RI dataset because of data quality issues.

Table 4-6. Summary of subsurface sediment sampling events included in the RI dataset in areas that have been dredged

Sampling Event	Event Code	Year of Sampling	Chemicals	Sample Summary	Sample Location Status	Reference
PSDDA characterization at the Lehigh Northwest Duwamish Waterway facility	LehighNW	2004	metals, PCB Aroclors, organochlorine pesticides, SVOCs, conventionals[a]	3 samples (impact corer) from 4 locations; 2 from 0 to 120 cm, 1 from 120 to 150 cm below mudline	Area was dredged in 2004.	MCS (2004d)
Sediment characterization results for the Duwamish River navigational channel turning basin	Turning-basin	2003	metals, PCB Aroclors, organochlorine pesticides, SVOCs, conventionals[a]	5 samples (vibracorer) from 5 locations; collected to depths of 144 to 390 cm	Area was most recently dredged in 2004.	Anchor (2003)
Glacier Northwest cement terminal	Glacier NW	2002	metals, PCB Aroclors, organochlorine pesticides, SVOCs, TBT, conventionals[a]	9 samples (vibracorer), each made from 3 separate cores collected to 90 to 150 cm below mudline	Area was dredged in 2005.	Pacific International Engineering (2002)
Dredge material characterization, Duwamish Yacht Club	Duwam Yacht Club	1999	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs, TBT, conventionals[a]	6 samples (vibracorer) from 6 locations, each made from 2 separate cores collected from 50 to 65 cm below mudline	Area was dredged in 1999.	Hart Crowser (1999)
Sediment sampling and analysis, James Hardie Gypsum, Inc. – Round 1	Hardie Gypsum-1	1999	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs, conventionals[a]	5 samples (vibracorer) made from single cores down to 120 cm below mudline	Area was dredged in 1999.	Spearman (1999)
Sediment sampling and analysis, James Hardie Gypsum, Inc. – Round 2	Hardie Gypsum-2	1999	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs, conventionals[a]	9 samples (vibracorer) made from single cores down to 90 cm below mudline	Area was dredged in 1999.	Spearman (1999)
EPA site inspection: Lower Duwamish River	EPA SI	1998	metals, PCB Aroclors and selected congeners, organochlorine pesticides, SVOCs, VOCs, TBT, conventionals[a]	33 samples (vibracorer) from 17 locations; 1 to 2 samples collected at each location, from 0 to 60 and 60 to 120 cm below mudline	The area at RM 0.5 (DR008) was dredged in 2003/2004.	Weston (1999a)
Dredge material characterization Hurlen Construction Company & Boyer Alaska Barge Lines berthing areas	Hurlen-Boyer	1998	metals, PCB Aroclors, organochlorine pesticides, SVOCs, TBT, TPH, conventionals[a]	6 samples (vibracorer) from 2 locations at Boyer and 4 locations at Hurlen, each made from 2 separate cores collected from 60 to 120 cm below mudline	Area was dredged in 1998.	Hart Crowser (1998)

Table 4-6, cont. Summary of subsurface sediment sampling events included in the RI baseline dataset in areas that have been dredged

Sampling Event	Event Code	Year of Sampling	Chemicals	Sample Summary	Sample Location Status	Reference
PSDDA sediment characterization of Duwamish River navigation channel: FY1999 operations and maintenance dredging data report	PSDDA98	1998	metals, PCB Aroclors, organochlorine pesticides, SVOCs, conventionals[a]	10 samples (vibracorer) from 12 locations; 7 samples from 0 to 60 to 90 cm, each from single location; 3 samples from 2 or 3 locations (0 to 60 cm, 0 to 120 cm, and 120 to 360 cm below mudline)	Area was most recently dredged in 1999.	Striplin (1998)
Duwamish/Diagonal cleanup study – Phase 2	Duw/Diag-2	1996	metals, PCB Aroclors, SVOCs, TPH, conventionals[a]	37 samples (vibracorer) from 14 locations; 1 to 6 samples per core, up to 270 cm below mudline	Area was dredged in 2003/2004.	King County (2000a)
1996 USACE Duwamish O&M	PSDDA96	1996	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs, conventionals[a]	4 samples (vibracorer) from 4 locations; collected to a depth of 120 cm below mudline	Area was most recently dredged in 1999.	Striplin (1996)
Proposed dredging of Slip No. 4, Duwamish River, Seattle, WA	Slip4-Crowley	1996	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs, TBT, conventionals[a]	4 samples (vibracorer) composited from sediment at 9 locations; collected to a depth of 70 to 130 cm below mudline	Area was dredged in 1996.	PTI (1996)
Lone Star Northwest and James Hardie Gypsum – Kaiser dock upgrade	Lone Star-Hardie Gypsum	1995	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs, conventionals[a]	5 samples (vibracorer) from 4 locations; 4 collected to a depth of 120 to 150 cm, 1 at 120 to 360 cm below mudline	Area was dredged in 1995.	Hartman (1995)
Norfolk CSO sediment cleanup study – Phase 2	Norfolk-cleanup2	1995	metals, PCB Aroclors and selected congeners, organochlorine pesticides, SVOCs, VOCs, TPH, conventionals[a]	27 samples (vibracorer) from 3 locations; collected at 30- or 60-cm intervals up to 180 cm below mudline	Area was dredged and capped in 1999.	King County (1996)
Duwamish/Diagonal cleanup study – Phase 1	Duw/Diag-1	1994	metals, PCB Aroclors, organochlorine pesticides, SVOCs, TBT, conventionals[a]	12 samples (vibracorer) from 2 locations; collected at 15- to 30-cm intervals down to 150 cm below mudline	Area was dredged in 2003/2004.	King County (2005a)
Norfolk CSO sediment cleanup study – Phase 1	Norfolk-cleanup1	1994	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs, conventionals[a]	3 samples from 1 location; collected at 15 to 30, 30 to 45, and 45 to 60 cm below mudline	Area was dredged and capped in 1999.	King County (1996)
Lone Star Northwest – West Terminal USACE – Seattle, WA	Lone Star 92	1992	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs, conventionals[a]	1 sample (vibracorer) made from 2 separate cores collected to 120 cm below mudline	Area was dredged in 1995.	Hartman (1992)
Sediment sampling and analysis, South Park Marina, Duwamish Waterway, Seattle, WA	South Park Marina	1991	metals, PCB Aroclors, organochlorine pesticides, SVOCs, conventionals[a]	2 samples (vibracorer), each made from 2 separate cores collected to 120 cm below mudline	Area was dredged in 1992.	Spearman (1991b)

Table 4-6, cont. Summary of subsurface sediment sampling events included in the RI baseline dataset in areas that have been dredged

Note: For reference, 1 ft is equal to 30 cm.

[a] Conventionals may include all or some of the following parameters: grain size, pH, total organic carbon, and total solids.

CSO – combined sewer overflow
EPA – Environmental Protection Agency
PCB – polychlorinated biphenyl
PSDDA – Puget Sound Dredged Disposal Analysis
RM – river mile
SVOC – semivolatile organic compound
TBT – tributyltin
TPH – total petroleum hydrocarbons
USACE – US Army Corps of Engineers
VOC – volatile organic compound

Table 4-7. Summary of subsurface sediment sampling events included in the RI dataset in areas that have not been dredged

Sampling Event	Event Code	Year of Sampling	Chemicals	Sample Summary	Sample Location Status	Reference
LDW RI: Subsurface sediment sampling for chemical analyses	LDW Subsurface Sediment 2006	2006	metals, PCB Aroclors, organochlorine pesticides, SVOCs, dioxins and furans, conventionals[a]	213 samples (impact corer or vibracorer) from 56 locations at 1- or 2-ft intervals to depths ranging from 6 to 12 ft below mudline ; 62 samples (impact corer or vibracorer) from 9 locations at 0.5-ft intervals to depths ranging from 2 to 4.5 ft below mudline	Area has not been dredged or remediated.	Windward and RETEC (2007)
Rhône-Poulenc (Rhodia) sediment and porewater investigation	Rhône-Poulenc AugSep 2004	2004	metals, PCB Aroclors, organochlorine pesticides, SVOCs, conventionals[a]	11 subtidal locations (push cores to a depth of 30 cm below mudline) and 13 intertidal locations (clam gun cores to a depth of 1 m below mudline); 2 samples (0 to 10 cm and > 10 cm) from each subtidal and intertidal location	Area has not been dredged or remediated.	EPA (2005d)
Additional vertical characterization, Duwamish Sediment Other Area	DSOAvert char3	2004	PCB Aroclors, conventionals[a]	7 samples (impact corer) from 5 locations; 1 to 3 samples from each location from 60 to 180 cm below mudline	Area has not been dredged or remediated.	MCS (2004b)
Triad approach (immunoassay as a real-time measure) to characterize PCBs in a Washington riverine sediment site	Jorgensen August 2004	2004	metals, PCB Aroclors, conventionals[a]	51 samples (impact corer) from 16 locations; 1 to 5 samples per location from 45 to 180 cm below mudline	Area has not been dredged or remediated.	unpublished data from USACE
Duwamish Sediment Other Area upriver (Area 1) sediment characterization	Jorgensen April 2004	2004	metals, PCB Aroclors, conventionals[a]	75 samples (impact corer) from 22 locations; 2 to 9 samples per location from 0 to 265 cm below mudline	Area has not been dredged or remediated.	MCS (2004c)
Boyer Towing dock replacement	Boyer Towing	2004	metals, PCB Aroclors, SVOCs, conventionals[a]	3 samples (push core) from 3 locations; 30 to 60 cm below mudline	Area has not been dredged.	WR Consulting (2004)
Additional vertical characterization, Duwamish Sediment Other Area	DSOAvert char2	2004	PCB Aroclors, conventionals[a]	28 samples (impact corer) from 15 locations; 1 to 3 samples from each location from 60 to 144 cm below mudline	Area has not been dredged or remediated.	MCS (2004a)
Slip 4 EAA site characterization	Slip4-EarlyAction	2004	PCB Aroclors, mercury, conventionals[a]	57 samples (vibracorer) from 11 locations; 4 to 6 samples taken at each location to a depth of 360 cm below mudline	Area has not been dredged or remediated.	Integral (2004)
Terminal 117 (T-117) EAA site characterization	T-117 Boundary Definition	2003-2004	metals, PCB Aroclors; SVOCs (selected samples), conventionals[a]	107 samples (vibracorer) from 25 locations, 3 to 6 samples collected at each core location to a depth of 300 cm	Area has not been dredged or remediated.	Windward (2004a, b)

Table 4-7, cont. Summary of subsurface sediment sampling events included in the RI dataset in areas that have not been dredged

Sampling Event	Event Code	Year of Sampling	Chemicals	Sample Summary	Sample Location Status	Reference
Preliminary site investigation for the South Park Bridge Project	SouthPark Bridge	2003	metals, TBT, VOCs, SVOCs, pesticides, PCB Aroclors, conventionals[a]	11 samples (mud-rotary drill unit) from 2 locations; 5 to 6 samples from each location at depths from 2.5 to 100 ft below mudline	Area has not been dredged.	Wilbur Consulting (2004)
Boeing Plant 2 transformer investigation – Phase 1	Plant 2-Trans-former Phase1	2003	PCB Aroclors, conventionals[a]	46 samples (impact corer) from 13 locations; 3 to 5 samples at each location from 0 to 240 cm below mudline	Area has not been dredged or remediated.	Floyd Snider McCarthy (2004)
Data report, DSOA vertical characterization and Outfall 12 data collection. Duwamish sediment other area, Boeing Plant 2	DSOAvert char	2001	PCB Aroclors, conventionals[a]	115 samples (impact corer) from 37 locations; 2 to 6 samples at each location; most locations starting at 60 cm to depths of 150 to 280 cm below mudline	Area has not been dredged or remediated.	Pentec (2001)
PSDDA sediment characterization of Duwamish River navigation channel: FY2000 operations and maintenance dredging data report	PSDDA99	1999	metals, PCB Aroclors, organochlorine pesticides, SVOCs, conventionals[a]	20 samples (vibracorer) from 20 locations; 3 borings made at each location; 18 samples from 0 to 120 cm; 2 samples from 120 to 240 cm below mudline	Area was proposed for dredging, but no dredging has been conducted since samples were collected.	SEA (2000a, b)
EPA site inspection: Lower Duwamish River	EPA SI	1998	metals, PCB Aroclors and selected congeners, organochlorine pesticides, SVOCs, VOCs, TBT, conventionals[a]	33 samples (vibracorer) from 17 locations; 1 to 2 samples collected at each location, from 0 to 60 and 60 to 120 cm below mudline	None of the areas were dredged after samples were collected, except at RM 0.5 (DR008), which was dredged in 2003/2004.	Weston (1999a)
RCRA facility investigation Duwamish Waterway sediment investigation, Plant 2 – Phase 2b	Plant 2 RFI-2b	1996	metals, PCB Aroclors, SVOCs, conventionals[a]	44 samples (vibracorer) from 16 locations; 2 to 4 samples per core, up to 480 cm below mudline	Area has not been dredged or remediated.	Weston (1998)
RCRA facility investigation Duwamish Waterway sediment investigation, Plant 2 – Phase 1	Plant 2 RFI-1	1995	metals, PCB Aroclors, TPH, SVOCs, VOCs, conventionals[a]	20 samples (vibracorer) from 12 locations; collected at 15- to 45-cm intervals down to 135 cm below mudline	Area has not been dredged or remediated.	Weston (1998)

Note: For reference, 1 ft is equal to 30 cm.

[a] Conventionals may include all or some of the following parameters: grain size, pH, total organic carbon, and total solids.

DSOA – Duwamish sediment other area (Boeing Plant 2)
EAA – early action area
EPA – Environmental Protection Agency
LDW – Lower Duwamish Waterway
O&M – operation and maintenance
PCB – polychlorinated biphenyl
PSDDA – Puget Sound Dredged Disposal Analysis
RCRA – Resource Conservation and Recovery Act
RI – remedial investigation
SVOC – semivolatile organic compound
TBT – tributyltin
TPH – total petroleum hydrocarbons
USACE – US Army Corps of Engineers
VOC – volatile organic compound

Subsurface data collected in areas that have since been dredged, as noted in Table 4-6, were not included in the data summary tables in Section 4.2. These data were excluded because they do not represent existing conditions. However, data from areas that have been dredged are presented on subsurface sediment maps in Section 4.2 to show spatial patterns of chemicals at depth from a historical perspective.

Subsurface samples were collected from different intervals within the cores, depending on the objectives of the different sampling events. Subsurface sediment data are summarized in Section 4.2 according to sampling intervals; these intervals included 1- or 2-ft intervals collected from the uppermost 10 ft of sediment.[44] Eighty-eight percent of the subsurface data was included in the 1- and 2-ft data summaries presented in Section 4.2 (i.e., 786 of the 895 subsurface samples for which data were available from areas that have not been dredged, including calculated data for some of the 2-ft intervals). The remaining 12% of the samples were not included in the 1- and 2-ft interval data summaries because they were not sectioned into 1- or 2-ft intervals. These data are included in the subsurface sediment data summaries, with all intervals combined in Section 4.2.

4.1.2.3 Fish, shellfish, and benthic invertebrate tissue

Tissue chemistry data for the study area are available for multiple tissue types collected as part of several sampling events conducted since 1990. Data from 421 composite samples of fish and shellfish tissue from both sampling events conducted for the RI and historical sampling events were considered suitable for use (Table 4-8). Approximately 74% of these samples were collected in 2004 through 2007 as part of the RI. The remainder of the samples were collected during five other sampling events from 1992 to 2002 and during a King County sampling event in 2006. Data for tissue samples collected in 2006 and 2007 were not included in datasets used in the ERA (Appendix A) or HHRA (Appendix B) because those risk assessments were completed prior to the availability of these data. Collection locations for fish tissue samples are shown on Map 4-9, and collection locations for invertebrate and shellfish samples are shown on Map 4-10.

The RI dataset also included 45 calculated whole-body concentrations: 10 concentrations calculated from English sole fillet and remainder samples collected in 2005 and 35 concentrations calculated from crab edible-meat and hepatopancreas samples collected in 1997, 2004, 2005, and 2007.

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[44] For the calculation of summary statistics, actual sampling intervals were rounded to the nearest foot. The data for each interval were then assigned to the 1- or 2-ft sampling category that best approximated the actual sampling interval. If there were data for two 1-ft intervals at a particular location, the concentrations were also averaged to obtain a calculated concentration for the corresponding 2-ft interval; these intervals were included in addition to the 1-ft intervals.

Table 4-8. Summary of tissue sampling events used in the RI dataset

Study	Year of Sampling	Species	No. of Composite Tissue Samples	No. of Individuals per Sample	Sample Type	Use in Risk Assessments		Chemicals
						HHRA	ERA	
LDW RI: chemical analyses of fish, crab, and clam tissue samples collected in 2007 (Windward 2009)	2007	English sole	9	5	skin-on fillet			PCB Aroclors (PCB congeners in a subset of samples), lipids
			19	5	whole body			
		starry flounder	1	5	skin-on fillet			
			3	5	whole body			
		Dungeness crab	4	4 – 5	hepatopancreas[a]			
			4	4 – 5	edible meat			
		slender crab	6	5	hepatopancreas[a]			
			6	5	edible meat			
		shiner surfperch	22	10	whole body			
		eastern softshell clam	15	20 – 23	whole body			total arsenic, inorganic arsenic, lipids (a subset of samples was analyzed for PCB aroclors)
			15	20 – 23	whole body – depurated			
King County fish tissue sampling and chemical analysis in the LDW (Anchor and King County 2007)	2006	shiner surfperch	7	10	whole body			PCB Aroclors, phthalates, lipids
		English sole	6[b]	5				
LDW RI: chemical analyses of fish and crab tissue samples collected in 2005 (Windward 2006c)	2005	English sole	10	5	skin-on fillet	X		PCB Aroclors,[d] lipids
			21	5	whole body[c]	X	X	
		Dungeness crab	3	5	edible meat	X	X	
			3	5	hepatopancreas[a]	X	X	
		slender crab	1	5	edible meat	X	X	
			1	10	hepatopancreas[a]	X	X	
		shiner surfperch	22	10	whole body	X	X	
		Pacific staghorn sculpin	4	10	whole body		X	

Table 4-8, cont. Summary of tissue sampling events used in the RI dataset

Study	Year of Sampling	Species	No. of Composite Tissue Samples	No. of Individuals per Sample	Sample Type	Use in Risk Assessments		Chemicals
						HHRA	ERA	
LDW RI: chemical analyses of fish and crab tissue samples collected in 2004 (Windward 2005b)	2004	English sole	7	5	skin-on fillet	X		metals, SVOCs, organochlorine pesticides, PCB Aroclors (PCB congeners in subset of samples), TBT, lipids
			21	5	whole body	X	X	
		starry flounder	1	5	skin-on fillet	X		
			3	5	whole body	X	X	
		Dungeness crab	7	5	edible meat	X	X	
			3	6 – 15	hepatopancreas[a]	X	X	
		slender crab	12	5	edible meat	X	X	
			4	15 – 18	hepatopancreas[a]	X	X	
		shiner surfperch	24	9 – 10	whole body	X	X	
		striped perch	1	12	skin-on fillet	X		
		pile perch	1	12	skin-on fillet	X		
		Pacific staghorn sculpin	24	7 – 10	whole body		X	
LDW RI: chemical analyses of benthic invertebrate and clam tissue samples and co-located sediment samples (Windward 2005a)	2004	benthic invertebrates	20	nd	whole-body		X	metals, SVOCs, alkylated PAHs, organochlorine pesticides, PCB Aroclors (PCB congeners in subset of samples), TBT, lipids
		eastern softshell clam	14	19 – 52	whole-body	X	X	
LDW RI: juvenile chinook salmon sampling (Windward 2004d)	2004	chinook salmon	18	7 – 12	whole-body		X	metals, SVOCs, alkylated PAHs, organochlorine pesticides, PCB Aroclors, TBT, lipids
			1	72[e]	stomach contents		X	
East Waterway, Harbor Island Superfund site: Tissue chemistry results for juvenile chinook salmon collected from Kellogg Island and East Waterway (Windward 2002)	2002	chinook salmon	6	6-7	whole body		X	mercury, PCB Aroclors, lipids
Waterway Sediment Operable Unit Harbor Island Superfund Site – Assessing human health risks from the consumption of seafood (ESG 1999)	1998	English sole	3	5	skinless fillet	X		mercury, TBT, PCB Aroclors
		red rock crab	2	5	edible meat	X		
		Dungeness crab	1	5	edible meat	X		
		red rock crab/ Dungeness crab	1	5	edible meat	X		
		striped perch	2	5 – 8	skin-on fillet	X		

Table 4-8, cont. Summary of tissue sampling events used in the RI dataset

Study	Year of Sampling	Species	No. of Composite Tissue Samples	No. of Individuals per Sample	Sample Type	Use in Risk Assessments		Chemicals
						HHRA	ERA	
King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay (King County 1999e)[f]	1996 – 1997	Dungeness crab	2	3	edible meat	X	X	metals, TBT, SVOCs, PCB Aroclors, lipids
			1	3	hepatopancreas[a]	X	X	
		English sole	3	20	skinless fillet	X		
		shiner surfperch	3	10	whole body		X	
		wild mussels	22	50 – 100	edible meat	X	X	
		transplanted mussels	32	50 – 100	edible meat			
		amphipods	6	nd	whole body		X	
Puget Sound Ambient Monitoring Program – annual sampling (West et al. 2001)	1992	English sole	3	5 – 20	skinless fillet	X		SVOCs, organochlorine pesticides, PCB Aroclors, arsenic, copper, lead, mercury, lipids
	1995	English sole	3	5 – 20	skinless fillet	X		organochlorine pesticides, PCB Aroclors, arsenic, copper, lead, mercury, lipids
	1997	English sole	3	5 – 20	skinless fillet	X		organochlorine pesticides
Elliott Bay/Duwamish River Fish Tissue Investigation (Battelle 1996; Frontier Geosciences 1996)	1995	English sole	3	6	skinless fillet	X		PCB Aroclors, mercury, methylmercury, TBT, lipids

[a] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Total PCB concentrations in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

[b] Nine individual English sole whole-body tissue samples were also collected and analyzed for PCB Aroclors, phthalates, and lipids.

[c] Whole-body samples include 10 composite samples in which concentrations were calculated using results from separate analyses of fillet tissue and remainder tissue (remainder tissue includes tissue and fluids remaining after fillets were removed from the specimens). The calculated English sole whole-body concentrations were based on the relative weights and total PCB concentrations in skin-on fillet and remainder tissues.

[d] A subset of samples from the 2005 sampling event was also analyzed for PCB congeners. These 2005 PCB congener data are included in the discussion of the nature and extent of PCBs in Section 4.2.3. However, the 2005 data were not included in the risk assessments because the final data were not available at the time those documents were prepared.

[e] An unknown fraction of these stomachs were empty.

[f] Additional samples of cooked crab and English sole were collected during the King County WQA (King County 1999e), but these data were not used.

ERA – ecological risk assessment
HHRA – human health risk assessment
LDW – Lower Duwamish Waterway
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SVOC – semivolatile organic compound
RI – remedial investigation
TBT – tributyltin

Some additional tissue chemistry data available for the LDW were not included (Table 4-9). Juvenile chinook salmon whole-body and stomach-content data from Varanasi et al. (1993) and from the National Marine Fisheries Service (NMFS) (2002) were available but were not used because the quality assurance/quality control (QA/QC) data were not readily available for EPA review.[45]

Data for adult salmon were excluded because it was estimated that less than 1% of the PCB body burden in adult salmon migrating through the LDW could have been obtained from prey items consumed in the LDW, based on an analysis presented in Appendix B.

Data associated with two individual shiner surfperch collected in Slip 4 by NMFS, 10 individual shiner surfperch collected and analyzed by LDWG in subarea T2E (RM 2.1 to RM 2.4), 10 individual English sole skin-on fillet samples collected and analyzed by LDWG, and 10 individual English sole skinless fillet samples collected and analyzed by LDWG were also excluded (Table 4-9). These data were not included because only data from composite tissue samples were used. The total PCB concentrations in individual fish samples were generally lower than concentrations in composite samples. In addition, juvenile chinook salmon collected upstream of the LDW during the RI were not used; mean PCB concentrations in these fish were lower than those in fish collected in the LDW.[46]

4.1.2.4 Surface water

LDW surface water data are available from three sampling events conducted for the King County water quality assessment (WQA) in 1996 and 1997 (King County 1999e) and during an additional sampling event in 2005, in which water samples were collected and analyzed for PCBs and conventional parameters (Mickelson and Williston 2006) (Table 4-10).

[45] Total PCB and total DDT concentrations in the NMFS dataset were similar to or lower than concentrations in the RI dataset (Windward 2005f). Total PAH concentrations in LDW juvenile chinook salmon stomach contents from three separate NMFS studies (Arkoosh et al. 1998; McCain et al. 1990; Stein et al. 1995) were higher than those in juvenile chinook salmon stomach contents collected in support of the RI from similar locations in the LDW (Windward 2004d).

[46] Data for upstream sampling were presented in the data report for the juvenile chinook salmon sampling event (Windward 2004d).

Table 4-9. Summary of additional tissue sampling events not included in the RI dataset

Study	Year of Sampling	Species	Sample Type	Number of Individual or Composite Samples	Chemicals	Reference
NMFS Duwamish injury assessment project	2000	shiner surfperch	whole body	2[a]	PCBs, pesticides	NMFS (2002)
		juvenile chinook salmon	whole body	29[a, b]		
			stomach contents	6[b]		
Contaminant exposure and associated biochemical effects in outmigrant juvenile chinook salmon from urban and non-urban estuaries of Puget Sound	1989 – 1990	juvenile chinook salmon	whole body	14[b]	PCBs, pesticides, PAHs	Varanasi et al. (1993)
			stomach contents	6[b]		
LDW RI – juvenile chinook salmon sampling	2003	juvenile chinook salmon	whole body	9[b,c]	Metals, PCB Aroclors, PAHs, organochlorine pesticides, lipids	Windward (2004d)
LDW RI – chemical analyses of fish and crab tissue samples	2004	shiner surfperch	whole body	10[d]	PCB Aroclors, lipids	Windward (2004i)
		English Sole	skinless fillet	10[e]	PCB Aroclors, lipids	Windward (2005b)
			skin-on fillet	10[e]	PCB Aroclors, lipids	
Puget Sound Ambient Monitoring Program – annual sampling	1992 – 1998	adult coho and chinook salmon	fillets	153[b]	SVOCs, arsenic, copper, lead, mercury, PCB Aroclors, organochlorine pesticides, lipids	West (2001)

[a] Individual samples were analyzed.
[b] Composite samples were analyzed.
[c] Collected from upstream locations in the Green River at RM 13 and RM 18.
[d] Individual shiner surfperch analyzed from subarea T2E.
[e] Individual English sole fillet samples analyzed from Area T1.

LDW – Lower Duwamish Waterway
PCB – polychlorinated biphenyl
PAH – polycyclic aromatic hydrocarbon
RI – remedial investigation
RM – river mile
SVOC – semivolatile organic compound

Table 4-10. Summary of surface water sampling events included in the RI dataset

Sampling Event	Dates of Sampling	Location	Depths Sampled	Sample Type	Number of Samples	Chemicals	Reference
King County WQA	Weekly from October 1996 to June 1997[a]	RM 1.1 (near the Brandon CSO outfall) – east and west banks, mid-channel	1 m below surface and 1 m above river bottom	filtered and unfiltered grab samples	465	antimony, arsenic, cadmium, cobalt, copper, lead, mercury, nickel, selenium, silver, thallium, vanadium, zinc, and SVOCs[c]	King County (1999e)
		RM 1.9 (near the southwest Michigan CSO outfall) – east and west banks, mid-channel					
		RM 4.9 (near the Norfolk CSO outfall) – east and west banks[b]					
King County WQA – SPMD sampling	March 26 to April 8, 1997	Duwamish/Diagonal CSO	1 m and 3 m below surface	SPMDs	4	PCBs, organochlorine pesticides, and PAHs	King County (1999e)
		Brandon Street CSO					
King County 2005	Four dates in 2005: August 22, September 26, November 28, and December 19	RM 0.0 at the south end of Harbor Island	1 m below surface and 1 m above river bottom	unfiltered grab samples	15	209 PCB congeners, total PCBs[d]	King County (2005b), Mickelson and Williston (2006)
		RM 3.3 at the South Park Bridge					

[a] After select storm events, samples were collected on three successive days following the event.

[b] Only two transects were sampled because of the narrow width and shallow water depth in the LDW at this location.

[c] PCBs, pesticides, and PAHs were not analyzed in these surface water samples because of difficulties with obtaining suitably low RLs.

[d] Total PCB concentrations were calculated as the sum of all detected PCB congener concentrations (data were blank-qualified, and RLs for undetected PCB congeners were not included).

CSO – combined sewer overflow
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
RM – river mile
SPMD – semipermeable membrane device
SVOC – semivolatile organic compound
WQA – water quality assessment

Grab samples were collected along transects at three locations in the LDW in 1996 and 1997: RM 1.1 (in the vicinity of the Brandon CSO outfall), RM 1.9 (in the vicinity of the Southwest Michigan CSO outfall), and RM 4.9 (in the vicinity of the Norfolk CSO outfall) (Map 4-11a). Samples were collected weekly from October 1996 to June 1997 at all three locations, except during storm events, when sampling was conducted on three successive days following the storm. Chemicals analyzed in both filtered and unfiltered samples included metals and trace elements and semivolatile organic compounds (SVOCs).

PCBs, pesticides, and polycyclic aromatic hydrocarbons (PAHs) were not analyzed in surface water samples collected in 1996 and 1997 because of the difficulty in obtaining suitably low RLs to allow concentrations of these chemicals to be reliably reported.[47] Instead, King County deployed semipermeable membrane devices (SPMDs) at two locations in the LDW from March 26 to April 8, 1997.[48] Three SPMDs, including one field duplicate SPMD, were deployed just offshore of the Duwamish/Diagonal CSO, and two SPMDs were deployed just offshore of the Brandon Street CSO. The SPMDs were analyzed for PCBs, organochlorine pesticides, and PAHs. Chemical concentrations in water were calculated using the mass of chemicals detected in each SPMD and the chemical-specific partition coefficients between the polyethylene and water, which were derived from laboratory experiments conducted at Battelle's Marine Science Laboratory. These calculated concentrations are summarized in Section 4.2 but were not included in the risk assessments because of uncertainty in using calculated concentrations.

In 2005, King County collected water column samples for PCB congener analysis during two dry-weather sampling events in August and September and two wet-weather sampling events in November and December (King County 2005b). Two locations were sampled in the LDW: one location at RM 0.0 at the southern end of Harbor Island, and one at RM 3.3 at the South Park Bridge (Map 4-11a). All 209 PCB congeners were analyzed using high-resolution methods, and total PCB concentrations were calculated as the sum of all detected PCB congener concentrations (data were blank-qualified, and RLs for undetected PCB congeners were not included).

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[47] King County analyzed a limited number of water samples for PCBs, organochlorine pesticides, and PAHs, but all results were reported as not detected. Because obtaining lower detection limits was not possible at that time, analyses for these analytes were discontinued in grab water samples.

[48] The SPMD sampler consisted of layflat, polyethylene tubing, containing a high-molecular-weight neutral lipid. SPMDs mimic the transport across biological membranes and can be used to provide time-averaged chemical concentrations in water, which may include episodic events. Given an adequate deployment time, the concentrations of lipophilic compounds in the SPMD should come close to equilibrium with the concentrations in the water.

4.1.2.5 Seep water

Seep water samples have been collected from shoreline areas along the LDW as part of the RI and other investigations conducted since 1990 (Table 4-11). In addition to the areas sampled for the RI, specific sites that have been sampled include Rhône-Poulenc, Boeing Plant 2, Boeing Isaacson, Terminal 117 (T-117), and GWI (Map 4-11a).

Table 4-11. Summary of seep sampling events included in the RI dataset

Site	Location	Number of Seeps Sampled	Year of Sampling	Sampling Method	Chemicals	Data Source
Entire LDW[a]	RM 0.2 to RM 4.3	18	2004	mini-piezometers and funnel with attached tubing to capture direct flow	Metals, SVOCs, VOCs, PCB Aroclors, pesticides, and TPH	Windward (2004b)
T-117[b]	RM 3.5 to RM 3.7 E	3	2003	funnel with attached tubing to capture direct flow	metals, SVOCs, and PCB Aroclors	Windward et al. (2005a)
GWI[c]	RM 2.3 to RM 2.4 E	5	1999	na	SVOCs and VOCs	Terra Vac and Floyd & Snider (2000)
		9	1998	na	VOCs	Terra Vac and Floyd & Snider (2000)
		10	1998	na	VOCs	Terra Vac and Floyd & Snider (2000)
		4	1997	na	VOCs	Terra Vac and Floyd & Snider (2000)
		5	1996	na	VOCs	Terra Vac and Floyd & Snider (2000)
		7	1995	na	VOCs	Terra Vac and Floyd & Snider (2000)
		7	1995	na	VOCs	Terra Vac and Floyd & Snider (2000)
		8	1994	na	VOCs	Terra Vac and Floyd & Snider (2000)
		2	1994	na	VOCs	Terra Vac and Floyd & Snider (2000)
		6	1994	na	VOCs	Terra Vac and Floyd & Snider (2000)
Boeing Plant 2[d]	RM 2.9 to RM 3.6 E	18	1995	capture of direct flow into sampling container	metals, SVOCs, VOCs, and PCB Aroclors, TPH	Weston (1998)

Site	Location	Number of Seeps Sampled	Year of Sampling	Sampling Method	Chemicals	Data Source
Rhône-Poulenc[e]	RM 4.0 to RM 4.2 E	7	1995	PVC pipe was placed horizontally out from the bank to capture direct flow; or a small hole was dug and contents were transferred to the sample container.	metals, VOCs, and phthalates	Rhône-Poulenc (1996)
Boeing Isaacson[f]	RM 3.7 E	1	2000	A peristaltic pump was used to pump seep water through a 0.45-micron filter into the sample container.	arsenic	ERM and Exponent (2000)

[a] Both filtered and unfiltered samples were analyzed for metals, PCBs, SVOCs, and pesticides; samples analyzed for VOCs and TPH were unfiltered.

[b] Both filtered and unfiltered samples were analyzed for metals; samples analyzed for PCBs and SVOCs were unfiltered. One seep was re-sampled in 2004 for PCB analysis; this sample was centrifuged.

[c] A total of 10 seeps were sampled; some of the seeps were sampled on more than one date; it is not known if samples were filtered or unfiltered.

[d] Both filtered and unfiltered samples were analyzed for metals; samples analyzed for PCBs and SVOCs were unfiltered.

[e] Data are available only for detected chemicals (metals, BEHP, and formaldehyde); samples were unfiltered.

[f] Samples were filtered.

BEHP – bis(2-ethylhexyl) phthalate
GWI – Great Western International
LDW – Lower Duwamish Waterway
na – not available
PCB – polychlorinated biphenyl
PVC – polyvinyl chloride
RM – river mile
SVOC – semivolatile organic compound
T-117 – Terminal 117
TPH – total petroleum hydrocarbon
VOC – volatile organic compound

4.1.2.6 Porewater

Table 4-12 summarizes the available porewater datasets collected from the LDW. Samples were collected from GWI and Boeing Plant 2/Jorgensen Forge in 2005 and analyzed for volatile organic compounds (VOCs) as part of the RI. At Rhône-Poulenc, porewater samples were collected in 2004 and were analyzed for metals and organic compounds. As part of the EPA site inspection (SI), porewater samples were collected in 1998 throughout the LDW and were analyzed for metals. Porewater samples were collected and analyzed for butyltins during five sampling events: Glacier Northwest, Duwamish Yacht Club, Hurlen-Boyer, PSDDA99, and PSDDA98. Data from the PSDDA99 sampling event are discussed in this RI; samples from the other four events are not discussed because they were collected from areas that have been dredged and thus do not represent current conditions. Porewater locations sampled during the GWI, Boeing Plant 2/Jorgensen Forge, Rhône-Poulenc, EPA SI, and PSDDA99 sampling events are shown on Map 4-12a.

Table 4-12. Summary of porewater sampling events

Site or Sampling Event	Location	Number of Samples	Year of Sampling	Sampling Method	Chemicals	Reference
Great Western International	RM 2.3 to RM 2.4 E	14	2005	mini-piezometer and peeper	VOCs	Windward (2006a)
Boeing Plant 2/ Jorgensen Forge	RM 3.6 E	14	2005	mini-piezometer and peeper	VOCs	Windward (2006a)
Rhône-Poulenc	RM 4.0 to RM 4.2 E	16	2004	mini-peizometer and seepage meter	metals, BTEX, PAHs, phthalates	EPA (2005d)
EPA SI	entire LDW	15	1998	centrifuge from sediment	metals and butyltins	Weston (1999a)
Glacier Northwest[a]	RM 1.4 to RM 1.5 W	5	2002	na	butyltins	PIE (2002)
Duwamish Yacht Club[a]	RM 4.1 W	2	1999	na	TBT	Hart Crowser (1999)
PSDDA99	RM 1.9 to RM 3.4 W	20	1999	na	TBT	SEA (2000b)
Hurlen-Boyer[a]	RM 2.4 to RM 2.7 W	2	1998	centrifuge from sediment	TBT	Hart Crowser (1998)
PSDDA98[a]	RM 4.4 to RM 4.6 in the navigation channel	2	1998	centrifuge from sediment	TBT	SEA (1998)

[a] Data from these events are not summarized in this document because sediment was dredged after porewater samples were collected.

BTEX – benzene, toluene, ethylbenzene, and xylene
EPA – US Environmental Protection Agency
LDW – Lower Duwamish Waterway
na – not available
PAH – polycyclic aromatic hydrocarbon
PIE – Pacific International Engineering, PLLC
PSDDA – Puget Sound Dredged Disposal Analysis
RM – river mile
SEA – Striplin Environmental Associates, Inc.
SI – site inspection
TBT – tributyltin
VOC – volatile organic carbon

4.1.3 Data suitability

Once data were determined to meet met DQOs, the suitability of data for specific purposes in the RI was evaluated according to EPA guidance (EPA 1988, 1992b). Of primary importance was the degree to which the data adequately represented site-related contamination and potential exposure of humans and ecological receptors at the site. Other considerations in determining the suitability of datasets that met DQOs included the availability of data validation results, whether results may have been confounded by analytical interferences, and whether data represented a significant departure from the standard analytical methods used for other samples in the dataset.

4.1.3.1 Representativeness

This section provides a discussion of whether the available sediment, tissue, and water data represent the ranges and distributions of chemical concentrations in the LDW.

Surface Sediment

Many historical environmental sampling events have included the collection and analysis of surface sediment from the LDW (Table 4-4). These studies were designed for site-wide or reconnaissance surveys (e.g., Boeing SiteChar, EPA SI, and NOAA SiteChar) or focused investigations of suspected areas of contamination (e.g., Boeing Resource Conservation and Recovery Act [RCRA] facility investigation [RFI], Rhône-Poulenc RFI). Because many of the sediment samples were collected to characterize contaminated areas, the dataset as a whole may have a relatively higher proportion of elevated chemical concentrations than is representative of site-wide conditions within the LDW. Of the 1,365 sampling locations in the RI baseline surface sediment dataset, 880 of these locations were sampled as part of a site-wide sampling event, and 485 locations were sampled during focused investigations, as shown on Maps 4-1 and 4-2, respectively.

Subsurface Sediment

Many historical environmental sampling events have included the collection of subsurface sediment from the LDW (Table 4-6). Of the 895 subsurface samples (from 309 cores that have not been dredged), 265 samples (from 78 cores) were collected as part of site-wide events for a more general characterization of the nature and extent of contamination. Of these 265 samples, 234 samples (from 62 cores) were collected in 2006 as part of the RI and 31 samples (from 16 cores) were collected during the EPA SI in 1998 (Map 4-6). The remaining 630 samples (from 231 cores) were collected from areas of suspected contamination (Map 4-5). Because many of the subsurface sediment samples were collected to characterize contaminated areas, the dataset as a whole likely has a higher proportion of samples with chemical concentrations that are elevated relative to the mean chemical concentrations expected throughout the entire LDW.

Tissue

To represent chemical concentrations in tissue within the LDW, data for various biological tissue types are necessary (Table 4-8). In addition, a representative set of tissue data should include spatial coverage for each species according to its home range and appropriate size classes to meet specific objectives of sampling for each organism, and should contain a sufficient number of samples to represent differing exposure regimes within the LDW.

To supplement tissue data for the LDW that were collected prior to the RI, large numbers of fish and crabs were collected as part of the RI data collection efforts for use primarily in the risk assessments (Windward 2004e, f).[49] These data were also used to summarize the nature and extent of chemical concentrations in biological matrices of the LDW. Species were selected to represent exposure of humans and ecological receptors, and thus various fish and crab species were collected. Samples collected for wildlife exposure included the entire specimen, while samples collected for human exposure included only the edible portions of fish or crab species (i.e., fillet and edible meat). The tissue sampling events conducted in 2004, 2005, 2006, and 2007 provided 28 to 74 composite samples for each of three fish species for whole-body tissue, 39 composite samples of English sole or starry flounder fillet tissue, 33 composite samples of crab edible meat tissue, and 21 composite samples of crab hepatopancreas tissue, all of which satisfied the minimum number of samples (i.e., six) that EPA, Ecology, and LDWG agreed was acceptable for calculation of a UCL for each chemical and tissue type for the LDW (Windward 2004f).

Tissue sampling performed for the RI was designed to generate data representative of the range of concentrations of key chemicals to which an organism may be exposed and to provide spatial coverage of the LDW. For mobile species such as fish and crabs, spatial representation of the LDW was accomplished by collecting samples from four sampling areas distributed throughout the LDW. These areas were selected to cover a range of rolling average concentrations of total PCBs in sediment, as discussed in detail in the fish and crab QAPP (Windward 2004f). For benthic invertebrates, 20 sampling locations were chosen to represent areas with a range of concentrations of total PCBs, arsenic, and lead in sediment, as well as to provide spatial coverage of intertidal areas in the LDW. For clams, 10 sampling locations were placed in known clam habitat areas to cover the concentration range of PCBs, cPAHs, and arsenic in sediment (Windward 2004e). Target sizes of fish and crabs collected during the RI were selected to represent the prey size ranges preferred by piscivorous wildlife receptors and reasonable size ranges of seafood consumed by people (Windward 2004f).

Surface Water

Surface water samples collected during the King County WQA and analyzed for metals and SVOCs were part of a large set of water samples collected weekly from October 1996 to June 1997 (and for three successive days following select storm events) along transects at three sites in the LDW (see Section 4.1.2.4) (King County 1999e). These data represent a seasonal range of flow conditions in the LDW. Time-integrated samples were also collected at two locations and two depths for PCBs, pesticides, and

[49] The 2006 and 2007 data were collected to evaluate changes in PCB concentrations over time; these data were not used in the risk assessments because they were finalized after the HHRA and ERA were completed.

PAHs using SPMDs during the King County WQA. In addition, PCB congeners were analyzed by King County in whole-water samples collected in 2005 during two dry-weather periods (August and September) and two wet-weather periods (November and December) at two locations and two depths. The PCB congener data represent a limited number of specific areas. They were assumed to represent general conditions within these two areas of the LDW because the LDW is a well-mixed tidal estuary; however, these data may not represent the full range of total PCB concentrations in water for all locations or seasons because of localized conditions or short-term fluctuations arising from a myriad of factors.

SPMDs, which are pre-cleaned polyethylene sheets, were deployed in the LDW over a period of 13 days. During deployment, PCBs, pesticides, and PAHs in the water column were sorbed onto the SPMDs. The SPMDs were extracted and analyzed using standard test methods, and compound-specific partitioning coefficients, if available, were applied to the resultant SPMD data to estimate the average surface water concentrations. PCBs were analyzed as both PCB congeners (17 of the 209 PCB congeners) and Aroclors. The total PCB concentrations calculated as PCB congener sums likely underestimate total PCBs because only a subset of the 209 congeners were analyzed, so these data were not used in the RI or the ERA. Instead, water samples collected by King County in 2005 that were analyzed for all 209 congeners were used (Mickelson and Williston (2006). The Aroclor data from SPMDs were not used in the RI or the ERA because non-Aroclor-specific partitioning coefficients were used, so the calculated concentrations are highly uncertain. There are also uncertainties associated with pesticide and PAH water concentrations back-calculated from the SPMD data. However, they are presented in the RI for informational purposes because no other surface water data are available for those compounds. Surface water data were not used to characterize risk from pesticides or PAHs in the ERA.

The water data were used in the ERA to estimate the exposure of fish and wildlife to chemicals through water ingestion. The surface water data were considered sufficient for use in the ERA because: 1) mean concentrations were of interest for the ERA because they represent chronic exposures ; 2) the exposure of fish to PCBs and pesticides was evaluated through a critical tissue-residue approach, which incorporated exposure through the water column, and 3) the ingestion of chemicals via water is a very minor component of the total ingestion of chemicals by birds and mammals from prey, sediment, and water combined (Appendix A, Section A.5.1.3.3).

The water data were also used to assess the nature and extent of contamination in the LDW and for use in the food web model (FWM). The PCB congener data collected in 2005 were also used to update King County's EFDC model, a hydrodynamic and chemical fate and transport model (Mickelson and Williston 2006). The EFDC model estimates PCB concentrations in water for the entire LDW over different spatial scales and over various temporal scales that include all four seasons. The results of the updated EFDC model were used in the RI to refine the predictions of total PCB concentrations in the LDW water column over monthly time periods at two different

spatial scales for the FWM (Appendix D). In addition, total PCB concentrations calculated as the sum of PCB congeners from these datasets were used to define the upper and lower limits of total PCB concentrations in water for the FWM. These upper and lower limits were used to represent LDW-wide mean PCB concentrations in the water. The FWM was used to estimate sediment risk-based threshold concentrations (RBTCs) for total PCBs. Appendix D addresses the sufficiency of the surface water data for updating the EFDC model and for use in the FWM.

Porewater

Porewater samples were collected as part of the RI to evaluate risks to the benthic invertebrate community [50] in areas assumed to represent worst-case exposure areas based on potential exposure to groundwater contamination. Porewater data were collected from two areas of the LDW (GWI and Boeing Plant 2/Jorgensen Forge) to investigate potential worst-case conditions for discharge of VOCs from the groundwater (Windward 2006a). Other areas in the LDW were assumed to have a lower potential for groundwater discharge of VOCs based on existing source data. Detailed groundwater conceptual site models were developed for both the GWI and Boeing Plant 2/Jorgensen Forge sites to ensure that sampling was conducted in areas with the highest potential for groundwater discharge (Windward 2005h). Porewater samples were collected using peepers deployed 10 cm beneath the sediment surface and left to equilibrate for 2 weeks. Because of their placement within the biologically active zone and the equilibration time allowed, these samples should reasonably represent benthic invertebrate exposure conditions within these areas.

Other historical porewater data provide information about potential sources in the LDW and were therefore included in the characterization of nature and extent of contamination. The Rhône-Poulenc investigation (EPA 2005d) collected porewater data for metals and SVOCs from locations along the shoreline of the facility using seepage meters and piezometers. The locations and methods for sampling porewater were designed to represent groundwater or surface water in the subsurface-surface transition zone from areas most likely to be contaminated from the Rhône-Poulenc site.

The EPA SI collected porewater data for metals from 15 locations throughout the LDW by centrifuging the porewater from sediment as part of a screening-level investigation of the LDW (Weston 1999a). The objectives for selecting these locations were not presented in the EPA SI documents; it is assumed that these samples were collected to represent a range of conditions throughout the LDW. Although porewater samples

[50] Because VOCs have a low affinity for sediment, analysis of porewater is the best way to estimate exposure. The primary use of porewater data in the RI was for the evaluation of risk to benthic invertebrates from exposure to VOCs. For other chemicals that have a higher affinity for sediment, risk to benthic invertebrates was better addressed using sediment chemistry data.

were analyzed for butyltins during five sampling events, data from four of these events were collected from areas that were subsequently dredged, so they do not represent current conditions. In the remaining sampling event, 20 samples were collected between RM 1.9 to RM 3.4. Note that different methods of porewater collection may generate different results.

Seep Water

As part of the RI, a reconnaissance survey was conducted in May 2004 to identify seeps along the entire LDW shoreline (Windward 2004b). Eighteen seeps from throughout the LDW were selected for collection and chemical analysis of seep water samples. Seeps were selected based on an evaluation of the proximity of the sampling locations to potential sources, surface sediment chemistry, and observations made during the reconnaissance survey. The primary objective of this sampling was to characterize suspected sources of contaminants to the LDW. Although rainfall was lower than usual in the spring of 2004 an analysis of expected groundwater elevations indicated that the lower rainfall would not have affected the ability to identify or sample seeps at that time (Windward 2004g)

In addition to the 18 seep locations sampled as part of the RI, seep data were available for four other sites along the LDW. Available data were used to describe the nature and extent of contamination in seep water.

4.1.3.2 QA/QC results

All datasets used in the RI (i.e., datasets for sediment, tissue, surface water, porewater, and seep water) were validated by the original authors of the individual studies or by third parties. Summaries of these data validations for historical sampling events have been presented in technical memoranda prepared by Windward (Windward 2005k, l, 2007e). Data validation reports for samples collected as part of the RI were included in the data reports for each sampling event. The only surface sediment chemistry dataset not considered acceptable for all uses in the RI/FS because the DQOs were not met were data collected from the Rhône-Poulenc facility in 1994; these data were not considered acceptable because Form 1s were not available.

Based on data quality, approximately 1,000 analytical results, across all media types, were qualified as unusable out of more than 150,000 analytical results. These data were excluded because of concerns such as extremely low matrix or surrogate spike recoveries, identified by the analytical laboratory or by the data validator. Almost all of the rejected results were for SVOCs (i.e., 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 2,4-dimethylphenol, 3,3′-dichlorobenzidine, 3-nitroaniline, 4-chloroaniline, 4-nitroaniline, aniline, benzidine, benzoic acid, hexachlorocyclopentadiene, pentachlorophenol, and pyridine). In addition, some sediment results for metals (i.e., antimony, cadmium, silver, and selenium) were rejected, as were several results for organochlorine pesticides (i.e., delta-benzene

hexachloride [BHC], endosulfan sulfate, and endrin aldehyde). Data qualified as unusable were not used in the risk assessments or presented in the RI.

Analytical interference with the quantification of organochlorine pesticides from the presence of PCB congeners occurred during the analyses of benthic invertebrate tissue (Windward 2005a) and fish and crab tissue (Windward 2005b). This issue was identified by both the analytical laboratory and the data validator. The organochlorine pesticides were analyzed using EPA Method 8081A (gas chromatography with electron capture detection [GC/ECD]), which is a standard method used in many environmental investigations for organochlorine pesticides. The detected results for both the benthic invertebrate and clam tissue samples collected in 2004 (Windward 2005a) and the fish and crab tissue samples collected in 2004 (Windward 2005b) were qualified JN, which indicates "the presence of an analyte that has been 'tentatively identified' and the associated numerical value represents its approximate concentration" (EPA 1999c). These data were qualified based on the probable interference in the organochlorine pesticide analysis from PCB congeners.

The JN-qualified results are highly uncertain and biased high. The high bias for DDTs (dichlorodiphenyltrichloroethane) was confirmed by re-analyzing six sediment samples co-located with benthic invertebrate tissue samples and eight fish and crab tissue samples that had high PCB and DDT concentrations using a gas chromatography/mass spectrometry (GC/MS) method, which is not susceptible to analytical interference by PCBs for organochlorine pesticides. Additional details regarding the confirmation analysis results are presented in Section A.2.4.2 of Appendix A. Both the HHRA and the ERA address the uncertainty associated with the use of the JN-qualified organochlorine pesticide data in evaluating risks to human and ecological receptors. This uncertainty is also relevant to the nature and extent characterization of organochlorine pesticides in sediment.

4.1.3.3 Analytical Methods

The sediment surveys from which the RI baseline surface sediment chemistry dataset was compiled used similar or identical analytical methods for most analytes, with one notable exception. PCB analyses for the NOAA site characterization were conducted using high-performance liquid chromatography/photodiode array detection (HPLC/PDA). This method was not used for PCB Aroclor analyses in any of the other events; other analyses were conducted using GC/ECD. NOAA laboratory data for total PCBs are based on a nonstandard analytical method and may not be quantitatively comparable to data generated using standard analytical techniques. Specifically, the NOAA laboratory data for total PCBs reflect the difference between the sum of PCBs and polychlorinated terphenyls (PCTs) and the results of a separate analysis for PCTs alone.

Krahn et al. (1998) reported the results for 30 samples that were analyzed using both HPLC/PDA and GC/ECD methods by two different laboratories.[51] The two laboratories calculated total PCBs for each sample, which were then compared with each other. Total PCB concentrations varied between the two laboratories by as much as a factor of 6 (Krahn et al. 1998). Regression analyses conducted for the two sets of results indicated that the GC/ECD results were lower than the HPLC/PDA results at high PCB concentrations and higher than the HPLC/PDA results at low PCB concentrations (Krahn et al. 1998). The regression coefficient (R^2) between the two sets of analyses was 0.92. The differences between the total PCB concentrations calculated by the two laboratories are not surprising given the differences between the two methods, including: 1) different ranges of linear response for the two detectors, 2) differences in methods for calculating total PCBs, 3) differences in methods for quantifying and/or removing analytical interferences, and 4) differences in RLs.

Despite the differences between the two analytical methods for PCBs, data from both methods were used in the RI and risk assessments, although the uncertainty associated with total PCB concentrations may be significant in some areas. Alternative risk calculations are presented in the HHRA (Appendix B, Section B.6) using total PCB data derived solely from summing PCB Aroclor concentrations analyzed using GC/ECD.

Although different laboratories, and in some cases different methods, were used for the various tissue analyses, all tissue data summarized in Table 4-8 met the DQOs established for the project (Section 4.1). The uncertainties associated with combining data from different events that used different analytical methods are described in more detail in the HHRA (Appendix B, Section B.6).

4.1.4 Data reduction

Data reduction refers to methods used to aggregate raw data received from the laboratory for use in the RI/FS. A detailed discussion of data reduction methods is presented in Appendix E, Section E.3, and briefly summarized as follows:

- Chemical concentrations obtained from the analysis of laboratory duplicates or replicates (i.e., two or more analyses of the same sample) were averaged.
- Chemical concentrations of discrete samples collected at a single sampling location that were submitted to the laboratory as individual samples and analyzed separately were averaged and evaluated as a single sample.
- In some instances, the laboratory generated more than one result for a chemical for a given sample if re-analysis was required or if two different analytical

[51] HPLC/PDA analyses were conducted by the NOAA laboratory in Seattle; GC/ECD analyses were conducted by ARI in Seattle.

methods were used for that chemical. The procedures for selecting the best result are described in Appendix E, Section E.3.

- The precision of each result was stored in the project database by recording the number of significant figures assigned by the laboratory. These significant figures were treated according to methods described in Appendix E, Section E.3.

For several chemicals (PCBs, DDTs, PAHs, and chlordane), total concentrations were calculated in individual samples by summing concentrations of individual components (i.e., seven Aroclor mixtures or individual congeners for total PCBs, six DDT isomers for total DDTs, specific individual PAH compounds for total PAHs, and specific individual chlordane compounds for total chlordane). The treatment of non-detects for these sums were as follows:

- If some of the individual components were detected in a sample and some were not, only the detected concentrations were included in the sum.
- If none of the individual components were detected in a sample, the total concentration was given a value equal to the highest RL of an individual component and assigned a U-qualifier, indicating the lack of detected concentrations.

When calculating the mean concentration for a group of samples for chemicals expressed as totals (e.g., Aroclors, DDT isomers, individual PAH compounds, or individual chlordane compounds), if none of the individual components of the mixture were detected in a given sample, then one-half the reported non-detect value was used for that sample. Calculation of the reported non-detect value is discussed in Appendix E. Toxic equivalents (TEQs) of dioxins and furans and PCBs were calculated by summing the products of concentrations and compound-specific toxic equivalency factors (TEFs) for individual congeners of polychlorinated dibenzo-*p*-dioxins and furans or PCBs, as discussed in more detail in Appendix E, Section E.3. Total cPAHs were calculated by summing the products of concentrations and compound-specific potency equivalency factors (PEFs) for individual cPAH compounds, also discussed in more detail in Appendix E, Section E.3. Congeners or individual cPAH compounds that were undetected for a given sample were assigned a value equal to one-half the sample-specific RL for use in the calculations. Only the congeners or compounds that were analyzed were included in the TEQ or cPAH calculations.

4.2 CHEMICAL-SPECIFIC NATURE AND EXTENT INFORMATION

This section presents the nature and extent of contamination in surface sediment, subsurface sediment, tissue, surface water, seep water, and porewater, including maps that show distributions of selected chemicals in the various media. To focus the presentation of sediment data, a chemical was included if it exceeded the SQS of the

SMS or was identified as a chemical of concern (COC) in the HHRA (Appendix B)[52] based on a sediment exposure pathway (as described in Sections 4.2.1.2 and 6.5, respectively). In tissue, a chemical was included if it was a COC for any fish or wildlife receptor in the ERA (Appendix A) or if it was identified as a COC in the HHRA based on seafood consumption (as described in Sections 5.5 and 6.5, respectively). In addition, data summary tables for tissue included any detected SVOCs and all organochlorine pesticides. All tissue data collected between 1992 and 2007 are included in the data summary tables. In general, data summary tables for surface water, seep water, and porewater included any chemicals with detected concentrations. Data for all chemicals in each media are included in Appendix E.

This section begins with a general LDW-wide comparison of all sediment chemistry data to the SQS and CSL criteria of the SMS. This SMS discussion is followed by chemical-specific descriptions of the nature and extent of contamination in various site media, organized as follows: Sections 4.2.3 through 4.2.7 present discussions of five risk driver chemicals (PCBs, arsenic, cPAHs, BEHP, and dioxins and furans) and Sections 4.2.8 through 4.2.11 present discussions for metals and tributyltin (TBT), SVOCs, organochlorine pesticides, and VOCs, respectively.

Summaries presented in this section are based on data of acceptable quality collected from 1990 to the present, as described in Section 4.1. Summary statistics for all chemicals analyzed in each media are presented in Appendix E, Section E.6. Percentiles of five risk driver chemical concentrations in the RI baseline surface sediment dataset were calculated to facilitate data presentation. These percentiles represent the concentration below which the corresponding percent of individual concentrations in the dataset fall (e.g., the 95th percentile is the concentration below which 95% of the concentrations fall). These percentiles are referred to as numerical percentiles. For some chemicals (i.e., PCBs, arsenic, cPAHs, and BEHP), area-based percentiles were also calculated based on either inverse distance weighting (IDW) or Thiessen polygon interpolations to illustrate the spatial distribution of these chemicals. Area-based percentiles are calculated in the same way as numerical percentiles, except the percentiles are established by the percentage of the total LDW area, rather than the range of concentrations (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated values below that concentration). Both numerical and area-based percentiles were based on dry weight (rather than OC-normalized) concentrations.

Area-based percentiles are discussed in the context of maps that present the interpolated concentrations. Where only point-based maps are presented, numerical percentiles are discussed.

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[52] A chemical was identified as a COC in the HHRA if the excess cancer risk estimate was greater than 1×10^{-6} or if the non-cancer HQ was greater than 1 for at least one reasonable maximum exposure scenario.

Appendix C presents the UCLs for arsenic, total PCBs, cPAHs, and dioxins and furans using the RI baseline surface sediment dataset and the same calculation methods as those used in the HHRA (Appendix B).[53] The FS presents another set of UCLs calculated using data from the FS dataset and a spatially weighted method.

4.2.1 Sediment chemistry and toxicity relative to SMS criteria

This section describes the SMS marine sediment criteria (WAC 173-204) followed by comparisons of surface and subsurface chemistry data and toxicity test results with those criteria. The discussion in this section presents the locations with exceedances of SMS criteria (for any chemical); more detailed information on the locations and extent of SQS/CSL exceedances for specific chemicals or chemical groups is provided in the chemical-specific sections that describe nature and extent of contamination (Sections 4.2.3 through 4.2.9).

4.2.1.1 SMS criteria

The SMS regulations provide both chemical and biological effects-based criteria. The numerical SMS chemical criteria are available for 47 chemicals or groups of chemicals. The SQS represents a numerical chemical concentration below which sediments are designated as having no adverse effects on biological resources. At chemical concentrations above the SQS but below the CSL, sediments are designated as having minor adverse effects on biological resources. At chemical concentrations above the CSL, there is a potential for more pronounced adverse affects. The SMS chemical criteria for the 47 chemicals (or groups of chemicals) are presented in Table 4-13.

Table 4-13. SMS chemical criteria for marine sediments

CHEMICAL	UNIT	SQS	CSL
Metals			
Arsenic	mg/kg dw	57	93
Cadmium	mg/kg dw	5.1	6.7
Chromium	mg/kg dw	260	270
Copper	mg/kg dw	390	390
Lead	mg/kg dw	450	530
Mercury	mg/kg dw	0.41	0.59
Silver	mg/kg dw	6.1	6.1
Zinc	mg/kg dw	410	960
PAHs			
2-Methylnaphthalene	mg/kg OC	38	64
Acenaphthene	mg/kg OC	16	57
Acenaphthylene	mg/kg OC	66	66

[53] These UCLs are presented as exposure point concentrations for the netfishing scenario in the HHRA (Appendix B), which uses the entire surface sediment dataset, in Table C.3-8 of Appendix C.

CHEMICAL	UNIT	SQS	CSL
Anthracene	mg/kg OC	220	1,200
Benzo(a)anthracene	mg/kg OC	110	270
Benzo(a)pyrene	mg/kg OC	99	210
Benzo(g,h,i)perylene	mg/kg OC	31	78
Total benzofluoranthenes	mg/kg OC	230	450
Chrysene	mg/kg OC	110	460
Dibenzo(a,h)anthracene	mg/kg OC	12	33
Dibenzofuran	mg/kg OC	15	58
Fluoranthene	mg/kg OC	160	1,200
Fluorene	mg/kg OC	23	79
Indeno(1,2,3-cd)pyrene	mg/kg OC	34	88
Naphthalene	mg/kg OC	99	170
Phenanthrene	mg/kg OC	100	480
Pyrene	mg/kg OC	1,000	1,400
Total HPAH[a]	mg/kg OC	960	5,300
Total LPAH[b]	mg/kg OC	370	780
Phthalates			
BEHP	mg/kg OC	47	78
BBP	mg/kg OC	4.9	64
Diethyl phthalate	mg/kg OC	61	110
Dimethyl phthalate	mg/kg OC	53	53
Di-n-butyl phthalate	mg/kg OC	220	1,700
Di-n-octyl phthalate	mg/kg OC	58	4,500
Other SVOCs			
1,2,4-Trichlorobenzene	mg/kg OC	0.81	1.8
1,2-Dichlorobenzene	mg/kg OC	2.3	2.3
1,4-Dichlorobenzene	mg/kg OC	3.1	9.0
2,4-Dimethylphenol	µg/kg dw	29	29
2-Methylphenol	µg/kg dw	63	63
4-Methylphenol	µg/kg dw	670	670
Benzoic acid	µg/kg dw	650	650
Benzyl alcohol	µg/kg dw	57	73
Hexachlorobenzene	mg/kg OC	0.38	2.3
Hexachlorobutadiene	mg/kg OC	3.9	6.2
n-Nitrosodiphenylamine	mg/kg OC	11	11
Pentachlorophenol	µg/kg dw	360	690
Phenol	µg/kg dw	420	1,200
PCBs			
Total PCBs	mg/kg OC	12	65

[a] Total HPAHs were calculated as the sum of benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, total benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene.

[b] Total LPAHs were calculated as the sum of acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
CSL – cleanup screening level
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
OC –organic carbon
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SMS – Washington State Sediment Management Standards
SQS – sediment quality standards
SVOC – semivolatile organic compound

Many of the SQS and CSL criteria are in units normalized to the organic carbon content in the sediment sample (mg/kg OC). Concentrations originally in units of µg/kg dry weight were converted to mg/kg OC using the following equation:

$$C_{OC} = \frac{C_{dw}}{TOC} \qquad \textbf{Equation 4-1}$$

Where:

C_{dw} = dry weight chemical concentration (mg/kg dw)
C_{OC} = OC-normalized chemical concentration (mg/kg OC)
TOC = fraction of total organic carbon

OC normalization is not considered to be appropriate for TOC concentrations ≤ 0.5% or ≥ 4.0% (Michelsen and Bragdon-Cook 1993). In these cases, dry weight chemical concentrations were compared with the lowest apparent effects threshold (LAET), which is functionally equivalent to the SQS, or the second lowest AET (2LAET), which is functionally equivalent to the CSL. The LAET and 2LAET values for chemicals with SMS criteria that are OC normalized are presented in Table 4-14.

Table 4-14. LAETs for chemicals with OC-normalized SMS criteria

Chemical	Concentration (µg/kg dw)	
	LAET	2LAET
PAHs		
2-Methylnaphthalene	670	1,400
Acenaphthene	500	730
Acenaphthylene	1,300	1,300
Anthracene	960	4,400
Benzo(a)anthracene	1,300	1,600
Benzo(a)pyrene	1,600	3,000
Benzo(g,h,i)perylene	670	720
Total benzofluoranthenes	3,200	3,600
Chrysene	1,400	2,800
Dibenzo(a,h)anthracene	230	540
Dibenzofuran	540	700
Fluoranthene	1,700	2,500

Chemical	Concentration (µg/kg dw)	
	LAET	2LAET
Fluorene	540	1,000
Indeno(1,2,3-cd)pyrene	600	690
Naphthalene	2,100	2,400
Phenanthrene	1,500	5,400
Pyrene	2,600	3,300
Total HPAH[a]	12,000	17,000
Total LPAH[b]	5,200	13,000
Phthalates		
BEHP	1,300	1,900
BBP	63	900
Diethyl phthalate	200	1,200
Dimethyl phthalate	71	160
Di-n-butyl phthalate	1,400	5,100
Di-n-octyl phthalate	6,200	nv
Other SVOCs		
1,2,4-Trichlorobenzene	31	51
1,2-Dichlorobenzene	35	50
1,4-Dichlorobenzene	110	120
Hexachlorobenzene	22	70
Hexachlorobutadiene	11	120
n-Nitrosodiphenylamine	28	40
PCBs		
Total PCBs	130	1,000

[a] Total HPAHs were calculated as the sum of benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, total benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene.

[b] Total LPAHs were calculated as the sum of acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LAET – lowest apparent effects threshold
2LAET – second lowest apparent effects threshold
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
nv – no value
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SMS – Washington State Sediment Management Standards
SVOC – semivolatile organic compound

The SMS regulations also include biological criteria (Washington State Administrative Code [WAC] 173-204) based on sediment toxicity tests or benthic infaunal abundance. Because AETs, which form the basis for the chemical criteria, are based on sediment samples with a mixture of chemicals from various locations in Puget Sound and exceedance of the SMS chemical criteria is not always an accurate predictor of adverse effects, the regulations state that site-specific biological tests (sediment toxicity tests or

assessment of benthic infaunal abundances) may be conducted to provide confirmation that site-specific chemistry data indicate a hazard to benthic invertebrate communities. The SQS and CSL biological effects criteria for the toxicity tests conducted for the RI are presented in Table 4-15; there were no assessments of benthic infaunal abundances, so effects criteria for those assessments are not included. The SQS is exceeded if the SQS biological criteria are exceeded for any one of the toxicity tests. Likewise, the CSL is exceeded if the CSL biological criteria are exceeded for any one of the toxicity tests. The CSL is also exceeded if the SQS biological effects criteria are exceeded in any two toxicity tests at one location (WAC 173-204-420(3)). The SQS and CSL designations based on biological criteria override the SQS and CSL designations based on chemistry results. For example, if a sample has a chemical SQS exceedance but is tested and found not to be toxic, it is not categorized as an SQS exceedance.

Table 4-15. SMS biological effects criteria for marine sediment toxicity tests conducted for the RI

Toxicity Test	Biological Effects Criteria	
	SQS	CSL
Amphipod	mean mortality > 25% on an absolute basis and statistically different from the reference sediment ($p \leq 0.05$)	mean mortality greater than the value in the reference sediment plus 30% and statistically different from the reference sediment ($p \leq 0.05$)
Polychaete[a]	mean individual growth rate < 70% of that of the reference sediment and statistically different ($p \leq 0.05$)	mean individual growth rate < 50% of that of the reference sediment and statistically different ($p \leq 0.05$)
Bivalve larvae	mean normal survivorship < 85% of that of the reference sediment and statistically different ($p \leq 0.10$)	mean normal survivorship < 70% of that of the reference sediment and statistically different ($p \leq 0.10$)

[a] The mortality endpoint for the polychaete toxicity test is not used for determination of SMS compliance.

CSL – cleanup screening level

SMS – Washington State Sediment Management Standards

SQS – sediment quality standards

4.2.1.2 Surface sediment chemistry relative to SMS

Table 4-16 presents a summary of SMS criteria and SQS and CSL exceedances for surface sediment samples in the RI baseline dataset. Detected concentrations of 39 SMS chemicals exceeded the CSL at one or more locations (Map 4-13). Two additional chemicals (i.e., anthracene and pentachlorophenol) were detected at concentrations that exceeded the SQS but did not exceed the CSL. Detected concentrations of the remaining six SMS chemicals (i.e., diethyl phthalate, di-n-butyl phthalate, di-n-octyl phthalate, acenaphthylene, hexachlorobutadiene, and 2-methylphenol) did not exceed the SQS or the CSL.

Total PCB concentrations in surface sediment exceeded the SQS more frequently than any other chemical (37% of the sampled locations exceeded the SQS, and, of those, 14% also exceeded the CSL). The chemical with the next highest number of locations with detected concentrations in surface sediment exceeding the SQS was BEHP (12.9% of

the sampled locations exceeded the SQS, and, of those, 7.1% also exceeded the CSL), followed by butyl benzyl phthalate (BBP) (9.6% of the sampled locations exceeded the SQS, and, of those, approximately 1% also exceeded the CSL) (Table 4-16). The remaining chemicals had SQS exceedance frequencies of 5.1% or less. Of the chemicals that infrequently exceeded the SQS in localized areas, those with the highest concentrations relative to the SQS were metals (e.g., lead), individual PAH compounds (e.g., acenapthene) and some SVOCs (e.g., 1,4-dichlorobenzene).

Table 4-16. Comparison of LDW surface sediment chemical data to SMS chemical criteria

Chemical	No. of Locations	Detection Frequency		Sediment Chemistry							
				Detected Concentrations > SQS and ≤ CSL[a]		Detected Concentrations > CSL[a]		Locations with RLs > SMS Criteria[c]		Maximum Ratio of Detected Conc. to SQS[a]	Maximum Ratio of Detected Conc. to CSL[a]
		No. of Detects	%	No.	%[b]	No.	%[b]	> SQS and ≤ CSL	> CSL		
Metals											
Arsenic	852	794	93	5	0.59	9	1.1	0	0	19	12
Cadmium	838	584	70	2	0.24	11	1.3	0	0	24	18
Chromium	850	850	100	1	0.12	8	0.94	0	0	4.2	4.1
Copper	852	852	100	0	0	12	1.4	0	0	31	31
Lead	852	852	100	2	0.23	19[d]	2.2	0	0	51	43
Mercury	868	746	86	16	1.8	27	3.1	0	0	11	7.8
Silver	823	499	61	0	0	10	1.2	0	0	44	44
Zinc	849	849	100	26	3.1	16	1.9	0	0	24	10
PAHs											
2-Methylnaphthalene	818	139	17	0	0	3	0.37	6	1	4.2	2.5
Acenaphthene	828	304	37	15	1.8	3	0.36	9	2	16	4.6
Acenaphthylene	818	128	16	0	0	0	0	0	1	0.38	0.38
Anthracene	828	576	70	2	0.24	0	0	0	0	1.7	0.32
Benzo(a)anthracene	828	748	90	9	1.1	4	0.48	0	0	4.0	1.6
Benzo(a)pyrene	822	747	91	5	0.61	4	0.49	0	0	4.2	2.0
Benzo(g,h,i)perylene	823	682	83	10	1.2	8	0.97	4	1	5.8	2.3
Total benzofluoranthenes	822	757	92	5	0.61	5	0.61	0	0	3.9	2.0
Chrysene	828	773	93	25	3.0	2	0.24	0	0	3.7	1.3
Dibenzo(a,h) anthracene	828	436	53	16	1.9	4	0.48	10	6	5.9	2.2
Dibenzofuran	827	248	30	6	0.73	3	0.36	9	2	15	3.8

Table 4-16, cont. Comparison of LDW surface sediment chemical data to SMS chemical criteria

Chemical	No. of Locations	Detection Frequency		Sediment Chemistry							
				Detected Concentrations > SQS and ≤ CSL[a]		Detected Concentrations > CSL[a]		Locations with RLs > SMS Criteria[c]		Maximum Ratio of Detected Conc. to SQS[a]	Maximum Ratio of Detected Conc. to CSL[a]
		No. of Detects	%	No.	%[b]	No.	%[b]	> SQS and ≤ CSL	> CSL		
Fluoranthene	828	797	96	32	3.9	10	1.2	0	0	8.1	2.7
Fluorene	828	382	46	10	1.2	3	0.36	8	1	13	3.7
Indeno(1,2,3-cd)pyrene	823	726	88	16	1.9	9	1.1	1	0	5.9	2.3
Naphthalene	818	152	19	0	0	2	0.24	0	0	2.6	1.7
Phenanthrene	828	759	92	24	2.9	3	0.36	0	0	15	3.1
Pyrene	828	788	95	2	0.24	4	0.48	0	0	1.8	1.5
Total HPAH[e]	828	803	97	24	2.9	4	0.48	0	0	4.7	1.5
Total LPAH[f]	828	763	92	3	0.36	3	0.36	0	0	6.2	2.9
Phthalates											
BEHP	832	674	81	48	5.8	59	7.1	3	2	11	7.4
BBP	822	425	52	71	8.6	8	0.97	75	1	110	8.3
Diethyl phthalate	832	41	4.9	0	0	0	0	4	0	0.33	0.18
Dimethyl phthalate	822	156	19	0	0	1	0.12	8	5	2.5	1.1
Di-n-butyl phthalate	822	189	23	0	0	0	0	0	0	0.64	0.082
Di-n-octyl phthalate	832	49	5.9	0	0	0	0	5	0	0.60	0.0078
Other SVOCs											
1,2,4-Trichlorobenzene	816	5	0.61	0	0	1	0.12	231	128	2.3	1.4
1,2-Dichlorobenzene	816	17	2.1	0	0	3	0.37	0	110	15	10
1,4-Dichlorobenzene	816	39	4.8	0	0	3	0.37	77	18	21	13
2,4-Dimethylphenol	813	5	0.62	0	0	1	0.12	0	222	10	10
2-Methylphenol	821	7	0.85	0	0	0	0	0	114	0.92	0.92
4-Methylphenol	831	82	9.9	0	0	4	0.48	0	9	6.9	6.9
Benzoic acid	822	70	8.5	0	0	8	0.97	0	107	6.9	6.9

Table 4-16, cont. Comparison of LDW surface sediment chemical data to SMS chemical criteria

Chemical	No. of Locations	Detection Frequency		Sediment Chemistry							
				Detected Concentrations > SQS and ≤ CSL[a]		Detected Concentrations > CSL[a]		Locations with RLs > SMS Criteria[c]		Maximum Ratio of Detected Conc. to SQS[a]	Maximum Ratio of Detected Conc. to CSL[a]
		No. of Detects	%	No.	%[b]	No.	%[b]	> SQS and ≤ CSL	> CSL		
Benzyl alcohol	812	15	1.8	2	0.25	3	0.37	7	106	12	9.2
Hexachlorobenzene	819	46	5.6	4	0.49	2	0.24	283	105	10	1.7
Hexachlorobutadiene	818	0	0	0	0	0	0	58	88	na	na
n-Nitrosodiphenylamine	818	23	2.8	0	0	2	0.24	34	33	3.9	2.8
Pentachlorophenol	785	12	1.5	1	0.13	0	0	88	29	1.1	0.59
Phenol	831	257	31	17	2.0	6	0.72	5	0	6.7	2.3
PCBs								0			
Total PCBs	1,327	1,243	94	314	24	174	13	0	0	830	150

[a] For individual locations with TOC ≥ 4% or ≤0.5%, locations were counted as greater than the SQS or CSL if the dry-weight concentration of chemicals with OC-normalized SMS criteria was greater than the LAET or 2LAET, respectively.

[b] Percentage of total number of locations with detected concentrations that were greater than the SQS and less than or equal to the CSL or greater than the CSL.

[c] Number of locations with RLs greater than the SQS or CSL.

[d] An additional sample collected from the Boeing Plant 2/Jorgensen Forge EAA had a lead concentration of 1,300 mg/kg dw, exceeding the CSL. According to data management rules (Section 4.1.2.1), data from this sample were excluded from the baseline RI dataset and replaced with data from a more recent sample (SD-343) collected within 10 ft of the original location, even though the more recent sample was not analyzed for lead.

[e] Total HPAHs were calculated as the sum of benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, total benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene.

[f] Total LPAHs were calculated as the sum of acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
CSL – cleanup screening level
dw – dry weight
EAA – early action area
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LAET – lowest apparent effects threshold
2LAET – second lowest apparent effects threshold
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
na – not applicable
OC – organic carbon
PCB – polychlorinated biphenyl
RI – remedial investigation
RL – reporting limit
SMS – Washington State Sediment Management Standards
SQS – sediment quality standards
SVOC – semivolatile organic compound

Maps 4-14a through 4-14f present detailed results for each location with SQS or CSL exceedances for any detected chemical in surface sediment. Details on the locations of SQS and CSL exceedances for specific chemicals are provided in Sections 4.2.3 through 4.2.9.

For certain chemicals, analytical laboratory RLs exceeded the SQS (and in fewer cases, the CSL) (Table 4-16). These elevated RLs, which generally reflected dilutions or analytical challenges, create some uncertainty in interpreting the data relative to potential effects on benthic invertebrates. Appendix A, Section A.6.1.1.1, presents a detailed discussion of RL exceedances at all locations, including those with detected chemical exceedances.

The RL for at least one chemical was greater than the SQS at 294 locations with no detected exceedances of the SQS, including only two locations from sampling events conducted for the RI (Map 4-15). The increased sensitivity of the analytical methods used during the RI greatly reduced the frequency of RL values above the SQS. There was no increase in the detection frequency of these compounds, which suggests that these chemicals are likely not present in the LDW at concentrations above the RL.

Of the 294 locations with RLs greater than the SQS and no detected exceedances, 94% of the locations had RLs for 1,2,4-trichlorobenzene, hexachlorobenzene, or 2,4-dimethylphenol that were greater than the SQS (Map 4-15). As discussed in Section A.6.1.1 of the ERA, 1,2,4-trichlorobenzene, hexachlorobenzene, and 2,4-dimethylphenol are difficult to analyze at low concentrations using the standard SVOC analytical method and were rarely detected in LDW sediments (Table 4-16). Overall, approximately 44, 50, and 27% of all the surface sediment samples in which 1,2,4-trichlorobenzene, hexachlorobenzene, and 2,4-dimethylphenol, respectively, were not detected had RLs greater than the SQS. Detected concentrations of these compounds were greater than the SQS in one sample for both 1,2,4-trichlorobenzene and 2,4-dimethylphenol (out of five detected concentrations for each) and in six samples (out of 46 detected concentrations) for hexachlorobenzene.

There were 18 locations with no detected exceedances of the SQS but with RLs greater than the SQS for one or more chemicals other than 1,2,4-trichlorobenzene, hexachlorobenzene, and 2,4-dimethylphenol (Map 4-15). These other chemicals included: benzoic acid (1 location), benzyl alcohol (1 location), hexachlorobutadiene (9 locations; never detected in LDW), n-nitrosodiphenylamine (14 locations; 2 of 23 detected concentrations were greater than the SQS), pentachlorophenol (1 location), phenol (1 location), one individual PAH (1 location), and two phthalate compounds (1 location each). Benzoic acid, benzyl alcohol, hexachlorobutadiene, n-nitrosodiphenylamine, pentachlorophenol, and phenol are also difficult to analyze at low concentrations. Thus, the available data suggest that locations with RLs greater than the SQS but no detected exceedances are likely the result of analytical difficulties; the likelihood of actual chemical concentrations greater than the SQS at these locations is low.

4.2.1.3 Toxicity test results relative to SMS

Surface sediment samples collected during Rounds 1 and 2 of the RI were tested for toxicity if chemical concentrations exceeded the SQS or were greater than the screening level (SL) of the Dredged Material Management Program (DMMP) with the following exceptions:

- Ten samples had chemical concentrations that exceeded the SQS or were greater than the SL but were not tested because they were assumed to be toxic or were located in an EAA.
- Two samples were tested at the request of EPA/Ecology because they were near potential upland source areas; chemical concentrations in these samples did not exceed the SQS and they were less than the SL.

Of the 46 samples in the RI baseline dataset that were tested for toxicity during the RI, 11 sediment samples exceeded the overall SQS biological effects criteria (i.e., the SQS is exceeded for any one of the three endpoints), 17 sediment samples exceeded the overall CSL biological effects criteria (i.e., the CSL is exceeded for any one of the three endpoints or the SQS is exceeded for any two of the three endpoints), and 18 sediment samples did not exceed either the SQS or CSL biological effects criteria (Table 4-17; Map 4-13). Two samples, as noted above, were tested at the request of EPA and Ecology although they had no chemical SQS or CSL exceedances; these samples did not exceed either the SQS or CSL biological effects criteria. For the amphipod mortality endpoint, 10 of the 46 samples failed the biological effects criteria of the SMS at the CSL level, and 4 of the 46 samples failed the biological effects criteria at the SQS level (Table 4-17). For the polychaete growth endpoint, 8 of the 46 samples failed the biological effects criteria at the SQS level; no samples failed the biological effects criteria at the CSL level. For the bivalve survival/development endpoint, 8 of the 46 samples failed the biological effects criteria at the CSL level, and 12 of the 46 samples failed the biological effects criteria at the SQS level.

Maps 4-13 and 4-14a through-4-14f present both the toxicity and chemistry SMS exceedances for 46 locations where split sediment samples were analyzed for both toxicity and chemistry. As described previously in this section, toxicity test results, relative to SQS and CSL biological criteria, overrule SQS or CSL designations based on chemistry because the toxicity test results provide a more direct assessment of sediment toxicity at the location tested. The SMS designation based on toxicity test results agreed with the SMS designation based on chemistry for 17 of the 46 samples (Map 4-13). The toxicity designation indicated a higher quality condition (i.e., lower toxicity than estimated based on chemistry alone) at 20 of the 29 locations where the toxicity and chemistry designations did not agree and a lower quality condition (i.e., higher toxicity than estimated based on chemistry alone) at the remaining 9 locations (see Appendix A, Section A.3.2.2, for a comprehensive discussion of the toxicity test results).

Table 4-17. Results of chemistry and site-specific toxicity testing of surface sediment samples from the LDW

Sample ID	Chemical Results	Toxicity Test Results							Overall SMS Exceedance
		Amphipod Toxicity Test		Polychaete Toxicity Test			Bivalve Larval Toxicity Test		
	SMS Exceedance	Percent Mean Mortality ± SD	SMS Exceedance[a, b]	Mean Mortality ± SD	Mean Individual Growth Rate ± SD (mg/day)	SMS Exceedance[a, c, d]	Percent Mean Normal Survivorship ± SD	SMS Exceedance[a, e]	
LDW-SS2-010	SQS	39.0 ± 16.0	CSL	0.0 ± 0.0	0.76 ± 0.20	no exceedances	31.8 ± 15.1	CSL	CSL
LDW-SS6-010	CSL	47.0 ± 21.7	CSL	4.0 ± 8.9	0.81 ± 0.04	no exceedances	23.6 ± 16.3	CSL	CSL
LDW-SS15-010	CSL	28.0 ± 8.4	SQS	0.0 ± 0.0	0.73 ± 0.10	no exceedances	75.4 ± 8.7	no exceedances	SQS
LDW-SS16-010	SQS	16.0 ± 10.2	no exceedances	4.0 ± 8.9	0.96 ± 0.13	no exceedances	64.3 ± 3.2	SQS	SQS
LDW-SS17-010	SQS	35.0 ± 20.9	SQS	0.0 ± 0.0	0.92 ± 0.22	no exceedances	62.9 ± 7.6	no exceedances	SQS
LDW-SS24-010	CSL	7.0 ± 4.5	no exceedances	0.0 ± 0.0	0.77 ± 0.17	SQS	18.3 ± 3.3	CSL	CSL
LDW-SS26-010	SQS	23.0 ± 11.0	no exceedances	0.0 ± 0.0	0.86 ± 0.17	no exceedances	76.7 ± 7.4	no exceedances	no exceedances
LDW-SS29-010	no exceedances	12.0 ± 7.6	no exceedances	0.0 ± 0.0	0.90 ± 0.08	no exceedances	64.7 ± 6.8	no exceedances	no exceedances
LDW-SS31-010	CSL	43.0 ± 5.7	CSL	4.0 ± 8.9	0.81 ± 0.10	no exceedances	62.9 ± 7.6	SQS	CSL
LDW-SS32-010	SQS	34.0 ± 11.9	SQS	0.0 ± 0.0	0.69 ± 0.10	no exceedances	78.9 ± 15.7[f]	no exceedances	SQS
LDW-SS37-010	CSL	45.0 ± 14.6	CSL	0.0 ± 0.0	0.78 ± 0.05	no exceedances	65.8 ± 19.2[g]	SQS	CSL
LDW-SS39-010	CSL	29.0 ± 11.4	SQS	0.0 ± 0.0	0.76 ± 0.12	SQS	83.4 ± 10.1	no exceedances	CSL
LDW-SS40-010	SQS	36.0 ± 12.9	CSL	0.0 ± 0.0	0.78 ± 0.14	no exceedances	79.7 ± 4.9	no exceedances	CSL
LDW-SS49-010	CSL	49.0 ± 19.5	CSL	0.0 ± 0.0	0.79 ± 0.22	no exceedances	55.1 ± 17.4	SQS	CSL
LDW-SS50-010	SQS	39.0 ± 10.8	CSL	0.0 ± 0.0	0.73 ± 0.11	no exceedances	70.2 ± 10.2	no exceedances	CSL
LDW-SS56-010	CSL	6.0 ± 4.2	no exceedances	0.0 ± 0.0	0.85 ± 0.14	no exceedances	67.6 ± 7.2	SQS	SQS
LDW-SS57-010	SQS	13.0 ± 12.5	no exceedances	0.0 ± 0.0	0.78 ± 0.13	no exceedances	55.3 ± 15.1	CSL	CSL
LDW-SS58-010	SQS	5.0 ± 5.0	no exceedances	0.0 ± 0.0	0.69 ± 0.07	SQS	61.0 ± 4.0	SQS	CSL
LDW-SS60-010	SQS	7.0 ± 5.7	no exceedances	4.0 ± 8.9	0.77 ± 0.17	no exceedances	84.7 ± 6.0	no exceedances	no exceedances
LDW-SS63-010	no exceedances	5.0 ± 6.1	no exceedances	0.0 ± 0.0	0.68 ± 0.19	no exceedances	80.0 ± 1.6	no exceedances	no exceedances

Table 4-17, cont. Results of chemistry and site-specific toxicity testing of surface sediment samples from the LDW

Sample ID	Chemical Results	Toxicity Test Results							Overall SMS Exceedance
		Amphipod Toxicity Test		Polychaete Toxicity Test			Bivalve Larval Toxicity Test		
	SMS Exceedance	Percent Mean Mortality ± SD	SMS Exceedance[a, b]	Mean Mortality ± SD	Mean Individual Growth Rate ± SD (mg/day)	SMS Exceedance[a, c, d]	Percent Mean Normal Survivorship ± SD	SMS Exceedance[a, e]	
LDW-SS68-010	CSL	12.0 ± 9.1	no exceedances	0.0 ± 0.0	0.85 ± 0.10	no exceedances	71.6 ± 12.5	no exceedances	no exceedances
LDW-SS69b-010	SQS	37.0 ± 15.7	CSL	0.0 ± 0.0	0.85 ± 0.29	no exceedances	59.0 ± 13.6	SQS	CSL
LDW-SS70-010	SQS	15.0 ± 7.1	no exceedances	4.0 ± 8.9	0.78 ± 0.12	no exceedances	60.7 ± 12.0	SQS	SQS
LDW-SS71-010	SQS	5.0 ± 6.1	no exceedances	0.0 ± 0.0	0.92 ± 0.16	no exceedances	61.8 ± 8.7	no exceedances	no exceedances
LDW-SS73-010	CSL	12.0 ± 9.1	no exceedances	0.0 ± 0.0	0.86 ± 0.11	no exceedances	56.8 ± 13.3	SQS	SQS
LDW-SS75-010	SQS	8.0 ± 7.6	no exceedances	4.0 ± 8.9	0.69 ± 0.16	no exceedances	76.5 ± 7.5	no exceedances	no exceedances
LDW-SS77-010	SQS	16.0 ± 9.6	no exceedances	4.0 ± 8.9	0.95 ± 0.12	no exceedances	10.1 ± 4.0	CSL	CSL
LDW-SS85-010	SQS	1.0 ± 2.2	no exceedances	0.0 ± 0.0	0.87 ± 0.18	no exceedances	86.8 ± 5.3	no exceedances	no exceedances
LDW-SS88-010	CSL	48.0 ± 25.9	CSL	0.0 ± 0.0	0.68 ± 0.14	no exceedances	11.9 ± 5.3	CSL	CSL
LDW-SS89-010	CSL	5.0 ± 3.5	no exceedances	0.0 ± 0.0	0.84 ± 0.26	no exceedances	86.9 ± 5.1[g]	no exceedances	no exceedances
LDW-SS92-010	CSL	1.0 ± 2.2	no exceedances	0.0 ± 0.0	0.79 ± 0.17	no exceedances	78.3 ± 14.3	no exceedances	no exceedances
LDW-SS106-010	SQS	6.0 ± 4.2	no exceedances	0.0 ± 0.0	0.91 ± 0.11	no exceedances	61.4 ± 8.8	no exceedances	no exceedances
LDW-SS112-010	CSL	4.0 ± 4.2	no exceedances	0.0 ± 0.0	0.82 ± 0.06	no exceedances	65.4 ± 9.6	no exceedances	no exceedances
LDW-SS114-010	CSL	85.0 ± 7.1	CSL	4.0 ± 8.9	0.77 ± 0.19	no exceedances	56.6 ± 8.5	SQS	CSL
LDW-SS115-010	SQS	9.0 ± 4.2	no exceedances	0.0 ± 0.0	0.76 ± 0.21	no exceedances	77.6 ± 11.0	no exceedances	no exceedances
LDW-SS119-010	SQS	3.0 ± 2.7	no exceedances	0.0 ± 0.0	0.79 ± 0.06	no exceedances	68.8 ± 7.6	no exceedances	no exceedances
LDW-SS120-010	SQS	3.0 ± 2.7	no exceedances	0.0 ± 0.0	0.71 ± 0.09	no exceedances	56.3 ± 11.2	SQS	SQS
LDW-SS121-010	CSL	4.0 ± 4.2	no exceedances	0.0 ± 0.0	0.90 ± 0.12	no exceedances	76.4 ± 8.0	no exceedances	no exceedances
LDW-SS122-010	SQS	7.0 ± 4.5	no exceedances	0.0 ± 0.0	0.83 ± 0.14	no exceedances	68.5 ± 14.9	no exceedances	no exceedances
LDW-SS143-010	CSL	6.0 ± 5.5	no exceedances	0.0 ± 0.0	0.75 ± 0.07	no exceedances	72.8 ± 3.2	no exceedances	no exceedances
LDW-SS144-010	SQS	1.0 ± 2.2	no exceedances	0.0 ± 0.0	0.72 ± 0.11	SQS	66.4 ± 12.1	no exceedances	SQS[h]

Table 4-17, cont. Results of chemistry and site-specific toxicity testing of surface sediment samples from the LDW

Sample ID	Chemical Results	Toxicity Test Results							Overall SMS Exceedance
		Amphipod Toxicity Test		Polychaete Toxicity Test			Bivalve Larval Toxicity Test		
	SMS Exceedance	Percent Mean Mortality ± SD	SMS Exceedance[a, b]	Mean Mortality ± SD	Mean Individual Growth Rate ± SD (mg/day)	SMS Exceedance[a, c, d]	Percent Mean Normal Survivorship ± SD	SMS Exceedance[a, e]	
LDW-SS148-010	SQS	6.0 ± 6.5	no exceedances	0.0 ± 0.0	0.78 ± 0.08	SQS	29.9 ± 6.6	CSL	CSL
LDW-SS157-010	CSL	8.0 ± 7.6	no exceedances	4.0 ± 8.9	0.78 ± 0.14	SQS	71.6 ± 8.5	no exceedances	SQS[h]
LDW-SS158-010	SQS	12.0 ± 4.5	no exceedances	0.0 ± 0.0	0.81 ± 0.10	no exceedances	67.5 ± 6.5	no exceedances	no exceedances
LDW-SSB2b-010	SQS	25.0 ± 12.2	no exceedances	0.0 ± 0.0	1.02 ± 0.10	no exceedances	42.1 ± 20.0	CSL	CSL
LDW-SSB6a-010	SQS	2.0 ± 4.5	no exceedances	0.0 ± 0.0	0.82 ± 0.14	SQS	60.1 ± 13.3	no exceedances	SQS[h]

[a] Statistical analyses in SEDQUAL 5.0 included Wilk-Shapiro test for normality and Levene's test for equality of variances followed by the appropriate statistical test for significance (i.e., Student's t-test, approximate t-test, or Mann-Whitney test).

[b] SQS – mean mortality > 25% on an absolute basis and statistically different from the reference sediment ($p \leq 0.05$); CSL – mean mortality greater than the value in the reference sediment plus 30% and statistically different from the reference sediment ($p \leq 0.05$). Reference sediment results are presented in the Round 1 and Round 2 surface sediment data reports (Windward 2005c, d).

[c] SQS – mean individual growth rate <70% of that of the reference sediment and statistically different ($p \leq 0.05$).

[d] No exceedance was reported for the polychaete growth endpoint for some of the sediment samples because of high variability in the reference and/or test samples.

[e] SQS – mean normal survivorship < 85% of that of the reference sediment and statistically different ($p \leq 0.10$); CSL – mean normal survivorship < 70% of that of the reference sediment and statistically different ($p \leq 0.10$).

[f] One of the five replicates from each of these tests was double-inoculated, so those replicates were not used in calculating mean normal survivorship and mean effective mortality for those test sediments.

[g] One of the five replicates from each of these tests was not inoculated at test initiation, so those replicates were not used in calculating mean normal survivorship and mean effective mortality for those test sediments.

[h] Exceeded the SQS criterion based on reduction in polychaete growth alone.

CSL – cleanup screening level

ID – identification

LDW – Lower Duwamish Waterway

SMS – Washington State Sediment Management Standards

SD – standard deviation

SQS – sediment quality standards

Thiessen polygons were used to estimate the areal extent of potential effects based on combined toxicity test results and surface sediment chemistry data (see Map 4-16). Using this approach, approximately 75% of the LDW area (345 ac) had chemical concentrations less than or equal to chemical SQS criteria, and sediments were non-toxic according to biological SQS criteria. In approximately 7% of the LDW area (34 ac), chemical concentrations or biological effects exceeded CSL criteria. The remaining 18% of the LDW area (82 ac) had chemical concentrations or biological effects between the SQS and CSL criteria. These area estimates are uncertain because they were based on interpolation using Thiessen polygons.

4.2.1.4 Subsurface sediment chemistry relative to SMS

Table 4-18 presents a summary of subsurface sediment samples with chemical concentrations greater than the SQS and CSL. Detected concentrations of 36 SMS chemicals were greater than the CSL at one or more locations. Eight additional chemicals (i.e., anthracene, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, butyl benzyl phthalate, di-n-octyl phthalate, hexachlorobenzene, hexachlorobutadiene, and n-nitrosodiphenylamine) were detected at concentrations that exceeded the SQS but did not exceed the CSL. Detected concentrations of the remaining three SMS chemicals (i.e., acenapthylene, di-n-butyl phthalate, and 4-methylphenol) did not exceed the SQS or the CSL.

Maps 4-17a through 4-17j show the distribution of chemicals with concentrations greater than the SMS criteria in subsurface samples outside of the Duwamish/Diagonal, Boeing Plant 2, and T-117 EAAs;[54] these maps show exceedances for specific chemical groups (i.e., PCBs, BEHP, SVOCs [excluding BEHP], and metals). Cores collected from the portion of the LDW between RM 0.0 and RM 1.5 frequently had subsurface samples with detected concentrations that were greater than the SQS and the CSLs. Most of these samples had PCB concentrations greater than the SQS (Map 4-17a), but there were also a number of other chemicals with concentrations greater than the SQS. These chemicals were primarily mercury, BEHP, and other metals (Map 4-17b).

[54] These areas were not included on Maps 4-16a through 4-16j because of the substantial number of cores collected and because these data will be evaluated in greater detail as part of individual site investigations.

Table 4-18. Comparison of subsurface sediment data to SMS criteria

Analyte	n[a]	Detection Frequency		Subsurface Sediment Chemistry							
				Detected Concentrations > SQS and ≤ CSL[b]		Detected Concentrations > CSL[b]		Samples with RLs > SMS Criteria[c]		Maximum Ratio of Detected Conc. to SQS	Maximum Ratio of Detected Conc. to CSL
		No. of Detects	%	No.	%[d]	No.	%[d]	> SQS and ≤ CSL	CSL		
Metals and Trace Elements											
Arsenic	325	267	82	6	1.8	19	5.8	0	0	35	22
Cadmium	388	257	66	1	0.26	8	2.1	0	0	4.0	3.0
Chromium	397	397	100	0	0	2	0.50	0	0	1.5	1.4
Copper	397	397	100	0	0	10	2.5	0	0	7.5	7.5
Lead	400	367	92	3	0.75	10	2.5	0	0	7.8	6.6
Mercury	440	345	78	22	5.0	33	7.5	0	0	24	17
Silver	372	166	45	0	0	2	0.54	0	0	1.2	1.2
Zinc	396	396	100	15	3.8	15	3.8	0	0	12	4.9
PAHs											
2-Methylnaphthalene	297	46	15	0	0	1	0.34	0	0	6.7	3.2
Acenaphthene	320	104	33	11	3.4	4	1.3	3	0	10	6.3
Acenaphthylene	297	57	19	0	0	0	0	0	0	0.22	0.22
Anthracene	320	216	68	2	0.63	0	0	0	0	3.1	0.57
Benzo(a)anthracene	320	259	81	6	1.9	2	0.63	0	0	5.0	2.3
Benzo(a)pyrene	320	253	79	4	1.3	2	0.63	0	0	2.3	1.1
Benzo(g,h,i)perylene	320	222	69	7	2.2	0	0	2	0	1.8	0.82
Total benzofluoranthenes	320	264	83	4	1.3	2	0.63	0	0	2.4	2.1
Chrysene	320	263	82	8	2.5	2	0.63	0	0	5.5	1.5
Dibenzo(a,h)anthracene	320	135	42	21	6.6	1	0.31	1	5	3.2	1.2
Dibenzofuran	320	66	21	7	2.2	2	0.63	4	0	6.7	2.4
Fluoranthene	320	278	87	16	5.0	3	0.94	0	0	11	3.2
Fluorene	320	112	35	4	1.3	3	0.94	2	0	8.0	4.3
Indeno(1,2,3-cd)pyrene	320	226	71	9	2.8	0	0	0	0	2.1	0.97

Table 4-18, cont. Comparison of subsurface sediment data to SMS criteria

Analyte	n[a]	Detection Frequency		Subsurface Sediment Chemistry							
				Detected Concentrations > SQS and ≤ CSL[b]		Detected Concentrations > CSL[b]		Samples with RLs > SMS Criteria[c]		Maximum Ratio of Detected Conc. to SQS	Maximum Ratio of Detected Conc. to CSL
		No. of Detects	%	No.	%[d]	No.	%[d]	> SQS and ≤ CSL	CSL		
Naphthalene	309	75	24	0	0	1	0.32	0	0	1.6	1.4
Phenanthrene	320	260	81	6	1.9	2	0.63	0	0	9.2	2.4
Pyrene	320	282	88	1	0.31	2	0.63	0	0	2.6	2.0
Total HPAH	320	284	89	9	2.8	2	0.63	0	0	5.1	2.0
Total LPAH	320	260	81	3	0.94	2	0.63	0	0	5.2	2.4
Phthalates											
BEHP	322	231	72	27	8.4	19	5.9	6	5	4.3	2.6
Butyl benzyl phthalate	299	163	55	17	5.7	0	0	7	0	5.8	0.41
Diethyl phthalate	322	1	0.31	0	0	1	0.31	1	0	6.7	3.7
Dimethyl phthalate	299	20	6.7	0	0	1	0.33	2	2	6.4	6.4
Di-n-butyl phthalate	299	64	21	0	0	0	0	0	0	0.086	0.024
Di-n-octyl phthalate	322	14	4.3	1	0.31	0	0	5	0	2.4	0.031
Other SVOCs											
1,2,4-Trichlorobenzene	309	29	9.4	3	0.97	2	0.65	49	8	3.5	2.2
1,2-Dichlorobenzene	308	35	11	0	0	3	0.97	1	7	4.3	4.3
1,4-Dichlorobenzene	308	60	19	0	0	1	0.32	2	2	6.8	6.3
2,4-Dimethylphenol	297	22	7.4	0	0	1	0.34	0	16	1.6	1.6
2-Methylphenol	297	38	13	0	0	1	0.34	0	4	2.5	2.5
4-Methylphenol	320	15	4.7	0	0	0	0	0	0	0.16	0.16
Benzoic acid	320	122	38	0	0	13	4.1	0	16	4.6	4.6
Benzyl alcohol	297	33	11	2	0.67	6	2.0	14	11	3.7	2.9
Hexachlorobenzene	296	3	1.0	1	0.34	0	0	127	7	1.8	0.30
Hexachlorobutadiene	309	2	0.65	1	0.32	0	0	8	4	1.2	0.11
n-Nitrosodiphenylamine	297	1	0.34	1	0.34	0	0	5	19	1.2	0.83
Pentachlorophenol	320	55	17	1	0.31	4	1.3	2	23	2.6	1.3

Table 4-18, cont. Comparison of subsurface sediment data to SMS criteria

Analyte	n[a]	Detection Frequency		Subsurface Sediment Chemistry							
				Detected Concentrations > SQS and ≤ CSL[b]		Detected Concentrations > CSL[b]		Samples with RLs > SMS Criteria[c]		Maximum Ratio of Detected Conc. to SQS	Maximum Ratio of Detected Conc. to CSL
		No. of Detects	%	No.	%[d]	No.	%[d]	> SQS and ≤ CSL	CSL		
Phenol	320	57	18	1	0.31	1	0.31	1	0	7.4	2.6
PCBs											
PCBs (total calc'd)	871	654	75	229	26	184	21	3	0	2,400	450

[a] The total number of samples includes all analyzed core intervals and does not represent the total number of cores.

[b] For individual samples with TOC ≥ 4.0% or ≤ 0.5%, samples were counted as greater than the SQS or CSL if the dry-weight concentration was greater than the LAET or 2LAET, respectively.

[c] Number of samples with RLs greater than the SQS or CSL, when undetected.

[d] Percentage of total number of locations with detected concentrations greater than the SQS or CSL. Percent exceeding SQS excludes samples with CSL exceedances.

BEHP – bis(2-ethylhexyl) phthalate
CSL – cleanup screening level
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
n – number of samples
PCB – polychlorinated biphenyl
SMS – Washington State Sediment Management Standards
SQS – sediment quality standards
SVOC – semivolatile organic compound

Between RM 1.5 and RM 4.0, there were comparatively fewer samples with chemical concentrations greater than the CSL, but samples frequently had concentrations greater than the SQS (Maps 4-17c through 4-17h). Most of the concentrations greater than the SQS were for total PCBs. South of RM 4.0, most of the concentrations greater than the SQS in subsurface samples were located in the vicinity of the Rhône-Poulenc site, including Slip 6 (RM 4.0 to RM 4.2), or in the vicinity of the Norfolk EAA (Maps 4-17i and 4-17j). Chemicals most frequently detected in subsurface samples at concentrations greater than the SQS in the vicinity of the Slip 6 were benzoic acid and dibenzo(a,h)anthracene. Chemicals most frequently detected in subsurface samples at concentrations greater than the SQS in the vicinity of the Norfolk EAA were PCBs, 1,4-dichlorobenzene, BEHP, and mercury. The cores in which these exceedances were detected (NFK207, NFK008, and NFK009) no longer represent current conditions because those core locations were subsequently dredged.

4.2.2 Water chemistry relative to water quality criteria

The LDW site includes the water column as well as the sediments. Chemical concentrations in biota are affected by chemicals in surface water as well as sediments, as discussed in Appendix D. This section describes the numerical criteria for toxic pollutants in surface water and summarizes LDW surface water, seep water, and porewater data, as requested by EPA and Ecology.

Federal water quality criteria (WQC) developed to protect ecological receptors and human consumers of fish and shellfish are relevant and appropriate requirements or minimum levels or standards for remedial action pursuant to CERCLA Section 121 (d)(2)(A)(ii) and RCW 70.105D.030(2)(e). Under CERCLA and MTCA, state water quality standards (WQS) approved by EPA are generally applicable requirements under the Clean Water Act (CWA). National recommended federal WQC established pursuant to Section 304(a)(1) of the CWA are compiled and presented on the EPA website at http://www.epa.gov/waterscience/criteria/wqctable/. Although these criteria are advisory only for CWA purposes, the last sentence of CERCLA Section 121 (d)(2)(A)(ii) makes them minimum cleanup levels or standards for the site. Consequently, the more stringent of the federal WQC and the state WQS approved by EPA for CWA purposes are the cleanup levels or standards for the site.

Washington State WQS for the protection of aquatic life are found at WAC 173-201A-240. The numerical criteria for aquatic life meet the federal requirements of Section 303(c)(2)(B) of the CWA, are at least as stringent as the federal WQC, and have been approved by EPA as applicable CWA criteria in accordance with 40 CFR 131.21.[55] The criteria for human health are listed in EPA's regulations at 40 CFR 131.36(d)(14) and

[55] Except for the Washington State copper criteria, which were amended by Washington in 2007 (72 Fed. Reg. 37,109, 37,115 [July 9, 2007]) and approved by EPA (40 CFR 131.36). Federal WQC are also presented in the tables in this section if their values are lower than state WQC.

cross-referenced in Washington's regulations at WAC 173-201A-240(5). The federal and state aquatic life and human health WQS and WQC are hereafter referred to as WQC in this document unless otherwise noted.

The aquatic life WQC are presented as both acute and chronic criteria. Aquatic life WQC are based on dissolved concentrations for metals (except mercury) and total concentrations for mercury and organic compounds. Acute WQC are 1-hr average concentrations not to be exceeded more than once every 3 years, with the exception of silver and pesticide concentrations, which are instantaneous concentrations not to be exceeded at any time, or the PCB concentration, which is a 24-hr average not to be exceeded at any time. Chronic WQC are 4-day average concentrations not to be exceeded more than once every 3 years, with the exception of pesticide and PCB concentrations, which are 24-hr average concentrations not to be exceeded at any time.

Both marine and freshwater values have been developed for aquatic life WQC. Under state regulations, freshwater values apply to waters with a salinity of 1 ppt or less 95% of the time (WAC 173-201A-260). These regulations also state that in brackish water of estuaries, where different criteria for the same use occurs for fresh and marine waters, the decision to use the freshwater or the marine water criteria must be selected and applied on the basis of vertically averaged daily maximum salinity. Federal regulations (40 CFR 131.36[c][3]) state that for waters in which the salinity is between 1 and 10 ppt, the applicable criteria are the more stringent of the freshwater or saltwater criteria. They do not contain provisions for vertically averaging salinity data.

As noted in Section 2.7, LDW is a well-stratified estuary. Fresh water flowing from the Green/Duwamish River system enters the headwaters of the LDW, and salt water from Puget Sound enters the lower reaches of the LDW from the mouth of the waterway. Typical of tidally influenced estuaries, the LDW has a relatively sharp interface between the freshwater outflow at the surface and saltwater inflow at depth. As the fresh water flows over the deeper saltwater wedge, only limited mixing occurs between these freshwater and saltwater lenses, resulting in a lens of fresh water overlying the salt wedge over a significant portion of the LDW a significant portion of the time. The salinity of the surface water varies with river flow and tidal conditions; during times of high river flow, the salinity in the surface water is low; whereas, during low-flow conditions, the surface water salinity is higher. At the river's mouth at the northern end of Harbor Island, a salinity of 25 ppt is typical for the entire water column; salinity decreases toward the upriver portion of the estuary. The upstream location or "toe" of the saltwater wedge, typically located between Slip 4 and the head of the navigation channel, is determined by both tidal elevation and freshwater inflow. As noted in Section 2.8, a more diverse biological community typical of marine environments generally exists in the downstream, more saline portion of the LDW (RM 0.0 to RM 2.0), transitioning upstream to a less-diverse community of species more tolerant of fluctuations in salinity (see Section 2.8.2.2).

Absent site-specific biological data to the contrary as outlined below, applicable (state) or relevant and appropriate (federal) criteria for LDW surface water data are the more stringent of state or federal WQC. In areas where the salinity in any portion or lens of the water column is greater than 1 ppt and less than 10 ppt 95% of the time, the more stringent of marine or freshwater criteria will be used. In areas where the salinity in all portions of the water column is greater than 10 ppt 95% of the time, only marine standards will be used. Freshwater criteria shall presumptively be used for any fresh water in the LDW pursuant to CERCLA section 121(d)(2)(A)(ii), unless it is demonstrated that they are not appropriate at particular locations based on site-specific biological information demonstrating that there are no freshwater biological receptors of significance found or expected to be present at such location(s).

For all locations generally, the determination of which standards apply must be made based on area-specific salinity measurements. The salinity in some areas is highly variable, depending on the tide and the flow rate from the Green/Duwamish River. For example, based on monthly salinity data collected at RM 3.3 as part of the King County Monthly Marine Monitoring Program (http://green.kingcounty.gov/marine/CTD.aspx), the salinity at this location is generally greater than 1 ppt and less than 10 ppt in the surface layer, which varies in depth from < 0.5 to 5 meters, with the deeper depths occurring under high river flow conditions. The more stringent of the freshwater or marine criteria would apply to this surface layer, provided the salinity is in the 1 to10 ppt range 95% of the time. Both freshwater and marine WQC are provided in Tables 4-19 though 4-22.

Human health WQC have been established for the consumption of organisms only (i.e., fish and shellfish) and also for the consumption of both organisms and water. The WQC based on consumption of both organisms and water are assigned to waters classified only for domestic water supply (40 CFR 131.36 [14]) and thus do not apply to the LDW. Human health WQC are based on dissolved concentrations for all chemicals.

Tables 4-19 through 4-22 present the criteria as well as summaries of surface water, seep water, and porewater data from the LDW. This information is provided only for informational purposes; comparisons of some of these criteria with the data may not be appropriate.

Table 4-19. Aquatic life WQC and human health WQC

Chemical	State WQC (µg/L)[a]				Federal AWQC (µg/L)[b]				
	Freshwater[c]		Marine[c]		Freshwater[c]		Marine[c]		Human Health[d]
	Acute[e]	Chronic[f]	Acute[e]	Chronic[f]	Acute[e]	Chronic[f]	Acute[e]	Chronic[f]	Organisms Only
Metals and Trace Elements									
Antimony	na	na	na	na	na	na	na	na	640
Arsenic	360	190	**69**	**36**	**340**	**150**	69	36	0.14[g,h]
Cadmium	3.7	1.0	42	9.3	**2.0**	**0.25**	**40**	**8.8**	na
Chromium (hexavalent)	**15**	**10**	**1,100**	**50**	16	11	1,100	50	na
Chromium (trivalent)	**550**	180	na	na	570	**74**	na	na	na
Copper	**17**	**11**	**4.8**	**3.1**	nc[j]	nc[j]	4.8	3.1	na
Lead	**65**	**2.5**	**210**	**8.1**	65	2.5	210	8.1	na
Mercury	2.1	**0.012**	**1.8**	**0.025**	**1.4**	0.77	1.8	0.94	0.15[i]
Nickel	1,400	160	**74**	**8.2**	**470**	**52**	74	8.2	4,600
Selenium	**20**	**5**	**290**	**71**	na	5	290	71	4,200
Silver	3.4	na	**1.9**	na	**3.2**	na	1.9	na	na
Thallium	na	na	na	na	na	na	na	na	0.47
Zinc	**110**	**100**	**90**	**81**	120	120	90	81	26,000
PAHs									
2-Chloronaphthalene	na	na	na	na	na	na	na	na	1,600
Acenaphthene	na	na	na	na	na	na	na	na	990
Anthracene	na	na	na	na	na	na	na	na	40,000
Benzo(a)anthracene	na	na	na	na	na	na	na	na	0.018[g]
Benzo(a)pyrene	na	na	na	na	na	na	na	na	0.018[g]
Benzo(b)fluoranthene	na	na	na	na	na	na	na	na	0.018[g]
Benzo(k)fluoranthene	na	na	na	na	na	na	na	na	0.018[g]
Chrysene	na	na	na	na	na	na	na	na	0.018[g]
Dibenzo(a,h)anthracene	na	na	na	na	na	na	na	na	0.018[g]
Fluoranthene	na	na	na	na	na	na	na	na	140

Table 4-19, cont. Aquatic life WQC and human health WQC

Chemical	State WQC (µg/L)[a]				Federal AWQC (µg/L)[b]				
	Freshwater[c]		Marine[c]		Freshwater[c]		Marine[c]		Human Health[d]
	Acute[e]	Chronic[f]	Acute[e]	Chronic[f]	Acute[e]	Chronic[f]	Acute[e]	Chronic[f]	Organisms Only
Fluorene	na	na	na	na	na	na	na	na	5,300
Indeno(1,2,3-cd)pyrene	na	na	na	na	na	na	na	na	0.018[g]
Pyrene	na	na	na	na	na	na	na	na	4,000
Phthalates									
BEHP	na	na	na	na	na	na	na	na	2.2[g]
Butyl benzyl phthalate	na	na	na	na	na	na	na	na	1,900
Diethyl phthalate	na	na	na	na	na	na	na	na	44,000
Dimethyl phthalate	na	na	na	na	na	na	na	na	1,100,000
Di-n-butyl phthalate	na	na	na	na	na	na	na	na	4,500
SVOCs									
1,2,4-Trichlorobenzene	na	na	na	na	na	na	na	na	70
1,2-Dichlorobenzene	na	na	na	na	na	na	na	na	1,300
1,2-Diphenylhydrazine	na	na	na	na	na	na	na	na	0.2[g]
1,3-Dichlorobenzene	na	na	na	na	na	na	na	na	960
1,4-Dichlorobenzene	na	na	na	na	na	na	na	na	190
2,4,6-Trichlorophenol	na	na	na	na	na	na	na	na	2.4[g]
2,4-Dichlorophenol	na	na	na	na	na	na	na	na	290
2,4-Dimethylphenol	na	na	na	na	na	na	na	na	850
2,4-Dinitrophenol	na	na	na	na	na	na	na	na	5,300
2,4-Dinitrotoluene	na	na	na	na	na	na	na	na	3.4[g]
2-Chlorophenol	na	na	na	na	na	na	na	na	150
3,3'-Dichlorobenzidine	na	na	na	na	na	na	na	na	0.028[g]
4,6-Dinitro-o-cresol (2-methyl-4,6-dinitrophenol)	na	na	na	na	na	na	na	na	280
Benzidine	na	na	na	na	na	na	na	na	0.0002
Bis(2-chloroethyl)ether	na	na	na	na	na	na	na	na	0.53[g]
Bis(2-chloroisopropyl)ether	na	na	na	na	na	na	na	na	65,000
Hexachlorobenzene	na	na	na	na	na	na	na	na	0.00029[g]

Table 4-19, cont. Aquatic life WQC and human health WQC

Chemical	State WQC (µg/L)[a]				Federal AWQC (µg/L)[b]				
	Freshwater[c]		Marine[c]		Freshwater[c]		Marine[c]		Human Health[d]
	Acute[e]	Chronic[f]	Acute[e]	Chronic[f]	Acute[e]	Chronic[f]	Acute[e]	Chronic[f]	Organisms Only
Hexachlorobutadiene	na	na	na	na	na	na	na	na	18[g]
Hexachlorocyclopentadiene	na	na	na	na	na	na	na	na	1,100
Hexachloroethane	na	na	na	na	na	na	na	na	3.3[g]
Isophorone	na	na	na	na	na	na	na	na	960[g] (**600**[i])
Nitrobenzene	na	na	na	na	na	na	na	na	690
n-Nitrosodimethylamine	na	na	na	na	na	na	na	na	3[g]
n-Nitroso-di-n-propylamine	na	na	na	na	na	na	na	na	0.51[g]
n-Nitrosodiphenylamine	na	na	na	na	na	na	na	na	6[g]
Pentachlorophenol	20[k]	**13**[k]	**13**	**7.9**	**19**[k]	15[k]	13	7.9	3[g]
Phenol	na	na	na	na	na	na	na	na	860,000
PCBs									
PCBs	**2**	**0.014**	**10**	**0.03**	na	0.014	na	0.03	0.000064[g]
Pesticides									
4,4′-DDD	na	na	na	na	na	na	na	na	0.00031[g]
4,4′-DDE	na	na	na	na	na	na	na	na	0.00022[g]
4,4′-DDT	**1.1**	**0.001**	**0.13**	**0.001**	1.1	0.001	0.13	0.001	0.00022[g]
Aldrin	na	na	na	na	**3.0**	na	**1.3**	na	0.000050[g]
Dieldrin	na	na	na	na	**0.24**	**0.056**	**0.71**	**0.0019**	0.000054[g]
Aldrin/dieldrin (sum)[l]	**2.5**	**0.0019**	**0.71**	**0.0019**	na	na	na	na	na
alpha-BHC	na	na	na	na	na	na	na	na	0.0049[g]
beta-BHC	na	na	na	na	na	na	na	na	0.017[g]
gamma-BHC (Lindane)	2.0	**0.08**	**0.16**	na	**0.95**	na	0.16	na	1.8
alpha-Endosulfan	**0.22**[m]	**0.056**[m]	**0.034**[m]	**0.0087**[m]	0.22	0.056	0.034	0.0087	89 (**2**[i])
beta-Endosulfan	**0.22**[m]	**0.056**[m]	**0.034**[m]	**0.0087**[m]	0.22	0.056	0.034	0.0087	89 (**2**[i])
Endosulfan sulfate	na	na	na	na	na	na	na	na	89 (**2**[i])
Endrin	0.18	**0.0023**	**0.037**	**0.0023**	**0.086**	0.036	0.037	0.0023	0.06
Endrin aldehyde	na	na	na	na	na	na	na	na	0.3

Table 4-19, cont. Aquatic life WQC and human health WQC

Chemical	State WQC (µg/L)[a]				Federal AWQC (µg/L)[b]				
	Freshwater[c]		Marine[c]		Freshwater[c]		Marine[c]		Human Health[d]
	Acute[e]	Chronic[f]	Acute[e]	Chronic[f]	Acute[e]	Chronic[f]	Acute[e]	Chronic[f]	Organisms Only
Heptachlor	**0.52**	**0.0038**	**0.053**	**0.0036**	0.52	0.0038	0.053	0.0036	0.000079[g]
Heptachlor epoxide	na	na	na	na	**0.52**	**0.0038**	**0.053**	**0.0036**	0.000039[g]
Toxaphene	**0.73**	**0.0002**	**0.21**	**0.0002**	0.73	0.0002	0.21	0.0002	0.00028[g]
Chlordane	**2.4**	**0.0043**	**0.09**	**0.004**	2.4	0.0043	0.09	0.004	0.00081[g]
VOCs									
1,1,2,2-Tetrachloroethane	na	na	na	na	na	na	na	na	4[g]
1,1,2-Trichloroethane	na	na	na	na	na	na	na	na	16[g]
1,1-Dichloroethene (1,1-dichloroethylene)	na	na	na	na	na	na	na	na	7,100
1,2-Dichloroethane	na	na	na	na	na	na	na	na	37
1,2-Dichloropropane	na	na	na	na	na	na	na	na	15[g]
Acrolein	na	na	na	na	**3**	**3**	na	na	9
Acrylonitrile	na	na	na	na	na	na	na	na	0.25[g]
Benzene	na	na	na	na	na	na	na	na	51[g]
Bromodichloromethane (dichlorobromomethane)	na	na	na	na	na	na	na	na	17[g]
Bromoform	na	na	na	na	na	na	na	na	140[g]
Bromomethane (methyl bromide)	na	na	na	na	na	na	na	na	1,500
Carbon tetrachloride	na	na	na	na	na	na	na	na	1.6[g]
Chlorobenzene	na	na	na	na	na	na	na	na	1,600
Chloroform	na	na	na	na	na	na	na	na	470
Dibromochloromethane (chlorobromomethane)	na	na	na	na	na	na	na	na	13[g]
Dichloromethane (methylene chloride)	na	na	na	na	na	na	na	na	590[g]
Ethylbenzene	na	na	na	na	na	na	na	na	2,100
Tetrachloroethene	na	na	na	na	na	na	na	na	3.3[g]
Toluene	na	na	na	na	na	na	na	na	15,000

Table 4-19, cont. Aquatic life WQC and human health WQC

Chemical	State WQC (µg/L)[a]				Federal AWQC (µg/L)[b]				
	Freshwater[c]		Marine[c]		Freshwater[c]		Marine[c]		Human Health[d]
	Acute[e]	Chronic[f]	Acute[e]	Chronic[f]	Acute[e]	Chronic[f]	Acute[e]	Chronic[f]	Organisms Only
trans-1,2-Dichloroethene	na	na	na	na	na	na	na	na	10,000
Trichloroethene (trichloroethylene)	na	na	na	na	na	na	na	na	30[g]
Vinyl chloride	na	na	na	na	na	na	na	na	2.4[g]
Dioxins and Furans									
2,3,7,8 TCDD	na	na	na	na	na	na	na	na	5.1E-09[g]

Note: Underlined values are hardness-dependent, and were calculated using a hardness value of 100 mg/L, which is the default assumption when site-specific hardness data are not available. Existing site-specific data or site-specific data that may be collected can be used to adjust values rather than using a default hardness value of 100 mg/L. Bolded criteria are the lower of the state and federal criteria (state criteria are bolded if the state and federal criteria are the same). The lower of the human health criteria (when multiple criteria are available) is also bolded.

[a] Standards are from WAC 173-201A-240. Available from: http://apps.leg.wa.gov/wac/default.aspx?cite=173-201A-240 (accessed on June 4, 2010).

[b] Standards are from EPA AWQC (except where noted). EPA AWQC available from: http://www.epa.gov/waterscience/criteria/wqctable/ (accessed on June 4, 2010).

[c] Aquatic life WQC are based on dissolved concentrations for metals (except mercury) and total concentrations for mercury and organic compounds.

[d] Human health WQC are based on dissolved concentrations for all chemicals.

[e] Acute WQC are 1-hr average concentrations not to be exceeded more than once every 3 years, with the exception of silver and pesticide concentrations, which are instantaneous concentrations not to be exceeded at any time, or the PCB concentration, which is a 24-hr average not to be exceeded at any time.

[f] Chronic WQC are 4-day average concentrations not to be exceeded more than once every 3 years, with the exception of pesticide and PCB concentrations, which are 24-hr average concentrations not to be exceeded at any time.

[g] Human health WQC are based on 1 x 10^{-6} excess cancer risk for carcinogenic chemicals.

[h] Criterion represents the inorganic fraction of arsenic.

[i] Standards are from 40 CFR 131.36 (NTR), as referenced in WAC 173-201A-240. Available from: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=879a68e0f8b500cb27fc2f8df4ec7f56&rgn=div5&view=text&node=40:21.0.1.1.18&idno=40 (accessed on June 4, 2010).

[j] Criteria based on the biotic ligand model. The acute and chronic biotic ligand model -based criteria for copper would be 2.3 and 1.5 µg/L, respectively, assuming DOC = 0.5 mg/L, pH = 7.5, hardness = 85 mg/L, and temperature of 20°C.

[k] The freshwater aquatic life WQC for pentachlorophenol are pH-dependent; a pH of 7.8 was assumed, which is the default assumption.

[l] Aldrin is metabolically converted to dieldrin. Therefore, the sum of aldrin and dieldrin concentrations is compared with the dieldrin criteria.

[m] Standards are for endosulfan.

AWQC – ambient water quality criteria
BEHP - Bis(2-ethylhexyl) phthalate
BHC – benzene hexachloride
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
MCL – maximum contaminant level
na – not available
nc – not calculated
NTR – National Toxics Rule
PAH – polycyclic aromatic hydrocarbon
PCB – polyvinyl chloride
SVOC – semivolatile organic compound
TCDD – tetrachlorodibenzo-*p*-dioxin
VOC – volatile organic compound
WAC – Washington Administrative Code
WQC – water quality criteria

Table 4-20. Summary of detected chemicals in LDW surface water, freshwater and marine aquatic life WQC, and human health WQC

Chemical	Detection Summary					State WQC (µg/L)[a]				Federal AWQC (µg/L)[b]				Human Health[d]
		Detection Frequency		Concentration Range (µg/L)		Freshwater[c]		Marine[c]		Freshwater[c]		Marine[c]		
	Number of Samples	Number of Detects	%	Detected	Non-Detected (RLs)	Chronic[e]	Acute[f]	Chronic[e]	Acute[f]	Chronic[e]	Acute[f]	Chronic[e]	Acute[f]	Consumption of Organisms
Metals and Trace Elements														
Filtered														
Antimony	159	157	99	0.0095 – 0.116	0.01 – 0.01	nc	nc	nc	nc	nc	nc	nc	nc	640
Arsenic	168	168	100	0.175 – 1.46	na	190	360	**36**	**69**	**150**	**340**	36	69	*0.14*[g,h]
Cadmium	166	156	94	0.0072 – 0.0795	0.0067 – 0.0073	1.0	3.7	9.3	42	**0.25**	**2.0**	**8.8**	**40**	nc
Chromium (hexavalent)	148	148	100	0.1 – 0.576	na	**10**	**15**	**50**	**1,100**	11	16	50	1,100	nc
Copper	155	152	98	0.37 – 1.89	0.354 – 0.628	**11**	**17**	**3.1**	**4.8**	na[j]	na[j]	3.1	4.8	nc
Lead	160	160	100	0.0077 – 0.553	na	**2.5**	**65**	**8.1**	**210**	2.5	65	8.1	210	nc
Mercury	15	14	93	0.00013 – 0.00071	0.0001 – 0.0001	nc	nc	nc	nc	nc	nc	nc	nc	0.15[i]
Nickel	146	136	93	0.19 – 1.5	0.118 – 0.387	160	1,400	**8.2**	**74**	**52**	**470**	8.2	74	4,600
Selenium	154	1	1	0.16	0.12 – 0.16	**5**	**20**	**71**	**290**	5	nc	71	290	4,200
Thallium	168	78	46	0.005 – 0.011	0.0043 – 0.0053	nc	nc	nc	nc	nc	nc	nc	nc	0.47
Zinc	166	166	100	0.75 – 5.39	na	**100**	**110**	**81**	**90**	120	120	81	90	26,000
Unfiltered														
Mercury	29	15	52	0.00013 – 0.00071	0.0001	**0.012**	2.1	**0.025**	**1.8**	0.77	**1.4**	0.94	1.8	nc
PAHs[k]														
Acenaphthene	4	4	100	0.016 – 0.030	na	nc	nc	nc	nc	nc	nc	nc	nc	990
Anthracene	4	4	100	0.0014 – 0.0023	na	nc	nc	nc	nc	nc	nc	nc	nc	40,000
Benzo(a)anthracene	4	4	100	0.00017 – 0.00036	na	nc	nc	nc	nc	nc	nc	nc	nc	0.018[g]
Benzo(a)pyrene	4	4	100	0.000020 – 0.000033	na	nc	nc	nc	nc	nc	nc	nc	nc	0.018[g]
Benzo(b)fluoranthene	4	4	100	0.000081 – 0.00015	na	nc	nc	nc	nc	nc	nc	nc	nc	0.018[g]
Benzo(k)fluoranthene	4	4	100	0.000027 – 0.00012	na	nc	nc	nc	nc	nc	nc	nc	nc	0.018[g]
Chrysene	4	4	100	0.00017 – 0.00040	na	nc	nc	nc	nc	nc	nc	nc	nc	0.018[g]
Dibenzo(a,h)anthracene	4	4	100	0.0000027 – 0.0000052	na	nc	nc	nc	nc	nc	nc	nc	nc	0.018[g]
Fluoranthene	4	4	100	0.0063 – 0.020	na	nc	nc	nc	nc	nc	nc	nc	nc	140
Fluorene	4	4	100	0.0099 – 0.020	na	nc	nc	nc	nc	nc	nc	nc	nc	5,300
Indeno(1,2,3-cd)pyrene	4	4	100	0.0000093 – 0.000022	na	nc	nc	nc	nc	nc	nc	nc	nc	0.018[g]
Pyrene	4	4	100	0.0031 – 0.0070	na	nc	nc	nc	nc	nc	nc	nc	nc	4,000
Phthalates (unfiltered)														
BEHP	94	19	20	0.14 – 23.8	0.14 – 1.31	nc	nc	nc	nc	nc	nc	nc	nc	*2.2*[g]
Di-n-butyl phthalate	94	9	10	0.25 – 1.2	0.24 – 0.46	nc	nc	nc	nc	nc	nc	nc	nc	*4,500*
Other SVOCs (unfiltered)														
Phenol	94	1	1	2.01 – 2.01	0.94 – 1.1	nc	nc	nc	nc	nc	nc	nc	nc	*860,000*

Chemical	Detection Summary					State WQC (µg/L)[a]				Federal AWQC (µg/L)[b]				Human Health[d]
		Detection Frequency		Concentration Range (µg/L)		Freshwater[c]		Marine[c]		Freshwater[c]		Marine[c]		
	Number of Samples	Number of Detects	%	Detected	Non-Detected (RLs)	Chronic[e]	Acute[f]	Chronic[e]	Acute[f]	Chronic[e]	Acute[f]	Chronic[e]	Acute[f]	Consumption of Organisms
Polychlorinated Biphenyls (unfiltered)														
Total PCBs	15	15	100	0.0001318 – 0.003211	na	**0.014**	**2**	**0.03**	**10**	0.014	nc	0.03	nc	*0.000064*[g]
Pesticides[k]														
4,4′-DDD	4	4	100	0.0000063 – 0.000013	na	nc	nc	nc	nc	nc	nc	nc	nc	0.00031[g]
4,4′-DDE	4	4	100	0.000000034 – 0.000065	na	nc	nc	nc	nc	nc	nc	nc	nc	0.00022[g]
DDT (and metabolites)	4	4	100	0.000035 – 0.000019	na	***0.001***[l]	***1.1***[l]	***0.001***[l]	***0.13***[l]	*0.001*[l]	*1.1*[l]	*0.001*[l]	*0.13*[l]	0.00022[g, l]
Aldrin	4	4	100	0.000003 –0.0000059	na	nc	nc	***0.0019***	***1.3***	nc	***3.0***	nc	*1.3*	0.000050[g]
Dieldrin	4	4	100	0.000020 – 0.000033	na	nc	nc	nc	nc	***0.056***	***0.24***	***0.0019***	***0.71***	0.000054[g]
Aldrin/dieldrin (sum)	4	4	100	0.0000037 – 0.000039	na	***0.0019***	***2.5***	***0.0019***	***0.71***	nc	nc	nc	nc	nc
Endrin	4	4	100	0.0000064 – 0.000014	na	***0.0023***	*0.18*	***0.0023***	***0.037***	*0.036*	***0.086***	*0.0023*	*0.037*	0.06
Chlordane	4	4	100	0.0000013 – 0.0000039	na	***0.0043***	***2.4***	***0.004***	***0.09***	*0.0043*	*2.4*	*0.004*	*0.09*	0.00081[g]

Note: Underlined values are hardness-dependent, and were calculated using a hardness value of 100 mg/L, which is the default assumption when site-specific hardness data are not available. A chemical is listed if it was detected in at least one LDW surface water sample and if it has a freshwater or marine aquatic life WQC or a human health WQC. WQC are italicized if the type of water data available does not match the type of data intended for comparison to a specific criterion (i.e., total vs. dissolved fraction or total arsenic vs. inorganic arsenic). Surface water samples were collected as single grab samples, except the four samples analyzed for PAHs and pesticides, which were collected using SPMDs. Bolded criteria are the lower of the state and federal criteria (state criteria are bolded if the state and federal criteria are the same).

[a] Standards are from WAC 173-201A-240. Available from: http://apps.leg.wa.gov/wac/default.aspx?cite=173-201A-240 (accessed on June 4, 2010).

[b] Standards are from EPA AWQC (except where noted). EPA AWQC available from: http://www.epa.gov/waterscience/criteria/wqctable/ (accessed on June 4, 2010).

[c] Aquatic life WQC are based on dissolved concentrations for metals (except mercury) and total concentrations for mercury and organic compounds. Data are presented for dissolved concentrations (filtered samples) for all metals (except mercury). Data are presented for total concentrations (unfiltered samples) for mercury and organic compounds.

[d] Human health WQC are based on dissolved concentrations for all chemicals. Data are presented for dissolved concentrations (filtered samples) when available. Data are presented for total concentrations (unfiltered samples) when dissolved data were not available.

[e] Chronic WQC are 4-day average concentrations not to be exceeded more than once every 3 years on average, with the exception of pesticide and PCB concentrations, which are 24-hr average concentrations not to be exceeded at any time.

[f] Acute WQC are 1-hr average concentrations not to be exceeded more than once every 3 years on average, with the exception of silver and pesticide concentrations, which are instantaneous concentrations not to be exceeded at any time, or the PCB concentration, which is a 24-hr average not to be exceeded at any time.

[g] Human health WQC are based on 1 x 10^{-6} excess cancer risk for carcinogenic chemicals.

[h] Criterion represents the inorganic fraction of arsenic. The water data represent total arsenic (i.e., the sum of the organic and inorganic arsenic species).

[i] Standards are from 40 CFR 131.36 (NTR), as referenced in WAC 173-201A-240. Available from: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=879a68e0f8b500cb27fc2f8df4ec7f56&rgn=div5&view=text&node=40:21.0.1.1.18&idno=40 (accessed on June 4, 2010).

[j] Criteria based on the biotic ligand model. The acute and chronic biotic ligand model -based criteria for copper would be 2.3 and 1.5 µg/L, respectively, assuming DOC = 0.5 mg/L, pH = 7.5, hardness = 85 mg/L, and temperature of 20°C.

[k] PAH and pesticide concentrations were estimated using SPMDs; these concentrations more closely represent the dissolved fraction than the total fraction of the chemical in the water column.

[l] Standards are based on criteria for 4,4′-DDT.

[m] Aldrin is metabolically converted to dieldrin. Therefore, the sum of aldrin and dieldrin concentrations is compared with the dieldrin criteria.

AWQC – ambient water quality criteria
BEHP – bis(2-ethylhexyl) phthalate
CFR – Code of Federal Regulations
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
LDW – Lower Duwamish Waterway
na – not applicable
nc – no criteria
NTR – National Toxics Rule
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
RL – reporting limit
SPMD – semipermeable membrane device
SVOC – semivolatile organic compound
WQC –water quality criteria

Table 4-21. Summary of detected chemicals in LDW seep water, freshwater and marine aquatic life WQC, and human health WQC

Chemical	Detection Summary					State WQC (µg/L)[a]				Federal AWQC (µg/L)[b]				
		Detection Frequency		Concentration Range (µg/L		Freshwater[c]		Marine[c]		Freshwater[c]		Marine[c]		Human Health[d]
	Number of Samples	Number of Detects	%	Detected	Non-Detected (RLs)	Chronic[e]	Acute[f]	Chronic[e]	Acute[f]	Chronic[e]	Acute[f]	Chronic[e]	Acute[f]	Consumption of Organisms
Metals and Trace Elements														
Filtered														
Arsenic	29	26	90	0.054 – 253	50	190	360	**36**	**69**	**150**	**340**	36	69	*0.14*[g,h]
Cadmium	29	16	55	0.009 – 0.508	2 – 10	1.0	3.7	9.3	42	**0.25**	**2.0**	**8.8**	**40**	nc
Chromium	29	2	7	8 – 9	1.51 – 20	**10**	**15**	**50**	**1,100**	11	16	50	1,100	nc
Copper	29	11	38	4 – 22.8	2 – 10	**11**	**17**	**3.1**	**4.8**	na[j]	na[j]	3.1	4.8	nc
Lead	29	16	55	0.036 – 3	1 – 20	**2.5**	**65**	**8.1**	**210**	2.5	65	8.1	210	nc
Mercury	26	16	62	0.00062 – 0.0153	0.1	nc	nc	nc	nc	nc	nc	nc	nc	0.15[i]
Nickel	26	12	46	0.84 – 5.25	0.04 – 50	160	1,400	**8.2**	**74**	**52**	**470**	8.2	74	4,600
Selenium	10	4	40	50 – 120	50 – 200	**5**	**20**	**71**	**290**	5	nc	71	290	4,200
Silver	29	14	48	0.012 – 0.112	0.015 – 20	nc	3.4	nc	**1.9**	nc	**3.2**	nc	1.9	nc
Thallium	10	2	20	50 – 70	50 – 200	nc	nc	nc	nc	nc	nc	nc	nc	0.47
Zinc	29	19	66	3.29 – 161	4 – 20	**100**	**110**	**81**	**90**	120	120	81	90	26,000
Unfiltered														
Mercury	34	17	50	0.00061 – 0.65	0.1	**0.012**	2.1	**0.025**	**1.8**	0.77	**1.4**	0.94	1.8	nc
Other SVOCs (filtered)[k]														
1,3-Dichlorobenzene	46	1	2	58	0.50 – 10	nc	nc	nc	nc	nc	nc	nc	nc	960
1,4-Dichlorobenzene	44	1	2	40.2	0.50 – 10	nc	nc	nc	nc	nc	nc	nc	nc	190
Polychlorinated Biphenyls														
Total PCBs (unfiltered)	34	8	24	0.020 – 8.9	0.017 – 1.0	**0.014**	**2**	**0.03**	**10**	0.014	nc	0.03	nc	nc
Total PCBs (filtered)[k]	16	1	6	0.26	0.017	nc	nc	nc	nc	nc	nc	nc	nc	0.000064[g]
Pesticides														
Heptachlor epoxide (unfiltered)	13	1	8	0.0076 – 0.0090	0.00080 – 0.016	nc	nc	nc	nc	**0.0038**	**0.52**	**0.0036**	**0.053**	nc
Heptachlor epoxide (filtered)[k]	16	1	6	0.0090	0.00080 – 0.016	nc	nc	nc	nc	nc	nc	nc	nc	0.000039[g]
VOCs (unfiltered)[l]														
1,1-Dichloroethene	96	5	5	1.0 – 27	1.0 – 20	nc	nc	nc	nc	nc	nc	nc	nc	*7,100*
1,2-Dichloroethane	96	6	6	1.0 – 27	1.0 – 20	nc	nc	nc	nc	nc	nc	nc	nc	*37*
1,2-Dichloropropane	96	3	3	1.0 - 16	1.0 - 20	nc	nc	nc	nc	nc	nc	nc	nc	*15*[g]
Benzene	96	5	5	2.2 – 36	1.0 – 10	nc	nc	nc	nc	nc	nc	nc	nc	*51*[g]
Chlorobenzene	96	3	3	4.1 – 8.8	1.0 – 20	nc	nc	nc	nc	nc	nc	nc	nc	*1,600*
Tetrachloroethene	96	24	25	1.0 – 760	1.0 – 20	nc	nc	nc	nc	nc	nc	nc	nc	*3.3*[g]

Chemical	Detection Summary					State WQC (µg/L)[a]				Federal AWQC (µg/L)[b]				
		Detection Frequency		Concentration Range (µg/L		Freshwater[c]		Marine[c]		Freshwater[c]		Marine[c]		Human Health[d]
	Number of Samples	Number of Detects	%	Detected	Non-Detected (RLs)	Chronic[e]	Acute[f]	Chronic[e]	Acute[f]	Chronic[e]	Acute[f]	Chronic[e]	Acute[f]	Consumption of Organisms
Toluene	96	2	2	2.0 – 2.7	1.0 – 20	nc	nc	nc	nc	nc	nc	nc	nc	*15,000*
Trichloroethene	96	24	25	1.0 – 480	1.0 – 20	nc	nc	nc	nc	nc	nc	nc	nc	*30*[g]
Vinyl chloride	96	18	19	1.0 – 3500	0.010 – 2.0	nc	nc	nc	nc	nc	nc	nc	nc	*2.4*[g]

Note: Underlined values are hardness-dependent, and were calculated using a hardness value of 100 mg/L, which is the default assumption when site-specific hardness data are not available. A chemical is listed if it was detected in at least one LDW seep water sample and if it has a freshwater or marine aquatic life WQC or a human health WQC. Seep water samples were collected as single samples at one point in time. WQC are italicized if the type of water data available does not match the type of data intended for comparison to a specific criterion (i.e., total vs. dissolved fraction or total arsenic vs. inorganic arsenic). Bolded criteria are the lower of the state and federal criteria (state criteria are bolded if the state and federal criteria are the same).

[a] Standards are from WAC 173-201A-240. Available from: http://apps.leg.wa.gov/wac/default.aspx?cite=173-201A-240 (accessed on June 4, 2010).

[b] Standards are from EPA AWQC (except where noted). EPA AWQC available from: http://www.epa.gov/waterscience/criteria/wqctable/ (accessed on June 4, 2010).

[c] Aquatic life WQC are based on dissolved concentrations for metals (except mercury) and total concentrations for mercury and organic compounds. Data are presented for dissolved concentrations (filtered samples) for all metals (except mercury). Data are presented for total concentrations (unfiltered samples) for mercury and organic compounds.

[d] Human health WQC are based on dissolved concentrations of the chemical for excess cancer risks of 1 x 10^{-6}, as presented in the NTR (40 CFR 131.36). Data are presented for dissolved concentrations (filtered samples) when available. Data for total concentrations are presented (unfiltered samples) when dissolved data were not available.

[e] Chronic WQC are 4-day average concentrations not to be exceeded more than once every 3 years on average, with the exception of pesticide and PCB concentrations, which are 24-hr average concentrations not to be exceeded at any time.

[f] Acute WQC are 1-hr average concentrations not to be exceeded more than once every 3 years on average, with the exception of silver and pesticide concentrations, which are instantaneous concentrations not to be exceeded at any time, or the PCB concentration, which is a 24-hr average not to be exceeded at any time

[g] Human health WQC are based on 1 x 10^{-6} excess cancer risk for carcinogenic chemicals.

[h] Criterion represents the inorganic fraction of arsenic. The water data represent total arsenic (i.e., the sum of the organic and inorganic arsenic species).

[i] Standards are from 40 CFR 131.36 (NTR), as referenced in WAC 173-201A-240. Available from: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=879a68e0f8b500cb27fc2f8df4ec7f56&rgn=div5&view=text&node=40:21.0.1.1.18&idno=40 (accessed on June 4, 2010).

[j] Criteria based on the biotic ligand model. The acute and chronic biotic ligand model -based criteria for copper would be 2.3 and 1.5 µg/L, respectively, assuming DOC = 0.5 mg/L, pH = 7.5, hardness = 85 mg/L, and temperature of 20°C.

[k] Data are presented for filtered samples. Data for the Boeing Plant 2 RFI, Terminal 117, and Rhône-Poulenc sampling events are from unfiltered samples, and it is not known if samples collected at Great Western from 1994 to 1999 were filtered. Data from those four areas were not included in this comparison to avoid combining results from both filtered and unfiltered samples.

[l] Data represent total concentrations because VOC samples were not filtered.

AWQC – ambient water quality criteria
BEHP – bis(2-ethylhexyl) phthalate
CFR – Code of Federal Regulations
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
LDW – Lower Duwamish Waterway
na – not applicable
nc – no criteria
NTR – National Toxics Rule
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
RFI – Resource Conservation and Recovery Act facility investigation
RL – reporting limit
SVOC – semivolatile organic compound
VOC – volatile organic compound
WQC – water quality criteria

Table 4-22. Summary of detected chemicals in LDW porewater, freshwater and marine aquatic life WQC, and human health WQC

Chemical	Detection Summary					State WQC (µg/L)[a]				Federal AWQC (µg/L)[b]				
						Freshwater[c]		Marine[c]		Freshwater[c]		Marine[c]		Human Health[d]
	Number of Samples	Detection Frequency		Concentration Range (µg/L)		Chronic[e]	Acute[f]	Chronic[e]	Acute[f]	Chronic[e]	Acute[f]	Chronic[e]	Acute[f]	Consumption of Organisms
		Number of Detects	%	Detected	Non-Detected (RLs)									
Metals and Trace Elements (unfiltered)														
Antimony	15	1	7	30	5 – 50	nc	nc	nc	nc	nc	nc	nc	nc	*640*
Arsenic	30	12	40	26 – 114	10 – 450	*190*	*360*	***36***	***69***	***150***	***340***	*36*	*69*	*0.14*[g,h]
Cadmium	30	4	13	4	5 – 30	*1.0*	*3.7*	*9.3*	*42*	***0.25***	***2.0***	***8.8***	***40***	nc
Copper	30	8	27	1 – 264	4 – 5	***11***	***17***	***3.1***	***4.8***	na[j]	na[j]	*3.1*	*4.8*	nc
Lead	30	13	43	0.6 – 4	1 – 250	***2.5***	***65***	***8.1***	***210***	*2.5*	*65*	*8.1*	*210*	nc
Mercury	30	10	33	0.0016 – 0.408	0.1 – 0.2	**0.012**	2.1	**0.025**	**1.8**	0.77	**1.4**	0.94	1.8	*0.15*[i]
Silver	15	6	40	0.3 – 0.5	1	nc	*3.4*	nc	***1.9***	nc	***3.2***	nc	*1.9*	nc
Zinc	30	6	20	4 – 1560	10 – 50	***100***	***110***	***81***	***90***	*120*	*120*	*81*	*90*	*26,000*
PAHs (unfiltered)														
Benzo(a)pyrene	9	1	11	0.032 – 0.032	0.37	nc	nc	nc	nc	nc	nc	nc	nc	*0.018*[g]
Benzo(b)fluoranthene	9	1	11	0.039 – 0.039	0.37	nc	nc	nc	nc	nc	nc	nc	nc	*0.018*[g]
Benzo(k)fluoranthene	9	1	11	0.039 – 0.039	0.37	nc	nc	nc	nc	nc	nc	nc	nc	*0.018*[g]
Fluoranthene	9	1	11	0.26 – 0.26	0.37	nc	nc	nc	nc	nc	nc	nc	nc	*140*
Pyrene	9	1	11	0.32 – 0.32	0.37	nc	nc	nc	nc	nc	nc	nc	nc	*4,000*
Phthalates (unfiltered)														
BEHP	9	5	56	2.0 – 390	1.9	nc	nc	nc	nc	nc	nc	nc	nc	*2.2*[g]
Other SVOCs (unfiltered)														
1,2-Dichlorobenzene	32	3	9	0.50 – 1.2	0.20 – 1.0	nc	nc	nc	nc	nc	nc	nc	nc	*1,300*
1,4-Dichlorobenzene	32	2	6	0.30	0.20 – 1.0	nc	nc	nc	nc	nc	nc	nc	nc	*190*
VOCs (unfiltered)														
1,1-Dichloroethene	32	3	9	0.30 – 4.9	0.20 – 1.0	nc	nc	nc	nc	nc	nc	nc	nc	*7,100*
1,2-Dichloroethane	32	2	6	7.4 – 15	0.20 – 1.0	nc	nc	nc	nc	nc	nc	nc	nc	*37*
1,2-Dichloropropane	32	2	6	1.7 – 2.5	0.20 – 1.0	nc	nc	nc	nc	nc	nc	nc	nc	*15*[g]
Benzene	41	1	2	9.4	0.20 – 4.7	nc	nc	nc	nc	nc	nc	nc	nc	*51*[g]
Chlorobenzene	32	4	12	0.30 – 1.4	0.20 – 1.0	nc	nc	nc	nc	nc	nc	nc	nc	*1,600*
Tetrachloroethene	32	2	6	0.40 – 1.1	0.20 – 1.0	nc	nc	nc	nc	nc	nc	nc	nc	*3.3*[g]
Toluene	41	5	12	0.30 – 3.5	0.20 – 2.0	nc	nc	nc	nc	nc	nc	nc	nc	*15,000*
trans-1,2-Dichloroethene	32	7	22	0.30 - 21	0.20 – 1.0	nc	nc	nc	nc	nc	nc	nc	nc	*10,000*
Trichloroethene	32	6	19	0.20 – 2.5	0.20 – 1.0	nc	nc	nc	nc	nc	nc	nc	nc	*30*[g]
Vinyl chloride	32	12	38	0.40 – 2,500	0.20 – 1.6	nc	nc	nc	nc	nc	nc	nc	nc	*2.4*[g]

Note: Underlined values are hardness-dependent, and were calculated using a hardness value of 100 mg/L, which is the default assumption when site-specific hardness data are not available. A chemical is listed if it was detected in at least one LDW porewater sample and if it has a freshwater or marine aquatic life WQC or a human health WQC. Porewater samples were collected as single samples at one point in time. WQC are italicized if the type of water data available does not match the type of data intended for comparison to a specific criterion (i.e., total vs. dissolved fraction or total arsenic vs. inorganic arsenic). Bolded criteria are the lower of the state and federal criteria (state criteria are bolded if the state and federal criteria are the same).

[a] Standards are from WAC 173-201A-240. Available from: http://apps.leg.wa.gov/wac/default.aspx?cite=173-201A-240 (accessed on June 4, 2010).

[b] Standards are from EPA AWQC (except where noted). EPA AWQC available from: http://www.epa.gov/waterscience/criteria/wqctable/ (accessed on June 4, 2010).

[c] Aquatic life WQC are based on dissolved concentrations for metals (except mercury) and total concentrations for mercury and organic compounds. Data are presented for total concentrations (unfiltered samples) for all chemicals because dissolved concentrations (filtered samples) were not available.

[d] Human health WQC are based on dissolved concentrations of the chemical for excess cancer risks of 1×10^{-6}, as presented in the NTR (40 CFR 131.36). Data are presented for total concentrations (unfiltered samples) because dissolved concentrations (filtered samples) were not available.

[e] Chronic WQC are 4-day average concentrations not to be exceeded more than once every 3 years on average, with the exception of pesticide and PCB concentrations, which are 24-hr average concentrations not to be exceeded at any time.

[f] Acute WQC are 1-hr average concentrations not to be exceeded more than once every 3 years on average, with the exception of silver and pesticide concentrations, which are instantaneous concentrations not to be exceeded at any time, or the PCB concentration, which is a 24-hr average not to be exceeded at any time.

[g] Human health WQC are based on 1×10^{-6} excess cancer risk for carcinogenic chemicals.

[h] Criterion represents the inorganic fraction of arsenic. The water data represent total arsenic (i.e., the sum of the organic and inorganic arsenic species).

[i] Standards are from CFR Title 40: Protection of Environment, Part 131 – Water Quality Standards, Subpart D: Federally Promulgated Water Quality Standards. Available from: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=879a68e0f8b500cb27fc2f8df4ec7f56&rgn=div5&view=text&node=40:21.0.1.1.18&idno=40 (accessed on June 4, 2010).

[j] Criteria based on the biotic ligand model. The acute and chronic biotic ligand model -based criteria for copper would be 2.3 and 1.5 µg/L, respectively, assuming DOC = 0.5 mg/L, pH = 7.5, hardness = 85 mg/L, and temperature of 20°C.

AWQC – ambient water quality criteria
BEHP – bis(2-ethylhexyl) phthalate
LDW – Lower Duwamish Waterway
na – not applicable
nc – no criteria
NTR – National Toxics Rule
PAH – polycyclic aromatic hydrocarbon
RL – reporting limit
SVOC – semivolatile organic compound
VOC – volatile organic compound
WQC – water quality criteria

4.2.3 PCBs (Aroclors and congeners)

This section discusses the nature and extent of PCBs in surface sediment, subsurface sediment, tissue, surface water, and seep water. PCBs were not analyzed in porewater samples collected from the LDW.

4.2.3.1 Surface sediment

This section presents a general discussion of total PCB concentrations in surface sediment throughout the LDW based on data in the RI baseline dataset. In addition, surface sediment data are used to elucidate temporal patterns in total PCB concentrations, including: 1) 57 locations with sample pairs representing locations that were resampled at different points in time, 2) data from Slip 4, where multiple sediment investigations have been conducted in a fairly confined area, and 3) 7 locations surrounding the Duwamish/Diagonal EAA which have been monitored on an annual basis since 2003.

This section also discusses spatially weighted average concentrations (SWACs) of total PCBs (as Aroclors) in surface sediment, which were calculated using IDW. IDW methods have evolved throughout the project. As documented in a technical memorandum to the agencies (Windward 2006e), the IDW interpolation used for the ERA and FWM was based on optimization over broad areas of the LDW, considering a neighborhood of sample concentrations when determining each individual grid cell value. Thiessen polygons, rather than IDW, were used in the HHRA (Appendix B).

The interpolation methods described in the technical memorandum (Windward 2006e) required that the LDW be divided into three separate sections: north, central, and south. Because IDW will be used in the FS to a much greater extent than in the RI, the 2006 interpolation methods were re-evaluated for the FS with two additional objectives: 1) create a streamlined computational method that does not require division of the LDW into separate sections, and 2) optimize the interpolation parameters to enhance prediction accuracy (relative to the 2006 methods) at areas with moderate PCB concentrations. The resulting parameterization, which is used in this RI (except for the ERA and FWM, which use the 2006 interpolation) and will be used in the FS, can be implemented across the entire LDW in one step and is described in detail by ENSR (2008).

LDW-Wide Data

Surface sediment samples collected from 1,030 of the 1,365 locations in the RI baseline dataset were analyzed for total PCBs as Aroclors, and an additional 297 samples were analyzed for total PCBs using NOAA methods.[56] Total PCBs were detected at 94% of

[56] These additional 297 samples were analyzed for selected PCB congeners, PCTs, and PCBs+PCTs using NOAA's HPLC/PDA and GC/ECD (equivalent to EPA 8082) methods. Total PCBs were calculated as the difference between total PCTs (which were determined using GC/ECD) and

the locations where PCB Aroclors were analyzed, with concentrations ranging from 1.6 to 220,000 µg/kg dw (Table 4-23). The highest total PCB concentrations were generally detected in EAAs (Maps 4-18 and 4-19), which are discussed in Appendix I. As presented in Table 4-23, the Aroclors detected most frequently in surface sediment were Aroclors 1254 and 1260, at 80 and 81% of the locations, respectively. Using the updated IDW interpolation method discussed above, the SWAC of total PCBs for the LDW from RM 0.0 to 5.25 was 350 µg/kg dw.

PCBs+PCTs, which were determined using HPLC/PDA. This method provides total PCB values but does not quantify the individual Aroclors.

Table 4-23. Summary of LDW-wide surface sediment data for detected Aroclors and total PCBs

Chemical	Detection Frequency		Unit	Concentration				SQS	CSL
	Ratio	%		Minimum Detect	Maximum Detect	Calculated Mean[a]	RL or Range of RLs[b]		
Aroclor 1242	108/1,021	11	µg/kg dw	7.8 J	2,700	49	0.87 – 6,100	na	na
Aroclor 1248	228/1,030	22	µg/kg dw	6.3	220,000	360	0.87 – 4,300	na	na
Aroclor 1254	817/1,022	80	µg/kg dw	2.2	110,000	500	1.3 – 4,300	na	na
Aroclor 1254/1260[c]	8/8	100	µg/kg dw	37	800	180	nc	na	na
Aroclor 1260	823/1,022	81	µg/kg dw	1.2 J	38,000	600	3.9 – 15,000	na	na
Aroclor 1262	2/12	17	µg/kg dw	270	840	97	3.3 – 20	na	na
Aroclor 1268	1/11	9	µg/kg dw	460 J	460 J	47	3.3 – 20	na	na
Total PCBs (dw)[d]	1,243/1,327	94	µg/kg dw	1.6 J	220,000	1,200	nc	na	na
Total PCBs (OC normalized)[e]	1,145/1,203	95	mg/kg OC	0.11 J	10,000	60	nc	12	65

[a] Calculated mean concentration is the average of detected concentrations and one-half the RL for non-detected results.

[b] RLs from non-detect samples only.

[c] Aroclors 1254 and 1260 could not be distinguished from each other in these eight samples, so they were reported together.

[d] Total PCBs (dw) represent the sum of the detected concentrations of the individual Aroclors. If no Aroclors were detected, the RL reported represents the highest RL for an individual Aroclor. As discussed in Section 4.1.3.3, 297 of these samples were analyzed using the NOAA method. which provides total PCB values but does not quantify the individual Aroclors.

[e] Summary statistics for OC-normalized PCB concentrations were calculated using only samples with TOC contents ≥ 0.5% and ≤ 4.0%. At very low or very high TOC contents, OC normalization is not appropriate for comparison to SMS (Michelsen and Bragdon-Cook 1993).

CSL – cleanup screening level
dw – dry weight
EPC – exposure point concentration
HHRA – human health risk assessment
J – estimated concentration
LDW – Lower Duwamish Waterway
na – not applicable
nc – not calculated
OC – organic carbon
PCB – polychlorinated biphenyl
RI – remedial investigation
RL – reporting limit
SQS – sediment quality standards
TEQ –toxic equivalent
TOC – total organic carbon

Area-based and numerical percentiles were calculated using the entire LDW dataset, which extends from RM 0.0 to RM 6.0. Five percent of the LDW area had a total PCB SWAC higher than 810 µg/kg dw (Table 4-24). The area-based percentiles derived from the IDW interpolations are lower than the numerical-based percentiles, as shown in Table 4-24, because many of the surface sediment samples were collected in more contaminated areas, and thus do not provide data that are representative of area-wide conditions.

Table 4-24. Percentiles of total PCB concentrations in LDW surface sediment collected from RM 0.0 to RM 6.0

Method	Total PCB Concentration (µg/kg dw)[a]				
	Entire Dataset	25th Percentile	50th Percentile	75th Percentile	95th Percentile
Area-based[b]	350[c] (SWAC)	48	110	210	810
Numerical	1,200[d] (mean)	58	140	390	4,300

[a] The UCL for total PCBs in surface sediment was 2,500 µg/kg dw using the RI baseline dataset, as calculated in Appendix C (Table C.3-8). This UCL is presented as the EPC for the netfishing scenario in the HHRA (Appendix B), which uses the entire surface sediment dataset.

[b] The 25th, 50th, 75th, and 95th percentiles calculated using the initial (Windward 2006e) IDW interpolation discussed in the ERA (Appendix A) and FWM were 51, 130, 220, and 1,117 µg/kg dw, respectively.

[c] The SWAC was calculated using surface sediment collected from RM 0.0 to RM 5.25.

[d] When calculating the mean concentration of total PCBs, if none of the individual Aroclors were detected in a given sample, then one-half the highest RL for an individual Aroclor was used for that sample.

dw – dry weight
EPC – exposure point concentration
HHRA – human health risk assessment
LDW – Lower Duwamish Waterway
PCB – polychlorinated biphenyl
RI – remedial investigation
RM – river mile
SWAC – spatially weighted average concentration
UCL – upper confidence limit on the mean

The maximum total PCB concentration was detected in 1995 at location NFK305, on the east side of the LDW between RM 4.8 and RM 4.9 (Map 4-18). Other areas with total PCB concentrations greater than the area-based 95th percentile concentration (810 µg/kg dw) were as follows: near RM 0.5 and RM 0.6 on the east side of the LDW (in the Duwamish/Diagonal EAA), near RM 1.0 in the navigation channel, between RM 2.2 and RM 2.3 on the west side (in EAA 2), in the Slip 4 EAA, between RM 3.2 and RM 3.7 on the east side of the LDW (in the Boeing Plant 2/Jorgensen Forge EAA), between RM 3.5 and RM 3.7 on the west side (in the T-117 EAA), and near RM 4.9 (in the Norfolk EAA) (Map 4-19). Patterns of total PCB concentrations in surface sediment are discussed in greater detail in Section 4.2.3.3 relative to subsurface data.

Total PCB concentrations expressed on an OC-normalized basis exceeded the SQS but not the CSL at 314 surface sediment locations (24%) and exceeded the CSL at 174 locations (13%) (Map 4-20; Table 4-16). Total PCB concentrations were less than either the SQS or CSL at 63% of the locations (Figure 4-1). Most of the total PCB concentrations that exceeded the CSL were in samples collected in or near EAAs between RM 0.0 and RM 1.0, between RM 3.2 and RM 4.0, and in Slip 4 (Map 4-20).

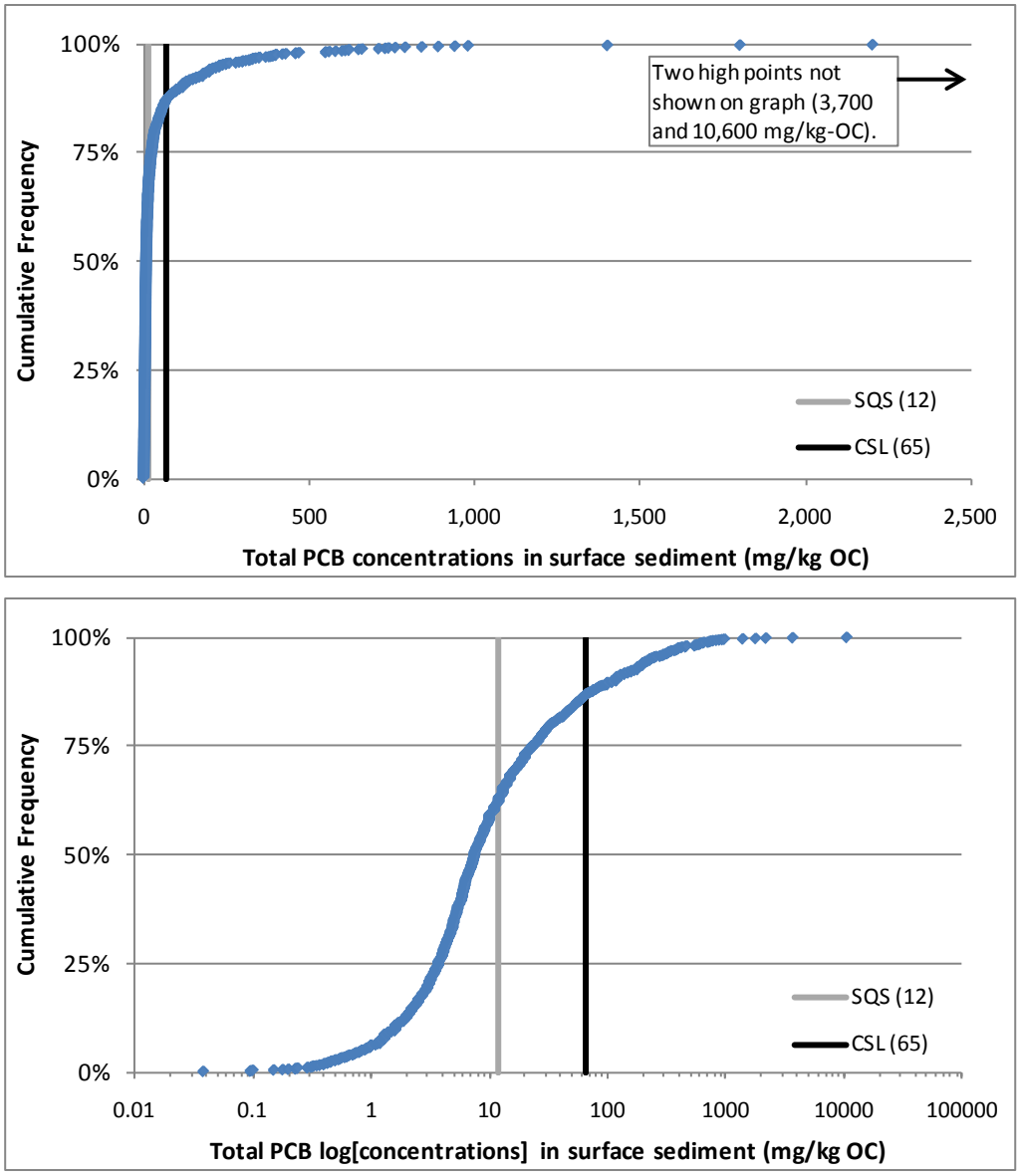

Figure 4-1. Cumulative frequency of OC-normalized total PCB concentrations in surface sediment (arithmetic and log-scale)

PCB congeners were analyzed in a subset of the surface sediment samples collected in 2005 for the RI and in samples collected during two sampling events in the late 1990s (the NOAA site characterization in 1997 and the EPA SI in 1998), as shown on Map 4-21. The PCB congener data collected in the late 1990s met DQOs, but RLs were relatively high. As part of the RI, surface sediment samples from 48 locations were analyzed for 26 PCB congeners.[57] The samples collected for PCB congener analyses

[57] Discrete surface sediment grab samples were collected during Rounds 1 and 2 of the surface sediment sampling event at 32 locations, and composite sediment samples were co-located with benthic invertebrate tissue samples or clam tissue samples at eight locations each.

were selected to provide adequate spatial coverage of the LDW and to ensure that a range of locations with low, moderate, and high total PCB concentrations was represented. The PCB congeners analyzed included the 12 congeners identified by the World Health Organization (WHO) as having dioxin-like properties (i.e., PCB congeners 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, and 189). In addition, six principal PCB congeners (i.e., PCB congeners 66, 101, 110, 138, 153, and 180) were selected for analysis because they were detected in surface sediment at high concentrations relative to the other PCB congeners in the two historical datasets for the LDW. An additional eight PCB congeners that coelute with the PCB congeners listed above were also included in the analysis. In general, the PCB congeners with the highest concentrations at the locations sampled as part of the RI were PCB congeners 90, 110, 118, 129, and 153. Appendix E, Section E.6, presents summary statistics for all PCB congeners in surface sediment.

PCB TEQs were calculated using data for the 12 dioxin-like PCB congeners. Historical PCB congener data were not included in these TEQ calculations because of elevated RLs. Methods for mammalian PCB TEQ calculations are described in Appendix A, Section A.5.1.1. TEQ data for PCB congeners in surface sediment are presented in Table 4-25. Total PCB TEQs ranged from 0.0908 to 1,380 ng/kg dw, with a mean of 45.9 ng/kg. The dioxin-like PCB congener that contributed most to the total PCB TEQ in surface sediment was PCB-126. Based on a regression analysis, concentrations of total PCBs and total PCB TEQs in sediment were significantly correlated ($R^2 = 0.99$) for the 48 locations analyzed for PCB congeners in 2005.

Table 4-25. Sediment PCB TEQs in surface sediment samples

Chemical	Detection Frequency		TEQ (ng/kg dw)		
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[a]
Total PCB TEQ	48/48	100	0.0908 J	1,380	45.9
PCB-077 TEQ	48/48	100	0.00104	8.05	0.429
PCB-081 TEQ	48/48	100	0.000119	2.09	0.0810
PCB-105 TEQ	48/48	100	0.00184	110	3.01
PCB-114 TEQ	48/48	100	0.0000825	6.21	0.167
PCB-118 TEQ	48/48	100	0.00462	360	9.42
PCB-123 TEQ	48/48	100	0.0000837	4.14	0.116
PCB-126 TEQ	48/48	100	0.0758	798	29.1
PCB-156 TEQ	48/48	100	0.000825	53.7	1.43
PCB-167 TEQ	48/48	100	0.000318	15.5	0.427
PCB-169 TEQ	0/48	0	nd	nd	nc
PCB-189 TEQ	48/48	100	0.0000918	1.97	0.0715

Note: PCB TEQs were calculated using TEFs for mammals presented in Van den Berg et al. (2006). Total PCB TEQs were calculated for each sample by summing the TEQs for each dioxin-like congener. TEQs for individual congeners were calculated as the product of individual PCB congener concentrations and PCB congener-specific TEFs. If an individual PCB congener was not detected, the TEF for that congener was multiplied by one-half the RL for that congener.

[a] Calculated mean concentration is the mean of detected concentrations and one-half the RL for non-detected results.

PCB – polychlorinated biphenyl

TEF – toxic equivalency factor

TEQ – toxic equivalent

dw – dry weight

nc – not calculated

nd – not detected

LDW Resampled Locations

This section presents an evaluation of the change in total PCB concentrations in surface sediment between older samples and newer samples collected within 10 ft of each other.[58] Total PCBs had to be detected in at least one of the two samples to be included in the evaluation. Changes in concentrations could result from the mixing of surface sediment, burial of older sediment by newer sediment with different concentrations, transport of older sediment away from an area, or from resampling slightly different locations in areas with spatial heterogeneity in surface sediment chemical concentrations. Data from the Duwamish/Diagonal area and the Norfolk area were not included in this evaluation; monitoring data for these areas are discussed in detail later in this section for the Duwamish/Diagonal perimeter area, in Appendix I, Section I.4.1 (Duwamish/Diagonal cap), and in Appendix I, Section I.4.8 (Norfolk).

Of the 57 resampled surface sediment locations, total PCB concentrations decreased over time at 28 locations (49%), increased at 18 locations (32%), and were indistinguishable from the initial concentrations at 9 locations (16%)[59] (Table 4-26; Map 4-22). Two resampled locations were not included in Table 4-26 because total PCBs were not detected in either of the paired samples; RLs ranged from 19 to 40 µg/kg dw. At 26 of the 46 locations where detected total PCB concentrations increased or decreased, the concentration increase or decrease was ≤ 250 µg/kg dw.

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[58] The older data at these resampled locations were not included in the baseline dataset, as described in Section 4.1.2.1. The age difference between the older and newer samples ranged from 1 to 13 years, with an average difference of approximately 8 years.

[59] Concentration differences at these locations were within the range of analytical variability (≤ 25% increase or decrease compared to the initial concentration).

Table 4-26. Difference in total PCB concentrations at resampled locations presented by concentration difference

Approximate River Mile	Sampling Location ID		Sampling Date		Concentration (µg/kg dw)		
	Initial	Resampled	Initial	Resampled	Initial	Resampled	Difference
4.7	DR271	LDW-SS148	9/15/1998	3/9/2005	9,400	520	-8,880
3.6	SD-DUW90	SD-343-S	4/4/1996	8/27/2004	7,500	260 J	-7,240
3.5	WST323	T117-SE-10-G	10/21/1997	12/8/2003	7,900 J	1,200	-6,700
0.8	EST219	LDW-SS27	9/17/1997	1/18/2005	4,400 J	97 J	-4,303
1.4	DR030	LDW-SS50	8/17/1998	1/24/2005	4,800	590	-4,210
2.2	WIT280	B5a-2	10/3/1997	9/24/2004	5,200 J	1,730	-3,470
2.2	DR113	LDW-SS81	8/19/1998	3/8/2005	2,030 J	210	-1,820
3.9	EST144	LDW-SS123	9/25/1997	1/24/2005	1,500 J	149	-1,351
3.9	EIT061	LDW-SS121	9/29/1997	1/25/2005	2,400 J	1,060 J	-1,340
2.1	CH0023	LDW-SS79	10/16/1997	1/24/2005	1,200 J	68	-1,132
0.3	DUD042	LDW-SS17	11/11/1995	1/24/2005	1,060 J	120	-940
2.0	R7	LDW-SS75	10/15/1997	1/21/2005	1,200	520	-680
1.2	DR088	LDW-SS40	8/31/1998	1/18/2005	1,010 J	510 J	-500
3.9	R30	LDW-SS119	10/11/1997	1/19/2005	1,250 J	880 J	-370
0.2	DR035	LDW-SS12	8/11/1998	1/17/2005	516 J	171 J	-345
3.7	R21	LDW-SS113b	10/9/1997	1/20/2005	200	18 J	-182
4.2	R42	LDW-SS129	10/13/1997	1/20/2005	193	19 U	-174
1.3	DR053	LDW-SS44	8/31/1998	1/21/2005	260 J	103 J	-157
1.5	DR123	LDW-SS57	9/14/1998	1/24/2005	900	750	-150
2.1	DR106	LDW-SS76	8/19/1998	1/20/2005	227	117	-110
4.1	A11-05	LDW-SS126	8/18/1994	1/20/2005	109	20 U	-89
4.2	R45	LDW-SS130	10/16/1997	1/20/2005	101	26	-75
1.0	DR020	LDW-SS31	8/17/1998	1/21/2005	169 J	96	-73
4.2	R40	LDW-SS127	10/13/1997	1/20/2005	119	58	-61
0.2	K-05	LDW-SS10	9/27/1991	1/17/2005	91 J	31	-60
0.3	DR079	LDW-SS15	8/24/1998	1/17/2005	187 J	128 J	-59
2.8	DR175	LDW-SS94	8/20/1998	1/21/2005	120	72	-48
4.3	DR286	B10b	8/26/1998	8/19/2004	54	9.8 J	-44.2
1.0	DR019	LDW-SS32	8/17/1998	1/18/2005	162	122 J	**-40**
0	K-11	LDW-SS1	9/30/1991	1/17/2005	200 J	161 J	**-39**
1.7	DR097	LDW-SS63	8/20/1998	1/21/2005	126 J	95	**-31**
3.8	DR187	LDW-SS115	8/27/1998	1/25/2005	246	220	**-26**
3.2	DR202	LDW-SS104	8/27/1998	1/25/2005	98	75	**-23**
3.1	DR198	LDW-SS102	8/20/1998	1/24/2005	85	74	**-11**
1.9	DR131	LDW-SS70	8/13/1998	1/21/2005	97 J	96	**-1**

Approximate River Mile	Sampling Location ID		Sampling Date		Concentration (µg/kg dw)		
	Initial	Resampled	Initial	Resampled	Initial	Resampled	Difference
3.8	R24	LDW-SS117	10/10/1997	1/20/2005	73	79 J	**6**
1.4	DR065	LDW-SS52	8/17/1998	1/25/2005	185	209	**24**
4.2	EST135	B8b	11/12/1997	8/19/2004	10 J	37 J	27
2.4	WST342	DR141	10/23/1997	8/20/1998	38 J	68 J	30
1.4	DR160	LDW-SS51	8/12/1998	1/18/2005	115	155 J	40
1.0	WST367	DR048	9/19/1997	8/12/1998	29 J	88	59
0.1	K-07	LDW-SS4	9/30/1991	1/17/2005	87 J	153 J	66
4.2	DR242	SB-1	8/24/1998	8/25/2004	93 J	170	77
3.6	EST154	SD-334-S	9/24/1997	8/26/2004	150	290	140
3.6	SD-SWY07	SD-SWY17	6/13/1995	9/9/2003	320	460	140
1.4	DR028	B4b	8/17/1998	8/28/2004	207	400	193
0.9	DR021	LDW-SS319	8/17/1998	10/4/2006	142 J	350	208
2.6	EIT074	LDW-SS88	11/3/1997	1/25/2005	450	660	210
3.6	EST152	SD-309-S	9/24/1997	8/16/2004	290	570	280
0.9	DR085	LDW-SSB2b	8/31/1998	3/11/2005	413 J	790	377
2.8	EST180	LDW-SS92	10/6/1997	1/25/2005	230	970	740
3.7	DR186	LDW-SS111	8/27/1998	1/19/2005	1,180	3,200 J	2,020
3.7	SD-323-S	LDW-SS110	8/17/2004	1/25/2005	9,400 J	13,000	3,600
1.0	DR087	LDW-SS37	8/12/1998	1/18/2005	696	5,100	4,404
3.7	SD-DUW92	SD-320-S	4/2/1996	8/16/2004	1,500	8,900	7,400

Note: Concentrations in bold were within the range of analytical variability (≤ 25% increase or decrease compared with the initial concentration).

dw – dry weight
ID – identification
J estimated concentration
PCB – polychlorinated biphenyl
RL reporting limit
U not detected at RL shown

Three general areas had more than one location with decreases in total PCB concentrations of more than 250 µg/kg dw):

- **RM 0.2 to RM 0.4 –** At two locations in this area, concentrations decreased by 339 and 940 µg/kg dw; at two other resampled locations nearby, concentrations were relatively low and decreased by about 60 µg/kg dw at each location.
- **RM 2.0 to RM 2.3 –** Concentrations at four resampled locations in this area decreased by 680 to 3,470 µg/kg; the only other resampled location in this area (in Slip 3) had a decrease in concentration of 113 µg/kg dw.
- **RM 3.9 to RM 4.0 –** Concentrations at all the resampled locations in this area decreased by 370 to 1,351 µg/kg dw.

The remaining six locations with total PCB concentrations that decreased more than 250 µg/kg dw were at various single locations throughout the LDW.

Total PCB concentrations increased by more than 250 µg/kg dw at seven locations, most notably on the east side of the river near RM 3.7 (within the Boeing Plant 2/ Jorgensen Forge EAA), where there were three resampled locations with increases ranging from 2,020 to 7,400 µg/kg dw. There was also an area between RM 0.8 and RM 1.1 in the navigation channel with two resampled locations where PCB concentrations increased by 380 and 4,410 µg/kg dw.

The changes in total PCB concentrations over time at the resampled locations could reflect actual differences within an area from changes in sources or as a result of localized disturbances, or could reflect the heterogeneity of the sediment samples in a given location.[60] In addition, there is uncertainty in the accuracy of the recorded sampling locations as a result of inherent measurement error in the differential global positioning system (GPS) used in the sampling surveys, so the exact locations of two samples with coordinates within 10 ft of each other cannot be determined.[61] Therefore, although there is some uncertainty in the interpretation of these data, the more frequent observation of lower concentrations over time may indicate a decreasing trend in total PCB concentrations at some locations in the LDW.

To determine if total PCB concentrations were significantly different at locations that were resampled (i.e., if the mean difference between the paired concentrations was greater than zero), a non-parametric, paired t-test (Wilcoxon signed-rank test) was used. Because some of the differences were very large, a non-parametric test was considered more appropriate than a parametric test. The non-parametric test is more powerful than a parametric test when the data are not normally distributed and only slightly less powerful if data are normal. The test was run separately for each reach of the LDW (as defined in the STM) and for the entire LDW. Data for five locations were not included the analysis presented in Table 4-27 because these locations were sampled less than 6 years apart or where PCBs were not detected in either the initial or later samples.

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[60] Field duplicate samples (i.e., sample splits from a grab sample after homogenization) provide information on heterogeneity related to sample homogenization and laboratory variability. The relative percent difference in total PCB concentrations between paired field duplicate samples in the RI (n = 11) ranged from 1.6 to 190%, with an average of 39%.

[61] The differential GPS used for Phase 2 surface sediment sampling had a measurement error of approximately 3 to 6 ft. Prior to 2001, GPS technology was less accurate, so measurement errors may have been greater for samples collected before 2001.

Table 4-27. Results of statistical analyses of differences in total PCB concentrations in surface sediment at resampled locations

Reach of the LDW	n[a]	Mean Concentration (µg/kg dw)		Significance (p value)
		Initial	Resampled	
RM 0.0 to RM 2.2	26	990	500	**0.027**
RM 2.2 to RM 4.0	18	1,400	1,100	0.74
RM 4.0 to RM 4.8	6	1,600	140	0.35
Entire LDW	50	1,200	660	**0.042**

[a] Data were not included for five locations (R42, A11-05, WST342, WST367, and SD-323-S) because they were sampled less than 6 years apart or PCBs were not detected in either the initial or later samples.

dw – dry weight

LDW – Lower Duwamish Waterway

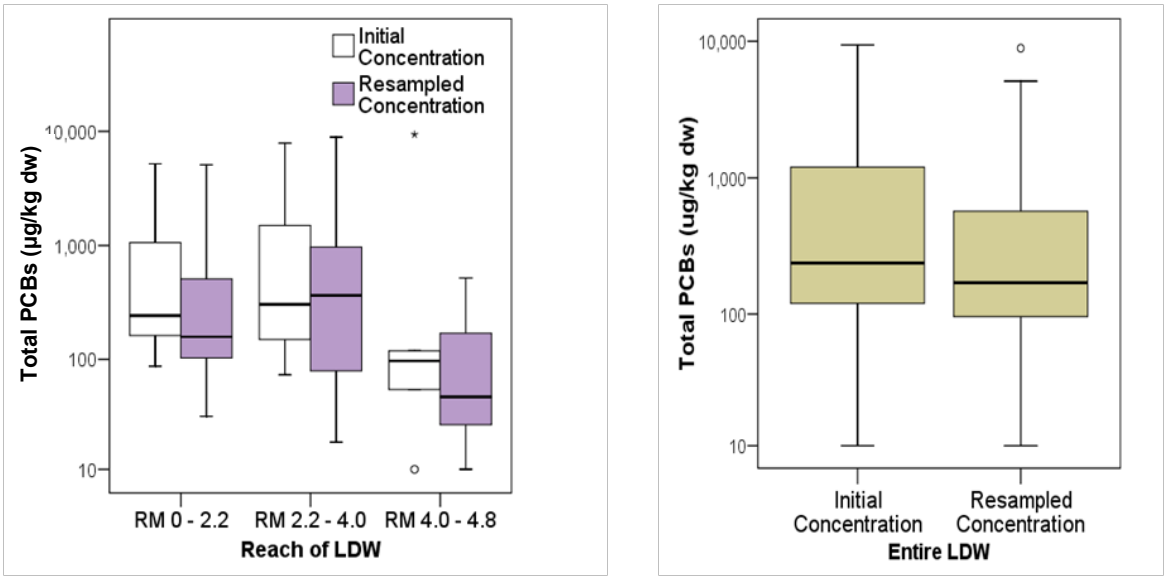
n – number of samples

RM – river mile

PCB – polychlorinated biphenyl

Bold identifies p values that are significant at the 95% confidence level.

When the data were analyzed by reach of the LDW, the differences between initial and resampled total PCB concentrations were significant at the 95% confidence level in the reach between RM 0.0 and RM 2.2 (Table 4-27; Figure 4-2). Differences in the other reaches were not significant at the 95% confidence level. When data were analyzed for the entire LDW, differences between the initial and resampled total PCB concentrations were significant at the 95% level.



Note: The boxes indicate the 25th and 75th percentiles within which 50% of the data lie. The length of this box indicates the interquartile range (IQR). The line in the center of the box is the 50th percentile (median). The whiskers of the box plot indicate the maximum and minimum values from the dataset that are within 1.5 IQRs of the 25th and 75th percentile values. Outliers are indicated by a circle and have a value between 1.5 and 3 of the IQR from the upper or lower edge of the box (75th or 25th percentile). Extreme values are indicated by an asterisk and have a value > 3 times the IQR from the 75th or 25th percentile. Data were not included for three locations (WST342, WST367, and SD-323-S) that were sampled less than 1year apart (all other paired locations were sampled at least 6 years apart). Therefore, the maximum value of 13,000 µg/kg dw from location SD-323-S was not included in this figure. Also, data were not included for two locations (R42 and A11-05) where PCBs were not detected in the later sample.

Figure 4-2. Differences in total PCB concentrations in surface sediment at resampled locations

Slip 4

Slip 4, located near RM 2.8 on the east side of the LDW (Map 4-23), is one of seven areas within the LDW that have been identified as an EAA[62] (Windward 2003e). Surface sediment data for PCBs have been collected during six sampling events conducted in Slip 4 between 1990 and 2004. Slip 4 is the only area in the LDW sampled during more than two time periods at a relatively high sampling density, providing an opportunity to evaluate the data for temporal trends on an area-specific basis. The western portion of Slip 4 was most recently dredged in 1996 to allow barge and tug access to the Crowley Marine Services pier; this dredged area is shown on Map 4-23.

The six surface sediment investigations conducted in Slip 4 included:

- Environmental site assessment in 1990 (Landau 1990) (9 surface sediment samples)
- NOAA sediment characterization study in 1997 (NOAA 1998) (18 surface sediment samples)

[62] EAAs are discussed in greater detail in Section 9.

- Phase 1 site characterization study in 1997 (Exponent 1998) (7 surface sediment samples)
- EPA site inspection in 1998 (Weston 1999a) (7 surface sediment samples)
- EAA investigation in 2004 (Integral 2004) (30 surface sediment samples)
- RI benthic invertebrate sampling event in 2004 (Windward 2005a) (3 surface sediment samples collected with co-located clam samples)

To evaluate changes in total PCB concentrations over time, the data were classified by collection date into three temporal groups: 1990 (n = 9), 1997-1998 (n = 32), and 2004 (n = 33). Data were also classified spatially into four areas: two areas inside the EAA (head of the slip and mid-slip) and two areas outside the EAA (mouth of the slip and outside the slip). Map 4-23 shows the total PCB concentrations detected at each location during each time period, the boundary of the four areas, and the boundary of the currently approved Slip 4 EAA. No locations were sampled more than once at the same coordinates (i.e., within 10 ft of each other).

In all years, the highest concentrations were reported within the EAA boundary, and there was little overlap between concentrations within the EAA and outside the EAA (Map 4-23; Figures 4-3 and 4-4). Two-way analysis of variance and *post hoc* multiple comparison tests were conducted to evaluate the effects of location (inside vs. outside the EAA) and time (1990, 1997-1998, and 2004) on log-transformed PCB concentrations (in µg/kg dw). These tests indicated the following:

- The difference in mean log total PCB concentrations between 1990 and 1997-1998 was not significant either within or outside of the EAA at Slip 4.[63]
- The difference in mean log total PCB concentration between 1997-1998 and 2004 means was significant in both areas.[64]
- The difference in mean log total PCB concentrations between 1990 and 2004 was not significant in the area outside the EAA but was significant within the EAA.[65]

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[63] Year effect was significant ($p < 0.0005$) in two-way ANOVA testing for effects of year, area, and area-by-year interaction. P values for *post hoc* one-way ANOVA testing for effects of year within area, using Bonferonni correction for multiple comparisons, were as follows: $p = 0.252$ within EAA, $p = 1.000$ outside EAA, indicating non-significant differences.

[64] P values for *post hoc* one-way ANOVA testing for effects of year within area using Bonferonni correction for multiple comparisons, were as follows: $p < 0.0005$ within EAA, $p = 0.005$ outside EAA.

[65] P values for *post hoc* one-way ANOVA testing for effects of year within area using Bonferonni correction for multiple comparisons, were as follows: $p < 0.0005$ within EAA, $p = 1.000$ outside EAA.

Uncertainties associated with this analysis include the low number of samples and minimal spatial coverage in the slip in the 1990 sampling, and the fact that the same locations were not re-sampled in the three different time periods.

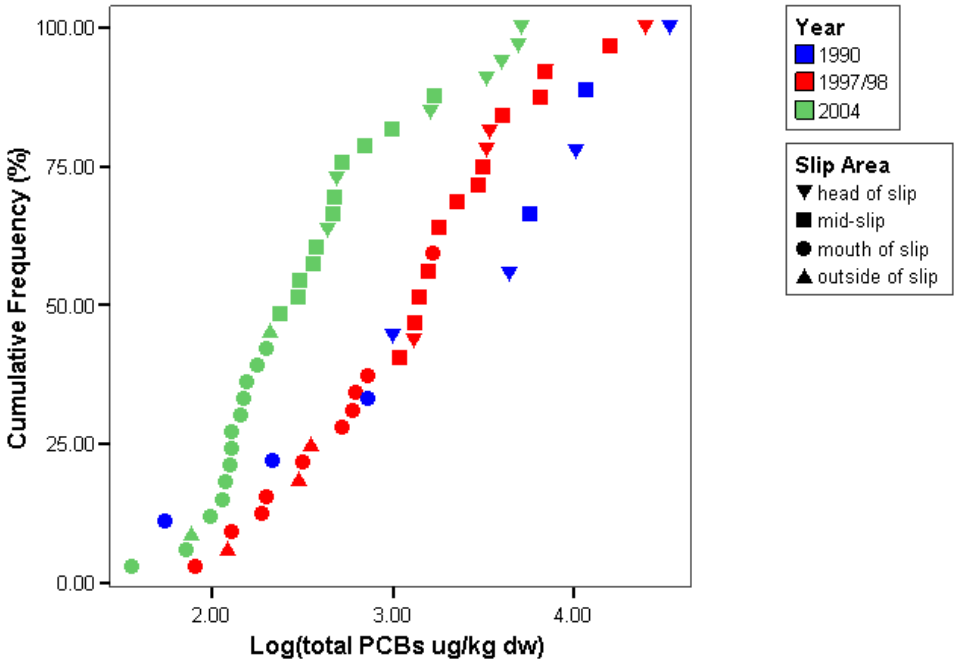
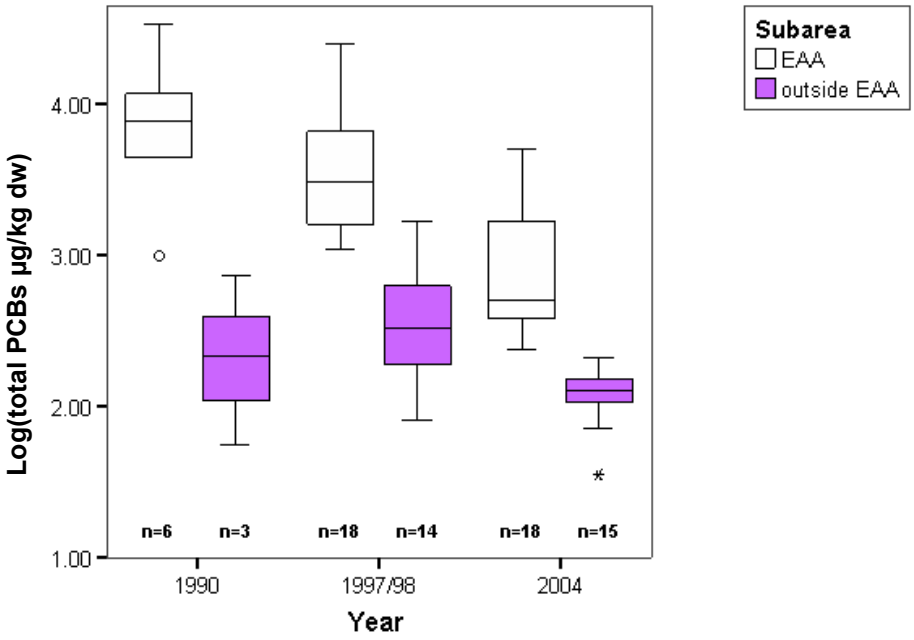


Figure 4-3. Cumulative frequency distributions of total PCB concentrations in Slip 4 surface sediment



Note: The boxes indicate the 25th and 75th percentiles within which 50% of the data lie. The length of this box indicates the interquartile range (IQR). The line in the center of the box is the 50th percentile (median). The whiskers of the box plot indicate the maximum and minimum values from the dataset that are within 1.5 IQRs of the 25th and 75th percentile values. Outliers are indicated by a circle and have a value between 1.5 and 3 of the IQR from the upper or lower edge of the box (75th or 25th percentile). Extreme values are indicated by an asterisk and have a value > 3 times the IQR from the 75th or 25th percentile.

Figure 4-4. Boxplot of total PCB concentrations in Slip 4 sediment

Duwamish/Diagonal Perimeter

Surface sediment sampling has been conducted at the Duwamish/Diagonal EAA on an annual basis since 2003 to monitor sediment quality following remedial actions. This section discusses total PCB data collected at seven locations along the perimeter of the remediated area that have been monitored during five sampling events (Map 4-24). Any samples collected within 200 ft after completion of dredging and capping of the remediated area in 2004 were excluded from the RI baseline dataset. The baseline dataset represents pre-dredge conditions, and these sediments could have been influenced by dredge residuals.[66] Although not in the RI baseline dataset, these perimeter data are presented in this section and in Appendix I, Section I.4.1 to evaluate changes at these locations over time. Monitoring data for samples collected within the capped area are also discussed in Appendix I, Section I.4.1.

Remediation at the Duwamish/Diagonal EAA consisted of dredging sediment from the area between RM 0.4 and RM 0.6 from November 2003 to January 2004 (King County et al. 2005b). The dredged area was then capped between January and March

[66] Dredge residuals affected the area south and west of Cap Area B and resulted in the need for placement of the thin-layer cap.

of 2004 by placing clean cap material over a 5-ac rectangle (Area A) and a 2-ac rectangle (Area B), as shown on Map 4-24. A 9-in. thin-layer placement was later placed over an area to the south and west of Area B in February 2005. Monitoring of surface sediment chemistry at the seven perimeter locations began in October 2003 before remediation began and was then conducted on an annual basis beginning in March 2004.

In general, total PCB concentrations in surface sediment at the seven perimeter monitoring locations showed a decreasing trend from 2004 to 2007 (Map 4-24), although trends were more variable at locations 1C and 11C.[67] At locations 1C, 2C, 8C, and especially 11C, it appears that lower concentrations in 2004 were likely affected by the higher sand content deposited over some of the perimeter areas during capping operations, as shown on Map 4-24. At most perimeter stations, the percentage of sand decreased in 2007, indicating the deposition of finer-grained material. As discussed in more detail in Appendix I, Section I.4. 1, monitoring data from capped Areas A and B showed different patterns. In Area A, total PCB concentrations were generally lowest in 2004 immediately after capping, higher in 2005 and 2006, and then lower again in 2007. In Area B, total PCB concentrations were relatively unchanged from 2004 through 2007.

4.2.3.2 Subsurface sediment

Subsurface sediment cores were sampled at various intervals during different sampling events. To calculate summary statistics, two categories were created according to specified intervals. The following intervals were selected: 2-ft intervals of 0 to 2 ft, 2 to 4 ft, 4 to 6 ft, 6 to 8 ft, and 8 to 10 ft; and 1-ft intervals (e.g., 0 to 1 ft, 1 to 2 ft) to a depth of 10 ft below mudline. Data were assigned to these intervals by first rounding (to the nearest foot) the top and bottom depths of each sample (in feet below mudline) and then assigning the data to the appropriate sampling interval. If data were available from two 1-ft intervals at a particular location, the concentrations were also averaged to obtain a calculated concentration for the corresponding 2-ft interval category; these intervals are presented in addition to the 1-ft intervals. For example, if a location had data in both the 0-to-1-ft and 1-to-2-ft intervals, the concentrations were averaged for a calculated concentration in the 0-to-2-ft interval.

Total PCBs were detected in 74% of the subsurface sediment samples, at concentrations ranging from 0.52 to 890,000 µg/kg dw (Table 4-28). Most of the subsurface samples analyzed for total PCBs were from the top 4 ft of the sediment cores. Data shown on Maps 4-25a through 4-25c and presented in Table 4-28 are discussed in more detail in Section 4.2.3.3.

[67] The 2003 samples are not included in this analysis because they represent conditions before dredging.

Table 4-28. Summary of LDW-wide subsurface sediment data for total PCBs (as Aroclors)

Sampling Interval (ft)	Detection Frequency		Total PCB Concentration (µg/kg dw)[a]	
	Ratio	%	Minimum Detect	Maximum Detect
All Data				
Any interval	609/821	74	0.52 J	890,000
1-ft Intervals[b]				
0 to 1	114/118	97	13.5	108,000
1 to 2	83/101	82	19.6	6,500
2 to 3	75/104	72	4 J	32,000
3 to 4	36/49	73	0.52 J	9,100
4 to 5	26/57	46	23	6,400
5 to 6	13/18	72	22	4,700
6 to 7	6/21	29	21	2,400
7 to 8	2/5	40	540	910
8 to 9	3/10	30	25	690
2-ft Intervals[b]				
0 to 2	130/137	95	12.9	890,000
2 to 4	106/135	79	3 J	19,000 J
4 to 6	47/60	78	3.9 J	15,000
6 to 8	20/30	67	4.5 J	3,800
8 to 10	12/24	50	14 J	540

Note: Data included in the subsurface dataset are described in Section 4.1.2.2; subsurface sediment samples collected from areas that were subsequently dredged are not summarized in this table because they do not represent existing conditions.

[a] Mean concentrations were not calculated because sampling was generally focused in contaminated areas, resulting in a non-random sampling pattern, which is not likely representative of the entire LDW.

[b] For the calculation of summary statistics, actual sampling intervals were rounded to the nearest foot. The data for each interval were then assigned to either the 1- or 2-ft sampling category, whichever best approximated the actual sampling interval. If there were data for two 1-ft intervals at a particular location, the concentrations were averaged to obtain a calculated concentration for the corresponding 2-ft interval. Some of the subsurface data were collected from intervals other than 1 or 2 ft; therefore, the detection frequency ratio for "any interval" may reflect data for intervals not included in these categories.

dw – dry weight

PCB – polychlorinated biphenyl

J – estimated concentration

Of the subsurface sediment samples collected and analyzed as part of the RI, 27 of the 47 samples analyzed for total PCBs were collected entirely within the lower alluvium unit. The lower alluvium unit is predominantly dense sand that was deposited prior to the industrialization of the area. The depth from the river bottom to the surface of this unit ranged widely from 0.2 to 12 ft, with an average depth of 6.2 ft, and is discussed in greater detail in Section 2.5.4.

Total PCB concentrations in subsurface sediment samples collected from entirely within the lower alluvium unit were ≤ 53 µg/kg dw and less than the SQS in all samples.[68]

4.2.3.3 Surface and subsurface sediment patterns

This section presents the spatial and vertical patterns of total PCB concentrations in surface and subsurface sediment by river mile. These patterns were assessed to identify areas with relatively high concentrations in surface and subsurface sediment, to evaluate the spatial relationships between the two, and to identify areas where maximum total PCB concentrations were detected in uppermost intervals or in deeper subsurface intervals. To limit the discussion, specific surface sediment locations were noted in the text if: 1) total PCB concentrations were higher in surface sediment samples than in sampling intervals of co-located subsurface cores, 2) the total PCB concentration in surface sediment was greater than the 75th percentile, 3) the total PCB concentration in surface sediment was at least 25% greater than the highest total PCB concentration in any subsurface interval, and 4) the location was outside of the Boeing Plant 2/Jorgensen Forge or T-117 EAAs (these areas are discussed in more general terms). Total PCB concentrations in all co-located surface and subsurface sediment samples are presented on Maps 4-26a through 4-26h. Maps 4-27a and 4-27b show only the subsurface sediment locations with co-located surface sediment data. The integration of this information with the physical CSM (as presented in Section 3) is discussed in Section 4.3.

The LDW was divided into five sections for discussion purposes (RM 0.0 to RM 1.0, RM 1.0 to RM 2.2, RM 2.2 to RM 3.0, RM 3.0 to RM 4.0, RM 4.0 to RM 5.0). Boundaries for some of these sections correspond to the river reaches defined by the STM (i.e., Reach 1 from RM 0.0 to RM 2.2, Reach 2 from RM 2.2 to RM 4.0, and Reach 3 from RM 4.0 to RM 4.8). Maps in this section present data separately for locations within the navigation channel, west of the channel, and east of the channel to facilitate comparisons of river bench vs. navigation channel areas and for consistency with results of sediment transport modeling (Maps 4-26a through 4-26 h). According to the

[68] Subsurface data are compared to SMS criteria in Appendix J. One sample collected from the 6-to-8.8-ft interval at LDW-SC10 had a total PCB concentration exceeding the SQS of 12 mg/kg OC (35 mg/kg OC; 350 µg/kg dw). This sampling interval was identified as lower alluvium in the draft core logs presented in the subsurface sampling data report (Windward and RETEC 2007), but this sample contained silt and sand from the upper alluvium unit.

STM, bench and channel areas have some distinct differences in sedimentation rates and potential scour depths in some sections of the LDW.

It is important to note that the certainty and scale of the analyses presented in this section (and in Sections 4.2.4 and 4.2.5 for arsenic and cPAHs, respectively), are dictated by the availability of surface and subsurface sediment data. Sources of uncertainty include:

- Uncertainty in the interpretation of subsurface data dictated by the size of the sampling interval within each core, which is variable across the site.
- Uncertainty in distinguishing vertical patterns in locations with larger sampling intervals.
- Uncertainty in comparing surface sediment data to subsurface core data because samples may have been collected at different times and conditions at the surface may have changed; interpolated surface sediment data are particularly uncertain.

RM 0.0 to RM 1.0

Total PCB concentrations in surface and subsurface sediment samples collected between RM 0.0 and RM 1.0 were highly variable (Map 4-26a). Within this section of the LDW, three areas had total PCB concentrations in surface sediment greater than the area-based 95th percentile (810 µg/kg dw): 1) RM 0.1 on the eastern shoreline, 2) the vicinity of the Duwamish/Diagonal EAA (between RM 0.4 and RM 0.6), and 3) RM 0.6 on the western shoreline.

At RM 0.1 to RM 0.2 on the eastern shoreline, the peak total PCB concentrations in subsurface cores were detected in the 2-to-4-ft interval (2,900 µg/kg dw at LDW-SC2 and 600 µg/kg dw at LDW-SC4). In a finer-resolution core collected just south of Harbor Island near an SD (LDW-SC1 sampled at 0.5-ft intervals), there was a peak in total PCB concentrations (6,700 µg/kg dw) in the 1-to-1.5-ft interval. Just east of the navigation channel at RM 0.15 (LDW-SC3), PCBs were not detected in subsurface sediment samples.

On the west side, a core (LDW-SC5) was collected near a small area at RM 0.15; the peak total PCB concentration was detected in the uppermost 1-ft interval (510 µg/kg dw) and concentrations decreased with depth. Farther south, at RM 0.3, the peak total PCB concentration was detected in the 4-to-4.5-ft interval (2,600 µg/kg dw at LDW-SC6). A historical core collected 290 ft to the south (DR068) had the same concentration (2,600 µg/kg dw) in the only interval sampled (0 to 2 ft).

A relatively large number of cores from within and near the Duwamish/Diagonal EAA have been analyzed for total PCBs. Sediments within the EAA were either dredged and capped or covered with a thin layer of sand subsequent to the collection and analysis of these samples. Prior to dredging and capping, total PCB concentrations in this area were high in surface sediment (greater than the 75th percentile) and in subsurface sediment (generally having at least one interval greater than the 95th

percentile). A cluster of cores near the center of the dredged area at RM 0.5 (DUD254, DUD253, DUD020, DUD006, DR008, DUD256, and LDW-SC10) had peak PCB concentrations below 2 ft. In three other cores from the dredged area (DUD252, DUD251, and DUD255) and cores from the thin-layer cap area (DUD257, DUD260, DUD262, DUD027, and DUD261), peak total PCB concentrations were in the uppermost intervals. In the co-located surface sediment sample at the DUD027 subsurface core location, the total PCB concentration (56,200 µg/kg dw) was higher than the peak concentration in the subsurface core. At another sampling location just west of the EAA (LDW-SC9), the total PCB concentration (4,610 µg/kg dw) in the co-located surface sediment sample was also higher than the peak concentration in the subsurface core. There is high uncertainty associated with the interpretation of data from cores collected within the Duwamish/Diagonal EAA because many of them were collected at 3-ft intervals.

Relatively few subsurface sediment core samples have been collected from the Kellogg Island area. Interpolated total PCB concentrations in surface sediment throughout this area were generally low (≤ 110 µg/kg dw), with a few higher concentrations (between the 75th and 95th percentiles) on the west side of the island. Two cores collected at the same location north of the island at RM 0.6 had peak PCB concentrations (~2,000 µg/kg dw) at depth (in the 2-to-2.5-ft interval at LDW-SC12 and in the 2-to-4-ft interval at DR044).

On the western shoreline of the LDW to the north of Kellogg Island, a single core (LDW-SC11) was collected, with high total PCB concentrations (3,000 µg/kg dw) in the uppermost interval (0 to 0.8 ft);PCBs were not detected below this interval. In a core collected south of the island (LDW-SC19) in an area of low interpolated PCB concentrations in surface sediment, PCBs were highest in the 6-to-7-ft interval (2,400 µg/kg dw).

Interpolated total PCB concentrations were generally between the 50th and 95th percentile in surface sediments in Slip 1. At the head of the slip, total PCB concentrations in core LDW-SC17 were highest at depth (9,800 µg/kg dw in the 2-to-4-ft interval), although all intervals had high concentrations (greater than the 95th percentile). Near the mouth of the slip, peak total PCB concentrations (ranging from 1,950 to 5,400 µg/kg dw) were detected at depth (in the 2-to-4-ft and 4-to-6-ft intervals) in all three cores collected in this area (LDW-SC15, LDW-SC16, and DR021).

Two cores were collected just downstream of Slip 1 at RM 0.85. In the navigation channel, the core from LDW-SC14 had high total PCB concentrations (1,550 to 4,500 µg/kg dw) in the uppermost intervals down to 4.1 ft, with the peak concentration in the 0-to-1.4-ft interval. Near the eastern shoreline of the LDW (LDW-SC13) the highest total PCB concentrations were in the uppermost intervals down to 2 ft, but concentrations were somewhat lower, ranging from 280 to 470 µg/kg dw.

In summary, the LDW between RM 0.0 and RM 1.0 is highly variable. Interpolated concentrations in surface sediment covered all percentile categories, although only a few areas had concentrations greater than the 95th percentile. Many of the areas sampled with subsurface cores had peak total PCB concentrations at depth. Exceptions to this general pattern include a few locations along the western shoreline (LDW-SC5 and LDW-SC11), a location in the navigation channel near RM 0.9, and a number of locations in the Duwamish/Diagonal EAA where peak concentrations were detected in the uppermost interval of the cores.

RM 1.0 to RM 2.2

Total PCB concentrations in surface and subsurface sediment samples collected between RM 1.0 and RM 2.2 were also variable (Map 4-26b). One area just south of RM 1.0 in the navigation channel had the peak total PCB concentration in the uppermost interval (3,200 µg/kg dw in LDW-SC20 in the 0-to-2-ft interval). In the co-located surface sediment sample associated with that core, the total PCB concentration was higher, at 5,100 µg/kg dw. In the core collected on the western shoreline at RM 1.0 (LDW-SC21), the peak total PCB concentration (1,680 µg/kg dw) was detected at depth (4 to 6.2 ft). Cores along the eastern shoreline at RM 1.0 (C2, C3, A1, LDW-SC18, and LDW-SC22) had relatively lower PCB concentrations, but samples from within the historical cores were collected over relatively large intervals (e.g., 4-ft intervals); thus, it was not possible to determine the depth or magnitude of peak concentrations. At sampling location LDW-SC18, the total PCB concentration (650 µg/kg dw) in the co-located surface sediment sample was higher than the peak concentration in the subsurface core.

Total PCB concentrations in surface sediment areas along the eastern shoreline between RM 1.2 and RM 1.4 were variable. Peak concentrations in cores in this area were detected at depth, with peak concentrations in the 4-to-6-ft, 2-to-4-ft, and 1-to-1.5-ft intervals in cores LDW-SC23, DR025, and LDW-SC27, respectively.

Just downstream of Slip 2 along the eastern shoreline, numerous historical cores and two RI cores were collected and analyzed for PCBs. The historical cores were collected prior to dredging in this area and were generally composited over larger intervals (0 to 3 ft or 0 to 4 ft), so the depth of the peak total PCB concentration is unknown. In the cores collected as part of the RI, peak concentrations (12.9 µg/kg dw at LDW-SC30 and 370 µg/kg dw at LDW-SC31) were in the uppermost intervals.

One core (LDW-SC32) was located within Slip 2. Total PCB concentrations in the uppermost 4 ft of this core were higher than the concentration in the co-located surface sediment sample. The peak total PCB concentration of 2,450 µg/kg dw in subsurface sediment was detected in the 2-to-4-ft interval, compared with the concentration of 211 µg/kg dw in surface sediment.

At the head of Slip 3, a subsurface peak of 950 µg/kg dw was detected in the 1-to-2-ft interval of core LDW-SC37. Near the mouth of Slip 3, in cores DR106 and LDW-SC36, subsurface concentrations of PCBs were low (less than the 50th percentile). In the core just upstream from Slip 3 (DR112), the peak concentration was detected in the 2-to-4-ft interval (330 µg/kg dw). Thus, peak concentrations were detected at depth at the head and just downstream of the slip, and were relatively low towards the mouth of the slip.

Multiple historical cores from the navigation channel between RM 1.7 and RM 2.0 were analyzed for total PCBs. These cores, collected over intervals from 0 to 4 ft, had variable total PCB concentrations, ranging from below the 25th percentile to the 95th percentile. Vertical patterns were not evident based on these cores because of the large sampling intervals. Core LDW-SC33, just east of the navigation channel at RM 1.9, was analyzed at 0.5-ft intervals down to 3 ft and had a peak total PCB concentration of 4,700 µg/kg dw in the 1-to-1.5-ft interval.[69]

Six locations between RM 1.2 and RM 1.5 on the west side of the navigation channel had sufficient data to determine the depth of peak concentrations within these cores. Two of these cores had the highest concentrations in the uppermost intervals (33 and 280 µg/kg dw in LDW-SC29 and LDW-SC24, respectively). Cores LDW-SC26 and LDW-SC28 had peak concentrations of 2,300 and 3,200 µg/kg dw in their 6-to-8-ft intervals. Peak concentrations were somewhat lower (750 to 800 µg/kg dw) and shallower (2 to 4 ft or 4 to 6 ft) in the other two cores (LDW-SC25 and DR054). Thus, in this area, peak concentrations were detected at depth in the cores with the highest subsurface concentrations.

Along the western shoreline between RM 1.8 and RM 2.2, four cores were analyzed. Peak concentrations were detected at depth in three of the four cores: LDW-SC34 (280 µg/kg dw in the 1-to-2-ft interval), LDW-SC38a (3,400 µg/kg dw in the 2-to-3-ft interval), and LDW-SC39 (440 µg/kg dw in the 1-to-2-ft interval). In the remaining core (LDW-SC35), the peak concentration was 370 µg/kg dw in the 0-to-2-ft interval.

In summary, peak concentrations in this section of the LDW were detected in the uppermost intervals and at depth. Peak concentrations were at depth for the locations with the highest subsurface concentrations (i.e., greater than the 95th percentile). One notable exception was in the navigation channel near RM 1.0, where the uppermost interval of the core had a peak concentration of 3,200 µg/kg dw. At other locations where the peak concentrations were in the uppermost interval of the core, concentrations were always less than or equal to 370 µg/kg dw.

[69] Samples were collected from coarser depth intervals in the replicate core collected at this location (LDW-SC201); the peak concentration in this core was 1,450 µg/kg dw in the 0-to-1.5-ft interval.

RM 2.2 to RM 3.0

The highest interpolated total PCB concentrations (i.e., greater than the 95th percentile) in surface sediment between RM 2.2 and RM 3.0 were detected between RM 2.2 and RM 2.3 on the west side of the LDW in EAA 2 (up to 23,000 µg/kg dw), in the Slip 4 EAA (up to 25,000 µg/kg dw), and on the east side of the LDW between RM 2.9 and RM 3.0 in the Boeing Plant 2/Jorgensen Forge EAA (up to 16,000 µg/kg dw) (Map 4-26c). The highest concentrations in subsurface sediment were in Slip 4 (up to 35,000 µg/kg dw).

In the vicinity of EAA 2 between RM 2.2 and RM 2.3 on the western shoreline, two cores were collected. Core LDW-SC40 had low concentrations of total PCBs in the uppermost interval (160 µg/kg dw in the 0-to-1.3-ft interval) and PCBs were not detected below 1.3 ft. Core DR137, located just downstream from this area, had a peak PCB concentration of 730 µg/kg dw in the 2-to-4-ft interval, higher than the concentration of 181 µg/kg dw in the co-located surface sediment sample.

Interpolated total PCB concentrations in surface sediment along the western shoreline between RM 2.3 and RM 3.0 were relatively low (generally ≤ 110 µg/kg dw). Historical cores collected along the western shoreline between RM 2.4 and RM 2.8 had large composite intervals (generally 0 to 3 ft or 0 to 4 ft). The RI core with greater resolution in this area (LDW-SC46), near RM 2.7, had a peak total PCB concentration of 270 µg/kg dw in the 2-to-4-ft interval.

In the navigation channel between RM 2.2 and RM 2.7, total PCB concentrations in surface sediment were generally between the 25th and 75th percentiles. Historical cores in the navigation channel had larger intervals of 2 or 4 ft and had total PCB concentrations similar to interpolated concentrations in surface sediment in that area (with a maximum concentration of 270 µg/kg dw).

Along the eastern shoreline between RM 2.3 and RM 2.8, five cores were collected as part of the RI. Total PCB concentrations in two of the cores (LDW-SC42 and LDW-SC43) were relatively low (less than the 75th percentile). In the other cores (LDW-SC41, LDW-SC44, and LDW-SC45), peak total PCB concentrations were in lower core intervals.

Cores located at the mouth of Slip 4 had total PCB concentrations ranging from 320 to 980 µg/kg dw in the subsurface samples composited over 3 to 4 ft. However, the depth of the peak concentration was not discernable because of the large interval sampled. Seven cores at the head of Slip 4 and halfway through the slip generally had total PCB concentrations greater than the 95th percentile in at least one of the subsurface intervals. The peak total PCB concentration was in the 0-to-2-ft interval in three of the cores and in the 2-to-4-ft or 4-to-6-ft interval in the remaining four cores. High concentrations were detected in the subsurface intervals in these seven cores. For example, core SC01 had a peak concentration of 35,000 µg/kg dw in the 0-to-2-ft

interval, and core SC03 had a peak concentration of 15,000 µg/kg dw in the 4-to-6-ft interval.

In cores collected from RM 2.9 to RM 3.0 on the eastern shoreline, data were not available from the uppermost 2 ft, so the location of the peak concentrations within those cores is not known. Concentrations in intervals between 2 and 5 ft were highly variable ranging from non-detect in cores DUW106, DUW138, and DUW109 to 9,200 µg/kg dw in core DUW 37.

In summary, total PCB concentrations were variable in this section of the LDW. Outside of Slip 4, in areas with sufficient data, peak concentrations were either low (≤ 160 µg/kg dw) or were detected at depth within the cores. Within Slip 4, concentrations were greater than the 95th percentile both at depth and in uppermost core intervals. Peak concentrations in subsurface cores from Slip 4 ranged from 990 to 35,000 µg/kg dw. The depths of peak concentrations in Slip 4 were highly variable.

RM 3.0 to RM 4.0

The highest total PCB concentrations (less than the 95th percentile) in surface sediment between RM 3.0 and RM 4.0 were detected between RM 3.5 and RM 3.9 on the east side of the LDW (up to 38,000 µg/kg dw in the Boeing Plant 2/Jorgensen Forge EAA), and on the west side of the LDW between RM 3.5 and RM 3.7 (up to 110,000 µg/kg dw) in the T-117 EAA (Map 4-26d).

Surface sediment concentrations were generally low (between the 25th and 50th percentiles) along the western shoreline from RM 3.0 to RM 3.5 (Map 4-26d). Subsurface samples in this area had relatively low total PCB concentrations, except for cores LDW-SC47 at RM 3.05 and SB-5 at RM 3.35; peak concentrations were detected in the 1-to-2-ft interval (2,000 µg/kg dw) and 2.5-to-5-ft interval (1,720 µg/kg dw), respectively, in these cores. Thus, total PCB concentrations were either low or the peak concentrations were detected at depth in this area.

In cores collected in the Boeing Plant 2/Jorgensen Forge EAA between RM 3.0 and RM 3.7 along the eastern shoreline, total PCB data from the uppermost 1- or 2-ft intervals were generally only available for cores collected between RM 3.5 and RM 3.7 (Maps 4-26e and 4-26f). Interpolated concentrations in surface sediment for most of this area were greater than the 95th percentile. In general, most core locations north of RM 3.6 with available subsurface data had peak concentrations in the uppermost intervals; these peak concentrations were greater than the 95th percentile concentration. South of RM 3.6, a number of cores had peak concentrations in deeper intervals; these peak concentrations were generally less than the 95th percentile. Fifty-six percent of the locations in the Boeing Plant 2/Jorgensen Forge EAA with co-located surface and subsurface sediment samples had total PCB concentrations in the surface sediment samples that were higher than the peak concentrations in the associated subsurface cores (see Maps 4-26e and 4-26f for concentrations in every sample).

In the 15 cores collected from the T-117 EAA between RM 3.5 and RM 3.7 on the western shoreline, the seven highest total PCB concentrations in subsurface sediment samples (ranging from 2,800 to 51,000 µg/kg dw) were all detected within the uppermost subsurface intervals (Map 4-26g) and 13 of the 15 cores in the T-117 EAA had the peak total PCB concentration in the uppermost interval. In most of these cores with co-located surface sediment data, the highest total PCB concentration was in the surface sediment (i.e., 9 out of 13 cores).

Peak total PCB concentrations in subsurface cores LDW-SC49a, SD-321-C, and SD-322-C, in the navigation channel between RM 3.5 and RM 3.7, were detected at depth (> 1 ft), with concentrations ranging from 750 to 2,770 µg/kg dw (Map 4-26d). All other cores in the navigation channel between RM 3.0 and RM 4.0 had low total PCB concentrations in subsurface intervals (≤ 110 µg/kg dw).

Surface sediment along the eastern shoreline between RM 3.7 and RM 3.9 generally had relatively high interpolated total PCB concentrations (between the 75th and 95th percentiles; Map 4-26d). In three cores in this area (LDW-SC51, DR220, and LDW-SC52), the peak concentrations were greater than the 95th percentile and were in the uppermost interval. In two of these cores, which had co-located surface sediment data, the concentrations were lowest in the surface sediment. In another core from this area at RM 3.8 (LDW-SC50a), the peak total PCB concentration (780 µg/kg dw) was in the 1-to-2-ft interval, although the concentration was higher (820 µg/kg dw) in the co-located surface sediment sample.

In summary, two EAAs with high total PCB concentrations are located within this reach. Vertical gradients were generally difficult to discern in the Boeing Plant 2/ Jorgensen Forge EAA, but in general the highest concentrations appeared to be in the uppermost intervals, particularly north of RM 3.6. In the T-117 EAA, peak concentrations were generally found in the uppermost intervals of the cores. Along the eastern shoreline south of RM 3.7, peak concentrations were generally in the uppermost intervals. In cores between RM 3.0 and RM 3.5, in the navigation channel and along the western shoreline, total PCB concentrations were generally low or peaks were detected at depth.

RM 4.0 to RM 5.0

Total PCB concentrations in surface and subsurface sediment between RM 4.0 and RM 5.0 were generally relatively low (less than the 50th percentile) (Map 4-26h), except for the eastern shoreline at RM 4.1 and the area between RM 4.8 and RM 5.0 (including the Norfolk EAA), where concentrations were greater than the 95th percentile in surface and subsurface sediment.

At RM 4.1 on the eastern shoreline, one small area had interpolated concentration in surface sediment greater than the 95th percentile; the only subsurface concentration greater than the 95th percentile near RM 4.1 on the eastern shoreline was also near this small area (2,500 µg/kg dw in core SH-04 in the only interval analyzed at 0.33 to

0.82 ft). In the area between RM 4.0 and RM 4.3 on the east side, including Slip 6, total PCB concentrations in subsurface sediments were generally less than the 75th percentile concentration. However,, only one relatively shallow subsurface core was analyzed at each of these locations, so it is not possible to determine the concentration gradient in deeper intervals at these locations.

Between RM 4.8 and RM 5.0, total PCB concentrations were variable. The total PCB concentration was low in core SC55 (13.5 µg/kg dw in the 0-to-1-ft interval), but concentrations were high in a co-located surface sediment sample (2,700 µg/kg dw). Within the Norfolk EAA, peak total PCB concentrations were 81,700 µg/kg dw in the 1-to-2-ft interval at NFK008 and 247 µg/kg dw in the 0-to-1-ft interval at nearby location NFK009. The area within the Norfolk EAA was dredged and backfilled with clean material after these cores were collected. The interpolated surface sediment data shown on Map 4-26h reflect post-dredging conditions.

Subsurface sediment cores were collected at two other locations between RM 4.0 and 5.0 as part of the RI. At one location (LDW-SC54), concentrations were low (less than the 50th percentile), and at the other location (LDW-SC56), the peak concentration (330 µg/kg dw) was detected in the uppermost interval of 0-to-2 ft. In summary, total PCB concentrations in both surface and subsurface sediments were generally lower in this section of the LDW than in downstream areas, except at one location near RM 4.1 and locations near the Norfolk EAA. Concentrations in all cores from the navigation channel were low.

4.2.3.4 Tissue

The RI tissue dataset contained data from 421 composite samples of fish and shellfish collected in the LDW between 1992 and 2007.[70] Over 74% of these samples were collected in 2004, 2005, and 2007 as part of the RI, as described in Section 4.1.1.3. Tissue data collected between 1992 and 2005 were used in the risk assessments; additional tissue data were collected in 2006 and 2007 after the risk assessments had been completed. The additional data from 2006 were collected by King County from Area T1 (Anchor and King County 2007). The additional data from 2007 were collected as part of the RI in all four tissue sampling areas (Map 4-10). This section presents total PCB data, as Aroclor sums and as a sum of individual PCB congener sums, and presents various analyses of these data.

[70] An additional 45 whole-body concentrations calculated from concentrations in 10 English sole fillet and remainder samples and 35 crab edible meat and hepatopancreas samples were also included in the dataset (see Section 4.1.2).

Aroclor Data

Table 4-29 summarizes the total PCB (Aroclor sum) data in the RI tissue dataset. PCBs were detected in most of the tissue samples collected between 1992 and 2007, with a few exceptions.[71] In whole-body composite samples of fish, the lowest mean total PCB concentration was 71 µg/kg ww in juvenile chinook salmon collected between RM 0.5 and RM 0.9. The highest mean concentration in fish within a sampling area was 4,300 µg/kg ww in shiner surfperch in Area T2 (Table 4-29; Map 4-28). In general, mean concentrations in whole-body fish within individual sampling areas were highest in English sole and shiner surfperch (ranging from 300 to 3,900 µg/kg ww in English sole and from 270 to 4,300 µg/kg in shiner surfperch) and lowest in juvenile chinook salmon (ranging from 71 to 260 µg/kg ww).

[71] Of all the tissue samples analyzed, PCBs were not detected in 4 of the 22 wild mussel samples, 19 of the 32 transplanted mussel samples, 1 of the 20 benthic invertebrate samples, and 3 of the 13 Dungeness crab edible-meat samples.

Table 4-29. Summary of composite tissue data for total PCBs (Aroclor sum)

Tissue Type	Area[a]	1992 – 2003				2004				2005				2006				2007			
			Total PCBs (µg/kg ww)				Total PCBs (µg/kg ww)				Total PCBs (µg/kg ww)				Total PCB (µg/kg ww)				Total PCBs (µg/kg ww)		
		n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]
Fish, Whole Body																					
Juvenile chinook salmon	RM 0.5 – RM 0.9[c]	15	9.3 J	320 J	71	0	no data			0	no data			0	no data			0	no data		
	RM 2.6 – RM 2.9[d]	9	6.9 J	1,200	260	0	no data			0	no data			0	no data			0	no data		
English sole	T1	0	no data			6	2,700	4,700	3,700	6[e]	1,120	2,200	1,600	6	630	1,470	920	6	360	780	530
	T2	0	no data			6	3,300	4,200	3,900	6[e]	1,600	2,400	2,000	0	no data			6	380	980	690
	T3	0	no data			6	1,320	4,300	2,600	6[e]	610	2,200	1,400	0	no data			6	600	1,600 J	890
	T4	0	no data			3	1,640	1,800	1,700	3[e]	910	1,180	1,000	0	no data			1	300	300	300
Pacific staghorn sculpin	T1	0	no data			6	580	860	730	1	720 J	720 J	720	0	no data			0	no data		
	T2	0	no data			6	620	1,260	770	1	620	620	620	0	no data			0	no data		
	T3	0	no data			6	810	2,800	1,500	1	590	590	590	0	no data			0	no data		
	T4	0	no data			6	510	1,300	780	1	430	430	430	0	no data			0	no data		
Shiner surfperch	T1	3	350	620	500	6	970	1,830	1,400	6	530 J	960 J	780	7	250	730	457	6	200 J	360 J	270
	T2	0	no data			6	1,260	18,400 J	4,300	6	660	2,000	1,300	0	no data			6	290 J	610 J	420
	T3	0	no data			6	1,280	8,800	3,800	6	700	2,400	1,500	0	no data			6	430 J	1,330 J	760
	T4	0	no data			6	640	960	800	4	540	600	580	0	no data			4	260 J	410 J	320
Starry flounder	T4	0	no data			3	450	660	570	0	no data			0	no data			3	156	240	190
Fish, Fillet																					
English sole (with skin)	T1	0	no data			2	1,330	1,600	1,500	3	920	1,450	1,200	0	no data			3	260	500	340
	T2	0	no data			2	1,840	2,010	1,930	3	850	1,400	1,000	0	no data			3	170	360	290
	T3	0	no data			2	850	1,640	1,200	3	450	860	680	0	no data			3	340	490	400
	T4	0	no data			1	710	710	710	1	530	530	530	0	no data			0	no data		

Table 4-29, cont. Summary of composite tissue data for total PCBs (Aroclor sum)

Tissue Type	Area[a]	1992 – 2003				2004				2005				2006				2007			
			Total PCBs (µg/kg ww)				Total PCBs (µg/kg ww)				Total PCBs (µg/kg ww)				Total PCB (µg/kg ww)				Total PCBs (µg/kg ww)		
		n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]
English sole (without skin)	T1 and RM 1.1 – RM 1.4[f]	12	79	360	190	0	no data			0	no data			0	no data			0	no data		
	RM 2.1 – RM 2.9	1	300 J	300 J	300	0	no data			0	no data			0	no data			0	no data		
	RM 2.9 – RM 3.6	1	280 J	280 J	280	0	no data			0	no data			0	no data			0	no data		
	RM 3.6 – RM 4.4	1	530 J	530 J	530	0	no data			0	no data			0	no data			0	no data		
Starry flounder (with skin)	T4	0	no data			1	450	450	450	0	no data			0	no data			1	63	63	63
Pile perch (with skin)	T3	0	no data			1	300	300	300	0	no data			0	no data			0	no data		
Striped perch (with skin)	RM 0.0 – RM 0.2	2	164 J	171 J	168	0	no data			0	no data			0	no data			0	no data		
	RM 4.0 – RM 4.1	0	no data			1	630	630	630	0	no data			0	no data			0	no data		
Crab, Edible Meat																					
Dungeness crab	T1	3	80 J	180	132	3	206 J	290	230	1	20 U	20 U	20 U	0				1	15	15	15
	T2	0	no data			0	no data			0	no data			0	no data			0	no data		
	T3	0	no data			3	212	300	250	1	20 U	20 U	20 U	0	no data			3	39	51 J	43
	T4	0	no data			1	240 J	240 J	240	1	20 U	20 U	20 U	0	no data			0	no data		
Red rock crab	T1	2	85	164	125	0	no data			0	no data			0	no data			0	no data		
Red rock/ Dungeness crab	T1	1	60	60	60	0	no data			0	no data			0	no data			0	no data		
Slender crab	T1	0	no data			3	210 J	390 J	270	0	no data			0	no data			3	41	48 J	43
	T2	0	no data			6	108	260 J	190	1	64	64	64	0	no data			3	27	46 J	38
	T3	0	no data			3	146	220	180	0	no data			0	no data			0	no data		
	T4	0	no data			0	no data			0	no data			0	no data			0	no data		

Table 4-29, cont. Summary of composite tissue data for total PCBs (Aroclor sum)

Tissue Type	Area[a]	1992 – 2003				2004				2005				2006				2007			
		n	Total PCBs (µg/kg ww)			n	Total PCBs (µg/kg ww)			n	Total PCBs (µg/kg ww)			n	Total PCB (µg/kg ww)			n	Total PCBs (µg/kg ww)		
			Min	Max	Mean[b]		Min	Max	Mean[b]		Min	Max	Mean[b]		Min	Max	Mean[b]		Min	Max	Mean[b]
Crab, Hepatopancreas																					
Dungeness crab	T1	1	1,700	1,700	1,700	1	4,000	4,000	4,000	1	1,420	1,420	1,420	0	no data			1	280	280	280
	T2	0	no data			0	no data			0	no data			0	no data			0	no data		
	T3	0	no data			1	4,500	4,500	4,500	1	1,310	1,310	1,310	0	no data			3	420	1,020	650
	T4	0	no data			1	5,500	5,500	5,500	1	1,320	1,320	1,320	0	no data			0	no data		
Slender crab	T1	0	no data			1	1,490 J	1,490 J	1,490	0	no data			0	no data			3	480	660	540
	T2	0	no data			2	1,950 J	2,190 J	2,070	1	660	660	660	0	no data			3	250	270	260
	T3	0	no data			1	1,640	1,640	1,640	0	no data			0	no data			0	no data		
	T4	0	no data			0	no data			0	no data			0	no data			0	no data		
Crab, Whole Body (calc'd)[g]																					
Dungeness crab	T1	2	620 M	650 M	635	3	1,400 JM	1,400 JM	1,400	1	454 M	454 M	454	0	no data			1	97 M	97 M	97
	T2	0	no data			0	no data			0	no data			0	no data			0	no data		
	T3	0	no data			3	1,500 JM	1,600 JM	1,600	1	420 M	420 M	420	0	no data			3	160 M	351 JM	230
	T4	0	no data			1	1,900 JM	1,900 JM	1,900	1	423 M	423 M	423	0	no data			0	no data		
Slender crab	T1	0	no data			3	607 JM	731 JM	1650	0	no data			0	no data			3	180 M	240 JM	200
	T2	0	no data			6	729 JM	838 JM	776	1	250 M	250 M	250	0	no data			3	100 M	120 JM	110
	T3	0	no data			3	609 M	660 M	631	0	no data			0	no data			0	no data		
	T4	0	no data			0	no data			0	no data			0	no data			0	no data		
Invertebrates, Whole Body																					
Amphipods	RM 0.5 – RM 0.7	4	106	410	230	0	no data			0	no data			0	no data			0	no data		
Benthic invertebrates	LDW-wide[h]	0	no data			20	60 J	1,400	270	0	no data			0	no data			0	no data		
Shellfish																					
Clams, non-depurated	LDW-wide[h]	0	no data			14	24	580 J	140	0	no data			0	no data			6	15 J	310	110
Clams, depurated	LDW-wide[h]	0	no data			0	no data			0	no data			0	no data			6	14 J	270	98

Table 4-29, cont. Summary of composite tissue data for total PCBs (Aroclor sum)

Tissue Type	Area[a]	1992 – 2003				2004				2005				2006				2007			
		n	Total PCBs (µg/kg ww)			n	Total PCBs (µg/kg ww)			n	Total PCBs (µg/kg ww)			n	Total PCB (µg/kg ww)			n	Total PCBs (µg/kg ww)		
			Min	Max	Mean[b]		Min	Max	Mean[b]		Min	Max	Mean[b]		Min	Max	Mean[b]		Min	Max	Mean[b]
Mussels, wild	RM 0.3 – RM 2.8[i]	22	16	60	34	0	no data			0	no data			0	no data			0	no data		
Mussels, transplanted	RM 0.5 – RM 1.2	32	35.9	73.1	27	0	no data			0	no data			0	no data			0	no data		

[a] Tissue sampling areas are shown on Maps 4-9 and 4-10.

[b] Mean concentration is the average of detected concentrations and one-half the RL for non-detected results. For non-detected results, the RL represents the highest RL for an individual Aroclor in that sample.

[c] Includes nine samples collected between RM 0.5 and RM 0.9 during the RI sampling event in 2003 and six samples collected between RM 0.8 and RM 0.9 during the East Waterway sampling event (both locations are within Area T1).

[d] These nine samples were collected between RM 2.6 and RM 2.9 (slightly downstream from Area T3) during the RI sampling event.

[e] A subset of these samples are calculated "whole-body" samples (three each from Areas T1, T2, and T3 and one from T4). Concentrations in "whole-body" samples were calculated using results from separate analyses of fillet and remainder composite samples (i.e., all remaining tissue and fluids after fillets were removed from the specimens). The calculated English sole "whole-body" concentrations were based on the relative weights of and total PCB concentrations in skin-on fillet and remainder tissues collected in 2005.

[f] Includes data from three samples collected between RM 1.1 and RM 1.4 in 1995 (slightly upstream from Area T1) (Battelle 1996; Frontier Geosciences 1996), and nine samples collected between RM 0.5 and RM 1.0 (within Area T1) during the PSAMP and King County WQA studies between 1992 and 1997 (West et al. 2001; King County 1999e).

[g] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Total PCB concentrations in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

[h] The benthic invertebrate and clam samples were collected throughout the LDW (Map 4-10).

[i] All but three of the wild mussel samples were collected between RM 0.3 and 1.2; the remaining three samples were collected at one sampling location at the mouth of Slip 4 near RM 2.8.

J – estimated concentration
JM – calculated from an estimated concentration
M – calculated concentration
n – number of samples
PCB – polychlorinated biphenyl
PSAMP – Puget Sound Ambient Monitoring Program
RM – river mile
U – not detected at RL shown
WQA – water quality assessment
ww – wet weight

One shiner surfperch composite sample collected from Subarea T2E in 2004 had a total PCB concentration based on the sum of Aroclors (18,400 µg/kg ww) that was much higher than any other tissue samples in the LDW.[72] The total PCB concentration in this sample based on the sum of PCB congeners was also very high (12,230 µg/kg ww), providing confirmation of the Aroclor result. To better understand the variability of total PCB concentrations in shiner surfperch collected from Subarea T2E in 2004, 10 archived fish from this subarea were analyzed individually.[73] Total PCB concentrations in these individual fish ranged from 172 to 1,140 µg/kg ww, with a mean concentration of 640 µg/kg ww. Based on these data, it is likely that one or more of the 10 fish included in the composite sample with 18,400 µg/kg ww had a very high concentration of total PCBs.

Fillet samples from four different fish species were also analyzed. The largest fillet dataset for PCBs is for English sole, with 15 composite samples (without skin) collected between 1992 and 1998 and 26 composite samples (with skin) collected between 2004 and 2007. Other species with available fillet data are pile perch (one composite sample), starry flounder (one composite sample), and striped perch (three composite samples); all of these fillet samples were analyzed with skin. In fillet samples collected in the 1990s without skin, total PCB tissue concentrations generally were lower than those in samples collected between 2004 and 2007 with skin (79 to 530 µg/kg ww and 290 to 2,010 µg/kg ww, respectively). This difference may be related to the year of sampling (1992 to 1998 vs. 2004 to 2007), the absence of skin,[74] or other factors.

Mean total PCB concentrations within all sampling areas for crab edible meat, benthic invertebrates, and clams were 270 µg/kg ww or lower; in general, these concentrations were lower than those in fish (Table 4-29). In crabs, mean total PCB concentrations in edible-meat composite samples from the four tissue sampling areas were much lower (non-detected to 270 µg/kg ww) than those in hepatopancreas composite samples (260 to 5,500 µg/kg ww) (Table 4-29). Mean concentrations in invertebrate samples (amphipods collected from RM 0.5 to RM 0.7 and benthic invertebrates collected from

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[72] Using Rosner's test for outliers from a log-normal distribution, this value was considered to be a statistical outlier ($p < 0.005$).

[73] A total of 20 shiner surfperch (> 80 mm) were collected in subarea T2E in 2004. Ten of these fish were included in the initial composite sample for this area, and the 10 remaining fish were archived frozen as individual fish.

[74] The potential influence of skin on the total PCB concentrations in the 2004 English sole fillet samples was investigated to facilitate comparison of 2004 samples with historical data. One fillet with skin and one fillet without skin were created from each of 10 individual fish archived from Area T1, for a total of 20 samples. Total PCB concentrations in the fillets with skin (420 to 1,440 µg/kg ww) and in the fillets without skin (230 to 1,570 µg/kg ww) were not significantly different when tested with analysis of variance ($p = 0.47$).

throughout the LDW) were 230 and 270 µg/kg ww, respectively. These invertebrate tissues, as well as soft-shell clam tissues collected from throughout the LDW (140 µg/kg\ ww), were generally lower than fish tissues. Some of the lowest mean total PCB concentrations in any of the tissue types were detected in wild and transplanted mussels collected primarily from RM 0.3 to RM 1.2 (34 and 27 µg/kg, respectively). Mean total PCB concentrations in Dungeness crab edible meat samples collected in 2005 (20 U µg/kg ww) and 2007 (15 to 43 µg/kg ww) were lower than in mussels, but mean total PCB concentrations in Dungeness crab edible meat samples in 2004 (230 to 250 µg/kg ww) were higher than in mussels.

Mean lipid contents in whole-body fish and crab tissue were higher in English sole and shiner surfperch (3.67 to 7.1% and 2.8 to 6.38%, respectively) than in Pacific staghorn sculpin and crabs (1.18 to 2.3% and 0.928 to 5.4% respectively) (Table 4-30). Mean lipid contents were lower in English sole fillet tissues (1.7 to 4.0%) than in English sole whole-body tissues (3.68 to 7.1%), and mean lipid contents in crab edible-meat tissues (0.15 to 2.0%) were lower than in hepatopancreas tissues (1.9 to 13%). Lipid contents were relatively low in benthic invertebrates (0.89 to 3.0%), clams (0.71 to 0.87%), and mussels (0.89 to 1.3%).

Mean lipid-normalized total PCB concentrations in fish tissue ranged from 2.8 to 100 mg/kg-lipid, with no clear differences in concentrations among fish species or tissue types (i.e., whole body vs. fillet) (Table 4-31). Mean lipid-normalized total PCB concentrations in crab tissue ranged from non-detected to 87 mg/kg-lipid; there were no clear differences among crab species or tissue types (i.e., hepatopancreas or edible meat) (Table 4-31). Mean lipid-normalized total PCB concentrations ranged from 12 to 41 mg/kg-lipid in benthic invertebrates, 11 to 21 mg/kg-lipid in clams, and 3.3 to 4.5 mg/kg-lipid in mussels.

Table 4-30. Summary of composite tissue data for lipids

Tissue Type	Area[a]	1992 – 2003				2004				2005				2006				2007			
		n	Lipids (% ww) Min	Max	Mean[b]	n	Lipids (% ww) Min	Max	Mean[b]	n	Lipids (% ww) Min	Max	Mean[b]	n	Lipids (% ww) Min	Max	Mean[b]	n	Lipids (% ww) Min	Max	Mean[b]
Fish, Whole Body																					
Juvenile chinook salmon	RM 0.5 – RM 0.9[b]	15	0.55	3.5	2.0	0	no data			0	no data			0	no data			0	no data		
	RM 2.6 – RM 2.9[c]	9	0.74	2.8	1.6	0	no data			0	no data			0	no data			0	no data		
English sole	T1	0	no data			6	4.3	6.8	5.6	6[d]	3.13	6.14	4.74	6	2.46	5.06	3.67	6	3.83	7.22	6.04
	T2	0	no data			6	5.7	8.7	7.1	6[d]	4.89	6.83	5.74	0	no data			6	4.46	9.00	6.44
	T3	0	no data			6	2.6	6.6	4.9	6[d]	3.09	7.53	5.19	0	no data			6	2.34	10.9	6.44
	T4	0	no data			3	4.8	6.2	5.6	3[d]	3.85	6.25	5.24	0	no data			1	4.62	4.62	4.62
Pacific staghorn sculpin	T1	0	no data			6	1.8	2.4	2.2	1	2.17	2.17	2.17	0	no data			0	no data		
	T2	0	no data			6	1.8	2.7	2.3	1	1.92	1.92	1.92	0	no data			0	no data		
	T3	0	no data			6	1.8	2.1	1.9	1	1.34	1.34	1.34	0	no data			0	no data		
	T4	0	no data			6	1.3	2.5	2.1	1	1.18	1.18	1.18	0	no data			0	no data		
Shiner surfperch	T1	3	1.6	4.0	2.8	6	2.3	5.0	3.4	6	4.31	6.16	5.58	7	2.79	7.32	5.17	6	1.80	4.94	3.13
	T2	0	no data			6	2.5	5.6	4.0	6	4.74	5.99	5.43	0	no data			6	2.90	4.86	4.04
	T3	0	no data			6	3.1	5.6	4.0	6	4.98	6.92	5.78	0	no data			6	3.43	4.94	4.14
	T4	0	no data			6	3.0	5.6	4.1	4	6.16	6.93	6.38	0	no data			4	3.62	4.78	4.33
Starry flounder	T4	0	no data			3	2.1	2.5	2.2	0	no data			0	no data			3	0.917	3.29	1.95
Fish, Fillet																					
English sole (with skin)	T1	0	no data			2	2.6	3.1	2.9	3	2.95	5.09	3.69	0	no data			3	2.85	4.11	3.32
	T2	0	no data			2	3.4	4.3	3.9	3	3.42	4.62	3.98	0	no data			3	2.14	3.63	2.97
	T3	0	no data			2	1.6	3.6	2.6	3	2.04	4.12	3.14	0	no data			3	1.77	3.26	2.66
	T4	0	no data			1	1.7	1.7	1.7	1	2.82	2.82	2.82	0	no data			0	no data		

Table 4-30, cont. Summary of composite tissue data for lipids

Tissue Type	Area[a]	1992 – 2003				2004				2005				2006				2007			
		n	Lipids (% ww) Min	Max	Mean[b]	n	Lipids (% ww) Min	Max	Mean[b]	n	Lipids (% ww) Min	Max	Mean[b]	n	Lipids (% ww) Min	Max	Mean[b]	n	Lipids (% ww) Min	Max	Mean[b]
English sole (without skin)	T1 and RM 1.1 – RM 1.4[g]	12	0.24	12	3.0	0	no data			0	no data			0	no data			0	no data		
	RM 2.1 – RM 2.9	0	no data			0	no data			0	no data			0	no data			0	no data		
	RM 2.9 – RM 3.6	0	no data			0	no data			0	no data			0	no data			0	no data		
	RM 3.6 – RM 4.4	0	no data			0	no data			0	no data			0	no data			0	no data		
Starry flounder (with skin)	T4	0	no data			1	2.6	2.6	2.6	0	no data			0	no data			1	2.23	2.23	2.23
Pile perch (with skin)	T3	0	no data			1	1.1	1.1	1.1	0	no data			0	no data			0	no data		
Striped perch (with skin)	RM 0.0 – RM 0.2	0	no data			0	no data			0	no data			0	no data			0	no data		
	RM 4.0 – RM 4.1	0	no data			1	1.4	1.4	1.4	0	no data			0	no data			0	no data		
Crab, Edible Meat																					
Dungeness crab	T1	2	1.6	2.4	2.0	3	0.28	0.39	0.34	1	0.191	0.191	0.191	0	no data			1	0.440	0.440	0.440
	T2	0	no data			0	no data			0	no data			0	no data			0	no data		
	T3	0	no data			3	0.23	0.47	0.37	1	0.146	0.146	0.146	0	no data			3	0.508	0.644	0.561
	T4	0	no data			1	0.72	0.72	0.72	1	0.232	0.232	0.232	0	no data			0	no data		
Red rock crab	T1	0	no data			0	no data			0	no data			0	no data			0	no data		
Red rock/ Dungeness crab	T1	0	no data			0	no data			0	no data			0	no data			0	no data		
Slender crab	T1	0	no data			3	0.43	0.74	0.57	0	no data			0	no data			3	0.408	0.444	0.427
	T2	0	no data			6	0.23	0.47	0.36	1	0.315	0.315	0.315	0	no data			3	0.452	0.628	0.557
	T3	0	no data			3	0.45	0.52	0.49	0	no data			0	no data			0	no data		
	T4	0	no data			0	no data			0	no data			0	no data			0	no data		

Table 4-30, cont. Summary of composite tissue data for lipids

Tissue Type	Area[a]	1992 – 2003				2004				2005				2006				2007			
			Lipids (% ww)				Lipids (% ww)				Lipids (% ww)				Lipids (% ww)				Lipids (% ww)		
		n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]
Crab, Hepatopancreas																					
Dungeness crab	T1	1	13	13	13	1	4.6	4.6	4.6	1	8.14	8.14	8.14	0	no data			1	3.72	3.72	3.72
	T2	0	no data			0	no data			0	no data			0	no data			0	no data		
	T3	0	no data			1	6.3	6.3	6.3	1	4.28	4.28	4.28	0	no data			3	4.56	6.87	5.81
	T4	0	no data			1	7.9	7.9	7.9	1	5.52	5.52	5.52	0	no data			0	no data		
Slender crab	T1	0	no data			1	1.9	1.9	1.9	0	no data			0	no data			3	1.64	2.79	2.05
	T2	0	no data			2	2.7	3.6	3.2	1	2.47	2.47	2.47	0	no data			3	3.07	4.10	3.69
	T3	0	no data			1	2.2	2.2	2.2	0	no data			0	no data			0	no data		
	T4	0	no data			0	no data			0	no data			0	no data			0	no data		
Crab, Whole Body (calc'd)[g]																					
Dungeness crab	T1	2	5.1	5.7	5.4	3	1.6	1.7	1.7	1	2.66	2.66	2.66	0	no data			1	1.46	1.46	1.46
	T2	0	no data			0	no data			0	no data			0	no data			0	no data		
	T3	0	no data			3	2.1	2.3	2.2	1	1.43	1.43	1.43	0	no data			3	1.76	2.50	2.19
	T4	0	no data			1	2.9	2.9	2.9	1	1.87	1.87	1.87	0	no data			0	no data		
Slender crab	T1	0	no data			3	0.89	1.1	0.98	0	no data			0	no data			3	0.790	1.17	0.928
	T2	0	no data			6	1.0	1.4	1.2	1	0.983	0.983	0.983	0	no data			3	1.39	1.62	1.53
	T3	0	no data			3	0.99	1.0	1.0	0	no data			0	no data			0	no data		
	T4	0	no data			0	no data			0	no data			0	no data			0	no data		
Invertebrates, Whole Body																					
Amphipods	RM 0.5 – RM 0.7	4	0.66	5.3	3.0	0	no data			0	no data			0	no data			0	no data		
Benthic invertebrates	LDW-wide[g]	0	no data			20	0.35	1.4	0.89	0	no data			0	no data			0	no data		
Shellfish																					
Clams, non-depurated	LDW-wide[g]	0	no data			14	0.55	0.83	0.71	0	no data			0	no data			15	0.599	1.03	0.788
Clams, depurated	LDW-wide[g]	0	no data			0	no data			0	no data			0	no data			15	0.619	1.10	0.866

Table 4-30, cont. Summary of composite tissue data for lipids

Tissue Type	Area[a]	1992 – 2003				2004				2005				2006				2007			
			Lipids (% ww)				Lipids (% ww)				Lipids (% ww)				Lipids (% ww)				Lipids (% ww)		
		n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]
Mussels, wild	RM 0.3 – RM 2.8[h]	21	0.29	2.4	0.89	0	no data			0	no data			0	no data			0	no data		
Mussels, transplanted	RM 0.5 – RM 1.2	32	0.25	2.6	1.3	0	no data			0	no data			0	no data			0	no data		

[a] Tissue sampling areas are shown on Maps 4-9 and 4-10.

[b] Includes nine samples collected between RM 0.5 and RM 0.9 during the RI sampling event in 2003 and six samples collected between RM 0.8 and RM 0.9 during the East Waterway sampling event in 2002 (both locations are within Area T1).

[c] These nine samples were collected between RM 2.6 and RM 2.9 (slightly downstream from Area T3) during the RI sampling event.

[d] A subset of these samples are calculated "whole-body" samples (three each from Areas T1, T2, and T3 and one from T4). Concentrations in "whole-body" samples were calculated using results from separate analyses of fillet and remainder composite samples (i.e., all remaining tissue and fluids after fillets were removed from the specimens). The calculated English sole "whole-body" concentrations were based on the relative weights of and total PCB concentrations in skin-on fillet and remainder tissues collected in 2005.

[e] Includes data from three samples collected between RM 1.1 and RM 1.4 (slightly upstream from Area T1) in 1995 (Battelle 1996; Frontier Geosciences 1996),, and nine samples collected between RM 0.5 and RM 1.0 (within Area T1) during the PSAMP and King County WQA studies between 1992 and 1997 (West et al. 2001; King County 1999e).

[f] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Total PCB concentrations in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

[g] The benthic invertebrate and clam samples were collected throughout the LDW (Map 4-10).

[h] All but three of the wild mussel samples were collected between RM 0.3 and 1.2; the remaining three samples were collected at one sampling location at the mouth of Slip 4 near RM 2.8.

LDW – Lower Duwamish Waterway
n – number of samples
PCB – polychlorinated biphenyl
PSAMP – Puget Sound Ambient Monitoring Program
RI – remedial investigation
RL – reporting limit
RM – river mile
WQA – water quality assessment
ww – wet weight

Table 4-31. Summary of composite tissue data for total PCBs (Aroclor sum) on a lipid-normalized basis

Tissue Type	Area[a]	1992 – 2003				2004				2005				2006				2007			
			Total PCBs (mg/kg lipid)				Total PCBs (mg/kg lipid)				Total PCBs (mg/kg lipid)				Total PCBs (mg/kg lipid)				Total PCBs (mg/kg lipid)		
		n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]
Fish, Whole Body																					
Juvenile chinook salmon	RM 0.5 – RM 0.9[c]	15	0.46	35 J	7.1	0	no data			0	no data			0	no data			0	no data		
	RM 2.6 – RM 2.9[d]	9	0.25 J	160	29	0	no data			0	no data			0	no data			0	no data		
English sole	T1	0	no data			6	58	75	65	6[e]	27.8 M	52.1	36	6	17	39.9	26	6	5.0	11	8.9
	T2	0	no data			6	48	59	55	6[e]	28.0 M	45	34	0	no data			6	8.5	17	11
	T3	0	no data			6	40	78	52	6[e]	18 M	36.8	26	0	no data			6	8.4 J	28 J	16
	T4	0	no data			3	27	34	30	3[e]	15 M	24	20	0	no data			1	6.5	6.5	6.5
Pacific staghorn sculpin	T1	0	no data			6	27 J	42 J	33	1	33 J	33 J	33	0	no data			0	no data		
	T2	0	no data			6	24 J	55	34	1	32	32	32	0	no data			0	no data		
	T3	0	no data			6	40	160	81	1	44	44	44	0	no data			0	no data		
	T4	0	no data			6	28	53	37	1	36	36	36	0	no data			0	no data		
Shiner surfperch	T1	3	12	33	20	6	19	55	44	6	8.6 J	22	14	7	4.7	14	9.2	6	6.8 J	14 J	9.2
	T2	0	no data			6	33	330 J	91	6	13	42	24	0	no data			6	6.6 J	14 J	10
	T3	0	no data			6	35	284	100	6	13	35	25	0	no data			6	11 J	26.9 J	18
	T4	0	no data			6	16	29	20	4	8.4	9.7	9.1	0	no data			4	5.4 J	8.6 J	7.3
Starry flounder	T4	0	no data			3	21	31	26	0	no data			0	no data			3	7.3	19	12
Fish, Fillet																					
English sole (with skin)	T1	0	no data			2	51	52	51	3	28.5	39.0	33	0	no data			3	9.0	12	10
	T2	0	no data			2	43	59	51	3	23	30	26	0	no data			3	7.9	11	9.6
	T3	0	no data			2	46	53	49	3	21	22	22	0	no data			3	13	19	16
	T4	0	no data			1	42	42	42	1	19	19	19	0	no data			0	no data		

Table 4-31, cont. Summary of composite tissue data for total PCBs (Aroclor sum) on a lipid-normalized basis

Tissue Type	Area[a]	1992 – 2003				2004				2005				2006				2007			
			Total PCBs (mg/kg lipid)				Total PCBs (mg/kg lipid)				Total PCBs (mg/kg lipid)				Total PCBs (mg/kg lipid)				Total PCBs (mg/kg lipid)		
		n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]
English sole (without skin)	T1 and RM 1.1 – RM 1.4[f]	12	1.5	130	42	0	no data			0	no data			0	no data			0	no data		
	RM 2.1 – RM 2.9	1	no lipids data			0	no data			0	no data			0	no data			0	no data		
	RM 2.9 – RM 3.6	1	no lipids data			0	no data			0	no data			0	no data			0	no data		
	RM 3.6 – RM 4.4	1	no lipids data			0	no data			0	no data			0	no data			0	no data		
Starry flounder (with skin)	T4	0	no data			1	17	17	17	0	no data			0	no data			1	2.8	2.8	2.8
Pile perch (with skin)	T3	0	no data			1	27	27	27	0	no data			0	no data			0	no data		
Striped perch (with skin)	RM 0.0 – RM 0.2	2	no lipids data			0	no data			0	no data			0	no data			0	no data		
	RM 4.0 – RM 4.1	0	no data			1	45	45	45	0	no data			0	no data			0	no data		
Crab, Edible Meat																					
Dungeness crab	T1	2	5.6	11	8.3	3	53 J	100	71	1	10 U	10 U	10 U	0	no data			1	3.4	3.4	3.4
	T2	0	no data			0	no data			0	no data			0	no data			0	no data		
	T3	0	no data			3	45	98	73	1	14 U	14 U	14 U	0	no data			3	6.2	9.6 J	7.8
	T4	0	no data			1	33 J	33 J	33	1	8.6 U	8.6 U	8.6 U	0	no data			0	no data		
Red rock crab	T1	2	no lipids data			0	no data			0	no data			0	no data			0	no data		
Red rock/ Dungeness crab	T1	1	no lipids data			0	no data			0	no data			0	no data			0	no data		
Slender crab	T1	0	no data			3	41	53 J	48	0	no data			0	no data			3	9.2	12 J	10
	T2	0	no data			6	23	78	58	1	20	20	20	0	no data			3	6.0	7.3 J	6.7
	T3	0	no data			3	28	49	37	0	no data			0	no data			0	no data		
	T4	0	no data			0	no data			0	no data			0	no data			0	no data		

Table 4-31, cont. Summary of composite tissue data for total PCBs (Aroclor sum) on a lipid-normalized basis

Tissue Type	Area[a]	1992 – 2003				2004				2005				2006				2007			
			Total PCBs (mg/kg lipid)				Total PCBs (mg/kg lipid)				Total PCBs (mg/kg lipid)				Total PCBs (mg/kg lipid)				Total PCBs (mg/kg lipid)		
		n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]	n	Min	Max	Mean[b]
Crab, Hepatopancreas																					
Dungeness crab	T1	1	13	13	13	1	87	87	87	1	17.4	17.4	17.4	0	no data			1	7.5	7.5	7.5
	T2	0	no data			0	no data			0	no data			0	no data			0	no data		
	T3	0	no data			1	71	71	71	1	30.6	30.6	30.6	0	no data			3	8.7	14.8	11
	T4	0	no data			1	70	70	70	1	23.9	23.9	23.9	0	no data			0	no data		
Slender crab	T1	0	no data			1	78 J	78 J	78	0	no data			0	no data			3	17	40	28
	T2	0	no data			2	61 J	72 J	67	1	27	27	27	0	no data			3	6.4	8.8	7.3
	T3	0	no data			1	75	75	75	0	no data			0	no data			0	no data		
	T4	0	no data			0	no data			0	no data			0	no data			0	no data		
Crab, Whole Body (calc'd)[g]																					
Dungeness crab	T1	2	11 M	13 M	12	3	82 JM	88 M	84	1	17.1 M	17.1 M	17.1	0	no data			1	6.6 M	6.6 M	6.6
	T2	0	no data			0	no data			0	no data			0	no data			0	no data		
	T3	0	no data			3	65 M	76 M	71	1	29 M	29 M	29	0	no data			3	8.3 M	14.0 JM	11
	T4	0	no data			1	66 JM	66 JM	66	1	22.6 M	22.6 M	22.6	0	no data			0	no data		
Slender crab	T1	0	no data			3	64 JM	68 JM	66	0	no data			0	no data			3	15 M	30 JM	22
	T2	0	no data			6	54 JM	73 JM	65	1	25 M	25 M	25	0	no data			3	6.3 M	8.6 JM	7.2
	T3	0	no data			3	61 M	67 M	63	0	no data			0	no data			0	no data		
	T4	0	no data			0	no data			0	no data			0	no data			0	no data		
Invertebrates, Whole Body																					
Amphipods	RM 0.5 – RM 0.7	4	5.3	17	12	0	no data			0	no data			0	no data			0	no data		
Benthic invertebrates	LDW-wide[h]	0	no data			20	6.5 J	400	41	0	no data			0	no data			0	no data		
Shellfish																					
Clams, non-depurated	LDW-wide[h]	0	no data			14	4.0	73 J	21	0	no data			0	no data			6	2.0 J	40	14
Clams, depurated	LDW-wide[h]	0	no data			0	no data			0	no data			0	no data			6	1.7 J	29	11

Table 4-31, cont. Summary of composite tissue data for total PCBs (Aroclor sum) on a lipid-normalized basis

Tissue Type	Area[a]	1992 – 2003				2004				2005				2006				2007			
		n	Total PCBs (mg/kg lipid)			n	Total PCBs (mg/kg lipid)			n	Total PCBs (mg/kg lipid)			n	Total PCBs (mg/kg lipid)			n	Total PCBs (mg/kg lipid)		
			Min	Max	Mean[b]		Min	Max	Mean[b]		Min	Max	Mean[b]		Min	Max	Mean[b]		Min	Max	Mean[b]
Mussels, wild	RM 0.3 – RM 2.8[i]	21	2.0	12	4.5	0	no data			0	no data			0	no data			0	no data		
Mussels, transplanted	RM 0.5 – RM 1.2	30	3.4	22	3.3	0	no data			0	no data			0	no data			0	no data		

[a] Tissue sampling areas are shown on Maps 4-9 and 4-10.

[b] Mean concentration is the average of detected lipid-normalized total PCB concentrations and one-half the lipid-normalized RL for non-detected results. For non-detected results, the RL represents the highest RL for an individual Aroclor in that sample.

[c] Includes nine samples collected between RM 0.5 and RM 0.9 during the RI sampling event in 2003 and six samples collected between RM 0.8 and RM 0.9 during the East Waterway sampling event in 2002 (both locations are within Area T1).

[d] These nine samples were collected between RM 2.6 and RM 2.9 (slightly downstream from Area T3) during the RI sampling event.

[e] Includes calculated "whole-body" samples (three each from Areas T1, T2, and T3 and one from T4). Concentrations in "whole-body" samples were calculated using results from separate analyses of fillet and remainder composite samples (i.e., all remaining tissue and fluids after fillets were removed from the specimens). The calculated English sole "whole-body" concentrations were based on the relative weights of and total PCB concentrations in skin-on fillet and remainder tissues collected in 2005.

[f] A subset of these samples are data from three samples collected between RM 1.1 and RM 1.4 (slightly upstream from Area T1) in 1995 (Battelle 1996; Frontier Geosciences 1996), and nine samples collected between RM 0.5 and RM 1.0 (within Area T1) during the PSAMP and King County WQA studies between 1992 and 1997 (West et al. 2001; King County 1999e).

[g] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Total PCB concentrations in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

[h] The benthic invertebrate and clam samples were collected throughout the LDW (Map 4-10).

[i] All but three of the wild mussel samples were collected between RM 0.3 and 1.2; the remaining three samples were collected at one sampling location at the mouth of Slip 4 near RM 2.8.

J – estimated concentration
LDW – Lower Duwamish Waterway
M – calculated concentration
n – number of samples
PCB – polychlorinated biphenyl
PSAMP – Puget Sound Ambient Monitoring Program
RI – remedial investigation
RL – reporting limit
RM – river mile
U – not detected at RL shown
WQA – water quality assessment

Tissue samples collected in 2004 were analyzed for PCB Aroclors by Columbia Analytical Services, Inc. (CAS); samples collected in 2005, 2006, and 2007 were analyzed by Analytical Resources, Inc. (ARI). The 2004 samples were reported as a mixture of Aroclors 1248, 1254, and 1260 (Table 4-32). In 2005, 2006, and 2007, the samples were reported as a mixture of Aroclors 1254 and 1260 (Aroclor 1248 was not detected), except for one shiner surfperch sample collected in 2005 (from Area T2-E) with a detected concentration of Aroclor 1248. Based on these data, the PCB mixtures in samples collected from 2005 to 2007 appear to have had a higher proportion of the more highly chlorinated PCB congeners than those collected in 2004.

Table 4-32. Aroclor composition of 2004 through 2007 fish tissue samples

Sample Type	Year	n	Mean Percent Composition of Total PCBs (SD)		
			Aroclor 1248	Aroclor 1254	Aroclor 1260
English sole – fillets	2004	7	19.2 (1.41)	40.3 (1.11)	40.5 (0.95)
	2005	10	nd	68.9 (2.19)	31.1 (2.19)
English sole – whole body	2004	21	19.2 (2.95)	41.2 (1.28)	39.6 (3.64)
	2005	21	nd	63.3 (5.52)	36.7 (5.52)
	2006	6	nd	49.1 (2.05)	50.9 (2.05)
	2007	19	nd	59.6 (4.95)	40.4 (4.95)
Shiner surfperch	2004	24	15.0 (6.19)	36.3 (7.93)	48.8 (13.62)
	2005	22	0.29 (1.21)	57.9 (9.65)	42.2 (8.65)
	2006	7	nd	44.2 (4.77)	55.8 (4.77)
	2007	22	nd	43.0 (6.33)	57 (6.33)
Pacific staghorn sculpin	2004	24	13.9 (6.31)	37.4 (2.93)	48.7 (8.86)
	2005	4	nd	54.6 (8.72)	45.4 (8.72)

n – number of composite samples
nd – not detected
PCB – polychlorinated biphenyl
SD – standard deviation

PCB Congener Data

PCB congener data are available for all tissue types except amphipods, mussels, red rock crab, and juvenile chinook salmon. All 209 PCB congeners were analyzed in a subset of all tissue types sampled in 2004, 2005, and 2007 as part of the RI. PCB congener data are also available for three English sole fillet samples from the 1995 Elliott Bay/Duwamish River fish tissue investigation (EVS unpublished). This section evaluates differences in the relative abundances of individual PCB congeners within a tissue type and among years. In addition, a summary of EPA's analysis of the relative abundance of the different PCB homolog groups in LDW sediments and tissues is presented.

The relative abundances of PCB congeners in each tissue type were calculated to determine if patterns were different in different species with different exposure regimes.

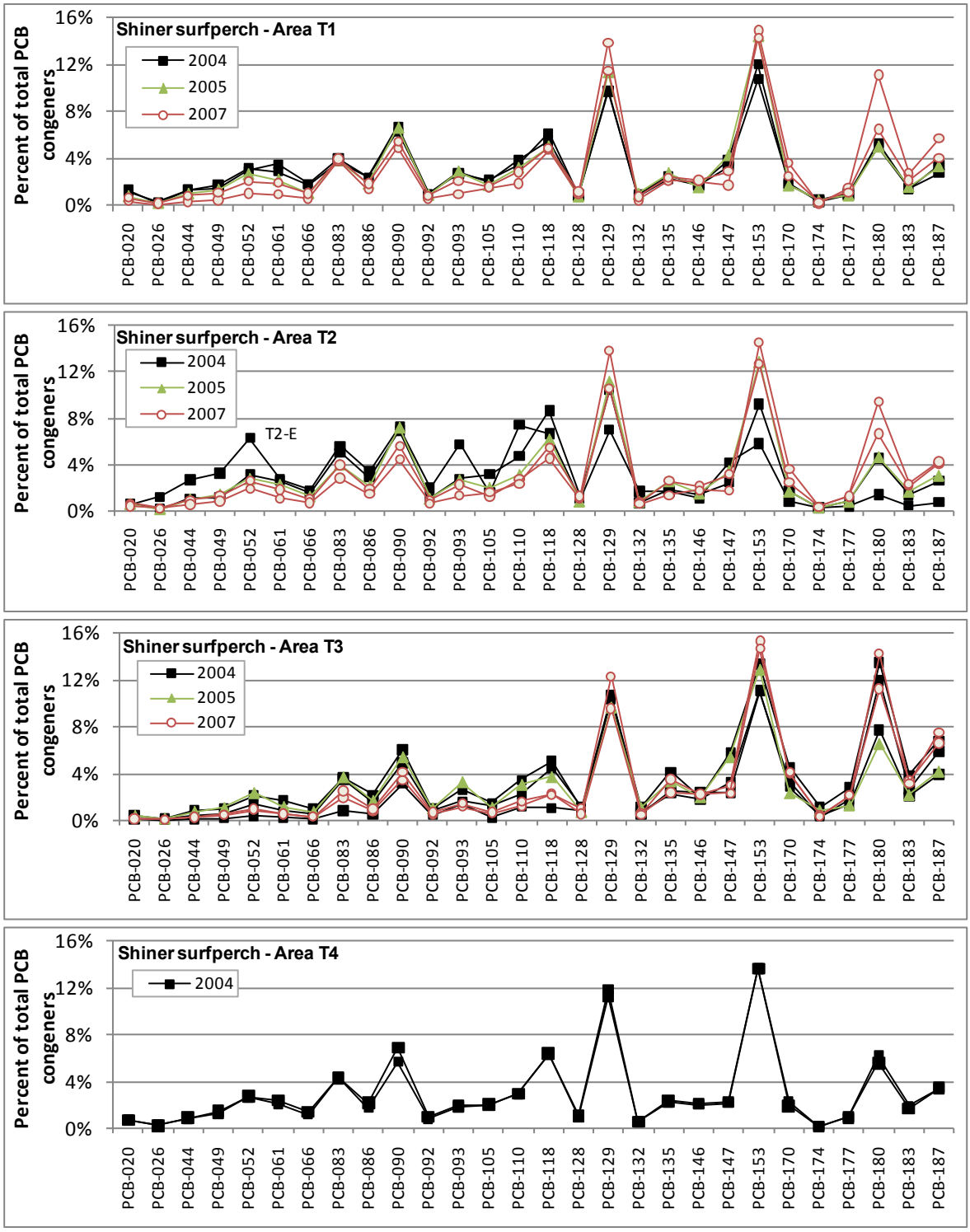
The first step in examining relative abundances of individual PCB congeners within a tissue type and among years (2004, 2005, and 2007) was to condense the list of 209 PCB congeners to a smaller list based on the PCB congeners that contributed most to the total PCB concentration in each sample. These PCB congeners were identified by calculating the percentage of the total PCB concentration represented by each PCB congener.[75]

A PCB congener was selected for inclusion in plots showing relative abundances of individual PCB congeners within a sample if the PCB congener was detected in every sample among all tissue types and if the concentration comprised at least 2% of the total PCB concentration in any single sample. Twenty-eight PCB congeners were identified using these criteria. Patterns in the relative abundances of PCB congeners among species were evaluated based on average relative abundance values for each PCB congener in each tissue type using available data collected in 2004, 2005, and 2007 for fish, benthic invertebrates, clams, and crabs. The sum of the concentrations of these 28 PCB congeners represented 76 to 84% of the total PCB concentrations in tissue samples.

The PCB congener patterns for shiner surfperch from each of the sampling areas were compared for 2004, 2005, and 2007 (Figure 4-5). The shiner surfperch composite samples collected in 2004 had the greatest variability in PCB congener patterns among individual composite samples. Two of the nine 2004 shiner surfperch composite samples (collected from subareas T3-E and T3-F) had higher contributions from the more highly chlorinated PCB congeners (PCB-180, PCB-183, and PCB-187) (Figure 4-5). One shiner surfperch composite sample (collected from subarea T2-E) had higher relative contributions from the less chlorinated PCB congeners (PCB-044, PCB-049, and PCB-052) (Figure 4-5). In general, PCB congener patterns for shiner surfperch composite samples in Areas T1 and T2 tended to contain a greater proportion of more highly chlorinated PCB congeners in 2007 and 2005 compared with 2004. There do not appear to be consistent differences in the PCB congener pattern over time in Area T3. Area T4 was sampled in 2004 only.

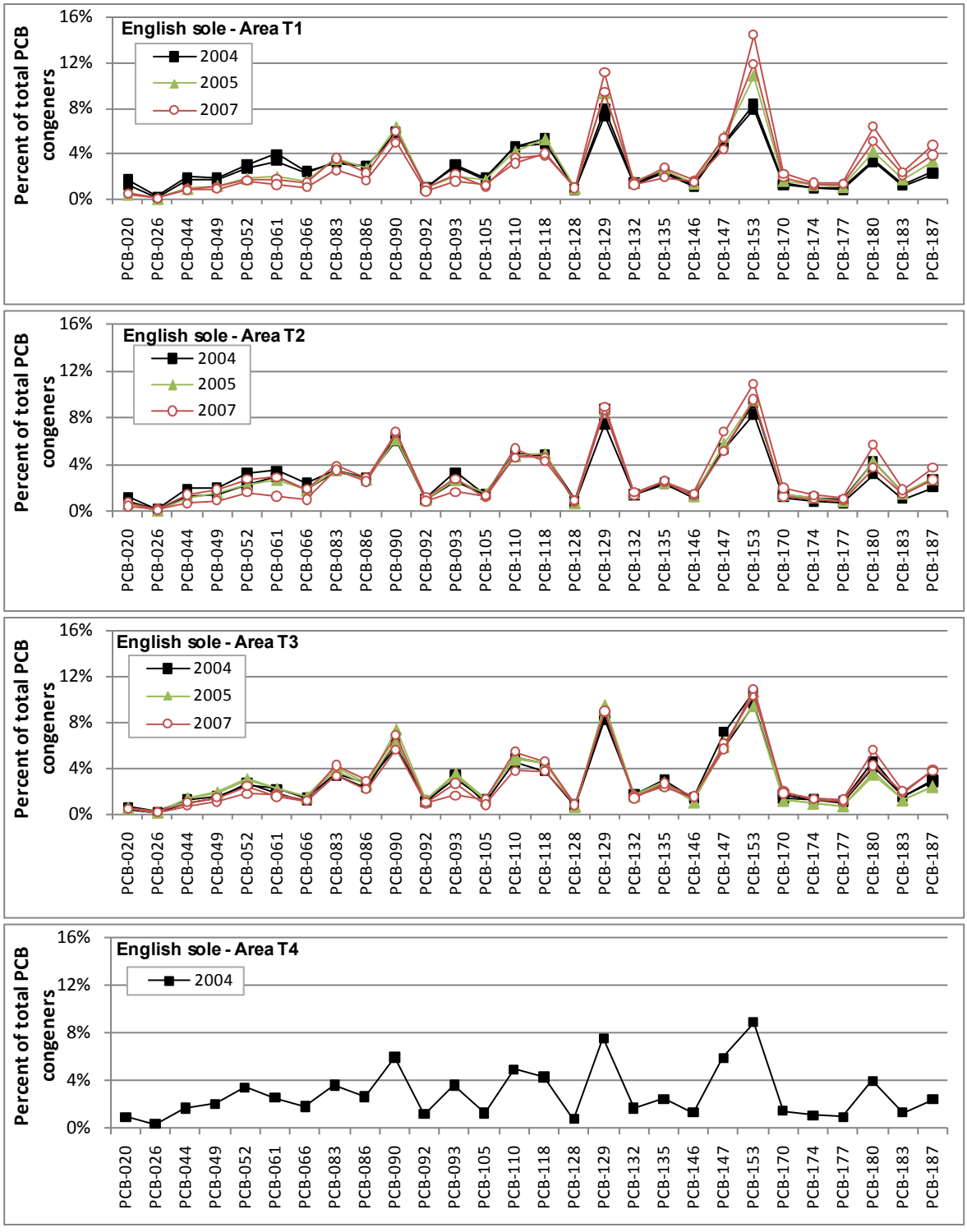
The PCB congener patterns in English sole showed higher contributions from the more highly chlorinated PCB congeners (PCB-153, PCB-180 and PCB-187) in Area T1 in 2005 and 2007 than in 2004 (Figure 4-6). The PCB congener patterns in Areas T2 and T3 were consistent for all three years. The PCB congener patterns for the composite Pacific staghorn sculpin samples (Figure 4-7) were consistent with the PCB congener patterns for English sole in 2004 (Figure 4-6). English sole samples collected from Area T4 were only analyzed for PCB congeners in 2004; Pacific staghorn sculpin were only collected in Area T4 in 2004.

[75] The percentage of total PCB concentrations for each PCB congener within a tissue type was calculated as the mean PCB congener concentration of a particular tissue type divided by the mean total PCB concentration (sum of all PCB congeners) of that tissue type. This analysis was not possible for sediment because sediment samples were not analyzed for all 209 PCB congeners.



Note: Each line represents an individual composite sample.

Figure 4-5. PCB congener patterns in each whole-body composite sample of shiner surfperch collected in 2004, 2005, and 2007 from areas T1, T2, T3, and T4



Note: Each line represents an individual composite sample.

Figure 4-6. PCB congener patterns in each whole-body composite sample of English sole collected in 2004, 2005, and 2007 from Areas T1, T2, T3, and T4

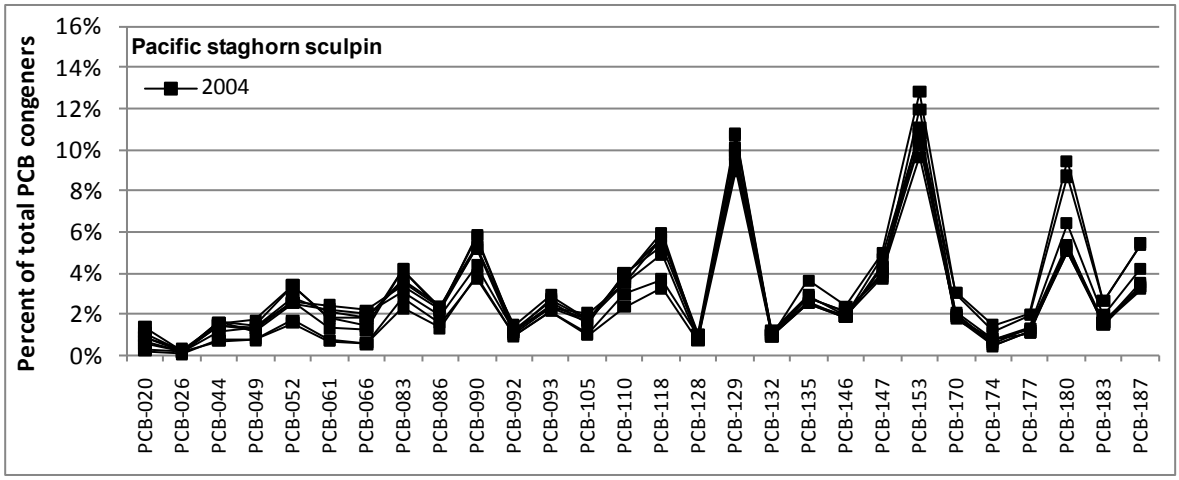
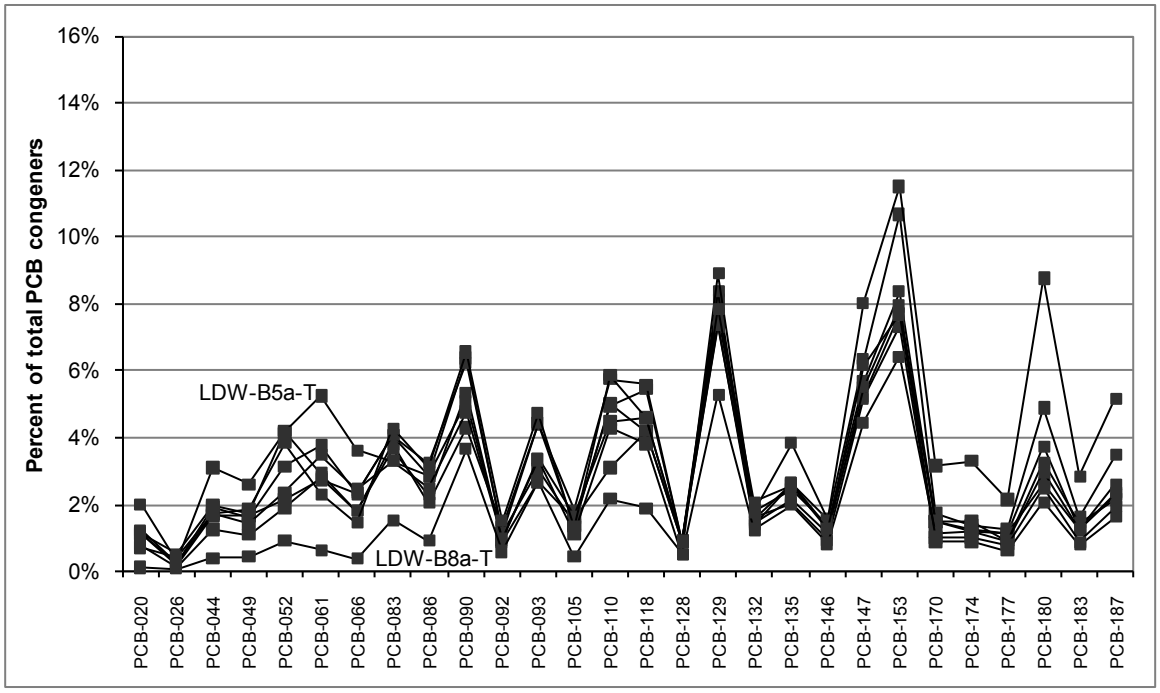


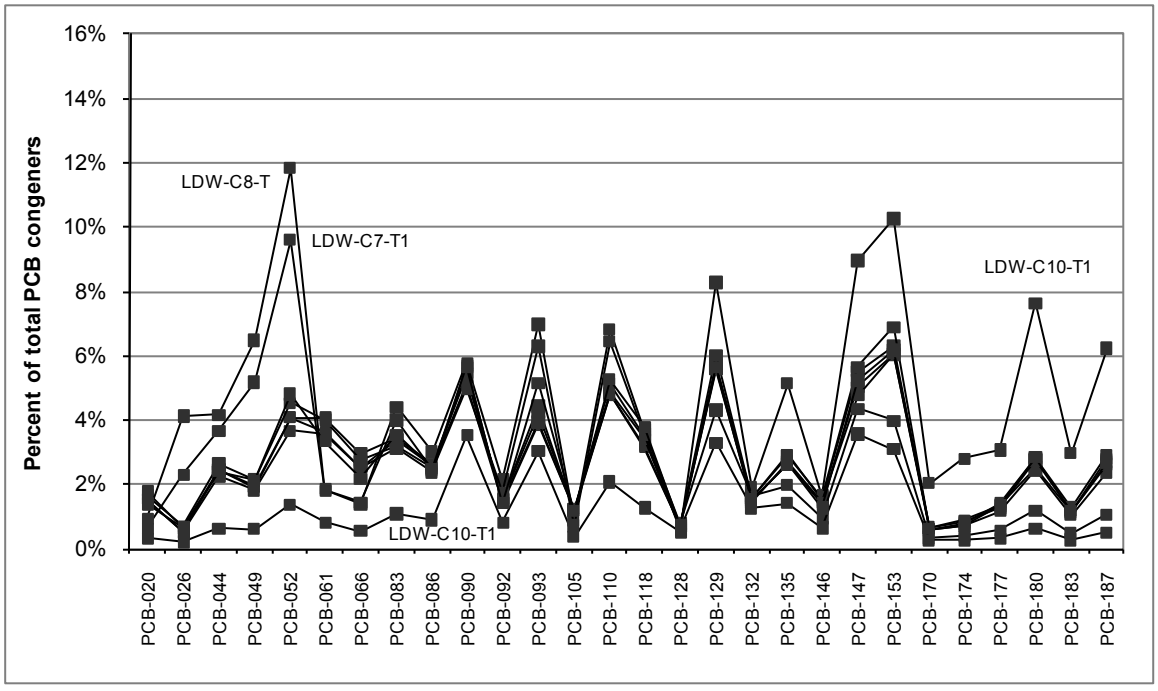
Figure 4-7. PCB congener patterns in each whole-body composite sample of Pacific staghorn sculpin collected in 2004

One benthic invertebrate sample (LDW-B8a from RM 3.5 on the east side of the LDW) had higher relative concentrations of several of the more highly chlorinated PCB congeners (Figure 4-8). Two of the eight clam samples (LDW-C8-T and LDW-C7-T1 from Slip 4) had higher relative concentrations of several less chlorinated PCB congeners, and one clam sample (LDW-C10-T from near RM 3.6 on the west side of the LDW) had relatively high concentrations of more highly chlorinated PCB congeners (Figure 4-9). The influence of the two clam samples from Slip 4 with high contributions of less chlorinated PCB congeners resulted in a mean pattern in clams that differed slightly from the patterns in other tissue types (Figure 4-9). The three clam samples with distinct congener patterns also had the highest total PCB concentrations in clam tissue samples.



Note: Each line represents an individual composite sample.

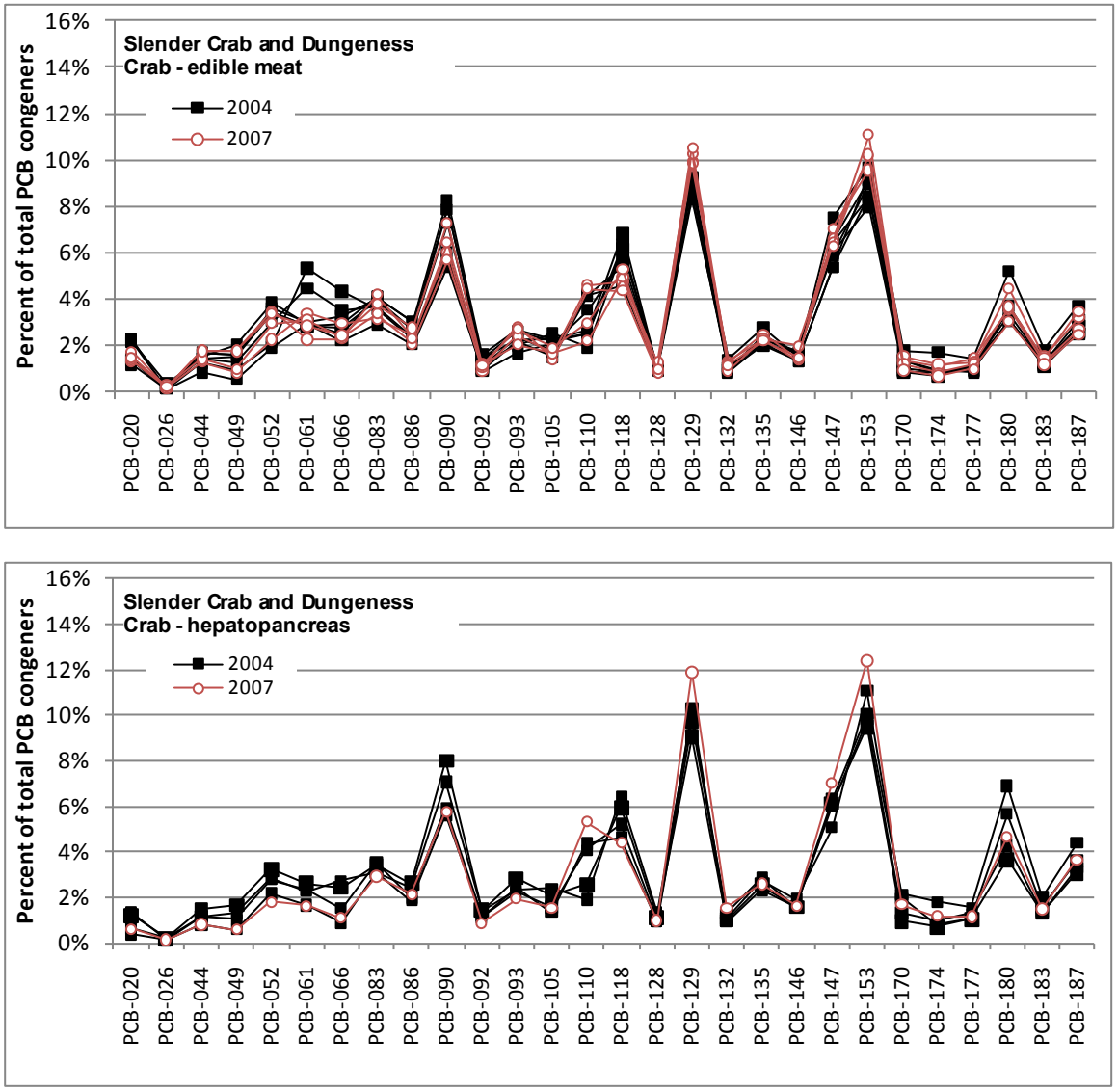
Figure 4-8. PCB congener patterns in each whole-body composite benthic invertebrate sample collected in 2004



Note: Each line represents an individual composite sample.

Figure 4-9. PCB congener patterns in each whole-body composite soft-shell clam sample collected in 2004

The PCB congener patterns for crab edible meat and hepatopancreas samples collected in 2004 and 2007 are presented in Figure 4-10. No discernable differences were observed between the PCB congener patterns in the slender and Dungeness crab samples. The PCB congener pattern in crab tissues collected in 2004 exhibited a slightly higher contribution of the less chlorinated PCB congeners than in 2005, but overall the patterns were similar to one another.



Note: Each line represents an individual composite sample.

Figure 4-10. PCB congener patterns in each edible-meat and hepatopancreas crab composite sample collected in 2004 and 2007

Mean PCB congener patterns in benthic invertebrate, clam, and crab tissue samples are shown relative to one another and to those in fish tissue in Figure 4-11. The mean pattern for whole-body fish samples in 2007 showed a small increase in the contribution from more highly chlorinated PCB congeners relative to the whole-body

fish samples from 2004. In general, the PCB congener pattern for the clams had a greater contribution of the less chlorinated PCB congeners than for the other tissue types, potentially reflecting the greater importance of a water exposure route, variation in the ability of different species to metabolize PCBs, or differences in the particular PCB congener mix to which each of these species is exposed.

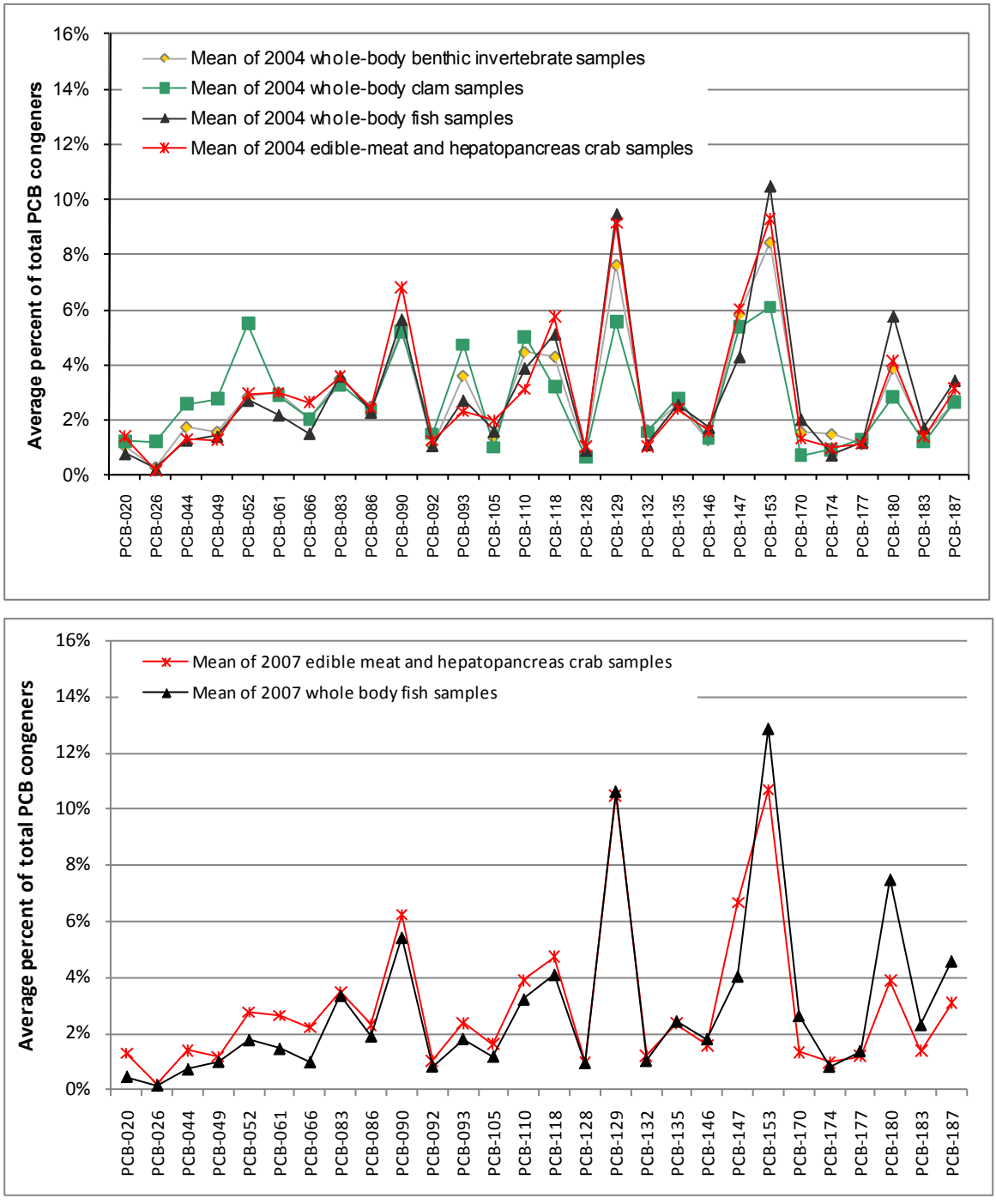


Figure 4-11. Mean PCB congener patterns for benthic invertebrate, clam, fish, and crab samples collected from the LDW in 2004 and 2007

The differences in PCB congener patterns among the shiner surfperch samples collected in 2004 may reflect spatial differences in exposures. This effect is particularly evident in Subareas T2-E, T3-E, and T3-F (Figure 4-4). The three composite samples collected from these subareas in 2004 with distinctly different PCB congener patterns had the three highest total PCB concentrations in fish tissue samples. The variability in the shiner surfperch PCB congener patterns is consistent with the assumption that this species may have a home range smaller than the LDW (Appendix D, Section D.3.2). For English sole, Pacific staghorn sculpin, and crabs, the PCB congener patterns were similar, with no consistent differences among species or collection areas.

PCB Homolog Analysis

EPA conducted an analysis of the relative abundance of the different PCB homolog[76] groups in LDW sediments and tissues based on the 2004 PCB congener data (Kissinger 2006). The homolog concentrations for tissue samples were calculated from the PCB congener concentrations for tissue samples. The homolog concentrations for the sediment samples were calculated from the Aroclor concentrations using the homolog percentages reported for commercial Aroclor mixtures. One sediment PCB homolog pattern was calculated for each of the four fish and crab sampling areas using Thiessen polygons and converting the area-weighted mean Aroclor concentrations into homologs. None of the comparisons have been evaluated statistically because of the small sample size.

The results of this analysis are summarized below.

- English sole, Dungeness crab, and slender crab had similar homolog patterns across the entire site.
- Shiner surfperch and Pacific staghorn sculpin sampled from Area T3 had higher percentages of hexa- and heptachlorobiphenyls than did the shiner surfperch and sculpin collected from Areas T1, T2, and T4.
- Sediment PCB homolog patterns were similar for Areas T1 and T2; tetra-, penta- and hexachlorobiphenyls were the dominant homologs. The homolog pattern for Area T3 was dominated by penta-, hexa-, and heptachlorobiphenyls. The homolog pattern for Area T4 was dominated by tetra- and pentachlorobiphenyls, with substantial contributions from the tri- and hexachlorobiphenyls.

[76] Homologs are PCB congeners that have the same number of chlorine atoms. These compounds have the same molecular weight and similar physical and chemical properties. The homolog groups are named based on the number of chlorine atoms (e.g., trichlorobiphenyls have three chlorine atoms; hexachlorobiphenyls have six chlorine atoms). The PCB congeners with fewer chlorine atoms have lower molecular weights and tend to be more volatile and more soluble in water.

- The homolog patterns for shiner surfperch and Pacific staghorn sculpin collected in Area T3 were consistent with the homolog pattern calculated for the sediment in this area.

Comparison of Total PCB Aroclor Sums and Total PCB Congener Sums

The sum of the individual PCB congener concentrations in fish and crab tissue samples (Table 4-33) were compared with the sum of the PCB Aroclor concentrations analyzed in the same samples. The sum of PCB congener concentrations is generally believed to provide the most accurate estimate of the total PCB concentration in the samples. Both methods have analytical variability, although Aroclors tend to have greater variability because of uncertainties associated with the identification and quantification of a chemical pattern compared with the identification and quantification of individual PCB congeners. The sums of the PCB congener concentrations in samples collected in 2004 were less than the sums of the Aroclor concentrations (Figure 4-12). In 2005, the PCB congener sums and the Aroclor sums were similar in the three shiner surfperch samples, while the Aroclor sums were less than the PCB congener sums in the three English sole whole-body samples. In 2007, the PCB congener sums were consistently greater than the Aroclor sums. The 2004 samples were analyzed for PCB Aroclors by CAS, and the 2005 and 2007 samples were analyzed for PCB Aroclors by ARI. The change in laboratory may have contributed to the noted differences among years; however, ARI analyzed a subset of the 2004 samples, and the detected PCB Aroclors and sums of PCB Aroclor concentrations were consistent with the CAS results. Overall, the Aroclor sums represented between 30% and 189% of the PCB congener sums for the combined dataset. This range is generally consistent the range of analytical accuracy for the Aroclor analysis (38 to 150%), as specified in the QAPPs (Windward 2004f, 2005g, 2007d).

Table 4-33. Total PCB concentrations (sum of PCB congeners) in composite tissue samples collected from the LDW

Tissue Type	Area[a]	2004				2005				2007			
		n	Total PCBs (µg/kg ww)			n	Total PCBs (µg/kg ww)			n	Total PCBs (µg/kg ww)		
			Min	Max	Mean[b]		Min	Max	Mean[b]		Min	Max	Mean[b]
Fish, Whole Body													
English sole	T1	2	1,614 J	2,481 J	2,048	1	2,589 J	2,589 J	2,589	2	774 J	1,165 J	970
	T2	2	2,126 J	2,712 J	2,419	1	3,214 J	3,214 J	3,214	2	1,603 J	1,632 J	1,618
	T3	2	1,419 J	2,457 J	1,938	1	1,433 J	1,433 J	1,433	2	1,032 J	2,928 J	1,980
	T4	1	1,361 J	1,361 J	1,361	0	no data			0	no data		
Shiner surfperch	T1	2	700.1 J	876.6 J	788.4	1	683.1 J	683.1 J	683.1	2	504.1 J	974 J	739
	T2	2	1,055 J	12,228 J	6,642	1	1,047 J	1,047 J	1,047	2	401.6 J	648.3 J	525.0
	T3	3	1,009 J	8,010 J	4,180	1	2,048 J	2,048 J	2,048	2	1,103 J	2,462 J	1,783
	T4	2	532.4 J	770 J	651	0	no data			0	no data		

Tissue Type	Area[a]	2004				2005				2007			
		n	Total PCBs (µg/kg ww)			n	Total PCBs (µg/kg ww)			n	Total PCBs (µg/kg ww)		
			Min	Max	Mean[b]		Min	Max	Mean[b]		Min	Max	Mean[b]
Pacific staghorn sculpin	T1	2	532.4 J	668.4 J	600.4	0	no data			0	no data		
	T2	2	481.6 J	496.3 J	489.0								
	T3	2	1,048 J	1,907 J	1,478								
	T4	2	349.6 J	504.9 J	427.3								
Starry flounder	T4	1	458 J	458 J	458	0	no data			0	no data		
Fish, Fillet													
English sole (with skin)	T1	2	857.5 J	1,119.2 J	988.4	0	no data			0	no data		
	T2	2	1,264.6 J	1,269 J	1,266.8								
	T3	2	641.1 J	1,022.9 J	832								
	T4	1	510 J	510 J	510								
Starry flounder (with skin)	T4	1	295.2 J	295.2 J	295.2	0	no data			0	no data		
Pile perch (with skin)	T3	1	192.2 J	192.2 J	192.2	0	no data			0	no data		
Striped perch (with skin)	RM 4.0 – RM 4.1	1	442.3 J	442.3 J	442.3	0	no data			0	no data		
Crab, Edible Meat													
Dungeness crab	T1	1	111 J	111 J	111	0	no data			1	49.45 J	49.45 J	49.45
	T3	1	149.3 J	149.3 J	149.3					1	86.2 J	86.2 J	86.2
	T4	1	148.7 J	148.7 J	148.7					0	no data		
Slender crab	T1	2	174.7 J	186.5 J	180.6	0	no data			1	112 J	112 J	112
	T2	2	129.7 J	180.6 J	155.2					1	86.2 J	86.2 J	86.2
	T3	1	134.3 J	134.3 J	134.3					0	no data		
Crab, Hepatopancreas													
Dungeness crab	T1	0	no data			0	no data			1	612.1 J	612.1 J	612.1 J
	T3	1	3,622 J	3,622 J	3,622					0	no data		
	T4	1	3,618 J	3,618 J	3,618								
Slender crab	T1	1	790.1 J	790.1 J	790.1	0	no data			0	no data		
	T2	1	1,047 J	1,047 J	1,047								
Crab, Whole Body (calc'd)[c]													
Dungeness crab	T1	0	no data			0	no data			1	223.9 JM	223.9 JM	223.9
	T3	1	1,226 JM	1,226 JM	1,226					0	no data		
	T4	1	1,224 JM	1,224 JM	1,224								
Slender crab	T1	2	365.5 JM	373.6 JM	369.6	0	no data			0	no data		
	T2	2	414.06 JM	449.18 JM	431.62								

Tissue Type	Area[a]	2004				2005				2007			
		n	Total PCBs (µg/kg ww)			n	Total PCBs (µg/kg ww)			n	Total PCBs (µg/kg ww)		
			Min	Max	Mean[b]		Min	Max	Mean[b]		Min	Max	Mean[b]
Invertebrates, Whole Body													
Benthic Invertebrates	LDW-wide[d]	8	32.13	1,346	393.5	0	no data			0	no data		
Shellfish													
Clams, non-depurated	LDW-wide[e]	8	41.05 J	930 J	222	0	no data			0	no data		

[a] Tissue sampling areas are shown on Maps 4-9 and 4-10.

[b] Mean concentration is the average of detected concentrations. There were no undetected results for total PCBs (as sum of PCB congeners).

[c] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Total PCB concentrations in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

[d] Benthic invertebrate and clam samples were collected throughout the LDW (Map 4-10).

J – estimated concentration
JM – calculated from an estimated concentration
LDW – Lower Duwamish Waterway
M – calculated concentration
n – number of samples
PCB – polychlorinated biphenyl
RM – river mile
ww – wet weight

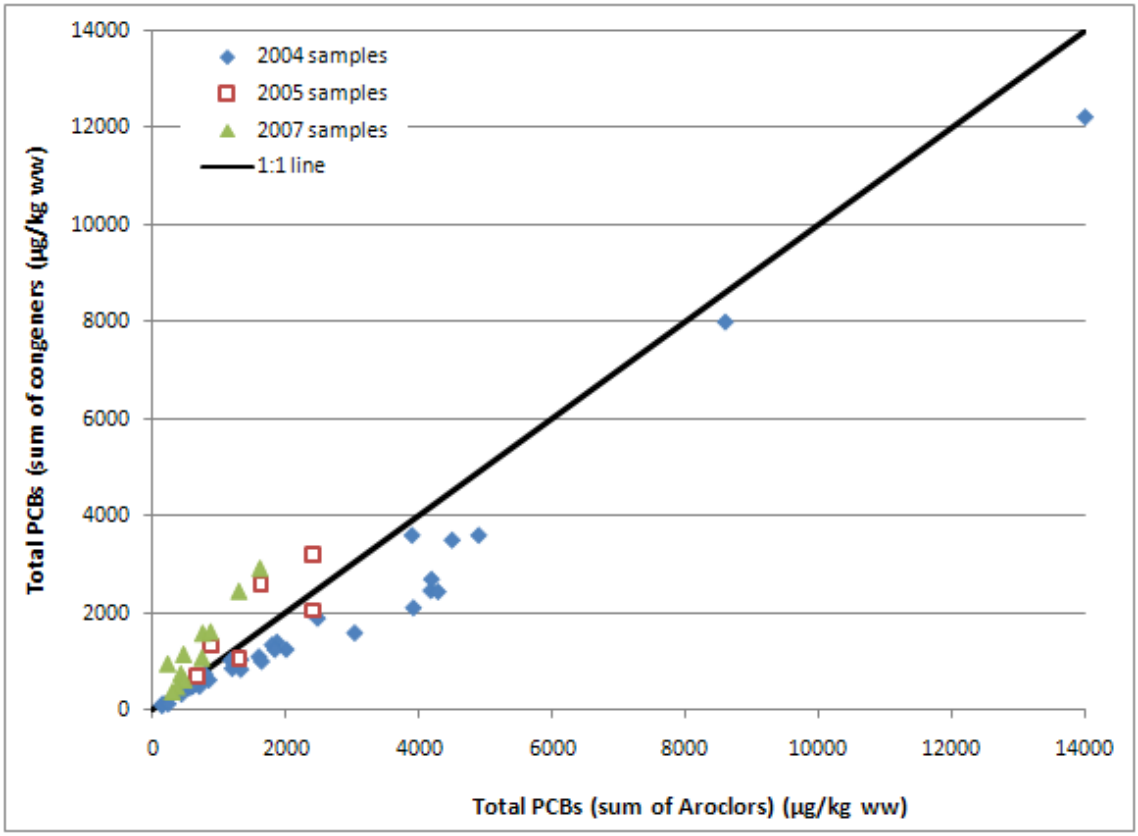


Figure 4-12. Total PCB concentration (sum of PCB congeners) compared with total PCB concentrations (sum of Aroclors) in fish and crab tissue samples

Dioxin Toxic Equivalent Potency

The dioxin toxic equivalent potency of a mixture of dioxin-like PCB congeners can be represented by the ratio of TEQ to total PCBs (sum of PCB congeners) in a sample. The relationship between the TEQ and the total PCB concentration is of interest from a toxicity perspective. Mean potencies calculated for each tissue type collected in 2004, 2005, and 2007 were generally similar to each other (Table 4-34 and Figure 4-13). The consistency of the calculated potencies suggests that the contribution of dioxin-like PCB congeners to the total PCB concentration is relatively consistent over time despite the small shifts in the PCB composition patterns.

Table 4-34. Dioxin toxic equivalent potency in various tissue types collected in 2004, 2005, and 2007

Tissue Type	2004 Samples		2005 Samples		2007 Samples	
	n	Potency Range (mean) (µg TEQ/g PCBs)	n	Potency Range (mean) (µg TEQ/g PCBs)	n	Potency Range (mean) (µg TEQ/g PCBs)
English sole – whole body	7	5.6 – 11.3 (8.9)	3	7.2 – 9.1 (8.2)	6	8.5-9.2 (8.3)
English sole – fillet	7	7.8 – 11.5 (9.8)	0	na	0	na
Pacific staghorn sculpin – whole body	8	5.3 – 13.2 (10.2)	0	na	0	na
Shiner surfperch – whole body	9	4.5 – 17.9 (11.8)	3	7.0 – 12.8 (10.8)	6	5.0-15 (10.9)
Dungeness crab – edible meat	3	9.2 – 12.6 (11.0)	0	na	2	8.8-11 (11.0)
Dungeness crab – hepatopancreas	2	7.5 – 9.3 (8.4)	0	na	1	14

n – number of samples
na – not available
PCB – polychlorinated biphenyl
TEQ – toxic equivalent

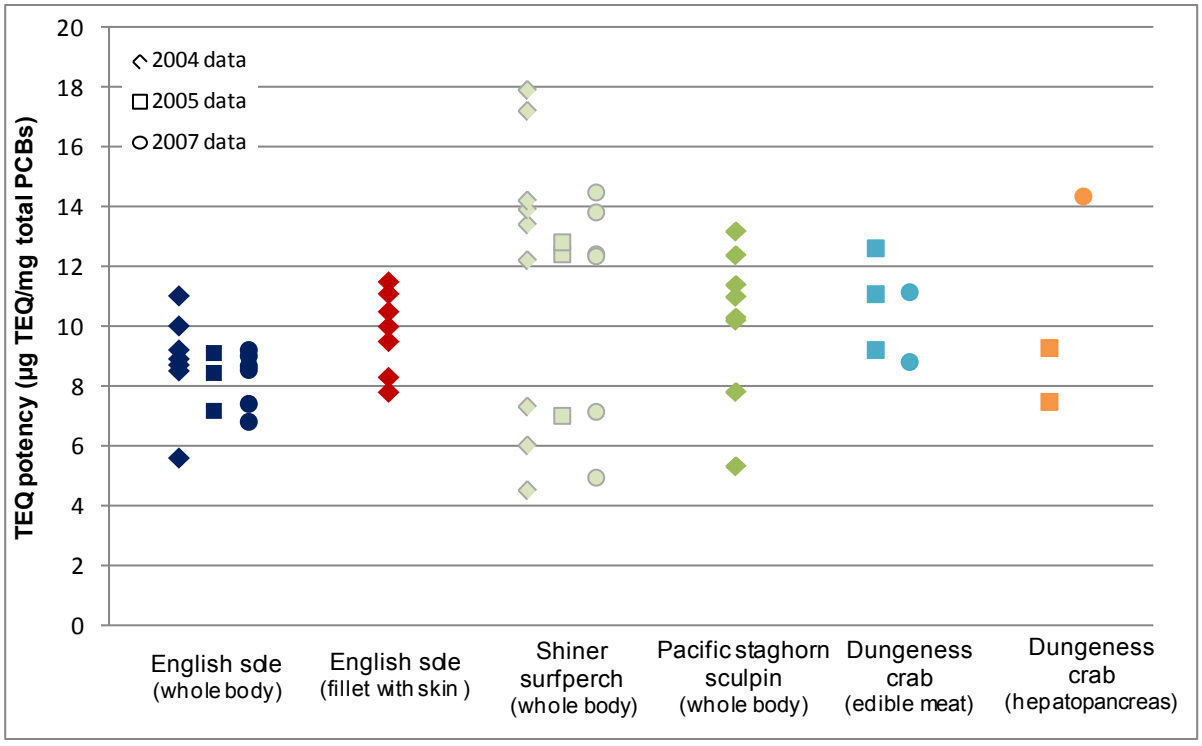


Figure 4-13. Calculated dioxin toxic equivalent potencies for various tissue types

Individual composite samples with the lowest potencies were those with the highest total PCB concentrations. For example, the two shiner surfperch composite samples with the highest total PCB concentrations (sum of PCB congeners) (12,230 and 8,010 µg/kg ww) had the lowest potencies (6.0 and 4.5 µg TEQ/g total PCBs, respectively) because the concentrations of dioxin-like PCB congeners relative to the overall total PCB concentration were relatively low in the mixture. PCB TEQs for the various tissue types are summarized in Table 4-35.

Table 4-35. PCB TEQs in composite tissue samples collected from the LDW

Tissue Type	Area[a]	2004				2005				2007			
		n	TEQ (µg/kg ww) Min	Max	Mean[b]	n	TEQ (µg/kg ww) Min	Max	Mean[b]	n	TEQ (µg/kg ww) Min	Max	Mean[b]
Fish, Whole Body													
English sole	T1	2	18.2	24.7	21.5	1	23.6	23.6	23.6	2	5.74	10.1	7.92
	T2	2	18.0	23.5	20.8	1	27.1 J	27.1 J	27.1	2	14.5	15.0	14.8
	T3	2	13.0 J	13.7 J	13.4	1	10.3	10.3	10.3	2	7.00	25.0 J	16.0
	T4	1	12.1	12.1	12.1	0	no data			0	no data		
Shiner surfperch	T1	2	9.41 J	15.7	12.6	1	8.49	8.49	8.49	2	7.29	12.1	9.70
	T2	2	18.2	73.0 J	45.6	1	13.4	13.4	13.4	2	5.54 J	8.00	6.77
	T3	3	12.3	36.1	24.7	1	14.4	14.4	14.4	2	7.87	12.2	10.0
	T4	2	7.55 J	10.7 J	9.13	0	no data			0	no data		

Tissue Type	Area[a]	2004				2005				2007			
		n	TEQ (µg/kg ww) Min	Max	Mean[b]	n	TEQ (µg/kg ww) Min	Max	Mean[b]	n	TEQ (µg/kg ww) Min	Max	Mean[b]
Pacific staghorn sculpin	T1	2	6.05 J	7.38 J	6.72	0	no data			0	no data		
	T2	2	6.00 J	6.56	6.28								
	T3	2	8.19	10.2	9.20								
	T4	2	3.58 J	5.18 J	4.38								
Starry flounder	T4	1	4.14 J	4.14 J	4.14	0	no data			0	no data		
Fish, Fillet													
English sole (with skin)	T1	2	9.03	12.9	11.0	0	no data			0	no data		
	T2	2	12.7	14.1	13.4								
	T3	2	5.00 J	9.68	7.34								
	T4	1	4.23 J	4.23	4.23								
Starry flounder (with skin)	T4	1	2.9 J	2.9 J	2.9	0	no data			0	no data		
Pile perch (with skin)	T3	1	2.8 J	2.8 J	2.8	0	no data			0	no data		
Striped perch (with skin)	RM 4.0 – RM 4.1	1	6.8 J	6.8 J	6.8	0	no data			0	no data		
Crab, Edible Meat													
Dungeness crab	T1	1	1.4 J	1.4 J	1.4	0	no data			1	0.553	0.553	0.553
	T3	1	1.65	1.65	1.65					1	0.761	0.761	0.761
	T4	1	1.37	1.37	1.37					0	no data		
Slender crab	T1	2	2.52	2.93	2.73	0	no data			1	1.40	1.40	1.40
	T2	2	1.74 J	2.65 J	2.20					1	1.17	1.17	1.17
	T3	1	1.73 J	1.73 J	1.73					0	no data		
Crab, Hepatopancreas													
Dungeness crab	T1	0	no data			0	no data			1	8.80	8.80	8.80
	T3	1	33.6	33.6	33.6					0	no data		
	T4	1	27.1	27.1	27.1								
Slender crab	T1	1	17.1	17.1	17.1	0	no data			0	no data		
	T2	1	12.7	12.7	12.7								
Crab, Whole Body (calc'd)[c]													
Dungeness crab	T1	0	no data			0	no data			1	3.11 M	3.11 M	3.11 M
	T3	1	11.6 M	11.6 M	11.6					0	no data		
	T4	1	9.35 M	9.35 M	9.35								
Slender crab	T1	2	7.04 M	7.32 M	7.18	0	no data			0	no data		
	T2	2	5.13 JM	5.76 JM	5.45								
Invertebrates, Whole Body													
Benthic Invertebrates	LDW-wide[d]	8	0.376 J	8.62 J	3.72	0	no data			0	no data		

Tissue Type	Area[a]	2004				2005				2007			
		n	TEQ (µg/kg ww)			n	TEQ (µg/kg ww)			n	TEQ (µg/kg ww)		
			Min	Max	Mean[b]		Min	Max	Mean[b]		Min	Max	Mean[b]
Shellfish													
Clams, non-depurated	LDW-wide[d]	8	0.440 J	5.65 J	1.48	0	no data			0	no data		

[a] Tissue sampling areas are shown on Maps 4-9 and 4-10.

[b] Mean concentration is the average of detected concentrations. There were no nondetected results for TEQs.

[c] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. TEQs in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

[d] Benthic invertebrate and clam samples were collected throughout the LDW (Map 4-10).

J – estimated concentration
JM – calculated from an estimated concentration
M – calculated concentration
n – number of samples
PCB – polychlorinated biphenyl
RM – river mile
TEQ – toxic equivalent
ww – wet weight

TEQs can be estimated from Aroclor concentrations using the calculated potencies of industrial Aroclor mixtures (Rushneck et al. 2004). Figure 4-14 shows the relationship between TEQs calculated using PCB congener concentrations and TEQs estimated from Aroclor concentrations for the same samples. In 2004, the Aroclor-estimated TEQs were similar to the TEQs calculated from the dioxin-like PCB congener concentrations. In 2005 and 2007, the Aroclor-estimated TEQs were less than the PCB congener-based TEQs. The difference may be a result of the fact that Aroclor 1248 was detected in 2004 and not detected in 2005 and 2007. It should be noted that the TEQs used in both the human health and ecological risk assessments were based on PCB congener concentrations. Aroclor-based TEQs were calculated at the request of EPA for the purposes of this comparison.

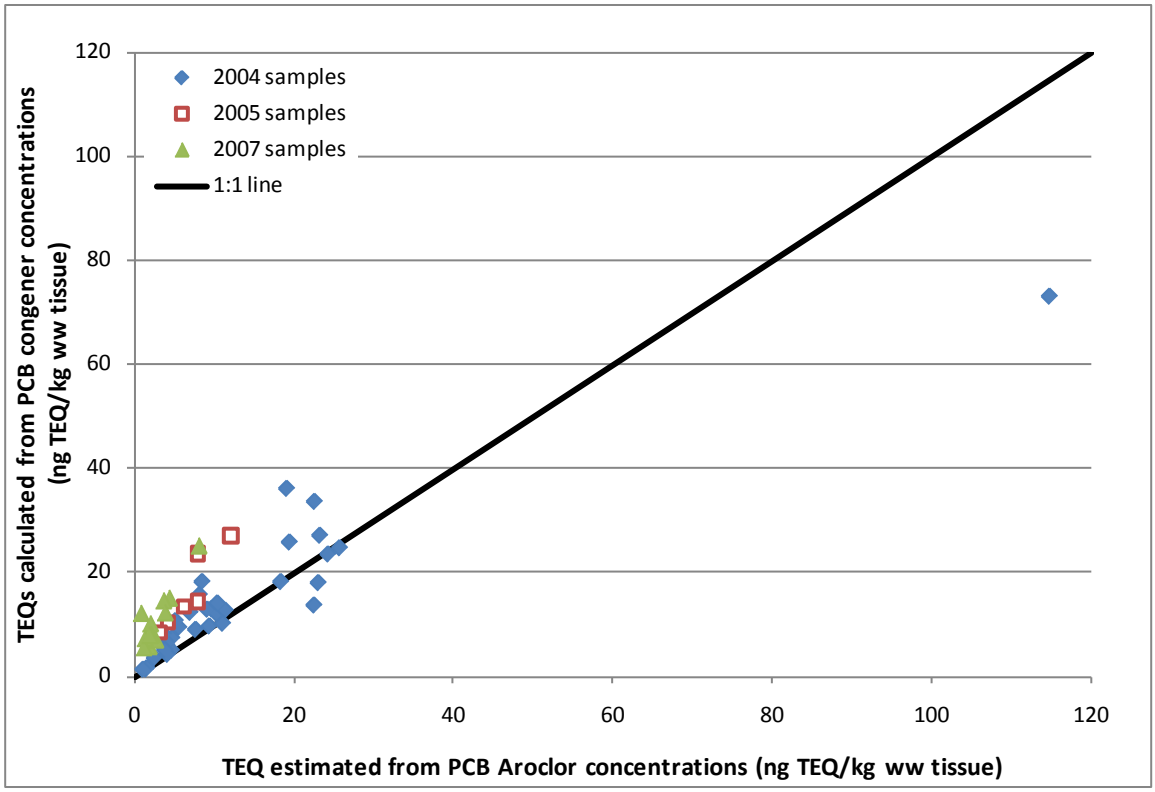


Figure 4-14. TEQs calculated from congener concentrations compared with TEQs estimated from Aroclor concentrations

Temporal Data

Most of the LDW tissue data were collected in 2004, 2005, and 2007 (Table 4-29). The 2004 and 2005 data were collected primarily to support the baseline risk assessments. The 2007 data were collected primarily to provide additional data to assess potential temporal trends. Area T1 was also sampled in 2006 by King County to assist in evaluating trends in T1 where the Duwamish/Diagonal remedial action occurred. Wet-weight and lipid-normalized tissue chemistry data for all of the species in each of the tissue sampling areas and in all sampling areas combined are presented in Appendix E, Section E.4.

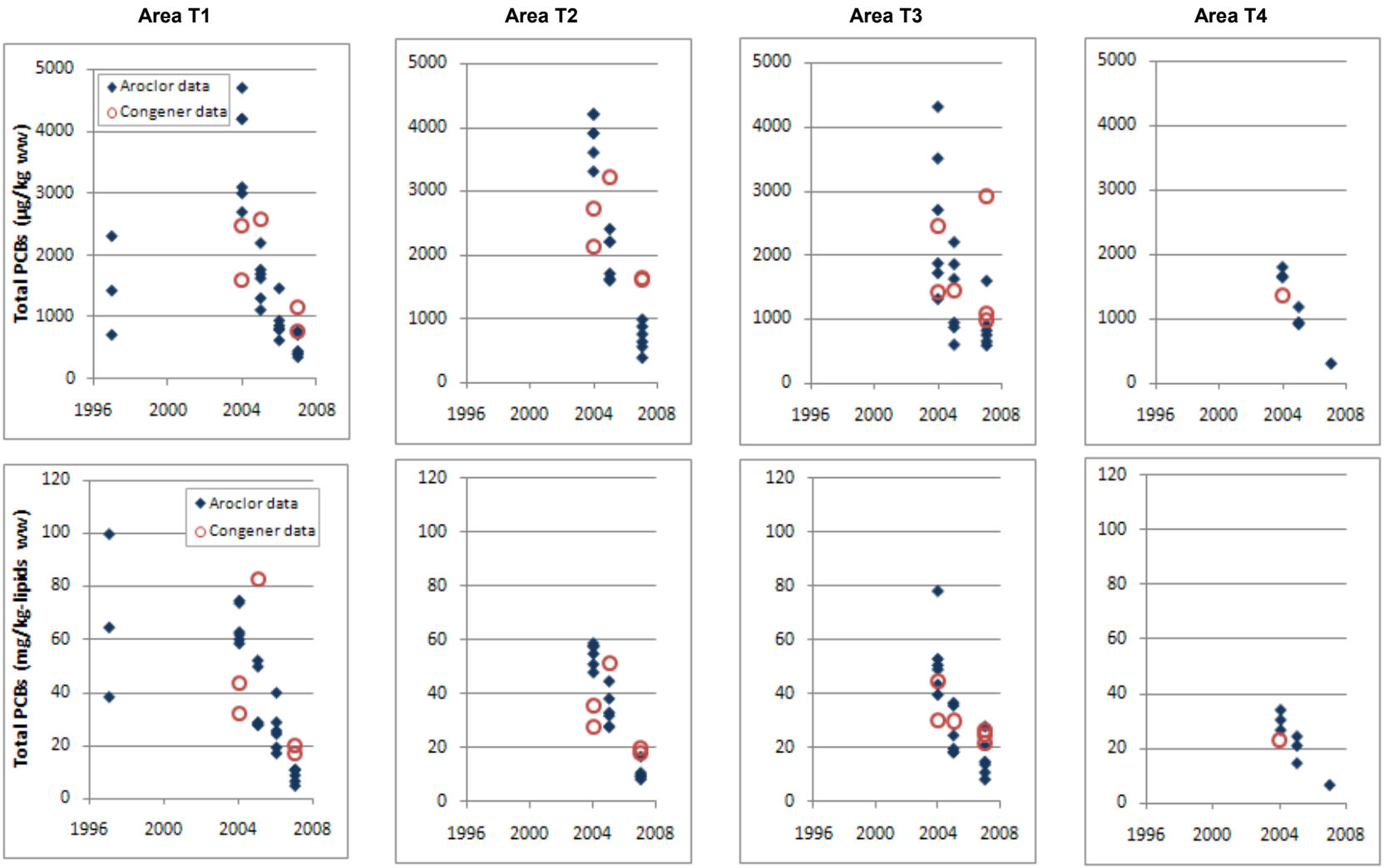
Wet-Weight Data

The highest total PCB concentrations based on Aroclor sums were reported in 2004 for English sole, shiner surfperch, and Dungeness crabs, with decreasing concentrations reported in subsequent years. At the six intertidal locations sampled for clams in both 2004 and 2007, total PCB concentrations in clam tissue were higher at each location in 2004 than in 2007 (Map 4-28). The PCB congener dataset was much smaller than the Aroclor tissue dataset; therefore, temporal trends based on these data are more uncertain.

In general, the total PCB concentrations based on PCB congener sums also appeared to decrease in English sole tissue in Area T1 and to some degree in Area T2; the data for Area T3 were less clear (Figure 4-15). The total PCB concentrations (PCB congener sums) in shiner surfperch tissue did not indicate a downward or upward trend in any of the areas, with the possible exception of a potential downward trend in Area T2 (Figure 4-16). Even fewer PCB congener data are available for crab tissues. However, every total PCB concentration (PCB congener sums) in 2007 was less than the corresponding concentration in 2004 (corresponding data are available for Dungeness and slender crab edible meat; Figure 4-17 and Table 4-33), potentially supporting the downward trend based on the Aroclor data.

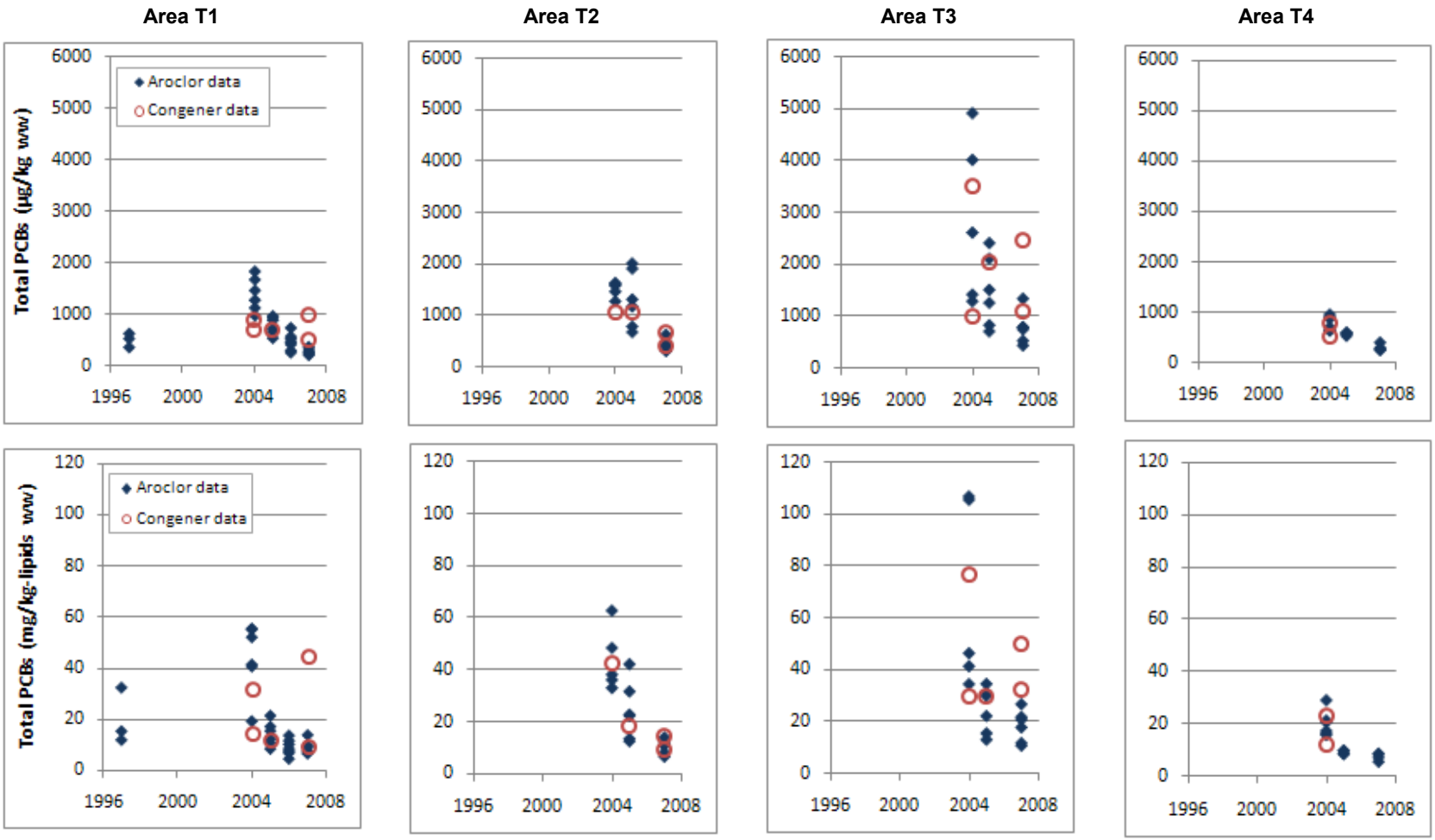
There are several uncertainties associated with these trends. The trends based on the PCB congener data are highly uncertain because of the small sample size of the dataset (i.e., the higher the variability, the more uncertain the interpretation of the small dataset). Regarding the Aroclor data, PCB Aroclors were analyzed by CAS in 2004 and by ARI in 2005, 2006, and 2007. In addition, the PCB congener pattern changed over time (2004 vs. 2005, 2006, and 2007), which may have affected the quantification of Aroclors.

The Aroclor wet-weight tissue data as a whole suggest total PCB concentrations in 2004 were higher than those in more recent years; total PCB concentrations appear to be decreasing based on Aroclor data. Trends based on the limited PCB congener data are more uncertain. The PCB congener data may suggest total PCB concentrations in English sole collected from Area T1 and possibly from Area T2 are decreasing, although the sample size is small. Total PCB concentrations (congener sums) in crabs collected from Areas T1 and T3 were also consistently lower in 2007 than 2004. The PCB congener data suggest temporal trends in total PCB concentrations in shiner surfperch are uncertain.



Note: English sole whole-body samples from 1997 consisted of tissue remaining after subsamples of fillets were removed. In addition, livers were removed from some fish in these composite samples. These data are not included in the RI dataset because of these uncertainties, but are shown here for informational purposes.

Figure 4-15. Temporal comparison of total PCB concentrations based on the sum of Aroclors and the sum of individual PCB congeners in English sole whole-body tissue by tissue sampling area



Note: The maximum concentrations in Areas T2 and T3 (both from 2004) are not shown. In Area T2, the maximum concentration was 18,400 µg/kg dw (329 mg/kg lipids) (Aroclor sum) or 12,228 µg/kg (218 mg/kg lipids) (congener sum). In Area T3, the maximum concentration was 8,800 µg/kg dw (284 mg/kg lipids) (Aroclor sum) or 8,010 µg/kg (258 mg/kg lipids) (congener sum).

Figure 4-16. Temporal comparison of total PCB concentrations based on the sum of Aroclors and the sum of individual PCB congeners in shiner surfperch whole-body tissue by tissue sampling area

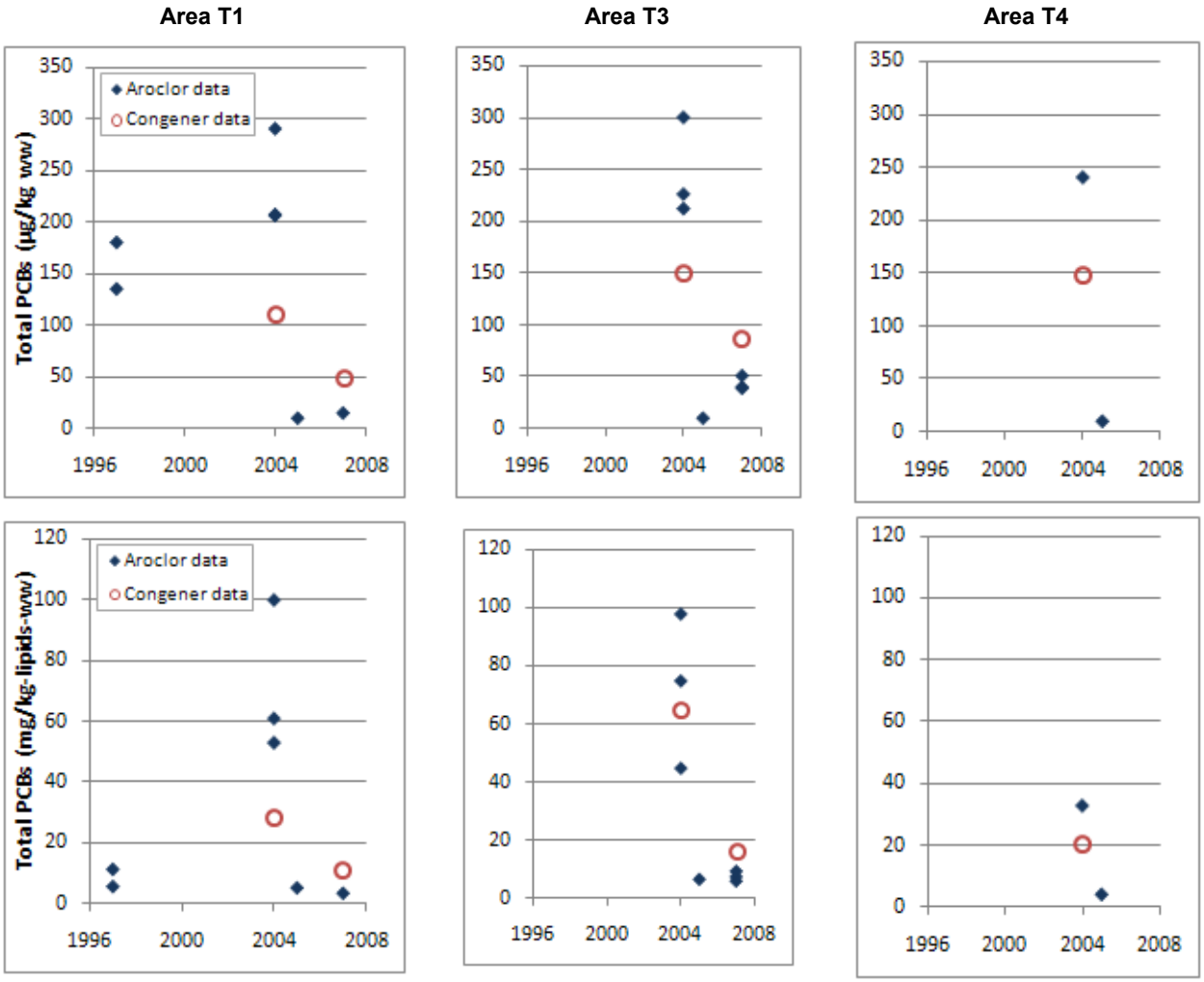


Figure 4-17. Temporal comparison of total PCB concentrations based on the sum of Aroclors and the sum of individual PCB congeners in Dungeness crab edible meat tissue by tissue sampling area (no Dungeness crabs were collected in Area T2)

Lipid-Normalized Data

The highest lipid-normalized total PCB concentrations based on Aroclor sums were reported in 1997 and 2004 for English sole (Figure 4-15) and in 2004 for shiner surfperch (Figure 4-16) and Dungeness crabs (Figure 4-17), with decreasing concentrations reported in subsequent years. Thus, similar to the wet-weight data, the lipid-normalized Aroclor data suggest that total PCB concentrations are decreasing over time.

As discussed above for wet-weight data, the PCB congener dataset was much smaller than the Aroclor tissue dataset; therefore, temporal trends based on these data are more uncertain. PCB congener data are available in Area T4 only for 2004 and are not available for crabs in any year in Area T2. Based on the small dataset, there are potential downward trends in lipid-normalized total PCB concentrations in Area T3 for English sole, Area T2 for shiner surfperch, and Areas T1 and T3 for Dungeness crab (Figures 4-15, 4-16, and 4-17, respectively).

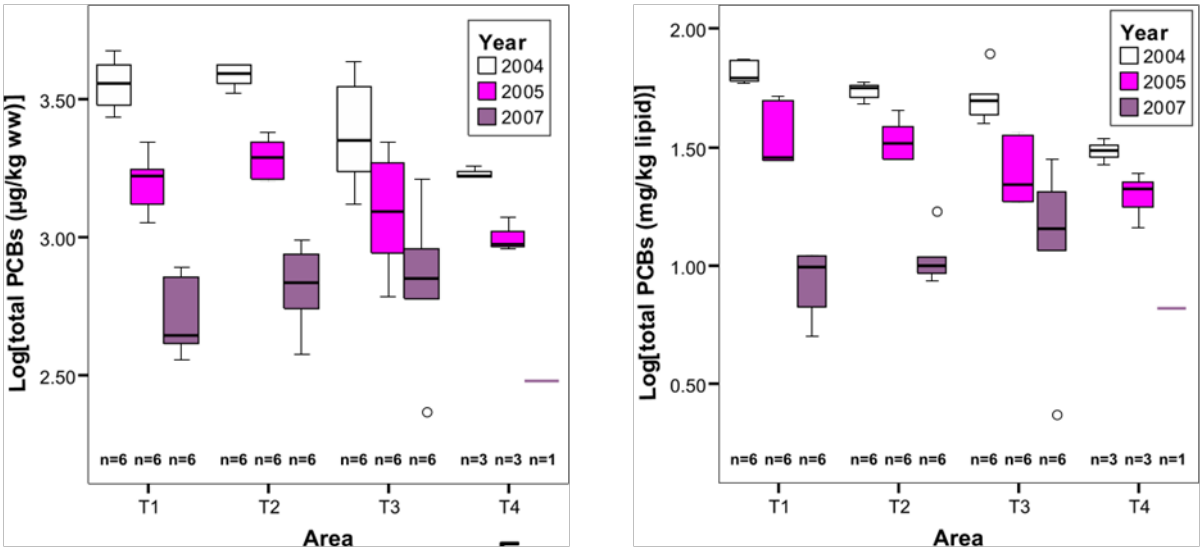
Spatial Trends

To evaluate whether differences were statistically significant among mean total PCB concentrations (sum of Aroclors in µg/kg ww) in the four sampling areas in whole-body English sole, shiner surfperch, and Pacific staghorn sculpin samples, analysis of variance (ANOVA) and *post hoc* tests were conducted. Two-way ANOVAs were conducted with the factors of year (2004, 2005, and 2007), area (T1 through T4), and year-by-area interaction. These tests were followed by *post hoc* Tukey honestly significant difference multiple comparisons to identify differences between areas (averaged over all years) and one-way ANOVA testing for effects of area within a year (Sidak's correction used to correct for multiple testing) to identify differences between particular years and to help evaluate the effects of small sample size in Area T4. Data were log-transformed to help homogenize variances in order to better meet the assumptions of the ANOVA and were also rankit-transformed to make the variables normally distributed and the analyses "non-parametric"(Conover 1980). Similar analyses were also conducted for lipid-normalized total PCB concentrations (sum of Aroclors in mg/kg lipid). Sufficient data were available for 2004, 2005, and 2007 for English sole (though sample sizes were small in area T4) and shiner surfperch and for only 2004 for Pacific staghorn sculpin. Data sufficient for statistical analyses were not available for crabs. Total PCB concentrations in tissues are shown for the four sampling areas on Map 4-28, with sediment SWACs included for context (see Appendix D.6 for correlations evaluated as part of the FWM). Results of the statistical analyses for each of the three fish species are presented below. Complete tables of p values for all analyses conducted are presented in Appendix E, Section E.5.

Whole-Body English Sole Wet-Weight Data

Means of wet-weight total PCB concentrations were lower in Area T4 than in all other areas in all years and averaged over all years ($p = 0.05$, Figures 4-15 and 4-18). The

two-way ANOVAs for log- and rankit-transformed total PCBs in whole-body English sole indicated that at least one area had a mean total PCB concentration (averaged over all years) that differed from at least one other area (significant area effect but no interaction between year and area for all variables[Appendix E5, Table E.5-1]). Tukey *post hoc* tests identified significant differences between Areas T4 and T2 (averaged over all years) for log-transformed wet-weight total PCB concentrations (see Appendix E, Tables E.5-2 and E.5-3, for p values).



Note: The boxes indicate the 25th and 75th percentiles within which 50% of the data lie. The length of this box indicates the interquartile range (IQR). The line in the center of the box is the 50th percentile (median). The whiskers of the box plot indicate the maximum and minimum values from the dataset that are within 1.5 IQRs of the 25th and 75th percentile values. Outliers are indicated by a circle and have a value between 1.5 and 3 of the IQR from the upper or lower edge of the box (75th or 25th percentile).

Figure 4-18. Box plots of log(10)-transformed wet-weight and lipid-normalized total PCB concentrations (Aroclor sum) in English sole collected in 2004, 2005, and 2007

Based on within-year ANOVAs (using Sidak's correction for testing of multiple years), area means for total PCB concentrations were not significantly different in 2005 and 2007 (Table 4-36). In 2004, significant differences were identified only between the area with the lowest mean (Area T4) and the areas with the highest or second highest mean (Areas T1 or T2) (see Appendix E, Table E.5-5, for p values).

Table 4-36. Results of *post hoc* one-way ANOVAs for equality of area mean total PCB concentrations (Aroclor sum) in English sole within year

Type of Data		Year			All Years[a]
		2004	2005	2007	
Log[total PCBs (µg/kg ww)]	highest	T2	T2	T3	T2
		T1	T1	T2	T1
		T3	T3	T1	T3
	lowest	T4	T4	T4	T4
Log[total PCBs (mg/kg lipid)]	highest	T1	T1	T3	T1
		T2	T2	T2	T2
		T3	T3	T1	T3
	lowest	T4	T4	T4	T4

Note: Test was conducted using Sidak's correction for multiple comparisons. Areas are listed from highest to lowest mean concentration. Areas connected with vertical lines are not significantly different.

[a] Differences among all year means are based on Tukey *post hoc* tests following two-way ANOVA for area, year, and area-by-year interaction.

PCB – polychlorinated biphenyl
ww – wet weight

Whole-Body English Sole Lipid-Normalized Data

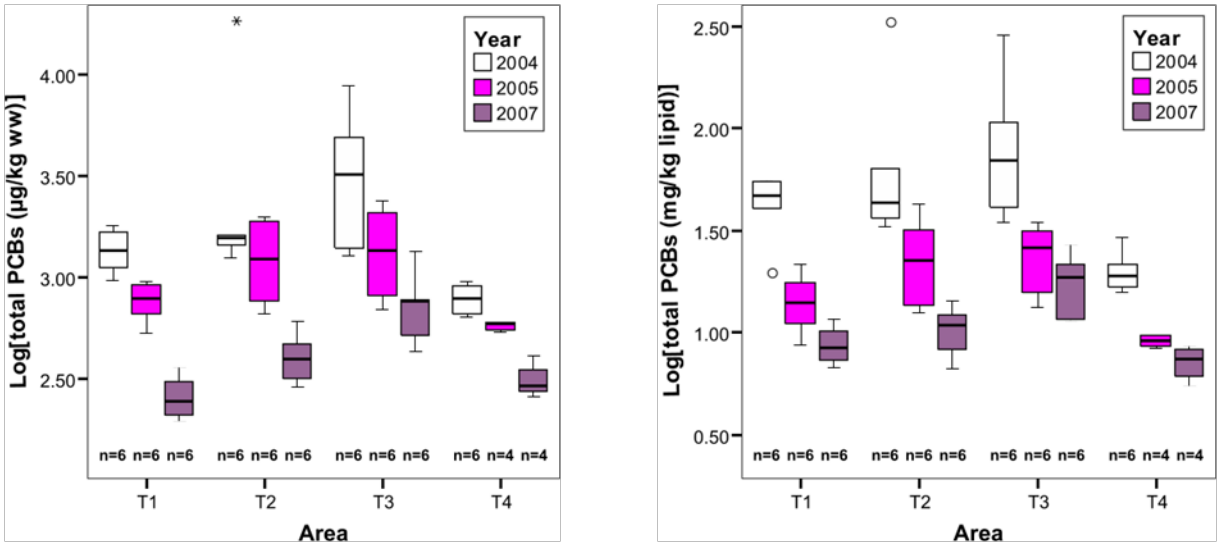
Means of lipid-normalized total PCB concentrations were lower in Area T4 than in all other areas in all years and averaged over all years (Figures 4-15 and 4-18). The two-way ANOVA indicated that for lipid-normalized total PCBs, at least one area had a mean concentration (averaged over all years) that differed from at least one other area (area effect of the two-way ANOVA was significant; $p = 0.022$). Tukey *post hoc* tests identified no significant differences among areas in log-transformed lipid-normalized total PCB concentrations (see Appendix E, Section E.5, for p values).

Based on individual, within-year ANOVAs (using Sidak's correction for testing of multiple years), area means were not significantly different in 2005 and 2007 (Table 4-36). In 2004, significant differences were identified only between the area with the lowest mean (Area T4) and the area with the highest mean (Area T1) (see Appendix E, Section E.5, for p values).

Whole-Body Shiner Surfperch Wet-Weight Data

Means of wet-weight total PCB concentrations were higher in Areas T2 and T3 and lower in Areas T1 and T4 in all years and averaged over all years (Figure 4-19). The two-way ANOVA indicated that for wet-weight total PCBs, at least one area had a mean concentration (averaged over all years) that differed from at least one other area (area effect of the two-way ANOVA was significant; $p < 0.0005$). Tukey *post hoc* tests identified no significant differences (averaged over all years) between log-transformed wet-weight total PCB concentrations in Areas T4 and T1 or between concentrations in Areas T2 and T3 but indicated that the means in the two groups (T4, T1 and T3, T2) were significantly different (Table 4-37; see Appendix E, Section E.5, for p values).

Based on one-way ANOVA testing for differences among areas within years, log-transformed wet-weight total PCB concentrations did not differ among areas in 2005 but were lower in Areas T1 and T4 than in Areas T2 and T3 in 2004 and 2007 (Table 4-37; see Appendix E, Section E.5, for p values).



Note: The boxes indicate the 25th and 75th percentiles within which 50% of the data lie. The length of this box indicates the interquartile range (IQR). The line in the center of the box is the 50th percentile (median). The whiskers of the box plot indicate the maximum and minimum values from the dataset that are within 1.5 IQRs of the 25th and 75th percentile values. Outliers are indicated by a circle and have a value between 1.5 and 3 of the IQRs from the upper or lower edge of the box (75th or 25th percentile). Extreme values are indicated by an asterisk and have a value > 3 IQRs from the 75th or 25th percentile.

Figure 4-19. Box plots of log(10)-transformed wet-weight and lipid-normalized total PCB concentrations (Aroclor sum) in shiner surfperch collected in 2004, 2005, and 2007

Table 4-37. Results of *post hoc* one-way ANOVAs for equality of area mean total PCB concentrations (Aroclor sum) in shiner surfperch within year

Type of Data		Year			All Years[a]
		2004	2005	2007	
Log[total PCBs (µg/kg ww)]	Highest	T2	T3	T3	T3
		T 3	T 2	T 2	T 2
		T1	T 1	T4	T1
	Lowest	T 4	T 4	T 1	T 4
Log[total PCBs (mg/kg lipid)]	Highest	T3	T3	T3	T3
		T 2	T 2	T 2	T2
		T 1	T 1	T 1	T1
	Lowest	T 4	T 4	T 4	T 4

Note: Test was conducted using Sidak's correction for multiple comparisons. Areas are listed from highest to lowest mean concentration. Areas connected with vertical lines are not significantly different.

[a] Differences among all year means are based on Tukey *post hoc* tests following two-way ANOVA for area, year, and area-by-year interaction.

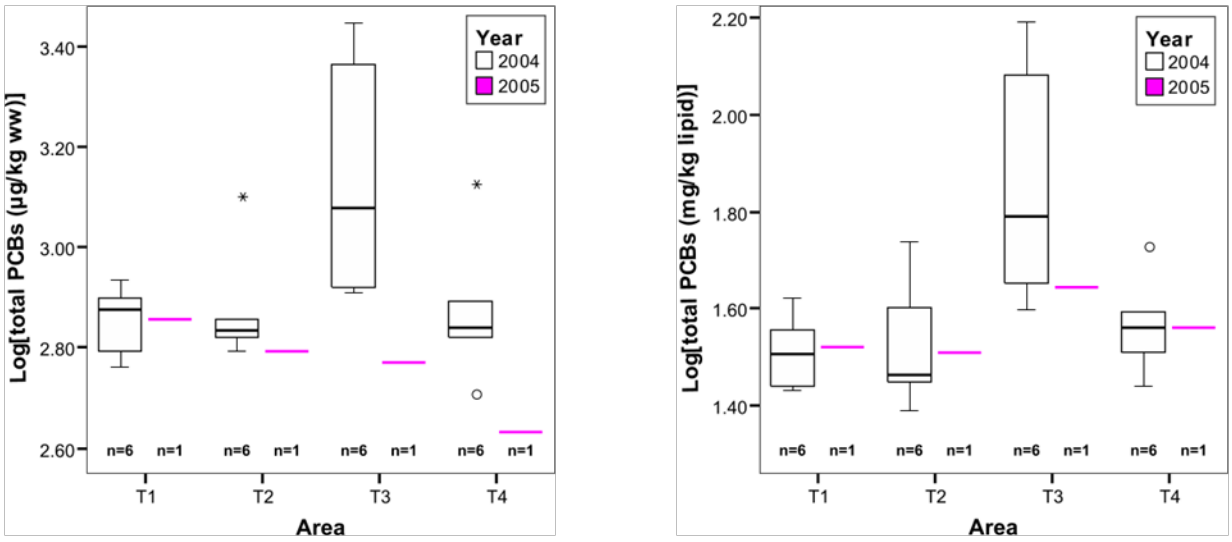
PCB – polychlorinated biphenyl

Whole-Body Shiner Surfperch Lipid-Normalized Data

Means of lipid-normalized total PCB concentrations were higher in Areas T2 and T3 and lower in Areas T1 and T4 in all years and averaged over all years (Figure 4-19). The two-way ANOVA indicated that for lipid-normalized total PCBs, at least one area had a mean concentration (averaged over all years) that differed from at least one other area (area effect of the two-way ANOVA was significant; $p < 0.0005$). Tukey *post hoc* tests for differences among all year means identified significant differences between Area T4 and Areas T3 and T2 based on log-transformed lipid-normalized total PCB concentrations (Table 4-37; see Appendix E, Section E.5, for p values). Based on one-way ANOVA testing for differences among areas within years, differences among areas were not significant in any year (Table 4-37; see Appendix E, Section E.5, for p values).

Whole-Body Pacific Staghorn Sculpin Wet-Weight and Lipid-Normalized Data

For Pacific staghorn sculpin, there were sufficient data in each of the four sampling areas to conduct statistical analyses of differences among the areas in 2004 but not in 2005 (six samples were collected in each area in 2004, and one sample was collected in each area in 2005). Box plots of log-transformed wet-weight and lipid-normalized total PCB concentrations in Pacific staghorn sculpin are shown in Figure 4-20. The one-way ANOVA using 2004 log-transformed total PCB concentrations identified a significant difference among area means ($p = 0.01$). *Post hoc* Tukey tests identified significant differences in the means of log-transformed total PCB concentrations between Area T3 and all other areas (p values ranged from 0.02 to 0.03). Conclusions were the same using log-transformed lipid-normalized total PCB concentrations.



Note: The boxes indicate the 25th and 75th percentiles within which 50% of the data lie. The length of this box indicates the interquartile range (IQR). The line in the center of the box is the 50th percentile (median). The whiskers of the box plot indicate the maximum and minimum values from the dataset that are within 1.5 IQRs of the 25th and 75th percentile values. Outliers are indicated by a circle and have a value between 1.5 and 3 of the IQR from the upper or lower edge of the box (75th or 25th percentile). Extreme values are indicated by an asterisk and have a value > 3 times the IQR from the 75th or 25th percentile.

Figure 4-20. Box plots of log(10)-transformed wet-weight and lipid-normalized total PCB concentrations in Pacific staghorn sculpin in 2004 and 2005

Tissue and Sediment Relationships

Relationships between total PCB concentrations in fish or crab tissue (ww) and surface sediment (dw) were evaluated as part of the FWM and are described in detail in Appendix D (Section D.3). Regression analyses to assess the relationships were conducted using data for the 24 subareas for shiner surfperch and Pacific staghorn sculpin, the two species believed to have smaller home ranges, and data from the four larger tissue sampling areas for English sole and crabs (see Map 4-9 for area locations). Significant relationships between tissue and surface sediment on a subarea basis were identified for shiner surfperch and Pacific staghorn sculpin using 2004 data; total PCB concentrations in surface sediment explained more than 50% of the variance in concentrations in tissue. Using 2005 data for shiner surfperch, the relationship was significant but less strong, explaining 29% of the variance. Sufficient data were not available to evaluate the relationship for Pacific staghorn sculpin in 2005. For English sole and crabs, regression relationships were not significant on an area basis using either 2004 or 2005 data.

The relationship between total PCB concentrations in benthic invertebrate tissue (ww) and co-located surface sediment (dw) was evaluated as part of the ERA (Appendix A; Attachment 11). The relationship was significant, with total PCB concentrations in surface sediment explaining 67% of the variance in tissue. The relationship between total PCB concentrations in clams (ww) and co-located sediment (dw) was evaluated

as part of the FWM (Appendix D; Section D.7.3). The sediment variable explained 80% of the variance in tissue concentrations ($R^2 = 0.80$), and the regression was significant.

4.2.3.5 Surface water

Concentrations of PCB congeners in surface waters are available from two different sampling methods and events. In 1997, King County used SPMDs to estimate PCB concentrations in surface waters of the LDW as part of the King County WQA. These data are not summarized in the RI because only a subset (17 of 209) PCB congeners were estimated using the SPMDs. It is likely the total PCB concentrations were underestimated because the totals did not include all PCB congeners.[77] In 2005, King County collected whole water samples that were analyzed by Axys for all 209 congeners (Table 4-38) (Mickelson and Williston 2006). The surface water samples were collected from two locations in the LDW: RM 0.0 at the southern end of Harbor Island (LTKE03) and RM 3.3 at the South Park Bridge (LTUM03). Each of these locations was sampled during two dry-weather periods (August and September) and two wet-weather periods (November and December). All 209 PCB congeners were analyzed in unfiltered water samples using high-resolution methods. Total PCB concentrations were calculated as the sum of detected PCB congeners.

Table 4-38. Summary of surface water data for total PCBs (as sum of PCB congeners)

Location ID	Collection Depth	Total PCB Concentration and Salinity by Date[a]							
		8/22/2005 (277 cfs)[b]		9/26/2005 (378 cfs)[b]		11/28/2005 (1,060 cfs)[b]		12/19/2005 (550 cfs)[b]	
		Total PCBs (µg/L)	Salinity (PSS)	Total PCBs (µg/L)	Salinity (PSS)	Total PCBs (µg/L)	Salinity (PSS)	Total PCBs (µg/L)	Salinity (PSS)
LTKE03 (RM 0.0)	1 m below the surface	0.001796	22.984	0.001024	25.174	0.000591	13.388	0.001947 J	25.987
	1 m above the bottom	0.001814	28.273	nc[c]	30.266	0.00025	30.118	0.000599	29.995
LTUM03 (RM 3.3)	1 m below the surface	0.001592 J	16.523	0.001452 J	17.133	0.000398	9.929	0.001122	9.423
	1 m above the bottom	0.003211	26.043	0.001883 J	29.402	0.000132	20.362	0.001341	27.775

[a] Total PCB concentration represents the sum of detected PCB congener concentrations. RLs for non-detects were not included in the calculation. Laboratory duplicate and field replicate samples were averaged using the data management rules presented in Appendix E, Section E.3. Detected results for select PCB congeners that were within 5 times the detected concentration in the associated method blank sample were qualified as non-detected at elevated RLs. Alternate data management procedures and data validation criteria were used to

[77] Total PCB concentrations calculated from SPMD data ranged from 0.000092 to 0.000193 µg/L based on the sum of the 17 estimated PCB congener concentrations. Total PCB concentrations were also calculated using Aroclor data collected with SPMDs (ranging from 0.000161 to 0.000320 µg/L), but these data are highly uncertain because Aroclor-specific partitioning coefficients were not available (King County 1999e). These concentrations were generally lower than total PCB concentrations in whole-water samples collected from the LDW in 2005.

calculate total PCB concentrations in the King County technical memorandum that presented these data (Mickelson and Williston 2006).

[b] Daily mean discharge flow rate in the Green River at USGS Gauge 12113000 at Auburn.

[c] A number of PCB congener results were rejected because method performance criteria were not met during analysis; therefore, total PCB concentrations were not calculated.

cfs – cubic feet per second
ID – identification
J – estimated concentration
nc – not calculated
PCB – polychlorinated biphenyl
PSS – practical salinity scale
RL – reporting limit

Total PCB concentrations (sum of PCB congener concentrations) in water at both depths in both locations were lowest in November. Flow, represented as the daily mean discharge from USGS Gauge 12113000 at Auburn, was also highest in November (1,060 cfs) than in August, September, and December (277, 378, and 550 cfs, respectively).

The highest flow rate was associated with the lowest total PCB concentration at each LDW location and depth, and the lowest flow rate was associated with the highest concentration, except at RM 0.0 at 1 m below the surface.

In August and September, total PCB concentrations in samples collected from 1 m above the bottom at RM 3.3 were higher than those in samples collected from 1 m below the surface at the same location; concentrations were similar in surface and bottom water in August samples from RM 0.0. In contrast, in November and December, total PCB concentrations in bottom water were lower than those in the surface water, except for the sample from RM 3.3 in December. Total PCB concentrations in surface water samples are compared with WQC in Section 4.2.2 (Table 4-20).

4.2.3.6 Seep water

PCB Aroclors were analyzed in unfiltered seep water samples collected at 16 locations throughout the LDW during the seep sampling event conducted in 2004 for the RI. In addition, PCB Aroclors were analyzed in seep water samples collected at three T-117 locations in 2003 and in unfiltered seep water samples collected at 17 Boeing Plant 2 locations in 1995 (Map 4-11a). Detected concentrations of PCBs in seep water samples are shown on Maps 4-11b through 4-11e.

PCBs were detected in unfiltered seep water samples collected from three of the locations sampled for the RI (SP-54 in the inlet at RM 2.2, SP-64 south of Kellogg Island, and SP-71 at RM 0.015 on the west side), from one location at T-117 (Seep 3), and from four locations at Boeing Plant 2 (SE-SWY01, SW-SWY01, SE-SWY03, and SE-84102) (Table 4-39). The maximum detected PCB concentration was 8.9 µg/L in an unfiltered sample collected at SP-54 near RM 2.2 in EAA 2. Unfiltered seep water samples may contain sediment that is suspended during sampling. PCBs were also detected in one filtered seep sample collected from SP-54 in the inlet at RM 2.2 (EAA 2). Total PCB concentrations in seep water samples are compared with WQC in Section 4.2.2 (Table 4-21).

Table 4-39. Summary of detected concentrations of PCBs in seep water

Sampling Event	Chemical	Detection Frequency		Concentration (µg/L)		
		Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs
RI – LDW-wide	**Total (not filtered or centrifuged)**					
	Aroclor 1248	2/14	14	0.092	4.7	0.017 – 0.02
	Aroclor 1254	3/14	21	0.020 J	2.3 J	0.017 – 0.02
	Aroclor 1260	2/14	14	0.16	1.9 J	0.017 – 0.02
	Total PCBs	3/14	21	0.020 J	8.9 J	nc
	Filtered[a]					
	Aroclor 1248	1/16	6	0.21	0.21	0.017
	Aroclor 1260	1/16	6	0.047	0.047	0.017
	Total PCBs	1/16	6	0.26	0.26	nc
T-117[b]	**Total (not filtered or centrifuged)**					
	Aroclor 1260	1/3	33	0.94 J	0.94 J	1.0
	Total PCBs	1/3	33	0.94 J	0.94 J	nc
Boeing Plant 2	**Total (not filtered or centrifuged)**					
	Aroclor 1254	1/17	6	0.93 J	0.93 J	1 – 1.5
	Aroclor 1260	3/17	18	1.7 J	4.6	1
	Total PCBs	4/17	24	0.93 J	4.6	nc

[a] A 1-µm filter was used during the RI sampling event.

[b] Seep 3 was resampled because it was suspected that the detected PCB concentration of 0.94 J µg/L may have been associated with suspended solids in the water sample. The sample was then centrifuged and analyzed, and PCBs were not detected at an RL of 0.033 µg/L.

LDW – Lower Duwamish Waterway
J – estimated concentration
nc – not calculated
PCB – polychlorinated biphenyl
RL – reporting limit
T-117 – Terminal 117

4.2.3.7 Summary of PCB data

A large sediment dataset is available to describe the nature and extent of PCB concentrations in the LDW, including a total of 1,327 surface sediment samples and 821 subsurface sediment samples from which lateral and vertical distributions of PCBs in LDW sediments can be described. Total PCB concentrations in surface sediment ranged from 1.6 to 220,000 µg/kg dw; the area-based 95th and 50th percentile concentrations calculated from the RI baseline dataset were 810 and 115 µg/kg dw, respectively. The highest total PCB concentrations in surface sediment were detected between RM 0.4 and RM 0.6 on the east side of the LDW (Duwamish/Diagonal EAA), in the Slip 4 EAA, between RM 3.3 and RM 3.7 on the east side (the Boeing Plant 2/ Jorgensen Forge EAA), between RM 3.5 and RM 3.7 on the west side (in the T-117 EAA), and between RM 4.8 and RM 4.9 (including the Norfolk EAA). Many samples in these areas had concentrations greater than the area-based 95th percentile of 810 µg/kg dw. The SWAC for the area between RM 0.0 and RM 5.25 was 350 µg/kg dw.

In general, the highest total PCB concentrations in subsurface samples were detected in the same areas with higher concentrations in surface sediment. At many locations in the LDW, sediment at deeper intervals had higher PCB concentrations than did sediment at uppermost intervals. There were several exceptions to this pattern, in which relatively high total PCB concentrations were detected in the uppermost interval: 1) in the navigation channel near RM 0.9 and RM 1.0, 2) near RM 2.2 on the western shoreline, 3) towards the head of Slip 4, 4) near RM 3.6 east of the navigation channel, and 5) between RM 3.5 and RM 3.7 west of the navigation channel. Discussions of how these patterns compare to the physical CSM are presented in Section 4.3.

The fish and invertebrate tissue dataset provides good spatial coverage of the waterway, represents various exposure regimes of biota, and provides representation of species of interest to the ecological risk assessment (as either receptors or prey for receptors) and to the human health risk assessment (as species and size classes used by people). In whole-body composite samples of fish, mean total PCB concentrations ranged from 71 µg/kg ww in juvenile chinook salmon in Area T1 to 4,320 µg/kg ww in shiner surfperch in Area T2. In crabs, sampling area mean total PCB concentrations in edible-meat samples (non-detected to 270 µg/kg ww) were much lower than those in hepatopancreas samples (260 to 5,500 µg/kg ww). Mean total PCB concentrations in amphipod and benthic invertebrate tissue samples were 230 and 270 µg/kg ww, respectively, and mean total PCB concentrations in softshell clam tissue samples ranged from 98 to 140 µg/kg ww. Thus, total PCB concentrations in invertebrate (except crab hepatopancreas) samples tended to be lower than in fish, and concentrations in juvenile chinook salmon were lower than concentrations in English sole and shiner surfperch. Mean lipid-normalized total PCB concentrations in fish and crab tissue ranged from non-detected to 100 mg/kg lipid, with no clear differences in concentrations among fish or crab species or tissue types (i.e., whole body, fillet, hepatopancreas, or edible meat). Mean lipid-normalized total PCB concentrations in benthic invertebrates, clams, and mussels were generally lower than in fish and crab tissue, ranging from 3.3 to 41 mg/kg lipid.

In general, the PCB congeners patterns for each tissue type were similar, except for two clam samples from Slip 4 with higher contributions of less chlorinated PCB congeners. Of the three fish species analyzed for PCB congeners, shiner surfperch had the greatest variability in congener patterns among the individual samples. The mean pattern for whole-body fish samples in 2007 showed a small increase in the contribution from more highly chlorinated PCB congeners relative to the pattern for whole-body fish samples from 2004. The TEQ potencies were similar in the English sole and shiner surfperch tissues collected in 2004, 2005, and 2007. The Aroclor composition in samples collected from 2005 to 2007 had a higher proportion of the more highly chlorinated PCB congeners than did tissues collected in 2004.

The Aroclor tissue data as a whole suggest total PCB concentrations in 2004 were higher than those in more recent years; total PCB concentrations appear to be

decreasing based on both wet-weight and lipid-normalized Aroclor data. Trends based on the limited PCB congener data are more uncertain. The PCB congener data suggest that wet-weight total PCB concentrations in English sole collected from Area T1 and possibly from Area T2 may be decreasing, although the sample size is small. Total wet-weight PCB concentrations (congener sums) in crabs collected from Areas T1 and T3 were also consistently lower in 2007 than 2004. The wet-weight PCB congener data suggest that temporal trends in total PCB concentrations in shiner surfperch are uncertain. The lipid-normalized PCB congener data suggest potential downward trends in Area T3 for English sole, in Area T2 for shiner surfperch, and in Areas T1 and T3 for Dungeness crab.

Differences in total PCB concentrations in English sole and shiner surfperch tissue among the four subareas were also evaluated for both wet-weight and lipid-normalized data. For wet-weight total PCB data, area means were not significantly different in 2005 and 2007 for English sole tissue. In 2004, significant differences were identified only between the area with the lowest mean (Area T4) and the areas with the highest or second highest mean (Area T1 or T2, respectively). For shiner surfperch, total PCB concentrations did not differ among areas in 2005 but were lower in Areas T1 and T4 than in Areas T2 and T3 in 2004 and 2007. Total PCB concentrations in Pacific staghorn sculpin were significantly higher in Area T3 than in the other areas in 2004, which was the only year with sufficient data for statistical analysis. For lipid-normalized total PCB data, area means were not significantly different in 2005 and 2007 for English sole. In 2004, significant differences were identified only between the area with the lowest mean (Area T4) and the area with the highest mean (Area T1). For shiner surfperch, lipid-normalized total PCB concentrations did not differ among areas in 2004, 2005, or 2007. Results using lipid-normalized data for Pacific staghorn sculpin were the same as those based on wet-weight data; total PCB concentrations were significantly higher in Area T3 than in the other areas in 2004.

The available dataset for water samples is small relative to the tissue and sediment datasets. Surface water grab samples were collected from the LDW on four sampling dates between August and December 2005 from two locations (near Harbor Island at RM 0.0 and near the South Park Bridge at RM 3.3) at two different depths. Total PCB concentrations ranged from 0.000132 to 0.003211 µg/L with an overall mean concentration of 0.001277 µg/L. Concentrations were lowest at all locations in November 2005, when flow rates were the highest.

PCBs were detected in unfiltered seep water samples collected from three of the 16 locations sampled as part of the RI, one of the T-117 locations, and four of the Boeing Plant 2 locations. Because these samples were not filtered, these detections may represent entrained sediment at locations with elevated total PCB concentrations in sediment. Total PCBs were detected in one filtered sample collected from the inlet at RM 2.2 (EAA 2). The maximum detected PCB concentration was 8.9 µg/L in an

unfiltered sample collected at a seep in EAA 2. PCBs were not analyzed in any porewater samples collected from the LDW.

4.2.4 Arsenic

This section summarizes the nature and extent of arsenic concentrations in surface sediment, subsurface sediment, tissue, surface water, seep water, and porewater. The extent of arsenic in site media is described in detail in this section because arsenic is a risk driver chemical.

4.2.4.1 Surface sediment

Surface sediment samples collected from 852 of the 1,365 locations in the RI baseline dataset were analyzed for total arsenic. Arsenic was detected in 93% of surface sediment samples analyzed for arsenic, with concentrations ranging from 1.2 mg/kg dw to 1,100 mg/kg dw and a mean concentration of 17 mg/kg dw (Table 4-40).

Table 4-40. Summary of surface sediment data for total arsenic

Chemical	Detection Frequency		Total Arsenic Concentration (mg/kg dw)				SQS	CSL
	Ratio	%	Minimum Detection	Maximum Detection	Calculated Mean[a]	RL or Range of RLs[b]		
Arsenic	794/852	93	1.2	1,100	17	3.1 – 31	57	93

[a] Calculated mean concentration is the mean of detected concentrations and one-half the RL for non-detected results.

[b] RLs based only on non-detect samples.

CSL – cleanup screening level
dw – dry weight
RL – reporting limit
SQS – sediment quality standards

Arsenic concentrations in surface sediment were much less variable than total PCB concentrations; the numerical 95th percentile of the surface sediment dataset was 30 mg/kg dw (Table 4-41; Map 4-29). Percentiles calculated on an area-basis using IDW interpolation were similar (Table 4-41; Map 4-30).

Table 4-41. Percentiles of arsenic concentrations in LDW surface sediment collected from RM 0.0 to RM 6.0

Method	Arsenic Concentration (µg/kg dw)[a]				
	Entire Dataset	25TH Percentile	50TH Percentile	75TH Percentile	95TH Percentile
Area-based	15 (SWAC)	8.6	11	14	25
Numerical	17 (mean)	7.9	11	15	30

[a] The UCL for arsenic in surface sediment was 21 mg/kg dw using the RI baseline dataset, as calculated in Appendix C (Table C.3-8). This UCL is presented as the EPC for the netfishing scenario in the HHRA (Appendix B), which uses the entire surface sediment dataset.

dw – dry weight
EPC – exposure point concentration
HHRA – human health risk assessment
LDW – Lower Duwamish Waterway
RI – remedial investigation
RM – river mile
SWAC – spatially weighted average concentration
UCL – upper confidence limit on the mean

The maximum arsenic concentration in surface sediment was detected at sampling location LDW-SS114, on the east side of the LDW between RM 3.7 and RM 3.8 (Map 4-29). Other areas with arsenic concentrations in surface sediment greater than the 95th percentile (30 mg/kg dw) were: 1) near RM 0.1 on the east side of the navigation channel, 2) between RM 0.4 and RM 0.6 in the Duwamish/Diagonal EAA, 3) at the head of Slip 1, 4) between RM 1.3 and RM 1.5 on the west side of the navigation channel, 5) at the mouth and head of Slip 3, 6) between RM 3.5 and RM 3.8 on the east side of the navigation channel in and just upstream of the Boeing Plant 2/Jorgensen Forge EAA, and 7) near RM 5.0 (Map 4-30).

Arsenic concentrations exceeded the SQS or CSL at 14 surface sediment locations in five areas of the LDW: RM 0.1 on the east side, Slip 1, RM 1.3 to RM 1.5 on the west side, Slip 3, and RM 3.7 to RM 3.8 on the east side (Map 4-29). Approximately 98% of the surface sediment samples analyzed for arsenic had concentrations less than the SQS (Figure 4-21).

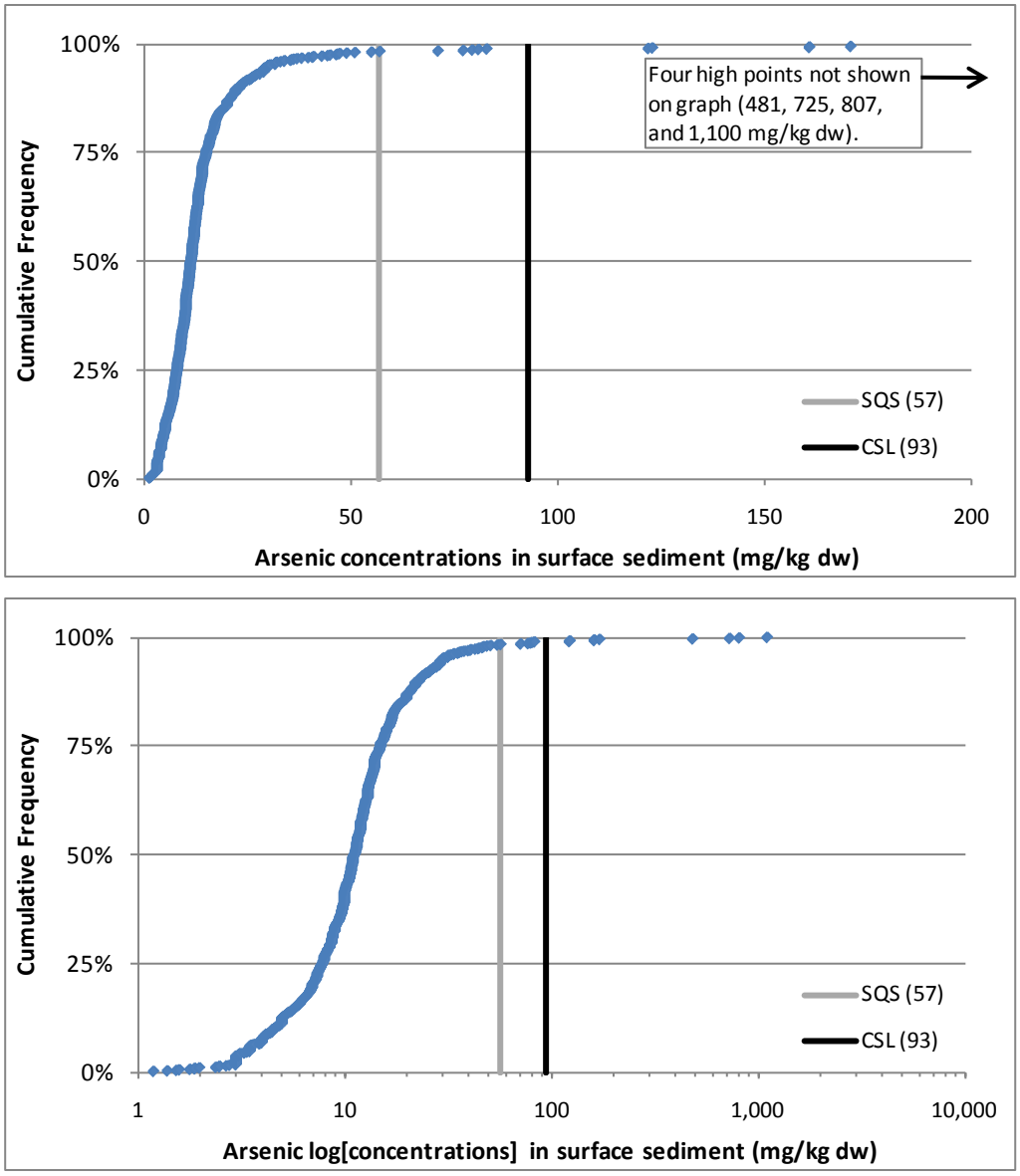


Figure 4-21. Cumulative frequency of arsenic concentrations in surface sediment (arithmetic and log-scale)

Forty-seven of the locations where surface sediment samples were collected and analyzed for arsenic were within 10 ft of where samples had previously been collected (Table 4-42). The older data were excluded from the RI baseline dataset, as described in Section 4.1.2.1 and Appendix E; however, older data for stations that were re-occupied in the RI were retained for the evaluation of changes in concentrations between older samples and newer samples only.

Table 4-42. Difference in arsenic concentrations at resampled locations, sorted by concentration difference

Approximate River Mile	Sampling Location ID		Sampling Date		Arsenic Concentration (mg/kg dw)		
	Initial	Resampled	Initial	Resampled	Initial	Resampled	Difference
1.3	SS-2	LDW-SS48	8/17/1993	1/18/2005	1,130	807	-323
1.4	SS-4	LDW-SS55	8/17/1993	1/24/2005	140	17.2	-123
1.5	DR123	LDW-SS57	9/14/1998	1/24/2005	52.4	35.4	-17.0
4.2	R42	LDW-SS129	10/13/1997	1/20/2005	21.1	10.6	-10.5
3.7	SD-323-S	LDW-SS110	8/17/2004	1/25/2005	32	24.7	**-7.3**
0	K-11	LDW-SS1	9/30/1991	1/17/2005	12.6	6.2	-6.4
4.3	DR286	B10b	8/26/1998	8/19/2004	10.7	5.05 J	-5.65
1.0	DR019	LDW-SS32	8/17/1998	1/18/2005	21.1	15.7	**-5.4**
4.2	R40	LDW-SS127	10/13/1997	1/20/2005	18.4	13.2	-5.2
1.7	DR097	LDW-SS63	8/20/1998	1/21/2005	14.6	10.2	-4.4
0	DR076	LDW-SS5	8/24/1998	1/17/2005	10.6	6.5	-4.1
0.2	DR035	LDW-SS12	8/11/1998	1/17/2005	16.7	13.0	**-3.7**
3.8	DR187	LDW-SS115	8/27/1998	1/25/2005	48.1	44.4	**-3.7**
0.3	DR079	LDW-SS15	8/24/1998	1/17/2005	15.1	11.5	**-3.6**
1.0	DR087	LDW-SS37	8/12/1998	1/18/2005	16.8 J	13.6	**-3.2**
3.7	R21	LDW-SS113b	10/9/1997	1/20/2005	10.8	8.3	**-2.5**
3.9	R30	LDW-SS119	10/11/1997	1/19/2005	12.4	10.9	**-1.5**
0.9	DR021	LDW-SS319	8/17/1998	10/4/2006	15.2	14.8	**-0.4**
4.1	DR238	LDW-SS125	8/27/1998	1/20/2005	8.9	8.6	**-0.3**
0.3	DUD042	LDW-SS17	11/11/1995	1/24/2005	15.0 J	14.9	**-0.1**
3.1	DR198	LDW-SS102	8/20/1998	1/24/2005	6.7	6.6	**-0.1**
0.9	DR085	LDW-SSB2b	8/31/1998	3/11/2005	16.5	16.5	**0.0**
1.4	DR028	B4b	8/17/1998	8/28/2004	9.9	10.3 J	**0.4**
2.0	R7	LDW-SS75	10/15/1997	1/21/2005	7.9	8.3	**0.4**
4.1	A11-05	LDW-SS126	8/18/1994	1/20/2005	6.5	7.3	**0.8**
4.1	06-intsed-2	SH-04	7/1/1996	8/24/2004	8.0	8.8	**0.8**
4.2	R45	LDW-SS130	10/16/1997	1/20/2005	13.9	15.0	**1.1**
1.2	DR088	LDW-SS40	8/31/1998	1/18/2005	15.4	16.7	**1.3**
2.1	DR106	LDW-SS76	8/19/1998	1/20/2005	12.7	14.5	**1.8**
4.2	DR242	SB-1	8/24/1998	8/25/2004	20	22	**2**
0.2	K-05	LDW-SS10	9/27/1991	1/17/2005	10	12.4	**2**
1.4	DR030	LDW-SS50	8/17/1998	1/24/2005	13.6	16.3	**2.7**
3.2	DR202	LDW-SS104	8/27/1998	1/25/2005	8.1	11.5	3.4
4.0	07-intsed-1	SH-02	7/1/1996	8/24/2004	7.0	11	4
3.8	R24	LDW-SS117	10/10/1997	1/20/2005	10.2	14.4	4.2

Approximate River Mile	Sampling Location ID		Sampling Date		Arsenic Concentration (mg/kg dw)		
	Initial	Resampled	Initial	Resampled	Initial	Resampled	Difference
2.2	DR113	LDW-SS81	8/19/1998	3/8/2005	13.4	18.1	4.7
1.4	DR065	LDW-SS52	8/17/1998	1/25/2005	10.3	15.5	5.2
1.9	DR131	LDW-SS70	8/13/1998	1/21/2005	8.1	14.8	6.7
3.7	DR186	LDW-SS111	8/27/1998	1/19/2005	24.9	31.7	6.8
1.4	DR160	LDW-SS51	8/12/1998	1/18/2005	9.6	16.9	7.3
3.7	SD-DUW92	SD-320-S	4/2/1996	8/16/2004	12	20	8
4.7	DR271	LDW-SS148	9/15/1998	3/9/2005	6.4	15.6	9.2
0.1	K-07	LDW-SS4	9/30/1991	1/17/2005	11.6	21.2	9.6
1.3	DR053	LDW-SS44	8/31/1998	1/21/2005	35.4 J	46.8	11.4
2.8	DR175	LDW-SS94	8/20/1998	1/21/2005	12.2	26.5	14.3
1.0	DR020	LDW-SS31	8/17/1998	1/21/2005	99.3	122	**22.7**
1.4	SS-3	LDW-SS49	8/17/1993	1/26/2005	66.0	171	105

Note: Concentrations in bold were within the range of analytical variability (≤25% increase or decrease compared with the initial concentration).

dw – dry weight

ID – identification

J – estimated concentration

At the 47 resampled surface sediment locations, arsenic concentrations decreased over time at 14 locations (30%), increased at 9 locations (19%), and were indistinguishable from the initial concentration at 24 locations (51%)[78] (Table 4-42 and Map 4-31). The area with both the highest negative (-323 and -122.8 mg/kg dw) and highest positive (+105 mg/kg dw) changes in arsenic concentrations was located between RM 1.3 and RM 1.4 on the west side of the LDW, perhaps because of high spatial variability in this area. At all other locations, changes in arsenic concentrations were relatively small (between -16.6 and +14.5 mg/kg dw).[79]

To determine if arsenic concentrations were significantly different at locations that were resampled (i.e., if the mean difference between the paired concentrations was greater than zero), a non-parametric, paired t-test (Wilcoxon signed-rank test) was used. The test was run separately for each reach of the LDW (as defined in the STM) and for the entire LDW. Data were not included for locations that were sampled less than 6 years apart.

[78] Concentration differences at these locations were within the range of analytical variability (≤ 25% increase or decrease compared to the initial concentration).

[79] Information on heterogeneity of arsenic in sediment related to sample homogenization and laboratory variability is provided by field duplicate samples (i.e., sample splits from a grab sample after homogenization). The relative percent difference in arsenic concentrations between paired field duplicate samples in the RI (n = 11) ranged from 0 to 26%, with an average of 8%.

When the data were analyzed by reach of the LDW, the differences between initial and resampled arsenic concentrations were not significant at the 95% confidence level in any of the reaches or for the entire LDW (Table 4-43; Figure 4-22).

Table 4-43. Results of statistical analyses of differences in arsenic concentrations in surface sediment at resampled locations

Reach of the LDW	n[a]	Mean Concentration (mg/kg dw)		Significance (p value)
		Initial	Resampled	
RM 0.0 to RM 2.2	27	67	55	0.86
RM 2.2 to RM 4.0	10	15	19	0.073
RM 4.0 to RM 4.8	9	13	12	0.80
Entire LDW	46	45	39	0.48

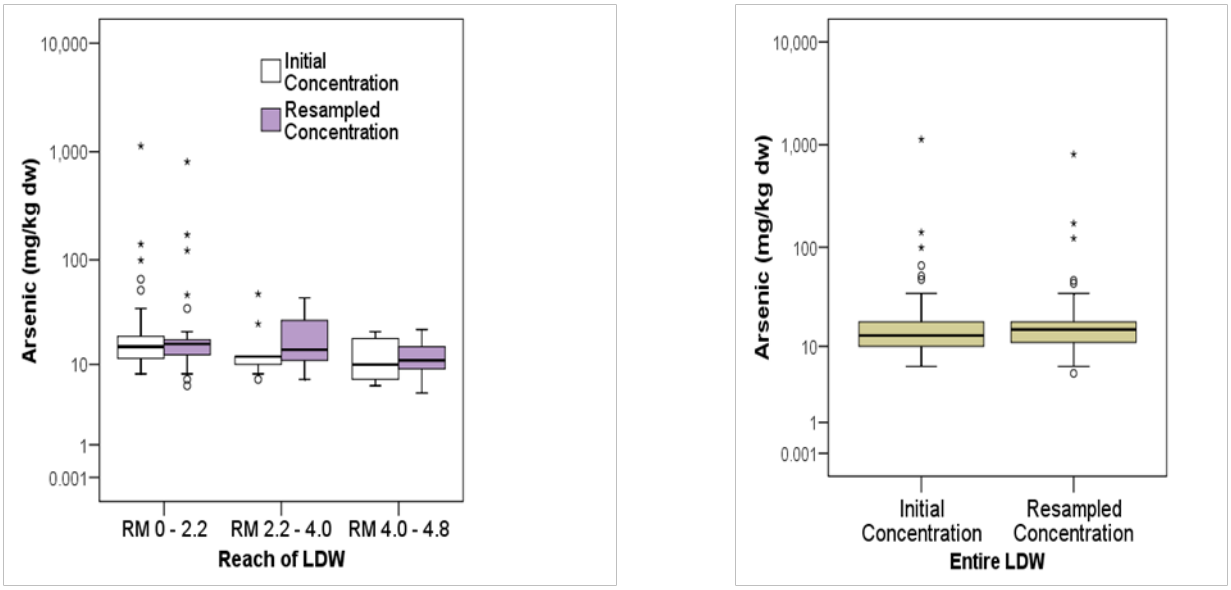
[a] One location (SD-323-S) was not included because it was resampled less than 1 year after the initial sample was collected.

dw – dry weight

LDW – Lower Duwamish Waterway

n – number of samples

RM – river mile



Note: The boxes indicate the 25th and 75th percentiles within which 50% of the data lie. The length of this box indicates the interquartile range (IQR). The line in the center of the box is the 50th percentile (median). The whiskers of the box plot indicate the maximum and minimum values from the dataset that are within 1.5 IQRs of the 25th and 75th percentile values. Outliers are indicated by a circle and have a value between 1.5 and 3 of the IQR from the upper or lower edge of the box (75th or 25th percentile). Extreme values are indicated by an asterisk and have a value > 3 times the IQR from the 75th or 25th percentile. One location (SD-323-S) was not included because it was resampled less than 1 year after the initial sample was collected.

Figure 4-22. Differences in arsenic concentrations in surface sediment at resampled locations

4.2.4.2 Subsurface sediment

Subsurface sediment cores were sampled at various intervals during the different sampling events. To calculate summary statistics, data were categorized according to specified sampling intervals, as described for total PCBs in Section 4.2.3.2.

Arsenic was detected in 82% of the subsurface sediment samples that were analyzed for arsenic, at concentrations ranging from 3.9 to 2,000 mg/kg dw (Table 4-44). Most of the subsurface arsenic data were collected in the top 4 ft of sediment cores. Arsenic data in 1- and 2-ft subsurface sampling intervals for the top 6 ft of sediment are shown graphically on Maps 4-32a through 4-32c. Data on these maps and in Table 4-44 are discussed in detail for individual cores in the following section.

Table 4-44. Summary of subsurface sediment data for total arsenic

Sampling Interval (ft)	Detection Frequency		Total Arsenic Concentration (mg/kg dw)[a]		
	Ratio	%	Minimum Detection	Maximum Detection	RL or Range of RLs[b]
All data					
Any interval	267/325	82	3.9	2,000	3.0 – 10.0
1-ft intervals[c]					
0 to 1	60/63	95	4.7	707	6.0 – 6.2
1 to 2	46/59	78	5.2	281	4.5 – 8.00
2 to 3	7/10	70	5.9	161	6.0 – 6.1
3 to 4	4/9	44	9	21	6.0 – 7
8 to 9	1/1	100	8	8	na
2-ft intervals[c]					
0 to 2	71/76	93	5.3	494	5.0 – 7
2 to 4	60/73	82	5.0	2,000	6 – 8.00
4 to 6	5/6	83	14	270	7.00
6 to 8	4/4	100	20	1,890	na
8 to 10	2/3	67	14	21	7.00

Note: Data included in the subsurface dataset are described in Section 4.1.2.2; subsurface sediment samples collected from areas that were subsequently dredged are not summarized in this table because they do not represent existing conditions.

[a] Mean concentrations were not calculated because sampling was generally focused in contaminated areas, resulting in a non-random sampling pattern, which is not likely representative of the entire LDW.

[b] RLs are presented only if there were no detected concentrations.

[c] For the calculation of summary statistics, actual sampling intervals were rounded to the nearest foot. The data for each interval were then assigned to the 1- or 2-ft sampling category that best approximated the actual sampling interval. If there were data for two 1-ft intervals at a particular location, the concentrations were averaged to obtain a calculated concentration for the corresponding 2-ft interval. Some of the subsurface data were collected from intervals other than 1 or 2 ft; therefore, the detection frequency ratio for "any interval" may reflect data for intervals not included in these categories.

dw – dry weight

na – not applicable

RL – reporting limit

4.2.4.3 Surface and subsurface sediment patterns

This section evaluates arsenic concentrations in surface and subsurface sediment to determine whether peak concentrations are found at the surface or at depth. The specific depths of peak concentrations within sediment cores were also evaluated. The percentiles for arsenic concentrations in sediment discussed in this section were calculated on an area-basis, using the method described in the introduction to Section 4.2 and IDW interpolation data. As discussed in Section 4.2.3.3 for total PCBs, although there is some uncertainty in the interpretation of patterns and spatial relationships between arsenic concentrations in surface and subsurface data, this analysis provides one line of evidence to understand the conceptual site model for arsenic in the LDW. Arsenic concentrations in all co-located surface and subsurface sediment samples are presented on Maps 4-33a through 4-33e. Maps 4-34 a and 4-34b show only the subsurface sediment locations with co-located surface sediment data.

Specific surface sediment locations were noted in the discussion if: 1) arsenic concentrations were higher in surface sediment samples than in sampling intervals of co-located subsurface cores, 2) the arsenic concentration in surface sediment was greater than the 75th percentile, and 3) the arsenic concentration in surface sediment was at least 25% greater than the highest arsenic concentration in any subsurface interval.

RM 0.0 to RM 1.0

Between RM 0.0 and RM 1.0, areas with the highest arsenic concentrations in surface sediment were located in Slip 1 (up to 725 mg/kg dw) and near RM 0.1 on the east side (up to 123 mg/kg dw) (Map 4-33a). These two areas also had the highest concentrations in subsurface cores collected in this section of the LDW. In the Duwamish/Diagonal EAA, between RM 0.4 and RM 0.7, arsenic concentrations in surface sediment were also higher than the area-based 95th percentile of 24 mg/kg dw prior to dredging (Map 4-33a); the maximum concentration in this area was 55 mg/kg dw.

Two subsurface cores were collected along the eastern shoreline of the LDW near RM 0.1 and RM 0.2. Peak arsenic concentrations in both cores were at depth. At LDW-SC2, the general area with the high arsenic concentrations in surface sediment, the maximum concentration (270 mg/kg dw) was in the 4-to-6-ft interval although the arsenic concentration was also relatively high (190 mg/kg dw) in the 0-to-2-ft interval. At LDW-SC4, the peak concentration (63 mg/kg dw) was detected in the 1-to-2-ft interval (Map 4-33a).

Maximum arsenic concentrations were low (non-detected to 22 mg/kg dw) in the three cores collected between RM 0.0 and RM 0.2 near the navigation channel and on the west side of the navigation channel. Peak arsenic concentrations were slightly higher (41 to 44 mg/kg dw) in two cores collected farther south along the western shoreline near RM 0.3 (LDW-SC6 and DR068). The peak concentration was at depth

(2-to-4-ft interval) in LDW-SC6 and unknown in the other core (DR068) because only one interval was sampled.

Multiple cores were collected and analyzed for arsenic between RM 0.4 to RM 0.6 in the Duwamish/Diagonal EAA (including several cores just outside of the area to the north and to the east). The highest arsenic concentration in subsurface sediment in this area was 36 mg/kg dw in DUD020. Most of the arsenic concentrations in subsurface sediment were relatively low. Four cores (LDW-SC9, DUD254, DUD020, and DUD261) had concentrations greater than the area-based 95th percentile. These peak concentrations were located at depth in these four cores. However, uncertainty is high for most of the cores because of the large 3-ft sampling intervals.

Two cores were collected within the navigation channel just outside of the Duwamish/Diagonal EAA. Peak arsenic concentrations in these cores (62 mg/kg dw in LDW-SC8 and 30 mg/kg dw in LDW-SC9) were at depth (4-to-6-ft interval and 1-to-3-ft interval, respectively). Arsenic concentrations in a third core in the navigation channel were similar throughout the core (22 to 24 mg/kg dw in LDW-SC14).

Relatively few cores were collected in the vicinity of Kellogg Island. In cores collected at three locations north and south of the island (LDW-SC12 and DR044 near RM 0.6 and LDW-SC19 near RM 1.0), arsenic concentrations were less than or equal to the 95th percentile and varied little with depth. In a fourth core, which was collected in the vicinity of the island along the western shoreline of the LDW between RM 0.5 and RM 0.6 (LDW-SC11), a peak concentration of 28 mg/kg dw was detected in the uppermost interval.

In a core collected at the head of Slip 1 (LDW-SC17), the peak arsenic concentration was at depth (170 mg/kg dw in the 1-to-2-ft interval). In three cores collected toward the mouth of Slip 1 and one core collected just downstream of Slip 1 (LDW-SC15, LDW-SC16, DR021, and LDW-SC13), arsenic concentrations were much lower (≤ 30 mg/kg dw) and did not vary much with depth. Three of these four cores had peak concentrations in the uppermost interval, and one core (DR021) had a peak concentration at depth (24 mg/kg dw in the 2-to-4-ft interval).

In summary, two areas had high arsenic concentrations (> 100 mg/kg dw) in surface sediment; cores in these areas had peak concentrations at depth. Arsenic concentrations in surface and subsurface sediment in the Duwamish/Diagonal EAA were also somewhat elevated (> 30 mg/kg dw) prior to dredging. In other areas, there were generally low arsenic concentration gradients within cores, with some peak concentrations at depth and some in the uppermost interval. In all of the cores with concentrations greater than 30 mg/kg dw (and with data for more than one interval), the peak concentrations were at depth.

RM 1.0 to RM 2.2

Between RM 1.0 and RM 2.2, the highest arsenic concentrations were detected at two locations: 1) between RM 1.3 and RM 1.5 on the west side of the LDW (up to 807 and

1,890 mg/kg dw in surface and subsurface sediment, respectively), and 2) at the head of Slip 3 (up to 81 and 2,000 mg/kg dw in surface and subsurface sediment, respectively) (Map 4-33b). In the other areas, surface and subsurface sediment concentrations were generally less than the 95th percentile.

West of the navigation channel, four cores were collected between RM 1.3 and RM 1.4 (LDW-SC25, DR054, LDW-SC26, and LDW-SC28). High arsenic concentrations were detected in subsurface sediment in these cores, with peak concentrations ranging from 250 to 1,890 mg/kg dw (Map 4-33b). The peak concentrations were at depth in each of these four cores; the two cores with the highest concentrations (760 and 1,890 mg/kg dw) each had peak concentrations at an interval of approximately 6 to 8 ft. Between RM 1.4 and RM 1.5, four cores were sampled at only one interval each, with concentrations ranging from 11 to 181 mg/kg dw; this area was dredged after the cores had been collected. In the only other core collected between RM 1.3 and RM 1.5 (LDW-SC29), arsenic concentrations were relatively low (≤ 14 mg/kg dw) and did not vary much with depth.

One core was collected from the head of Slip 3 (LDW-SC37). The peak concentration in this core (2,000 mg/kg dw) was detected at depth (2-to-4-ft interval). Two cores collected toward the mouth of Slip 3 (DR106 and LDW-SC36) had low arsenic concentrations (less than the 75th percentile) that varied only slightly with depth.

Other cores collected between RM 1.0 and RM 2.2 had relatively low arsenic concentrations (≤ 20 mg/kg dw) that varied little with depth, with four exceptions. In these four cores, arsenic concentrations were higher (ranging from 30 to 56 mg/kg dw). Peak concentrations were in the uppermost intervals at two of these locations (30 mg/kg dw in the 0-to-1-ft interval at LDW-SC24 and 56 mg/kg dw in the 0-to-2-ft interval at LDW-SC33) and in deeper intervals at the other two locations (40 mg/kg dw in the 1-to-2-ft interval at LDW-SC32 and 34 mg/kg dw in the 2-to-4-ft interval at LDW-SC21).

In summary, the two areas with relatively high arsenic concentrations in surface and subsurface sediment had peak concentrations at depth within cores. Most of the other subsurface sediment cores had relatively low arsenic concentrations that varied only slightly with depth.

RM 2.2 to RM 3.0

Arsenic concentrations were generally low in both surface and subsurface sediment samples collected between RM 2.2 and RM 3.0 (Map 4-33c). Only one area had concentrations that exceeded the area-based 95th percentile in either surface or subsurface sediment. A core collected in this area (LDW-SC45), located just downstream from Slip 4 on the east side of the LDW, had a peak arsenic concentration of 25 mg/kg dw at depth (2-to-4-ft interval). Four other subsurface cores were collected between RM 2.2 and RM 3.0 on the east side. Arsenic was not detected in the core collected at LDW-SC43 and was detected at relatively low concentrations

(≤ 20 mg/kg dw) in the other three cores (LDW-SC41, LDW-SC42, and LDW-SC44). Arsenic concentrations in these three cores varied only slightly with depth (Map 4-33c).

Four cores were collected within Slip 4 from an area that was subsequently dredged. Each of these cores was sampled at only one relatively large sampling interval (generally 4-ft intervals). Arsenic concentrations ranged from 4 to 16 mg/kg dw in these cores.

Arsenic concentrations were all less than 10 mg/kg dw in the five cores collected in the navigation channel. Only one core (DR171) was sampled at more than one interval, and arsenic concentrations were similar in both intervals in that core.

All of the 12 cores collected on the west side of the navigation channel had arsenic concentrations ≤ 20 mg/kg dw. Three of these twelve cores were sampled at more than one interval. There were minor arsenic concentration gradients with depth in these three cores.

In summary, arsenic concentrations were ≤ 25 mg/kg dw in this section of the LDW and did not vary much with depth. In the core with the highest concentration (25 mg/kg dw), the peak concentration was in the 2-to-4-ft interval.

RM 3.0 to RM 4.0

Arsenic concentrations in surface and subsurface sediment were generally less than or equal to the 75th percentile (13 mg/kg dw) between RM 3.0 and RM 4.0, except for a few areas between RM 3.5 and RM 3.8 along the eastern shoreline (Map 4-33d). The highest surface sediment concentrations were detected in the area between RM 3.7 and RM 3.8 (up to 1,100 mg/kg dw), just south of the Boeing Plant 2/Jorgensen Forge EAA. One of the cores collected in this area (LDW-SC50a) had a peak concentration in the uppermost interval (707 mg/kg dw), with decreasing concentrations at depth. The co-located surface sediment sample at this location had a higher arsenic concentration (1,100 mg/kg dw). Another sampling location in this area (DR220) also had an arsenic concentration in the co-located surface sediment sample (15.3 mg/kg dw) that was higher than the peak concentration in the subsurface core, although the concentration in surface sediment was relatively low. The third core in this area (LDW-SC51) had a peak concentration at depth (55 mg/kg dw in the 2-to-3.8-ft interval).

In surface sediment between RM 3.4 and RM 3.7, within the Boeing Plant 2/Jorgensen Forge EAA, arsenic concentrations were generally less than the 95th percentile, with a few locations with higher concentrations, up to 57 mg/kg dw. In subsurface sediment, concentrations were generally ≤ 21 mg/kg dw and many cores were sampled at only one interval. Three cores (SD-DUW53, SD-312-C, and SD-323-C) had peak concentrations higher than 21 mg/kg dw (31 mg/kg dw in the 8-to-12-ft interval, 26.7 mg/kg dw in the 1-to-2-ft interval, and 22.8 mg/kg dw in the 1-to-2-ft interval, respectively). Five of the locations with co-located surface and subsurface sediment samples had arsenic concentrations in the surface sediment that were higher than the

peak concentrations in the associated subsurface sediment cores. One of these locations (SD-314-C) had a concentration in surface sediment (23 mg/kg dw) that was greater than the 75th percentile and at least 25% greater than any concentration in the subsurface intervals in the associated subsurface sediment core.

On the west side of the navigation channel, all subsurface core samples had low arsenic concentrations (≤ 11 mg/kg dw), with the exception of one sample (SB-5) collected near RM 3.3. The core at this location had a peak concentration of 22 mg/kg dw at an interval of 5 to 7.5 ft, compared with somewhat lower concentrations (8 and 8.5 mg/kg dw) in shallower intervals.

Arsenic concentrations in the navigation channel were all less than the 75th percentile, and most of the cores were sampled at only one interval. In the two cores sampled at more than one interval, concentrations varied only slightly with depth.

In summary, this section of the LDW generally had low arsenic concentrations in surface and subsurface sediment, and concentrations did not vary much with depth. The highest subsurface concentrations were in three cores on the east side of the waterway; two of these occurred in areas where surface sediments were also greater than the area-based 95th percentile concentration, and two further south were at concentrations between the area-based 75th and 95th percentile concentrations. In the core with highest arsenic concentration (707 mg/kg dw) near RM 3.8, the peak concentration was in the uppermost interval collected from 0 to 1 ft.

RM 4.0 to RM 5.0

Arsenic concentrations were all ≤ 20 mg/kg dw in both surface and subsurface sediment between RM 4.0 and RM 5.0, with the exception of concentrations in surface sediment at two locations, one in Slip 6 LDW-SS128; 26.2 mg/kg dw) and the other near RM 5.0 (NFK006; 51 mg/kg dw) (Map 4-33e).

Surface and subsurface sediment concentrations in Slip 6 were between the 75th and 95th percentile concentrations. Of the 11 cores collected in Slip 6, only two had more than one interval sampled. Many of the locations in Slip 6 had higher arsenic concentrations in the co-located surface sediment samples than in the associated subsurface cores, but only four of the locations (SB-1, SB-4, SB-6, and SB-7) had concentrations in surface sediment that were both greater than the 75th percentile and at least 25% greater than concentrations in subsurface sediment. Subsurface sediment concentrations in cores collected downstream from Slip 6 on the eastern shoreline were less than or equal to the 50th percentile concentration.

Near RM 5.0, all four subsurface cores had arsenic concentrations less than the 50th percentile. No core was collected near the area with a high concentration of 51 mg/kg dw in surface sediment; therefore, concentration gradients with depth could not be evaluated at this location.

At all other locations between RM 4.0 and RM 5.0 (i.e., in the navigation channel and to the west of the navigation channel), subsurface concentrations were less than the 75th percentile, and, in general, only one interval was sampled. Also, many of the intervals were greater than 4 ft deep, so concentration gradients with depth could not be evaluated.

In summary, most of the surface and subsurface sediment arsenic concentrations in this section of the LDW were less than the 95th percentile of 24 mg/kg dw. In the few cores that had more than one sampling interval, concentrations were ≤ 20 mg/kg dw and varied little with depth.

4.2.4.4 Tissue

Total arsenic was detected in all tissue samples in which it was analyzed. In whole-body fish, the mean total arsenic concentration was higher in English sole (3.274 mg/kg ww) than in other species (0.738 to 0.99 mg/kg ww) (Table 4-45 and Figure 4-23). Likewise, in fillet samples, the mean total arsenic concentration was higher in English sole (5.255 mg/kg ww with skin and 11 mg/kg ww without skin) compared with other species (0.274 to 0.899 mg/kg ww with skin), although there were only three fillet samples for species other than English sole.

Table 4-45. Summary of LDW-wide tissue data for total arsenic

Tissue Type	Detection Frequency		Total Arsenic Concentration (mg/kg ww)		
	Ratio	%	Minimum Detect	Maximum Detect	Mean
Fish, Whole Body					
English sole	21/21	100	2.230	4.330	3.274
Pacific staghorn sculpin	24/24	100	0.364	1.430	0.738
Shiner surfperch	27/27	100	0.715	1.4	0.99
Starry flounder	3/3	100	0.793	0.973	0.887
Fish, Fillet					
English sole (with skin)	7/7	100	3.965	6.890	5.255
English sole (without skin)	9/9	100	9.0	15	11
Pile perch (with skin)	1/1	100	0.563	0.563	0.563
Starry flounder (with skin)	1/1	100	0.899	0.899	0.899
Striped perch (with skin)	1/1	100	0.274	0.274	0.274
Crab, Edible Meat					
Dungeness crab	9/9	100	2.540	13	5.5
Slender crab	12/12	100	1.670	3.570	2.612
Crab, Hepatopancreas					
Dungeness crab	4/4	100	3.080	7.0	4.6
Slender crab	4/4	100	2.230	3.310	2.645
Crab, Whole Body (calc'd)[a]					
Dungeness crab	9/9	100	2.707 M	11.0 M	5.2
Slender crab	12/12	100	1.844 M	3.489 M	2.622

Tissue Type	Detection Frequency		Total Arsenic Concentration (mg/kg ww)		
	Ratio	%	Minimum Detect	Maximum Detect	Mean
Invertebrates, Whole Body					
Amphipod	4/4	100	0.96	1.5	1.2
Benthic invertebrates	20/20	100	0.573	17.40	2.34
Shellfish					
Mussels, wild (edible meat)	22/22	100	0.34	1.1 J	0.81
Mussels, transplanted (edible meat)	35/35	100	0.573	1.42	0.791
Soft-shell clam, non-depurated (whole body)	29/29	100	1.30 J	15.2	4.21
Soft-shell clam, depurated (whole body)	15/15	100	2.350	19.70	6.803

[a] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Arsenic concentrations in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

J – estimated concentration
LDW –Lower Duwamish Waterway
M – calculated whole-body concentration
na – not applicable
ww –wet weight

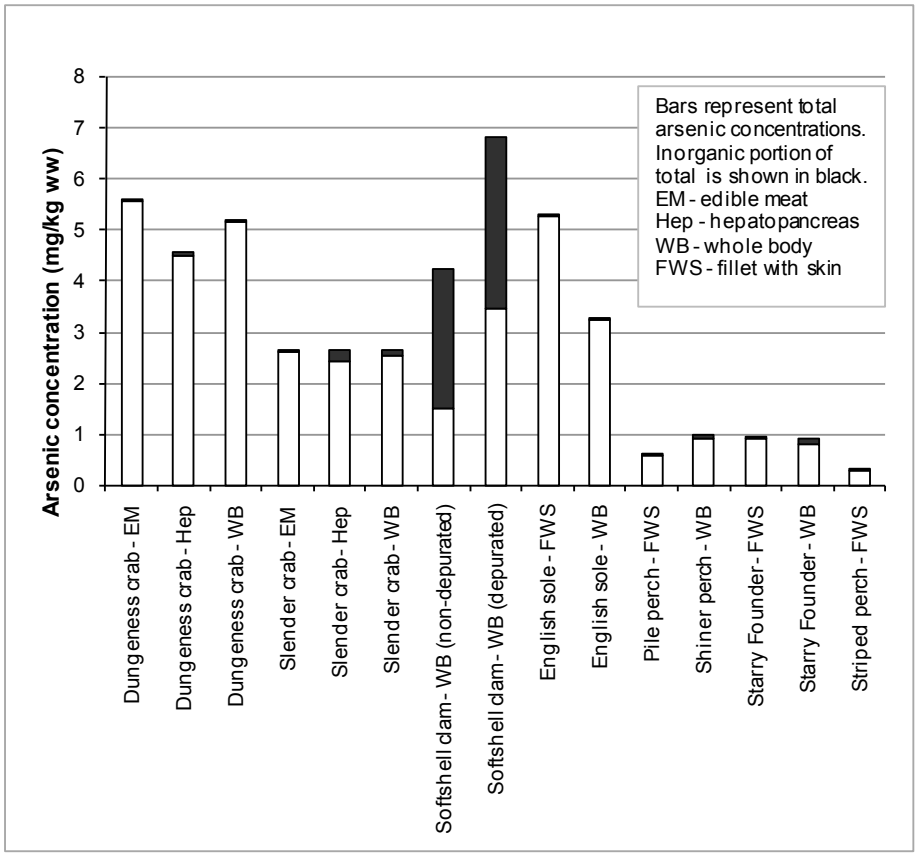


Figure 4-23. Inorganic arsenic concentrations as a percentage of total arsenic concentrations in tissue

Mean total arsenic concentrations were higher in Dungeness crabs than in slender crabs (5.2 and 2.645 mg/kg ww, respectively, in calculated whole-body samples) (Table 4-45). Mean total arsenic concentrations were lower in mussels (0.81 to 0.791 mg/kg dw) than in clams (4.21 and 6.803 mg/kg ww in non-depurated and depurated samples, respectively).[80]

The highest sample-specific total arsenic concentration in any tissue sample (19.70 mg/kg ww) was in a depurated clam sample collected from location C12 near RM 3.8 on the east side of the LDW. The non-depurated clam sample from location C12 also had a relatively high total arsenic concentration (15.2 mg/kg ww). The second highest sample-specific total arsenic concentration in any tissue sample (17.4 mg/kg ww) was in a benthic invertebrate composite sample (B3b) collected from Slip 1 (Map 4-35). The co-located sediment sample from this location had one of the highest arsenic concentrations (725 mg/kg dw) in surface sediment samples collected from the LDW. Slip 1 was also the location of a sediment core (LDW SC17) with relatively high arsenic concentrations at all intervals, to a depth of 8.5 ft.

Inorganic arsenic is the most toxic form of arsenic to humans and is a known human carcinogen, so a subset of tissue types consumed by humans (i.e., fish, crabs, and clams) was also analyzed for inorganic arsenic as part of the RI (Table 4-46). The concentration patterns of inorganic arsenic were different than those of total arsenic. The highest mean inorganic arsenic concentrations (3.37 and 2.72 mg/kg ww) were detected in depurated and non-depurated soft-shell clams, respectively. Mean inorganic arsenic concentrations in all other species were much lower, ranging from 0.002 to 0.24 mg/kg ww.

Table 4-46. Summary of LDW-wide tissue data for inorganic arsenic

Tissue Type	Detection Frequency		Inorganic Arsenic Concentration (mg/kg ww)			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[a]	RL or Range of RLs[b]
Fish, Whole Body						
English sole	7/7	100	0.020	0.090	0.051	na
Shiner surfperch	8/8	100	0.020	0.160	0.070	na
Starry flounder	1/1	100	0.090	0.090	0.090	na
Fish, Fillet						
English sole (with skin)	6/7	86	0.003	0.006 J	0.004	0.003
Pile perch (with skin)	0/1	0	nd	nd	0.0050	0.010
Starry flounder (with skin)	0/1	0	nd	nd	0.002	0.003

[80] A subset of the clam samples collected in 2007 were depurated by placing the clams in perforated plastic jars within a nylon frame, and suspending the frame in the water 3 to 5 ft beneath the boathouse (located over deep water) at Terminal 91 for 24 hours.

Tissue Type	Detection Frequency		Inorganic Arsenic Concentration (mg/kg ww)			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[a]	RL or Range of RLs[b]
Striped perch (with skin)	0/1	0	nd	nd	0.0050	0.010
Crab, Edible Meat						
Dungeness crab	2/2	100	0.010	0.010	0.010	na
Slender crab	4/4	100	0.030	0.030	0.030	na
Crab, Hepatopancreas						
Dungeness crab	2/2	100	0.050	0.090	0.070	na
Slender crab	4/4	100	0.080	0.330	0.24	na
Crab, Whole Body (calc'd)[c]						
Dungeness crab	nc	nc	0.022 JM	0.035 M	0.029	na
Slender crab	nc	nc	0.046 M	0.123 M	0.098	na
Shellfish, Whole Body						
Soft-shell clam, non-depurated	23/23	100	0.132	11.3	2.72	na
Soft-shell clam, depurated	15/15	100	0.720	9.300	3.37	na

[a] Calculated mean concentration is the average of detected concentrations and one-half the RL for non-detected results.

[b] RLs are based only on non-detect samples.

[c] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Inorganic arsenic concentrations in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data). Detection frequencies were not calculated for these samples because they do not represent individually analyzed samples.

J – estimated concentration
M – calculated whole-body concentration
na – not applicable
nc – not calculated
nd – not detected
RL – reporting limit
ww –wet weight

The amount of inorganic arsenic in fish and shellfish tissue as a percentage of total arsenic is presented in Table 4-47 and shown in Figure 4-23. Clam tissue had the highest percentage of inorganic arsenic, with a mean of 54 and 49% in the non-depurated and depurated samples analyzed for inorganic arsenic, respectively, and a range of 10 to 99% in individual samples. The ratio of inorganic to total arsenic was much lower in crab and fish tissues, typically less than 5% and always less than 15%.

Table 4-47. Inorganic arsenic as a percentage of total arsenic in tissue samples

Tissue Type	Number of Samples	Inorganic Arsenic as a Percentage of Total Arsenic		
		Mean (%)	Minimum (%)	Maximum (%)
Fish, Whole Body				
English sole	7	2	1	3
Shiner surfperch	8	7	2	13

Tissue Type	Number of Samples	Inorganic Arsenic as a Percentage of Total Arsenic		
		Mean (%)	Minimum (%)	Maximum (%)
Starry flounder	1	9	9	9
Fish, Fillet				
English sole	7	0	0	0
Pile perch	1	1	1	1
Starry flounder	1	0	0	0
Striped perch	1	2	2	2
Crab, Edible Meat				
Dungeness crab	2	0	0	0
Slender crab	4	1	1	1
Crab, Hepatopancreas				
Dungeness crab	2	2	1	3
Slender crab	4	10	2	15
Crab, Whole Body (calc'd)[a]				
Dungeness crab	2	1	1	1
Slender crab	4	4	1	5
Shellfish, Whole Body				
Soft-shell clam, non-depurated	23	54	10	99
Softshell clam, depurated	15	49	17	81

[a] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas.

For comparison, the fractions of inorganic arsenic in tissue collected from Puget Sound in other studies were well below 10%. The mean inorganic arsenic fraction for 16 fish and crab samples collected throughout Puget Sound was 0.29% (Ecology 2002a). The inorganic arsenic fractions calculated from the same study from 13 clam samples was 0.77%, much lower than the percentages found in the RI samples.

Total arsenic concentrations in tissues and sediment SWACs are presented for the four sampling areas on Map 4-35. Mean total arsenic concentrations in English sole and Pacific staghorn sculpin were similar among areas but were slightly higher in Area T1 (Map 4-35). Total arsenic concentrations in shiner surfperch tissue were similar among areas. In crab tissue, the highest total arsenic concentration was in Area T4, but only one Dungeness crab sample was collected in this area. Excluding this sample, the highest mean total arsenic concentrations in crab were in samples from Area T1.

Map 4-35 shows arsenic concentrations in benthic invertebrate and clam tissue samples at each location, along with concentrations in co-located sediment samples. The sample locations were selected to represent areas that covered the range of arsenic concentrations in sediment throughout the LDW so that a relationship between chemical concentrations in sediment and tissue could be evaluated (Windward 2004e).

Regression analyses were conducted to evaluate this relationship for arsenic concentrations in sediment and tissue (both benthic invertebrates and clams). [81]

The regression relationship for sediment and benthic invertebrates was used in the ERA (Appendix A) to estimate total arsenic concentrations in tissue throughout the LDW using the RI baseline dataset; actual tissue data were available from 20 locations. Log_{10}-transformed total arsenic concentrations in benthic invertebrate tissues were regressed against log_{10}-transformed total arsenic concentrations in sediments. Although the variance in tissue increased with sediment concentration (i.e., all of the largest residuals were found at sediment concentrations greater than 8 µg/kg dw), residuals from the regression were approximately normally distributed (R^2 of residuals against expected normal scores = 0.94), the regression was significant ($p < 0.0005$), and 78% of the variance in tissue was explained by the regression ($R^2 = 0.78$) (Figure 4-24).

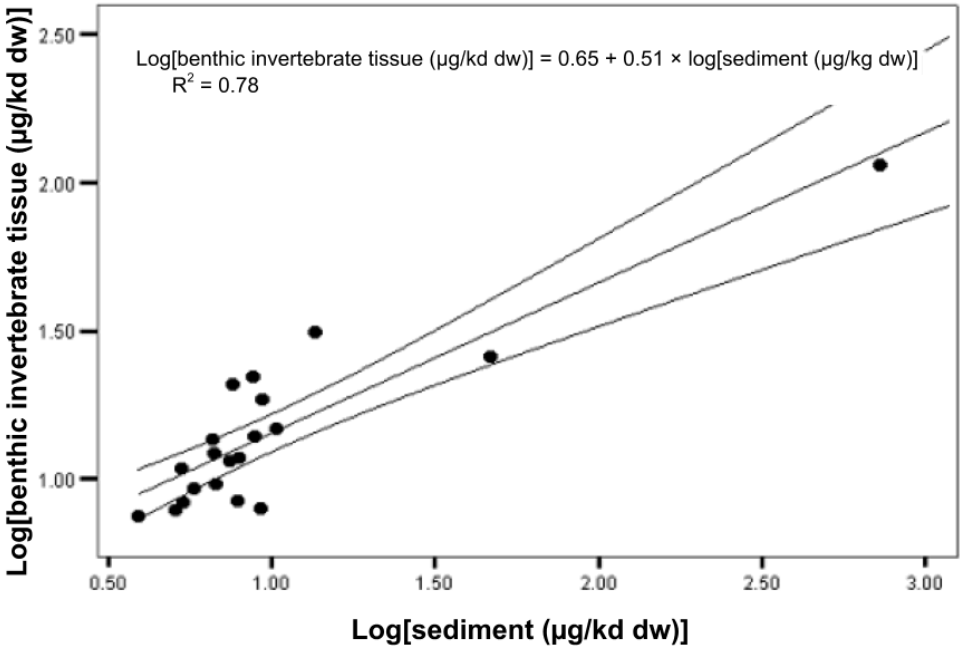


Figure 4-24. Regression equation for log_{10}-transformed total arsenic concentrations in co-located sediment and benthic invertebrate tissue samples, including 95% confidence intervals

The highest arsenic sediment concentration (725 mg/kg dw at location B3b in Slip 1) was co-located with the highest benthic invertebrate tissue concentration (17.4 mg/kg ww). This sediment-tissue pair could be considered an outlier in terms of its sediment

[81] Dry weight concentrations were used for benthic invertebrate tissue to be consistent with the ERA. Wet-weight concentrations were used for clam tissue to be consistent with the HHRA; clam consumption was not a primary exposure pathway in the ERA.

concentration (Leverage value = 0.76), but it was not an outlier with respect to its tissue concentration (Studentized deleted residual = 0.58, p = 0.57). It did not have a significant effect on the estimated tissue concentration at its sediment concentration (DFFit = 0.151), the estimate of the intercept (DFbeta0 = 0.067), the estimate of the slope (DFbeta1 = 0.076), or the regression relationship in general (Cook's Distance = 0.757, p = 0.395). These results indicate that the relationship between tissue and sediment is consistent across the range of sediment concentrations that was sampled and the regression was considered a reliable means for estimating total arsenic concentrations in benthic invertebrate tissue throughout the LDW.

For clams, inorganic arsenic in tissue rather than total arsenic was more relevant for the regression because arsenic is a risk driver for human health based on the toxicity of inorganic arsenic in seafood. A logarithmic regression analysis of the relationship between inorganic arsenic concentrations in tissue and total arsenic concentrations in sediment was conducted using the 2004 and 2007 data, as described in detail in Section 8.3.2. In summary, there was a high degree of uncertainty in the relationship as represented by the spread of data and the low R^2 (0.51).

The relationships between total arsenic concentrations in fish or crab tissue and sediment were not statistically evaluated. Based on data shown on Map 4-35, the highest mean total arsenic concentrations in whole body English sole, English sole fillet, whole body Pacific staghorn sculpin, and whole body slender crab were in Area T1, which had the highest arsenic SWAC in surface sediment.

4.2.4.5 Surface water

Dissolved and total arsenic were analyzed in hundreds of water samples collected from October 1996 to June 1997 at three LDW locations as part of the King County WQA (King County 1999e). Samples at these three locations were collected at two depths: 1 m below the surface and 1 m above the sediment. Mean dissolved and total arsenic concentrations in individual samples ranged from 0.175 to 1.57 µg/L (Table 4-48). Mean dissolved and total arsenic concentrations were slightly higher at the downstream end of the LDW (at RM 1.1 and RM 1.9) than at the upstream end at RM 4.9. Arsenic concentrations in surface water samples are compared with WQC in Section 4.2.2 (Table 4-20).

Table 4-48. Summary of surface water data for arsenic

Location ID[a]	Detection Frequency		Concentration (µg/L)		
	Ratio	%	Minimum Detect	Maximum Detect	Mean
Dissolved Arsenic					
BRN (RM 1.1)	72/72	100	0.237	1.46	0.855
SWM (RM 1.9)	72/72	100	0.224	1.42	0.806
NFK (RM 4.9)	24/24	100	0.175	0.456	0.319

Location ID[a]	Detection Frequency		Concentration (µg/L)		
	Ratio	%	Minimum Detect	Maximum Detect	Mean
Total Arsenic					
BRN (RM 1.1)	167/167	100	0.292	1.53	0.931
SWM (RM 1.9)	167/167	100	0.282	1.57	0.880
NFK (RM 4.9)	56/56	100	0.183	0.868	0.493

[a] BRN, SWM, and NFK are located in the LDW near the Brandon, SW Michigan, and Norfolk CSOs, respectively.

CSO – combined sewer overflow
ID – identification
LDW – Lower Duwamish Waterway
RM – river mile

4.2.4.6 Seep water

Arsenic was analyzed in 17 seep water samples collected from the Boeing Plant 2 site in 1995, in 7 seep water samples collected from the Rhône-Poulenc site in 1995, in 1 seep water sample from the Boeing Isaacson site in 2000, in 3 seep water samples from T-117 in 2003, and in 16 seep water samples from locations throughout the LDW during the RI sampling event in 2004 (Table 4-49). The RI locations were selected based on their proximity to potential sources in consultation with EPA and Ecology. Detected concentrations of arsenic in seep water samples are shown on Maps 4-11b through 4-11e. Arsenic concentrations in seep water samples are compared with WQC in Section 4.2.2 (Table 4-21).

Table 4-49. Concentrations of arsenic in LDW-wide seep water samples

Chemical	Detection Frequency		Concentration (µg/L)			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[a]	RL or Range of RLs[b]
Boeing Plant 2						
Dissolved arsenic	10/10	100	6	10	9	na
Total arsenic	16/17	94	2	20	9	5
Rhône-Poulenc						
Total arsenic	1/7	14	31.0	31.0	nc	nr
RI – LDW-wide						
Dissolved arsenic	16/16	100	0.054	253	22	na
Total arsenic	13/13	100	0.058	287	28	na
T-117						
Dissolved arsenic	0/3	0	nd	nd	25	50
Total arsenic	0/1	0	nd	nd	25	50
Boeing Isaacson						
Dissolved arsenic	1/1	100	7	7	7	na

[a] Calculated mean concentration is the average of detected concentrations and one-half the RL for non-detected results.
[b] RLs are based only on non-detect samples.
LDW – Lower Duwamish Waterway
na – not applicable
nc – not calculated
nd – not detected
nr – not reported (RLs for non-detects not reported for this sampling event)
RL – reporting limit

At Boeing Plant 2, total arsenic concentrations in seep water were generally low, ranging from 2 to 20 µg/L; dissolved arsenic concentrations ranged from 6 to 10 µg/L. At Boeing Isaacson, the single seep sample had a dissolved arsenic concentration of 7 µg/L. At Rhône-Poulenc, total arsenic was detected in one of the seven seep water samples at a concentration of 31 µg/L; RLs were not available for the samples with non-detects. At T-117, arsenic was not detected in seep water samples at an RL of 50 µg/L.

During the RI sampling event in 2004, the highest dissolved arsenic concentrations were detected in seep water collected at location SP-76 (Slip 1 at RM 1.0 E) and location SP-61 (RM 1.5 W) at concentrations of 253 µg/L and 72.4 µg/L, respectively (Map 4-36). These two sampling locations with the highest arsenic concentrations in seep water were near locations with high arsenic concentrations in surface sediment (725 mg/kg dw at B3b in Slip 1 and 161 mg/kg dw at LDW-SS56 near RM 1.4 W). At the other 14 seep locations sampled for the RI, arsenic concentrations (total and dissolved) were less than 7 µg/L.

4.2.4.7 Porewater

Arsenic was analyzed in 16 unfiltered porewater samples collected from 14 locations at the Rhône-Poulenc site in 2004 and in 15 porewater samples collected throughout the LDW during the EPA SI, as shown on Map 4-12a. Detected concentrations of arsenic in porewater samples are shown on Maps 4-12b through 4-12d. Total arsenic was detected in 12 of the 15 porewater samples collected during the EPA SI at concentrations ranging from 26 to 114 µg/L, with a mean concentration of 50 µg/L (Table 4-50). Arsenic concentrations in porewater samples are compared with WQC in Section 4.2.2 (Table 4-22).

Table 4-50. Arsenic concentrations in EPA SI porewater samples

Sampling Location	River Mile	Total Arsenic Concentration (µg/L)[a]
DR055	0.1	63
DR038	0.4	67
DR018	1.0	59
DR096	1.7	74
DR147	1.9	93

Sampling Location	River Mile	Total Arsenic Concentration (µg/L)[a]
DR133	2.0	43
DR109	2.1	103
DR140	2.4	10 U
DR181	2.9	34
DR228	3.4	31
DR260	4.1	36
DR244	4.2	114
DR262	4.2	26
DR298	5.3	10 U
DR301	5.4	30 U

EPA – US Environmental Protection Agency
SI – site inspection

4.2.4.8 Summary of arsenic data

Arsenic concentrations in surface sediment ranged from 1.2 mg/kg dw to 1,100 mg/kg dw; the 95th and 50th percentile concentrations calculated from the RI baseline dataset were 30 and 15 mg/kg dw, respectively. The highest concentration (1,100 mg/kg dw) was detected between RM 3.7 and RM 3.8 on the east side of the navigation channel. Surface sediment samples collected from several other areas, including from RM 0.4 to RM 0.7 on the east side and from RM 1.3 to RM 1.5 on the west side, had high arsenic concentrations (i.e., greater than the 95th percentile).

Areas with relatively high arsenic concentrations in surface sediment generally also had high concentrations in subsurface sediment. Specific areas with high subsurface concentrations were: 1) Slip 3 (2,000 mg/kg dw), 2) between RM 1.3 and RM 1.4 (1,890 mg/kg dw), 3) between RM 3.7 and RM 3.8 on the eastern shoreline (707 mg/kg dw), 4) Slip 1 (170 mg/kg dw), and 5) near RM 0.1 along the eastern shoreline (270 mg/kg dw). In all of these areas, peak arsenic concentrations were detected at depth within the cores, except for the core collected between RM 3.7 and RM 3.8, which had a peak concentration in the uppermost interval of the core.

In tissue, mean total arsenic concentrations were highest in depurated softshell clams (6.803 mg/kg ww), Dungeness crab tissue (5.5 mg/kg ww in edible meat and 5.2 mg/kg ww in whole-body samples), and in English sole fillet tissue (5.255 mg/kg ww with skin and 11 mg/kg ww without skin). Soft-shell clams had the highest mean inorganic arsenic concentrations (2.27 and 3.37 mg/kg ww); mean inorganic arsenic concentrations in other tissue types were ≤ 0.24 mg/kg ww.

Regression analyses showed a significant and strong positive relationship between log-transformed total arsenic concentrations in benthic invertebrate tissue and co-located samples ($R^2 = 0.78$, $p < 0.0005$). The relationship between inorganic arsenic concentrations in clam tissue and total arsenic concentrations in co-located sediment

using both the 2004 and 2007 data was considered too uncertain to provide a reliable estimate of the tissue-sediment relationship (see Section 8.3.2).

In surface water, mean dissolved and total arsenic concentrations were higher at the two downstream locations (RM 1.1 and RM 1.9), with concentrations ranging from 0.806 to 0.931 µg/L, than at the upstream location at RM 4.9 (with concentrations ranging from 0.319 to 0.493 µg/L). The highest dissolved arsenic concentrations in seep water (72.4 and 253 µg/L) were detected near RM 1.5 on the west side and in Slip 1, respectively. These areas also had high arsenic concentrations in surface sediment. Total arsenic concentrations in porewater samples collected from 15 locations throughout the LDW ranged from 26 to 114 µg/L.

4.2.5 cPAHs

This section summarizes the nature and extent of cPAH concentrations in surface sediment, subsurface sediment, tissue, and surface water. cPAHs were detected in one porewater sample but were not detected in any seep water samples. Porewater results are presented for individual PAH compounds in Section 4.2.9.6. Total cPAH concentrations in sediment, tissue, and surface water (estimated from SMPD samples) were calculated based on concentrations of seven individual PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(a)anthracene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and chrysene) and their carcinogenic potency relative to benzo(a)pyrene, using PEFs from California EPA (California EPA 1994) as described in Section 4.1.4 and in Appendix E, Section E3. None of the individual cPAH compounds were detected in seep water samples. cPAHs were detected in one porewater sample (data are presented in Section 4.2.9.6). Data for individual and total PAHs are summarized in Section 4.2.9.

4.2.5.1 Surface sediment

Surface sediment samples from 828 of the 1,365 locations in the RI baseline dataset were analyzed for at least one individual cPAH compound. Most of the 828 samples were analyzed for all cPAH compounds; samples from 17 locations were analyzed for only a subset of the individual cPAH compounds.[82] At least one cPAH compound was detected in 94% of sediment samples analyzed for PAHs, with cPAH concentrations ranging from 9.7 to 11,000 µg/kg dw (Table 4-51). The highest RLs (ranging from 65 to 130 µg/kg dw) were from samples collected in 1995. More sensitive analytical methods (e.g., EPA 8270-SIM) were used for recent data collection efforts, achieving RLs of 45 µg/kg dw or lower. The wide range of RLs in the surface sediment dataset for cPAHs is attributed to the use of different analytical methods (EPA 8270 full-scan or EPA 8270-SIM) and required analytical dilutions for some samples.

[82] The cPAHs in the total cPAH calculation always included at least five cPAH compounds.

Table 4-51. Summary of surface sediment data for cPAHs

Chemical	Detection Frequency		Concentration (µg/kg dw)[a]			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[b]	Range of Non-Detects[c]
cPAHs	780/828	94	9.7 J	11,000	500	9.0 – 130

[a] Total cPAHs were calculated by summing the products of concentrations and compound-specific PEFs for individual cPAH compounds, as discussed in detail in Appendix E, Section E.3.

[b] Calculated mean concentration is the average of detected concentrations and one-half the RL for non-detected results.

[c] Non-detect values were calculated for samples with no detected cPAH compounds. Non-detect values represent the sum of one-half the RL multiplied by the PEF for each compound.

cPAH – carcinogenic polycyclic aromatic hydrocarbon

dw – dry weight

J – estimated concentration

PEF – potency equivalency factor

RL – reporting limit

The numerical 95th percentile of cPAH concentrations in the surface sediment dataset was 1,500 µg/kg dw (Table 4-52; Figure 4-25; Map 4-37). Area-based percentiles calculated using IDW interpolation were slightly lower than the numerical percentiles (Table 4-52; Map 4-38).

Table 4-52. Percentiles of cPAH concentrations in LDW sediment collected from RM 0.0 to RM 6.0

Method	Concentration (µg/kg dw)[a, b]				
	Entire Dataset	25TH Percentile	50TH Percentile	75TH Percentile	95TH Percentile
Area-based	380 (SWAC)	130	260	460	1,100
Numerical	500 (mean)	100	260	540	1,500

[a] Total cPAHs were calculated by summing the products of concentrations and compound-specific PEFs for individual cPAH compounds, as discussed in detail in Appendix E, Section E.3.

[b] The UCL for cPAHs in surface sediment was 570 µg/kg dw using the RI baseline dataset as calculated in Appendix C (Table C.3-8). This UCL is presented as the EPC for the netfishing scenario in the HHRA (Appendix B), which uses the entire surface sediment dataset.

cPAH – carcinogenic polycyclic aromatic hydrocarbon

dw – dry weight

EPC – exposure point concentration

HHRA – human health risk assessment

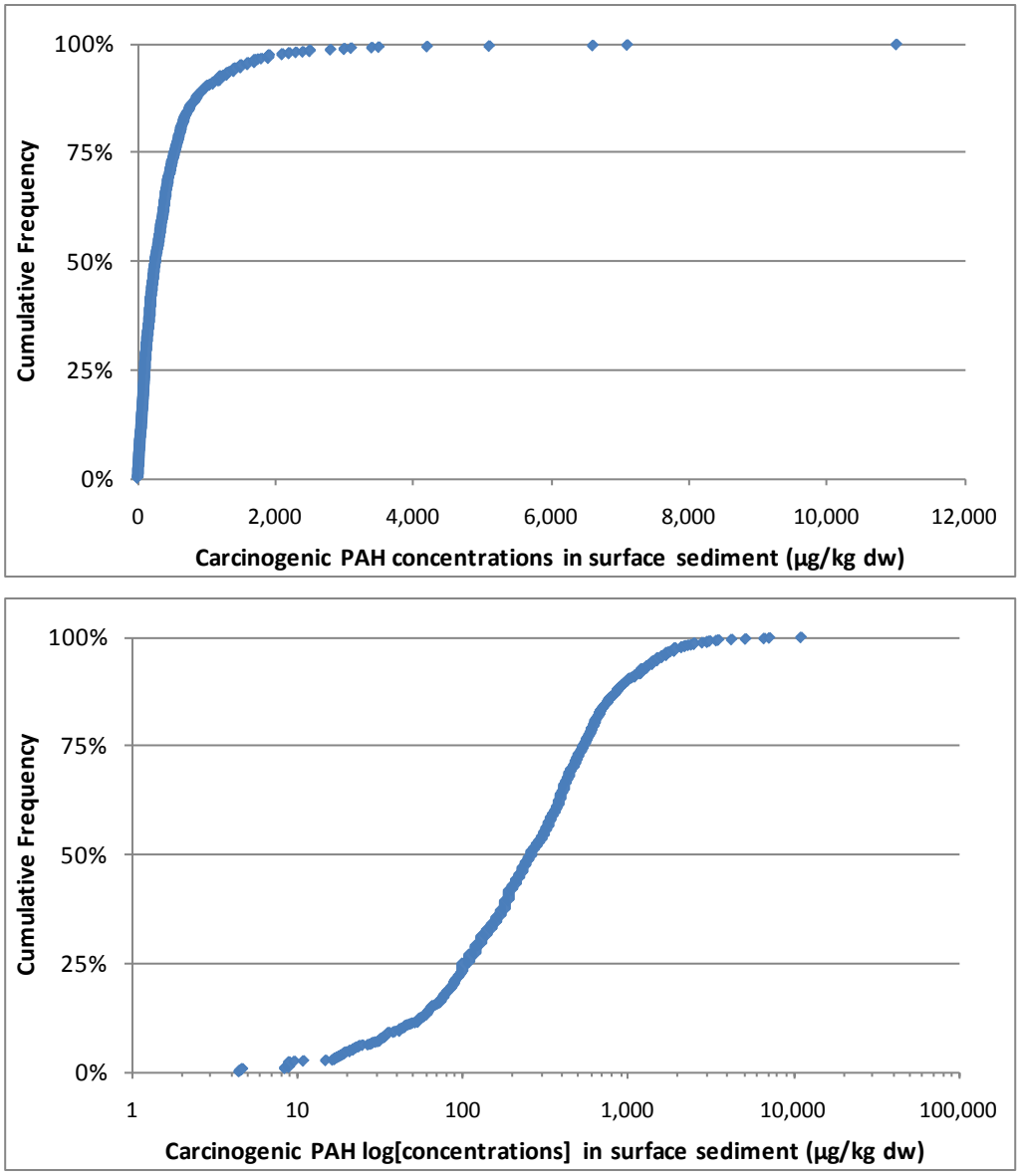
LDW – Lower Duwamish Waterway

RI – remedial investigation

RM – river mile

SWAC – spatially weighted average concentration

UCL – upper confidence limit on the mean



Note: Total cPAHs were calculated by summing the products of concentrations and compound-specific PEFs for individual cPAH compounds, as discussed in detail in Appendix E, Section E.3.

Figure 4-25. Cumulative frequency of cPAH concentrations in surface sediment (arithmetic and log-scale graphs)

The maximum cPAH concentration was detected at a location near RM 3.6 in the T-117 EAA (T117-SE-37-G). Other areas with the highest cPAH concentrations (greater than both the numerical and area-based 95th percentiles) were: 1) in the Slip 4 EAA (7,100 and 5,100 µg/kg dw at C8 and DR178, respectively), 2) in the RM 3.8 EAA on the eastern shoreline (6,600 and 3,500 µg/kg dw at R23 and R22, respectively), 3) near RM 0.6 on the western shoreline (4,200 µg/kg dw at LDW-SS312), 4) at RM 0.0 near Harbor Island (2,200 µg/kg dw at LDW-SS301), and 5) in the Duwamish/Diagonal EAA (2,900 µg/kg dw at DUD005). Other sample locations or areas with cPAH

concentrations greater than the numerical or area-based 95th percentiles are shown on Maps 4-37 and 4-38, respectively.

The primary component of the cPAH concentration was benzo(a)pyrene, which accounted for 66% of the carcinogenic potency of PAHs based on an average in all surface sediment samples (standard deviation of 7%). Benzo(b)fluoranthene accounted for an average of 9% of the carcinogenic potency of PAHs (standard deviation of 3%), and the remaining five individual cPAHs each accounted for 7% or less of the carcinogenic potency of PAHs.

Forty-four locations were resampled and analyzed for cPAHs between 2004 and 2006 at locations within 10 ft of the original samples;[83] most of the original samples were collected in 1997 or 1998. Of the 44 resampled surface sediment locations, cPAH concentrations decreased during this 6-to-9-year time period at 34 locations (77%), increased at 4 locations (9%), and were indistinguishable from the initial concentration at 6 locations (14%)[84] (Table 4-53; Map 4-39). The highest increase in cPAH concentration (1,830 µg/kg dw) was located in Slip 6.[85]

Table 4-53. Difference in chemical concentrations of cPAHs at resampled locations sorted by concentration difference

River Mile	Sampling Location ID		Sampling Date		Concentration (µg/kg dw)[a]		
	Initial	Resampled	Initial	Resampled	Initial	Resampled	Difference
4.2	R40	LDW-SS127	10/13/1997	1/20/2005	31,000	640	-30,360
4.2	R42	LDW-SS129	10/13/1997	1/20/2005	8,600	860	-7,740
4.2	R45	LDW-SS130	10/16/1997	1/20/2005	4,800	370	-4,430
3.8	DR187	LDW-SS115	8/27/1998	1/25/2005	5,600	2,400	-3,200
2.8	DR175	LDW-SS94	8/20/1998	1/21/2005	2,000	100	-1,900
1.0	DR019	LDW-SS32	8/17/1998	1/18/2005	2,100	340	-1,760
1.0	DR020	LDW-SS31	8/17/1998	1/21/2005	1,900	600	-1,300
1.3	DR053	LDW-SS44	8/31/1998	1/21/2005	1,700 J	670	-1,030
1.0	DR087	LDW-SS37	8/12/1998	1/18/2005	1,200	210	-990
1.7	DR097	LDW-SS63	8/20/1998	1/21/2005	1,000	190	-810
1.3	SS-2	LDW-SS48	8/17/1993	1/18/2005	2,160 J	1,400	-760

[83] The older data within 10 ft of the newer sample were excluded from the baseline dataset, as described in Section 4.1.2.1.

[84] Concentration differences at these locations were within the range of analytical variability (≤ 25% increase or decrease compared to the initial concentration).

[85] Information on heterogeneity of cPAHs in sediment related to sample homogenization and laboratory variability is provided by field duplicate samples (i.e., sample splits from a grab sample after homogenization). The relative percent difference in cPAH concentrations between paired field duplicate samples in the RI (n = 11) ranged from 13 to 156%, with an average of 48%.

River Mile	Sampling Location ID		Sampling Date		Concentration (µg/kg dw)[a]		
	Initial	Resampled	Initial	Resampled	Initial	Resampled	Difference
0.1	K-07	LDW-SS4	9/30/1991	1/17/2005	1,000 J	270	-730
1.4	SS-3	LDW-SS49	8/17/1993	1/26/2005	1,080	400	-680
0.2	DR035	LDW-SS12	8/11/1998	1/17/2005	840	200	-640
0.3	DUD042	LDW-SS17	11/11/1995	1/24/2005	1,080 J	440	-640
1.4	DR065	LDW-SS52	8/17/1998	1/25/2005	700	160	-540
1.5	DR123	LDW-SS57	9/14/1998	1/24/2005	770	350 J	-420
0	K-11	LDW-SS1	9/30/1991	1/17/2005	530 J	130	-400
2.1	DR106	LDW-SS76	8/19/1998	1/20/2005	510	110	-400
1.4	DR160	LDW-SS51	8/12/1998	1/18/2005	540	170	-370
1.4	SS-4	LDW-SS55	8/17/1993	1/24/2005	559	190	-369
3.7	SD-323-S	LDW-SS110	8/17/2004	1/25/2005	600	250	-340
0.2	K-05	LDW-SS10	10/14/1991	1/17/2005	800 J	480	-320
0.3	DR079	LDW-SS15	8/24/1998	1/17/2005	460	140	-320
1.4	DR028	B4b	8/17/1998	8/28/2004	600	300	-300
0.9	DR021	LDW-SS319	8/17/1998	10/4/2006	830	560 J	-270
4.7	DR271	LDW-SS148	9/15/1998	3/9/2005	430	230	-200
3.9	R30	LDW-SS119	10/11/1997	1/19/2005	420	260	-160
1.2	DR088	LDW-SS40	8/31/1998	1/18/2005	230	95	-135
0.9	DR085	LDW-SSB2b	8/31/1998	3/11/2005	390	260	-130
1.9	DR131	LDW-SS70	8/13/1998	1/21/2005	500	410	**-90**
3.1	DR198	LDW-SS102	8/20/1998	1/24/2005	150	61	-89
3.2	DR202	LDW-SS104	8/27/1998	1/25/2005	130	52 J	-78
4.3	DR286	B10b	8/26/1998	8/19/2004	100	24 J	-76
2.0	R7	LDW-SS75	10/15/1997	1/21/2005	170	130	**-40**
3.8	R24	LDW-SS117	10/10/1997	1/20/2005	100	78	**-22**
3.7	R21	LDW-SS113b	10/9/1997	1/20/2005	190	190	**0**
1.4	DR030	LDW-SS50	8/17/1998	1/24/2005	400	410	**10**
4.1	DR238	LDW-SS125	8/27/1998	1/20/2005	160	170	**10**
4.1	A11-05	LDW-SS126	8/18/1994	1/20/2005	130	180	**50**
0	DR076	LDW-SS5	8/24/1998	1/17/2005	18	89	71
2.2	DR113	LDW-SS81	8/19/1998	3/8/2005	140	270	130
3.7	DR186	LDW-SS111	8/27/1998	1/19/2005	1,200	1,900	700
4.2	DR242	SB-1	8/24/1998	8/25/2004	470 J	2,300 J	1,830

Note: Concentrations in **bold** were within the range of analytical variability (≤25% increase or decrease compared with the initial concentration). All seven cPAH compounds were analyzed in all samples presented in this table.

[a] Total cPAHs were calculated by summing the products of concentrations and compound-specific PEFs for individual cPAH compounds, as discussed in detail in Appendix E, Section E.3.

cPAH – carcinogenic polycyclic aromatic hydrocarbons
dw – dry weight
ID – identification
J estimated concentration

To determine if cPAH concentrations were significantly different at locations that were resampled (i.e., if the mean difference between the paired concentrations was greater than zero), a non-parametric, paired t-test (Wilcoxon signed-rank test) was used. The test was run separately for each reach of the LDW (as defined in the STM) and for the entire LDW. Data were not included for locations that were sampled less than six years apart.

When the data were analyzed by reach of the LDW, the differences between initial and resampled cPAH concentrations were significant at the 95% confidence level in the reach between RM 0.0 and RM 2.2 (Table 4-54; Figure 4-26). When data were analyzed for the entire LDW, differences between the initial and resampled cPAH concentrations were significant at the 95% confidence level.

Table 4-54. Results of statistical analyses of differences in cPAH concentrations in surface sediment at resampled locations

Reach of the LDW	n[a]	Mean Concentration (µg/kg dw)[b]		Significance (p value)
		Initial	Resampled	
RM 0.0 to RM 2.2	27	820	330	**< 0.005**
RM 2.2 to RM 4.0	8	1,200	630	0.13
RM 4.0 to RM 4.8	8	5,700	600	0.16
Entire LDW	43	1,800	440	**< 0.005**

[a] One location (SD-323-S) was not included because it was resampled less than 1 year after the initial sample was collected.

[b] Total cPAHs were calculated by summing the products of concentrations and compound-specific PEFs for individual cPAH compounds, as discussed in detail in Appendix E, Section E.3.

cPAH – carcinogenic polycyclic aromatic hydrocarbon

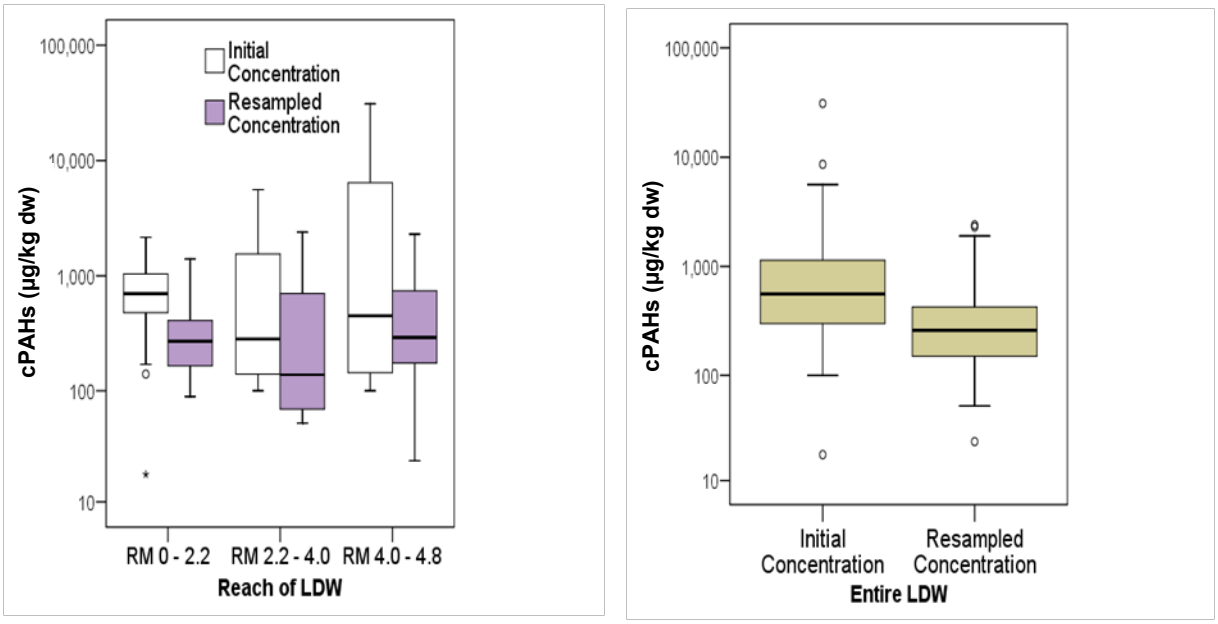
dw – dry weight

LDW – Lower Duwamish Waterway

n – number of samples

RM – river mile

Bold identifies p values that are significant at the 95% confidence level.



Note: Total cPAHs were calculated by summing the products of concentrations and compound-specific PEFs for individual cPAH compounds, as discussed in detail in Appendix E, Section E.3. The boxes indicate the 25th and 75th percentiles within which 50% of the data lie. The length of this box indicates the interquartile range (IQR). The line in the center of the box is the 50th percentile (median). The whiskers of the box plot indicate the maximum and minimum values from the dataset that are within 1.5 IQRs of the 25th and 75th percentile values. Outliers are indicated by a circle and have a value between 1.5 and 3 of the IQR from the upper or lower edge of the box (75th or 25th percentile). Extreme values are indicated by an asterisk and have a value > 3 times the IQR from the 75th or 25th percentile. One location (SD-323-S) was not included because it was resampled less than 1 year after the initial sample was collected.

Figure 4-26. Differences in cPAH concentrations in surface sediment at resampled locations

4.2.5.2 Subsurface sediment

Subsurface sediment cores were sampled at various intervals during the different sampling events. To calculate summary statistics, data were categorized according to specified intervals, as described for total PCBs in Section 4.2.3.2.

cPAHs were detected in 83% of the subsurface samples in which they were analyzed, at concentrations ranging from 18 to 7,000 µg/kg dw (Table 4-55). Most of the subsurface cPAH data were collected in the top 4 ft of the sediment cores. cPAH data in the 1- and 2-ft intervals for the top 6 ft of sediment are shown on Maps 4-40a through 4-40c. Data on these maps and in Table 4-55 are discussed in detail for individual cores in the following section (Section 4.2.5.3).

Table 4-55. Summary of subsurface sediment data for cPAHs

Sampling Interval (ft)	Detection Frequency		Concentration (µg/kg dw)[a, b]		
	Ratio	%	Minimum Detect	Maximum Detect	Non-Detect or Range of Non-Detects[c]
All Data					
Any interval	252/304	83	18	7,000	3.9 – 400
1-ft Intervals[d]					
0 to 1	60/64	94	19 J	4,400	18 – 400
1 to 2	34/45	76	19 J	7,000	17 – 35
2 to 3	6/10	60	18	530	18 – 90
3 to 4	2/9	22	19 J	52 J	17 – 36
4 to 5	1/1	100	75 J	75 J	na
2-ft Intervals[d]					
0 to 2	71/74	96	41.6 J	4,900	18
2 to 4	56/73	77	18 J	5,600	17 – 35
4 to 6	9/10	90	54.1	1,300	48
6 to 8	5/5	100	48	4,000 J	na
8 to 10	4/5	80	93 J	290	4.89

Note: Data included in the subsurface dataset are described in Section 4.1.2.2; subsurface sediment samples collected from areas that were subsequently dredged are not summarized in this table because they do not represent existing conditions.

[a] Mean concentrations were not calculated because sampling was generally focused in contaminated areas, resulting in a non-random sampling pattern, which is not likely representative of the entire LDW.

[b] Total cPAHs were calculated by summing the products of concentrations and compound-specific PEFs for individual cPAH compounds, as discussed in detail in Appendix E, Section E.3.

[c] Non-detect values were calculated for samples with no detected cPAH compounds. Non-detect values represent the sum of one-half the RL multiplied by the PEF for each compound.

[d] For the calculation of summary statistics in this table, actual sampling intervals were rounded to the nearest foot. The data for each interval were then assigned to the 1- or 2-ft sampling category that best approximated the actual sampling interval. If there were data for two 1-ft intervals at a particular location, the concentrations were averaged to obtain a calculated concentration for the corresponding 2-ft interval. Some of the subsurface data were collected from intervals other than 1 or 2 ft; therefore, the detection frequency ratio for "any interval" may reflect data for intervals not included in these categories.

cPAH – carcinogenic polycyclic aromatic hydrocarbon
dw – dry weight
J – estimated concentration
na – not applicable
nc – not calculated
PEF – potency equivalency factor
RL – reporting limit

4.2.5.3 Surface and subsurface sediment patterns for cPAHs

cPAH concentrations in surface and subsurface sediment were evaluated to determine whether peak concentrations were detected in the uppermost interval of sediment cores or at depth. The specific depths of peak concentrations within sediment cores were also evaluated to assess patterns (Maps 4-41a through 4-41e). The percentiles of cPAH concentrations in sediment discussed in this section were calculated on an area basis using the method described in the introduction to Section 4.2 and the results of

the IDW interpolation. As discussed in Section 4.2.3.3 for total PCBs, although there is some uncertainty in the interpretation of patterns and spatial relationships between cPAH concentrations in surface and subsurface data, this analysis provides one line of evidence to understand the conceptual site model for cPAHs in the LDW. Specific surface sediment locations were noted in the discussion if: 1) cPAH concentrations were higher in surface sediment samples than in sampling intervals of co-located subsurface cores, 2) the cPAH concentration in surface sediment was greater than the 75th percentile concentration, and 3) the cPAH concentration in surface sediment was at least 25% greater than the highest arsenic concentration in any subsurface interval. cPAH concentrations in all co-located surface and subsurface sediment samples are presented on Maps 4-41a through 4-41e. Maps 4-42a and 4-42b show only the subsurface sediment locations with co-located surface sediment data.

RM 0.0 to RM 1.0

In this reach, cPAH concentrations in surface and subsurface sediment were variable; many surface and subsurface sediment samples from RM 0.0 to RM 1.0 had cPAH concentrations higher than the area-based 75th percentile of 460 µg/kg dw. Areas with the highest cPAH concentrations (i.e., greater than the area-based 95th percentile of 1,100 µg/kg dw) in both surface and subsurface sediment included RM 0.4 to RM 0.6 (the Duwamish/Diagonal EAA), near RM 0.1 on the west side of the navigation channel, near RM 0.5 on the western shoreline, and in Slip 1 (Map 4-41a).

Six cores were collected north of RM 0.3. Three of these cores, along the eastern shoreline and near the navigation channel, had relatively low cPAH concentrations in subsurface sediment. Two of the cores, one near Harbor Island and one near RM 0.3 on the west side, had higher cPAH concentrations, with peak values detected in the uppermost interval (620 µg/kg dw at LDW-SC1 and 560 µg/kg dw at LDW-SC6). The remaining core (LDW-SC5), near RM 0.1, had a peak cPAH concentration of 1,900 µg/kg dw at depth (in the 1-to-2.2-ft interval).

In the vicinity of the Duwamish/Diagonal EAA, the highest surface and subsurface cPAH concentrations were generally located near RM 0.45. Three of the four cores with high subsurface cPAH concentrations (i.e., greater than the area-based 95th percentile) in the vicinity of the EAA were collected near RM 0.45; two of the cores in this area had peak concentrations in the uppermost interval (1,700 µg/kg dw at DR008 and 1,420 µg/kg dw at DUD256), and one core had a peak cPAH concentration at depth (1,630 µg/kg dw at DUD254). The depth of the peak in the fourth core (1,560 µg/kg dw at DUD258 near RM 0.5) is not known because only one interval (0 to 3 ft) was analyzed. The other cores collected within and close to the EAA had peak cPAH concentrations ranging from 35 to 940 µg/kg dw. Some of these peak cPAH concentrations were in the uppermost intervals, and some were at depth, with no clear spatial pattern. At two sampling locations (LDW-SC7 at RM 0.4 and DUD027 at RM 0.6), the cPAH concentrations (1,010 and 860 µg/kg dw, respectively) in co-located surface sediment samples were higher than the peak concentrations in the

associated subsurface cores. There is high uncertainty associated with interpretation of data from most of the samples collected within the Duwamish/Diagonal EAA because they were collected at 3-ft intervals.

In Slip 1, the core collected at the head of the slip (LDW-SC17) had a relatively high cPAH concentration (2,400 µg/kg dw) at an interval of 6 to 8.6 ft; concentrations were also high (1,800 µg/kg dw) in the uppermost interval. In a core collected near the mouth of the slip (LDW-SC16), the peak cPAH concentration (1,300 µg/kg dw) was detected at depth (in the 4-to-6-ft interval). Peak cPAH concentrations were also at depth (in the 2-to-4-ft interval) in two other cores collected at the mouth of Slip 1 (550 µg/kg dw at LDW-SC15 and 760 µg/kg dw at DR021); concentrations in the uppermost intervals of these cores were only slightly lower. The core collected just downstream from Slip 1 (LDW-SC13) had a peak concentration of 1,200 µg/kg dw in the 2-to-4-ft interval.

At the remaining locations between RM 0.0 and RM 1.0,[86] some of the peak cPAH concentrations were at depth, and some were in the uppermost interval; there were no notable concentration gradients within these cores. Peak cPAH concentrations in these cores ranged from 140 to 590 µg/kg dw, except for one core (LDW-SC11), located between RM 0.5 and RM 0.6 on the western shoreline, which had a peak cPAH concentration of 4,400 µg/kg dw in the uppermost interval (0 to 0.8 ft). The deeper intervals of this core did not have detectable cPAH concentrations. At two sampling locations near RM 0.6 (LDW-SC12 and DR044), the cPAH concentration was higher in the co-located surface sediment sample (1,600 µg/kg dw) that was associated with both of these subsurface samples.

In summary, cPAH concentrations in surface and subsurface sediment in this section of the LDW were variable; many subsurface cores had cPAH concentrations greater than the area-based 75th percentile. In Slip 1, high cPAH concentrations were detected primarily at depth within the cores. At other locations with high cPAH concentrations (i.e., greater than the area-based 95th percentile), peak concentrations were in the uppermost intervals at four locations and at depth at two locations.

RM 1.0 to RM 2.2

Concentrations of cPAHs were variable in both surface and subsurface sediment in this section of the LDW. Along the eastern shoreline between RM 1.0 and RM 1.5, subsurface cPAH concentrations were relatively low (≤ 610 µg/kg dw) in cores that were sectioned into more than one subsurface interval, with the exception of location LDW-SC23, which had a high cPAH concentration (4,600 µg/kg dw) in the 3-to-3.5-ft interval (Map 4-41b). The core from location LDW-SC18 near RM 1.0 had a peak cPAH

[86] The remaining cores were located at RM 0.35 on the western shoreline (one core), near RM 0.5 on the western shoreline (one core), in the channel (three cores), north of Kellogg Island (two cores), and south of Kellogg Island (one core).

concentration in subsurface sediment of 510 µg/kg dw in the 0-to-1-ft interval, compared with a relatively high cPAH concentration in the co-located surface sediment sample (3,000 µg/kg dw).

Along the western shoreline between RM 1.0 and RM 1.3, two cores were collected; peak cPAH concentrations (500 µg/kg dw in both cores) were detected at depth (2 to 4 ft) in the core near RM 1.0 and in the uppermost interval in the core near RM 1.2.

Four cores collected between RM 1.3 and RM 1.4 on the west side of the navigation channel had high cPAH concentrations at depth (Map 4-41b). In two of these cores (LDW-SC25 and DR054), the peak cPAH concentrations (980 and 2,000 mg/kg dw, respectively) were in the 2-to-4-ft interval. In the other two cores (LDW-SC26 and LDW-SC28), the peak cPAH concentrations (4,000 and 1,400 µg/kg dw, respectively) were within the approximate interval of 6 to 8 ft. Between RM 1.4 and RM 1.5, four cores were sampled at only one interval each, with concentrations ranging from 280 to 620 µg/kg dw; this area was dredged after the cores were collected. In the only other core collected between RM 1.3 and RM 1.5 (LDW-SC29), cPAH concentrations were relatively low (≤ 150 µg/kg dw).

Between RM 1.5 and RM 1.7 on the east side of the navigation channel in an area that has been dredged, cPAH concentrations in subsurface sediment were generally less than the 75th percentile, and most locations were sampled at only one relatively large interval (generally greater than 3 ft). Therefore, peak cPAH concentrations could not be determined at these locations. Similarly, in the navigation channel, subsurface cPAH concentrations were less than the 75th percentile, and samples were collected at only one relatively large interval of 4 ft.

The subsurface sample with the highest cPAH concentration in the entire LDW (7,000 µg/kg dw) was collected from the head of Slip 3, in the 1-to-2-ft interval. The concentration in the uppermost interval (0 to 1 ft) was lower (2,800 µg/kg dw), as were surface sediment concentrations based on IDW interpolation (≤ 1,100 µg/kg dw).

cPAH concentrations in the remaining nine core locations on the east and west sides of the navigation channel between RM 1.7 and RM 2.2 were ≤ 750 µg/kg dw. Peak concentrations were at depth, except at locations LDW-SC39 and LDW-SC36, which had relatively low peak concentrations (260 and 110 µg/kg dw, respectively) in the uppermost interval.

In summary, in this section of the LDW, peak cPAH concentrations were detected at depth at all of the locations that had high subsurface cPAH concentrations (i.e., greater than the 95th percentile), and at most of the locations that had cPAH concentrations greater than the 75th percentile.

RM 2.2 to RM 3.0

In the section of the LDW between RM 2.2 and RM 3.0, cPAH concentrations were generally variable, with concentrations between the 25th and 95th percentile in both

surface and subsurface sediment (Map 4-41c). The highest concentrations in both surface and subsurface sediment were located in Slip 4 and near RM 2.7 on the west shoreline.

In Slip 4, subsurface cPAH concentrations ranged from 280 to 3,400 µg/kg dw in four cores sampled over relatively large intervals (ranging from the surface to approximately 3 to 4 ft); thus, the depth of peak cPAH concentrations could not be determined. This area was subsequently dredged. Just downstream from Slip 4, a peak cPAH concentration of 1,000 µg/kg dw was detected at depth (in the 2-to-4-ft interval of core LDW-SC45).

Four cores were collected on the east side of the navigation channel between RM 2.2 and RM 2.7. cPAH concentrations were very low in one core (≤ 20 µg/kg dw at LDW-SC43). In the other three cores, peak cPAH concentrations ranged from 120 to 550 µg/kg dw; peak cPAH concentrations were detected at depth within each core.

In five cores collected within the navigation channel, cPAH concentrations were ≤ 290 µg/kg dw. Samples were collected from one interval in four of these cores. In the remaining core (DR171), cPAH concentrations were similar (250 to 290 µg/kg dw) in the uppermost intervals and at depth.

On the west side of the navigation channel, the highest subsurface cPAH concentrations were detected between RM 2.6 and RM 2.8. In four of the five cores collected in this area, only one interval (approximately 0 to 3 ft) was sampled in each core; cPAH concentrations in these cores ranged from 340 to 2,800 µg/kg dw. The area was dredged after these cores were collected. The remaining core (LDW-SC46) was collected after dredging. The peak cPAH concentration (1,200 µg/kg dw) at this location was detected at depth (in the 1-to-2-ft interval). However, the cPAH concentration was highest (3,100 µg/kg dw) in the co-located surface sediment sample at this location.

The remaining five cores on the west side of the navigation channel between RM 2.2 and RM 2.6 had subsurface cPAH concentrations of ≤ 570 µg/kg dw. Only two of these cores were sampled at more than one interval. The peak cPAH concentration was at depth in core DR137 (290 µg/kg dw in the 2-to-4-ft interval) and in the uppermost interval in core LDW-SC40 (51 µg/kg dw in the 0-to-1.3-ft interval).

In summary, all of the cores sampled at more than one interval and with cPAH concentrations ≥ 290 µg/kg dw had peak cPAH concentrations at depth. The location of the peak cPAH concentration is unknown in many cores collected between RM 2.2 and RM 3.0 because they were sampled at only one interval.

RM 3.0 to RM 4.0

In general, cPAH concentrations in surface and subsurface sediment between RM 3.0 and RM 4.0 were less than or equal to the area-based 50th percentile (260 µg/kg dw) (Map 4-41d). Subsurface cPAH concentrations were ≤ 460 µg/kg dw at all locations

except two. Of the eight locations east of the navigation channel (including four locations within the Boeing Plant 2/Jorgensen Forge EAA), peak concentrations were in the uppermost interval at three locations: near RM 3.3 (1,500 µg/kg dw at SD-04107), near RM 3.8 (2,200 µg/kg dw at LDW-SC51), and near RM 3.8 (360 µg/kg dw at LDW-SC50a). At the other five locations on the east side of the navigation channel, subsurface cPAH concentrations ranged from 18 to 460 µg/kg dw. Some of the peak cPAH concentrations were at depth, and some were in the uppermost interval at these locations. Two of the eight locations east of the navigation channel (LDW-SC50a and SB-04117) had cPAH concentrations in co-located surface sediment samples (1,800 and 2,500 µg/kg dw, respectively) that were at least 25% greater than those in subsurface intervals.

Eight cores were collected within the navigation channel between RM 3.0 and RM 4.0. Subsurface cPAH concentrations in these cores ranged from 33 to 270 µg/kg dw. The locations of peak cPAH concentrations in six of these cores are unknown because samples were collected from only one interval (either 0 to 2 ft or 0 to 4 ft). At the remaining two locations, the peak cPAH concentration of 40 µg/kg dw was detected within the uppermost interval (0 to 1 ft) of core LDW-SC48 and the peak concentration of 270 µg/kg dw was detected at depth (1-to-2-ft interval) in core LDW-SC49.

On the west side of the navigation channel, cPAH concentrations ranged from 18 to 340 µg/kg dw in cores collected from 12 locations. At two of these locations near RM 3.4, cPAHs were not detected in samples collected from the 0-to-4-ft interval. At five locations between RM 3.5 and RM 3.7 (in the T-117 EAA), there were no data for the uppermost intervals; cPAH concentrations in the samples collected at depth were ≤ 97.5 µg/kg dw. At two of the locations in the T-117 EAA (T117-SE-25-SC and T117-SE-37-SC), cPAH concentrations were much higher in co-located surface sediment samples (1,200 and 11,000 µg/kg dw, respectively) than in subsurface intervals. At the remaining five locations, where samples were collected at more than one interval, peak cPAH concentrations were ≤ 340 µg/kg dw and were detected at depth in four cores and in the uppermost interval in one core (Map 4-41d).

In summary, cPAH concentrations in surface and subsurface sediment were generally less than the 50th percentile in this section of the LDW. At the two locations with the highest cPAH concentrations in subsurface sediment (2,200 and 1,500 µg/kg dw at LDW-SC51 and SD-04107, respectively), peak concentrations were in the uppermost interval within the cores. At other locations where more than one interval was sampled, some peak concentrations were at depth, and some were in the uppermost interval.

RM 4.0 to RM 5.0

Most of the cPAH concentrations in both surface and subsurface sediment between RM 4.0 and RM 5.0 were less than the 50th percentile (230 µg/kg dw), except in and around Slip 6 and upstream of RM 4.6 (Map 4-41e).

In Slip 6, surface and subsurface cPAH concentrations were generally highest toward the head of the slip. Seventeen of the 19 subsurface sediment cores within the slip and downstream from the slip on the east side of the navigation channel were sampled at relatively shallow single intervals (either 0.33 to 0.69 ft or 0.33 to 0.82 ft); therefore, insufficient data were available to evaluate the depth of peak cPAH concentrations at these locations. cPAH concentrations in the eight shallow samples from within the slip ranged from 630 µg/kg dw at the mouth of the slip (SB-8) to 2,100 µg/kg dw at the head of the slip (SB-17). Some locations in Slip 6 had higher cPAH concentrations in co-located surface sediment samples than in associated subsurface cores, but only three of the locations (SB-12, SB-3, and SB-5) had concentrations in surface sediment that were both greater than the 75th percentile and at least 25% greater than concentrations in subsurface sediment. cPAH concentrations were generally lower downstream of the slip, ranging from 310 to 880 µg/kg dw. In one of the cores with available data from the head of the slip (LDW-SC53), the peak cPAH concentration (1,200 µg/kg dw) was detected in the uppermost interval (0 to 2 ft). In the other core with available data (DR246), just outside the slip, concentrations were similar in the two intervals (230 and 210 µg/kg dw in the 0-to-2-ft and 2-to-4-ft intervals, respectively).

All cores collected in the navigation channel between RM 4.0 and RM 5.0 were sampled at one interval and had relatively low cPAH concentrations, ranging from 14 to 170 µg/kg dw, except for one. This core (from location "Average of 10-12") had a peak cPAH concentration (1,100 µg/kg dw) in the uppermost interval (0 to 4 ft) and a lower cPAH concentration (57 µg/kg dw) at depth (4-to-11-ft interval).

Ten cores were collected along the west side of the LDW between RM 4.0 and RM 5.0. cPAH concentrations in these cores were less than or equal to the 50th percentile (230 µg/kg dw). Six of these cores were sampled at one interval (approximately 0 to 2 ft) in an area that was subsequently dredged near RM 4.1 (Map 4-41e). In the remaining four cores with available data, three cores had peak cPAH concentrations in the uppermost interval, and one had a peak cPAH concentration at depth; all cPAH concentrations were less than the 50th percentile.

Four cores were collected between RM 4.8 and RM 5.0, three of which were within the Norfolk EAA. The core collected outside the EAA had no detected cPAH concentrations. In the two cores within the EAA (NFK009 and NFK008) and one core just outside the EAA (NFK207), peak concentrations (220, 270, and 1,460 µg/kg dw, respectively) were all in the uppermost interval of the core, within the 0-to-1-ft interval. The area within the Norfolk EAA was dredged and backfilled with clean material after the two cores at NFK009 and NFK008 were collected. The interpolated surface sediment data shown on Map 4-41e reflect post-dredging conditions.

In summary, most of the subsurface cPAH concentrations between RM 4.0 and RM 5.0 were less than the 50th percentile, except in Slip 6 and in the Norfolk EAA, which had concentrations up to 2,100 and 1,460 µg/kg dw, respectively. Of the 11 cores sampled

at more than one interval in this section of the LDW, all but one had the peak concentration in the uppermost interval.

4.2.5.4 Tissue

The tissue dataset for the RI contained cPAH data for 214 composite samples of fish, shellfish, and benthic invertebrates; all of these samples were analyzed for each of the seven individual cPAH compounds. Table 4-56 presents a summary of cPAH concentrations for each tissue type. At least one cPAH compound was detected in 65% of tissue samples. The highest cPAH concentrations were detected in invertebrates (clams, mussels, and benthic invertebrates), with mean concentrations ranging from 15 to 44 µg/kg ww. cPAH concentrations in individual composite samples of all other species were less than 3 µg/kg ww, with the exception one Pacific staghorn sculpin sample with a concentration of 36 µg/kg ww from subarea T3. cPAHs were not detected in any of the other 23 Pacific staghorn sculpin samples, although the RLs for these samples (36 to 360 µg/kg ww) were elevated because analytical dilutions were used to minimize matrix interferences. The Pacific staghorn sculpin samples were analyzed by the same low-level analytical method, EPA 8270-SIM, as the other tissue samples collected in 2004. RLs for historical samples were generally higher than for samples collected in 2004; this uncertainty was discussed in Section B.6.1.1.5 of the HHRA.

Table 4-56. Summary of cPAH data in tissue

Tissue Type	Detection Frequency		Concentration (µg/kg ww)[a]			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[b]	Non-Detect or Range of Non-Detects[c]
Fish, Whole Body						
English sole	18/21	86	0.45 J	2.8	1.6	0.45
Pacific staghorn sculpin	1/24	4	36 J	36 J	130	36 – 360
Shiner surfperch	24/27	89	0.37 J	2.2	3.1	43
Starry flounder	3/3	100	0.47 J	0.66 J	0.59	na
Fish, Fillet						
English sole (with skin)	4/7	57	0.37 J	0.53	0.35	0.45
English sole (without skin)	0/6	0	nd	nd	8.9	6.4 – 29
Pile perch (with skin)	1/1	100	0.43 J	0.43 J	0.43	na
Starry flounder (with skin)	1/1	100	0.64 J	0.64 J	0.64	na
Striped perch (with skin)	1/1	100	0.43 J	0.43 J	0.43	na
Crab, Edible Meat						
Dungeness crab	6/9	67	0.54 J	0.84 J	3.7	0.65 – 29
Slender crab	2/12	17	0.33	0.63 J	0.35	0.65

Tissue Type	Detection Frequency		Concentration (µg/kg ww)[a]			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[b]	Non-Detect or Range of Non-Detects[c]
Crab, Hepatopancreas						
Dungeness crab	2/4	50	0.73 J	0.73 J	6.5	6.2 – 43
Slender crab	4/4	100	0.68 J	0.71	0.70	na
Crab, Whole Body (calc'd)[d]						
Dungeness crab	nc	nc	0.60 JM	2.4 JM	2.6	17
Slender crab	nc	nc	0.45 M	0.67 M	0.65	na
Invertebrates, Whole Body						
Amphipod	0/4	0	nd	nd	22	43
Benthic invertebrates	20/20	100	4.2 J	290 J	44	na
Shellfish						
Mussels, wild (edible meat)	11/22	50	30	33	23	29
Mussels, transplanted (edible meat)	16/34	47	29	35	27	29 – 50
Soft-shell clam (whole body)	14/14	100	6.8	44	15	na

[a] Total cPAHs were calculated by summing the products of concentrations and compound-specific PEFs for individual cPAH compounds, as discussed in detail in Appendix E, Section E.3.

[b] Calculated mean concentration is the average of detected concentrations and one-half the RL for non-detected results.

[c] Non-detect values were calculated for samples with no detected cPAH compounds. Non-detect values represent the sum of one-half the RL multiplied by the PEF for each compound.

[d] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. cPAH concentrations in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data). Detection frequencies were not calculated for these samples because they do not represent individually analyzed samples.

cPAH – carcinogenic polycyclic aromatic hydrocarbon
J – estimated concentration
M – calculated whole-body concentration
na – not applicable
nc – not calculated
nd – not detected
PEF – potency equivalency factor
RL – reporting limit
ww – wet weight

Mean cPAH concentrations by sampling area for the various tissue types and sediment SWACs for the tissue sampling areas are presented on Map 4-43. cPAH concentrations in whole-body English sole samples were significantly lower in Area T4 than in Areas T1 and T2. For shiner surfperch, mean concentrations were significantly lower in Area T4 than in Area T3. In Dungeness crab samples, cPAH concentrations were similar among all areas, except the single sample collected from Area T4 had a higher concentration. The relationships between cPAH concentrations in fish or crabs and sediment were not statistically evaluated. However, cPAH concentrations in English sole and shiner surfperch tissue and sediment (SWAC) were lowest in Area T4 (Map 4-43). There is no apparent relationship between cPAH

concentrations in crab tissue and sediment in the four areas based on the data shown on Map 4-43.

All 14 clam composite tissue samples had detected concentrations of cPAHs. The maximum cPAH concentration in clams (44 µg/kg ww) was detected at location C8 in Slip 4, which had the highest cPAH concentration in sediment co-located with clam tissue samples (7,100 µg/kg ww) (Map 4-43). A detailed evaluation of the cPAH concentrations in clam tissue and co-located sediment did not find a strong relationship (see Section 8.3.3).

The primary component of the cPAH concentration in tissue was benzo(a)pyrene, which accounted for 50% of the carcinogenic potency of PAHs in tissue on average (standard deviation of 10%). Benzo(b)fluoranthene accounted for an average of 20% of the carcinogenic potency of PAHs (standard deviation of 10%), and the remaining five individual cPAHs each accounted for 7% or less of the carcinogenic potency of PAHs.

4.2.5.5 Surface water

Surface water samples collected by King County as part of the KC WQA (King County 1999a) did not contain detectable concentrations of any individual cPAH compounds. Because many organic compounds are not typically detected in ambient grab samples, particularly in the dissolved phase, King County also deployed SPMDs to collect data for selected organic compounds, including PAHs, at 1 and 3 m below the water surface near the Duwamish/Diagonal (RM 0.5) and Brandon (RM 1.1) CSO outfalls, as described in Section 4.1.2.4. Ambient PAH concentrations in water were calculated using the mass of chemicals detected in each SPMD and the chemical-specific partition coefficients between polyethylene and water, which were derived from laboratory experiments conducted at Battelle's Marine Science Laboratory.

Calculated cPAH concentrations from SPMD samples ranged from 0.000055 to 0.00010 µg/L (Table 4-57). Calculated benzo(a)pyrene and benzo(a)anthracene concentrations accounted for an average of 36% and 32%, respectively, of the total carcinogenic potency of PAHs among the four SPMD samples. The remaining five individual cPAH compounds each accounted for an average of 10% or less of the total carcinogenic potency of PAHs. Individual cPAH concentrations in surface water samples are compared with available WQC in Section 4.2.2 (Table 4-20).

Table 4-57. cPAH concentrations calculated from SPMDs deployed near the Duwamish/Diagonal and Brandon CSOs

CSO	Calculated cPAH Concentration (µg/L)[a]	
	1-m Depth	3-m Depth
Duwamish/Diagonal	0.00010	0.000071
Brandon	0.000068	0.000055

[a] Total cPAHs were calculated by summing the products of concentrations and compound-specific PEFs for individual cPAH compounds, as discussed in detail in Appendix E, Section E.3.

cPAH – carcinogenic polycyclic aromatic hydrocarbon

CSO – combined sewer overflow
LDW – Lower Duwamish Waterway
SPMD – semi-permeable membrane device

4.2.5.6 Summary of cPAH data

cPAH concentrations in surface sediment ranged from 9.7 to 11,000 µg/kg dw; the area-based 95th and 50th percentiles calculated from the RI baseline dataset were 1,100 and 230 µg/kg dw, respectively. The highest cPAH concentrations in surface sediment were in the T-117 EAA, in the Slip 4 EAA, in the RM 3.8 EAA on the eastern shoreline, near RM 0.6 on the western shoreline, near RM 0.0 close to Harbor Island, and in the Duwamish/Diagonal EAA.

Areas with the highest cPAH concentrations in subsurface sediment were Slip 3, near RM 1.2 on the east side, near RM 0.5 on the western shoreline, and near RM 1.4 west of the navigation channel. Peak cPAH concentrations were generally detected at depth within cores at locations with more than one interval sampled and with concentrations greater than the area-based 95th percentile (1,100 µg/kg dw). Cores with peak cPAH concentrations detected in uppermost intervals were located at the head of Slip 6, in the Norfolk EAA, near RM 0.5 on the western shoreline, and in some of the cores from the Duwamish/Diagonal EAA.

The highest cPAH concentrations in tissue were detected in clams, mussels, and benthic invertebrates, with mean concentrations ranging from 15 to 44 µg/kg ww. cPAH concentrations detected in individual composite samples of all other species were less than 3 µg/kg ww, with the exception of one Pacific staghorn sculpin sample with a concentration of 36 µg/kg ww. Although low-level analytical methods were used for all tissue samples collected in 2004, RLs were high for Pacific staghorn sculpin samples because analytical dilutions were used to minimize matrix interferences at the discretion of the laboratory for the sake of reducing impact to their analytical equipment. The dilutions resulted in reduced sensitivity of the analysis (i.e., higher RLs) for this subset of samples.

Mean cPAH concentrations in English sole (whole-body tissue) were significantly lower in Area T4 than in Areas T1 and T2. For shiner surfperch, mean concentrations were significantly lower in Area T4 than in Area T3. The relationship between cPAH concentrations in clam tissue and sediment was relatively uncertain (Section 8.3.3).

Grab surface water samples did not contain detectable concentrations of individual cPAH compounds. Concentrations of cPAHs calculated from SPMD samples ranged from 0.000055 to 0.00010 µg/L.

4.2.6 BEHP

This section summarizes the nature and extent of BEHP concentrations in surface sediment, subsurface sediment, tissue, surface water, seep water, and porewater. BEHP is a risk driver chemical for benthic invertebrates; detected concentrations of

BEHP exceeded the SQS in 5.8% and the CSL in 7.1% of surface sediment samples, second only to the number of samples with PCB exceedances.

4.2.6.1 Surface sediment

Surface sediment samples from 832 of the 1,365 locations in the RI baseline dataset were analyzed for BEHP. BEHP was detected in 81% of surface sediment samples analyzed for BEHP, with concentrations ranging from 5.4 to 14,000 µg/kg dw (Table 4-58). The numerical 95th percentile based on BEHP concentrations in the surface sediment dataset was 2,400 µg/kg dw (Table 4-59). The area-based 95th percentile calculated using Theissen polygons (990 µg/kg dw) was less than half of the numerical 95th percentile, because many of the surface sediment samples were collected in more contaminated areas, and are thus not representative of area-wide conditions.

Table 4-58. Summary of surface sediment data for BEHP

Detection Frequency		Unit	Concentration				SQS	CSL
Ratio	%		Minimum Detect	Maximum Detect	Calculated Mean[a]	RL or Range of RLs[b]		
674/832	81	µg/kg dw	5.4	14,000	600	15 – 1,500	na	na
637/764	83	mg/kg OC	0.20	387	25	0.88 – 170	47	78

[a] Calculated mean concentration is the average of detected concentrations and one-half the RL for non-detected results.

[b] RLs are based only on non-detect samples.

BEHP – bis(2-ethylhexyl) phthalate
CSL – cleanup screening level
dw – dry weight
na – not applicable
OC – organic carbon
RL – reporting limit
SQS – sediment quality standards

Table 4-59. Percentiles of BEHP concentrations in LDW surface sediment collected from RM 0.0 to RM 6.0

Method	BEHP Concentration (µg/kg dw)				
	Entire Dataset	25th Percentile	50th Percentile	75th Percentile	95th Percentile
Area-based	380 (SWAC)	84	200	440	990
Numerical	600 (mean)	95	230	490	2,400

BEHP – bis(2-ethylhexyl) phthalate
dw – dry weight
LDW – Lower Duwamish Waterway
RM – river mile
SWAC – spatially weighted average concentration

The majority of locations with the highest BEHP concentrations in surface sediment were between RM 0.4 and RM 0.6 in and near the Duwamish/Diagonal EAA.[87] Other areas with more than one sample with BEHP concentrations greater than the area- based 75th percentile were near RM 2.2 on the west side of the LDW (EAA 2), in Slip 4, and near RM 3.5 on the east side (in the Boeing Plant 2/Jorgensen Forge EAA) (Map 4-44).

BEHP concentrations exceeded the SQS but not the CSL at 48 locations (5.8%) and exceeded the CSL at 59 locations (7.1%) (Table 4-16 in Section 4.2.1). At the remainder of the locations (approximately 87%), BEHP concentrations were less than the SQS (Figure 4-27). Most of the BEHP SQS and CSL exceedances were located within EAAs, particularly between RM 0.4 and RM 0.6, in and around the Duwamish/Diagonal EAA (Map 4-44).

[87] Monitoring data for BEHP concentrations as a function of year are shown for the Duwamish/Diagonal and Norfolk in Appendix I, Sections I.4.1 and I.4.8, respectively.

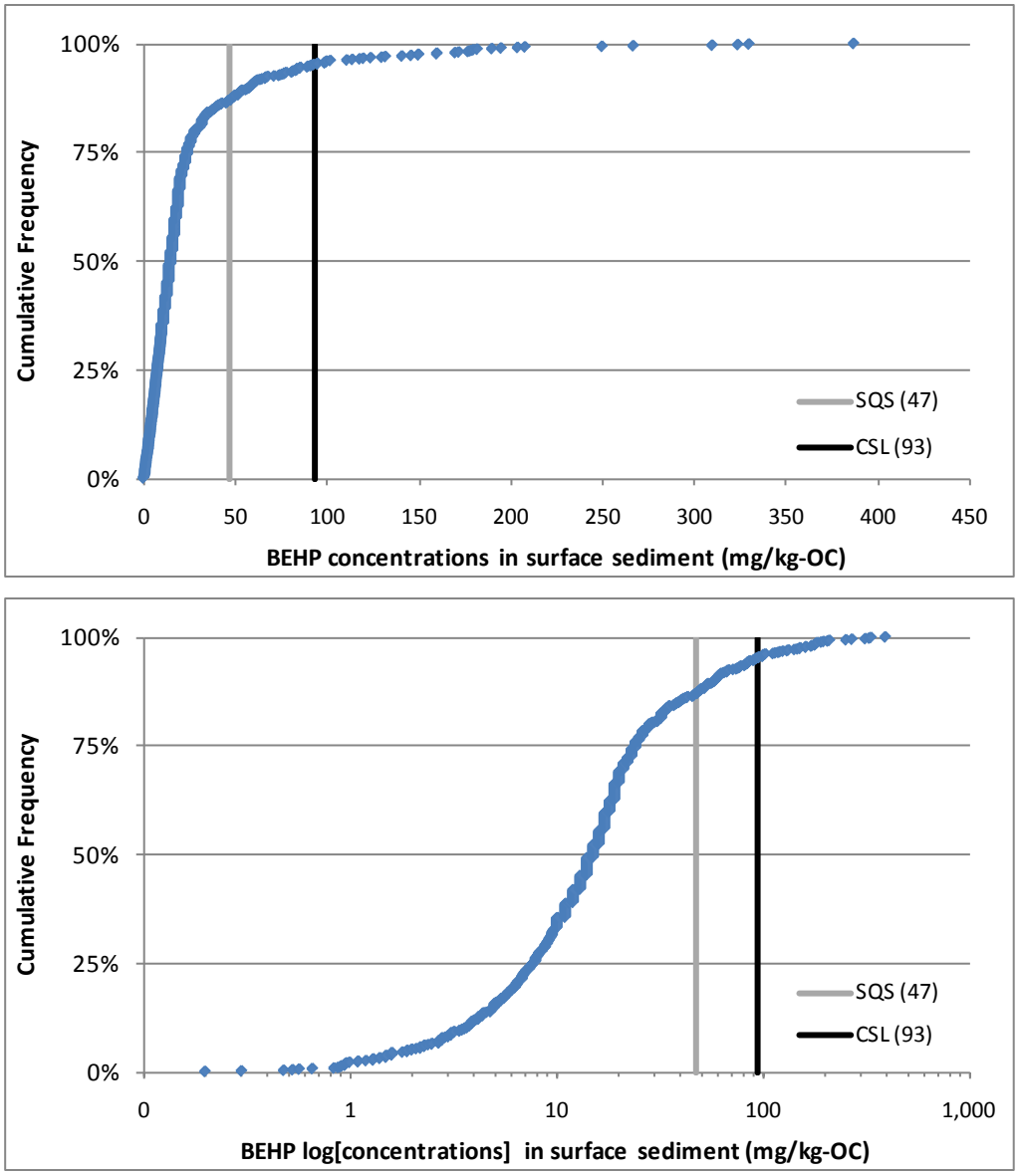


Figure 4-27. Cumulative frequency of OC-normalized BEHP concentrations in surface sediment (arithmetic and log-scale)

An analysis was conducted to assess changes in BEHP concentrations at 44 locations sampled in the 1990s that were resampled during sampling events in 2004 through 2006; such comparisons were limited to those locations where sediments were sampled within 10 ft of the original sample and where BEHP was detected in either the original or the later sample (Table 4-60).[88]

[88] The older data within 10 ft of the newer sample were excluded from the baseline dataset as described in Section 4.1.2.1.

Table 4-60. Difference in BEHP concentrations at resampled locations sorted by concentration difference

River Mile	Location ID		Date		Concentration (µg/kg dw)		
	Initial	Resampled	Initial	Resampled	Initial	Resampled	Difference
0	DR076	LDW-SS5	8/24/1998	1/17/2005	6,100	20 U	-6,080
1.3	DR053	LDW-SS44	8/31/1998	1/21/2005	3,800 J	120	-3,680
1.4	SS-4	LDW-SS55	8/17/1993	1/24/2005	2,200	98	-2,102
1.4	DR160	LDW-SS51	8/12/1998	1/18/2005	1,900	120 U	-1,780
4.2	R40	LDW-SS127	10/13/1997	1/20/2005	1,400	140	-1,260
3.8	DR187	LDW-SS115	8/27/1998	1/25/2005	1,500	330	-1,170
4.2	R45	LDW-SS130	10/16/1997	1/20/2005	1,200	72	-1,128
1.7	DR097	LDW-SS63	8/20/1998	1/21/2005	1,200	150	-1,050
0.3	DR079	LDW-SS15	8/24/1998	1/17/2005	1,100	64 U	-1,036
1.4	DR030	LDW-SS50	8/17/1998	1/24/2005	1,500	560	-940
0.3	DUD042	LDW-SS17	11/11/1995	1/24/2005	2,000	1,100	-900
1.3	SS-2	LDW-SS48	8/17/1993	1/18/2005	1,600	770	-830
1.4	SS-3	LDW-SS49	8/17/1993	1/26/2005	960	160	-800
3.8	R24	LDW-SS117	10/10/1997	1/20/2005	940	140	-800
4.2	R42	LDW-SS129	10/13/1997	1/20/2005	930	170	-760
2.2	DR113	LDW-SS81	8/19/1998	3/8/2005	910	190 U	-720
0.1	K-07	LDW-SS4	9/30/1991	1/17/2005	740 J	83 U	-657
1.0	DR019	LDW-SS32	8/17/1998	1/18/2005	710	93 U	-617
0.2	DR035	LDW-SS12	8/11/1998	1/17/2005	720	180	-540
2.1	DR106	LDW-SS76	8/19/1998	1/20/2005	460	59	-401
1.0	DR020	LDW-SS31	8/17/1998	1/21/2005	550	160	-390
1.4	DR065	LDW-SS52	8/17/1998	1/25/2005	410	95	-315
1.5	DR123	LDW-SS57	9/14/1998	1/24/2005	560	290	-270
1.4	DR028	B4b	8/17/1998	8/28/2004	390	140 J	-250
3.7	SD-323-S	LDW-SS110	8/17/2004	1/25/2005	410	170	-240
2.8	DR175	LDW-SS94	8/20/1998	1/21/2005	270	46	-224
0.9	DR021	LDW-SS319	8/17/1998	10/4/2006	710	520	-190
3.9	R30	LDW-SS119	10/11/1997	1/19/2005	460	280	-180
1.2	DR088	LDW-SS40	8/31/1998	1/18/2005	410	270	-140
4.3	DR286	B10b	8/26/1998	8/19/2004	150 UJ	35 J	-115
2.0	R7	LDW-SS75	10/15/1997	1/21/2005	180	74	-106
4.7	DR271	LDW-SS148	9/15/1998	3/9/2005	260	160 U	-100
3.2	DR202	LDW-SS104	8/27/1998	1/25/2005	80	36 J	-44
4.1	DR238	LDW-SS125	8/27/1998	1/20/2005	130	97 J	**-33**
3.1	DR198	LDW-SS102	8/20/1998	1/24/2005	150 UJ	130	**-20**

River Mile	Location ID		Date		Concentration (µg/kg dw)		
	Initial	Resampled	Initial	Resampled	Initial	Resampled	Difference
3.7	R21	LDW-SS113b	10/9/1997	1/20/2005	220	200	**-20**
0.9	DR085	LDW-SSB2b	8/31/1998	3/11/2005	340	350	**10**
4.1	A11-05	LDW-SS126	8/18/1994	1/20/2005	81	92 J	**11**
1.0	DR087	LDW-SS37	8/12/1998	1/18/2005	570	760	190
1.9	DR131	LDW-SS70	8/13/1998	1/21/2005	1,500	1,700	**200**
3.7	DR186	LDW-SS111	8/27/1998	1/19/2005	210	580	370
4.2	DR242	SB-1	8/24/1998	8/25/2004	620	1,600	980

Note: Concentrations in bold were within the range of analytical variability (≤ 25% increase or decrease compared with the initial concentration).
BEHP – bis(2-ethylhexyl) phthalate
dw – dry weight
ID – identification
J – estimated concentration
U – not detected at RL shown
UJ – not detected at estimated RL shown

At the 44 resampled surface sediment locations, BEHP concentrations decreased over time at 33 locations (79%), increased at 3 locations (7%), and were indistinguishable from the initial concentration at 6 locations (14%)[89] (Table 4-60 and Map 4-45). Two resampled locations were not included in Table 4-60 because BEHP was not detected in either of the paired samples; RLs ranged from 67 to 710 µg/kg dw. At the three locations with higher concentrations in more recent samples, differences ranged from 190 to 980 µg/kg dw, with the greatest increase in a sample from the head of Slip 6. Concentration differences ranged from 44 to 6,080 µg/kg dw at the 35 locations with lower concentrations in more recent samples, with the greatest decrease located near RM 0.0. [90]

To determine if BEHP concentrations were significantly different at locations that were resampled (i.e., if the mean difference between the paired concentrations was greater than zero), a non-parametric, paired t-test (Wilcoxon signed-rank test) was used. The test was run separately for each reach of the LDW (as defined in the STM) and for the entire LDW. Data were not included for 10 locations in Table 4-60 that were sampled less than 6 years apart or where BEHP was not detected in either the initial or later sample.

[89] Concentration differences at these locations were within the range of analytical variability (≤ 25% increase or decrease compared to the initial concentration).

[90] Information on heterogeneity of BEHP in sediment related to sample homogenization and laboratory variability is provided by field duplicate samples (i.e., sample splits from a grab sample after homogenization). The relative percent difference in BEPH concentrations between paired field duplicate samples in the RI (n = 7) ranged from 0 to 38%, with an average of 18%.

When the data were analyzed by reach of the LDW, the differences in between initial and resampled BEHP concentrations were significant at the 95% confidence level in the reach between RM 0.0 and RM 2.2 (Table 4-61; Figure 4-28). When data were analyzed for the entire LDW, differences between the initial and resampled BEHP concentrations were significant at the 95% level.

Table 4-61. Results of statistical analyses of differences in BEHP concentrations in surface sediment at resampled locations

Reach of the LDW	n[a]	Mean Concentration (µg/kg dw)		Significance (p value)
		Initial	Resampled	
RM 0.0 to RM 2.2	19	1,100	400	**0.001**
RM 2.2 to RM 4.0	7	530	230	0.13
RM 4.0 to RM 4.8	6	730	360	0.25
Entire LDW	32	880	350	**< 0.005**

[a] Data were not included for 10 locations (DR076, DR160, DR079, DR113, K-07, DR019, SD-323-S, DR286, DR271, and DR198) because they were sampled less than 6 years apart or BEHP was not detected in either the initial or later sample.

BEHP – bis(2-ethylhexyl) phthalate

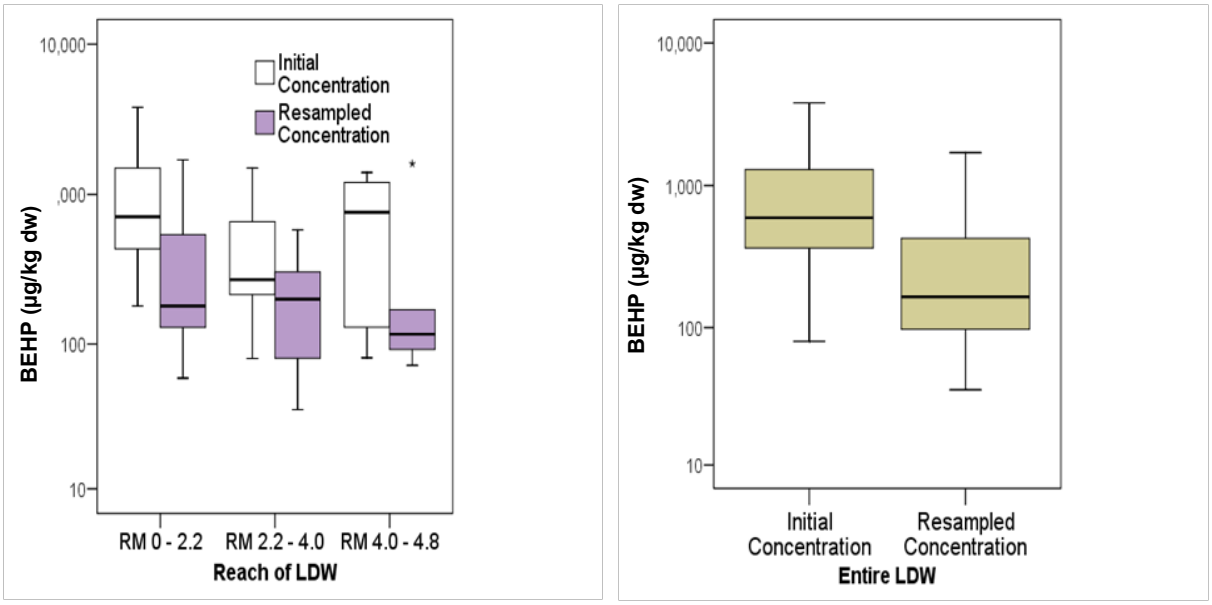
dw – dry weight

LDW – Lower Duwamish Waterway

n – number of samples

RM – river mile

Bold identifies values that are significant at the 95% confidence level.



Note: The boxes indicate the 25th and 75th percentiles within which 50% of the data lie. The length of this box indicates the interquartile range (IQR). The line in the center of the box is the 50th percentile (median). The whiskers of the box plot indicate the maximum and minimum values from the dataset that are within 1.5 IQRs of the 25th and 75th percentile values. Outliers are indicated by a circle and have a value between 1.5 and 3 of the IQR from the upper or lower edge of the box (75th or 25th percentile). Extreme values are indicated by an asterisk and have a value > 3 times the IQR from the 75th or 25th percentile. Data were not included for 10 locations because they were sampled less than 6 years apart or BEHP was not detected in either the initial or later sample.

Figure 4-28. Differences in BEHP concentrations in surface sediment at resampled locations

4.2.6.2 Subsurface sediment

Subsurface sediment cores were sampled at various intervals during different sampling events. To calculate summary statistics, data were categorized according to specified intervals, as described for total PCBs in Section 4.2.3.2.

BEHP was detected in 71% of the subsurface samples in which phthalates were analyzed, at concentrations ranging from 12 to 5,100 µg/kg dw (Table 4-62). Maps 4-46a through 4-46c present BEHP data in 1- and 2-ft subsurface intervals for the top 6 ft of sediment. Most of the locations with BEHP concentrations in subsurface sediment that were greater than the 95th percentile were located between RM 0.4 and RM 0.6, in the vicinity of the Duwamish/Diagonal EAA. The maximum concentration in this area was 18,000 µg/kg dw in the 3-to-6-ft interval at DUD261.

Table 4-62. Summary of subsurface sediment data for BEHP

Sampling Interval (ft)	Detection Frequency		Concentration (µg/kg dw)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[a]
All data					
Any interval	216/306	71	12 J	5,100	19 – 2,400
1-ft intervals[b]					
0 to 1	44/64	69	22	2,100	27 – 1,400
1 to 2	24/45	53	13 J	3,900	19 – 400
2 to 3	7/10	70	20 J	820	20 – 59
3 to 4	2/9	22	17 J	24	19 – 20
4 to 5	1/1	100	290	290	na
2-ft intervals[b]					
0 to 2	65/74	88	12 J	2,400	20 – 530
2 to 4	51/73	70	13 J	3,900	19 – 280
4 to 6	8/10	80	56 J	2,200	20.0 – 65
6 to 8	4/5	80	1,000	3,800	65
8 to 10	2/5	40	72.00	260	61 – 66

Note: Data included in the subsurface dataset are described in Section 4.1.2.2; subsurface sediment samples collected from areas that were subsequently dredged are not summarized in this table because they do not represent existing conditions.

[a] RLs were based only on non-detect samples.

[b] For the calculation of summary statistics, actual sampling intervals were rounded to the nearest foot. The data for each interval were then assigned to the 1- or 2-ft sampling category that best approximated the actual sampling interval. If there were data for two 1-ft intervals at a particular location, the concentrations were averaged to obtain a calculated concentration for the corresponding 2-ft interval. Some of the subsurface data were collected from intervals other than 1 or 2 ft; therefore, the detection frequency ratio for "any interval" may reflect data for intervals not included in these categories.

BEHP – bis(2-ethylhexyl) phthalate
dw – dry weight
J – estimated concentration
na – not applicable
RL – reporting limit

4.2.6.3 Surface and subsurface sediment patterns for BEHP

BEHP concentrations in surface and subsurface sediment were evaluated to determine whether peak concentrations were detected in the uppermost interval of sediment cores or at depth. The specific depths of peak concentrations within sediment cores were also evaluated to assess patterns (Maps 4-47a through 4-47e). The percentiles of BEHP concentrations in sediment discussed in this section were calculated on an area basis using the method described in the introduction to Section 4.2 and Thiessen polygon data. Area-based percentiles are discussed rather than numerical percentiles because they are more representative of area-wide conditions. In calculating numerical percentiles, each sampling location is given equal weight although more samples were collected in contaminated areas. As discussed in Section 4.2.3.3 for total PCBs, although there is some uncertainty in the interpretation of patterns and spatial

relationships between BEHP concentrations in surface and subsurface data, this analysis provides one line of evidence to understand the conceptual site model for BEHP in the LDW. Specific surface sediment locations were noted in the discussion if: 1) BEHP concentrations were higher in surface sediment samples than in sampling intervals of co-located subsurface cores, 2) the BEHP concentration in surface sediment was greater than the 75th percentile, and 3) the BEHP concentration in surface sediment was at least 25% greater than the highest arsenic concentration in any subsurface interval. BEHP concentrations in all co-located surface and subsurface sediment samples are presented on Maps 4-47a through 4-47e. Maps 4-48a and 4-48b show only the subsurface sediment locations with co-located surface sediment data.

RM 0.0 to RM 1.0

Between RM 0.0 and RM 1.0, BEHP concentrations in surface sedment greater than the 95th percentile of 990 µg/kg dw were located within or near the Duwamish/Diagonal EAA (Map 4-47a). In subsurface sediment, BEHP concentrations greater than the 95th percentile were located in the Duwamish/Diagonal EAA and also near Harbor Island and Slip 1.

Six cores were collected north of RM 0.3. Two of these cores had relatively low or non-detected BEHP concentrations in subsurface sediment (Map 4-47a; LDW-SC3 and LDW-SC5). The remaining four cores (LDW-SC1, LDW-SC2, LDW-SC4, and LDW-SC6) had peak BEHP concentrations ranging from 830 to 2,400 µg/kg dw at depth within the cores.

Of the 13 subsurface cores collected within the Duwamish/Diagonal EAA at more than one depth interval, all but three (DUD254, DUD006, and DUD261) had the peak BEHP concentration in the uppermost interval (generally 0 to 3 ft). Identifying the depth of the peak BEHP concentration within the EAA is generally not possible because most of the cores had relatively large sampling intervals of 3 ft. Surface sediment data were also evaluated for four locations within the Duwamish/Diagonal EAA where surface sediment samples were collected within 10 ft of the subsurface cores. At two of these locations (DR008 and DUD027), concentrations in surface sediment (11,000 and 13,000 µg/kg dw, respectively) were at least 25% higher than those in associated subsurface sediment cores (Map 4-47a).

Of the four subsurface cores collected just outside the Duwamish/Diagonal EAA at more than one depth interval, two had peak BEHP concentrations in the uppermost intervals (1,200 µg/kg dw in the 0-to-1-ft interval at LDW-SC7 and 1,700 µg/kg dw in the 0-to-1-ft interval at LDW-SC9). These two core locations had higher BEHP concentrations in co-located surface sediment samples (2,600 µg/kg dw at LDW-SC7 and 2,420 µg/kg dw at LDW-SC9).The other two cores had peak BEHP concentrations at depth (2,200 µg/kg dw in the 4-to-6-ft interval at LDW-SC8 and 3,900 µg/kg dw in the 2-to-4-ft interval at LDW-SC10).

Four subsurface cores were collected within Slip 1 (LDW-SC15, LDW-SC16, LDW-SC17, and DR021). The peak BEHP concentrations were located within the 2-to-4-ft interval in each of these cores, with concentrations ranging from 480 to 3,100 µg/kg dw. One subsurface core located just downstream from Slip 1 (LDW-SC13) had low concentrations of BEHP (≤ 160 µg/kg dw).

In one subsurface core located near RM 0.9 in the navigation channel (LDW-SC14), the peak BEHP concentration of 1,200 µg/kg dw was in the uppermost core interval, although the concentration in a co-located surface sediment sample was lower (350 µg/kg dw).

The remaining four subsurface cores were collected near RM 0.5 along the western shoreline (LDW-SC11), north of Kellogg Island near RM 0.6 (LDW-SC12 and DR044), and south of Kellogg Island near RM 1.0 (LDW-SC19). BEHP concentrations in these cores were relatively low (≤ 380 µg/kg dw) and peak BEHP concentrations were at depth in three of the four cores. The one core with a peak concentration in the uppermost interval was LDW-SC11 (310 µg/kg dw in the 0-to-1-ft interval).

In summary, outside of the Duwamish/Diagonal EAA, the majority of subsurface core samples with BEHP concentrations greater than the 75th percentile had peak concentrations at depth within the cores. Within the Duwamish/Diagonal EAA, most of the peak BEHP concentrations were in the uppermost depth intervals of the cores, although this interval was generally large (i.e., greater than 3 ft). Surface sediment data also indicated that peak BEHP concentrations may be highest within the surface intervals in most locations in this area.

RM 1.0 to RM 2.2

In this reach of the LDW, BEHP concentrations in both surface and subsurface sediment were variable, and generally less than the 95th percentile (990 µg/kg dw). Between RM 1.0 and RM 1.3, seven subsurface cores were sectioned into more than one depth interval. In three of these cores, BEHP concentrations were relatively low (≤ 390 µg/kg dw). In three other cores, the peak BEHP concentrations were between the 75th and 95th percentiles (440 and 990 µg/kg dw, respectively) and were detected at depth within the cores (at 2 to 4 ft in cores from LDW-SC21 and DR025, and at 3.5 to 4 ft in the core from LDW-SC23). In the remaining core (LDW-SC20), collected from the navigation channel at RM 1.0, the highest BEHP concentration was in the surface interval of the core (620 µg/kg dw at 0 to 2 ft) and was higher in a surface sediment sample (760 µg/kg dw) collected at the same location (Map 4-47b).

Between RM 1.3 and 1.5, six cores collected on both the east and west side of the navigation channelwere sectioned into more than one depth interval. Peak BEHP concentrations in all but one of these cores were relatively high, ranging from 740 to 3,900 µg/kg dw. In three of the cores, the peak concentrations were at depth (580 µg/kg dw at the 2-to-4-ft interval in LDW-SC25, 3,900 µg/kg dw at the 6-to-8-ft interval in LDW-SC26, and 1,000 µg/kg dw at the 5.5to-7.5-ft interval in LDW-SC28).

In another two of the five cores (DR054 and LDW-SC27), the peak concentrations (1,200 and 910 µg/kg dw, respectively) were in the uppermost interval (0 to 2 ft), although the concentrations were lower in co-located surface sediment samples (450 and 560 µg/kg dw, respectively) (Map 4-47b). In the remaining core collected between RM 1.3 and RM 1.5 (LDW-SC29), BEHP concentrations were below the 25th percentile of 84 µg/kg dw.

Between RM 1.5 and RM 1.7 on the east side of the navigation channel in an area that has been dredged, BEHP concentrations in subsurface sediment were generally less than the 75th percentile, and most locations were sampled at only one relatively large interval (generally greater than 3 ft). Therefore, the depth of peak BEHP concentrations could not be determined at these locations. In the navigation channel between RM 1.8 and RM 2.2, subsurface BEHP concentrations were relatively low (less than the 75th percentile of 440 µg/kg dw), and samples were collected at only one relatively large interval of 4 ft.

In Slip 2, one core was collected within the slip (LDW-SC32), and one core was collected at the mouth (DR101). In both cores, BEHP concentrations were greater than the 75th percentile and were detected at depth (650 µg/kg dw at the 1-to-2-ft interval and 1,400 µg/kg dw at the 2-to-4-ft interval).

At the remaining 10 subsurface locations sampled between RM 1.8 and RM 2.2, all but 3 locations had peak BEHP concentrations less than the 75th percentile. At the three locations with concentrations greater than the 75th percentile (LDW-SC34, LDW-SC37, and DR112), peak concentrations were at depth within the cores.

In summary, the depth of the peak BEHP concentration is unknown in most cores collected within the navigation channel and in many of the cores collected from the east side of the navigation channel between RM 1.5 and RM 1.8. In 12 of the 15 cores with BEHP concentrations greater than the 75th percentile, peak concentrations were at depth within the core.

RM 2.2 to RM 3.0

Between RM 2.2 and RM 3.0, BEHP concentrations in both surface and subsurface sediment were variable and generally less than the 75th percentile Map 4-47c). Two subsurface cores were collected in the vicinity of EAA 2, where three surface sediment samples had high BEHP concentrations (ranging from 2,300 to 4,200 µg/kg dw). The peak BEHP concentration of 450 µg/kg dw in one of the two cores (DR137) was in the 2-to-4 ft interval, and BEHP concentrations were very low (less than or equal to 84 µg/kg dw) in the other core (LDW-SC40).

Between RM 2.4 and RM 2.8 on the west side, nine of the ten subsurface cores were sampled at only one depth interval, so the depth of the peak BEHP concentration within those cores could not be determined. In the one core sampled at more than one depth interval (LDW-SC46 near RM 2.7), the BEHP concentrations were similar

throughout the core (200 to 250 µg/kg dw) and were slightly higher in the surface sediment sample collected at the same location (430 µg/kg dw).

Five subsurface cores were collected within the navigation channel. Only one of these cores (DR171) was analyzed at more than one depth interval. The peak BEHP concentration (460 µg/kg dw) in this core was in the 2-to-4-ft interval.

Between RM 2.3 and RM 2.8 on the east side of the navigation channel, five subsurface sediment cores were collected as part of the RI. The core from LDW-SC41 was the only core with BEHP concentrations greater than 220 µg/kg dw. In this core, the peak concentration of 480 µg/kg dw was in the uppermost interval of 0 to 1 ft.

Slip 4 had high BEHP concentrations (up to 5,100 µg/kg dw) in surface sediment samples collected at the head of the slip, but no subsurface samples were collected from this area. Subsurface samples collected from the western half of the slip were analyzed at only one depth interval; BEHP concentrations in these cores were relatively low (< 300 µg/kg dw).

In summary, the depth of the peak BEHP concentration is unknown in many of the cores collected between RM 2.2 and RM 3.0 because they were sampled at only one depth interval. Most subsurface BEHP concentrations were less than the 75th percentile. In three of the cores with BEHP concentrations greater than the 75th percentile, two had peak concentrations at depth, and one had a peak concentration in the uppermost interval.

RM 3.0 to RM 4.0

Most of the BEHP concentrations in surface sediment between RM 3.0 and RM 4.0 were less than the 75th percentile, and most concentrations in subsurface sediment were less than the 50th percentile (Map 4-47d). In subsurface cores from locations west of the navigation channel and outside of the T-117 EAA, BEHP concentrations were generally low. In the only two cores with concentrations greater than the 50th percentile, one peak BEHP concentration was at depth (350 µg/kg dw in the 2-to-3-ft interval at SC47) and one peak concentration was in the uppermost interval (220 µg/kg dw in the 0-to-2.5-ft interval at SB-5).

Eight subsurface cores were collected within the navigation channel. Six of these cores were analyzed at only one depth interval. The remaining two cores had BEHP concentrations less than the 25th percentile of 84.

In the Boeing Plant 2/Jorgensen Forge EAA, five subsurface cores were collected. Each of these cores was either analyzed at only one depth interval, or not all depth intervals were analyzed, so it is not possible to determine the depth of peak BEHP concentrations.

In the T-117 EAA, six subsurface cores were collected. Five of these cores were either analyzed at only one interval or not all depth intervals were analyzed. In the one core with data from two depth intervals (DR206), the peak BEHP concentration (520 µg/kg

dw) was in the uppermost interval (0-to-2 ft). The BEHP concentration was lower (260 µg/kg dw) in the co-located surface sediment sample.

Between RM 3.8 and 3.9 on the east side of the navigation channel, two subsurface cores had peak BEHP concentrations at depth and two had peak concentrations in the uppermost intervals. In cores from LDW-SC50a and LDW-SC52, peak BEHP concentrations (680 and 660 µg/kg dw, respectively) were in the 0-to-1-ft interval. At sampling location LDW-SC50a, the BEHP concentration (1,200 µg/kg dw) in the co-located surface sediment sample was higher than the peak concentration in the subsurface core. In cores from LDW-SC51 and DR220, peak concentrations (1,800 and 470 µg/kg dw, respectively) were in the 0.5-to-1-ft and 2-to-4-ft intervals, respectively.

In summary, BEHP concentrations in surface and subsurface sediment were generally less than the 75th percentile in this section of the LDW. At the five locations where BEHP concentrations in subsurface cores were greater than the 75th percentile and where data were available for more than one interval, three cores had peak concentrations in the uppermost interval and two had peak concentrations at depth. In addition, one core location had data from only one subsurface depth interval but had a peak BEHP concentration in the co-located surface sediment sample.

RM 4.0 to RM 5.0

Concentrations of BEHP in surface and subsurface sediment between RM 4.0 and RM 5.0 were variable, with most concentrations less than the 75th percentile. In the six subsurface cores collected from a dredged area on the west side of the navigation channel between RM 4.0 and RM 4.2, BEHP concentrations were low, ranging from 160 to 340 µg/kg dw. Only one interval was sampled in each of these cores, so the depth of the peak BEHP concentration could not be determined. In one subsurface core collected just outside this dredged area (DR284), the peak BEHP concentration (650 µg/kg dw) was at depth (2 to 4 ft).

Three subsurface cores were collected between RM 4.2 and RM 4.8 on the west side of the navigation channel. BEHP concentrations were very low in these cores (less than or equal to 140 µg/kg dw).

At the Rhône-Poulenc site between RM 4.0 and RM 4.3 on the east side of the navigation channel (including Slip 6), 20 very shallow subsurface core samples were collected and only one subsurface interval (0.33 to approximately 0.7 ft) was analyzed from each. In nine of these cores, surface intervals (0 to 0.33 ft) were also analyzed for BEHP; these samples were classified as surface sediment samples in the RI. The surface and subsurface intervals in most of these nine cores had very similar BEHP concentrations (Map 4-47e). All of the subsurface cores in this area with BEHP concentrations greater than the 95th percentile were in cores collected within the slip. Two deeper subsurface cores were collected in the area near Rhône-Poulenc: LDW-SC53 near the head of the slip and DR246 near the mouth of the slip. Peak BEHP

concentrations (880 and 650 µg/kg dw, respectively) were at depth (2 to 4 ft) in both of these cores.

In the Norfolk EAA, three subsurface cores were collected. Peak BEHP concentrations were in the uppermost interval (0-to-1 ft) in each of these cores (600 µg/kg dw at NFK008, 1,400 µg/kg dw at NFK207 and 570 µg/kg dw at NFK009). It should be noted that the area where these three cores were collected was subsequently dredged and capped; surface sediment data at these locations represent post dredging/capping conditions. At one location just outside the Norfolk EAA (LDW-SC55), BEHP was not detected at any depth interval.

In summary, most of the very shallow subsurface cores collected from the vicinity of Slip 6 had similar BEHP concentrations in the 0-to-0.33-ft and 0.33-to-0.7-ft intervals. In the Norfolk EAA, peak BEHP concentrations were greater than the 75th percentile, and were in the uppermost intervals (0-to-1 ft); cores in this area were collected before dredging and capping. Three other subsurface cores between RM 4.0 and RM 5.0 had concentrations greater than the 75th percentile; peak concentrations in these cores were at depth.

4.2.6.4 Tissue

BEHP data are available for 227 composite samples of fish, shellfish, and benthic invertebrate tissues (Table 4-63). BEHP was detected most frequently in soft-shell clams (in 10 of 14 samples); other samples of various tissue types generally had low detection frequencies of BEHP (Table 4-63). The highest concentrations of BEHP were detected in a benthic invertebrate composite tissue sample from LDW B1b near RM 0.1 (2,200 µg/kg ww) and a shiner surfperch sample collected from Area T2E (2,100 µg/kg ww).

Table 4-63. Summary of BEHP data in specific tissue types

Tissue Type	Detection Frequency		Concentration (µg/kg ww)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[a]
Fish, Whole Body					
English sole	1/27	4	170	170	50 – 3,600
Pacific staghorn sculpin	0/24	0	nd	nd	490 – 5,000
Shiner surfperch	5/34	15	280 J	2,100 J	24 – 3,600
Starry flounder	0/3	0	nd	nd	66 – 67
Fish, Fillet					
English sole (with skin)	2/7	29	1,100	1,300 J	67 – 130
English sole (without skin)	0/6	0	nd	nd	3.6 – 16
Pile perch (with skin)	0/1	0	nd	nd	67
Starry flounder (with skin)	0/1	0	nd	nd	67

Tissue Type	Detection Frequency		Concentration (µg/kg ww)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[a]
Striped perch (with skin)	0/1	0	nd	nd	67
Crab, Edible Meat					
Dungeness crab	0/9	0	nd	nd	16 – 130
Slender crab	0/12	0	nd	nd	66 – 260
Crab, Hepatopancreas					
Dungeness crab	0/4	0	nd	nd	24 – 130
Slender crab	1/4	25	100 J	100 J	66 – 230
Crab, Whole Body (calc'd)[b]					
Dungeness crab	nc	nc	nd	nd	9 – 55
Slender crab	nc	nc	100 JM	100 JM	33 – 100
Invertebrates, Whole Body					
Amphipod	2/4	50	170	530	24
Benthic invertebrates	5/20	25	1,100 J	2,200 J	2,500
Shellfish					
Mussels, wild (edible meat)	2/22	9	28	190	16
Mussels, transplanted (edible meat)	0/34	0	nd	nd	16 – 26
Soft-shell clam (whole body)	10/14	71	56 J	220 J	490 – 500

[a] RLs are based only on non-detect samples.

[b] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Concentrations in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data). Detection frequencies were not calculated for these samples because they do not represent individually analyzed samples.

BEHP – bis(2-ethylhexyl) phthalate
J – estimated concentration
M – calculated whole-body concentration
na – not applicable
nc – not calculated
nd – not detected
RL – reporting limit
ww – wet weight

BEHP RLs were elevated (up to 5,000 µg/kg ww) in some of the English sole, Pacific staghorn sculpin, shiner surfperch, and benthic invertebrate samples collected for the RI in 2004 because of analytical dilutions. Original RLs in 49 tissue samples of various types were very high (7,200 µg/kg ww), resulting in the need for re-analysis using additional sample extract clean-up steps and alternate analytical methods to achieve lower RLs. All 49 samples with original RLs of 7,200 µg/kg ww were reanalyzed; 71 other samples with elevated RLs ranging from 240 to 5,000 µg/kg ww were not reanalyzed. The remaining 22 samples collected for the RI in 2004 had detected concentrations and were also not reanalyzed. BEHP was detected in only one of the re-analyzed tissue samples at a concentration of 100 µg/kg ww; RLs for the re-analyses of the remaining 48 samples ranged from 66 to 230 µg/kg ww. BEHP was detected in

tissue only once in the 2006 King County sampling event in Area T1 (170 µg/kg ww in an English sole composite sample) (Anchor and King County 2007). RLs for the 2006 King County analyses of English sole and shiner surfperch from Area T1 ranged from 50 to 200 µg/kg ww. There were 74 samples collected between 1992 and 1998 in the RI dataset. BEHP was detected in four of these samples at concentrations of 28 to 530 µg/kg ww, and RLs ranged from 3.6 to 26 µg/kg ww. The reanalysis of the subset of 2004 tissues suggests that RLs in the 2004 dataset would have been much lower if samples had not been diluted; the more recent results from 2006 suggest that BEHP is rarely detected in fish.

4.2.6.5 Surface water

On multiple occasions, surface water samples were collected in the LDW along transects near three CSO outfalls and analyzed for SVOCs as part of the King County WQA (King County 1999e). BEHP detection frequencies ranged from 18 to 31% (Table 4-64), with concentrations ranging from 0.14 to 23.8 µg/L. Phthalates were often detected in the method blank samples, and therefore, these results were likely influenced by laboratory contamination. During data validation, detected sample concentrations were compared with the detected method blank concentrations, and sample concentrations less than 10 times the concentration in the associated method blank samples were qualified as non-detected at elevated RLs for 67 results. Concentrations of BEHP in surface water samples are compared with WQC in Section 4.2.2 (Table 4-20).

Table 4-64. Summary of surface water data for BEHP at three locations in the LDW

Location ID[a]	Detection Frequency		Concentration (µg/L)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[b]
BRN (RM 1.1)	7/39	18	0.21	3.51	0.14 – 1.31
SWM (RM 1.9)	8/42	19	0.302	23.8	0.14 – 0.667
NFK (RM 4.9)	4/13	31	0.14	0.253	0.15 – 0.859

[a] BRN, SWM, and NFK are located in the LDW near the Brandon, SW Michigan, and Norfolk CSOs, respectively.

[b] RLs are based only on non-detect samples.

BEHP – bis(2-ethylhexyl) phthalate
CSO – combined sewer overflow
ID – identification
LDW – Lower Duwamish Waterway
RL – reporting limit
RM – river mile

4.2.6.6 Seep water

BEHP was analyzed in 3 seep water samples collected at T-117; 7 seep water samples collected at Rhône-Poulenc in 1995; 9 and 5 seep water samples collected at GWI in 1998 and 1999, respectively; 17 seep water samples collected at Boeing Plant 2; and 16 seep water samples collected throughout the LDW as part of the RI in 2004 (Map 4-11a).

BEHP was detected in two unfiltered seep water samples from the Rhône-Poulenc sampling event and one unfiltered seep water sample from the T-117 sampling event, at concentrations ranging from 8.9 to 27.0 µg/L (Table 4-65; Maps 4-11d and 4-11e). BEHP was not detected in any of the 15 filtered seep water samples or 16 unfiltered samples collected throughout the LDW as part of the RI sampling event. BEHP was not detected in the filtered seep water samples, so comparisons to WQC were not made in Section 4.2.2.

Table 4-65. Summary of seep water data for BEHP

Sampling Event/Year	Detection Frequency		Detected Concentration (µg/L)[a]	RL (µg/L)[b]
	Ratio	%		
Rhône-Poulenc RFI-3 (1995)	2/7	29	13.8 – 27.0	nr[c]
T-117 (2003)	1/3	33	8.9 J	1.0

[a] Unfiltered samples
[b] RLs are based only on non-detect samples.
[c] RLs for non-detected chemicals were not reported for this sampling event.

BEHP – bis(2-ethylhexyl) phthalate
J – estimated concentration
nr – not reported
RFI – RCRA facility investigation
RL – reporting limit
T-117 – Terminal 117

4.2.6.7 Porewater

The only porewater samples from the LDW that have been analyzed for BEHP were those collected during the 2004 Rhône-Poulenc sampling event. BEHP was detected at locations SH-02, SH-03, SH-04, SH-05, and SH-08 at concentrations up to 390 µg/L (Table 4-66; Map 4-12d).[91] BEHP concentrations in porewater samples are compared with WQC in Section 4.2.2 (Table 4-22).

Table 4-66. Summary of BEHP concentrations in porewater samples collected from Rhône-Poulenc

Detection Frequency		Concentration (µg/L)		
Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[a]
5/9	56	2.0	390	1.9

[a] RLs are based only on non-detect samples.
BEHP – bis(2-ethylhexyl) phthalate
J – estimated concentration
RL – reporting limit

4.2.6.8 Summary of BEHP data

BEHP concentrations in surface sediment ranged from 5.4 to 14,000 µg/kg dw; the area-based 95th and 50th percentiles calculated from the RI baseline dataset were

[91] BEHP was not detected in two method blanks at RLs of 2 µg/L.

990 and 440 µg/kg dw, respectively. The highest BEHP concentrations in both surface and subsurface sediment were between RM 0.4 and RM 0.6 in and near the Duwamish/Diagonal EAA. Peak BEHP concentrations in subsurface sediment were frequently detected at depth within cores at concentrations greater than the area-based 75th percentile (440 µg/kg dw), except for the Duwamish/Diagonal, which had relatively large depth intervals, and the Norfolk EAA, where dredging was conducted after cores were collected.

In tissue, BEHP was detected most frequently in soft-shell clams; only 17 of the other 227 samples of various tissue types had detected concentrations of BEHP. The highest concentrations of BEHP were detected in a benthic invertebrate composite tissue sample from LDW B1b near RM 0.1 (2,200 µg/kg ww) and a shiner surfperch sample collected from Area T2E (2,100 µg/kg ww). BEHP RLs for some of the English sole, Pacific staghorn sculpin, shiner surfperch, and benthic invertebrate samples collected for the RI in 2004 were elevated (up to 7,200 µg/kg ww) because of analytical dilutions. Reanalysis of 49 tissue samples of various types with RLs greater than 5,000 µg/kg ww resulted in substantially lower RLs and only one detected concentration. In addition, more recent results from 2006 suggested that BEHP is rarely detected in fish.

In surface water samples collected from three LDW locations, detection frequencies of BEHP ranged from 18 to 31%, with concentrations ranging from 0.14 to 23.8 µg/L. BEHP was detected in unfiltered seep water samples collected from two of the four site-specific sampling events (Rhône-Poulenc and T-117) at concentrations ranging from 8.9 to 27 µg/L in unfiltered samples. BEHP was not detected in any of the 15 filtered seep water samples or 16 unfiltered samples collected throughout the LDW during the RI sampling event. Rhône-Poulenc is the only area from which porewater samples have been collected and analyzed for BEHP. During the 2004 Rhône-Poulenc sampling event, BEHP was detected in porewater at five locations at concentrations ranging from 2 to 390 µg/L.

4.2.7 Dioxins and furans

This section summarizes the nature and extent of dioxin and furan concentrations in surface and subsurface sediment samples. Dioxins and furans have not been analyzed in tissue, surface water, seep water, or porewater samples collected from the LDW.

4.2.7.1 Surface sediment

Surface sediment samples from within the LDW area were analyzed for dioxin and furan congeners from 26 locations as part of the RI (Windward 2005d) and from 28 locations as part of the EPA SI (Weston 1999a). At least one dioxin or furan congener was detected in every sample, with individual congener concentrations ranging from 0.0590 to 241,000 ng/kg dw (Table 4-67).

Table 4-67. Summary of dioxin and furan data in LDW surface sediment

Chemical	Detection Frequency		Concentration (ng/kg dw)			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[a]	Non-Detect or Range of Non-Detects[b]
2,3,7,8-TCDD	26/54	48	0.0660 J	30.6	1.5	0.27 – 1.1
1,2,3,7,8-PeCDD	27/54	50	0.100 J	57.1	4.2	0.53 – 4.1
1,2,3,4,7,8-HxCDD	27/54	50	0.193 J	124	8.2	0.72 – 5.4
1,2,3,6,7,8-HxCDD	45/54	83	0.978 J	3,400	100	0.74 – 4.3
1,2,3,7,8,9-HxCDD	38/54	70	0.537 J	315	25	0.537 – 11.3
1,2,3,4,6,7,8-HpCDD	52/54	96	25.5	73,700	2,500	0.99 – 1.1
OCDD	54/54	100	7.8 J	241,000	16,000	na
2,3,7,8-TCDF	44/54	81	0.113 J	397	12	0.18 – 1.7
1,2,3,7,8-PeCDF	26/54	48	0.0950 J	69.3	4.5	0.28 – 5.0
2,3,4,7,8-PeCDF	27/54	50	0.212	230	15	0.44 – 5.4
1,2,3,4,7,8-HxCDF	39/54	72	0.513 J	2,530	120	0.29 – 4.2
1,2,3,6,7,8-HxCDF	27/54	50	0.174 J	365	21	0.22 – 4.3
1,2,3,7,8,9-HxCDF	25/54	46	0.0730 J	33.8 J	1.8	0.12 – 2.4
2,3,4,6,7,8-HxCDF	27/54	50	0.155 J	302 J	12	0.29 – 2.5
1,2,3,4,6,7,8-HpCDF	51/54	94	5.18 J	40,300	1,000	0.62 – 7.7
1,2,3,4,7,8,9-HpCDF	36/54	67	0.385 J	3,720	100	0.77 – 4.2
OCDF	53/54	98	12.5	93,700	2,600	0.74
Dioxin and furan mammalian TEQ (Van den Berg et al. 2006)[c]	54/54	100	0.878	2,100 J	82	na

[a] Calculated mean concentration is the average of detected concentrations and one-half the RL for non-detected results.

[b] Non-detect values were calculated for samples with no detected dioxin or furan congeners. Non-detect values represent the sum of one-half the RL multiplied by the TEF for each compound.

[c] The UCL for dioxin and furan TEQs in surface sediment was 610 ng/kg dw using the RI baseline dataset as calculated in Appendix C (Table C.3-8). This UCL is presented as the EPC for the netfishing scenario in the HHRA (Appendix B), which uses the entire surface sediment dataset.

dw – dry weight
EPC – exposure point concentration
HHRA – human health risk assessment
HpCDD – heptachlorodibenzo-*p*-dioxin
HpCDF – heptachlorodibenzofuran
HxCDD – hexachlorodibenzo-*p*-dioxin
HxCDF – hexachlorodibenzofuran
J – estimated concentration
LDW – Lower Duwamish Waterway
na – not applicable
OCDD – octachlorodibenzo-*p*-dioxin
OCDF – octachlorodibenzofuran
PeCDD – pentachlorodibenzo-*p*-dioxin
PeCDF – pentachlorodibenzofuran
RL – reporting limit
TCDD – tetrachlorodibenzo-*p*-dioxin
TCDF – tetrachlorodibenzofuran
TEF – toxic equivalency factor
TEQ – toxic equivalent
UCL – upper confidence limit on the mean
WHO – World Health Organization

TEQs were calculated using mammalian TEFs for 17 dioxin or furan congeners.[92] Methods for these calculations are described in Appendix B, Section B.2.2.4. Dioxin and furan TEQs in surface sediment ranged from 0.878 to 2,100 ng/kg dw (Table 4-67). Forty-two of the fifty-four dioxin and furan TEQs were less than 20 ng/kg dw. The median and 95th percentile TEQs were 10 and 490 ng/kg dw, respectively (Figure 4-29).

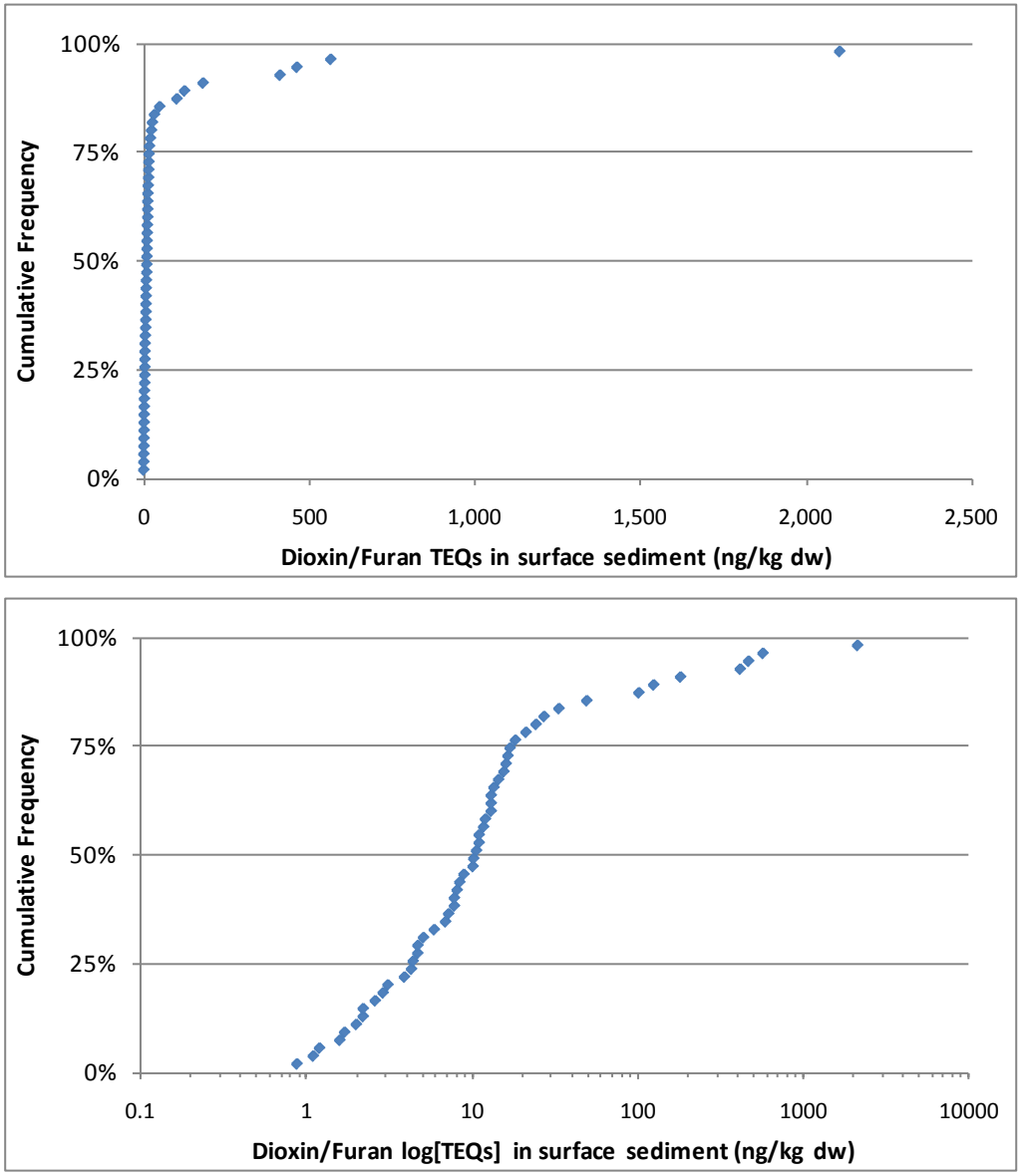


Figure 4-29. Cumulative frequency of dioxin and furan TEQs in surface sediment (arithmetic and log-scale)

[92] For the purposes of describing the distribution of dioxins and furans in the LDW, TEQ concentrations were calculated using TEFs for mammals as presented in Van den Berg et al. (2006). If a dioxin or furan congener concentration was reported as undetected, then the TEF was multiplied by half the RL.

The three highest dioxin and furan TEQs (2,100, 565, and 463 ng/kg dw) were detected in surface sediment samples collected from the embayment between RM 1.4 and RM 1.5 on the west side of the LDW (Map 4-49). Other areas with notable dioxin and furan TEQs were: 1) the inlet at RM 2.2 in EAA 2 on the west side of the LDW (412 ng/kg dw), 2) near RM 0.5 E in the Duwamish/Diagonal EAA (180 ng/kg dw), 3) near RM 1.0 in the navigation channel (124 ng/kg dw), and 4) near RM 3.6 E in the Boeing Plant 2/Jorgensen Forge EAA (101 ng/kg dw).

Seven samples analyzed for dioxins and furans were not included in the baseline RI dataset but were included in Table 4-67 and Map 4-49 at the request of EPA and Ecology.[93] Four of these samples were collected during the EPA SI (DR021 at RM 0.9, DR065 at RM 1.4, DR187 at RM 3.8, and DR238 at RM 4.1) and were not included in the baseline RI dataset because older data were excluded if a location was resampled within 10 ft (see Section 4.1.2.1). However, dioxins and furans were not analyzed in the more recent samples from these four EPA SI locations. Dioxin and furan TEQs in the four EPA SI samples ranged from 3.1 to 13 ng/kg dw. The remaining three samples not included in the baseline RI dataset were collected during the RI (LDW-SS18 and LDW-SS20 at RM 0.4, and LDW-SS22 at RM 0.5) and were excluded because of their proximity to the Duwamish/Diagonal EAA dredge perimeter; the baseline dataset was intended to only represent pre-dredge conditions (see Section 4.1.2.1). Dioxin and furan TEQs in these three RI samples ranged from 0.878 to 24.2 ng/kg dw.

4.2.7.2 Subsurface sediment

Subsurface sediment samples were analyzed for dioxins and furans from eight locations as part of the RI. These locations were selected because of relatively high dioxin and furan TEQs in nearby surface sediment. Dioxin and furan TEQs at these eight subsurface sediment locations ranged from 0.147 to 194 ng/kg dw (Table 4-68; Map 4-49). The highest TEQ (194 ng/kg dw) was detected in the 4-to-6-ft interval in the core from location LDW-SC20 in the navigation channel at RM 1.0.

Table 4-68. Summary of dioxin and furan mammalian TEQ data in LDW subsurface sediment

Subsurface Sediment			Surface Sediment	
Subsurface Core Sampling Location	Sampling Interval (ft)	TEQ (ng/kg dw)[a]	Sampling Location Closest to Subsurface Core	TEQ (ng/kg dw)[a]
LDW-SC19 (RM 1.0 south of Kellogg Island)	0 – 1	22.8 J	LDW-SS36	27.1 J
	1 – 2	20.1 J		
	2 – 4	20.5 J		

[93] The entire surface sediment dataset, including data that were not included in the baseline RI dataset, are available on a CD that accompanies this RI.

Subsurface Sediment			Surface Sediment	
Subsurface Core Sampling Location	Sampling Interval (ft)	TEQ (ng/kg dw)[a]	Sampling Location Closest to Subsurface Core	TEQ (ng/kg dw)[a]
LDW-SC20 (RM 1.0 in the navigation channel)	0 – 2	38.7 J	LDW-SS37	124 J
	2 – 4	27.1		
	4 – 6	194 J		
	8 – 10	5.60 J		
LDW-SC26 (RM 1.4 on the west side of the navigation channel)	0 – 1	15.9 J	none[b]	no data
	1 – 2	13.1 J		
	2 – 4	22.4 J		
	6 – 8	136 J		
LDW-SC28 (RM 1.4 on the west side of the navigation channel)	0 – 1	19.9 J	none[b]	no data
	1 – 2	14.8		
	2 – 4	18.5 J		
LDW-SC29 (RM 1.4 west of the Glacier Northwest dock)	0 – 1	54.1 J	LDW-SS56	2,100 J
	1 – 2	1.03 J		
	2 – 4	0.147 J		
LDW-SC39 (between RM 2.1 and RM 2.2 on the western shoreline)	0 – 1	7.91 J	none[b]	no data
	1 – 2	12.4 J		
	2 – 4	13.1 J		
LDW-SC40 (near RM 2.3 on the western shoreline)	0 – 1	6.71 J	none[b]	no data
	1 – 2	0.485 J		
	2 – 4	0.355 J		
LDW-SC41 (near RM 2.4 on the east side in the Myrtle Street Embayment)	0 – 1	13.8	LDW-SS83	33.3 J
	1 – 2	12.5 J		
	2 – 4	14.0 J		

[a] TEQs were calculated using TEFs for mammals presented in Van den Berg et al. (2006).

[b] No surface samples were collected near subsurface cores.

dw – dry weight
J – estimated concentration
LDW – Lower Duwamish Waterway
RM – river mile
TEQ – toxic equivalent

Core LDW-SC29, collected near the surface sediment location with the highest TEQ (2,100 ng/kg dw) had low TEQs in comparison (Table 4-68). The highest TEQ in this subsurface core was 54.1 ng/kg dw in the 0-to-1-ft interval. In core LDW-SC26 collected just outside the embayment, the highest TEQ (136 ng/kg dw) was detected at an interval of 6 to 8 ft. A third subsurface core collected in that general area (LDW-SC28) had relatively low TEQs (14.8 to 19.9 ng/kg dw) in all three subsurface intervals.

In core LDW-SC20 near RM 1.0 in the navigation channel, the highest TEQ (194 ng/kg dw in the 4-to-6-ft interval) was higher than the TEQ in the surface sediment sample from that area (124 ng/kg dw).

In the other two cores collected from locations where surface sediment data were available (LDW-SC19 and LDW-SC41), TEQs in subsurface samples were slightly lower than TEQs in associated surface sediment samples (up to 22.8 ng/kg dw in subsurface samples and up to 33.3 ng/kg dw in surface samples) (Table 4-68). There was little variability in TEQs among the different subsurface intervals in each core.

4.2.8 Metals

This section summarizes the nature and extent of metals and TBT concentrations in surface sediment, subsurface sediment, tissue, surface water, seeps, and porewater.

4.2.8.1 Surface sediment

Surface sediment samples collected from 884 locations were analyzed for at least one metal or TBT. Table 4-69 presents detection frequencies and a summary of concentrations in surface sediment for nine metals (cadmium, chromium, copper, lead, mercury, nickel, silver, vanadium, and zinc) and TBT.[94]

Table 4-69. Summary of surface sediment data for metals and TBT

Chemical	Detection Frequency		Concentration (mg/kg dw)				SMS Criteria (mg/kg dw)	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[a]	RL or Range of RLs[b]	SQS	CSL
Cadmium	584/838	70	0.030 J	120	1	0.04 – 2.5	5.1	6.7
Chromium	850/850	100	4.8	1,100 J	40	na	260	270
Copper	852/852	100	5	12,000 J	100	na	390	390
Lead	852/852	100	2	23,000	100	na	450	530
Mercury	746/868	86	0.021	4.6 J	0.2	0.02 – 0.10	0.41	0.59
Nickel	812/812	100	5	910	30	na	nv	nv
Silver	499/823	61	0.020	270	1	0.046 – 5	6.1	6.1
Vanadium	597/597	100	15	150	58	na	nv	nv
Zinc	849/849	100	16	9,700	190	na	410	960
TBT as ion	142/158	90	0.00028 J	3.0	0.09	0.001 – 0.0053	nv	nv

[a] Calculated mean concentration is the average of detected concentrations and one-half the RL for non-detected results.

[b] RLs are based only on non-detect samples.

CSL – cleanup screening level RL – reporting limit

[94] A metal was included if detected concentrations exceeded SMS criteria in at least on surface sediment sample in the LDW.

dw – dry weight
J – estimated concentration
na – not applicable
nv – no value
SMS – Washington State Sediment Management Standards
SQS – sediment quality standards
TBT – tributyltin

Maps 4-50 through 4-59 summarize the concentrations of these metals and TBT in surface sediment samples collected from locations throughout the LDW. Concentrations of metals are shown as individual locations. These data are most relevant on a point-by-point basis, consistent with SMS, because metals other than arsenic are risk drivers for the benthic invertebrate community only. Therefore, only numerical percentiles are discussed. Most of the samples with concentrations that exceeded the 95th percentile[95] for each of the nine metals discussed in this section were located either downstream of RM 2.0 or between RM 3.5 and RM 3.7 on the east side of the navigation channel (within the Boeing Plant 2/Jorgensen Forge EAA). There were several areas of the LDW where the highest concentrations (i.e., greater than the 95th percentile) of various metals were co-located. Most notable of these areas was the Boeing Plant 2/Jorgensen Forge EAA. The maximum concentrations for each of the nine metals (as presented in Table 4-69) were detected in samples collected between RM 3.5 and RM 3.6 within the Boeing Plant 2/Jorgensen Forge EAA.

The Duwamish/Diagonal EAA and its vicinity also had multiple locations with high concentrations of all metals (but most notably cadmium, mercury, and silver). Other metals also had high concentrations at a few locations in this area.

Other areas with concentrations greater than the 95th percentile for multiple metals (Maps 4-50 through 4-58) included:

- One area near RM 0.1 on the eastern shoreline (LDW-SS6, DR001, and LDW-SS305, as identified on Map 4-4a) (cadmium, copper, lead, silver, and zinc)
- One sampling location near RM 1.0 in the navigation channel (LDW-SS37, as identified on Map 4-4c) (cadmium, chromium, mercury, and silver)
- Slip 1 (LDW-SS30, LDW-SS31, LDW-SS32, B3b, and DR018, as identified on Map 4-4c) (cadmium, copper, lead, mercury, nickel, zinc, and vanadium)
- RM 1.3 to RM 1.5 on the west side of the navigation channel (copper, zinc, and vanadium at multiple locations, including LDW-SS48 [see Map 4-4c], which also had concentrations of cadmium, chromium, lead, mercury, and nickel greater than the 95th percentile)

[95] The SQS for each metal and the SL for nickel were greater than or equal to the corresponding 95th percentile concentrations.

- RM 2.2 on the west side of the navigation channel (LDW-SS84, DR157, and DR139, as identified on Map 4-4e) (cadmium, chromium, lead, mercury, silver, and zinc)
- Slip 4 (R14, DR177, DR178, and DR179, as identified on Map 4-4f) (cadmium, lead, mercury, silver, and vanadium)

Spatial patterns for mercury were different than those for other metals. Additional locations with mercury concentrations greater than the 95th percentile include RM 0.0 to RM 0.1 near Harbor Island, RM 0.3 to RM 0.4 in the channel and to the west of the channel, RM 0.5 to RM 0.6 along the western shoreline, and between RM 0.9 and RM 1.1 in the channel and to the east of the channel. In addition, spatial patterns for TBT were also different than those for the nine metals. The maximum concentration of 3.0 mg/kg dw was detected at sampling location LDW-SS46, located at RM 1.3 on the west side of the LDW (Map 4-59). Additional sampling locations with concentrations of TBT greater than the 95th percentile were in Slip 1 and between RM 0.0 and RM 0.5.

SMS chemical criteria are available for cadmium, chromium, copper, lead, mercury, silver, and zinc. Each of these metals had a relatively small number of SQS or CSL exceedances throughout the LDW compared with the total number of locations sampled; zinc had the highest number of exceedances, with 26 locations (3.1%) exceeding the SQS and 16 locations (1.9%) exceeding the CSL (Table 4-16). The Boeing Plant 2/Jorgensen Forge EAA had the highest number of SQS or CSL exceedances of multiple metals; these exceedances were located primarily between RM 3.5 and RM 3.7. Other areas with SQS or CSL exceedances of multiple metals included the Duwamish/Diagonal EAA, RM 0.5 to RM 0.6 on the west side, Slip 1, RM 1.3 to RM 1.5 on the west side, and EAA 2 at RM 2.2 (Maps 4-50 through 4-58). Outside of these areas, there were three locations (RM 0.1, RM 3.9, and RM 4.8) with lead exceedances (Map 4-53), two locations (RM 1.6 and RM 2.5) with zinc exceedances (Map 4-58), and multiple locations with mercury exceedances (Map 4-54).

4.2.8.2 Subsurface sediment

Subsurface sediment samples collected from 205 cores (471 samples) prior to dredging were analyzed for at least one metal or TBT. Subsurface sediment cores were sampled at various intervals during the different sampling events. To calculate summary statistics, data were categorized according to specified subsurface intervals, as described for total PCBs in Section 4.2.3.2. Table 4-70 presents a summary of subsurface metals and TBT data for samples collected from any interval, and Table 4-71 presents a summary of data for samples collected from specific 1- and 2-ft intervals within the top 10 ft of sediment.

Table 4-70. Summary of data for metals and TBT from any subsurface sediment core interval

Chemical	Detection Frequency		Concentration (mg/kg dw)[a]		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[b]
Cadmium	257/388	66	0.088	20.4	0.18 – 0.9
Chromium	397/397	100	6.67	386	na
Copper	397/397	100	7.1	2,940	na
Lead	361/394	92	2.8	3,520 J	2 – 3.6
Mercury	341/436	78	0.020	10	0.020 – 0.100
Nickel	317/317	100	4.8	226	na
Silver	166/372	45	0.050	7.5	0.30 – 1
Vanadium	251/251	100	18	223	na
Zinc	396/396	100	16.2 J	4,720	na
Tributyltin as ion	58/95	61	0.00055 J	6.2	0.0010 – 0.0054

Note: Data included in the subsurface dataset are described in Section 4.1.2.2; subsurface sediment samples collected from areas that were subsequently dredged are not summarized in this table because they do not represent existing conditions.

[a] Mean concentrations were not calculated because sampling was generally focused in contaminated areas, resulting in a non-random sampling pattern, which is not likely representative of the entire LDW.

[b] RLs are based only on non-detect samples.

dw – dry weight
J – estimate concentration
LDW – Lower Duwamish Waterway
na – not applicable
RL – reporting limit
TBT – tributyltin

Table 4-71. Summary of subsurface sediment data for metals and TBT in samples collected from 1- and 2-ft intervals within the top 10 ft of sediment

Chemical	Sampling Interval (ft)[a]	Detection Frequency		Concentration (mg/kg dw)[b]		
		Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[c]
Cadmium – 1-ft intervals	0 to 1	52/78	67	0.3	4.5	0.2 – 0.9
	1 to 2	51/80	64	0.3	7.6	0.2 – 0.5
	2 to 3	11/19	58	0.3	18.7	0.20 – 0.38
	3 to 4	1/9	11	0.8	0.8	0.2 – 0.36
	4 to 5	3/9	33	0.50	3.8 J	0.20 – 0.30
	6 to 7	0/5	0	nd	nd	0.20 – 0.30
	8 to 9	1/4	25	0.70	0.70	0.20
Cadmium – 2-ft intervals	0 to 2	72/97	74	0.22	18	0.20 – 0.5
	2 to 4	47/73	64	0.3	15	0.2 – 0.8
	4 to 6	6/6	100	0.7	4.0	na
	6 to 8	3/4	75	1.4	20.4	0.3
	8 to 10	3/3	100	0.12	1.9	0.30
Chromium – 1-ft intervals	0 to 1	86/86	100	6.67	143 J	na
	1 to 2	80/80	100	9.96	135	na
	2 to 3	20/20	100	10.9	300	na
	3 to 4	9/9	100	8.9	24.2	na
	4 to 5	9/9	100	9.9	140 J	na
	6 to 7	5/5	100	10	19.1	na
	8 to 9	4/4	100	8.3	26.5	na
Chromium – 2-ft intervals	0 to 2	97/97	100	11.4 J	210 J	na
	2 to 4	73/73	100	8.1	386	na
	4 to 6	6/6	100	22	92	na
	6 to 8	4/4	100	13.0	160	na
	8 to 10	3/3	100	11.20	54.7	na
Copper – 1-ft intervals	0 to 1	86/86	100	10.9	327	na
	1 to 2	80/80	100	7.1	339	na
	2 to 3	20/20	100	9.20	599	na
	3 to 4	9/9	100	9.00	37.9	na
	4 to 5	9/9	100	7.4	67.3	na
	6 to 7	5/5	100	9.0	26.8	na
	8 to 9	4/4	100	7.5	31.9	na

Table 4-71, cont. Summary of subsurface sediment data for metals and TBT in samples collected from 1- and 2-ft intervals within the top 10 ft of sediment

Chemical	Sampling Interval (ft)[a]	Detection Frequency		Concentration (mg/kg dw)[b]		
		Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[c]
Copper – 2-ft intervals	0 to 2	97/97	100	10.7	800	na
	2 to 4	73/73	100	7.6	2,940	na
	4 to 6	6/6	100	29.7	663	na
	6 to 8	4/4	100	23.2	1,950	na
	8 to 10	3/3	100	15.00	89.4	na
Lead – 1-ft intervals	0 to 1	84/84	100	4.9	639	na
	1 to 2	73/80	91	2.8	514	2.0 – 3
	2 to 3	18/19	95	3	356	2.0
	3 to 4	5/9	56	3	37 J	2 – 3.6
	4 to 5	8/9	89	3.0	64	2.0
	6 to 7	2/5	40	3.0	11	2.0
	8 to 9	1/4	25	43	43	2.0
Lead – 2-ft intervals	0 to 2	95/97	98	3	772	2.5 – 3
	2 to 4	65/73	89	3	3,520 J	2 – 3
	4 to 6	6/6	100	18.0	1,210	na
	6 to 8	4/4	100	42	1,350	na
	8 to 10	3/3	100	3.00	89	na
Mercury – 1-ft intervals	0 to 1	81/84	96	0.05	0.71	0.05 – 0.100
	1 to 2	54/66	82	0.06	0.6	0.040 – 0.0600
	2 to 3	13/19	68	0.070	0.64	0.030 – 0.060
	3 to 4	2/9	22	0.07	0.17	0.020 – 0.06
	4 to 5	3/10	30	0.060	0.24 J	0.040 – 0.060
	6 to 7	2/5	40	0.050	0.16	0.040 – 0.050
	8 to 9	1/3	33	0.19	0.19	0.050
Mercury – 2-ft intervals	0 to 2	102/107	95	0.05	10	0.04 – 0.07
	2 to 4	68/84	81	0.07	1.4	0.020 – 0.06
	4 to 6	9/15	60	0.080	0.98	0.050 – 0.060
	6 to 8	6/15	40	0.075	4.34	0.040 – 0.060
	8 to 10	4/12	25	0.25	0.89	0.050 – 0.080
Nickel – 1-ft intervals	0 to 1	65/65	100	4.8	36	na
	1 to 2	53/53	100	6.92	51.1	na
	2 to 3	10/10	100	9	32	na
	3 to 4	9/9	100	6 J	25	na
	8 to 9	1/1	100	5	5	na

Table 4-71, cont. Summary of subsurface sediment data for metals and TBT in samples collected from 1- and 2-ft intervals within the top 10 ft of sediment

Chemical	Sampling Interval (ft)[a]	Detection Frequency		Concentration (mg/kg dw)[b]		
		Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[c]
Nickel – 2-ft intervals	0 to 2	76/76	100	7 J	37	na
	2 to 4	70/70	100	6	226	na
	4 to 6	5/5	100	13	34	na
	6 to 8	4/4	100	10	69	na
	8 to 10	3/3	100	12.00	24	na
Silver – 1-ft intervals	0 to 1	15/62	24	0.500	3.0	0.4 – 1
	1 to 2	23/80	29	0.5	2.6	0.3 – 1
	2 to 3	8/19	42	0.060	7.3	0.40 – 0.5
	3 to 4	1/9	11	0.61	0.61	0.3 – 0.5
	4 to 5	1/9	11	1.2	1.2	0.30 – 0.40
	6 to 7	0/5	0	nd	nd	0.30 – 0.40
	8 to 9	0/4	0	nd	nd	0.30 – 0.40
Silver – 2-ft intervals	0 to 2	52/97	54	0.050	3.3	0.4 – 1
	2 to 4	34/73	47	0.080	5	0.3 – 1
	4 to 6	4/6	67	1.4	4.3	0.400 – 1
	6 to 8	3/4	75	2	3	0.4
	8 to 10	2/3	67	0.5	2.3	0.40
Vanadium – 1-ft intervals	0 to 1	64/64	100	18	85	na
	1 to 2	37/37	100	39.6	84.3	na
	2 to 3	9/9	100	47.0	67	na
	3 to 4	8/8	100	36.1	71.5	na
	8 to 9	1/1	100	37.5	37.5	na
Vanadium – 2-ft intervals	0 to 2	73/73	100	37	87	na
	2 to 4	68/68	100	26	223	na
	4 to 6	5/5	100	39.8	95.1	na
	6 to 8	4/4	100	41.0	112	na
	8 to 10	2/2	100	63.9	75.4	na
Zinc – 1-ft intervals	0 to 1	86/86	100	18.6	1,260	na
	1 to 2	80/80	100	20.2	2,050	na
	2 to 3	19/19	100	22.3	1,770	na
	3 to 4	9/9	100	18.5	69	na
	4 to 5	9/9	100	20.8	324 J	na
	6 to 7	5/5	100	22.0	47.0	na
	8 to 9	4/4	100	17.6	84.7	na

Table 4-71, cont. Summary of subsurface sediment data for metals and TBT in samples collected from 1- and 2-ft intervals within the top 10 ft of sediment

Chemical	Sampling Interval (ft)[a]	Detection Frequency		Concentration (mg/kg dw)[b]		
		Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[c]
Zinc –2-ft intervals	0 to 2	97/97	100	21	1,660	na
	2 to 4	73/73	100	16.2 J	4,720	na
	4 to 6	6/6	100	69.0	1,430	na
	6 to 8	4/4	100	88.4	4,550	na
	8 to 10	3/3	100	21.00	186	na
Tributyltin as ion – 1-ft intervals	0 to 1	11/11	100	0.0055	0.22	na
	1 to 2	6/14	43	0.021	0.35	0.0036 – 0.0054
	2 to 3	0/1	0	nd	nd	0.0010
	3 to 4	0/1	0	nd	nd	0.0036
	8 to 9	0/1	0	nd	nd	0.0036
Tributyltin as ion – 2-ft intervals	0 to 2	22/27	81	0.0030	2.5	0.0010 – 0.0049
	2 to 4	16/26	62	0.010	2.1	0.0010 – 0.0038
	4 to 6	3/3	100	0.014	1.0	na
	6 to 8	2/2	100	3.4	6.2	na
	8 to 10	0/1	0	nd	nd	0.0052569

Note: Data included in the subsurface dataset are described in Section 4.1.2.2; subsurface sediment samples collected from areas that were subsequently dredged are not summarized in this table because they do not represent existing conditions.

[a] For the calculation of summary statistics in this table, actual sampling intervals were rounded to the nearest foot. The data for each interval were then assigned to the 1- or 2-ft sampling category that best approximated the actual sampling interval. If there were data for two 1-ft intervals at a particular location, the concentrations were averaged to obtain a calculated concentration for the corresponding 2-ft interval. Some of the subsurface data were collected from intervals other than 1 or 2 ft; therefore, the detection frequency ratio for "any interval" in Table 4-70 may reflect data for intervals not included in these categories.

[b] Mean concentrations were not calculated because sampling was generally focused in contaminated areas, resulting in a non-random sampling pattern, which is not likely representative of the entire LDW.

[c] RLs based only on non-detect samples.

dw – dry weight

J – estimated concentration

na – not applicable

nd – not detected

RL – reporting limit

Over 90% of the subsurface sediment samples summarized in Table 4-71 were collected from the top 4 ft of sediment. There were relatively few samples analyzed from depths greater than 4 ft below mudline; most of those samples were collected and analyzed as part of the RI at locations with SMS exceedances in upper intervals or during other investigations targeting specific locations.

The highest copper and zinc concentrations were detected in a subsurface sediment sample collected from the head of Slip 3 and the highest cadmium concentration was in a subsurface sediment sample collected from the head of Slip 1. The highest concentrations of lead, chromium, and silver in any subsurface sediment samples (Table 4-70) were detected in the 0-to-3-ft or 0-to-1-ft intervals within or just outside of the Duwamish/Diagonal EAA. In this area, high metal concentrations were detected in samples collected from both uppermost core intervals as well as deeper intervals within the cores. High metal concentrations were also detected in subsurface samples from both uppermost intervals and at depth in the Boeing Plant 2/Jorgensen Forge EAA.

Other notable areas with subsurface metal concentrations greater than the 95th percentile for multiple metals include:

- RM 0.1 on the east side (LDW-SC2, as identified on Map 4-7a) (cadmium and silver, with peak concentrations in the 2-to-4-ft interval and lead and zinc, with peak concentrations in the 4-to-6-ft interval)
- RM 0.5 on the western shoreline (LDW-SC11, as identified on Map 4-7a) (cadmium, copper, lead, mercury, and zinc, with peak concentrations in the 0-to-1-ft interval)
- Slip 1 (DR021, LDW-SC16 and LDW-SC17, as identified on Map 4-7a) (up to nine metals in each core, with peak concentrations at intervals of 2 to 4 ft, 4 to 6 ft, or 6 to 8 ft)
- RM 1.3 to RM 1.5 on the west side of the navigation channel (DR054, LDW-SC25, LDW-SC26, LDW-SC27, and LDW-SC28, as identified on Map 4-7b) (up to eight metals in each core, with peak concentrations primarily at intervals of 2 to 4 ft, 4 to 6 ft, or 6 to 8 ft, but some high concentrations were also in the 0-to-2-ft interval)
- Slip 3 (LDW-SC37, as identified on Map 4-7b) (nine metals, with peak concentrations primarily in the 2-to-4-ft interval)
- RM 3.9 on the east side (LDW-SC52, as identified on Map 4-7d) (lead and mercury, with peak concentrations in the 0-to-1-ft interval; chromium, nickel, and silver, with peak concentrations in the 1-to-2-ft interval; and cadmium with the same concentration in both the 0-to-1-ft and 1-to-2-ft intervals)

TBT concentrations in subsurface sediment greater than the 95th percentile were located primarily near RM 1.3 and RM 1.4 on the west side (Map 4-60). The two highest TBT concentrations (6.2 and 3.4 mg/kg dw) were in the 6-to-8-ft interval in cores LDW-SC26 and LDW-SC28, respectively, collected in this area.

4.2.8.3 Tissue

Table 4-72 presents the detection frequencies and ranges of concentrations of seven metals and TBT that were identified as COCs in specific tissue types.[96] Appendix E, Section E.6, presents a summary of data for other metals and inorganic substances that were analyzed in tissue but are not discussed in this section.

The tissue types with the highest mean concentrations of each metal (including TBT) were invertebrates (i.e., clams, crabs, benthic invertebrates, and amphipods). In general, fish fillet samples had the lowest mean concentrations of TBT and metals, except for mercury. Mean concentrations in whole-body fish samples were higher than those in fish fillets for TBT and all metals, except mercury. In crab hepatopancreas, mean concentrations of cadmium, copper, lead, and TBT were higher than in crab edible meat.

TBT concentrations were higher in soft-shell clams relative to other tissue types. TBT concentrations in the 14 clam samples ranged from 0.15 to 0.66 mg/kg ww; whereas the mean concentrations in other tissue types ranged from 0.0033 to 0.029 mg/kg ww.

As part of the ERA, regression analyses were conducted using co-located sediment and benthic invertebrate tissue data for metals and TBT (see Appendix A, Attachment 11). TBT was the only analyte with a significant relationship ($R^2 = 0.59$, $p < 0.05$). However, there is uncertainty in this relationship because of one sediment-tissue pair that was highly influential (Appendix A, Attachment 11).

[96] A metal is discussed in Section 4.2.7.3 for tissue if it was identified as a COC in the HHRA (Appendix B) based on seafood consumption or if the LOAEL-based HQ was ≥ 1.0 for any fish or wildlife receptor in the ERA (Appendix A).

Table 4-72. Summary of metals and TBT data in tissue composite samples

Tissue Type[a]	Unit	Detection Frequency		Concentration			
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[b]	RL or Range of RLs[c]
Cadmium							
Crab, edible meat	mg/kg ww	21/21	100	0.0055	0.0444	0.023	na
Crab, hepatopancreas	mg/kg ww	8/8	100	0.11	0.8530	0.48	na
Crab, whole body (calc'd)[d]	mg/kg ww	nc	nc	0.04 M	0.2951 M	0.16	na
Fish, fillet (with or without skin)	mg/kg ww	1/13	8	0.0013 J	0.0013 J	nc	0.0042 – 0.0079
Fish, whole body	mg/kg ww	75/75	100	0.002 J	0.0240	0.01	na
Amphipod, whole body	mg/kg ww	4/4	100	0.017	0.15	0.058	na
Benthic invertebrates, whole body	mg/kg ww	20/20	100	0.0175 J	0.202 J	0.060	na
Mussels, wild (edible meat)	mg/kg ww	22/22	100	0.19	0.84	0.49	na
Mussels, transplanted (edible meat)	mg/kg ww	35/35	100	0.231	0.781	0.379	na
Soft-shell clam, whole body	mg/kg ww	14/14	100	0.064	0.148	0.10	na
Chromium							
Crab, edible meat	mg/kg ww	2/21	10	0.13	0.16	0.05	0.07 – 0.11
Crab, hepatopancreas	mg/kg ww	3/8	38	0.04 J	0.16	0.05	0.01 – 0.08
Crab, whole body (calc'd)[d]	mg/kg ww	nc	nc	0.07 JM	0.140 M	0.04	0.03 – 0.05
Fish, fillet (with or without skin)	mg/kg ww	2/13	15	0.054	0.062	nc	0.049 – 0.12
Fish, whole body	mg/kg ww	53/75	71	0.06 J	3.74	0.2	0.10 – 0.14
Amphipod, whole body	mg/kg ww	4/4	100	0.45 J	0.56 J	0.52	na
Benthic invertebrates, whole body	mg/kg ww	20/20	100	0.08	3.90	1.0	na
Mussels, wild (edible meat)	mg/kg ww	21/22	95	0.10	0.35	0.16	0.050
Mussels, transplanted (edible meat)	mg/kg ww	33/35	94	0.059	0.305	0.1	0.05
Soft-shell clam, whole body	mg/kg ww	14/14	100	0.36	1.32	0.67	na
Copper							
Crab, edible meat	mg/kg ww	21/21	100	4.430	16	7.5	na
Crab, hepatopancreas	mg/kg ww	8/8	100	12.4	49.9	28	na
Crab, whole body (calc'd)[d]	mg/kg ww	nc	nc	6.9 M	24 M	14	na

Table 4-72, cont. Summary of metals and TBT data in tissue composite samples

Tissue Type[a]	Unit	Detection Frequency		Concentration			
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[b]	RL or Range of RLs[c]
Fish, fillet (with or without skin)	mg/kg ww	19/19	100	0.18	1.390	0.67	na
Fish, whole body	mg/kg ww	75/75	100	0.494	3.470	1.4	na
Amphipod, whole body	mg/kg ww	4/4	100	9.8	30	19	na
Benthic invertebrates, whole body	mg/kg ww	20/20	100	1.940 J	21.8	8.52	na
Mussels, wild (edible meat)	mg/kg ww	22/22	100	0.58	1.7 J	1.2	na
Mussels, transplanted (edible meat)	mg/kg ww	35/35	100	0.513	2.08	1.13	na
Soft-shell clam, whole body	mg/kg ww	14/14	100	3.50	7.30	5.34	na
Lead							
Crab, edible meat	mg/kg ww	21/21	100	0.012	0.24 J	0.045	na
Crab, hepatopancreas	mg/kg ww	8/8	100	0.037	0.2690	0.11	na
Crab, whole body (calc'd)[d]	mg/kg ww	nc	nc	0.020 M	0.22 JM	0.067	na
Fish, fillet (with or without skin)	mg/kg ww	10/19	53	0.006	0.137	0.04	0.020 – 0.030
Fish, whole body	mg/kg ww	75/75	100	0.012	0.946	0.17	na
Amphipod, whole body	mg/kg ww	4/4	100	0.95	7.4	3.7	na
Benthic invertebrates, whole body	mg/kg ww	20/20	100	0.1430	14.60	1.77	na
Mussels, wild (edible meat)	mg/kg ww	22/22	100	0.13	0.72	0.41	na
Mussels, transplanted (edible meat)	mg/kg ww	35/35	100	0.043	0.288	0.13	na
Soft-shell clam, whole body	mg/kg ww	14/14	100	0.368	6.370	1.96	na
Mercury							
Crab, edible meat	mg/kg ww	25/25	100	0.023	0.11	0.057	na
Crab, hepatopancreas	mg/kg ww	8/8	100	0.020	0.067	0.031	na
Crab, whole body (calc'd)[d]	mg/kg ww	nc	nc	0.022 M	0.097 M	0.046	na
Fish, fillet (with or without skin)	mg/kg ww	27/27	100	0.013	0.083	0.040	na
Fish, whole body	mg/kg ww	81/81	100	0.005	0.088	0.03	na
Amphipod, whole body	mg/kg ww	4/4	100	0.0067	0.017	0.011	na
Benthic invertebrates, whole body	mg/kg ww	18/20	90	0.002 J	0.044	0.01	0.004 – 0.009
Mussels, wild (edible meat)	mg/kg ww	21/21	100	0.0088	0.023	0.013	na
Mussels, transplanted (edible meat)	mg/kg ww	35/35	100	0.0051	0.0088	0.0066	na

Table 4-72, cont. Summary of metals and TBT data in tissue composite samples

Tissue Type[a]	Unit	Detection Frequency		Concentration			
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[b]	RL or Range of RLs[c]
Soft-shell clam, whole body	mg/kg ww	14/14	100	0.009	0.022	0.02	na
Vanadium							
Crab, edible meat	mg/kg ww	0/19	0	nd	nd	nc	0.14 – 0.21
Crab, hepatopancreas	mg/kg ww	4/7	57	0.11 J	0.2 J	0.1	0.13 – 0.21
Crab, whole body (calc'd)[d]	mg/kg ww	nc	nc	0.13 M	0.2 JM	0.1	0.08 – 0.11
Fish, fillet (with or without skin)	mg/kg ww	0/10	0	nd	nd	nc	0.2 – 0.25
Fish, whole body	mg/kg ww	56/72	78	0.1 J	1.23	0.3	0.2 – 0.25
Benthic Invertebrates,	mg/kg ww	20/20	100	0.26	3.04	1.2	na
Mussels, wild (edible meat)	mg/kg ww	8/8	100	0.058	0.26	0.15	na
Mussels, transplanted (edible meat)	mg/kg ww	10/10	100	0.119	0.281	0.195	na
Soft-shell clam, whole body	mg/kg ww	14/14	100	0.68	2.65	1.3	na
Zinc							
Crab, edible meat	mg/kg ww	21/21	100	26.1	39.3	34	na
Crab, hepatopancreas	mg/kg ww	8/8	100	14.8	33.6	23	na
Crab, whole body (calc'd)[d]	mg/kg ww	nc	nc	24.6 M	37.3 M	31	na
Fish, fillet (with or without skin)	mg/kg ww	13/13	100	3.8	9.33	7.0	na
Fish, whole body	mg/kg ww	75/75	100	9.95	28.0	16	na
Amphipod, whole body	mg/kg ww	4/4	100	7.9	26	14	na
Benthic invertebrates, whole body	mg/kg ww	20/20	100	8.22	43.6	20.9	na
Mussels, wild (edible meat)	mg/kg ww	22/22	100	17	44	30	na
Mussels, transplanted (edible meat)	mg/kg ww	35/35	100	4.78	20.6	9.71	na
Soft-shell clam, whole body	mg/kg ww	14/14	100	16.1	32.3	23.7	na
Tributyltin as ion							
Crab, edible meat	mg/kg ww	9/25	36	0.00081 J	0.082	0.0062	0.0015 – 0.0020
Crab, hepatopancreas	mg/kg ww	6/8	75	0.00050 J	0.059	0.019	0.0015
Crab, whole body (calc'd)[d]	mg/kg ww	nc	nc	0.00120 JM	0.075 M	0.0099	0.0008
Fish, fillet (with or without skin)	mg/kg ww	14/21	67	0.0012 J	0.016 J	0.0033	0.00074 – 0.0020
Fish, whole body	mg/kg ww	78/92	85	0.0018 J	0.18	0.027	0.0015 – 0.0021

Table 4-72, cont. Summary of metals and TBT data in tissue composite samples

Tissue Type[a]	Unit	Detection Frequency		Concentration			
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[b]	RL or Range of RLs[c]
Amphipod, whole body	mg/kg ww	4/4	100	0.018	0.036	0.029	na
Benthic invertebrates, whole body	mg/kg ww	19/20	95	0.0038 J	0.092	0.028	0.0050
Mussels, wild (edible meat)	mg/kg ww	22/22	100	0.012	0.037	0.023	na
Mussels, transplanted (edible meat)	mg/kg ww	32/32	100	0.00935	0.0369	0.0196	na
Soft-shell clam, whole body	mg/kg ww	14/14	100	0.15	0.66	0.32	na

Note: A metal is included in this table if it was detected in any tissue sample and was identified as a COC in the HHRA (Appendix B) based on seafood consumption or if it was a COC for any fish or wildlife receptor in the ERA (Appendix A).

[a] Crab tissue includes a combination of Dungeness, slender, and red rock crabs. Fish tissue includes English sole, Pacific staghorn sculpin, pile perch, shiner surfperch, starry flounder, and striped perch, as available.

[b] Calculated mean concentration is the average of detected concentrations and one-half the RL for non-detected results. Mean concentrations were not calculated if the detection frequency was ≤ 25%.

[c] RLs are based only on non-detect samples.

[d] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Concentrations in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data). Detection frequencies were not calculated for these samples because they do not represent individually analyzed samples.

COC – chemical of concern
ERA – ecological risk assessment
HHRA – human health risk assessment
J – estimated concentration
M – calculated whole-body concentration
na – not applicable
nc – not calculated
nd – not detected
RL – reporting limit
TBT – tributyltin
ww – wet weight

4.2.8.4 Surface water

Table 4-73 presents a summary of metal concentrations in LDW surface water samples collected as part of the King County WQA (Map 4-11a). Chromium, lead, vanadium, and zinc were detected in every surface water sample. Silver was not detected in any sample. TBT was not analyzed in surface water samples. Mean concentrations of chromium, copper, lead, nickel, vanadium, and zinc in unfiltered samples and copper, lead, and zinc in filtered samples were higher in samples from RM 4.9 than in samples from RM 1.1 and RM 1.9. Concentrations of metals in surface water samples are compared with WQC in Section 4.2.2 (Table 4-20).

Table 4-73. Summary of surface water data for metals from three locations in the LDW

Location ID[a]	Detection Frequency		Concentration (µg/L)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[b]
Cadmium					
Filtered					
BRN (RM 1.1)	72/72	100	0.011	0.0755	na
SWM (RM 1.9)	72/72	100	0.0079	0.0795	na
NFK (RM 4.9)	12/22	55	0.0072	0.021	0.0067 – 0.0073
Unfiltered					
BRN (RM 1.1)	173/173	100	0.0088	0.0780	na
SWM (RM 1.9)	171/173	99	0.0076	0.391	0.0067 – 0.0068
NFK (RM 4.9)	49/56	88	0.0071	0.032	0.0068 – 0.0073
Chromium					
Filtered					
BRN (RM 1.1)	68/68	100	0.11 J	0.576 J	na
SWM (RM 1.9)	56/56	100	0.10 J	0.453 J	na
NFK (RM 4.9)	24/24	100	0.14 J	0.423 J	na
Unfiltered					
BRN (RM 1.1)	165/165	100	0.240 J	1.74 J	na
SWM (RM 1.9)	157/157	100	0.277 J	2.32 J	na
NFK (RM 4.9)	58/58	100	0.256 J	2.37 J	na
Copper					
Filtered					
BRN (RM 1.1)	65/65	100	0.384 J	1.54 J	na
SWM (RM 1.9)	64/66	97	0.370 J	1.89 J	0.354 – 0.368
NFK (RM 4.9)	23/24	96	0.496 J	1.34 J	0.628
Unfiltered					
BRN (RM 1.1)	166/166	100	0.536 J	5.83 J	na
SWM (RM 1.9)	166/167	99	0.474 J	4.03 J	0.643

Location ID[a]	Detection Frequency		Concentration (µg/L)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[b]
NFK (RM 4.9)	58/58	100	0.728 J	4.24 J	na
Lead					
Filtered					
BRN (RM 1.1)	70/70	100	0.010 J	0.553 J	na
SWM (RM 1.9)	66/66	100	0.0077 J	0.198 J	na
NFK (RM 4.9)	24/24	100	0.0611 J	0.343 J	na
Unfiltered					
BRN (RM 1.1)	171/171	100	0.0459 J	1.45 J	na
SWM (RM 1.9)	167/167	100	0.0570 J	1.57 J	na
NFK (RM 4.9)	58/58	100	0.143 J	2.81 J	na
Mercury					
Filtered[c]					
BRN (RM 1.1)	8/9	89	0.00013	0.00051	0.0001
NFK (RM 4.9)	6/6	100	0.00046	0.00071	na
Unfiltered					
BRN (RM 1.1)	9/15	60	0.00056	0.00336	0.20
SWM (RM 1.9)	0/6	0	nd	nd	0.20
NFK (RM 4.9)	6/8	75	0.00104	0.00689	0.20
Nickel					
Filtered					
BRN (RM 1.1)	61/65	94	0.274 J	0.910 J	0.154 – 0.387
SWM (RM 1.9)	54/60	90	0.259 J	1.50 J	0.118 – 0.306
NFK (RM 4.9)	21/21	100	0.190 J	0.472 J	na
Unfiltered					
BRN (RM 1.1)	145/147	99	0.394 J	2.11 J	0.348 – 0.386
SWM (RM 1.9)	137/143	96	0.328 J	2.88 J	0.291 – 0.575
NFK (RM 4.9)	55/55	100	0.434 J	2.91 J	na
Silver					
Filtered					
BRN (RM 1.1)	0/72	0	nd	nd	0.11 – 0.13
SWM (RM 1.9)	0/72	0	nd	nd	0.097 – 0.13
NFK (RM 4.9)	0/24	0	nd	nd	0.10 – 0.13
Unfiltered					
BRN (RM 1.1)	0/173	0	nd	nd	0.10 – 0.13
SWM (RM 1.9)	0/173	0	nd	nd	0.10 – 0.13
NFK (RM 4.9)	0/58	0	nd	nd	0.11 – 0.13

Location ID[a]	Detection Frequency		Concentration (µg/L)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[b]
Vanadium					
Filtered					
BRN (RM 1.1)	50/50	100	0.193	1.57	na
SWM (RM 1.9)	42/42	100	0.370	1.56	na
NFK (RM 4.9)	18/18	100	0.141	0.400	na
Unfiltered					
BRN (RM 1.1)	133/133	100	0.267	2.96	na
SWM (RM 1.9)	125/125	100	0.220	3.99	na
NFK (RM 4.9)	46/46	100	0.315	3.57	na
Zinc					
Filtered					
BRN (RM 1.1)	72/72	100	0.750 J	5.39 J	na
SWM (RM 1.9)	72/72	100	0.825 J	4.09 J	na
NFK (RM 4.9)	22/22	100	0.881 J	5.24 J	na
Unfiltered					
BRN (RM 1.1)	173/173	100	0.70 J	8.34 J	na
SWM (RM 1.9)	173/173	100	1.08 J	6.62 J	na
NFK (RM 4.9)	56/56	100	0.979 J	9.04 J	na

[a] BRN, SWM, and NFK are located in the LDW near the Brandon, SW Michigan, and Norfolk CSOs, respectively.

[b] RLs are based only on non-detect samples.

[c] Mercury data are not available for filtered samples from the SWM (RM 1.9) location.

J – estimated concentration
na – not applicable
nc – not calculated
nd – not detected
RM – river mile

4.2.8.5 Seep water

Seep water samples were collected and analyzed for metals during four sampling events (Table 4-74; Map 4-11a). At Boeing Plant 2, 10 filtered seep water samples and 17 unfiltered samples were analyzed for metals. During the Rhône-Poulenc sampling event, unfiltered seep water samples from seven locations were analyzed for metals, with only detected concentrations reported. At T-117, three filtered and three unfiltered seep water samples were analyzed for metals. As part of the LDW-wide RI sampling event, 16 filtered and 13 unfiltered seep water samples were analyzed for metals. No seep water samples were analyzed for TBT during any of the four sampling events. Detected concentrations of metals in seep water samples are shown on Maps 4-11b through 4-11e.

Table 4-74. Summary of seep water data for metals

Chemical	Detection Frequency		Concentration (µg/L)			Location of Maximum Detect[b]
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[a]	
Cadmium						
Boeing Plant 2						
Cadmium (filtered)	0/10	0	nd	nd	2 – 10	na
Cadmium (unfiltered)	0/17	0	nd	nd	2 – 10	na
Rhône-Poulenc						
Cadmium (unfiltered)	2/7	29	2.1	11.6	nr	02-SP
T-117						
Cadmium (filtered)	0/3	0	nd	nd	2.00	na
Cadmium (unfiltered)	0/3	0	nd	nd	2.0	na
LDW RI						
Cadmium (filtered)	16/16	100	0.009	0.508	na	SP-82
Cadmium (unfiltered)	13/13	100	0.022	0.710	na	SP-54
Chromium						
Boeing Plant 2						
Chromium (filtered)	0/10	0	nd	nd	5 – 20	na
Chromium (unfiltered)	6/17	35	6	49	5 – 20	SE-SWY03
Rhône-Poulenc						
Chromium (unfiltered)	1/7	14	202	202	nr	02-SP
T-117						
Chromium (filtered)	2/3	67	8.00 J	9.00 J	5.00	SEEP_2
Chromium (unfiltered)	2/3	67	6.00	7.00	5.00	SEEP_3
LDW RI						
Chromium (filtered)	0/16	0	nd	nd	1.51 – 9.74	na
Chromium (unfiltered)	1/13	8	74.9	74.9	0.07 – 11.4	SP-54
Copper						
Boeing Plant 2						
Copper (filtered)	1/10	10	8	8	2 – 10	SE-94105
Copper (unfiltered)	11/17	65	2	60	2 – 10	SE-SWY03
Rhône-Poulenc						
Copper (unfiltered)	1/7	14	203	203	nr	02-SP
T-117						
Copper (filtered)	3/3	100	4 J	5.00 J	na	SEEP_2, SEEP_1
Copper (unfiltered)	3/3	100	2.50	4.00	na	SEEP_3
LDW RI						
Copper (filtered)	7/16	44	8.16 J	22.8	3.28 – 7.77	SP-80
Copper (unfiltered)	10/13	77	8.06 J	50.9	4.75 – 6.47	SP-76

Table 4-74, cont. Summary of seep water data for metals

Chemical	Detection Frequency		Concentration (µg/L)			Location of Maximum Detect[b]
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[a]	
Lead						
Boeing Plant 2						
Lead (filtered)	0/10	0	nd	nd	1 – 20	na
Lead (unfiltered)	14/17	82	1	104	20	SE-SWY02
Rhône-Poulenc						
Lead (unfiltered)	1/7	14	44.1	44.1	nr	02-SP
T-117						
Lead (filtered)	0/3	0	nd	nd	20	na
Lead (unfiltered)	0/3	0	nd	nd	20	na
LDW RI						
Lead (filtered)	16/16	100	0.036	3	na	SP-76
Lead (unfiltered)	13/13	100	0.080	296	na	SP-54
Mercury						
Boeing Plant 2						
Mercury (filtered)	0/10	0	nd	nd	0.1	na
Mercury (unfiltered)	3/17	18	0.2	0.2	0.1	SE-31003, SE-SWY01, SE-SWY03
Rhône-Poulenc						
Mercury (unfiltered)	1/7	14	0.65	0.65	nr	05-SP
T-117						
Mercury (unfiltered)	0/3	0	nd	nd	0.10	na
LDW RI						
Mercury (filtered)	16/16	100	0.00062	0.0153	na	SP-76
Mercury (unfiltered)	13/13	100	0.00061	0.582	na	SP-54
Nickel						
Boeing Plant 2						
Nickel (filtered)	0/10	0	nd	nd	10 – 50	na
Nickel (unfiltered)	4/17	24	10	50	10 – 50	SE-SWY04
Rhône-Poulenc						
Nickel (unfiltered)	1/7	14	70.0	70.0	nr	02-SP
LDW RI						
Nickel (filtered)	12/16	75	0.84	5.25	0.040	SP-20
Nickel (unfiltered)	12/13	92	2.80	8.83	0.040	SP-20
Silver						
Boeing Plant 2						
Silver (filtered)	0/10	0	nd	nd	3 – 20	na
Silver (unfiltered)	0/17	0	nd	nd	3 – 20	na

Table 4-74, cont. Summary of seep water data for metals

Chemical	Detection Frequency		Concentration (µg/L)			Location of Maximum Detect[b]
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[a]	
T-117						
Silver (filtered)	0/3	0	nd	nd	3.00	na
Silver (unfiltered)	0/3	0	nd	nd	3.00	na
LDW RI						
Silver (filtered)	14/16	88	0.012	0.112	0.015	SP-20
Silver (unfiltered)	11/13	85	0.025	0.11	0.015	SP-82
Vanadium						
Boeing Plant 2						
Vanadium (filtered)	2/10	20	2	4	2 – 10	SE-11001
Vanadium (unfiltered)	15/17	88	2	50	2 – 10	SE-31003
Rhône-Poulenc						
Vanadium (unfiltered)	7/7	100	2.8	400	na	02-SP
Zinc						
Boeing Plant 2						
Zinc (filtered)	3/10	30	30	90	4 – 20	SE-SWY04
Zinc (unfiltered)	14/17	82	6	200	20	SE-SWY04
Rhône-Poulenc						
Zinc (unfiltered)	1/7	14	223	223	nr	02-SP
T-117						
Zinc (filtered)	0/3	0	nd	nd	6.00	na
Zinc (unfiltered)	1/3	33	7.00 J	7.00 J	6.00	SEEP_1
LDW RI						
Zinc (filtered)	16/16	100	3.29	161	na	SP-82
Zinc (unfiltered)	13/13	100	3.49	322	na	SP-54

[a] RLs are based only on non-detect samples.
[b] Sampling locations are shown on Map 4-11a.

J – estimated concentration
na – not applicable
nc – not calculated
nd – not detected
nr – not reported; RLs for non-detects not reported for this sampling event
RI – remedial investigation
RL – reporting limit

The unfiltered seep water sample collected from location 02-SP near Slip 6 (Map 4-11e) had the highest concentrations of cadmium, chromium, copper, nickel, and vanadium of any samples collected during the four sampling events. Concentrations of metals in seep water samples are compared with WQC in Section 4.2.2 (Table 4-21).

4.2.8.6 Porewater

Metals were analyzed in 15 unfiltered porewater samples collected during the 2004 Rhône-Poulenc sampling event and in 15 unfiltered porewater samples collected throughout the LDW during the 1998 EPA SI (Table 4-75). In addition, TBT was

analyzed in 20 unfiltered samples collected by USACE between RM 1.8 and RM 3.2 in 1999. Concentrations of the seven metals detected in individual porewater samples are shown on Maps 4-12b through 4-12d and are compared with WQC in Section 4.2.2 (Table 4-22). TBT was detected in 95% of the porewater samples at concentrations ranging from 0.010 to 0.15 µg/L, with the exception of one sample collected near RM 2.5 that had a concentration of 0.55 µg/L, which was greater than the DMMP SL of 0.15 µg/L (Maps 4-12b and 4-12c).

Table 4-75. Summary of porewater data for detected metals

Chemical	Detection Frequency		Concentration (µg/L)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[a]
Rhône-Poulenc					
Total copper	4/15	27	5.4	264	5
Total mercury	10/15	67	0.0016	0.408	0.2
Total zinc	3/15	20	263	1,560	50
EPA SI					
Total cadmium	4 /15	27	4 J	4 J	5
Total copper	4/15	27	1	5	4
Total lead	13/15	87	0.6 J	4	1
Total silver	6/15	40	0.3 J	0.5 J	1
Total vanadium	15/15	100	3 J	22	na
Total zinc	3/15	20	4 J	6 J	10
PSDDA99					
TBT	19/20	95	0.010 J	0.55	0.020

[a] RLs are based only on non-detect samples.

EPA – US Environmental Protection Agency
J – estimated concentration
na – not applicable
PSDDA – Puget Sound Dredged Disposal Analysis
RL – reporting limit
SI – sediment investigation
TBT – tributyltin

4.2.8.7 Summary of metals and TBT data

Most samples with concentrations greater than the numerical 95th percentile for each metal were located either downstream of RM 2.2 or between RM 3.5 and RM 3.7 (within the Boeing Plant 2/Jorgensen Forge EAA). The Duwamish/Diagonal EAA and the Boeing Plant 2/Jorgensen Forge EAA had many of the highest metals concentrations in surface sediment. Other notable areas with high concentrations of more than one metal in surface sediment include Slip 1, Slip 4, RM 1.3 to RM 1.5 on the west side, and RM 2.2 on the west side. TBT concentrations in surface sediment were highest near RM 1.3 on the west side of the LDW and downstream of RM 1.0.

In tissue, the highest mean concentrations of metals (including TBT) were detected in invertebrate species (i.e., clams, crabs, benthic invertebrates, and amphipods). Mean

concentrations of metals (except mercury) and TBT in whole-body fish samples were higher than those in fish fillets. In crab hepatopancreas, mean concentrations of cadmium, copper, lead, and TBT were higher than those in crab edible meat.

In surface water, higher mean concentrations of chromium, copper, lead, nickel, vanadium, and zinc in unfiltered samples and copper, lead, and zinc in filtered samples were detected in samples from RM 4.9 than in samples from RM 1.1 and RM 1.9. In seep water, one unfiltered sample collected near Slip 6 had the highest concentrations of cadmium, chromium, copper, nickel, and vanadium. Thirty unfiltered porewater samples collected from throughout the LDW were analyzed for metals; seven metals were detected in these samples. Twenty porewater samples were collected between RM 1.8 and RM 3.2 and analyzed for TBT. The highest TBT concentration (0.55 µg/L) was detected in a sample collected near RM 2.5. This was the only sample with a TBT concentration that exceeded the DMMP SL of 0.15 µg/L.

4.2.9 SVOCs

This section summarizes the nature and extent of SVOC concentrations in surface sediment, subsurface sediment, tissue, surface water, seep water, and porewater. The nature and extent of cPAH and BEHP concentrations is discussed in Sections 4.2.5 and 4.2.6, respectively.

4.2.9.1 Surface sediment

Table 4-76 presents detection frequencies and a summary of concentrations in surface sediment for selected SVOCs.[97] Table 4-77 presents detection frequencies and a summary of OC-normalized concentrations for SVOCs with SMS criteria expressed in units of mg/kg OC. Surface sediment samples collected from 828 of the 1,365 locations in the RI baseline dataset were analyzed for one or more PAHs, samples from 832 locations were analyzed for one or more phthalates, and samples from 831 locations were analyzed for at least one other SVOC included in Table 4-76.

Table 4-76. Summary of surface sediment data for selected SVOCs

Chemical	Detection Frequency		Concentration (µg/kg dw)				SMS Criteria (µg/kg dw)	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[a]	RL or Range of RLs[b]	SQS	CSL
PAHs								
2-Methylnaphthalene	139/818	17	1.0 J	3,300	nc	1.0 – 2,000	na[c]	na[c]
Acenaphthene	304/828	37	1.0 J	5,200	70	1.8 – 2,000	na[c]	na[c]
Anthracene	576/828	70	2.0	10,000	100	13 – 2,000	na[c]	na[c]

[97] An SVOC was included in Section 4.2.8.1 if it exceeded the SQS in at least one surface sediment sample or if it was identified as a COC in the HHRA based on a sediment exposure pathway.

Chemical	Detection Frequency		Concentration (µg/kg dw)				SMS Criteria (µg/kg dw)	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[a]	RL or Range of RLs[b]	SQS	CSL
Benzo(a)anthracene	748/828	90	7.3 J	8,400	320	6.4 – 200	na[c]	na[c]
Benzo(a)pyrene	747/822	91	6.5	7,900	310	6.4 – 350	na[c]	na[c]
Benzo(g,h,i)perylene	682/823	83	6.1	3,800	200	13 – 2,000	na[c]	na[c]
Total benzofluoranthenes	757/822	92	6.6 J	17,000	740	nc	na[c]	na[c]
Chrysene	773/828	93	12	7,700	500	18 – 170	na[c]	na[c]
Dibenzo(a,h)anthracene	436/828	53	1.6 J	1,500	60	1.0 – 2,000	na[c]	na[c]
Dibenzofuran	248/827	30	1.0 J	4,200	50	1.7 – 2,000	na[c]	na[c]
Fluoranthene	797/828	96	18	24,000	900	19 – 340	na[c]	na[c]
Fluorene	382/828	46	1.4 J	6,800	80	1.8 – 2,000	na[c]	na[c]
Indeno(1,2,3-cd)pyrene	726/823	88	6.5	4,300	200	6.4 – 1,600	na[c]	na[c]
Naphthalene	152/818	19	3.0 J	5,300	nc	1.0 – 2,000	na[c]	na[c]
Phenanthrene	759/828	92	7.1	28,000	400	18 – 200	na[c]	na[c]
Pyrene	788/828	95	19	16,000	700	18 – 170	na[c]	na[c]
Total HPAH[d]	803/828	97	20	85,000	4,000	nc	na[c]	na[c]
Total LPAH[e]	763/828	92	9.1	44,000	700	nc	na[c]	na[c]
Total PAH	805/828	97	20	128,000	4,000	nc	nv	nv
Phthalates[f]								
BBP	425/822	52	2.0	7,100	80	1.8 – 2,000	na[c]	na[c]
Dimethyl phthalate	156/822	19	2.0 J	200	nc	1.8 – 2,000	na[c]	na[c]
Chlorobenzenes								
1,2,4-Trichlorobenzene	5/816	1	1.6 J	72 J	nc	0.40 – 2,000	na[c]	na[c]
1,2-Dichlorobenzene	17/816	2	1.3 J	520 J	nc	0.40 – 2,000	na[c]	na[c]
1,4-Dichlorobenzene	39/816	5	1.7 J	1,600 J	nc	0.20 – 2,000	na[c]	na[c]
Hexachlorobenzene	46/819	6	0.4 J	95 J	nc	0.11 – 2,000	na[c]	na[c]
Other SVOCs								
2,4-Dimethylphenol	5/813	1	6.1	290 J	nc	6.0 – 2,000	29	29
4-Methylphenol	82/831	10	4.8 J	4,600 J	nc	8.6 – 2,000	670	670
Benzoic acid	70/822	9	54 J	4,500	nc	13 – 3,000	650	650
Benzyl alcohol	15/812	2	8.2 J	670	nc	9.2 – 690	57	73
n-Nitrosodiphenylamine	23/818	3	6.5	230	nc	1.8 – 2,000	na[c]	na[c]
Pentachlorophenol	12/785	2	14 J	410	nc	7.6 – 4,900	360	690
Phenol	257/831	31	10 J	2,800	90	7.3 – 790	420	1,200

Note: An SVOC was included in this table if it exceeded the SQS or if it was identified as a COC in the HHRA (Appendix B) based on a sediment exposure pathway.

[a] Calculated mean concentration is the average of detected concentrations and one-half the RL for non-detected results. Mean concentrations were not calculated if the number of samples was ≤ 20 or the detection frequency was ≤ 25% because it is uncertain if these means would represent LDW-wide conditions.

[b] RLs are based only on non-detect samples.

[c] SMS criteria are in mg/kg OC for these chemicals; OC-normalized concentrations and criteria for these chemicals are presented in Table 4-77.

[d] Total HPAHs were calculated as the sum of benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, total benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene.

[e] Total LPAHs were calculated as the sum of acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene.

[f] BEHP data are summarized in Table 4-56 in Section 4.2.6.1.

BBP – butyl benzyl phthalate
CSL – cleanup screening level
dw – dry weight
na – not applicable
nc – not calculated
nd – not detected
nv – no value
J – estimated concentration
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
OC – organic carbon
PAH – polycyclic aromatic hydrocarbon
RL – reporting limit
SVOC – semivolatile organic compound
SMS – Washington State Sediment Management Standards
SQS – sediment quality standards

Table 4-77. Summary of OC-normalized surface sediment data for selected SVOCs with OC-normalized SMS criteria

Chemical	Detection Frequency		Concentration (mg/kg OC)[a]				SMS Criteria (mg/kg OC)	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[B]	Range of RLs[c]	SQS	CSL
PAHs								
2-Methylnaphthalene	123/753	16	0.090	160	nc	0.059 – 94	38	64
Acenaphthene	283/760	37	0.064 J	260	3	0.059 – 94	16	57
Anthracene	548/760	72	0.10	380	7	0.65 – 94	220	1,200
Benzo(a)anthracene	712/760	94	0.44	440	20	0.29 – 34	110	270
Benzo(a)pyrene	710/756	94	0.25	420	20	0.29 – 68	99	210
Benzo(g,h,i)perylene	648/755	86	0.22	180	8	0.65 – 94	31	78
Total benzofluoranthenes	715/754	95	0.49 J	890	40	nc	230	450
Chrysene	731/760	96	0.86	410	20	0.67 – 34	110	460
Dibenzo(a,h)anthracene	413/760	54	0.080	71	3	0.034 – 170	12	33
Dibenzofuran	232/759	31	0.10 J	220	3	0.059 – 94	15	58
Fluoranthene	750/760	99	0.92	1,300	50	0.67 – 68	160	1,200
Fluorene	357/760	47	0.090	290	4.0	0.059 – 94	23	79
Indeno(1,2,3-cd)pyrene	689/755	91	0.23	200	9	0.29 – 59	34	88
Naphthalene	135/753	18	0.13 J	260	2.3	0.059 – 94	99	170
Phenanthrene	719/760	95	0.36	1,500	20	0.67 – 34	100	480
Pyrene	743/760	98	0.87	840	40	0.67 – 34	1,000	1,400
Total HPAH[d]	754/760	99	1.6 J	4,500	200	nc	960	5,300
Total LPAH[e]	721/760	95	0.46	2,300	30	nc	370	780
Phthalates[f]								
BBP	406/757	54	0.071	530 J	4	0.060 – 94	4.9	64

Chemical	Detection Frequency		Concentration (mg/kg OC)[a]				SMS Criteria (mg/kg OC)	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean[b]	Range of RLs[c]	SQS	CSL
Dimethyl phthalate	149/757	20	0.14 J	15	nc	0.059 – 94	53	53
Chlorobenzenes								
1,2,4-Trichlorobenzene	4/751	1	0.057 J	0.61 J	nc	0.020 – 94	0.81	1.8
1,2-Dichlorobenzene	15/751	2	0.068 J	2.9 J	nc	0.020 – 94	2.3	2.3
1,4-Dichlorobenzene	34/751	5	0.097 J	65	nc	0.023 – 94	3.1	9
Hexachlorobenzene	45/753	6	0.02 J	3.8	nc	0.0095 – 94	0.38	2.3
Other SVOCs								
n-Nitrosodiphenylamine	21/753	3	0.23	7.9	nc	0.059 – 94	11	11

[a] Summary statistics for OC-normalized concentrations were calculated using only samples with TOC contents ≥ 0.5% and ≤ 4.0%. At very low or very high TOC contents, OC normalization is not appropriate for comparison to SMS (Michelsen and Bragdon-Cook 1993).

[b] Calculated mean concentration is the average of detected concentrations and one-half the RL for non-detected results. Mean concentrations were not calculated if the number of samples was ≤ 20 or the detection frequency was ≤ 25% because it is uncertain if these means would represent LDW-wide conditions.

[c] RLs are based only on non-detect samples.

[d] Total HPAHs were calculated as the sum of benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, total benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene.

[e] Total LPAHs were calculated as the sum of acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene.

[f] BEHP data are summarized in Table 4-58 in Section 4.2.6.1.

BBP – butyl benzyl phthalate
CSL – cleanup screening level
J – estimated concentration
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
nc – not calculated
OC – organic carbon
PAH – polycyclic aromatic hydrocarbon
RL – reporting limit
SVOC – semivolatile organic compound
SMS – Washington State Sediment Management Standards
SQS – sediment quality standards

At least one individual PAH listed in Table 4-76 was detected in samples from 97% of the locations. The individual PAHs with the highest mean concentrations were fluoranthene (900 µg/kg dw), pyrene (700 µg/kg dw), chrysene (500 µg/kg dw), and phenanthrene (400 µg/kg dw). Concentrations of total high-molecular-weight polycyclic aromatic hydrocarbons (HPAHs) were generally higher than those of total LPAHs (means of 4,000 and 700 µg/kg, respectively).

The maximum total HPAH concentration (85,000 µg/kg dw) was detected at a location near RM 3.6 in the T-117 EAA (T117-SE-37-G). Other areas with high total HPAH concentrations were: 1) west of the navigation channel near RM 0.6 (51,000 µg/kg dw at DR044), 2) at the RM 3.8 EAA on the eastern shoreline (51,000 µg/kg dw at R23), 3) near RM 2.7 on the western shoreline (48,000 µg/kg dw at LDW-SS95), and 4) near RM 1.0 on the eastern shoreline (42,000 µg/kg dw at LDW-SS35). HPAH concentrations exceeded the SQS but not the CSL in 24 samples (2.9%) and exceeded

the CSL in 4 samples (0.48%) (Table 4-16). Approximately half of the exceedances were located within EAAs (Map 4-61).

The maximum total LPAH concentration (44,000 µg/kg dw) was detected at a location near RM 2.7 on the western shoreline (LDW-SS95). Other areas with high total LPAH concentrations were: 1) in the T-117 EAA (43,000 µg/kg dw at T117-SE-37-G), 2) near RM 1.0 on the eastern shoreline (34,000 µg/kg dw at LDW-SS35), and 3) in the Boeing Plant 2/Jorgensen Forge EAA at RM 3.6 (10,900 µg/kg dw at SD-307-S). Several other areas also had total HPAH and LPAH concentrations greater than the numerical 95th percentile, as shown on Maps 4-61 and 4-62. Total LPAH concentrations exceeded the SQS but not the CSL in three samples and exceeded the CSL in three samples, both inside and outside of EAAs (Table 4-16; Map 4-62).

Of the two phthalate compounds presented in Table 4-76, BBP was detected more frequently than dimethyl phthalate (in 52 and 19% of samples, respectively). Most of locations with high BBP concentrations in surface sediment were located in the vicinity of the Duwamish/Diagonal EAA (Map 4-63), as were the highest dimethyl phthalate concentrations.

BBP concentrations exceeded the SQS but not the CSL in 71 samples (8.6%) and exceeded the CSL in 8 samples (0.97%) (Table 4-16). Most of the BBP SQS and CSL exceedances were located within EAAs, although six SQS exceedances were located south of the RM 3.8 EAA, and several other isolated SQS exceedances were located at various areas in the LDW. Approximately half of the exceedances were located between RM 0.4 and RM 0.6 in and around the Duwamish/Diagonal EAA (Map 4-63).

Each of the four chlorobenzenes listed in Table 4-76 was detected in 6% or fewer of the surface sediment samples. Samples with detected concentrations of 1,2-dichlorobenzene, 1,4-dichlorobenzene, and 1,2,4-trichlorobenzene were collected primarily between RM 0.4 and RM 0.6 on the east side of the LDW in the vicinity of the Duwamish/Diagonal EAA. The highest hexachlorobenzene concentrations (95 and 63 µg/kg dw) were detected near RM 1.8 west of the navigation channel (LDW-SS68) and between RM 3.0 and RM 3.1 on the western shoreline (B7a), respectively. All other detected hexachlorobenzene concentrations were less than 30 µg/kg dw.

Among the seven chemicals in the "other SVOC" category in Table 4-76, phenol was detected most frequently (in 31% of the samples). The highest concentrations of phenol were primarily located between RM 3.5 and RM 3.7 in the Boeing Plant 2/Jorgensen Forge EAA, near RM 3.6 in the T117 EAA, and in Slip 6 (Map 4-64). Phenol concentrations exceeded the SQS but not the CSL in 17 samples (2.0%) and exceeded the CSL in 6 samples (0.72%) (Table 4-16). Three of the phenol CSL exceedances were located in the T-117 EAA, and two were in Slip 6. Most of the remaining phenol SQS and CSL exceedances were located within the Boeing Plant 2/Jorgensen Forge EAA, although there were also several other isolated SQS exceedances at various locations in the LDW (Map 4-64).

The highest concentrations of benzoic acid were located primarily between RM 4.0 and RM 4.2 and in Slip 6 (Map 4-65). Five of the eight benzoic acid CSL exceedances were located in this area (Map 4-65).

4.2.9.2 Subsurface sediment

Detection frequencies and ranges of concentrations of SVOCs in all subsurface sediment samples collected from any interval are presented in Table 4-78. The most frequently detected SVOCs in subsurface sediment were PAH compounds; individual PAHs were detected in 15 to 88% of all samples. Other SVOCs presented in Table 4-78 that were most frequently detected were BBP and benzoic acid in 52 and 40% of all samples, respectively.

Table 4-78. Summary of subsurface sediment data from any interval for selected SVOCs

Chemical	Detection Frequency[a]		Concentration (µg/kg dw)[b]		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[c]
PAHs					
2-Methylnaphthalene	43/281	15	2.9 J	4,500	1.6 – 400
Acenaphthene	94/304	31	1.3 J	4,600	4.30 – 400
Anthracene	200/304	66	4.3 J	1,900	4.30 – 400
Benzo(a)anthracene	243/304	80	12 J	4,500	4.30 – 180
Benzo(a)pyrene	237/304	78	11 J	5,300	4.30 – 400
Benzo(g,h,i)perylene	207/298	69	11 J	1,000	4.30 – 400
Total benzofluoranthenes	248/304	82	21 J	10,200	nc
Chrysene	247/304	81	12 J	7,200	4.30 – 180
Dibenzo(a,h)anthracene	119/304	39	3.2 J	660 J	4.30 – 910
Dibenzofuran	58/304	19	2.9 J	1,700	1.7 – 400
Fluoranthene	262/304	86	12 J	13,000	4.30 – 340
Fluorene	104/304	34	4.9 J	4,300	2.3 – 400
Indeno(1,2,3-cd)pyrene	212/298	71	10 J	1,500	4.30 – 400
Naphthalene	70/293	24	1.9 J	3,400	1.7 – 400
Phenanthrene	244/304	80	10 J	13,000	4.30 – 400
Pyrene	266/304	88	9.9 J	10,000	4.30 – 170
Total HPAH[d]	268/304	88	9.9 J	47,000	nc
Total LPAH[e]	244/304	80	12.00	27,000 J	nc
Total PAH	269/304	88	9.9 J	57,000 J	nc
Phthalates[f]					
BBP	147/283	52	5.6 J	610	5.8 – 400
Dimethyl phthalate	20/283	7	4.2 J	8,800	2.4 – 400

Chemical	Detection Frequency[a]		Concentration (µg/kg dw)[b]		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[c]
Chlorobenzenes					
1,2,4-Trichlorobenzene	27/293	9	3.6 J	110 J	0.87 – 400
1,2-Dichlorobenzene	31/292	11	0.98 J	160	0.78 – 400
1,4-Dichlorobenzene	56/292	19	2.1 J	750 J	0.86 – 400
Hexachlorobenzene	3/280	1	4.6 J	10	0.78 – 400
Other SVOCs					
2,4-Dimethylphenol	21/281	7	3.7 J	46	5.8 – 790
4-Methylphenol	15/304	5	8.6 J	110 J	3.8 – 400
Benzoic acid	122/304	40	35 J	3,000 J	58 – 4,000
Benzyl alcohol	32/281	11	7.7 J	210	4.9 – 2,000
n-Nitrosodiphenylamine	1/281	< 1	33	33	2.9 – 7,300
Pentachlorophenol	54/304	18	16 J	930 J	12 – 3,100
Phenol	57/304	19	12 J	3,100	4.4 – 790

Note: Data included in the subsurface dataset are described in Section 4.1.2.2; subsurface sediment samples collected from areas that were subsequently dredged are not summarized in this table because they do not represent existing conditions. An SVOC was included in this table if it exceeded the SQS in at least one surface sediment sample or if it was identified as a COC in the HHRA (Appendix B) based on a sediment exposure pathway.

[a] Subsurface sediment samples collected from areas that were subsequently dredged are not included in this table

[b] Mean concentrations were not calculated because sampling was generally focused in contaminated areas, resulting in a non-random sampling pattern, which is not likely representative of the entire LDW.

[c] RLs are based only on non-detect samples.

[d] Total HPAHs were calculated as the sum of benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, total benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene.

[e] Total LPAHs were calculated as the sum of acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene.

[f] BEHP data are summarized in Table 4-61 in Section 4.2.6.2.

BBP – butyl benzyl phthalate
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
J – estimated concentration
nc – not calculated
PAH – polycyclic aromatic hydrocarbon
RL – reporting limit
SVOC – semivolatile organic compound
U – not detected at RL shown

Detection frequencies and ranges of concentrations of SVOCs in subsurface sediment collected from specific 1- and 2-ft intervals[98] within the top 10 ft of sediment are presented in Table 4-79. Over 90% of the samples represented in these tables were collected from the top 4 ft of sediment. Relatively few samples were analyzed from

[98] Subsurface sediment cores were sampled at various depth intervals during different sampling events. To calculate summary statistics, data were categorized according to specified depth intervals, as described for total PCBs in Section 4.2.2.2.

depths greater than 4 ft below mudline; most of these samples were collected and analyzed as part of the RI at locations with SMS exceedances of SVOCs in upper intervals.

Table 4-79. Summary of subsurface sediment data for selected SVOCs in samples collected from 1- and 2-ft intervals within the top 10 ft of sediment

Chemical	Sampling Interval (ft)[a]	Detection Frequency		Concentration (µg/kg dw)[b]		
		Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[c]
PAHs						
Total HPAH[d] – 1-ft intervals	0 to 1	60/64	94	122 J	34,700	nc
	1 to 2	38/45	84	13 J	40,000	nc
	2 to 3	7/10	70	115 J	4,400	nc
	3 to 4	4/9	44	21 J	323 J	nc
	4 to 5	1/1	100	580 J	580 J	nc
Total HPAH[d] – 2-ft intervals	0 to 2	72/74	97	80	27,900	nc
	2 to 4	62/73	85	9.9 J	47,000	nc
	4 to 6	10/10	100	140	22,000	nc
	6 to 8	5/5	100	60 J	38,000 J	nc
	8 to 10	5/5	100	58.0	2,040	nc
Total LPAH[e] – 1-ft intervals	0 to 1	54/64	84	12 J	2,100 J	nc
	1 to 2	34/45	76	24 J	7,500	nc
	2 to 3	4/10	40	20	2,630 J	nc
	3 to 4	2/9	22	43 J	220 J	nc
	4 to 5	1/1	100	47 J	47 J	nc
Total LPAH[e] – 2-ft intervals	0 to 2	72/74	97	15 J	3,800 J	nc
	2 to 4	56/73	77	20	27,000 J	nc
	4 to 6	9/10	90	141 J	3,900	nc
	6 to 8	4/5	80	770 J	9,800	nc
	8 to 10	5/5	100	12.00	275 J	nc
Total PAH – 1-ft intervals	0 to 1	61/64	95	24	36,200	nc
	1 to 2	38/45	84	13 J	42,600 J	nc
	2 to 3	7/10	70	135 J	5,000 J	nc
	3 to 4	4/9	44	21 J	366 J	nc
	4 to 5	1/1	100	630 J	630 J	nc
Total PAH – 2-ft intervals	0 to 2	73/74	99	24	29,500 J	nc
	2 to 4	62/73	85	9.9 J	57,000 J	nc
	4 to 6	10/10	100	281 J	23,000 J	nc
	6 to 8	5/5	100	60 J	46,000 J	nc
	8 to 10	5/5	100	70.0	2,210	nc
Phthalates[f]						
BBP– 1-ft intervals	0 to 1	33/41	80	5.9	610	5.9 – 180
	1 to 2	22/45	49	14	400	5.8 – 36

Table 4-79, cont. Summary of subsurface sediment data for selected SVOCs in samples collected from 1- and 2-ft intervals within the top 10 ft of sediment

Chemical	Sampling Interval (ft)[a]	Detection Frequency		Concentration (µg/kg dw)[b]		
		Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[c]
	2 to 3	3/10	30	6.6	10	5.9 – 400
	3 to 4	2/9	22	6.4	7.7	5.8 – 20
	4 to 5	1/1	100	18	18	na
BBP – 2-ft intervals	0 to 2	51/74	69	5.9	610	5.8 – 110
	2 to 4	34/73	47	5.8 J	180	5.8 – 42
	4 to 6	5/10	50	12 J	48	6.5 – 36
	6 to 8	4/5	80	15 J	35 J	6.5
	8 to 10	0/5	0	nd	nd	6.1 – 20.0
Dimethyl phthalate – 1-ft intervals	0 to 1	3/41	7	13 J	1,700	13 – 180
	1 to 2	1/45	2	16 J	16 J	12 – 130
	2 to 3	0/10	0	nd	nd	14 – 400
	3 to 4	0/9	0	nd	nd	14 – 20
	4 to 5	0/1	0	nd	nd	6.6
Dimethyl phthalate – 2-ft intervals	0 to 2	5/74	7	9.9 J	84	12 – 110
	2 to 4	4/73	5	30	8,800	14 – 140
	4 to 6	2/10	20	20	210	6.5 – 44
	6 to 8	3/5	60	16	69 J	6.5
	8 to 10	0/5	0	nd	nd	6.6 – 62
Chlorobenzenes						
1,2,4-Tri-chlorobenzene – 1-ft intervals	0 to 1	5/42	12	3.6 J	18 J	5.8 – 180
	1 to 2	6/46	13	4.1 J	17 J	5.8 – 20.0
	2 to 3	0/11	0	nd	nd	5.9 – 400
	3 to 4	0/10	0	nd	nd	5.8 – 20
	4 to 5	0/2	0	nd	nd	6.6 – 8.3
	5 to 6	0/1	0	nd	nd	8.3
	6 to 7	0/1	0	nd	nd	8.2
	7 to 8	0/1	0	nd	nd	9.5
	8 to 9	0/1	0	nd	nd	9.5
	9 to 10	0/1	0	nd	nd	8.4
1,2,4-Tri-chlorobenzene – 2-ft intervals	0 to 2	11/76	14	3.9 J	13 J	5.8 – 110
	2 to 4	4/74	5	4.1 J	110 J	5.8 – 25.0
	4 to 6	2/11	18	11	18	6.5 – 20.0
	6 to 8	3/6	50	9.8	14	6.5 – 8.2
	8 to 10	0/5	0	nd	nd	5.40 – 6.6

Table 4-79, cont. Summary of subsurface sediment data for selected SVOCs in samples collected from 1- and 2-ft intervals within the top 10 ft of sediment

Chemical	Sampling Interval (ft)[a]	Detection Frequency		Concentration (µg/kg dw)[b]		
		Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[c]
1,2-Dichlorobenzene – 1-ft intervals	0 to 1	4/42	10	1.7 J	17	2.0 – 180
	1 to 2	4/46	9	2.9 J	9.6	0.78 – 20.0
	2 to 3	0/11	0	nd	nd	0.86 – 400
	3 to 4	0/10	0	nd	nd	0.86 – 6.0
	4 to 5	1/2	50	10	10	1.7
	5 to 6	0/1	0	nd	nd	1.7
	6 to 7	0/1	0	nd	nd	1.6
	7 to 8	0/1	0	nd	nd	1.9
	8 to 9	0/1	0	nd	nd	1.9
	9 to 10	0/1	0	nd	nd	1.7
1,2-Dichlorobenzene – 2-ft intervals	0 to 2	8/76	11	1.7 J	20	1.7 – 110
	2 to 4	8/74	11	3.6 J	150	0.86 – 42
	4 to 6	2/11	18	10	12	1.7 – 20.0
	6 to 8	3/6	50	12	160	1.6 – 6.6
	8 to 10	0/5	0	nd	nd	1.10 – 6.6
1,4-Dichlorobenzene – 1-ft intervals	0 to 1	15/42	36	3.0 J	750 J	2.0 – 180
	1 to 2	9/46	20	3.5 J	17 J	1.7 – 20
	2 to 3	2/11	18	2.1 J	3.0 J	1.8 – 400
	3 to 4	0/10	0	nd	nd	0.86 – 6.0
	4 to 5	1/2	50	7.9	7.9	1.7
	5 to 6	0/1	0	nd	nd	1.7
	6 to 7	0/1	0	nd	nd	1.6
	7 to 8	0/1	0	nd	nd	1.9
	8 to 9	0/1	0	nd	nd	1.9
	9 to 10	0/1	0	nd	nd	1.7
1,4-Dichlorobenzene – 2-ft intervals	0 to 2	16/76	21	3.0 J	380 J	1.7 – 110
	2 to 4	13/74	18	2.1 J	38	1.6 – 42
	4 to 6	7/11	64	3.9 J	31	1.7 – 20.0
	6 to 8	4/6	67	4.0 J	24	1.6 – 6.5
	8 to 10	0/5	0	nd	nd	1.10 – 6.6
Hexachlorobenzene – 1-ft intervals	0 to 1	1/41	2	5.9	5.9	0.83 – 180
	1 to 2	1/45	2	10	10	0.78 – 20.0
	2 to 3	0/10	0	nd	nd	0.86 – 400
	3 to 4	0/9	0	nd	nd	0.86 – 6.0
	4 to 5	0/1	0	nd	nd	6.6

Table 4-79, cont. Summary of subsurface sediment data for selected SVOCs in samples collected from 1- and 2-ft intervals within the top 10 ft of sediment

Chemical	Sampling Interval (ft)[a]	Detection Frequency		Concentration (µg/kg dw)[b]		
		Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[c]
Hexachlorobenzene – 2-ft intervals	0 to 2	2/74	3	5.9	10	0.78 – 110
	2 to 4	0/73	0	nd	nd	0.86 – 42
	4 to 6	0/10	0	nd	nd	6.5 – 20.0
	6 to 8	1/5	20	4.6 J	4.6 J	6.5 – 6.6
	8 to 10	0/5	0	nd	nd	6.1 – 20.0
Other SVOCs						
2,4-Dimethylphenol – 1-ft intervals	0 to 1	2/41	5	25 J	27 J	5.8 – 350
	1 to 2	3/45	7	9.5 J	14 J	5.8 – 30
	2 to 3	0/10	0	nd	nd	5.9 – 790
	3 to 4	0/9	0	nd	nd	5.8 – 34
	4 to 5	0/1	0	nd	nd	6.6
2,4-Dimethylphenol – 2-ft intervals	0 to 2	5/74	7	9.5 J	27 J	5.8 – 330
	2 to 4	5/73	7	6.3 J	46	5.8 – 42
	4 to 6	3/10	30	6.5 J	9.2	6.5 – 20.0
	6 to 8	4/5	80	8.5 J	24 J	6.5
	8 to 10	3/5	60	3.7 J	10	6.6 – 20.0
4-Methylphenol – 1-ft intervals	0 to 1	2/64	3	17 J	42 J	20 – 310
	1 to 2	1/45	2	24	24	19 – 130
	2 to 3	0/10	0	nd	nd	20 – 400
	3 to 4	0/9	0	nd	nd	19 – 34
	4 to 5	0/1	0	nd	nd	66
4-Methylphenol – 2-ft intervals	0 to 2	3/74	4	13 J	42 J	20 – 110
	2 to 4	3/73	4	23	110 J	19 – 140
	4 to 6	1/10	10	42 J	42 J	20.0 – 66
	6 to 8	2/5	40	37 J	48 J	65 – 66
	8 to 10	0/5	0	nd	nd	20.0 – 66
Benzoic acid – 1-ft intervals	0 to 1	40/64	62	52 J	2,000 J	59 – 2,700
	1 to 2	23/45	51	48 J	450 J	59 – 200
	2 to 3	5/10	50	66	110 J	100 – 4,000
	3 to 4	6/9	67	35 J	130	58 – 140
	4 to 5	0/1	0	nd	nd	590
Benzoic acid – 2-ft intervals	0 to 2	41/74	55	50 J	490	58 – 1,100
	2 to 4	32/73	44	54 J	3,000 J	58 – 350
	4 to 6	0/10	0	nd	nd	200 – 590
	6 to 8	1/5	20	320 J	320 J	590
	8 to 10	0/5	0	nd	nd	200 – 620

Table 4-79, cont. Summary of subsurface sediment data for selected SVOCs in samples collected from 1- and 2-ft intervals within the top 10 ft of sediment

Chemical	Sampling Interval (ft)[a]	Detection Frequency		Concentration (µg/kg dw)[b]		
		Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[c]
Benzyl alcohol – 1-ft intervals	0 to 1	10/41	24	18 J	200	29 – 890
	1 to 2	7/45	16	19 J	210	19 – 99
	2 to 3	0/10	0	nd	nd	29 – 2,000
	3 to 4	0/9	0	nd	nd	29 – 34
	4 to 5	0/1	0	nd	nd	33
Benzyl alcohol – 2-ft intervals	0 to 2	11/74	15	18 J	200	19.0 – 550
	2 to 4	7/73	10	20 J	34 J	20.0 – 210
	4 to 6	1/10	10	52	52	20.0 – 33
	6 to 8	0/5	0	nd	nd	33
	8 to 10	0/5	0	nd	nd	20.0 – 38
n-Nitroso-diphenylamine – 1-ft intervals	0 to 1	1/41	2	33	33	8.2 – 320
	1 to 2	0/45	0	nd	nd	5.8 – 620
	2 to 3	0/10	0	nd	nd	5.9 – 400
	3 to 4	0/9	0	nd	nd	5.8 – 34
	4 to 5	0/1	0	nd	nd	32
n-Nitroso-diphenylamine – 2-ft intervals	0 to 2	1/74	1	33	33	6 – 870
	2 to 4	0/73	0	nd	nd	5.8 – 7,300
	4 to 6	0/10	0	nd	nd	20.0 – 510
	6 to 8	0/5	0	nd	nd	6.5 – 2,600
	8 to 10	0/5	0	nd	nd	20.0 – 65
Pentachlorophenol – 1-ft intervals	0 to 1	15/64	23	16 J	930 J	29 – 3,100
	1 to 2	8/45	18	17 J	120 J	29 – 100
	2 to 3	1/10	10	26 J	26 J	29 – 2,000
	3 to 4	0/9	0	nd	nd	29 – 34
	4 to 5	0/1	0	nd	nd	33
Pentachlorophenol – 2-ft intervals	0 to 2	17/74	23	17 J	730	29 – 550
	2 to 4	10/73	14	18 J	190	29 – 180
	4 to 6	9/10	90	36	63	100
	6 to 8	4/5	80	45	800	33
	8 to 10	1/5	20	19 J	19 J	30 – 98.00
Phenol – 1-ft intervals	0 to 1	17/64	27	14 J	3,100	20 – 350
	1 to 2	9/45	20	15 J	150	19 – 130
	2 to 3	1/10	10	13 J	13 J	20 – 790
	3 to 4	2/9	22	13 J	13 J	19 – 140
	4 to 5	0/1	0	nd	nd	66

Table 4-79, cont. Summary of subsurface sediment data for selected SVOCs in samples collected from 1- and 2-ft intervals within the top 10 ft of sediment

Chemical	Sampling Interval (ft)[a]	Detection Frequency		Concentration (µg/kg dw)[b]		
		Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[c]
Phenol – 2-ft intervals	0 to 2	20/74	27	14 J	180	19 – 220
	2 to 4	17/73	23	13 J	110	19 – 140
	4 to 6	0/10	0	nd	nd	20.0 – 73
	6 to 8	0/5	0	nd	nd	65 – 66
	8 to 10	0/5	0	nd	nd	20.0 – 66

Note: Data included in the subsurface dataset are described in Section 4.1.2.2; subsurface sediment samples collected from areas that were subsequently dredged are not summarized in this table because they do not represent existing conditions.An SVOC was included in this table if it exceeded the SQS or if it was identified as a COC in the HHRA (Appendix B) based on a sediment exposure pathway.

[a] For the calculation of summary statistics in this table, actual sampling intervals were rounded to the nearest foot. The data for each interval were then assigned to the 1- or 2-ft sampling category that best approximated the actual sampling interval. If there were data for two 1-ft intervals at a particular location, the concentrations were averaged to obtain a calculated concentration for the corresponding 2-ft interval. Some of the subsurface data were collected from intervals other than 1 or 2 ft; therefore, the detection frequency ratio for "any interval" in Table 4-78 may reflect data for intervals not included in these categories.

[b] Mean concentrations were not calculated because sampling was generally focused in contaminated areas, resulting in a non-random sampling pattern, which is not likely representative of the entire LDW.

[c] RLs are based only on non-detect samples.

[d] Total HPAHs were calculated as the sum of benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, total benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene.

[e] Total LPAHs were calculated as the sum of acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene.

[f] BEHP data are summarized in Table 4-61 in Section 4.2.6.2.

BBP – butyl benzyl phthalate

BEHP – bis(2-ethylhexyl) phthalate

dw – dry weight

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon

J – estimated concentration

na – not applicable

nc – not calculated

nd – not detected

PAH – polycyclic aromatic hydrocarbon

RL – reporting limit

SVOC – semivolatile organic compound

PAH data in 1- and 2-ft subsurface intervals for the top 6 ft of sediment are shown on Maps 4-66a through 4-66c (total HPAHs) and Maps 4-67a through 4-67c (total LPAHs). The maximum total HPAH concentration (64,000 µg/kg dw) was detected at a location near RM 1.2 on the eastern shoreline (LDW-SC23) at an interval of 3 to 3.5 ft. Other areas with high total HPAH concentrations include:

- Slip 3 (LDW-SC37) (47,000 µg/kg dw in the 2-to-4-ft interval)
- Near RM 2.7 on the western shoreline (C3; within an area that was subsequently dredged) (41,000 µg/kg dw in the 0-to-3.3-ft interval)
- Near RM 1.4 on the west side of the navigation channel (LDW-SC26) (38,000 µg/kg dw in the 6-to-8-ft interval)
- Near RM 0.5 on the western shoreline (LDW-SC11) (34,700 µg/kg dw in the 0-to-1-ft interval)

The maximum total LPAH concentration (27,000 µg/kg dw) was detected in Slip 1 (LDW-SC17) at an interval of 2 to 4 ft. High total HPAH concentrations were also reported in the following areas:

- Near RM 1.2 on the east side of the navigation channel (LDW-SC23) (25,000 µg/kg dw in the 3-to-3.5-ft interval)
- Slip 3 (LDW-SC37) (10,500 µg/kg dw in the 2-to-4-ft interval)
- Near RM 2.7 on the western shoreline (C3; within an area that was subsequently dredged) (10,000 µg/kg dw in the 0-to-3.3-ft interval)
- Near RM 1.4 on the west side of the navigation channel (LDW-SC26) (8,500 µg/kg dw in the 6-to-8-ft interval)

Of the SVOCs described in this section, BBP and benzoic acid were the most frequently detected in subsurface sediment samples after PAHs (Table 4-78). Most of the locations with the highest BBP concentrations in any subsurface interval were located between RM 0.4 and RM 0.6, in the vicinity of the Duwamish/Diagonal EAA (similar to BEHP, as described in Section 4.2.6.2). The highest BBP concentration in this area was 1,300 µg/kg dw in the 2-to-2.5-ft interval at DUD006. The highest benzoic acid concentration in subsurface sediment was detected in a sample from Slip 1 (3,000 µg/kg in the 2-to-4-ft interval at LDW-SS17). Benzoic acid concentrations ranging from 1,200 to 2,000 µg/kg were in detected in 11 samples collected in the vicinity of RM 4.2.

Chlorobenzenes were detected in 1 to 19% of all subsurface samples in which they were analyzed from any interval (Table 4-78). Of the other SVOCs listed in Table 4-78, benzoic acid was the most frequently detected (in 40% of all subsurface samples) and had the highest mean concentration (200 µg/kg dw). Other SVOCs were detected in 17% or less of all subsurface samples in which they were analyzed from any interval.

4.2.9.3 Tissue

Table 4-80 presents the detection frequency and range of SVOC concentrations in tissue.[99] Of the SVOCs listed in Table 4-80, PAHs, benzoic acid, and phenol were the only compounds detected in 17% or more of the composite tissue samples.

Table 4-80. Summary of data for selected SVOCs in tissue samples

Chemical	Detection Frequency		Concentration (µg/kg ww)		
	Ratio	%	Minimum Detect	Maximum Detect	Range of RLs[a]
PAHs					
Total HPAH[b]	180/235	77	0.21 J	3,200 J	nc
Total LPAH[c]	150/235	64	0.094 J	450 J	nc
Total PAH	187/235	80	0.43 J	3,630 J	nc
Phthalates[d]					
BBP	25/230	11	190 J	2,800	9 – 4,000
Dimethyl phthalate	6/235	3	7.6 J	420 JM	3.6 – 2,900
Chlorobenzenes					
Hexachlorobenzene	23/235	10	0.38 JN	6.6 JN	0.8 – 26
Other SVOCs					
2,4-Dimethylphenol	2/235	1	71 J	210 J	3.6 – 1,200
4-Methylphenol	20/235	9	15 J	44,000	3.6 – 1,200
Benzoic acid	154/235	66	340 J	54,000	36 – 12,000
Benzyl alcohol	44/235	19	12 J	3,450	3.6 – 1,200
Carbazole	2/235	1	6,000	14,000	3.6 – 2,900
n-Nitrosodiphenylamine	1/235	<1	170 J	170 J	3.6 – 2,900
Pentachlorophenol	16/235	7	1.1 J	4,700	1.7 – 5,800
Phenol	40/235	17	17 J	2,200	3.6 – 1,500

Note: An SVOC is included in this table if it was detected in any tissue sample and was identified as a chemical of potential concern in either the HHRA (Appendix B) based on seafood consumption or in the ERA (Appendix A) based on a tissue exposure pathway.

[a] RLs are based only on non-detect samples.

[b] Total HPAHs were calculated as the sum of benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, total benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene.

[c] Total LPAHs were calculated as the sum of acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene.

[d] BEHP data are summarized in Table 4-63 in in Section 4.2.6.4.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
J – estimated concentration
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
M – calculated whole-body concentration
N – tentative identification
nc – not calculated
SVOC – semivolatile organic compound
ww – wet weight

[99] An SVOC is discussed in this section if a LOAEL-based HQ was greater than or equal to 1.0 for any receptor in the ERA, if it was identified as a COC in the HHRA based on seafood consumption, or if it was detected in any tissue sample.

In general, individual PAHs were detected frequently in all tissue types except Pacific staghorn sculpin (in only 3 of the 24 samples), English sole fillets without skin (in none of the 6 samples), and amphipods (in only 1 of the 4 samples) (Table 4-81). Although the same analytical method was used to analyze the Pacific staghorn sculpin samples as was used for the other tissue samples collected in 2004, the RLs for PAHs and phthalates were high for Pacific staghorn sculpin samples because analytical dilutions were used to minimize matrix interferences at the discretion of the laboratory to reduce the potential impact to their analytical equipment. The dilutions resulted in reduced sensitivity of the analysis (i.e., higher RLs) for this subset of samples. cPAH concentrations in tissue are discussed in Section 4.2.5.4. Benzoic acid, which, after PAHs, was the next most frequently detected SVOC in tissue, was detected frequently in fish, benthic invertebrates, mussels, and clams but was not detected in any crab samples (Table 4-81).

RLs for pentachlorophenol (PCP) were elevated (up to 5,800 µg/kg ww) for some of the English sole, Pacific staghorn sculpin, shiner surfperch, and benthic invertebrate samples because of analytical dilutions. Forty-nine samples of various tissue types with RLs of 5,700 to 5,800 µg/kg ww were re-analyzed using a different analytical method to achieve lower RLs. PCP was detected in six of the re-analyzed tissue samples at low concentrations ranging from 1.1 to 2.8 µg/kg ww; RLs for the re-analyses ranged from 3.3 to 11 µg/kg ww. In the original analyses, PCP was detected in two shiner surfperch whole-body samples at 2,200 µg/kg ww. Neither of these detected results were confirmed by the re-analysis; both samples had non-detected concentrations with RLs of 4.5 and 4.6 µg/kg ww. The results from the re-analysis were selected as the final result because of the enhanced sensitivity of the analytical method.

Table 4-81. Summary of detection frequencies for SVOCs in tissue samples

Chemical	Detection Frequency (%)																	
	Fish – Whole Body				Fish – Fillet					Crab – EM		Crab – HP		Invertebrates and Shellfish				
	English Sole (n = 21)	Pacific Staghorn Sculpin (n = 24)	Shiner Surfperch (n = 27)	Starry Flounder (n = 3)	English Sole – with Skin (n = 7)	English Sole – without Skin (n = 6)	Pile Perch – with Skin (n = 1)	Starry Flounder with Skin (n = 1)	Striped Perch – with Skin (n = 1)	Dungeness Crab (n = 9)	Slender Crab (n = 12)	Dungeness Crab (n = 4)	Slender Crab (n = 4)	Amphipod – WB (n = 4)	Benthic Invert – WB (n = 20)	Mussels, Wild – EM (n = 22)	Mussels, Transplanted – EM (n = 34)	Soft-shell Clam – WB (n = 14)
PAHs																		
Total HPAH (calc'd)	100	4	89	100	57	0	100	100	100	78	100	50	100	25	100	95	71	100
Total LPAH (calc'd)	100	8	93	100	100	0	100	100	100	78	100	75	100	0	100	0	29	100
Total PAH (calc'd)	100	12	93	100	100	0	100	100	100	78	100	75	100	25	100	95	71	100
Phthalates[a]																		
BBP	14	0	29	0	0	0	0	0	0	0	0	25	75	0	5	0	0	0
Dimethyl phthalate	0	0	0	0	0	0	0	0	0	0	8	0	25	0	0	0	0	0
Chlorobenzenes																		
Hexachlorobenzene	19	8	4	0	14	0	0	0	0	11	0	25	0	0	0	0	0	64
Other SVOCs																		
2,4-Dimethylphenol	0	4	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
4-Methylphenol	0	17	4	0	0	0	0	0	0	0	0	0	0	0	30	0	6	50
Benzoic acid	67	96	63	100	86	0	100	100	0	0	0	0	0	0	95	100	100	100
Benzyl alcohol	52	29	22	0	0	0	100	0	0	0	8	25	0	0	40	5	15	0
Carbazole	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
n-Nitrosodiphenylamine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
Pentachlorophenol	24	12	7	33	0	0	0	0	0	0	0	0	0	0	25	0	0	0
Phenol	0	8	48	0	0	0	0	0	0	0	8	0	0	50	45	0	0	86

[a] BEHP data are summarized in Table 4-63 in Section 4.2.6.4.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
EM – edible meat
HP – hepatopancreas
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PAH – polycyclic aromatic hydrocarbon
SVOC – semivolatile organic compound

4.2.9.4 Surface water

On multiple occasions, surface water samples were collected in the LDW near three CSO outfalls and analyzed for SVOCs as part of the King County WQA (King County 1999e). Three SVOCs were detected in surface water samples: benzoic acid, di-n-butyl phthalate, and phenol (Table 4-82).[100] Detection frequencies of these three chemicals were generally low, ranging from 2 to 38% at the three locations. Di-n-butyl phthalate was detected at all three locations, with concentrations ranging from 0.25 to 1.2 µg/L. However, it should be noted that phthalates were often detected in the method blank samples, and, therefore, these results could be influenced by laboratory contamination. During data validation, detected sample concentrations were compared with the detected method blank concentrations, and sample concentrations less than 10 times the concentration in the associated method blank samples were qualified as undetected at elevated RLs (nine results for di-n-butyl phthalate). Benzoic acid was detected at the two downstream locations, with concentrations ranging from 0.98 to 1.5 µg/L. Phenol was detected once, at RM 1.9, at a concentration of 2.01 µg/L. Concentrations of SVOCs in surface water samples are compared with WQC in Section 4.2.2 (Table 4-20).

Table 4-82. Summary of surface water data for detected SVOCs at three locations in the LDW

Chemical by Location ID[a, b]	Detection Frequency		Concentration (µg/L)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[c]
BRN (RM 1.1)					
Benzoic acid	5/39	13	0.98	1.4	0.94 – 0.97
Di-n-butyl phthalate	2/39	5	0.25	0.26	0.24
SWM (RM 1.9)					
Benzoic acid	3/42	7	1.1	1.5	0.94 – 0.97
Di-n-butyl phthalate	2/42	5	0.27	0.483	0.24
Phenol	1/42	2	2.01	2.01	0.94 – 0.97
NFK (RM 4.9)					
Di-n-butyl phthalate	5/13	38	0.39	1.2	0.24 – 0.46
Phenanthrene	0/13	0	nd	nd	0.14 – 0.17

[a] BRN, SWM, and NFK are located in the LDW near the Brandon, SW Michigan, and Norfolk CSOs, respectively.

[b] BEHP data are summarized in Table 4-64 in Section 4.2.6.5.

[c] RLs are based only on non-detect samples.

BEHP – bis(2-ethylhexyl) phthalate
ID – identification
RL – reporting limit
RM – river mile
SVOC – semivolatile organic compound

[100] BEHP data are presented in Section 4.2.6.5.

PAHs were not detected in any of the surface water samples collected by King County during the WQA (King County 1999e).

Because many organic compounds are not typically detected in ambient grab samples, particularly in the dissolved phase, King County also deployed SPMDs to collect data for selected organic compounds, including PAHs, at 1 and 3 m below the water surface near the Duwamish/Diagonal (RM 0.5) and Brandon (RM 1.1) CSO outfalls, as described in Section 4.1.2.4. Ambient PAH concentrations in water were calculated using the mass of chemicals detected in each SPMD and the chemical-specific partition coefficients between the polyethylene and water, which were derived from laboratory experiments conducted at Battelle's Marine Science Laboratory.

Calculated concentrations of individual PAHs ranged from 0.0000027 to 0.030 µg/L (Table 4-83). None of the calculated water concentrations for PAHs were higher than the lowest RLs achieved for PAHs during the analysis of the grab water samples (0.100 µg/L). The individual PAHs with the highest calculated concentrations were acenaphthene (0.030 µg/L), phenanthrene (0.025 µg/L), fluorene (0.020 µg/L), and fluoranthene (0.020 µg/L).

Table 4-83. PAH concentrations in LDW surface water calculated from SPMDs deployed near the Duwamish/Diagonal and Brandon CSOs

Chemical	Calculated Concentration (µg/L)			
	Duwamish/Diagonal CSO		Brandon CSO	
	1-m Depth	3-m Depth	1-m Depth	3-m Depth
Acenaphthene	0.0300	0.016	0.019	0.018
Acenaphthylene	0.0016	0.00091	0.0008	0.00071
Anthracene	0.0023	0.0016	0.0016	0.0014
Benzo(a)anthracene	0.00036	0.00021	0.00022	0.00017
Benzo(a)pyrene	0.000033	0.00003	0.000024	0.00002
Benzo(b)fluoranthene	0.00015	0.00011	0.000095	0.000081
Benzo(g,h,i)perylene	0.000048	0.000061	0.00003	0.000027
Benzo(k)fluoranthene	0.00012	0.000027	0.000078	0.000066
Chrysene	0.0004	0.00024	0.00021	0.00017
Dibenzo(a,h)anthracene	0.0000044	0.0000052	0.0000034	0.0000027
Fluoranthene	0.02	0.007	0.0075	0.0063
Fluorene	0.02	0.011	0.011	0.0099
Indeno(1,2,3-c,d)pyrene	0.000022	0.000019	0.000015	0.0000093
Naphthalene	0.0016[a]	nd	0.00066[a]	nd
Phenanthrene	0.025	0.013	0.013	0.011
Pyrene	0.007	0.0038	0.0038	0.0031

Note: Unvalidated PAH data are available for four sampling events conducted by King County in 2003 and 2004 at one sampling location at RM 0.2 (Williston 2009). Surface water grab samples were collected at 1 m below the surface and 1 m above the bottom during these events. Of the 17 PAH compounds analyzed, six were detected (acenaphthene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene) at concentrations ranging from 0.0098 to 0.0842 µg/L. Method detection limits ranged from 0.0094 to 0.095 µg/L.

[a] Results for naphthalene are highly uncertain because high concentrations were found in the trip blanks (Mickelson 2007).

CSO – combined sewer overflow

LDW – Lower Duwamish Waterway

nd –non-detect

SPMD – semi-permeable membrane device

4.2.9.5 Seeps

SVOCs were analyzed in 3 seep water samples collected at T-117; 7 seep water samples collected at Rhône-Poulenc in 1995; 9 and 5 seep water samples collected at GWI in 1998 and 1999, respectively; 17 seep water samples collected at Boeing Plant 2; and 16 seep water samples collected throughout the LDW as part of the RI in 2004 (Map 4-11a). Detected concentrations of SVOCs in seep water samples are shown on Maps 4-11b through 4-11e.

SVOCs were detected in one unfiltered seep water sample from the Boeing Plant 2 sampling eventand in unfiltered and filtered seep water samples collected at one location (SP-54 in EAA 2) during the RI event (Table 4-84).[101] SVOCs were also detected in seep water samples collected at GWI; it is not known if these samples were filtered. SVOCs concentrations in seep water samples are compared with WQC in Section 4.2.2 (Table 4-21).

Table 4-84. Summary of seep water data for detected SVOCs

Sampling Event/Year	Chemical[a, b]	Detection Frequency		Detected Concentration (µg/L)	RL (µg/L)[c]
		Ratio	%		
Boeing Plant 2 (1995)	fluoranthene	1/17	6	1.3	1.0
	phenanthrene	1/17	6	1.0	1.0
GWI (1998)	1,2-dichlorobenzene	1/9	11	1.3	1.0
GWI (1999)	acenaphthene	1/5	20	1.3	0.5
	1,2-dichlorobenzene	1/5	20	1.0	0.5
LDW RI (2004)	**Unfiltered**				
	1,2-dichlorobenzene	1/16	6	2.9	1.0
	1,3-dichlorobenzene	1/16	6	58.3	1.0
	1,4-dichlorobenzene	1/16	6	40.2	1.0
	Filtered				
	1,3-dichlorobenzene	1/15	7	3.6	1.0
	1,4-dichlorobenzene	1/15	7	3.9	1.0

[a] BEHP data are summarized in Table 4-65 in Section 4.2.6.6.

[b] Samples collected at Boeing Plant 2, Rhône-Poulenc, and T-117 were unfiltered, as were some of the samples collected for the RI; it is not known if samples collected from GWI were filtered.

[101] BEHP data for seep water are presented in Section 4.2.6.6.

[c] RLs are based only on non-detect samples.

BEHP – bis(2-ethylhexyl) phthalate
GWI – Great Western International
J – estimated concentration
nr – not reported
RI – remedial investigation
RL – reporting limit
SVOC – semivolatile organic compound
T-117 – Terminal 117

4.2.9.6 Porewater

The only porewater samples from the LDW that have been analyzed for SVOCs were those collected during the 2004 Rhône-Poulenc sampling event. Table 4-85 summarizes concentrations of SVOCs that were detected in at least one porewater sample from this event.[102] Five individual PAHs were detected in the sample from location SH-02 at concentrations up to 0.32 µg/L (Map 4-12d). SVOC concentrations in porewater samples are compared with WQC in Section 4.2.2 (Table 4-22).

Table 4-85. Summary of porewater data from Rhône-Poulenc for detected SVOCs

Chemical[a]	Detection Frequency		Concentration (µg/L)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[b]
Benzo(a)pyrene	1/9	11	0.0320 J	0.0320 J	0.37
Benzo(b)fluoranthene	1/9	11	0.0390 J	0.0390 J	0.37
Benzo(k)fluoranthene	1/9	11	0.0390 J	0.0390 J	0.37
Fluoranthene	1/9	11	0.26 J	0.26 J	0.37
Pyrene	1/9	11	0.32 J	0.32 J	0.37

[a] BEHP data are summarized in Table 4-65 in Section 4.2.6.7.
[b] RLs are based only on non-detect samples.

BEHP – bis(2-ethylhexyl) phthalate
J – estimated concentration
PAH – polycyclic aromatic hydrocarbon
RL – reporting limit
SVOC – semivolatile organic compound

4.2.9.7 Summary of SVOC data

PAHs and BEHP were the most frequently detected SVOCs in surface sediment.[103] The mean concentrations of total HPAHs and total LPAHs were 4,000 and 700 µg/kg dw, respectively. Areas with the highest concentrations of PAHs (i.e., greater than the numerical 95th percentile) were generally located in the following areas: the Duwamish/Diagonal EAA, Slip 1, between RM 1.3 and RM 1.5 on the west side, Slip 4, the Boeing Plant 2/Jorgensen Forge EAA, T-117, RM 3.8 EAA, and Slip 6.

[102] BEHP data for porewater are presented in Section 4.2.6.7.

[103] BEHP data are summarized in Section 4.2.6.

At least one PAH compound was detected in nearly all surface sediment samples, and PAHs were also detected frequently in tissue. In subsurface sediment, areas with the highest total LPAH and HPAH concentrations included RM 0.5 on the west side; RM 1.2 on the east side; RM 1.4 on the west side; RM 2.7 on the west side; Slips 1, 3, 4, and 6; the Duwamish/Diagonal EAA; and the Boeing Plant 2/Jorgensen Forge EAA.

In general, individual PAHs were detected frequently in most tissue types. Although low-level analytical methods were used for all tissue samples collected in 2004, RLs were high for Pacific staghorn sculpin samples because analytical dilutions were used to minimize matrix interferences, resulting in reduced sensitivity of the analysis. PAHs were infrequently detected in Pacific staghorn sculpin at these elevated RLs. Benzoic acid, which was the second most frequently detected SVOC in tissue, was detected frequently in fish, benthic invertebrates, mussels, and clams, but was not detected in any crab samples. Other SVOCs, most notably the phthalates that were commonly detected in sediments, were generally infrequently detected in tissue, even when highly sensitive analytical methods were applied.

SVOCs were detected infrequently in surface water, seep, and porewater samples collected from the LDW.

4.2.10 Organochlorine pesticides

This section summarizes the nature and extent of organochlorine pesticide concentrations in surface sediment, subsurface sediment, tissue, surface water, and seep water. None of the porewater samples collected from the LDW were analyzed for organochlorine pesticides.

Some of the pesticide data are uncertain because of analytical interference from the presence of PCB congeners, as identified by both the analytical laboratory and the data validators during the pesticide analyses of benthic invertebrate, fish, and crab tissue as part of the RI. Samples with this probable interference were assigned a JN-qualifier, indicating the results are highly uncertain and biased high. A more detailed discussion of this data quality issue is provided in Section 4.1.3.2.

4.2.10.1 Surface sediment

Table 4-86 presents a summary of organochlorine pesticides detected in surface sediment. Most organochlorine pesticides were detected in 6% or fewer of the surface sediment samples in which they were analyzed. 4,4′-DDD (dichlorodiphenyldichloro-ethane), 2,4′-DDT, 4,4′-DDT, and gamma-chlordane were the organochloride pesticides most frequently detected in surface sediment, in 34, 31, 21, and 17% of the samples in which they were analyzed, respectively. Other DDT compounds were detected at frequencies of 5 to 31%, and other chlordane compounds were detected at frequencies of 9 to 11%.

Table 4-86. Summary of surface sediment data for detected organochlorine pesticides

Pesticide	Detection Frequency		Concentration (µg/kg dw)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[a]
DDT and Metabolites					
2,4′-DDD	5/93	5	1.6 JN	10 JN	0.97 – 34
2,4′-DDE	2/93	2	2.8 JN	11 JN	0.97 – 34
2,4′-DDT	29/93	31	0.24 JN	11 JN	1.9 – 460
4,4′-DDD	66/193	34	0.29 JN	840	0.81 – 540
4,4′-DDE	29/193	15	0.28 JN	370 J	0.81 – 800
4,4′-DDT	40/193	21	0.48 JN	1,700	0.81 – 56
Total DDTs	76/193	39	0.72 JN	2,900 J	nc
Chlordane Compounds					
alpha-Chlordane	13/149	9	0.10 JN	36	0.72 – 30
gamma-Chlordane	25/149	17	0.20 JN	200	0.72 – 96
Chlordane	5/44	11	25	62	7.7 – 330
Total chlordanes	28/149	19	0.20 JN	230	nc
Aldrin/Dieldrin					
Aldrin	4/193	2	0.014 J	1.6 JN	0.40 – 56
Dieldrin	8/193	4	0.099 J	280	0.81 – 91
Other Pesticides					
alpha-BHC	3/193	2	0.14 J	1.8 JN	0.40 – 56
beta-BHC	4/193	2	0.087 J	13	0.40 – 56
gamma-BHC	11/193	6	0.050 J	6.7 JN	0.40 – 56
delta-BHC	3/155	2	0.081 J	11 JN	0.40 – 56
alpha-Endosulfan	9/147	6	0.18 JN	71 JN	0.40 – 100
beta-Endosulfan	3/149	2	0.47 J	10 JN	0.81 – 200
Endosulfan	1/46	2	0.11 J	0.11 J	0.81 – 56
Endosulfan sulfate	3/191	2	0.63 JN	25 JN	0.81 – 200
Endrin	4/193	2	0.99 JN	9.1	0.81 – 200
Endrin aldehyde	6/182	3	0.28 JN	130	0.81 – 250
Endrin ketone	7/137	5	0.83 JN	110 JN	0.81 – 200
Heptachlor	6/193	3	0.12 J	5.2	0.43 – 70
Heptachlor epoxide	5/193	3	0.47 JN	4.9 JN	0.40 – 510
Methoxychlor	11/193	6	0.34 JN	99	0.97 – 330
Mirex	3/93	3	0.29 JN	1.0 JN	0.97 – 34
Toxaphene	2/191	1	340 JN	6,300 JN	1.0 – 4,300

[a] RLs based only on non-detect samples.

BHC – benzene hexachloride
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
dw – dry weight
J – estimated concentration
LDW – Lower Duwamish Waterway
N – tentative identification
nc – not calculated
RL – reporting limit

The highest concentration of total DDTs (2,900 µg/kg ww) in surface sediment was detected in sample DR178 collected in Slip 4 (Map 4-68). This location also had a high PCB concentration in surface sediment (7,000 µg/kg dw), indicating a potential for analytical interference. Other areas with relatively high total DDT concentrations in surface sediment were located between RM 0.4 and RM 0.6 on the east side of the LDW (Duwamish/Diagonal EAA), the inlet at RM 2.2 on the west side of the LDW (EAA 2), and at the mouth of Slip 3.

4.2.10.2 Subsurface sediment

Organochlorine pesticides were analyzed in a subset of subsurface sediment samples collected in the LDW. Of the samples analyzed for organochlorine pesticides, 17% had one or more detected DDT compounds (Table 4-87). Other organochlorine pesticides were detected in 17% or fewer of the samples in which they were analyzed.

Table 4-87. Summary of subsurface sediment data for organochlorine pesticides from any interval

Pesticide	Detection Frequency		Concentration (µg/kg dw)[a]		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[b]
DDT and Metabolites					
2,4′-DDD	0/40	0	nd	nd	1.9 – 29
2,4′-DDE	0/40	0	nd	nd	1.9 – 100
2,4′-DDT	0/40	0	nd	nd	1.9 – 29
4,4′-DDD	13/95	14	0.27 J	10	1.5 – 39
4,4′-DDE	14/95	15	0.45 J	18 J	0.62 – 90
4,4′-DDT	5/95	5	0.64 J	2.8	0.96 – 160
Total DDTs	16/95	17	0.27 J	20 J	nc
Chlordane Compounds					
alpha-Chlordane	1/89	1	0.44 J	0.44 J	0.052 – 14
gamma-Chlordane	4/87	5	0.22 J	0.71 J	0.92 – 82
Chlordane	1/6	17	29.0	29.0	7.5 – 35
Total chlordanes	4/89	4	0.22 J	1.59 J	nc
Aldrin/Dieldrin					
Aldrin	1/95	1	1.5 J	1.5 J	0.33 – 16.00
Dieldrin	3/95	3	0.80 J	1.8	0.14 – 95.00

Pesticide	Detection Frequency		Concentration (µg/kg dw)[a]		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[b]
Other Pesticides					
alpha-BHC	3/71	4	0.20 J	0.47 J	0.086 – 14
beta-BHC	0/66	0	nd	nd	0.96 – 24
gamma-BHC	0/95	0	nd	nd	0.099 – 14
delta-BHC	7/48	15	7.0	1,100	0.96 – 14
alpha-Endosulfan	0/62	0	nd	nd	0.96 – 14
beta-Endosulfan	0/62	0	nd	nd	1.90 – 29
Endosulfan	0/4	0	nd	nd	1.5 – 1.6
Endosulfan sulfate	0/62	0	nd	nd	1.90 – 69
Endrin	0/66	0	nd	nd	1.5 – 150
Endrin aldehyde	1/66	2	10	10	1.5 – 29
Endrin ketone	0/62	0	nd	nd	1.90 – 29
Heptachlor	2/95	2	0.25 J	1.3	0.097 – 14
Heptachlor epoxide	0/66	0	nd	nd	0.96 – 120
Methoxychlor	0/66	0	nd	nd	1.0 – 140
Mirex	0/40	0	nd	nd	1.9 – 29
Toxaphene	0/66	0	nd	nd	10 – 1,400

Note: Data included in the subsurface dataset are described in Section 4.1.2.2; subsurface sediment samples collected from areas that were subsequently dredged are not summarized in this table because they do not represent existing conditions.

[a] Mean concentrations were not calculated because sampling was generally focused in contaminated areas, resulting in a non-random sampling pattern, which is not likely representative of the entire LDW.

[b] RLs are based only on non-detect samples.

BHC – benzene hexachloride
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
dw – dry weight
J – estimated concentration
LDW – Lower Duwamish Waterway
N – tentative identification
nc – not calculated
nd – not detected at any location
RL – reporting limit

Total DDT concentrations in subsurface sediment ranged from 0.27 to 20 µg/kg dw, with the three highest concentrations (17, 18, and 20 µg/kg dw) detected during the EPA SI sampling conducted in 1998. These concentrations were detected in the 2-to-4-ft interval of core DR025 at RM 1.2, in the 0-to-2-ft interval of core DR137 at RM 2.2 near EAA 2, and in the 2-to-4-ft interval of core DR021 at RM 0.9 at the mouth of Slip 1, respectively.

4.2.10.3 Tissue

Table 4-88 presents the detection frequency and range of organochlorine pesticide concentrations in LDW tissue samples. 2-4′-DDT and gamma chlordane were the most frequently detected pesticides (91 and 85%, respectively, of all tissue samples in which

they were analyzed). Other DDT compounds were detected at a frequency of 8 to 78%, and other chlordane compounds were detected at a frequency of 0 to 33% in all tissue samples in which they were analyzed. Heptachlor epoxide, alpha-endosulfan, and beta-BHC were detected in 33, 26, and 26%, respectively, of all tissue samples in which they were analyzed. The remaining organochlorine pesticides were detected in 16% or fewer of all tissue samples in which they were analyzed. The maximum tissue concentrations of most organochlorine pesticides have a JN-qualifier, as shown in Table 4-88. This qualifier indicates probable interference in the analysis from PCB congeners, resulting in data that are highly uncertain and biased high.

Table 4-88. Summary of organochlorine pesticide data in all tissue samples

Chemical	Detection Frequency		Concentration (µg/kg ww)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[a]
DDT and Metabolites					
2,4′-DDD	46/179	26	0.49 J	57 JN	0.18 – 88
2,4′-DDE	14/179	8	0.72 J	110 JN	0.26 – 45
2,4′-DDT	163/179	91	1.8 J	440 JN	0.22 – 34
4,4′-DDD	126/212	59	0.23 JN	20 JN	0.13 – 18
4,4′-DDE	155/212	73	0.70 JN	46 JN	1.0 – 14
4,4′-DDT	165/212	78	0.56 J	470 JN	0.38 – 82
Total DDTs	186/212	88	1.1	1,020 JN	nc
Chlordane Compounds					
alpha-Chlordane	44/188	23	0.60 JN	12 JN	0.36 – 18
gamma-Chlordane	160/188	85	0.52 J	330 JN	0.14 – 56
Oxychlordane	6/18	33	0.23 J	1.5 J	0.12 – 1.0
cis-Nonachlor	0/18	0	nd	nd	0.12 – 2.3
trans-Nonachlor	6/18	33	0.70 J	3.2	0.14 – 1.5
Chlordane	0/24	0	nd	nd	6.7
Total chlordane	165/188	88	0.24 J	330 JN	nc
Aldrin/Dieldrin					
Aldrin	6/212	3	0.61 J	6.2 JN	0.20 – 18
Dieldrin	12/212	6	0.76 J	5.7	0.11 – 34
Other Pesticides					
alpha-BHC	13/212	6	0.20 JN	21 JN	0.16 – 18
alpha-Endosulfan	55/212	26	0.21 J	30 JN	0.13 – 15
beta-BHC	55/212	26	0.27 JN	15 JN	0.38 – 18
beta-Endosulfan	33/212	16	0.94 J	44 JN	0.35 – 18
delta-BHC	3/212	1	0.51 JN	2.2 JN	0.34 – 18
Endosulfan sulfate	4/212	2	0.73 J	2.3	0.27 – 190

Chemical	Detection Frequency		Concentration (µg/kg ww)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[a]
Endrin	34/212	16	0.10 JN	40 JN	0.099 – 72
Endrin aldehyde	31/212	15	0.42 JN	78 JN	0.17 – 18
Endrin ketone	4/179	2	0.60 JN	8.4 JN	0.29 – 18
gamma-BHC	17/212	8	0.51 JN	7 JNM	0.28 – 18
Heptachlor	10/212	5	0.96 J	9.7 JN	0.45 – 18
Heptachlor epoxide	69/212	33	0.72 J	45 JN	0.15 – 18
Methoxychlor	11/212	5	0.49	130 JN	0.27 – 23
Mirex	0/179	0	nd	nd	0.27 – 18
Toxaphene	0/212	0	nd	nd	10 – 4,800

[a] RLs are based only on non-detect samples.

BHC – benzene hexachloride
DDD – dichlorodiphenyldichloroethane
DDE - dichlorodiphenyldichloroethylene
DDT - dichlorodiphenyltrichloroethane
J – estimated concentration
M – calculated whole-body concentration
N – tentative identification
nc – not calculated
nd – not detected
RL – reporting limit
ww – wet weight

4.2.10.4 Surface water

Surface water grab samples collected during the pilot study for the King County WQA (King County 1999e) did not contain detectable concentrations of organochlorine pesticides. Instead, organochlorine pesticides were analyzed in the SPMDs deployed at 1 and 3 m below the water surface just offshore of the Duwamish/Diagonal and Brandon CSOs (at RM 0.5 and RM 1.1, respectively), as described in Section 4.1.2.4. Organochlorine pesticide concentrations in the SPMDs were used to calculate concentrations in surface water using the mass of chemicals detected in each SPMD and the chemical-specific partition coefficients between polyethylene and water, which were derived from laboratory experiments conducted at Battelle's Marine Science Laboratory. Calculated concentrations were very low, ranging from 0.000000034 to 0.000033 µg/L (Table 4-89). Calculated pesticide concentrations in surface water samples are compared with WQC in Section 4.2.2 (Table 4-20).

Table 4-89. Organochlorine pesticide concentrations in surface water calculated from SPMDs deployed near Duwamish/Diagonal and Brandon CSOs

Pesticide	Calculated Concentration (µg/L)			
	Duwamish/Diagonal CSO		Brandon CSO	
	1-m Depth	3-m Depth	1-m Depth	3-m Depth
2,4′-DDD	0.000013	0.0000067	0.0000079	0.0000063
4,4′-DDD	0.000015	0.0000091	0.000010	0.0000085
4,4′-DDE	0.0000065	0.0000019	0.00000093	0.000000034

Pesticide	Calculated Concentration (µg/L)			
	Duwamish/Diagonal CSO		Brandon CSO	
	1-m Depth	3-m Depth	1-m Depth	3-m Depth
4,4′-DDT	nd	nd	nd	nd
Aldrin	0.0000059	0.0000040	0.0000037	0.0000030
alpha-Chlordane	0.0000026	0.0000017	0.0000015	0.0000013
gamma-Chlordane	0.0000013	0.000000077	0.00000011	nd
Dieldrin	0.000033	0.000023	nd	0.000020
Endrin	0.000014	0.0000089	0.0000064	nd

Note: Unvalidated pesticide data are available for four sampling events conducted in 2003 and 2004 by King County at one sampling location at RM 0.2 (Williston 2009). Surface water grab samples were collected at 1 m below the surface and 1 m above the bottom during these events. Pesticides were not detected at method detection limits ranging from 0.0047 to 0.056 µg/L.

[a] Value for chlordane.

DDD – dichlorodiphenyldichloroethane
DDE - dichlorodiphenyldichloroethylene
DDT - dichlorodiphenyltrichloroethane
CSO – combined sewer overflow
nd – not detected
SPMD – semi-permeable membrane device

4.2.10.5 Seep water

The only LDW seep water samples analyzed for organochlorine pesticides were those collected as part of the RI (Windward 2004b). Heptachlor epoxide (a degradation product of heptachlor) was detected in both the filtered and unfiltered seep water samples collected at Seep 39, at concentrations of 0.0090 and 0.0076 µg/L, respectively (Map 4-11e). No other organochlorine pesticides were detected in seep water samples. Pesticide concentrations in seep water samples are compared with WQC in Section 4.2.2 (Table 4-21).

4.2.10.6 Summary

Organochlorine pesticides were analyzed in a subset of surface sediment, subsurface sediment, tissue, and seep water samples. Analytical interference in the organochlorine pesticide analyses from the presence of PCBs in the samples resulted in high uncertainty and high bias in some of the organochlorine pesticide data, particularly samples with high PCB concentrations.

4,4′-DDD, 2,4′-DDT, 4,4′-DDT, and gamma-chlordane were the organochlorine pesticides most frequently detected in surface sediment, in 34, 31, 21, and 17% of the samples in which they were analyzed, respectively. The highest total DDT concentration in surface sediment (2,900 µg/kg dw) was detected in a sample collected from Slip 4; this sample also had a relatively high total PCB concentration (7,000 µg/kg dw). Organochlorine pesticides were infrequently detected in subsurface sediment; 4,4′-DDE (dichlorodiphenyldichloroethylene) was most frequently detected (in 15% of the samples in which it was analyzed), at a maximum concentration of 18 µg/kg dw.

DDT and chlordane compounds were frequently detected in tissue samples, but there is high uncertainty in these data because of analytical interference by PCBs. Organochlorine pesticide concentrations in surface water were estimated from SPMDs deployed at two locations in the LDW. Calculated concentrations of organochlorine pesticides in surface water ranged from 0.000000034 to 0.000033 µg/L. Organochlorine pesticides were detected in one seep sample collected as part of the RI (Seep 39 near RM 4.3 on the western shoreline); heptachlor epoxide was detected in both the filtered and unfiltered samples from this location at concentrations of 0.0090 and 0.0076 µg/L, respectively.

4.2.11 VOCs

This section summarizes the nature and extent of VOC concentrations in surface sediment, subsurface sediment, seep water, and porewater samples collected from the LDW.

4.2.11.1 Surface sediment

VOCs were analyzed in 36 surface sediment samples collected throughout the LDW as part of the 1998 EPA SI, in 3 surface sediment samples collected at RM 3.3 as part of the 1995 Boeing Plant 2 RFI, and in 2 surface sediment samples collected near RM 0.5 as part of the 1991 Harbor Island RFI.

The highest VOC concentration (dichloromethane at 1,600 µg/kg dw) was detected in sample DR008 collected near RM 0.5 (Table 4-90). The second highest VOC concentration (acetone at 1,000 µg/kg dw) was detected in sample DR047 collected near RM 0.9 south of Kellogg Island. The remaining detected VOC concentrations were less than 160 µg/kg dw.

Table 4-90. Summary of surface sediment data for detected VOCs

Chemical	Detection Frequency		Concentration (µg/kg dw)		
	Ratio	%	Minimum Detect	Maximum Detect	Range of RLs[a]
Acetone	3/41	7	110 J	1,000 J	11 – 21,000
Carbon disulfide	12/41	29	0.84 J	4.0 J	1.4 – 1,100
p-Cymene	3/36	8	1.6 J	25	1.5 – 530
Dichloromethane	1/41	2	1,600	1,600	2.8 – 21
Methyl ethyl ketone	15/41	37	5.3	35	3.0 – 1,100
Tetrachloroethene	2/41	5	0.21 J	0.52 J	1.4 – 530
Toluene	3/41	7	1.0 J	2.2 J	1.4 – 530

[a] RLs based only on non-detect samples.

dw – dry weight

J – estimated concentration

RL – reporting limit

VOC – volatile organic compounds

4.2.11.2 Subsurface sediment

VOCs were analyzed in subsurface core samples collected from eight locations between RM 3.3 and RM 3.5 as part of four sampling events. As part of the RI, one subsurface core was analyzed for VOCs because of elevated readings from the photoionization detector during core processing. VOCs were not analyzed in other cores because the detector did not indicate that they were present at elevated concentrations. This core was collected at LDW-SC49 between RM 3.5 and RM 3.6 and analyzed at 1-ft intervals to a depth of 12 ft below the sediment surface.

Detected VOC concentrations in subsurface sediment ranged from 1.5 to 200,000 µg/kg dw (Table 4-91). The most frequently detected VOCs were acetone, carbon disulfide, and methyl ethyl ketone, with detection frequencies of 81, 50, and 44% of the samples in which they were analyzed, respectively. With the exception of these chemicals, individual VOCs were detected in less than 25% of samples.

Table 4-91. Summary of subsurface sediment data for detected VOCs

Chemical	Detection Frequency		Concentration (µg/kg dw)[a]		
	Ratio	%	Minimum Detect	Maximum Detect	Range of RLs[b]
1,1-Dichloroethene	2/32	6	120	320	0.90 – 9.6
1,2,4-Trimethylbenzene	3/24	13	14 J	580 J	0.90 – 39
1,3,5-Trimethylbenzene	4/24	17	1.9	350 J	0.90 – 39
Acetone	26/32	81	8.20	640	6.6 – 37
Benzene	5/32	16	4.4	62	0.90 – 9.6
Carbon disulfide	16/32	50	1.30	18	0.90 – 9.6
Chloroform	1/32	3	1.8	1.8	0.90 – 9.6
cis-1,2-Dichloroethene	7/32	22	2.2	200,000	0.90 – 9.6
p-Cymene	5/24	21	4.1 J	130 J	0.90 – 39
Dichloromethane	10/32	31	1.5 J	5.90	1.90 – 11
Ethylbenzene	3/58	5	27	360 J	0.75 – 9.6
Isopropylbenzene	3/24	13	3.9 J	87 J	0.90 – 39
Methyl ethyl ketone	14/32	44	9.60	100	4.60 – 28
n-Butylbenzene	2/24	8	58	78 J	0.90 – 39
n-Propylbenzene	3/24	13	1.8 J	100 J	0.90 – 39
sec-Butylbenzene	2/24	8	57	57	0.90 – 39
tert-Butylbenzene	1/24	4	6.1	6.1	0.90 – 39
Toluene	7/32	22	1.8	8,300	0.90 – 9.6
trans-1,2-Dichloroethene	3/32	9	22	1,700 J	0.90 – 9.6
Trichloroethene	4/58	7	3.6 J	23	0.37 – 9.6
Vinyl chloride	5/32	16	29	60,000	0.90 – 11
Xylene (ortho)	3/52	6	31	610 J	0.90 – 9.6
Xylene (meta and para)	3/41	7	74 J	4,700	1.1 – 9.6
Total xylenes (calc'd)	3/52	6	105 J	5,300 J	nc

Note: Data included in the subsurface dataset are described in Section 4.1.2.2; subsurface sediment samples collected from areas that were subsequently dredged are not summarized in this table because they do not represent existing conditions.

[a] Mean concentrations were not calculated because sampling was generally focused in contaminated areas, resulting in a non-random sampling pattern, which is not likely representative of the entire LDW.

[b] RLs based only on non-detect samples.

dw – dry weight

J – estimated concentration

LDW – Lower Duwamish Waterway

RL – reporting limit

VOC – volatile organic compounds

The highest concentrations of VOCs were detected in the 9-to-10-ft, 10-to-11-ft, and 11-to-12-ft intervals of core LDW-SC49b, collected in the navigation channel at RM 3.55. The VOCs with the highest concentrations in this core were cis-1,2-dichloroethene (200,000 and 140,000 µg/kg dw in the 10-to-11-ft and 11-to-12-ft intervals, respectively) and vinyl chloride (60,000 µg/kg dw in the 11-to-12-ft interval). These two VOCs were not detected in samples collected from the top 6 ft of the core.

4.2.11.3 Seep water

VOCs have been analyzed in seep water samples collected at three sites: Boeing Plant 2 (in 1995), Rhône-Poulenc (in 1995), and GWI (during 10 sampling events from 1994 to 1999). In addition, 16 seep water samples collected from throughout the LDW were analyzed for VOCs as part of the RI (Map 4-11a). Table 4-92 and Maps 4-11b through 4-11e present data for detected VOCs in seep water samples from the LDW investigations listed above. No VOCs were detected in seep water samples collected from Rhône-Poulenc. VOC concentrations in seep water samples are compared with WQC in Section 4.2.2 (Table 4-21).

Table 4-92. Concentrations of VOCs with at least one detected value in seep water samples

Chemical	Detection Frequency		Concentration (µg/L)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[a]
Boeing Plant 2 – 1995					
Benzene	1/18	6	2.2	2.2	1
cis-1,2-Dichloroethene	6/18	33	1.2	40	1
Trichloroethene	3/18	17	1.9	13	1
Vinyl chloride	4/18	22	3.1	36	0.01 – 2
GWI – April 1994					
1,1-Dichloroethane	3/6	50	1.0	2.0	1.0
1,1-Dichloroethene	1/6	17	1.0	1.0	1.0
Total 1,2-dichloroethene	3/6	50	7.0	110	1.0
Tetrachloroethene	2/6	33	3.0	760	1.0
Trichloroethene	3/6	50	1.0	370	1.0
Vinyl chloride	1/6	17	1.0	1.0	1.0
GWI – July 1994					
1,1-Dichloroethane	1/2	50	1.0	1.0	1.0
1,2-Dichloroethene (total)	2/2	100	3.0	40	na
Tetrachloroethene	2/2	100	2.0	220	na
Trichloroethene	1/2	50	94	94	1.0
Vinyl chloride	1/2	50	3.0	3.0	1.0
GWI – November 1994					
1,2-Dichloroethene (total)	2/7	29	1	50	1.0
Tetrachloroethene	2/7	29	1	440	1.0
Trichloroethene	1/7	14	130	130	1.0
GWI – May 1995					
1,1,1-Trichloroethane	1/7	14	1.0	1.0	1.0
1,1-Dichloroethane	2/7	29	1.0	2.0	1.0
1,2-Dichloroethane	1/7	14	1.0	1.0	1.0
1,2-Dichloroethene (total)	3/7	43	3.0	150	1.0
Tetrachloroethene	2/7	29	6.0	710	1.0
Trichloroethene	2/7	29	8.0	480	1.0
Vinyl chloride	2/7	29	2.0	2.0	1.0
GWI – 1995 annual monitoring					
1,1-Dichloroethane	2/7	29	1.0	1.0	1.0
1,2-Dichloroethane	1/7	14	1.0	1.0	1.0
1,2-Dichloroethene (total)	4/7	57	1.0	160	1.0

Table 4-92, cont. Concentrations of VOCs with at least one detected value in seep water samples

Chemical	Detection Frequency		Concentration (µg/L)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[a]
Tetrachloroethene	2/7	29	4.0	610	1.0
Trichloroethene	2/7	29	4.0	360	1.0
Vinyl chloride	2/7	29	1.0	1.0	1.0
GWI – 1996 annual monitoring					
1,1-Dichloroethane	1/5	20	1.0	1.0	1.0
1,2-Dichloroethane	1/5	20	8.0	8.0	1.0
1,2-Dichloroethene (total)	3/5	60	8.0	310	1.0
1,2-Dichloropropane	1/5	20	1.0	1.0	1.0
Tetrachloroethene	2/5	40	13	79	1.0
Toluene	1/5	20	2.	2.0	1.0
Trichloroethene	2/5	40	7.0	58	1.0
Vinyl chloride	1/5	20	3.0 J	3.0 J	1.0
Total xylenes	1/5	20	1.0	1.0	1.0
GWI – 1997 annual monitoring					
1,1-Dichloroethane	1/4	25	1.0	1.0	1.0
1,2-Dichloroethene (total)	2/4	50	37	470	1.0
Tetrachloroethene	2/4	50	19	150	1.0
Trichloroethene	2/4	50	7.0	200	1.0
GWI – 1998 annual monitoring					
1,1-Dichloroethane	2/9	22	4.1	53	1.0
1,1-Dichloroethene	1/9	11	18	18	1.0
1,2-Dichloroethane	1/9	11	8.5	8.5	1.0
1,2-Dichloropropane	1/9	11	2.7	2.7	1.0
Benzene	1/9	11	28	28	1.0
Chlorobenzene	1/9	11	4.1	4.1	1.0
cis-1,2-Dichloroethene	3/9	33	41	3,300	1.0
Tetrachloroethene	4/9	44	1.3	290	1.0
trans-1,2-Dichloroethene	2/9	22	3.5	46	1.0
Trichloroethene	3/9	33	4	170	1.0
Vinyl chloride	2/9	22	1.0	760	1.0
o-Xylene	1/9	11	1.4	1.4	1.0
Total xylenes	1/9	11	1.4	1.4	nc
GWI – 1999 annual monitoring					
1,1-Dichloroethane	1/5	20	58	58	1.0 – 2.0
Benzene	1/5	20	28	28	1.0 – 2.0

Table 4-92, cont. Concentrations of VOCs with at least one detected value in seep water samples

Chemical	Detection Frequency		Concentration (µg/L)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[a]
cis-1,2-Dichloroethene	3/5	60	5.6	3,200	1.0
Tetrachloroethene	2/5	40	3.7	190	1.0 – 20
trans-1,2-Dichloroethene	2/5	40	12	27	1.0
Trichloroethene	2/5	40	2.1	270	1.0 – 20
Vinyl chloride	1/5	20	3,500	3,500	1.0 – 2.0
GWI – 1998 Embayment Study					
1,1-Dichloroethane	5/10	50	1.5	62	1.0
1,1-Dichloroethene	3/10	30	1.0	27	1.0 – 10
1,2,4-Trimethylbenzene	1/4	25	4.1	4.1	10
1,2-Dichloroethane	2/10	20	6.6	27	1.0 – 10
1,2-Dichloropropane	1/10	10	16	16	1.0 – 10
Acetone	3/8	38	1.0	6.4	5.0 – 11
Benzene	2/10	20	21	36	1.0 – 10
Chlorobenzene	1/10	10	8.8	8.8	1.0 – 10
cis-1,2-Dichloroethene	4/4	100	29	5,400	na
Tetrachloroethene	4/10	40	2.6	180	1.0 – 10
Toluene	1/10	10	2.7	2.7	1.0 – 10
trans-1,2-Dichloroethene	3/10	30	16	110	1.0
Trichloroethene	3/10	30	6.0	110	1.0 – 10
Vinyl chloride	4/10	40	3.8	1,600	1.0 – 1.0
o-Xylene	1/10	10	2.8	2.8	1.0 – 10
Total xylenes	1/10	10	2.8	2.8	nc
LDW RI – 2004					
Carbon disulfide	2/16	13	1.1	2.4	1.0
Chlorobenzene	1/16	6	6.5	6.5	1.0

[a] RLs based only on non-detect samples.

GWI – Great Western International
J – estimated concentration
LDW – Lower Duwamish Waterway
na – not applicable
nc – not calculated (RLs not available)
nr – not reported (only detected chemicals reported in the data report; RLs for undetected results not available)
RI – remedial investigation
RL – reporting limit
VOC – volatile organic compound

At Boeing Plant 2, four VOCs were detected in seep water samples. The highest VOC concentration (40 µg/L of cis-1,2-dichloroethene) was detected in seep sample SE-11001.

At GWI, numerous VOCs were detected during the various sampling events. The VOCs with the highest detected concentrations were cis-1,2-dichloroethene (5,400 µg/L in S-13), tetrachloroethene (760 µg/L in S-2), trichloroethene (480 µg/L in S-2), and vinyl chloride (3,500 µg/L in S-13). The seep locations where VOCs were most frequently detected and where the highest concentrations were found were S-1, S-2, S-4, and S-13.

As part of the RI, two VOCs were detected in seep water samples. Carbon disulfide was detected in seep water from two locations (SP- 80 at 1.1 µg/L and SP-54 at 2.4 µg/L), and chlorobenzene was detected in seep water from location SP-54 at a concentration of 6.5 µg/L.

4.2.11.4 Porewater

VOCs were analyzed in porewater samples collected from GWI and Boeing Plant 2/ Jorgensen Forge as part of the RI in 2005 and from Rhône-Poulenc during a sampling event in 2004 (Map 4-12a). VOCs analyzed in the nine porewater samples collected during the Rhône-Poulenc sampling event were benzene, toluene, ethylbenzene, and xylene; none of these VOCs was detected. VOC concentrations in porewater samples are compared with WQC in Section 4.2.2 (Table 4-22).

Table 4-93 and Maps 4-12c and 4-12d present data for detected VOCs in porewater samples collected using peepers in shallow nearshore areas offshore of GWI and Boeing Plant 2/Jorgensen Forge as part of the RI. Porewater samples were also collected from deeper, offshore areas at these two sites using piezometers (see Map 4-12a); VOCs were not detected in any porewater samples collected using piezometers at either site.

Table 4-93. Summary of VOC data for porewater samples collected from locations using peepers

Chemical	Detection Frequency[a]		Concentration (µg/L)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[b]
GWI					
1,1-Dichloroethane	8/10	80	0.4	16	0.2
1,1-Dichloroethene	3/10	30	0.3	4.9	0.2 – 0.4
1,2-Dichlorobenzene	3/10	30	0.5	1.2	0.2 – 0.4
1,2-Dichloroethane	2/10	20	7.4	15	0.2 – 0.4
1,2-Dichloropropane	2/10	20	1.7	2.5	0.2 – 0.4
1,4-Dichlorobenzene	2/10	20	0.3	0.3	0.2 – 0.4
Benzene	1/10	10	9.4	9.4	0.2 – 4.7

Chemical	Detection Frequency[a]		Concentration (µg/L)		
	Ratio	%	Minimum Detect	Maximum Detect	RL or Range of RLs[b]
Carbon disulfide	5/10	50	0.2	0.7	0.2 – 0.4
Chlorobenzene	4/10	40	0.3	1.4	0.2 – 0.4
cis-1,2-Dichloroethene	10/10	100	0.5	2,900	na
Isopropylbenzene	2/10	20	0.2	0.3	0.2 – 0.4
Tetrachloroethene	2/10	20	0.4	1.1	0.2 – 0.4
Toluene	5/10	50	0.3	3.5	0.2 – 0.4
trans-1,2-Dichloroethene	7/10	70	0.3	21 J	0.2 – 0.4
Trichloroethene	4/10	40	0.4	2.5	0.2 – 0.4
Vinyl chloride	10/10	100	0.4	2,500	na
Boeing Plant 2/Jorgensen Forge					
1,1-Dichloroethane	1/10	10	0.3	0.3	0.2
cis-1,2-Dichloroethene	7/10	70	0.2	1.7	0.2
Trichloroethene	2/10	20	0.2	0.2	0.2
Vinyl chloride	2/10	20	1.1	13	0.2

[a] Two of the 10 samples from GWI were field replicates collected at PE-08 and two of the 10 samples from Boeing Plant 2 were field replicates collected at PE-10.

[b] RLs are based only on non-detect samples.

GWI – Great Western International
J – estimated concentration
na – not applicable
nd – not detected
RL – reporting limit
VOC – volatile organic compound

The highest concentrations of VOCs were detected in samples collected from GWI. Vinyl chloride and cis-1,2-dichloroethene were detected in all samples collected using peepers and had the highest concentrations. Maximum concentrations of vinyl chloride and cis-1,2-dichloroethene were 2,500 and 2,900 µg/L, respectively, at location PE-06 (Map 4-12c).

At Boeing Plant 2/Jorgensen Forge, four VOCs were detected in porewater samples (Table 4-93). Cis-1,2-dichloroethene was the most frequently detected VOC, in 7 of the 10 samples collected using peepers, at concentrations ranging from 0.2 to 1.7 µg/L. The highest VOC concentration (13 µg/L of vinyl chloride) was detected in a porewater sample collected from location PE-11 (Map 4-12d).

4.2.11.5 Summary

Seven VOCs were detected in surface sediment samples collected from the LDW. The highest concentrations were 1,600 µg/kg dw for dichloromethane and 1,000 µg/kg dw for acetone. All other VOCs were detected at concentrations less than 35 µg/kg dw. In subsurface sediment collected between RM 3.5 and RM 3.6 as part of the RI, high concentrations of cis-1,2-dichloroethene and vinyl chloride (200,000 and 60,000 µg/kg dw, respectively) were detected at depth (between 10 and 12 ft). These VOCs were not detected within the top 6 ft of sediment in this core.

Few VOCs were detected in seep water samples collected from Boeing Plant 2, Rhône-Poulenc, and at locations throughout the LDW as part of the RI; concentrations were low (≤ 40 µg/L). Numerous VOCs were frequently detected in seep water samples from GWI. VOCs with the highest concentrations were cis-1,2-dichloroethene (5,400 µg/L) and vinyl chloride (3,500 µg/L).

Porewater samples were collected and analyzed for VOCs at Boeing Plant 2/Jorgensen Forge and GWI as part of the RI. At GWI, cis-1,2-dichloroethene and vinyl chloride were detected in all 10 nearshore samples, at maximum concentrations of 2,900 and 2,500 µg/L, respectively. At Boeing Plant 2/Jorgensen Forge, VOCs were detected at low concentrations in porewater samples (≤ 13 µg/L).

4.3 COMPARISON OF DEPTHS OF PEAK PCB CONCENTRATIONS IN CORES WITH PREDICTIONS OF THE STM

This section combines information on depth patterns in sediment chemistry (from sediment cores) with net sedimentation and erosion estimates from the STM to determine whether vertical patterns of total PCB concentrations are consistent with the CSM and with the predictions of the STM. This analysis is focused on total PCBs because PCBs are persistent, have a relatively clear history of use, and are widespread. The FS will consider this type of analysis and other lines of evidence when evaluating remedial alternatives and remedial technologies. The FS will also include a site-specific analysis of areas with localized erosion (e.g., berthing activities and associated ship-induced bed scour).

The CSM for sediment transport was refined based on results of the STM, which generates estimates of net sedimentation and net erosion for each LDW model cell (Maps 3-4, 3-5, 3-6, and 3-9).[104] Results of the STM indicate that the LDW is net depositional over annual time scales, although rates of net sedimentation vary across the LDW from < 0.5 cm/year to approximately 140 cm/year (the latter value only in the Upper Turning Basin), with typical rates for most of the LDW between 0.5 and 3 cm/yr. The STM also identified areas of the LDW where erosion could occur during high-flow events.[105] According to the STM, high-flow events are unlikely to erode sediment to depths greater than approximately 22 cm, and net erosion up to this depth is expected in relatively small areas (Map 3-7). Other physical events that could potentially expose subsurface sediments deeper than approximately 22 cm include

[104] The STM models conditions within 2,000 horizontal grid cells, with seven lateral (i.e., from bank to bank) grid cells at most locations in the LDW. Cell lengths (north-south axis) ranged from 20 to 150 m. For each model cell, the STM estimated annual average net sedimentation rates over a 30-year simulation and net erosion depths over the course of a high-flow event.

[105] High-flow events include above-average flows with return periods of 2 years (8,400 cfs), 10 years (10,800 cfs), and 100 years (12,000 cfs). The average LDW flow is 1,350 cfs. The results from the three high-flow event simulations were similar.

stationary tugboats using high thrust, dredge events, or construction events; these events are expected to be highly localized and of short duration. Results of an analysis of ship-induced bed scour conducted as part of the STM (see Section 3.1.7) indicated that erosive forces from tugboats transiting the navigation channel tend to repeatedly mix the upper 1 to 2 cm of sediment in the areas frequented by these ships. Ship-induced mixing was evaluated only for ships traveling within the navigation channel, not for ships maneuvering in berthing areas (QEA 2008).

As described in Section 3.1.4, net sedimentation rates were also estimated empirically using several lines of evidence. These empirically-derived sedimentation rates were compared with the sedimentation rates from the STM in Table 3-9. In general, net sedimentation rates estimated using the empirical approach agreed reasonably well with the model estimates, considering the different methods used to derive the estimates. One of the empirical lines of evidence used to estimate net sedimentation rates was the vertical profile of PCB concentrations in sediment cores. This line of evidence is discussed in greater detail below by comparing to STM-derived net sedimentation rates (in addition to the comparisons presented in Section 3.2.5).

Much of the sediment contamination in the LDW, and particularly PCB contamination, is believed to have originated from historical sources in the LDW (see Section 9). In undisturbed depositional areas with no ongoing or recent sources, PCB concentrations should be higher in deeper core intervals than in shallower intervals. In areas with little or no deposition, localized disturbances, or ongoing or recent secondary sources (e.g., erosion of contaminated soil), this pattern may be reversed, with higher PCB concentrations in the shallowest core intervals.

Assuming that an area is depositional and has not been disturbed, the depth[106] of the maximum total PCB concentration within a core should be a function of both the time since peak PCB use and release and the estimated rate of net sedimentation. In this analysis, the maximum total PCB concentration within a core is referred to as the peak total PCB concentration. To investigate this CSM, the expected depth of peak total PCB concentration was estimated for each core. This depth within a core was calculated as described in Equation 4-2:

$$D = (Tc - Tm) \times S \qquad \textbf{Equation 4-2}$$

Where:

D = depth of peak total PCB concentration (cm)
Tc = year of core collection

[106] Sampling intervals in cores in the RI dataset were based on recovered depths for all cores collected for the RI, and for most cores collected as part of other sampling events.

Tm = assumed year of maximum concentration in surface sediment, corresponding to the assumed peak in PCB use and releases to the LDW

S = net sedimentation rate (cm/yr) estimated from the STM for the cell containing the core[107]

General uncertainties associated with estimating the depth of the peak total PCB concentration using Equation 4-2 include uncertainties in the net sedimentation rate estimated by the STM and uncertainty in the estimate of the year of the peak release of PCBs. In addition, there is uncertainty associated with identifying the exact depth of the peak total PCB concentration within a core because of compositing within each core section. Uncertainty is particularly high at locations where the core intervals analyzed were 3 ft or greater and is lowest at locations where the core was sectioned into 0.5-ft intervals. Location-specific uncertainties include the possibility of sediment disturbance near berthing areas or local structures, and the potential for PCB releases to continue after the peak use/release date.

To address the uncertainty in the year of maximum historical PCB releases to the LDW, a range of estimated depths of the peak total PCB concentration was calculated for each core corresponding to a range of years during which maximum releases may have occurred (i.e., estimated depths within each core were calculated assuming maximum PCB releases in 1960, 1965, and 1974). Three years were assessed to acknowledge the uncertainty in the year of maximum PCB release. Peak PCB concentrations were found in Puget Sound sediment cores at depths corresponding to between 1960 and 1970 (Van Metre and Mahler 2004; Lefkovitz et al. 1997); the use of PCBs was banned in 1978 and they were phased out over the next few years.[108] The specific years selected were based on the following rationale that applies throughout the LDW site: 1960 is the earliest justifiable year based on the Puget Sound core data, 1965 is mid-way through the 1960s, and 1974 was the year of a PCB spill in Slip 1 and PCBs were still being produced with the potential for release into the environment.

These estimated depths were then compared with the actual depth of the interval with the peak total PCB concentration in each core. If the depth of the interval with the peak total PCB concentration in a core was within the range of estimated depths or deeper than the range of estimated depths, then the core was considered to be consistent with the CSM and with the predictions of the STM. If peak depths estimated by the STM for the three years assumed to be associated with maximum PCB releases were all deeper than the core depth with the peak total PCB concentration, then the core was considered inconsistent with the CSM and the predictions of the STM (i.e., actual net

[107] If a core was collected in an area outside the boundaries of the STM, the net sedimentation rate of the nearest cell was used.

[108] Even after PCBs were phased out, releases could continue from secondary sources (e.g., contaminated soils, paints).

sedimentation rates must be lower than those estimated by the STM). See Maps 4-69a through 4-69d for examples of consistent and inconsistent cores.

Detailed results of this analysis for each individual core are presented in Appendix F. Of the 366 cores available in the RI dataset, 157 cores were used in the analysis and 209 cores were not used because the type of information needed for the analysis was not available for those cores (Table 4-94). Cores were excluded if at least one of the following conditions was met: 1) only one core interval was analyzed for total PCBs, 2) no core interval was analyzed within the depth range of the expected peak, 3) PCBs were not detected in any core interval, or 4) the sediment was disrupted by dredging prior to sampling.

Table 4-94. Results of the analysis comparing expected and actual depths of peak total PCB concentrations in subsurface sediment

Determination	Reason	Number of Cores	
		All Cores	Excluding Cores with Larger Intervals
Consistent with STM	Peak was as deep or deeper than expected depth range.	110 (70%)	86 (65%)
Inconsistent with STM	Peak was shallower than expected depth range.	47 (30%)	47 (35%)
Total number of cores included		157	133
Excluded from analysis	At least one of the following conditions was associated with a core: 1) only one core interval was analyzed for total PCBs, 2) no core interval was analyzed within the depth range of the expected peak, 3) PCBs were not detected, or 4) dredging occurred prior to sampling.	209	233[a]
Total number of cores		**366[b]**	**366[b]**

[a] Twenty-four cores were excluded from the analysis because they had ≥ 3 ft sampling intervals in the portion of the core near the estimated and actual peak depths. These cores are identified in Tables F-1 and F-2 of Appendix F.

[b] Four of the cores were collected outside of the STM boundaries so the net sedimentation rate of the nearest cell was used.

PCB – polychlorinated biphenyl

STM – sediment transport model

Of the 157 cores included in the analysis, 110 cores (70%) had peak total PCB concentrations at depths equal to or greater than the estimated depths, consistent with the predictions of the STM. Forty-seven cores (30%) had maximum total PCB concentrations that were shallower than the estimated depth range based on net sedimentation rates from the STM, assumed maximum PCB releases to the LDW in the 1960s and 1970s, and minimal localized disturbances. Thirty-two of these forty-seven cores were located in EAAs with either very low net sedimentation rates or in areas where source investigations have suggested the potential for ongoing releases of PCBs.

Uncertainty in determining whether cores were consistent or inconsistent was higher in cores with samples composited over larger intervals (i.e., ≥ 3 ft). To assess this uncertainty, 24 cores with samples composited over ≥ 3 ft intervals in the portion of the core where the estimated and actual peak depths occurred were removed to assess the influence on the results. Cores were retained in this uncertainty analysis if the intervals ≥ 3 ft were substantially deeper than the estimated and actual peak depths because these data were not expected to affect the outcome of the analysis. Note that these 24 cores were consistent with the STM; however, because of the larger intervals, their intrepretation is more uncertain. When the 24 cores were removed from the analysis, for a total of 133 cores in the analysis, 86 cores (65%) were considered consistent with the predictions of the STM, and 47 cores (35%) were considered inconsistent.

The results of the initial analysis using all 157 cores are discussed in more detail in the following sections for each of the three reaches defined in the CSM: Reach 1 – from RM 0.0 to RM 2.2; Reach 2 – from RM 2.2 to RM 4.0; and Reach 3 – from RM 4.0 to RM 4.8.

4.3.1 Reach 1 – RM 0.0 to RM 2.2

Based on the results of the STM, Reach 1 was characterized as net depositional on annual time scales in both the navigation channel and the adjacent bench areas. The sedimentation rates in the navigation channel and bench areas were generally classified as intermediate net depositional (1 to 2 cm/yr) within the first RM, and as intermediate to high depositional (1 to 3 cm/yr) in the remaining portion of this reach. Some relatively small areas that were classified as lower net depositional (0 to 1 cm/yr) are also present in this reach (Map 3-9).

In general, the potential for re-exposing buried sediments in this reach as a result of scour during high-flow events is considered minimal. The STM identified the potential for relatively low bed scour (< 2 cm) during a 100-year event in a small area between RM 0.8 and RM 0.9 and in several areas between RM 1.8 and RM 2.2 (Map 3-7). Ship-induced mixing of the surficial bed layer from ships traveling within the navigation channel was estimated to extend to average depths of about 1 to 2 cm in the bench areas and less than 1 cm in the navigation channel.

Maps 4-69a through 4-69d present an overlay of sediment core locations on a map depicting estimated average annual net sedimentation rates in the LDW. These maps show the depth interval of the actual peak total PCB concentration in subsurface sediment relative to the estimated depth of the peak concentration and indicate whether the actual depth is consistent with (the same depth or deeper than) or shallower than the estimated depth.

Most patterns of total PCB concentrations as a function of depth within the cores in this reach were consistent with the net sedimentation rates estimated by the STM and estimated period of peak PCB releases to the LDW. Three of the fifty-nine cores in this

reach with data sufficient to assess consistency with the predictions of the STM were field replicates; thus, those fifty-nine cores represent fifty-six locations. Of the 56 locations with sufficient core data, 43 (77%) had peak total PCB concentrations as deep or deeper than expected, and 13 locations (23%) had peak total PCB concentrations shallower than expected (Table 4-95). Examples of cores in which peak total PCB concentrations were consistent with the STM can be found at locations throughout the reach, including cores along the eastern bench, along the western bench, and in the navigation channel (Maps 4-69a and 4-69b).

Table 4-95. Results of the analysis comparing expected and actual depths of peak total PCB concentrations in subsurface sediment by river reach

River Reach	Area Within Reach	Number of Cores		
		Consistent with STM	Inconsistent with STM	Excluded from Analysis[a]
RM 0 to RM 2.2	EAA 1 (Duwamish/Diagonal)	13	0	0
	rest of reach	31	15	49
	Subtotal	**44 (43)[b]**	**15 (13)[c]**	**49**
RM 2.2 to RM 4	EAA 2 (RM 2.2)	0	1	0
	EAA 3 (Slip 4)	6	0	0
	Boeing Plant 2/Jorgensen Forge EAA	47	19	66
	EAA 5 (Terminal 117)	3	8	9
	EAA 6 (RM 3.8 to 3.9)	0	1	0
	rest of reach	9	3	40
	Subtotal	**65**	**32**	**115**
RM 4 to RM 4.8	entire reach	1	0	45
	subtotal	**1**	**0**	**45**
Total		**110**	**47**	**209**

[a] Cores were excluded from this analysis if at least one of the following conditions was met: 1) only one core interval was analyzed for total PCBs, 2) no core interval was analyzed within the depth range of the expected peak, 3) PCBs were not detected, or 4) dredging occurred prior to sampling.

[b] One core of the 44 cores was a field replicate.

[c] Two cores of the 15 cores were field replicates.

EAA – early action area

PCB – polychlorinated biphenyl

RM – river mile

STM – sediment transport model

There were 13 locations (23%) at which the peak total PCB concentration was in a shallower core interval than expected. Six of these locations were on the eastern bench, six were on the western bench, and one was in the channel. Differences between the expected and actual depths of the peak total PCB concentration may be a result of: 1) uncertainty in the sedimentation rates or scour depth predicted by the STM, particularly if the location was just outside of the modeling area or in areas with in-

water structures or bathymetric features not captured by the model, 2) the presence of localized, ongoing sources of PCBs, or 3) the occurrence of localized disturbance events sufficient to expose subsurface sediment.

Ten of the thirteen locations that did not fit the expected pattern had relatively high PCB concentrations (> 210 µg/kg dw [the 75th percentile]) in the uppermost core interval. These 10 locations were situated throughout the reach, mostly close to the shoreline. Most of the 10 locations were near an outfall of some kind; in addition, one was outside of the modeling area and four were near berthing areas. Potential sources of PCBs have not been characterized in detail in these areas.

Total PCB concentrations in cores from the remaining 3 of the 13 locations were ≤ 75 µg/kg dw throughout the core profile. Two of these locations were on the east side of the navigation channel (near RM 1.1 and at the mouth of Slip 3) and one location was on the west side of the channel (near RM 1.4). Therefore, although the expected and actual peak total PCB concentrations were not at the same depth, differences in concentrations among the intervals within cores were relatively small.

In summary, data from a majority of the cores (77%) in Reach 1 were consistent with the predictions of the STM, with the peak PCB concentration as deep or deeper than the estimated depth. In the remaining 23% of the cores in which the peak PCB concentration was in a shallower interval than estimated, it is uncertain if the discrepancy was a result of uncertainties in the STM, the occurrence of localized disturbances, low PCB concentrations throughout the core resulting in relatively small differences in among the intervals, or the presence of ongoing sources. In such areas, it will be important to evaluate additional lines of evidence to predict changes in chemical concentrations in the future.

4.3.2 Reach 2 – RM 2.2 to RM 4.0

Reach 2 was characterized as net depositional, with high spatial variability in net sedimentation rates, ranging from 0 to approximately 11 cm/year (Maps 4-69c and 4-69d). Some of the benches within the reach were characterized as having high net sedimentation rates (> 3 cm/yr), including both eastern and western benches between RM 2.0 and RM 2.6 and the western bench between RM 3.3 and RM 3.6. This reach also includes several areas with the lowest net annual sedimentation rates (0 to 0.5 cm/yr). Estimated scour depths were also variable, with a maximum net erosion depth of 21 cm in a small area near RM 3.6. Scour depths were generally higher in the navigation channel than in the bench areas. Ship-induced mixing of the surficial bed layer from ships traveling within the navigation channel is expected to be minimal, potentially extending to average depths of less than 1 cm in the bench areas and less than 0.1 cm in the navigation channel.

As in Reach 1, most patterns of total PCB chemical concentrations as a function of depth within the cores in Reach 2 were consistent with the net sedimentation rates estimated by the STM and the assumed peak usage of PCBs (Maps 4-69c and 4-69d).

Of the 97 locations in this reach with data sufficient to assess consistency with the predictions of the STM, 65 (67%) had peak total PCB concentrations as deep or deeper than expected based on the estimated net sedimentation rate over the time period since the expected peak usage and release of PCBs (Table 4-95). These cores were distributed throughout the reach (Maps 4-69c and 4-69d).

There were 32 locations (33%) that had peak total PCB concentrations in a shallower interval than expected. Eight of the cores were collected near T-117 and nineteen of the cores were collected in the Boeing Plant 2/Jorgensen Forge EAA near RM 3.6. The remaining five cores were located near RM 2.2 (in EAA 2) and near RM 2.8, RM 3.3, RM 3.8, and RM 3.9. Most of these cores were also located near outfalls. Potential sources have been characterized in the EAAs, but not in all of the other areas.

Twenty-seven of the thirty-two cores in Reach 2 that did not fit the expected pattern had relatively high total PCB concentrations (> 210 µg/kg dw) in the uppermost core interval analyzed. The five cores that did not have total PCB concentrations greater than 210 µg/kg dw were located near the inlet at RM 2.2, in the channel near RM 3.3, in the T-117 EAA near RM 3.7, and in the Boeing Plant 2/Jorgensen Forge EAA (two cores).

In summary, data from 65 (67%) of the cores in this reach were consistent with the predictions of the STM, with the peak PCB concentration as deep or deeper than the estimated depth. However, at 32 (33%) of the core locations, peak PCB concentrations were detected in a shallower core interval than that estimated by the STM. At these 32 locations, it appears that either net sedimentation is lower than expected, localized disturbances are occurring, or ongoing sources may be present. All but three of these 32 cores were located in EAAs, and all but one of the three cores outside EAAs were near outfalls.

4.3.3 Reach 3 – RM 4.0 to RM 4.8

This reach was characterized as net depositional, with relatively high net sedimentation rates: 2 to 3 cm/year in Slip 6; 4 to 23 cm/year between RM 4.0 and RM 4.5, and up to 151.5 cm/year in the Upper Turning Basin, which is designed to act as a trap for much of the coarser fraction of the bed load entering the LDW from upstream. Episodic erosion may occur during high-flow events in some areas of the reach (up to approximately 21 cm in one small area at RM 4.6), but most of the reach is not expected to experience scour greater than 10 cm in depth during high-flow events. Ship-induced mixing of the surficial bed layer from ships traveling within the navigation channel is expected to be minimal.

Of the 47 cores in this reach, only one location (in Slip 6) had sufficient data to assess consistency with the predictions of the STM using this method (Table 4-95). At this location in Slip 6, peak total PCB concentrations were at a depth in the core consistent with expectations based on the STM and peak PCB usage.

4.3.4 Summary of comparison of depths of peak PCB concentrations in cores with predictions of the STM

A total of 157 cores from throughout the LDW were evaluated for consistency with the predictions of the STM. Most (70%) of the cores were consistent with the assumptions of the analysis, with peak PCB concentrations as deep or deeper than those estimated by the STM. The remaining 30% of the cores had peak concentrations that were shallower than expected assuming net sedimentation rates from the STM, peak PCB usage and release in the 1960s and 1970s, and minimal localized disturbances. Therefore, one or more of these assumptions were likely not valid at these particular locations. The principal limitations of this analysis include uncertainties in the net sedimentation rate estimated by the STM, the estimate of the peak year of PCB release in the LDW, and the identification of the depth of peak PCB concentrations in sediment cores with larger intervals. An uncertainty analysis was conducted to assess the influence of the larger intervals. When the 24 cores were removed from the analysis (because they had samples composited over ≥ 3 ft in the interval with the actual or predicted peak), 86 cores (65%) were considered consistent with the predictions of the STM, and 47 cores (35%) were considered inconsistent.

The FS will evaluate other lines of evidence and will include a more detailed analysis of core locationsthat were inconsistent with the predictions of the STM to look for the presence of site features or used that may account for these inconsistencies. Eighteen percent of the cores with shallower than expected peaks were located in EAAs.

4.4 SUMMARY

This section provides a summary of the nature and extent of contamination in the LDW based on a comprehensive chemical dataset for surface sediment, subsurface sediment, tissue, surface water, seep water, and porewater.

Surface sediment samples from 1,484 locations within the LDW were used to evaluate the nature and extent of contamination. Chemical contamination of surface sediment in the LDW is characterized by a discrete set of localized areas with high chemical concentrations (hot spots) separated by relatively large areas with much lower contamination.

Table 4-96 presents summary statistics for selected risk driver chemicals identified in the risk assessments and also lists locations with the highest concentrations. The SWAC provides an indication of average concentrations within the LDW that is not biased by sampling density, whereas the area-based 95th percentile identifies areas with the highest concentrations in the waterway (95% of the LDW, by area, has lower concentrations). As shown on Maps 4-70a through 4-70c, areas with the highest chemical concentrations of risk driver chemicals tend to be co-located. Many of the locations with the highest concentrations are within areas that have been identified as EAAs (see Appendix I).

Table 4-96. Summary of LDW surface sediment data

Chemical	Unit	95TH Percentile[a]	50TH Percentile[a]	SWAC	Areas with Highest Concentrations[b]
Total PCBs	µg/kg dw	810	110	350	Duwamish/Diagonal EAA RM 1.0 in navigation channel EAA 2 Slip 4 EAA Boeing Plant 2/Jorgensen Forge EAA T-117 EAA Norfolk EAA
Arsenic	mg/kg dw	25	11	15	RM 3.8 EAA near RM 0.1 on the east side Duwamish/Diagonal EAA Slip 1 RM 1.3 to RM 1.5 on the west side Slip 3 Boeing Plant 2/Jorgensen Forge EAA Between RM 3.7 and RM 3.9 EAA on the east side
cPAHs	µg/kg dw	1,100	260	380	T-117 EAA Slip 4 EAA RM 3.8 EAA near RM 0.6 on the west side RM 0.0 near Harbor Island Duwamish/Diagonal EAA
BEHP	µg/kg dw	990	200	380	Duwamish/Diagonal EAA EAA 2 Slip 4 EAA Boeing Plant 2/Jorgensen Forge EAA Norfolk EAA
Dioxin and furan TEQ	ng/kg dw	490	10	nc	RM 1.4 to RM 1.5 on the west side EAA 2 Duwamish/Diagonal EAA near RM 1.0 in the navigation channel Boeing Plant 2/Jorgensen Forge EAA
Cadmium	mg/kg dw	1.8	0.39	nc	Boeing Plant 2/Jorgensen Forge EAA Duwamish/Diagonal EAA Slip 1 Slip 4 RM 1.3 to RM 1.5 on the west side near RM 0.1 on the east side near RM 1.0 in the navigation channel EAA 2
Chromium	mg/kg dw	70	29		
Copper	mg/kg dw	147	52		
Lead	mg/kg dw	210	36		
Mercury	mg/kg dw	0.41	0.14		
Nickel	mg/kg dw	43	22		
Silver	mg/kg dw	1.7	0.3		
Vanadium	mg/kg dw	81	57		
Zinc	mg/kg dw	407	113		
TBT	µg/kg dw	250	22	nc	near RM 1.3 on the west side between RM 0.0 and RM 0.4
HPAH	µg/kg dw	13,300	1,985	nc	T-117 EAA Between RM 0.5 and RM 0.6 in the navigation channel and on the west side RM 3.8 EAA RM 2.7 on the west side near RM 1.0 on the east side Boeing Plant 2/Jorgensen Forge EAA Duwamish/Diagonal EAA Slip 1 Slip 4

Chemical	Unit	95th Percentile[a]	50th Percentile[a]	SWAC	Areas with Highest Concentrations[b]
LPAH	µg/kg dw	2,300	230	nc	RM 2.7 on the west side T-117 EAA near RM 1.0 on the east side Boeing Plant 2/Jorgensen Forge EAA Duwamish/Diagonal EAA

[a] The 95th and 50th percentiles were calculated on an area basis for total PCBs, arsenic, cPAHs, and BEHP. For the remaining chemicals, the percentiles were calculated arithmetically using all values from the baseline surface sediment dataset. UCLs for total PCBs, arsenic, cPAHs, and dioxins and furans in surface sediment were calculated using the RI baseline dataset in Appendix C (Table C.3-8). These UCLs (2,500 µg/kg dw for total PCBs, 21 mg/kg dw for arsenic, 570 µg/kg dw for cPAHs, and 610 ng/kg dw for dioxin and furan TEQ) are presented as EPCs for the netfishing scenario in the HHRA (Appendix B), which uses the entire surface sediment dataset.

[b] Areas with the highest concentrations are listed but may not include all areas with concentrations greater than the 95th percentile; see individual maps for all locations.

BEHP – bis(2-ethylhexyl) phthalate
cPAH – carcinogenic polycyclic aromatic hydrocarbon
CSO – combined sewer overflow
dw – dry weight
EAA – early action area
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LDW – Lower Duwamish Waterway
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
nc – not calculated
PCB – polychlorinated biphenyl
RM – river mile
SWAC – spatially weighted average concentration
T-117 – Terminal 117
TBT – tributyltin

Surface sediment data were compared with SMS criteria, and Thiessen polygons were used to estimate the areal extent of potential effects based on combined toxicity test results and surface sediment chemistry data. Using this approach, approximately 7% (34 ac) of the LDW area, had chemical concentrations or biological effects that exceeded CSL criteria and 18% (82 ac) of the LDW area had chemical concentrations or biological effects between the SQS and CSL criteria.

Subsurface sediment contamination was also characterized by many studies within the LDW. Many of the areas with high chemical concentrations in surface sediment also had high concentrations in subsurface sediment, although some areas with less contaminated surface sediment had contamination in the subsurface, particularly for PAHs.

A detailed analysis of the locations of peak concentrations of total PCBs, arsenic, and cPAHs within individual subsurface cores was conducted. At many locations, subsurface sediment at deeper intervals contained higher total PCB and cPAH concentrations than did sediment from the uppermost intervals, with some exceptions.[109]

The two highest dioxin and furan TEQs (194 and 136 ng/kg dw) in subsurface sediment were detected in samples collected deeper than 4 ft at locations LDW-SC20 (RM 1.0 in the navigation channel) and LDW-SC26 (RM 1.4 W), respectively. The next

[109] The exceptions for total PCBs were near RM 1.0 in the navigation channel, EAA 2, the Slip 4 EAA, the T-117 EAA, and the Boeing Plant 2/Jorgensen Forge EAA. The exceptions for cPAHs were Slip 6, the Norfolk EAA, the Duwamish/Diagonal EAA, and near RM 0.5 on the west side. In all but one of the five areas with high arsenic concentrations in subsurface sediment, peak concentrations were at depth within the cores.

highest concentration in subsurface sediment (54.1 ng/kg dw) was detected in the uppermost core interval at LDW-SC29 (the embayment at RM 1.5 W) that also had a very high concentration (2,100 ng/kg dw) in surface sediment. Concentrations decreased with depth at this location.

Chemical patterns in sediment cores collected throughout the site were evaluated for consistency with the CSM and with the predictions of the STM. Based on the CSM, total PCB concentrations should be higher in deeper intervals of the subsurface sediment cores than in shallower intervals, except in areas with low net sedimentation, localized disturbances, or ongoing or recent secondary sources. Available core data collected throughout the LDW are generally consistent with this expected pattern: most (70%)[110] of the cores showed that peak total PCB concentrations are as deep or deeper than those estimated by the STM. The remaining 30% of the cores had peak concentrations that were shallower than expected. Most of these locations were either in areas just outside the STM modeling areas, in dredged areas, near berthing areas, or near locations with the potential for ongoing sources. This analysis focused on only one of the lines of evidence to be used in the evaluation of remedial alternatives in the FS. The FS will consider additional lines of evidence and will include a site-specific analysis of areas with localized erosion (e.g., berthing activities and associated ship-induced bed scour).

A large number of tissue composite samples have been collected in the LDW for various fish, crab, and invertebrate species. The locations and number of the four sampling areas for fish and crabs were selected primarily to reflect the longitudinal distribution of PCB concentrations in the sediment characterized by a rolling average PCB sediment concentration. In whole-body composite samples of fish, mean sampling area total PCB concentrations ranged from 71 µg/kg ww in juvenile chinook salmon in Area T1 to 4,300 µg/kg ww in shiner surfperch collected in 2004 in Area T2. The highest mean total PCB concentration was in crab hepatopancreas tissue (5,500 µg/kg ww in T4 in 2004); mean concentrations in edible crab meat were much lower, ranging from non-detect to 270 µg/kg ww. In general, total PCB concentrations in invertebrates (except crab hepatopancreas samples) tended to be lower than in fish, and concentrations in juvenile chinook salmon were lower than concentrations in English sole and shiner surfperch. Mean lipid-normalized total PCB concentrations in fish and crab tissue ranged from non-detected to 100 mg/kg-lipid, with no clear differences in concentrations among fish or crab species or tissue types (i.e., whole body, fillet, hepatopancreas, or edible meat). Mean lipid-normalized total PCB

[110] An uncertainty analysis was conducted to assess the influence of the larger intervals. When the 24 cores were removed from the analysis (because they had samples composited over ≥ 3 ft in the interval with the actual or predicted peak), 86 cores (65%) were considered consistent with the predictions of the STM, and 47 cores (35%) were considered inconsistent.

concentrations in benthic invertebrates, clams, and mussels were generally lower than in fish and crab tissue, ranging from 3.3 to 41 mg/kg-lipid.

In general, the PCB congener patterns for each tissue type were similar, except for two clam samples from Slip 4 with higher contributions of less chlorinated PCB congeners. Of the three fish species analyzed for PCB congeners, shiner surfperch had the greatest variability in congener patterns among the individual samples. The mean pattern for whole-body fish samples in 2007 showed a small increase in the contribution from more highly chlorinated PCB congeners relative to the whole-body fish samples from 2004. The TEQ potencies were similar in the English sole and shiner surfperch tissues collected in 2004, 2005, and 2007. The Aroclor composition in samples collected from 2005 to 2007 appear to have had a higher proportion of the more highly chlorinated PCB congeners than those collected in 2004.

The Aroclor tissue data as a whole suggest total PCB concentrations in 2004 were higher than those in more recent years; total PCB concentrations appear to be decreasing based on Aroclor data. Trends based on the limited PCB congener data are more uncertain. The PCB congener data may suggest total PCB concentrations in English sole collected from Area T1 and possibly from Area T2 are decreasing, although the sample size is small. Total PCB concentrations (congener sums) in crabs collected from Areas T1 and T3 were also consistently lower in 2007 than 2004. The PCB congener data suggest temporal trends in total PCB concentrations in shiner surfperch are uncertain.

Differences in total PCB concentrations in English sole and shiner surfperch tissue among the four subareas were also evaluated. Area means were not significantly different in 2005 and 2007 for either wet-weight or lipid-normalized total PCB concentrations in English sole tissue. In 2004, significant differences were identified only between the area with the lowest mean (Area T4) and the areas with the highest or second highest mean (Area T1 or T2). For shiner surfperch, differences among areas were not significant in any year based on lipid-normalized total PCB concentrations. Wet-weight total PCB concentrations did not differ among areas in 2005 but were lower in Areas T1 and T4 than in Areas T2 and T3 in 2004 and 2007. Sufficient data for statistical analyses for Pacific staghorn sculpin were available for only 1 year (2004). Wet-weight and lipid-normalized total PCB concentrations in Pacific staghorn sculpin were significantly higher in Area T3 than in the other areas in 2004.

Mean total arsenic concentrations were highest in soft-shell clams (6.803 mg/kg dw in depurated samples). Mean inorganic arsenic concentrations, which are more relevant from a risk perspective, were also highest in soft-shell clams (3.37 mg/kg ww in depurated samples). Clam tissue had a very high percentage of inorganic arsenic (10 to 99%), much higher than fractions detected in tissue from other studies in Puget Sound. Regression analyses showed a statistically significant positive correlation between arsenic concentrations in benthic invertebrate tissue and co-located sediment; this

relationship was used to calculate area-wide tissue concentrations for use in the ERA (Appendix A).

The highest cPAH concentrations in tissue were detected in clams, mussels, and benthic invertebrates at mean concentrations ranging from 15 to 44 µg/kg ww; cPAH concentrations in fish tissue were relatively low. Mean cPAH concentrations in English sole (whole-body tissue) were significantly lower in Area T4 than in Areas T1 and T2. For shiner surfperch, mean concentrations were significantly lower in Area T4 than in Area T3. The cPAH SWAC in surface sediment was also significantly lower in Area T4 than in any other areas.

The highest mean concentrations of metals (including TBT) were detected in invertebrates (i.e., clams, crabs, benthic invertebrates, and amphipods). Other than PAHs, which were detected in most tissue samples, SVOCs were infrequently detected in tissue. DDT and chlordane compounds were detected in tissue samples, but there is high uncertainty in these data because of analytical interference from PCBs.

To determine concentrations of various chemicals in surface water in the LDW, grab samples were collected and SPMDs were deployed in the mid 1990s as part of the WQA by King County**.** In 2005, surface water grab samples were also analyzed for PCB congeners. Total PCB congener concentrations in grab samples collected from two locations in the LDW on four sampling dates in 2005 ranged from 0.000132 to 0.003211 µg/L. Concentrations were lowest at all locations in November 2005, when water flow was the highest.

In surface water grab samples, mean dissolved and total arsenic concentrations were higher at RM 1.1 and RM 1.9 than at RM 4.9. Mean concentrations of chromium, copper, lead, nickel, vanadium, and zinc in unfiltered samples and copper, lead, and zinc in filtered samples were higher in samples from RM 4.9 than in samples from RM 1.1 and RM 1.9. SVOCs were detected infrequently in surface water samples collected from the LDW. Calculated PAH and organochlorine pesticide concentrations in surface water based on the SPMD data ranged from 0.0000029 to 0.030 µg/L for PAHs and from 0.000000034 to 0.000033 µg/L for pesticides.

Seep water chemical data have been collected at four sites along the LDW, including Rhône-Poulenc, Boeing Plant 2, T-117, and GWI as well as during an LDW-wide seep investigation conducted for the RI. In seep water samples, PCBs were detected in a filtered sample collected from one of the RI locations (in the inlet at RM 2.2). The highest dissolved arsenic concentrations in seep water (72.4 and 253 µg/L) were detected in the embayment near RM 1.5 on the west side and in Slip 1, respectively. These areas also had some of the highest arsenic concentrations in surface sediment. An unfiltered seep water sample collected near Slip 6 had the highest concentrations of cadmium, chromium, copper, nickel, and vanadium. SVOCs were detected infrequently in seep water samples collected from the LDW. One organochlorine pesticide (heptachlor epoxide) was detected at one seep location in both filtered and unfiltered samples.

Few VOCs were detected in seep water samples collected from Boeing Plant 2, from Rhône-Poulenc, and at locations throughout the LDW; concentrations were ≤ 40 µg/L. VOCs were frequently detected in seep water samples collected during various GWI investigations. VOCs with the highest concentrations were cis-1,2-dichloroethene (5,400 µg/L) and vinyl chloride (3,500 µg/L).

Porewater samples collected from non-dredged sediment have been analyzed in four separate sampling events (EPA SI, PSDDA 1999, Rhône-Poulenc, and the RI). As part of the EPA SI, 15 unfiltered porewater samples were collected from throughout the LDW and analyzed for metals; seven metals, including arsenic, were detected in these samples. TBT was also analyzed in porewater as part of the EPA SI and the PSDDA 1999 sampling event. Only one of the 35 porewater samples had a TBT concentration (0.55 µg/L) that was greater than the DMMP SL (0.15 µg/L). Most SVOCs were detected infrequently, except BEHP in the Rhône-Poulenc study, which was detected in 56% of porewater samples analyzed. Organochlorine pesticides and PCBs were not analyzed in porewater.

Porewater samples were collected and analyzed for VOCs at the Boeing Plant 2/ Jorgensen Forge EAA and at GWI. At GWI, cis-1,2-dichloroethene and vinyl chloride were detected in all 10 nearshore samples, at maximum concentrations of 2,900 and 2,500 µg/L, respectively. At the Boeing Plant 2/Jorgensen Forge EAA, VOCs were detected in porewater samples at concentrations less than 13 µg/L.

5 Summary of the Baseline Ecological Risk Assessment

The baseline ERA estimated risks for the benthic invertebrate, fish, and wildlife species that may be exposed to chemicals in sediment, water, and aquatic biota in the LDW. This assessment was based on historical data (used in the Phase 1 ERA) (2003a) and sediment and tissue chemistry data collected as part of the RI. This section summarizes the problem formulation, exposure assessment, effects assessment, risk characterization, uncertainty analysis, and selection of risk drivers for ecological receptors. The complete ERA is included as Appendix A to this RI.

5.1 PROBLEM FORMULATION

The problem formulation of the ERA established the overall scope of the assessment. The problem formulation included a description of the data available for conducting the ERA, the suitability of the data for risk assessment purposes, and a risk-based screening process that allowed the risk assessment to focus on chemicals of potential concern (COPCs) and eliminate chemicals that posed minimal risks to ecological receptors.

Data used in the ERA consisted largely of:

- Surface sediment (uppermost 0 to 15 cm) chemistry data[111]
- Tissue chemistry data for benthic invertebrates (including benthic infauna and epifauna, crabs, clams, and mussels), English sole, Pacific staghorn sculpin, shiner surfperch, and juvenile chinook salmon
- Site-specific sediment toxicity test results
- Site-specific evaluation of imposex in field-collected gastropods
- Sediment porewater chemistry data

Because it is generally considered impractical to evaluate risks for every potentially exposed species, it is standard ERA practice and consistent with the SMS to focus on representative receptor species that typify groups of organisms with specific exposure pathways. One objective of selecting representative receptors is to choose species for which the risk conclusions will be protective or representative of other species that were not explicitly evaluated. For example, an assessment of risks to great blue herons would be assumed to be protective of all wading birds that eat fish because of the higher exposure potential of great blue herons. Receptors may also be selected for risk

[111] The ERA was conducted using the baseline surface sediment dataset, which included sediment data collected prior to early actions in the LDW. Since these data were collected, early actions in the LDW have been conducted at two locations (Duwamish/Diagonal and the BDC south SD in the Norfolk area). Therefore, the risks discussed in the ERA may not be representative of current risks at areas where cleanup has already occurred.

analysis if the species is highly valued by society (e.g., endangered or threatened species) or if the species is particularly sensitive to COPCs. Representative receptors of concern (ROCs) selected for the baseline ERA were the benthic invertebrate community, crabs, English sole, Pacific staghorn sculpin, great blue heron, spotted sandpiper, osprey, river otter, and harbor seal (Table 5-1).

Table 5-1. ROCs selected for the LDW and a summary of the considerations for selection

ROC	Exposure Route	Ecological Significance	Societal Significance	Site Use	Exposure Data Availability	Sensitivity
Benthic invertebrate community	direct contact, diet, sediment ingestion	food source for other invertebrates, fish, and mammals; nutrient cycling	target community for protection in the development of numerical sediment quality criteria	present year-round; multiple life stages	abundant surface sediment data available	because of the diversity of organisms in this ROC group, the range of sensitivities is represented
Crabs	direct contact, diet, incidental sediment ingestion	higher-trophic-level benthic invertebrate	some recreational and commercial value	present year-round; multiple life stages	site-specific tissue data available	effects data are available for decapods; unknown relative sensitivity of crabs
Pacific staghorn sculpin	incidental sediment ingestion; preys on both invertebrates and other fish; thus potential for elevated exposure via bioaccumulation because of trophic position	serves as prey for higher-trophic-level species such as birds and mammals	considered to be a nuisance by anglers	adults and juveniles present year-round; may spawn in the LDW	site-specific tissue data and prey tissue data available	Effects data are available for other fish species; unknown relative sensitivity of sculpin
English sole	direct contact, diet, incidental sediment ingestion	important prey item for birds and fish; key benthic predator	some recreational and commercial value	juveniles present year-round; adults present except during spawning migrations to Puget Sound	site-specific tissue and prey tissue data available	NMFS data suggest that they are as sensitive as other flatfish species (Myers et al. 1998b)
Juvenile chinook salmon	diet	important prey item for birds and fish; seasonally one of the most abundant juvenile salmonids in the LDW	threatened and endangered species;[a] returning adults important to commercial, sport, and tribal fisheries	generally present April to July; most estuary-dependent juvenile salmonid	site-specific tissue and prey tissue data available	believed to be sensitive to a wide range of COPCs
Great blue heron	preys on fish; thus potential for elevated exposure via bioaccumulation because of trophic position	high on food chain	valued by society	present year-round; feed in LDW	site-specific data available for some food resources	effects data available for other bird species; unknown relative sensitivity of heron
Osprey	preys on fish; thus potential for elevated exposure via bioaccumulation because of trophic position	top of food chain	valued by society; protected under migratory bird treaty	nests along the LDW and forages at shallow depths in the LDW	site-specific data available for food resources	effects data available for other bird species; unknown relative sensitivity of osprey
Spotted sandpiper	diet, incidental sediment ingestion	important role as an intermediate predator	protected under migratory bird treaty	present June to September; nests along the LDW	site-specific data available for food resources	effects data available for other bird species; unknown relative sensitivity of sandpiper.

ROC	Exposure Route	Ecological Significance	Societal Significance	Site Use	Exposure Data Availability	Sensitivity
River otter	preys on fish; thus, potential for elevated exposure via bioaccumulation because of trophic position	top of food chain	valued by society	present year-round	site-specific data available for food resources	some mustelids shown to be highly sensitive to some chemicals (e.g., PCBs)
Harbor seal	preys on fish; thus potential for elevated exposure via bioaccumulation because of trophic position	top of food chain	protected under Marine Mammal Act	infrequent	site-specific data available for food resources	pinnipeds suspected to be sensitive to some chemicals (e.g., PCBs)

[a] Species listed under the Endangered Species Act.

COPC – chemical of potential concern

LDW – Lower Duwamish Waterway

NMFS – National Marine Fisheries Service

PCB – polychlorinated biphenyl

ROC – receptor of concern

In addition, juvenile chinook salmon was selected as an ROC because this species is federally protected and uses the LDW during outmigration to Puget Sound.

For each ROC selected, COPCs were identified through a conservative, risk-based screening process using maximum exposure concentrations and the SQS for benthic community or no-observed-adverse-effect levels (NOAELs) from the scientific literature for other receptors. COPCs identified included: 46 chemicals for the benthic invertebrate community (including TBT, metals, and PCBs and other organic compounds) (Table 5-2); 2 chemicals for crabs (total PCBs and zinc); 6 chemicals for at least one fish ROC (arsenic, cadmium, copper, total PCBs, TBT, and vanadium) (Table 5-3), and 12 chemicals for at least one wildlife ROC (arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, total PCBs, zinc, and vanadium) (Table 5-4). COPCs were evaluated only in the uncertainty analysis if there was uncertainty regarding their presence at concentrations of concern (i.e., chemicals were never detected in tissue, but RLs were above the screening criteria) or if they did not have effect-level toxicity information. Risks from organochlorine pesticides were also assessed in the uncertainty analysis. Detected concentrations of organochlorine pesticides in some sediment samples and in all tissue samples collected in 2004 were qualified as estimates (JN-qualified) because of probable analytical interference from PCBs, resulting in a high bias in concentration and a tentative identification (Windward 2005a, b).

Table 5-2. COPCs evaluated in the risk characterization for the benthic invertebrate community and for crabs

COPC	Benthic Invertebrate Community	Crabs
Metals		
Arsenic	X	
Cadmium	X	
Chromium	X	
Copper	X	
Lead	X	
Mercury	X	
Nickel	X	
Silver	X	
Zinc	X	X
Organometals		
TBT	X	
PAHs		
Acenaphthene	X	
Anthracene	X	
Benz(a)anthracene	X	
Benzo(a)pyrene	X	
Benzo(g,h,i)perylene	X	

COPC	BENTHIC INVERTEBRATE COMMUNITY	CRABS
Chrysene	X	
Dibenzo (a,h)anthracene	X	
Fluoranthene	X	
Fluorene	X	
Indeno (1,2,3,-c,d)pyrene	X	
Naphthalene	X	
Phenanthrene	X	
Pyrene	X	
Total benzofluoranthenes	X	
HPAH	X	
LPAH	X	
Phthalates		
BBP	X	
BEHP	X	
Dimethyl phthalate	X	
Other SVOCs		
1,2,4-Trichlorobenzene	X	
1,2-Dichlorobenzene	X	
1,4-Dichlorobenzene	X	
2-Methylnaphthalene	X	
4-Methylphenol	X	
2,4-Dimethylphenol	X	
Benzoic acid	X	
Benzyl alcohol	X	
Dibenzofuran	X	
Hexachlorobenzene	X	
n-Nitrosodiphenylamine	X	
Pentachlorophenol	X	
Phenol	X	
VOCs		
cis-1,2-Dichloroethene	X	
PCBs		
Total PCBs	X	X
Organochlorine Pesticides		
Total DDTs	X	
Total chlordane	X	

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
COPC – chemical of potential concern
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SVOC – semivolatile organic compound
TBT – tributyltin
VOC – volatile organic compound

Table 5-3. COPCs selected for fish ROCs

COPC	Juvenile Chinook Salmon	English Sole	Pacific Staghorn Sculpin
Arsenic	X	X	X
Cadmium	X	X	X
Copper	X	X	X
Vanadium	X	X	X
TBT			X
Total PCBs		X	X

COPC – chemical of potential concern
PCB – polychlorinated biphenyl
ROC – receptor of concern
TBT – tributyltin

Table 5-4. COPCs selected for wildlife ROCs

COPC	Spotted Sandpiper	Great Blue Heron and Osprey	River Otter	Harbor Seal
Arsenic	X		X	
Cadmium	X			
Chromium	X	X		
Cobalt	X		X	
Copper	X			
Lead	X	X		
Mercury	X	X	X	X
Nickel	X			
Selenium	X		X	
Vanadium	X			
Zinc	X			
Total PCBs	X	X	X	X

COPC – chemical of potential concern
PCB – polychlorinated biphenyl
ROC – receptor of concern

No quantitative ecological risks were estimated for dioxins and furans because tissue samples from the LDW were not available for dioxins and furans at the time the risk assessments were completed.[112] Therefore, the level of ecological risk from dioxins and

[112] In the human health risk assessment, it was assumed that risks associated with exposure to dioxins and furans are unacceptable, although tissue data were not available for specific exposure estimates. Dioxins and furans were assumed to be a risk driver based on human health risks associated with both the seafood consumption and direct contact pathways.

furans is unknown. Although risk from exposure to dioxin-like PCB congeners was evaluated for English sole and wildlife receptors, risks associated with exposure to all dioxin-like chemicals were not quantified. Thus, the combined exposure from all chemicals that bind with the Ah receptor was likely underestimated, although it is uncertain whether the inclusion of dioxins and furan exposure would have changed risk conclusions. The decision to not analyze dioxins and furans in tissue was made based on the difficulties associated with assessing site-specific risks from dioxins and furans, the need for a large background dataset with which to compare site-specific data, and the paucity of background tissue data in the Puget Sound area. Risk management decisions to address dioxin and furan contamination in LDW sediment will be based on relevant guidance and regulations, including those specifically related to the role of background-level contamination in the CERCLA process (EPA 2002a). Remedial decisions to address dioxin and furan contamination in sediment will be made by EPA and Ecology as part of the FS process.

The problem formulation also presented the conceptual site models for the ROCs (Figures 5-1 and 5-2). Conceptual site models identify and describe pathways in which ROCs may be exposed to COPCs associated with sediment within the LDW. The pathways evaluated in the ERA included both direct exposure through sediment and water and indirect exposure through the ingestion of prey from the LDW. The potential exposure pathways of sediment-associated chemicals to upper-trophic-level ROCs in the LDW were presented in a generalized food web diagram (Figure 5-3).

Assessment and measurement endpoints were also identified in the problem formulation (Table 5-5). Survival, growth, and reproduction were included as endpoints for all ROCs except juvenile chinook salmon. Assessment endpoints for juvenile chinook salmon included survival and growth; studies reporting reproductive endpoints were not used to derive reproductive TRVs for juvenile chinook salmon because of their life stage at the time of exposure (migrating juveniles) and because their exposure to LDW sediments as adults is limited.[113] Biomarker, behavioral, and histological endpoints were not included as assessment endpoints. Typically, ERAs focus on ecological effects at the individual level or higher (i.e., population level). In this way, the emphasis is placed on endpoints that integrate an overall response by an organism, rather than indicators of a biochemical response that may or may not result in an ecologically relevant effect. The assessment scale for each ROC was identified based on the potential exposure area for the ROC (Table 5-5).

[113] PCBs that accumulate in juvenile salmon during the time they spend in the LDW constitute a small fraction of the PCBs in adult salmon. Most of the PCBs in adults result from foraging activities in Puget Sound or the Pacific Ocean.

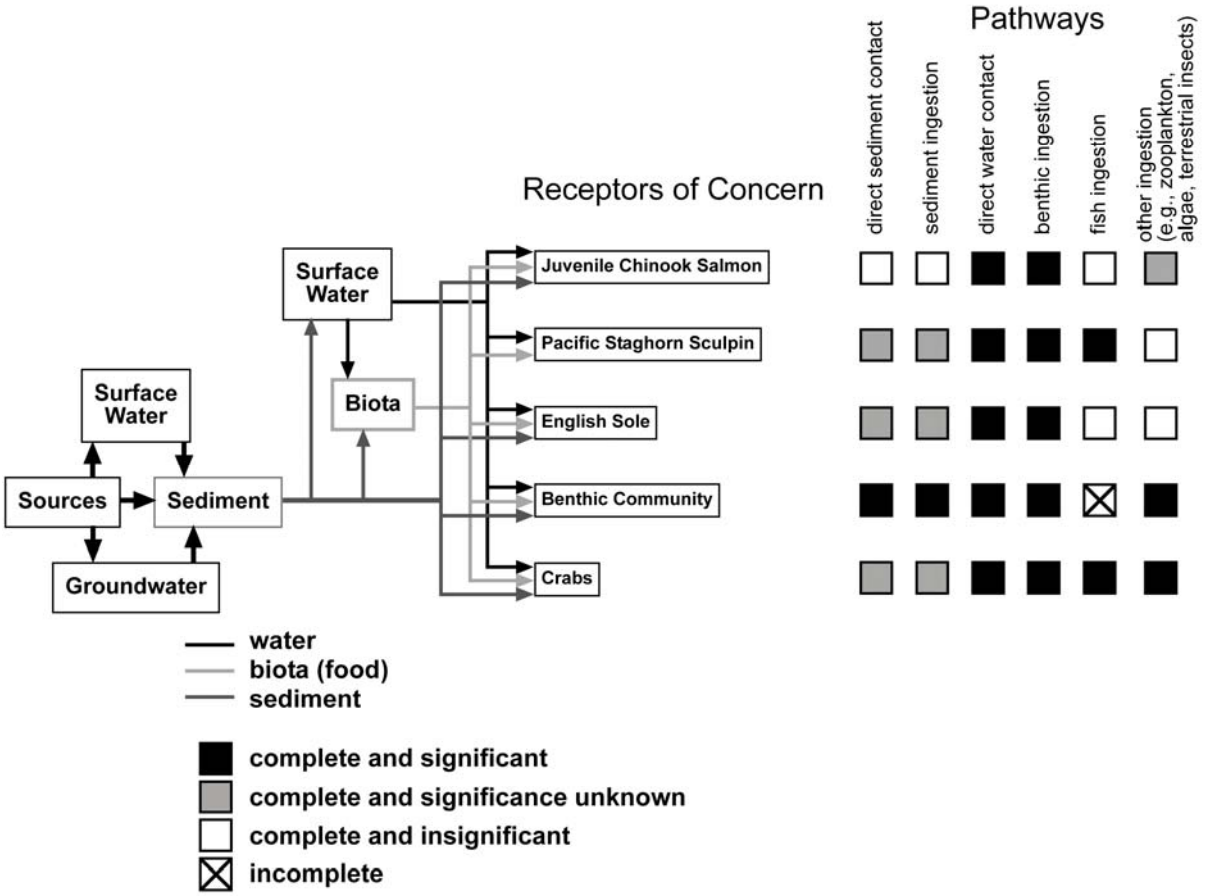


Figure 5-1. Conceptual site model for fish and the benthic invertebrate community

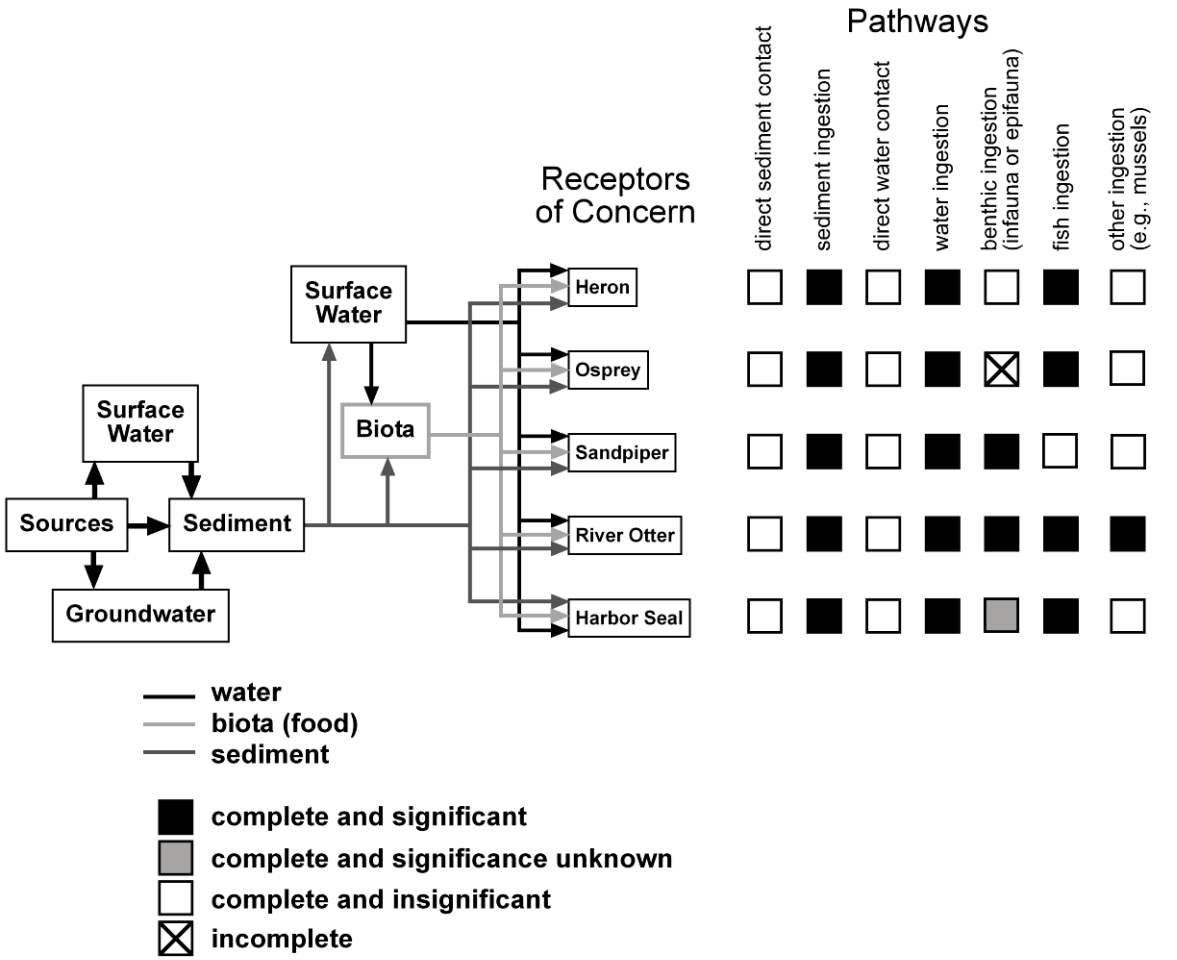


Figure 5-2. Conceptual site model for wildlife

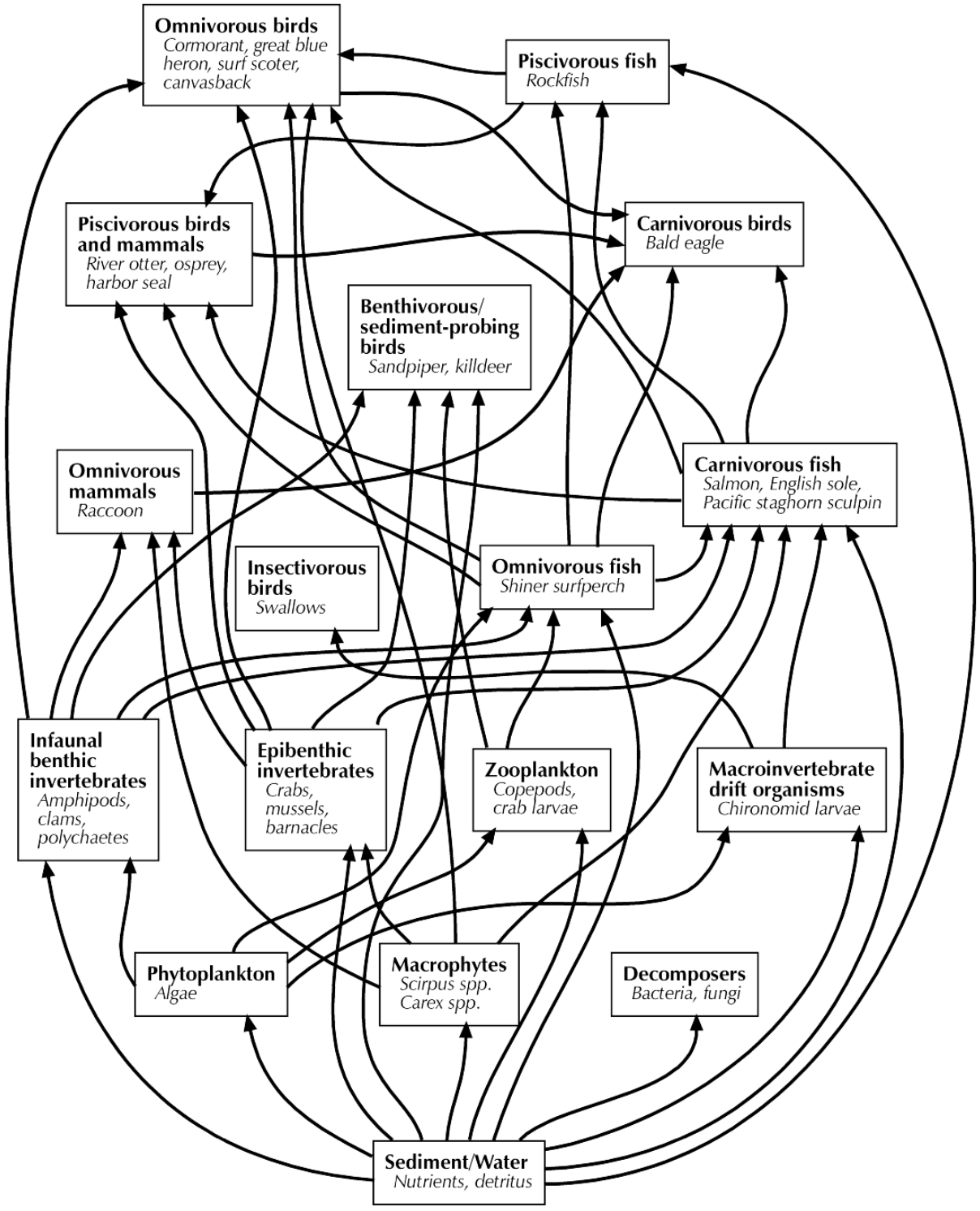


Figure 5-3. Generalized food web diagram for the LDW

Table 5-5. Assessment endpoints for ROCs and measures of effect and exposure

ROC	Assessment Endpoint	Assessment Scale	Measures of Effect	Measures of Exposure
Benthic				
Benthic invertebrate community	survival, growth, reproduction	potential exposure area: small exposure areas for individuals assessment scale: small exposure areas throughout the LDW	SMS and toxicologically based sediment guidelines or TRVs[a]	chemical concentrations in sediment
			water-based TRVs for VOCs	VOC concentrations in porewater
			site-specific toxicity tests	chemical concentrations in sediment samples co-located with toxicity test samples
			tissue-based TRVs for TBT (excluding imposex in gastropods)	TBT concentrations in sediment samples co-located with benthic invertebrate tissue collection
			assessment of imposex in field-collected gastropods	TBT concentrations in sediment samples co-located with gastropod collection
Crabs	survival, growth, reproduction	potential exposure area: crabs may forage throughout the LDW assessment scale: LDW-wide	tissue-based TRVs for decapods	chemical concentrations in crab tissue collected from four tissue sampling areas located throughout the LDW
Fish				
Juvenile chinook salmon	survival and growth	potential exposure area: juvenile salmonids migrate throughout the LDW and forage in shallow areas assessment scale: intertidal areas throughout the LDW	tissue-based TRVs for chemicals evaluated using a critical tissue-residue approach	chemical concentrations in juvenile chinook salmon tissue collected from middle and lower segments of the LDW
			dietary-based TRVs for chemicals evaluated using a dietary approach	chemical concentrations in juvenile chinook salmon prey collected from intertidal habitat throughout the LDW, stomach contents collected from juvenile chinook salmon captured throughout the LDW, and sediment collected from intertidal habitats throughout the LDW
English sole	survival, growth, reproduction	potential exposure area: English sole may forage throughout the LDW assessment scale: LDW-wide	tissue-based TRVs for chemicals evaluated using a critical tissue-residue approach	chemical concentrations in English sole tissue collected from four tissue sampling areas located throughout the LDW
			dietary-based TRVs for chemicals evaluated using a dietary approach	chemical concentrations in English sole prey and sediment collected throughout the LDW
Pacific staghorn sculpin	survival, growth, reproduction	potential exposure area: sculpin may forage throughout the LDW or small segments of LDW assessment scale: LDW-wide and four modeling areas	tissue-based TRVs for chemicals evaluated using a critical tissue-residue approach	chemical concentrations in sculpin tissue collected from four tissue sampling areas located throughout the LDW
			dietary-based TRVs for chemicals evaluated using a dietary approach	chemical concentrations in sculpin prey and sediment collected throughout the LDW and divided into four modeling areas

ROC	Assessment Endpoint	Assessment Scale	Measures of Effect	Measures of Exposure
Wildlife				
Great blue heron	survival, growth, reproduction	potential exposure area: herons may forage in areas of shallow water depths throughout the LDW assessment scale: LDW-wide intertidal	dietary-based TRVs for birds	chemical concentrations in heron prey collected throughout the LDW and in sediment collected from intertidal habitats throughout the LDW
Osprey	survival, growth, reproduction	potential exposure area: osprey may forage from the top meter of water throughout the LDW assessment scale: LDW-wide	dietary-based TRVs for birds	chemical concentrations in osprey prey collected throughout the LDW and in sediment collected from intertidal habitats throughout the LDW
Spotted sandpiper	survival, growth, reproduction	potential exposure area: sandpipers predominantly forage within small home range segments of the LDW assessment scale: three intertidal modeling areas	dietary-based TRVs for birds	chemical concentrations in sandpiper prey and sediment collected from intertidal habitats throughout the LDW
River otter	survival, growth, reproduction	potential exposure area: river otters may forage throughout the LDW assessment scale: LDW-wide	dietary-based TRVs for mammals	chemical concentrations in river otter prey and sediment collected throughout the LDW
Harbor seal	survival, growth, reproduction	potential exposure area: harbor seals may forage throughout the LDW assessment scale: LDW-wide	dietary-based TRVs for mammals	chemical concentrations in harbor seal prey and sediment collected throughout the LDW

[a] A DMMP SL guideline is available for TBT; however, this guideline was not used in this ERA because it is based on an interstitial water concentration. TBT was included as a COPC based on the results of the Phase 1 ERA (Windward 2003b); the potential for adverse effects associated with exposure to TBT was evaluated using benthic invertebrate tissue data consistent with EPA (1999b) and Meador et al. (2002), and through a direct assessment of effects (i.e., imposex in gastropods collected from the LDW).

DMMP – Dredged Material Management Program
COPC – chemical of potential concern
ERA – ecological risk assessment
LDW – Lower Duwamish Waterway
ROC – receptor of concern
SMS – Washington State Sediment Management Standards
SL – screening level
TBT – tributyltin
TRV – toxicity reference value
VOC – volatile organic compound

5.2 BENTHIC INVERTEBRATE ASSESSMENT

This section presents an overview of the risk assessment for the benthic invertebrate community and crabs. The complete assessment is presented in Appendix A, Sections A.3 and A.6.1.

5.2.1 Exposure and effects assessment

This section presents the exposure and effects assessment for benthic invertebrates. The following approaches were used in the assessment for the benthic invertebrate community and crabs:

- Risks to the benthic invertebrate community were evaluated by comparing surface sediment chemical concentrations and site-specific sediment toxicity test results to the SMS; when these were not available, DMMP guidelines and toxicity reference values (TRVs) were used.
- Risks to the benthic invertebrate community from VOC exposure were evaluated by comparing VOC concentrations in porewater[114] to TRVs from the scientific literature.
- Risks to the benthic invertebrate community from TBT exposure were evaluated using results from a site-specific imposex study with gastropods and by comparing TBT concentrations in LDW benthic invertebrate tissue to TRVs from the scientific literature.
- Risks to crabs were evaluated by comparing COPC concentrations in LDW crab tissue to TRVs from the scientific literature.

Each of these approaches is described in the following sections.

5.2.1.1 Sediment data and toxicity test results

The exposure assessment for the benthic invertebrate community summarized the available surface sediment chemistry data for each COPC. The potential for effects on the benthic invertebrate community was assessed by comparing the COPC concentrations in LDW surface sediment to SQS and CSLs of the SMS (WAC 173-204). These numerical chemical criteria are based on apparent effects thresholds (AETs) developed for four different benthic endpoints by the Puget Sound Estuary Program (PSEP) (Barrick et al. 1988). An AET is the highest "no effect" chemical-specific sediment concentration above which a significant adverse biological effect always occurred among the several hundred samples used in its derivation. In general, the lowest of the four AETs for each chemical was identified as the SQS; the second lowest AET was identified as the CSL. According to the SMS (WAC 173-204), locations with all

[114] Seep water data were not evaluated in the benthic invertebrate risk assessment; however, seep water data and a comparison to Washington State water quality standards are presented in Section 4.2.

chemical concentrations less than or equal to the SQS are defined as having no acute or chronic adverse effects on biological resources, locations with any chemical concentrations between the SQS and CSL are defined as having minor adverse effects, and locations with any chemical concentration greater than the CSL are defined as having more pronounced adverse effects.

Three COPCs identified during the screening process did not have SMS criteria: nickel, total DDTs, and total chlordane. TRVs for nickel were based on toxicologically based DMMP guidelines for nickel. Because the DMMP guidelines for total DDTs and total chlordane were not toxicologically based, TRVs for these COPCs were selected from the scientific literature.

The effects assessment for the benthic invertebrate community also included the results of site-specific toxicity tests conducted using LDW sediment samples during the RI. Three toxicity tests were conducted with surface sediments (0 to 10 cm) collected at each of 48 locations (Windward 2005c, d). Locations were selected for toxicity testing if one or more chemicals exceeded SMS at that location; the suite of locations selected for testing was selected in consultation with EPA and Ecology. The toxicity tests included:

- Acute 10-day amphipod (*Eohaustorius estuarius*) survival test
- Acute 48-hr bivalve larvae (*Mytilus galloprovincialis*) normal survival test
- Chronic 20-day juvenile polychaete (*Neanthes arenaceodentata*) survival and growth test

Biological responses in these tests were evaluated with respect to the biological criteria from the SMS. In addition to the toxicity tests conducted as part of the RI, the effects assessment included results from toxicity tests conducted by King County on sediment samples collected from seven locations at the Duwamish/Diagonal CSO/SD site.

5.2.1.2 VOCs in porewater

Cis-1,2-dichloroethene was the only VOC with a maximum detected concentration in porewater greater than the no-observed-effect concentration (NOEC) in the problem formulation, and thus was the only COPC identified in porewater for the benthic invertebrate community. The concentrations of cis-1,2-dichloroethene detected in porewater at the two sites sampled as part of the RI (GWI and Boeing Plant 2/Jorgensen Forge) were reported in the exposure assessment. The effects assessment identified the NOEC and lowest-observed-effect concentration (LOEC) that were selected for cis-1,2-dichloroethene in water, based on a review of the scientific literature.

5.2.1.3 TBT

The exposure assessment for the benthic invertebrate community for TBT included the results of the co-located benthic invertebrate tissue and sediment samples collected and analyzed as part of the RI from 20 locations throughout the LDW. There was a significant non-linear regression relationship between the TBT concentrations in benthic invertebrate tissue and co-located sediment samples. This relationship was used to

estimate the maximum TBT concentration in benthic invertebrates tissue. TBT exposure concentrations included both the maximum concentration estimated from the regression and the maximum detected TBT concentration in benthic invertebrates tissue.

The effects assessment identified the NOAEL and LOAEL for TBT in tissue from the scientific literature. The effects assessment also discussed the results of a site-specific evaluation of imposex (a condition known to be associated with exposure to TBT) in gastropods collected from the LDW. Imposex analysis was performed on multiple individuals of three neogastropod species (*Nassarius mendicus, Astyris gausapata*, and *Olivella baetica)* and on a few individuals (two to five) of four mesogastropod species (*Natica* sp., *Polinices* sp., *L. vincta*, and *Melanella* sp.). Signs of imposex (Stage 2 and maximum relative penis size [RPS] index of 3.4) were observed in *N. mendicus,* but no signs of imposex were observed in the other gastropod species. Stage 2 imposex is not considered to adversely affect the ability of gastropods to reproduce.

5.2.1.4 Crab tissue residue

The exposure assessment for crabs presented UCL concentrations of the two COPCs (zinc and total PCBs) in crab tissue from the LDW. The effects assessment for crab identified NOAELs and LOAELs for zinc and total PCBs in tissue, based on a review of the scientific literature.

5.2.2 Risk characterization and uncertainty analysis

The exposure and effects data for the benthic invertebrate community and for crabs were evaluated in the risk characterization to estimate the potential for adverse effects. The ERA also evaluated uncertainties associated with these risk estimates.

5.2.2.1 Sediment data and toxicity test results

The SQS and CSL were exceeded by 39 chemicals at one or more locations; 2 additional chemicals exceeded the SQS only (Table 5-6). Total DDTs, nickel, and total chlordane also exceeded their DMMP guidelines or literature-based TRVs at one or more locations. Total PCBs and BEHP were the chemicals with the highest number of detected concentrations exceeding both the SQS and CSL criteria.

Table 5-6. Benthic invertebrate community COPCs with detected concentrations in LDW surface sediments greater than SMS criteria, DMMP guidelines, or TRVs

COPC	Number of Detected Concentrations > SQS and ≤ CSL	Number of Detected Concentrations > CSL
Total PCBs	301	173
BEHP	48	58
Mercury	14	23
Lead	2	19

COPC	Number of Detected Concentrations > SQS and ≤ CSL	Number of Detected Concentrations > CSL
Zinc	26	16
Total chlordane[a]	19	14
Copper	0	12
Cadmium	2	11
Silver	0	10
Fluoranthene	31	8
BBP	69	8
Indeno(1,2,3-cd)pyrene	15	8
Chromium	1	8
Arsenic	5	8
Phenol	18	7
Benzo(g,h,i)perylene	9	7
Benzoic acid	0	7
Dibenzo(a,h)anthracene	15	4
Nickel[b]	9	4
Total benzofluoranthenes	5	4
4-Methylphenol	0	4
Phenanthrene	24	3
Total HPAH	21	3
Acenaphthene	16	3
Fluorene	11	3
Benzo(a)anthracene	9	3
Dibenzofuran	7	3
Benzo(a)pyrene	5	3
Total LPAH	3	3
Pyrene	1	3
1,4-Dichlorobenzene	0	3
1,2-Dichlorobenzene	0	3
2-Methylnaphthalene	0	3
Dimethyl phthalate	0	2
Naphthalene	0	2
n-Nitrosodiphenylamine	0	2
Hexachlorobenzene	4	2
Benzyl alcohol	2	2
Chrysene	23	1
Total DDTs[a]	1	1
1,2,4-Trichlorobenzene	0	1

COPC	Number of Detected Concentrations > SQS and ≤ CSL	Number of Detected Concentrations > CSL
2,4-Dimethylphenol	0	1
Anthracene	2	0
Pentachlorophenol	1	0

[a] SMS criteria do not exist for these chemicals; the number of exceedances was based on a comparison of sediment chemical concentrations to a TRV.

[b] SMS criteria do not exist for nickel. The DMMP SL and ML values were used for the comparison.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
COPC – chemical of potential concern
CSL – cleanup screening level
DMMP – Dredged Material Management Program
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
ML – maximum level
PCB – polychlorinated biphenyl
SL – screening level
SMS – Washington State Sediment Management Standards
SQS – sediment quality standard
TRV – toxicity reference value

The SMS criteria for biological effects were applied to interpret results of site-specific sediment toxicity tests: 18 of the 48 sediment samples (37.5%) did not exceed the SQS biological effects criteria, 11 sediment samples (22.9%) exceeded the SQS biological effects criteria but not the CSL biological effects criteria, and 19 samples (39.6%) exceeded the CSL biological effects criteria. Locations tested and results are shown on Maps 4-14a through 4-14f; results are also presented in Table 4-16. Because these tests are direct measures of effects at a particular location, the uncertainty in their interpretation was considered to be low at the specific locations tested compared with locations with chemistry data but no site-specific toxicity data. The potential for adverse effects was considered to be uncertain at locations where no detected chemicals exceeded the chemical criteria, guidelines, or TRVs but RLs were greater than criteria and guidelines. RLs were greater than criteria for some chemicals because the sample was diluted or because analysis of the chemical posed analytical challenges in the laboratory.

Thiessen polygons were used to estimate the areal extent of potential effects based on combined toxicity test results and surface sediment chemistry data (see Map 4-16). Using this approach, no adverse effects to benthic invertebrates living in intertidal and subtidal sediments were estimated for 75% of the LDW area (i.e., the area in which chemical concentrations were less than or equal to chemical SQS criteria and where sediments were nontoxic according to biological SQS criteria). There was a higher likelihood for adverse effects in approximately 7% of the LDW area, which was designated as having chemical concentrations or biological effects in excess of CSL criteria. The remaining 18% of the LDW area had chemical concentrations or biological effects between the SQS and CSL criteria, indicating that risks to benthic invertebrate communities were considered to be less certain in these areas than in areas with concentrations greater than one or more CSL values. Some uncertainty was associated with these area estimates because areas were estimated by interpolating from individual points at which sediments were sampled.

5.2.2.2 VOCs in porewater

Risks to the benthic invertebrate community from exposure to cis-1,2-dichloroethene were estimated by calculating HQs as the ratio of the concentration in porewater to the NOEC and LOEC concentrations. LOEC-based HQs were less than 1.0 at all locations where cis-1,2-dichloroethene was detected in porewater. At two locations at the GWI site, NOEC-based HQs were greater than 1.0 (4.9 and 21); NOEC-based HQs were less than 1.0 at all other locations. These results indicate it is uncertain whether exposure to cis-1,2-dichloroethene within this small area of the LDW is sufficiently high to result in adverse effects. The limited amount of relevant toxicity data available in the literature was identified as a primary uncertainty in the risk characterization for benthic invertebrates exposed to VOCs in porewater.

5.2.2.3 TBT

Risks to the benthic invertebrate community from exposure to TBT were estimated by calculating HQs as the ratio of the TBT concentration in benthic invertebrate tissue collected from the LDW to the selected NOAEL and LOAEL for benthic invertebrate tissue. Risks to benthic invertebrates from TBT were considered to be very low based on NOAEL-based HQs of less than 1.0. The largest source of uncertainty associated with the critical tissue-residue evaluation of risk to benthic invertebrates was the TRV value. The selected TRV was based on the response of a single species, the polychaete *Armandia brevis,* in a spiked sediment bioassay.

Risks to the benthic invertebrate community from TBT exposure were also considered to be low based on the absence of imposex in all gastropods, except one neogastropod species with imposex characterized as Stage 2, a stage that is not expected to impact reproduction.[115] There was uncertainty in the imposex assessment because: 1) neo- and mesogastropod species may already have been affected by TBT and therefore were no longer present in the LDW, and 2) relatively low numbers of gastropods were collected in the LDW.

5.2.2.4 Crab tissue-residue

Risks to crabs from exposure to total PCBs and zinc were estimated by calculating HQs as the ratio of the COPC concentrations in LDW crab tissue to the selected NOAELs and LOAELs for crab tissue. Total PCB concentrations in crab tissue were equal to the lowest concentrations associated with adverse effects in crabs, indicating the potential for adverse effects (Table 5-7). Zinc concentrations in crab tissue were greater than concentrations associated with no effects but less than those associated with adverse effects, indicating that there is uncertainty as to whether exposure within the LDW

[115] Imposex is the presence of male reproductive organs in female gastropods, including a penis and vas deferens (a sperm-carrying duct). Imposex was classified according to stages as defined by Oehlmann et al. (1991): Stages 1 through 3 associated with early effects, Stage 4 associated with transitional effects, and Stages 5 and 6 associated with complete sterilization.

would result in adverse effects. The primary uncertainty in the crab risk characterization was the limited number of tissue-based TRVs for total PCBs and zinc available in the literature.

Table 5-7. HQs for crabs using a critical tissue-residue approach

COPC	NOAEL-BASED HQ	LOAEL-BASED HQ
Total PCBs	**10**	**1.0**
Zinc	**2.5**	0.91

COPC – chemical of potential concern
HQ – hazard quotient
LOAEL – low-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
Bold identifies NOAEL-based HQs greater than 1.0 or LOAEL-based HQs greater than or equal to 1.0.

Risks to crabs from exposure to total DDTs and methoxychlor were evaluated in the uncertainty section because of the uncertainty associated with JN-qualified tissue organochlorine pesticide data. These data were considered to be highly uncertain because of analytical interference from PCBs, likely resulting in overestimates of organochlorine pesticide concentrations. The LOAEL-based HQs were less than 1.0 for both methoxychlor and total DDTs. The NOAEL-based HQ was 3.6 for methoxychlor and equal to 1.0 for total DDTs. The TRVs were based on a survival endpoint following acute exposures. Overall, risks to crabs from these pesticides are uncertain.

5.3 FISH ASSESSMENT

This section presents an overview of the risk assessment for fish. The complete assessment is presented in Appendix A, Sections A.4 and A.6.2. Three ROCs were selected in the problem formulation to represent fish that use the LDW and may be exposed to sediment-associated chemicals. The three ROCs and COPCs identified for those species were as follows:

- Juvenile chinook salmon—arsenic, cadmium, copper, and vanadium
- English sole—arsenic, cadmium, copper, vanadium, and PCBs
- Pacific staghorn sculpin—arsenic, cadmium, copper, vanadium, TBT, and PCBs

Risks to fish were evaluated using two approaches, depending on the COPC. For TBT and PCBs, concentrations in LDW fish tissue were compared with concentrations in fish tissue associated with adverse effects. For arsenic, cadmium, copper, and vanadium, concentrations in the diet of LDW fish were compared with concentrations associated with adverse effects. A dietary approach was used for these metals because they are metabolically regulated by fish.

5.3.1 Exposure and effects assessment

Estimated concentrations of arsenic, cadmium, copper, and vanadium in fish diets were presented in the exposure assessment for all three fish ROCs. Dietary concentrations of cadmium, copper, and vanadium were estimated using UCL concentrations of COPCs in prey tissue (i.e., benthic invertebrates for all three ROCs plus shiner surfperch for Pacific staghorn sculpin) and incidentally ingested sediment. For arsenic, the linear regression relationship between benthic invertebrate tissue and co-located sediment was used to estimate the arsenic concentration in benthic invertebrate tissue; the UCL of this estimated concentration in tissue was used as the exposure concentration for estimating risk. For juvenile chinook salmon, dietary concentrations were also estimated based on chemical analysis of stomach contents of juvenile chinook salmon collected from the LDW.

To evaluate risk using a tissue-residue approach, the exposure assessment presented the UCL concentration of total PCBs in English sole tissue and total PCBs and TBT in Pacific staghorn sculpin tissue analyzed in whole-body tissue samples collected from the LDW.

For Pacific staghorn sculpin, exposure was evaluated for two foraging scenarios because the foraging range for this species is unknown and may be smaller than the entire LDW. The two scenarios were: 1) foraging throughout the LDW, and 2) foraging in smaller segments of the LDW corresponding to food web modeling areas M1, M2, M3, and M4 (Map 5-1). For English sole, data from the entire LDW was combined to estimate the exposure concentrations.

In the effects assessment, toxicological studies from the scientific literature reporting dietary and fish tissue concentrations associated with potential adverse effects on growth, survival, and reproduction of fish were used to derive NOAELs and LOAELs. As discussed above, studies reporting reproductive endpoints were not used for deriving juvenile chinook salmon TRVs.

5.3.2 Risk characterization and uncertainty analysis

The exposure and effects data were compared in the risk characterization to assess the potential for sediment-associated COPCs to cause adverse effects to juvenile chinook salmon, English sole, and Pacific staghorn sculpin, as discussed in the following subsections.

5.3.2.1 Juvenile chinook salmon

In the risk characterization for juvenile chinook salmon, HQs were calculated as the ratio of the COPC concentrations in the diet (based on either benthic invertebrate data or juvenile chinook stomach content data) to the dietary NOAELs and LOAELs for arsenic, cadmium, copper, and vanadium. Dietary exposure estimates based on benthic invertebrate tissue data from the LDW resulted in higher HQs for all COPCs than did juvenile chinook salmon stomach content data.

No COPC had a LOAEL-based HQ that exceeded 1.0 (Table 5-8). The cadmium LOAEL-based HQs were 1.0 and 0.92 based on concentrations in benthic invertebrates collected from the LDW and in stomach contents, respectively. These HQs are uncertain because the cadmium TRVs were based on juvenile rockfish.

Table 5-8. Summary of risk characterization for juvenile chinook salmon

COPC	HIGHEST NOAEL-BASED HQ[a]	HIGHEST LOAEL-BASED HQ[a]
Arsenic	**1.1**	0.73
Cadmium	**5.0**	**1.0**
Copper	**1.9**	0.93
Vanadium	**4.0**	0.79

[a] Dietary exposure based on benthic invertebrate tissue data resulted in higher HQs for all COPCs than did juvenile chinook salmon stomach content data. Thus, the HQs presented in this table are based on benthic invertebrate tissue data.

COPC – chemical of potential concern
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
Bold identifies NOAEL-based HQs greater than 1.0 and LOAEL-based HQs greater than or equal to 1.0.

NOAEL-based HQs for arsenic, copper, and vanadium were greater than 1.0, whereas LOAEL-based HQs for these COPCs were less than 1.0. Therefore, risks from these COPCs were low and uncertain. The vanadium HQ is based on a NOAEL TRV extrapolated from the only available TRV, which was an unbounded LOAEL. Therefore, risks from vanadium are uncertain and could be higher or lower than the HQs indicate.

An evaluation of risks to juvenile chinook salmon from exposure to endrin was presented in the uncertainty section because of PCB interference in the organochlorine pesticide analyses and resulting uncertainty in the chemistry data. The NOAEL- and LOAEL-based HQs were 3.7 and 0.37, respectively, indicating a low risk with some uncertainty. The HQs are uncertain because: 1) the selected TRVs were based on survival and may have underestimated the potential for sublethal effects, and 2) analytical interference from PCBs was likely to have overestimated actual organochlorine pesticide concentrations in LDW tissue samples.

Risk from chromium was evaluated in the uncertainty section because a LOAEL TRV was not identified. The NOAEL-based HQ was 2.1 based on benthic invertebrate tissue data and 0.18 based on stomach contents data, indicating low risk with some uncertainty.

A number of uncertainties were evaluated in addition to uncertainties in the TRVs discussed above. In the exposure section, there were uncertainties associated with ROC selection, assessment endpoints, foraging habitat, dietary composition, water exposure

to PAHs and metals, benthic invertebrate tissue data, and future habitat changes resulting from restoration. Risks to juvenile chinook salmon from exposure to vanadium would be slightly higher if juvenile chinook salmon were assumed to forage throughout the LDW rather than in intertidal areas only. It is not known if juvenile chinook salmon forage in deeper waters, such as the navigation channel, of the LDW, but it is generally considered less likely. In the effects assessment, there were uncertainties associated with exclusion of field studies in TRV selection and interpretation of regional studies.

5.3.2.2 English sole

In the risk characterization for English sole, HQs were calculated as the ratio of the COPC concentrations in the diet to the dietary NOAELs and LOAELs for arsenic, cadmium, copper, and vanadium. For the critical tissue-residue approach, HQs were calculated as the ratio of the total PCB concentration in English sole tissue to the tissue-based NOAEL and LOAEL TRVs.

Dietary concentrations for two of the six COPCs for fish (cadmium and vanadium) were greater than concentrations associated with adverse effects for English sole (LOAEL-based HQs for cadmium and vanadium were both 1.2); therefore, there is a potential for adverse effects (Table 5-9). Effects data for cadmium were highly variable, and there was uncertainty associated with the selected TRV because effects were partially attributed to reduced feeding. Thus, risks from cadmium were low but uncertain. The vanadium LOAEL-based HQ was based on an unbounded LOAEL reported in the only dietary toxicity study identified. The NOAEL TRV was estimated from the unbounded LOAEL TRV using a safety factor of 5. Because of the very limited effects data, risk from vanadium was uncertain and could have been higher or lower than the HQs indicated.

Table 5-9. Summary of risk characterization for English sole

APPROACH	COPC	NOAEL-BASED HQ	LOAEL-BASED HQ
Tissue residue	total PCBs	**4.9 – 25**[a]	0.98 – **5.0**[a]
Dietary	arsenic	**1.2**	0.80
	cadmium	**6.1**	**1.2**
	copper	**1.9**	0.93
	vanadium	**5.9**	**1.2**

[a] Because of uncertainty in the LOAEL, LOAEL-based HQs were calculated from a range of effects concentrations reported in Hugla and Thome (1999). The NOAEL TRV range was estimated by dividing the LOAEL TRV range by an uncertainty factor of 5.

COPC – chemical of potential concern
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
Bold identifies NOAEL-based HQs greater than 1.0 and LOAEL-based HQs greater than or equal to 1.0.

For PCBs, the LOAEL-based HQs ranged from 0.98 to 5.0 based on toxicity information presented in one study reporting the lowest TRVs (Hugla and Thome 1999). A NOAEL was not available from this study, and no NOAELs were reported for any other study below the selected LOAEL range. There is uncertainty in the risk estimates because of uncertainties with the study reporting the lowest TRVs. If the study reporting the next higher LOAEL TRV had been selected, exposures would have been below the effects thresholds (LOAEL-based HQ of 0.28). Risks were also estimated from PCB congener concentrations in English sole tissue using a TEQ approach; those risks were determined to be very low. TEQs were calculated using only the dioxin-like PCB congeners because dioxin and furan tissue data were not available. Thus, exposure associated with dioxin-like chemicals was likely underestimated, although it is uncertain whether the inclusion of dioxins and furan exposure would have changed the risk conclusions.

Estimated dietary exposures of English sole to two additional COPCs (arsenic and copper) were greater than their respective no-effects levels but lower than the adverse effect levels associated with survival, growth, or reproduction, indicating that there is uncertainty as to whether exposure to these metals within the LDW is sufficiently high to result in adverse effects.

An evaluation of risks to English sole from exposure to endosulfan and endrin was presented in the uncertainty section because of PCB interference in the organochlorine pesticide analyses. The LOAEL-based HQs were less than 1.0 for endosulfan and 1.2 for endrin. These HQs are uncertain because: 1) the selected TRVs were based on survival and may have underestimated the potential for sublethal effects, and 2) analytical interference from PCBs is likely to have overestimated actual organochlorine pesticide concentrations in LDW tissue samples.

LOAEL TRVs were not available for chromium and benzoic acid, so risks from these chemicals were evaluated in the uncertainty analysis. Comparison of dietary exposure concentrations to NOAEL TRVs resulted in NOAEL-based HQs of 1.1 and 1.5, respectively, for chromium and benzoic acid, indicating low risk with some uncertainty.

Regional studies, which included samples collected from the LDW, indicated an increased risk of adverse effects on English sole reproduction in the LDW. Potential causal factors included PAHs and PCBs; however, these effects cannot be conclusively associated with exposure to specific chemicals or chemical mixtures in the LDW because, among other factors, of the complex mixtures of chemicals in the field and uncertainties in the English sole home range.

A number of uncertainties were evaluated in addition to uncertainties in the TRVs and additional chemicals discussed above. Uncertainties associated with ROC selection, incidental sediment ingestion, dietary composition, foraging range, water exposure to PAHs and metals, benthic invertebrate tissue data, and future habitat changes resulting from restoration were not expected to have an effect on risk conclusions. Uncertainties associated with the use of field studies were also discussed.

5.3.2.3 Pacific staghorn sculpin

In the risk characterization for Pacific staghorn sculpin, HQs were calculated as the ratio of the COPC concentrations in the diet to the dietary NOAELs and LOAELs for arsenic, cadmium, copper, and vanadium. For the critical tissue-residue approach, HQs were calculated as the ratio of the total PCB or TBT concentrations in Pacific staghorn sculpin tissue to the tissue-based NOAEL and LOAEL TRVs.

Both the NOAEL- and LOAEL-based HQs were greater than 1.0 for vanadium in modeling areas M2 and M3 (NOAEL- and LOAEL-based HQs of 1.2 and 5.9, respectively, in both areas) (Table 5-10). In modeling areas M1 and M4 and LDW-wide, NOAEL-based HQs were greater than 1.0, but LOAEL-based HQs were less than or equal to 1.0. As discussed above for English sole, because of the limited amount of effects data available, risks from vanadium were uncertain and could have been higher or lower than the HQs indicated.

Table 5-10. Summary of risk characterization for Pacific staghorn sculpin

Approach	COPC	Foraging Assumption	NOAEL-Based HQ or Range of HQs[a]	LOAEL-Based HQ or Range of HQs[a]
Tissue residue	total PCBs	LDW-wide	**2 – 11**[b]	0.42 – **2.1**[b]
		modeling areas	**1.5** – **19**	0.30 – **3.8**
	TBT	LDW-wide	**2.0**	0.23
		modeling areas	**1.6 – 2.9**	0.18 – 0.33
Dietary	arsenic	LDW-wide	0.75	0.50
		modeling areas	0.60 – 0.80	0.40 – 0.53
	cadmium	LDW-wide	**3.8**	0.76
		modeling areas	**3.0 – 5.2**	0.60 – **1.0**
	copper	LDW-wide	**1.1**	0.56
		modeling areas	0.90 – **1.5**	0.45 – 0.77
	vanadium	LDW-wide	**4.0**	0.79
		modeling areas	**3.2 – 5.9**	0.65 – **1.2**

[a] Range of HQs for the four modeling areas evaluated for Pacific staghorn sculpin.

[b] Because of uncertainty in the LOAEL, LOAEL-based HQs were calculated from a range of effects concentrations reported in Hugla and Thome (1999). The NOAEL TRV range was estimated by dividing the LOAEL TRV range by an uncertainty factor of 5.

COPC – chemical of potential concern
HQ – hazard quotient
LDW – Lower Duwamish Waterway
LOAEL – lowest-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
TBT – tributyltin
TRV – toxicity reference value

Bold identifies NOAEL-based HQs greater than 1.0 and LOAEL-based HQs greater than or equal to 1.0.

For PCBs, the LOAEL-based HQs ranged from 0.30 to 3.8 based on toxicity information presented in one study reporting the lowest TRVs (Hugla and Thome 1999) and exposure data from discrete areas in the LDW as well as LDW-wide. A NOAEL was not available from Hugla and Thome (1999), and no NOAELs below the selected LOAEL

range were reported for any other study. There is uncertainty in the risk estimates because of uncertainties with the study reporting the lowest TRVs. If the study reporting the next higher LOAEL TRV had been selected, the LOAEL-based HQ would have been 0.12 for LDW-wide exposure instead of ranging from 0.42 to 2.1.

The LOAEL-based HQ for cadmium was equal to 1.0 in modeling area M3 but lower than 1.0 in all other modeling areas and LDW-wide. As discussed above for English sole, there was some uncertainty associated with the selected cadmium TRV because effects were partially attributed to reduced feeding. In addition, data used to represent crabs in Pacific staghorn sculpin dietary exposure calculations were uncertain; the LOAEL-based HQ for cadmium would have been 1.9 if crab data had been used instead of benthic invertebrate data. LOAEL-based HQs were less than 1.0 for TBT and copper. NOAEL-based HQs for TBT and copper were greater than 1.0 LDW-wide and in one or more modeling areas, indicating that the potential for adverse effects was low but uncertain.

An evaluation of risks to Pacific staghorn sculpin from exposure to endosulfan and endrin was presented in the uncertainty section because the presence of PCBs interfered in the organochlorine pesticide analyses. This evaluation indicated a low risk from endosulfan and the potential for adverse effects from endrin (LOAEL-based HQ of 3.1). These HQs were uncertain because: 1) the selected TRVs were based on survival and may have underestimated the potential for sublethal effects, and 2) analytical interference from PCBs is likely to have overestimated actual organochlorine pesticide concentrations in LDW tissue samples.

LOAEL TRVs were not available for chromium and benzoic acid, so risks from these chemicals were evaluated in the uncertainty analysis. Comparison of dietary exposure concentrations to NOAEL TRVs resulted in NOAEL-based HQs of 0.85 and 2.1, respectively, for chromium and benzoic acid, indicating low risk with some uncertainty.

A number of uncertainties were evaluated in addition to uncertainties in the TRVs discussed above. Uncertainties associated with the COPC screen, ROC selection, water exposure to PAHs and metals, PCB analysis approach (total PCBs versus PCB TEQ), and future habitat changes resulting from restoration were not expected to have an effect on risk conclusions.

In the uncertainty analysis, uncertainty associated with the benthic invertebrate portion of Pacific staghorn sculpin diet was evaluated. Use of large crab tissue data versus benthic invertebrate tissue samples (which included crabs and shrimps < 20 mm) resulted in slight changes in LOAEL-based HQs for cadmium, copper, and vanadium. For arsenic, no HQs changed from less than 1.0 to greater than 1.0 or vice versa, based on this data substitution.

5.4 WILDLIFE ASSESSMENT

This section presents an overview of the risk assessment for wildlife. The complete assessment is presented in Appendix A, Sections A.5 and A.6.3. Five ROCs were selected in the problem formulation to represent wildlife that use the LDW and may be exposed to sediment-associated chemicals. The five ROCs and associated COPCs were:

- Spotted sandpiper – arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, vanadium, zinc, and PCBs
- Great blue heron – chromium, lead, mercury, and PCBs
- Osprey – arsenic, chromium, lead, mercury, and PCBs
- River otter – arsenic, cobalt, mercury, selenium, and PCBs
- Harbor seal – mercury and PCBs

Risks to wildlife ROCs were evaluated by comparing estimated COPC concentrations as a dietary dose for each ROC to dietary doses associated with adverse effects from the scientific literature.

5.4.1 Exposure and effects assessment

For wildlife ROCs, the daily exposure doses of COPCs through the ingestion of prey, water, and incidental sediment were estimated in the exposure assessment. Exposure doses were calculated as follows:

$$\text{Exposure dose} = \frac{[(\text{FIR} \times C_{\text{food}}) + (\text{WIR} \times C_{\text{water}}) + (\text{SIR} \times C_{\text{sed}})] \times \text{SUF}}{\text{BW}} \qquad \textbf{Equation 5-1}$$

Where:

Exposure dose	=	COPCs ingested per day via food, water, and sediment (mg COPC/kg body weight/day)
FIR	=	food ingestion rate (kg food dw/day)
C_{food}	=	concentration in prey items (mg COPC/kg food dw)
WIR	=	water ingestion rate (L water/day)
C_{water}	=	concentration in water (mg COPC/L water)
SIR	=	sediment ingestion rate (kg sediment dw/day)
C_{sed}	=	concentration in sediment (mg COPC/kg dw)
SUF	=	site use factor (unitless); fraction of time that a receptor spends foraging in the LDW relative to the entire home range
BW	=	ROC species body weight (kg ww)

Body weights, and food, water, and sediment ingestion rates for each receptor were derived from the literature. Site use factors for great blue heron, osprey, and harbor seal were less than 1.0 because site-specific data showed that in addition to foraging in the LDW, these receptors also foraged outside the LDW. Spotted sandpiper and river otter were assumed to forage only in the LDW. Within the LDW, the foraging areas for all wildlife ROCs except spotted sandpiper, were assumed to be the entire LDW. Spotted

sandpiper foraging areas were identified based on a field survey conducted as part of the RI in 2004 (Windward 2004j). The field survey identified potential nesting and foraging habitat. Assuming a foraging range of about 1 mile from the nesting habitat, three hypothetical exposure areas were created. Within each area, two foraging scenarios were evaluated: one in which spotted sandpipers forage in only high-quality habitat, and another in which they forage in both high- and poor-quality habitats. These two foraging scenarios in each of the three exposure areas resulted in a total of six exposure scenarios for spotted sandpiper (Map 5-2).

Concentrations of COPCs in prey, sediment, and water were calculated as the UCL of the data within the relevant exposure area for each ROC, with a few exceptions. Total PCBs in sediment were calculated as the 95% UCL of the SWAC within relevant exposure areas. A linear regression relationship between benthic invertebrate tissue and co-located sediment was used to estimate UCL on the mean benthic invertebrate tissue concentrations of arsenic and total PCBs in each exposure area.

The effects assessment presented a review of the scientific literature for dietary exposure doses associated with adverse effects on survival, growth, and reproduction in birds and mammals. NOAELs and LOAELs were selected for each COPC based on these toxicity data.

5.4.2 Risk characterization and uncertainty analysis

The exposure and effects data were compared in the risk characterization to assess the potential for sediment-associated COPCs to have adverse effects on the ROCs. For each ROC, HQs were calculated as the ratio of the COPC concentration in the daily exposure dose to the NOAELs and LOAELs. The following sections present the risk conclusions for each wildlife receptor.

5.4.2.1 Spotted sandpiper

The following COPCs had LOAEL-based HQs greater than or equal to 1.0 for spotted sandpiper: chromium, copper, lead, mercury, and vanadium (Table 5-11). LOAEL-based HQs ranged from 1.0 to 5.5 for these COPCs. LOAEL-based HQs were equal to or greater than 1.0 in Exposure Area 2 for chromium (1.8) and lead (5.5), in Exposure Area 3 for copper (1.1) and mercury (1.0), and in all three exposure areas for vanadium (1.0 to 1.4) (see Map 5-2 for exposure areas). Risks to spotted sandpiper from copper and vanadium may be under- or overestimated because the selected TRVs were based on subchronic growth endpoints. The ingested dose was primarily from sediment for copper and lead in Exposure Area 3 and for vanadium in all areas. Bioavailability of metals in sediment is unlikely to be 100%, so the LOAEL-based HQs (ranging from 1.0 to 1.5) for copper, lead, and vanadium may have been overestimated. Overall, these findings indicated risks to spotted sandpiper in some areas of the LDW from exposure to chromium, copper, lead, mercury, and vanadium, but these risks are expected to be low.

Table 5-11. Summary of risk characterization for spotted sandpiper

COPC	RANGE OF NOAEL-BASED HQS[a]	RANGE OF LOAEL-BASED HQS[a]
Arsenic	0.34 – 0.58	< 0.1 – 0.15
Cadmium	< 0.1 – 0.21	< 0.1
Chromium	**1.3** – **8.8**	0.26 – **1.8**
Cobalt	0.22 – 0.27	< 0.1
Copper	0.62 – **1.5**	0.45 – **1.1**
Lead	0.58 – **19**	0.17 – **5.5**
Mercury	**1.1** – **5.3**	0.21 – **1.0**
Nickel	< 0.1 – 0.22	< 0.1– 0.11
Selenium	0.62 – 0.90	0.38 – 0.55
Vanadium	**2.0** – **2.7**	**1.0** – **1.4**
Zinc	0.41 – 0.78	0.27 – 0.52
Total PCBs	0.51 – **2.0**	0.18 – 0.71
PCB TEQs	**1.9** – **10**	0.18 – **1.5**

[a] Range of HQs for the six spotted sandpiper exposure scenarios for each COPC.
COPC – chemical of potential concern
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
Bold identifies NOAEL-based HQs greater than 1.0 and LOAEL-based HQs greater than or equal to 1.0.

For total PCBs, the NOAEL-based HQs were greater than 1.0 in some of the spotted sandpiper exposure areas, but LOAEL-based HQs in all areas were less than 1.0, indicating low risk with some uncertainty because the true threshold of effects between the NOAEL and the LOAEL is not known. For PCB TEQs, the LOAEL-based HQs were less than 1.0, except in Exposure Area 2 under the high-quality foraging habitat scenario, in which the LOAEL-based HQ was 1.5. Uncertainty was considered to be high for PCB TEQ risk estimates because the TRVs were based on a study that used an acute weekly dose via intraperitoneal (IP) injection, and TEFs derived from studies of toxicity to eggs were applied to dietary exposure estimates for adults. Therefore, risks to spotted sandpiper from PCBs were considered to be low in most areas of the LDW, with some uncertainty.

For the remaining COPCs (arsenic, cadmium, cobalt, nickel, selenium, and zinc), all NOAEL- and LOAEL-based HQs were less than 1.0 in all sandpiper exposure areas. Exposure of spotted sandpipers to these COPCs was not expected to result in adverse effects.

An evaluation of risks from exposure to total DDT was conducted in the uncertainty section because of PCB interference in the organochlorine pesticide analyses. The NOAEL-based HQs were greater than 1.0 in some of the spotted sandpiper exposure

areas, but LOAEL-based HQs were less than 1.0, indicating low risk. It is likely that HQs would have been lower if there had been no analytical interferences from PCBs because the interference is known to bias the DDT concentrations high. Therefore, risks to spotted sandpiper from DDT are expected to be very low in most areas of the LDW, with some uncertainty.

A number of additional uncertainties were evaluated in the uncertainty section. Uncertainties in COPC selection, food ingestion rate, direct sediment contact, incidental sediment ingestion, dietary composition, and site use were expected to have minimal or no effect on risk conclusions. Risks were considered to be uncertain for cadmium, cobalt, copper, nickel, vanadium, and zinc because TRVs were based on subchronic exposure and growth endpoints. Uncertainties in toxicity data for chromium, lead, mercury, selenium, and PCBs (based on a total PCB approach) could also have affected risk estimates. Risks could have been underestimated for arsenic because of the lack of arsenite toxicity data.

5.4.2.2 Great blue heron

The NOAEL- and LOAEL-based HQs for great blue heron were all less than 1.0, indicating very low risks to great blue herons were expected from exposure to chromium, lead, mercury, and PCBs in the LDW (Table 5-12). For chromium and for PCB TEQs, there was high uncertainty in the TRVs, but the LOAEL TRVs would have needed to be lower by a factor of 14 for the LOAEL-based HQs to equal 1.0. There was also some uncertainty in the PCB TEQ risk estimate because TEFs derived from studies of toxicity to eggs were applied to dietary exposure estimates for adults.

Table 5-12. Summary of risk characterization for great blue heron

COPC	NOAEL-Based HQ	LOAEL-Based HQ
Chromium	< 0.1	< 0.1
Lead	< 0.1	< 0.1
Mercury	0.17	< 0.1
Total PCBs	0.35	0.12
PCB TEQs	0.66	< 0.1

COPC – chemical of potential concern
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
TEQ – toxic equivalent

Uncertainties in incidental sediment ingestion, dietary composition, and site use were evaluated and expected to have minimal or no effect on risk conclusions. The uncertainty analysis section also evaluated risks from the exposure of great blue heron to total DDTs. The NOAEL-based HQ was less than 1.0, indicating very low risk.

5.4.2.3 Osprey

The NOAEL- and LOAEL-based HQs for osprey for chromium, lead, and mercury were less than 1.0, indicating that there are very low risks to osprey from exposure to these COPCs in the LDW (Table 5-13). There was high uncertainty in the chromium TRV, but the LOAEL TRV would have needed to be lower by a factor of 50 for the LOAEL-based HQ to equal 1.0.

Table 5-13. Summary of risk characterization for osprey

COPC	NOAEL-BASED HQ	LOAEL-BASED HQ
Chromium	0.11	< 0.1
Lead	< 0.1	< 0.1
Mercury	0.28	< 0.1
Total PCBs	0.65	0.23
PCB TEQs	**1.6**	0.16

COPC – chemical of potential concern
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
TEQ – toxic equivalent
Bold identifies NOAEL-based HQs greater than 1.0.

NOAEL- and LOAEL-based HQs for total PCBs were less than 1.0. The LOAEL-based HQ for PCBs using the PCB TEQ approach was less than 1.0, but the NOAEL-based HQ was 1.6, indicating a low risk with uncertainty. There were no PCB congener data for juvenile chinook salmon, one of the three species assumed to be ingested by osprey in this assessment, so the portion of prey ingestion that had been assigned to juvenile chinook salmon (45%) was divided proportionally among shiner surfperch and English sole. Shiner surfperch had higher PCB concentrations than did juvenile chinook salmon, so is it possible that PCB TEQ HQs would have been lower if PCB congener data had been available for juvenile salmon. There was also high uncertainty in the PCB TEQ TRV because: 1) birds in the study were given an acute weekly dose via IP injection rather than via the diet, which may result in an overestimate of exposure and resulting toxicity, and 2) TEFs derived from studies of toxicity to eggs were applied to dietary exposure estimates for adults.

The uncertainty assessment included an estimate of total PCB concentrations in osprey eggs using a biomagnification factor relating total PCB concentrations in fish to concentrations in bird eggs. The comparison of the estimated total PCB concentration in eggs to the LOAEL TRV resulted in an HQ of 1.4. This approach was highly uncertain, resulting in potential over- or underestimates of risk. Thus, for total PCBs, the ingested dose approach with its associated uncertainties indicated that risks to osprey were low,

while risks calculated using estimated concentrations in eggs indicated that risks were low with a high level of uncertainty.

Uncertainties in incidental sediment ingestion and dietary composition were evaluated and expected to have minimal or no effect on risk conclusions. The uncertainty section also evaluated risks from exposure of osprey to total DDTs. The NOAEL-based HQ was less than 1.0, indicating very low risk.

5.4.2.4 River otter

The NOAEL- and LOAEL-based HQs for PCBs of 5.8 and 2.9, respectively, using the total PCB approach, indicated a risk to river otters from PCB exposure (Table 5-14). The PCB TRVs were based on an 18-month study with mink in which reduced growth of offspring was reported. The NOAEL-based HQ of 4.5 using PCB congener data and the PCB TEQ approach indicated that there could be some risk to river otters from PCB exposure, although the LOAEL-based HQ was less than 1.0 using this approach. The PCB TEQ TRVs were based on a 90-day study with guinea pigs in which reduced body weights were reported. There were some uncertainties associated with the PCB TRVs and with the TEF approach, but it was not known whether these uncertainties would result in an under- or overestimate of risk. Therefore, risks to river otter from PCBs were considered to be low, with some uncertainty.

Table 5-14. Summary of risk characterization for river otter

COPC	NOAEL-BASED HQ	LOAEL-BASED HQ
Arsenic	0.12	< 0.1
Cobalt	0.16	< 0.1
Mercury	**2.8**	0.57
Selenium	0.58	0.40
Total PCBs	**5.8**	**2.9**
PCB TEQs	**4.5**	0.59

COPC – chemical of potential concern
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
TEQ – toxic equivalent
Bold identifies NOAEL-based HQs greater than 1.0 and LOAEL-based HQs greater than or equal to 1.0.

For mercury, the LOAEL-based HQ was less than 1.0 (0.57), but the NOAEL-based HQ was greater than 1.0 (2.8). There was some uncertainty in the TRV, which was based on a chronic study of rats resulting in effects on growth, because the NOAEL was estimated from the LOAEL using an uncertainty factor of 5. Therefore, risks to river otter from mercury were considered to be low, with some uncertainty.

The NOAEL- and LOAEL-based HQs for river otter for arsenic, cobalt, and selenium were less than 1.0, indicating very low risks to river otters from exposure to these COPCs in the LDW.

Uncertainties in food and incidental sediment ingestion rates and dietary composition were evaluated and were expected to have minimal or no effect on risk conclusions.

5.4.2.5 Harbor seal

The NOAEL- and LOAEL-based HQs for harbor seal for mercury and PCBs were less than 1.0, indicating very low risk to harbor seals from exposure to these COPCs in the LDW (Table 5-15). Uncertainties in incidental sediment ingestion rates and dietary composition were expected to have minimal or no effect on risk conclusions.

Table 5-15. Summary of risk characterization for harbor seal

COPC	NOAEL-BASED HQ	LOAEL-BASED HQ
Mercury	0.19	< 0.1
Total PCBs	0.44	0.22
PCB TEQs	0.35	< 0.1

COPC – chemical of potential concern
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
TEQ – toxic equivalent

5.5 SUMMARY AND SELECTION OF ECOLOGICAL RISK DRIVERS

In summary, risk estimates for PCBs indicated a potential for adverse effects to the benthic invertebrate community, crabs, spotted sandpiper, and river otter (Table 5-16), and thus, PCBs were identified as a COC. COCs were defined as chemicals with LOAEL-based HQs greater than or equal to 1.0, which indicates a potential for adverse effects. There is a potential for adverse effects to English sole, and Pacific staghorn sculpin; however, the risk estimates for PCBs for these two fish species are uncertain both because the exposure concentrations were in between the concentrations selected as the LOAEL TRV range and because of the uncertainty in the study that served as the basis for the LOAEL TRV range itself. There is also a potential for adverse effects for osprey from PCBs based on the PCB TEQ, which was highly uncertain. Other COCs with exposures greater than or equal to levels associated with adverse effects for at least one fish or wildlife receptor were cadmium, chromium, copper, lead, mercury, and vanadium. Numerous additional chemicals pose a risk to the benthic invertebrate community, as indicated in Table 5-6. No quantitative ecological risk estimates were calculated for dioxins and furans.

Table 5-16. List of chemicals with NOAEL- or LOAEL-based HQs ≥ 1.0

CHEMICAL	ROC	NOAEL-BASED HQ	LOAEL-BASED HQ
COCs with LOAEL-based HQs ≥ 1.0[a]			
Total PCBs	English sole	**4.9 – 25[b]**	**0.98 – 5.0[b]**
	Pacific staghorn sculpin	**3.8 – 19[b]**	**0.76 – 3.8[b]**
	crabs	**10**	**1.0**
	river otter	**5.8**	**2.9**
PCB TEQs	spotted sandpiper	**1.9 – 15**	0.18 – **1.5**
Cadmium	juvenile chinook salmon	**5.0**	**1.0**
	English sole	**6.1**	**1.2**
	Pacific staghorn sculpin	**3.0 – 5.2**	0.60 – **1.0**
Chromium	spotted sandpiper	**1.3 – 8.8**	0.26 – **1.8**
Copper	spotted sandpiper	0.62 – **1.5**	0.45 – **1.1`**
Lead	spotted sandpiper	0.58 – **19**	0.17 – **5.5**
Mercury	spotted sandpiper	**1.1 – 5.3**	0.21 – **1.0**
Vanadium	English sole	**5.9**	**1.2**
	Pacific staghorn sculpin	**3.2 – 5.9**	0.65 **– 1.2**
	spotted sandpiper	**2.0 – 2.7**	**1.0 – 1.4**
COPCs with NOAEL-based HQs ≥ 1.0 and LOAEL-based HQs < 1.0[c]			
Total PCBs	English sole	**1.4**	0.28
	Pacific staghorn sculpin	0.42 – **1.1**	< 0.1 – 0.22
	spotted sandpiper	0.51 – **2.0**	0.18 – 0.71
PCB TEQs	osprey	**1.6**	0.16
	river otter	**4.5**	0.59
Arsenic	juvenile chinook salmon	**1.1**	0.73
	English sole	**1.2**	0.80
	crabs	**3.9**	na
Benzoic acid	English sole	**1.5**	na
	Pacific staghorn sculpin	**2.1**	na
Cadmium	Pacific staghorn sculpin	**3.0 – 4.9**	0.60 – 0.98
Chromium	juvenile chinook salmon	**2.1**	na
	English sole	**1.1**	na

CHEMICAL	ROC	NOAEL-BASED HQ	LOAEL-BASED HQ
Copper	juvenile chinook salmon	**1.9**	0.93
	English sole	**1.9**	0.93
	Pacific staghorn sculpin	0.9 – **1.5**	0.45 – 0.77
Mercury	river otter	**2.8**	0.57
TBT	Pacific staghorn sculpin	**1.6** – **2.9**	0.18 – 0.33
Vanadium	juvenile chinook salmon	**4.0**	0.79
Zinc	crabs	**2.5**	0.91

Note: HQs reported for fish are the highest HQs in cases where more than one approach was used.

[a] The LOAEL-based HQs for endrin were 1.2 and 3.1 for English sole and Pacific staghorn sculpin, respectively, based on risk calculations discussed in the uncertainty analysis. These calculations were discussed only in the uncertainty analysis because of analytical interferences from PCB Aroclors in the organochlorine pesticide analyses, resulting in uncertainties in pesticide identification and a high bias in pesticide concentrations.

[b] LOAEL-based HQs were calculated from a range of effects concentrations reported in Hugla and Thome (1999) because of uncertainty in the LOAEL. The NOAEL TRV range was estimated by dividing the LOAEL TRV range by an uncertainty factor of 5. Ranges reported for Pacific staghorn sculpin also included the range in exposure estimates for areas smaller than the entire LDW.

[c] The NOAEL-based HQs were greater than 1.0 for the following COPC/ROC pairs based on risk calculations discussed in the uncertainty analysis: 1) total DDTs and spotted sandpiper (2.6 to 4.3), 2) endrin and juvenile chinook salmon (3.6), 3) alpha-endosulfan and English sole (6.8) and Pacific staghorn sculpin (2.3), 4) beta-endosulfan and English sole (29) and Pacific staghorn sculpin (6.6), 5) endrin and juvenile chinook salmon (3.6), and 6) methoxychlor and crabs (3.6). These calculations were discussed in the uncertainty analysis because of analytical interferences from PCB Aroclors in the organochlorine pesticide analyses, resulting in uncertainties in pesticide identification and a high bias in pesticide concentrations.

COC – chemical of concern
COPC – chemical of potential concern
HQ – hazard quotient
LOAEL – low-observed-adverse-effect level
na – not available
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
ROC – receptor of concern
TBT – tributyltin
TEQ – toxic equivalent

Bold identifies NOAEL-based HQs greater than 1.0 or LOAEL-based HQs greater than or equal to 1.0.

Chemicals were identified as risk drivers for ecological receptors based on the risk estimates, uncertainties discussed in the ERA (Appendix A), preliminary natural background concentrations, and residual risks following planned early actions in the LDW. The risk drivers from both the ERA and the HHRA will be the focus of remedial analyses in the FS.

In consultation with EPA and Ecology, PCBs were identified as a risk driver for river otter because estimated exposures of river otter were greater than the LOAEL by a factor of 2.9 and uncertainties in the risk estimate were relatively low. In addition, 41 chemicals were selected as risk drivers for benthic invertebrates because detected concentrations of these 41 chemicals exceeded the SQS of the Washington SMS in one or more locations.

Other COCs that exceeded risk thresholds (LOAEL-based HQ greater than or equal to 1.0) were not selected as risk drivers because of high uncertainty in the effects or exposure data, comparisons to preliminary background concentrations, or the

expectation of low residual risk following remediation in EAAs, as discussed in detail in Section 7 of the ERA. COCs that were not selected as risk drivers will be addressed through focused evaluation in the FS. These chemicals may also be considered in remedial design for specific areas in or near the LDW and in the post-remedial monitoring program that is part of the 5-year review that EPA conducts at all Superfund sites where hazardous substances, pollutants, or contaminants remain in place after cleanup is completed.

6 Summary of the Baseline Human Health Risk Assessment

The baseline HHRA estimated risks for people who may be exposed to COPCs present in sediment, water, and aquatic biota in the LDW. The dataset used in the baseline HHRA consisted of historical data used in the Phase 1 HHRA and sediment and tissue chemistry data collected from the LDW as part of the RI, as summarized in Appendix B, Section B.2.1. This section summarizes the exposure assessment (including the conceptual site model and selection of exposure pathways, the screening and evaluation of COPCs, and the selection of exposure parameters), toxicity assessment, risk characterization, uncertainty analysis, and selection of risk drivers for human health. The complete HHRA is included as Appendix B of this RI.

6.1 EXPOSURE ASSESSMENT

This section summarizes the conceptual site model, selection of exposure pathways, screening and evaluation of COPCs, and selection of exposure parameters used in the baseline HHRA.

6.1.1 Conceptual site model and selection of exposure pathways

The conceptual site model developed in the baseline HHRA describes scenarios in which people could be exposed to COPCs associated with sediment in the LDW (Figure 6-1). The primary exposure scenarios were identified through input from site users, including local residents and members of the Muckleshoot and Suquamish Tribes, and through the review of prior risk assessments of the LDW. Exposure pathways consisted of direct contact with sediments during commercial netfishing, beach play, and clam harvesting in the LDW, as well as indirect exposure through consumption of seafood from the LDW. Exposures associated with swimming in the LDW were evaluated through the inclusion of risk estimates developed previously as part of the King County water quality assessment HHRA (1999c).

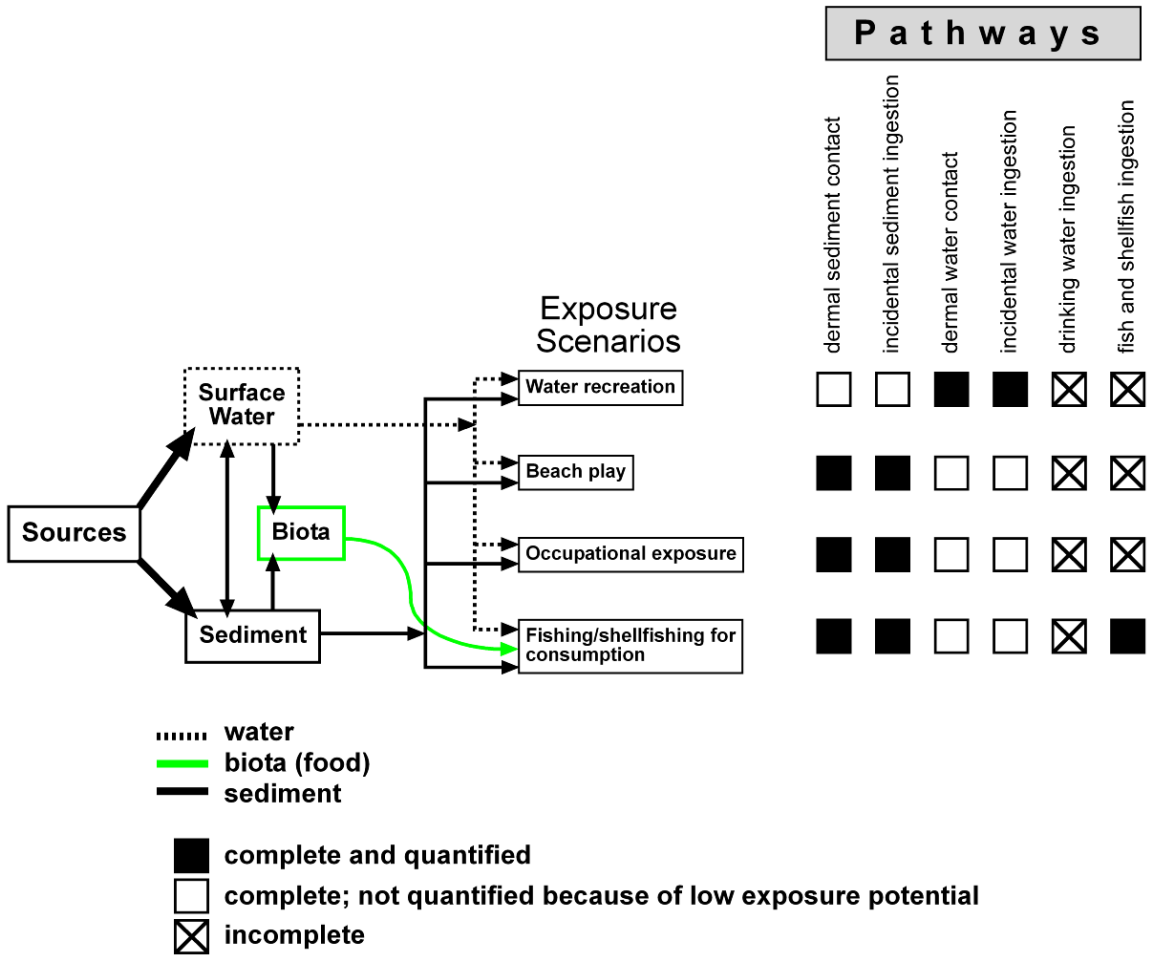


Figure 6-1. Conceptual site model for baseline human health risk assessment

6.1.2 Screening and evaluation of chemicals of potential concern

This section provides a review of the COPC screening process, including the data evaluation.

6.1.2.1 Data evaluation

Sediment chemistry data used in the baseline HHRA consisted of chemical concentrations in the uppermost 15 cm of the sediment (i.e., surface sediment). The dataset included approximately 600 surface sediment samples from intertidal locations and approximately 750 surface sediment samples from subtidal locations in the LDW. The dataset consisted of data collected prior to early removal actions in the LDW in order to reflect baseline conditions. In addition, some chemistry data for tissue and sediment samples from outside the LDW were identified from other datasets or collected as part of the RI for comparison to LDW data.

Tissue data were available for English sole, starry flounder, crabs, clams, mussels, and perch caught within the LDW. Seafood consumption rates applied to these tissue data

were based largely on consumption studies representative of seafood harvest from other areas of Puget Sound. Many of the species that may be consumed from these other areas (e.g., speckled sanddab, Pacific cod, rockfish, spiny dogfish, walleye pollock) are rarely found in the LDW, and no LDW tissue chemistry data were available for those species. Therefore, data from a representative trophic group were used as a surrogate. In addition, although salmon are a highly preferred and consumed fish from the LDW and tissue data were available for salmon, human health risks were not calculated for the consumption of adult salmon. The exposure of juvenile salmon to risk driver chemicals in LDW sediment is not anticipated to significantly influence chemical concentrations in tissues of adult salmon. PCBs in juvenile salmon accumulated during the time they spend in the LDW constitute a small fraction of the PCBs in adult salmon. Most of the PCBs in adult salmon result from foraging activities in Puget Sound or the Pacific Ocean. Consequently, site-related PCB human health risks associated with salmon consumption were not estimated. Although risks from salmon consumption were not included in the baseline HHRA, risks to juvenile salmon were addressed in the ERA (Appendix A).

Sediment and tissues samples were analyzed for numerous chemicals, including metals, SVOCs, organochlorine pesticides, and PCBs. Most organochlorine pesticides in seafood tissues collected in 2004 were qualified as estimated concentrations with uncertain presence. The tissue concentrations used to determine the intake of these chemicals were thus highly uncertain. There is uncertainty as to whether these chemicals were present; however, if present, their concentrations were likely biased high because of PCB interferences. Therefore, organochlorine pesticide data may not accurately represent exposures to these chemicals from seafood consumption within the LDW. Uncertainties in the data used in this assessment are summarized in Section 4.2.10.3 and in Appendix B, Section B.6.1.

6.1.2.2 COPC screening

Using the dataset defined for the baseline HHRA, a risk-based screen was performed following EPA guidance to identify COPCs to be evaluated. Briefly, the maximum concentrations in sediment were screened against risk-based concentrations (RBCs) for soil provided by EPA Region 9 (EPA 2004). The maximum seafood tissue concentrations were screened against EPA Region 3 RBCs (EPA 2005c) for fish tissue, which had been adjusted to account for tribal consumption rates (97.5 g/day) (EPA 2006c) and a lower target HQ of 0.1, as required by EPA Region 10 (EPA 1996). Sixty-four chemicals were identified as COPCs in sediment or tissue for one or more exposure scenarios. Many of these 64 chemicals were identified for more detailed analysis using both seafood consumption and direct sediment exposure scenarios (Table 6-1). Of the 64 COPCs, 6 chemicals were never detected in tissue (but were detected in sediment), and 20 were

never detected in either sediment or tissue.[116] These 26 chemicals were included as COPCs because analytical RLs were above the screening criteria for tissue, sediment, or both. The undetected COPCs were evaluated in the uncertainty analysis: 26 of these COPCs were evaluated for seafood consumptions scenarios, and 5 were evaluated for direct-contact scenarios.

Table 6-1. COPCs identified for direct-contact sediment exposure and seafood consumption scenarios

Chemical	Netfishing Scenarios	Beach Play and Clamming Scenarios	Seafood Consumption Scenarios
Chemicals detected in both tissue and sediment			
Inorganic			
Aluminum[a]	X	X	
Antimony	X	X	X
Arsenic	X	X	X[b]
Barium[a]	X	X	
Cadmium	X	X	X
Chromium	X	X	X
Copper	X	X	X
Iron[a]	X	X	
Lead	X	X	X[c]
Manganese[a]	X	X	
Mercury		X	X
Molybdenum		X	
Nickel			X
Silver		X	
TBT			X
Thallium	X	X	
Vanadium	X	X	X
Zinc		X	X
Organic			
4-methylphenol			X
Aldrin			X
alpha-BHC			X

[116] N-nitroso-di-n-propylamine was not included in the risk characterization but was discussed in the uncertainty analysis despite being detected in one tissue sample. This chemical was never detected in sediment samples, and had high RLs in tissue samples. The detection in tissue was qualified as JN (estimated concentration, tentative identification).

Chemical	Netfishing Scenarios	Beach Play and Clamming Scenarios	Seafood Consumption Scenarios
beta-BHC			X
gamma-BHC			X
BEHP			X
BBP			X
Carbazole			X
cPAHs	X	X	X
Total chlordane			X
Total DDTs		X	X
Dieldrin	X	X	X
Dioxin and furan TEQ[a]	X	X	X[d]
Endrin			X
Endrin aldehyde			X
Heptachlor			X
Heptachlor epoxide			X
Hexachlorobenzene			X
PCB TEQ	X	X	X
Total PCBs	X	X	X
Pentachlorophenol			X
Chemicals detected in sediment, but not detected in tissue			
1,3-Dichlorobenzene			X_{ND}
1,4-Dichlorobenzene			X_{ND}
Aniline[e]			X_{ND}
Hexachlorocyclopentadiene			X_{ND}[e]
n-Nitrosodiphenylamine			X_{ND}
Toxaphene	X	X	X_{ND}
Chemicals not detected in sediment or tissue			
1,2-Diphenylhydrazine			X_{ND}
2,4,6-Trichlorophenol			X_{ND}
2,4-Dichlorophenol			X_{ND}
2,4-Dinitrophenol			X_{ND}
2,4-Dinitrotoluene			X_{ND}
2,6-Dinitrotoluene			X_{ND}
2-Chlorophenol			X_{ND}
3,3'-Dichlorobenzidine			X_{ND}
3-Nitroaniline			X_{ND}
4,6-Dinitro-o-cresol		X_{ND}	X_{ND}

Chemical	Netfishing Scenarios	Beach Play and Clamming Scenarios	Seafood Consumption Scenarios
4-Chloroaniline			X_{ND}
4-Nitroaniline			X_{ND}
Benzidine	X_{ND}	X_{ND}	X_{ND}
Bis(2-chloroethyl)ether		X_{ND}	X_{ND}
Bis(2-chloroisopropyl)ether			X_{ND}
Hexachlorobutadiene			X_{ND}
Hexachloroethane			X_{ND}
Nitrobenzene			X_{ND}
n-Nitrosodimethylamine	X_{ND}	X_{ND}	X_{ND}
n-Nitroso-di-n-propylamine		X_{ND}	X_{ND}[f]

[a] This chemical was not analyzed in tissue.

[b] For the seafood consumption scenarios, the arsenic assessment was based on inorganic arsenic exposure and toxicity data.

[c] No RBC was available for lead. An alternative toxicity evaluation method recommended by EPA was used instead (see Appendix B, Section B.3.4.4, for more information on lead models).

[d] Dioxin and furan TEQ was identified as a COPC in sediment and tissue; although dioxins and furans were not analyzed in tissue, they were identified as potential bioaccumulative compounds by EPA (EPA 2000a).

[e] This chemical was detected in one sediment sample.

[f] One composite sample of whole-body English sole contained a detected concentration of n-nitroso-di-n-propylamine (270 µg/kg ww). However, this result was qualified as JN (estimated concentration, tentative identification). Given the uncertain quantification for this single result (all other results were undetected), the risks for this chemical were discussed in the uncertainty analysis.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
BHC – benzene hexachloride
COPC – chemical of potential concern
cPAH – carcinogenic polycyclic aromatic hydrocarbon
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
TEQ – toxic equivalent

X indicates that the chemical was selected as a COPC and was detected in the exposure scenario media.
X_{ND} indicates that the chemical was selected as a COPC but was not detected in the exposure scenario media.

6.1.3 Exposure scenarios and associated exposure parameters

Human exposures to COPCs were estimated for several seafood consumption and direct-contact sediment exposure scenarios, as described below. Exposure estimates were based on the concentration data for each COPC and health-protective assumptions regarding the rates and frequency of seafood intake and the rates, frequency, and duration of direct sediment contact associated with incidental ingestion and dermal exposure.

The exposure scenarios that were developed are based on assumptions that cover a range of expected behavior. At the high end, EPA (1989) defines the reasonable maximum exposure (RME) as "the highest exposure that is reasonably expected to occur at a site." The scenarios developed in the baseline HHRA are consistent with RME guidelines. Average exposures, on the other hand, are referred to as central tendency (CT) scenarios.

Another method of examining exposure is to identify a unit of exposure that a member of the public can use to assess the risks associated with their individual behavior. This last approach was used to characterize seafood consumption exposure on an individual basis. The unit of exposure used in this risk assessment was one meal per month. The one-meal-per-month exposure scenario is not meant to actually describe behavior that is occurring on the LDW because there are no actual data on current seafood consumption rates for the LDW.

EPA generally uses RME scenarios to evaluate the need for remedial actions at a site (EPA 1989). RME, by definition, likely overestimates exposure for many individuals. CT exposures are useful for characterizing uncertainty in exposure and risks (National Research Council 1994). However, average exposure estimates are not favored in decision-making because they will underestimate exposure for a substantial number of individuals (EPA 1989).

6.1.3.1 Seafood consumption scenarios

Several different seafood consumption scenarios were evaluated, as summarized in Table 6-2. Seafood consumption rates that were assumed for the seafood consumption scenarios with multiple species were developed by EPA based on data collected from several surveys. Specifically, for the adult tribal RME seafood consumption scenario based on Tulalip data, a consumption rate of 194 g per day was considered However, given that adult salmon were deemed not to have a significant site-related contribution of PCBs and other risk driver chemicals (i.e., most of their chemical accumulation results from exposures outside of the LDW), only the consumption of resident seafood was used for the risk assessment. Therefore, a resident seafood consumption rate of 97.5 g per day (which equals approximately three 227-g [8-oz] meals per week)[117] was assumed, based on EPA's analysis (*Framework for Selecting and Using Tribal Fish and Shellfish Consumption Rates for Risk-Based Decision Making at CERCLA and RCRA Cleanup Sites in Puget Sound and the Strait of Georgia* [EPA 2007]) of a survey of the Tulalip Tribes' consumption of resident species from the Puget Sound region (Toy et al. 1996). This rate was intended to reflect the 95th percentile of Puget Sound non-anadromous seafood consumption and was designated as a RME scenario. For some pathways, both RME exposure estimates and CT exposure estimates were developed to describe the range of possible exposures and risks, as discussed above. Specific assumptions for the CT scenarios were developed in consultation with EPA (EPA 2007d; Kissinger 2005).

[117] Rate does not include consumption of anadromous fish. Total consumption rate including anadromous fish is 194 g/day (EPA 2007d).

Table 6-2. Summary of seafood consumption scenarios

Scenario	Ingestion Rate (g/day)					Exposure Duration (years)
	Pelagic Fish	Benthic Fish	Crabs	Other Shellfish	Total[a]	
Adult tribal RME (Tulalip data)	8.1	7.5	43.4[b]	38.5[b]	97.5	70
Adult tribal CT (Tulalip data)	1.3	1.2	6.6[b]	5.9[b]	15.0	30
Child tribal RME (Tulalip data)	3.2	3.0	17.4[b]	15.4[b]	39.0	6
Child tribal CT (Tulalip data)	0.52	0.48	2.64[b]	2.34[b]	6.0[c]	6
Adult tribal (Suquamish data)	56	29.2[c]	55[c]	444[c]	584.2[c]	70
Adult API – RME	4.9	2.4	10.6	33.6	51.5	30
Adult API – CT	0.5	0.24	1.1	3.5	5.3	12
Adult one meal per month[d]	7.5	7.5	7.5	7.5	na	30

[a] Rates do not include consumption of anadromous fish.

[b] This table presents the same consumption rates based on the Tulalip Tribes survey as were previously provided by EPA and used in the LDW HHRA, Appendix B. These rates were also used in the risk results summarized in this section. The apportionment of shellfish (i.e., the amount of crab consumed relative to other shellfish, but not the total quantity consumed) for scenarios based on the Tulalip Tribes survey has since been updated per a correction provided by EPA (2009). The influence of this correction on the total risk estimates is relatively minor. This change and its impact on risk estimates are described in detail in an errata to Appendix B. The updated consumption rates are provided in Section 8 and were used in the development of RBTCs.

[c] Totals of benthic and shellfish categories (and overall total) differ slightly from values provided by EPA (2007d) because of significant figure and rounding issues when total consumption was allocated to more specific consumption categories. Overall total listed here is slightly higher than the corresponding value provided by EPA (2007d).

[d] Adult one-meal-per-month consumption was evaluated for individual seafood categories independently to reflect different fishing and consumption practices.

API – Asian and Pacific Islander

CT – central tendency

na – not applicable

RBTC – risk-based threshold concentration

RME – reasonable maximum exposure

The consumption rate for the adult tribal RME scenario based on Tulalip data was assumed to represent the consumption of seafood caught from the LDW and was further divided into seafood categories as shown in Table 6-2. It is likely that current seafood consumption rates within the LDW are lower than those documented in the Tulalip tribal study because of existing seafood consumption advisories or general concerns about contamination.

EPA's Superfund risk assessment guidance (EPA 1989) requires that exposure estimates be protective of future uses. Tribes with treaty rights to obtain seafood from the LDW may increase their seafood consumption rate in the future as chemical contamination in the LDW decreases. Habitat improvements may also increase the harvestable population of fish and shellfish to some degree. Consequently, the RME seafood consumption rates evaluated in the baseline HHRA were intended to be protective of both current and future uses.

Health risks were also quantified for several seafood consumption scenarios[118] in addition to the adult tribal RME scenario based on Tulalip data:

- Two Asian and Pacific Islander (API) scenarios (5.3 and 51.5 g/day of resident seafood for CT and RME, respectively (Kissinger 2005)
- An adult tribal CT scenario based on Tulalip data (15 g/day of resident seafood) (Hiltner 2007)
- Two child tribal scenarios based on Tulalip data (8.6 and 55.9 g/day of resident seafood for CT and RME, respectively) (EPA 2006d, 2007c; Hiltner 2007)
- A second adult tribal scenario based on Suquamish data (584.2 g/day of resident seafood) (EPA 2007d)
- Four adult one-meal-per-month consumption scenarios based on individual seafood categories (7.5 g/day)

Table 6-2 presents the ingestion rates and exposure durations associated with the various seafood consumption categories.

"Based on policy considerations, EPA is intending to use the Tulalip Tribes' seafood consumption rate as the principal rate to compute health protective tribal seafood consumption risks" for the LDW (EPA 2006d). The Suquamish seafood consumption scenario was included at the request of the Suquamish and Muckleshoot Indian Tribes to assist in characterizing the potential range of seafood consumption risks, although EPA (2005a) has questioned whether the high Suquamish rate could be sustained within the LDW.

The adult tribal seafood consumption scenarios based on Tulalip data, child tribal seafood consumption scenarios based on Tulalip data, adult tribal seafood consumption scenario based on Suquamish data, and adult API seafood consumption scenarios included a combination of all the seafood categories. For the adult one-meal-per-month scenario, risk was evaluated based on a consumption rate of one meal per month of pelagic fish (such as perch), benthic fish fillets (such as English sole and starry flounder), crab edible meat, or clams. The one-meal-per-month scenario was included for risk communication to enable individuals to estimate the risk associated with specific behaviors, rather than to describe the behavior of any particular group. Consistent with EPA risk assessment guidance, all assumptions regarding the amount of seafood ingested were selected to be health-protective to avoid underestimating risks. Consequently, individual risk estimates are more likely to be overestimates for most chemicals.

[118] Rates do not include consumption of anadromous fish. Total consumption rates for tribal and API scenarios were higher than values presented here when anadromous fish were included (EPA 2007d; Kissinger 2005).

6.1.3.2 Direct sediment exposure scenarios

Risks associated with sediment skin contact or incidental sediment ingestion were quantified in the baseline HHRA for adults engaging in clamming or tribal netfishing and for children playing in intertidal sediment areas (hereafter referred to as "beach play"). Exposure frequency and duration assumptions for the evaluation of direct sediment exposure under the commercial netfishing scenario were based on site use information collected from the Muckleshoot Indian Tribe, which conducts commercial netfishing for adult salmon within the LDW. Exposure parameter values for the beach play and clam harvesting scenarios were based primarily on EPA guidance, a King County lakes recreational survey (applied to beach play scenario only) (Parametrix 2003), a recent EPA memo on tribal clamming (Kissinger 2007), and best professional judgment because site-specific data on exposure frequency and duration for these scenarios were not available. Table 6-3 provides a summary of the exposure parameters for these scenarios.

Table 6-3. Summary of sediment exposure scenarios

Scenario	Incidental Sediment IR (g/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Skin Surface Area Exposed (cm^2)
Netfishing RME	0.05	119	44	3,600
Netfishing CT	0.05	63	29	3,600
Child beach play RME[a]	0.2	65	6	varies with age
Clamming (7 days per year)	0.1	7	30	6,040
Tribal clamming RME (120 days per year)	0.1	120	64	6,040
Tribal clamming (183 days per year)	0.1	183	70	6,040

[a] For the beach play scenarios, the LDW was divided into eight areas to assess risks associated with different parts of the LDW. Children were evaluated from birth through 6 years of age.

CT – central tendency

IR – ingestion rate

RME – reasonable maximum exposure

6.1.3.3 Exposure point concentrations

Exposure point concentrations (EPCs) for COPCs are intended to represent health-protective estimates of long-term exposure concentrations for a given scenario. In the baseline HHRA, the EPC was one of the following:

- If there were at least six detected concentrations or calculated totals, the EPC was the UCL[119] (calculated using EPA ProUCL software, Version 4).

[119] The 95% UCL was typically used; but in some cases, 97.5% or 99% UCLs were recommended by ProUCL and were used for risk calculations.

- If there were one to five detected concentrations, the EPC was the higher of one-half the maximum RL or the maximum detected value. For calculated totals, such as total PCBs, cPAHs, and dioxins/furans, the EPC was the higher of the maximum detected value or one-half the maximum non-detect value reported. The methods used for calculating these totals are presented in Section 4.1.4.
- If the chemical was not detected in any samples, one-half the maximum RL (or the maximum non-detect value for calculated totals) was selected as the EPC.

All concentrations qualified as estimates (i.e., J-qualified data) were assumed to indicate positive identification of the chemical and were used without modification in subsequent calculations. Some J-qualified data, most notably the 2004 pesticide results, were also N-qualified, indicating a tentative identification of the chemical. In the case of pesticides, the N-qualifier was necessary because of the high potential for analytical interference from PCBs (Windward 2005b). JN-qualified data were used in the risk assessment, but the uncertainty associated with these results was higher than the uncertainty associated with J-qualified results. Accordingly, in the risk characterization (Appendix B, Section B.5), the JN-qualified organochlorine pesticide data were presented separately from data for chemicals that were not JN-qualified. Analytical results for organochlorine pesticides used in the baseline HHRA from events prior to 2004 were likely to also have been complicated by interference from PCBs; however, the detected results were not all JN-qualified.

The EPCs for the direct sediment exposure scenarios (i.e., netfishing, beach play, and clam harvesting) were calculated for the sediment area over which exposure could potentially occur. The netfishing scenario assumed that tribal members who engage in commercial netfishing could be exposed to both intertidal and subtidal sediment adhering to their nets; consequently, the entire baseline surface sediment dataset was used for EPC calculation for this scenario.

For the beach play scenario, EPCs were based on data for intertidal sediment (i.e., sediment periodically exposed to air during low tides) from areas that are accessible to the public. The LDW was divided into eight areas for the beach play scenarios, corresponding to eight contiguous areas where access to intertidal sediments is relatively easy. Separate risk estimates were made for each of those eight areas. The areal extent of each beach, EPCs, and risks associated with the beach play scenario are presented in Map 6-1. The exposure frequency selected for the beach play scenario (i.e., 65 days per year) was based on King County's survey of parks immediately adjacent to lakes (Parametrix 2003) and represents the 95th percentile of exposure frequency for children up to 6 years old who play in sand near the water. This behavior is consistent with the behavior that is assumed for the beach play scenario in the LDW.

The clam harvesting scenarios assumed that people are exposed to COPCs in sediment as they dig for clams. The two tribal clamming scenarios (RME and 183 days per year) included all potential clam habitat areas (as identified during a 2004 survey) that could be accessed either by boat or on foot from the bank. Another clamming scenario used a

lower exposure frequency (7 days per year) and included only potential clam habitat areas that could be accessed from the bank (Map 6-2).

EPCs for the seafood consumption scenarios were calculated separately for various types of seafood, or consumption categories. Seven consumption categories were developed based on available seafood tissue types: pelagic fish, benthic fish—fillet, benthic fish—whole body, crab—edible meat, crab—whole body, clams, and mussels. In some cases, chemistry data for more than one species were combined within a single consumption category (e.g., data for Dungeness crab and slender crab edible meat were combined in the edible crab meat category). A COPC intake rate was then calculated for each consumption category using the COPC tissue dataset and the consumption rate for each category. The chemical intakes for each consumption category were then summed within each seafood consumption scenario (except the adult one-meal-per-month scenario) to yield an overall COPC intake for that scenario.

6.2 TOXICITY ASSESSMENT

EPA toxicity values (i.e., slope factors [SFs] for the evaluation of carcinogenic risks or reference doses [RfDs] for the evaluation of effects other than cancer) were identified for all COPCs. Toxicity values for each COPC have been established by EPA and other agencies and are based on either laboratory experiments using animals or epidemiological studies of human populations unintentionally exposed in the workplace or the environment. The SFs provide a health-protective means to evaluate risks because they represent upper bound estimates of carcinogenic potency. Similarly, non-cancer toxicity values (i.e., RfDs) are health-protective in that they are typically derived based on the most sensitive endpoint and population for which adequate data are available and include uncertainty factors or extrapolations to account for sensitive sub-populations or other limitations of the toxicity study data on which they were based. A detailed discussion of the toxicity values used in the HHRA is presented in Appendix B, Section B.4.

6.3 RISK CHARACTERIZATION

This section presents the risk estimates calculated using the exposure parameters and toxicity values discussed in Sections 6.1 and 6.2, respectively.

6.3.1 Risk estimate calculations

Carcinogenic risks and non-carcinogenic health effects were evaluated separately in the baseline HHRA because of fundamental differences in assumptions about the mechanism of these toxic effects. Carcinogenic risk estimates were calculated by multiplying the estimated chemical intake by the SF. Excess cancer risk estimates were compared with EPA's acceptable risk range of 10^{-6} to 10^{-4} established in the National Contingency Plan for Superfund sites (40 CFR 300). The lifetime risk of developing cancer in the US population is one in two (i.e., 5×10^{-1}) for men and one in three (i.e., 3×10^{-1}) for women (American Cancer Society 2006). A 1×10^{-6} excess cancer risk

represents an additional one-in-one-million probability that an individual may develop cancer over a 70-year lifetime as a result of exposure to chemicals in LDW sediments and surface water (either through direct exposure or indirect exposure through the consumption of seafood).

Carcinogenic risks associated with PCBs may be assessed based on either the dose of total PCBs and a PCB slope factor or the dose of a subset of PCB congeners that have a chemical structure and toxicity similar to that of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) and the TCDD slope factor**.** The toxicity of these dioxin-like PCB congeners is evaluated in terms of PCB TEQs. The TEQ relates the toxicity of coplanar PCBs to the toxicity TCDD. Risk estimates from the two approaches may be partially overlapping in terms of both exposure and toxicity. There is currently no consensus approach for considering these two risk approaches together. Some risk assessments have added these risks together to evaluate overall PCB risks, likely overestimating PCB risks. Other risk assessments have set overall PCB risks at either the risk calculated using the overall PCB dose and PCB Aroclor slope factor or the risk calculated using the PCB TEQ dose and dioxin TCDD slope factor. This latter approach may underestimate PCB risks. In this risk assessment, two different total excess cancer risk estimates were provided: one estimate included all COPC risks except those for PCB TEQ (i.e., including risks from all non-PCB COPCs plus total PCBs); the other estimate included all COPCs except total PCBs (i.e., including risks from all non-PCB COPCs plus PCB TEQ).

Chemicals with non-carcinogenic health effects are generally not toxic below a certain threshold; a critical chemical dose must be exceeded before adverse health effects are observed. The potential for non-carcinogenic health effects is represented by the ratio of the estimated chemical intake to the critical chemical dose (called a reference dose) and is expressed as an HQ. Exposures resulting in an HQ less than or equal to 1 are unlikely to result in non-cancer adverse health effects. For chemicals sharing a common toxicity endpoint, the HQs were summed to develop a hazard index (HI) for that endpoint.

6.3.2 Risk characterization results

Tables 6-4 to 6-6 summarize the excess cancer risk estimates and non-cancer hazards for chemicals that exceeded 1×10^{-6} excess cancer risk or an HQ of 1 for at least one scenario. All other risk estimates are presented in Appendix B, Section B.5.

Estimated excess cancer risk estimates were highest for the seafood consumption scenarios (Table 6-4). The cumulative risk for all carcinogenic chemicals was 3×10^{-3} for the adult tribal RME seafood consumption scenario based on Tulalip data; the primary contributors were PCBs (2×10^{-3}) and inorganic arsenic (1×10^{-3}). The cumulative excess cancer risk for the seafood consumption scenarios did not include dioxins and furans, which were not analyzed in tissue samples. It was assumed that if dioxins and furans had been analyzed and detected in tissue samples, risks would have been unacceptable. The majority of the excess cancer risk for PCBs was attributable to consumption of pelagic fish and clams. The excess cancer risk estimates from inorganic arsenic were

largely attributable to consumption of clams. Inorganic arsenic concentrations in fish and crabs were much lower and were very similar to background tissue concentrations.

Cumulative excess cancer risk estimates for the other seafood consumption scenarios (except for the adult tribal scenario based on Suquamish data) were lower (approximately 1.3 to 33% of cancer risk estimates for the adult tribal RME scenario based on Tulalip data) (Table 6-4). Specifically, the total excess cancer risks were 2×10^{-5} to 1×10^{-3} for the API consumption scenarios; 1×10^{-4} for the adult tribal CT scenario based on Tulalip data; 6×10^{-5} to 8×10^{-4} for the child tribal scenarios based on Tulalip data; 3×10^{-2} for the adult tribal scenario based on Suquamish data; and 2×10^{-4} (pelagic fish), 1×10^{-4} (benthic fish fillets), 4×10^{-5} (crab edible meat), and 2×10^{-4} (clams) for individuals who consumed those seafood categories at a rate of one meal per month. The risks for the adult tribal scenario based on Suquamish data were 10 times higher than risks for the adult tribal RME scenario based on Tulalip data, reflecting the much higher seafood consumption rate (almost three 8-oz meals per day) used in the adult Suquamish scenario estimates. In the evaluation of non-cancer hazards, arsenic and PCBs had HQs greater than 1 for one or more of the RME seafood consumption scenarios, indicating some potential for adverse effects other than cancer. In addition, HQs were greater than 1 for the child tribal RME scenario based on Tulalip data for TBT and vanadium (Table 6-5). For the adult tribal scenario based on Suquamish data, two additional chemicals had HQs greater than 1: chromium and mercury. HQs for these chemicals were less than 1 for all other seafood consumption scenarios. For the purpose of brevity, chemical-specific HQ estimates are provided in Table 6-5 only for chemicals exceeding an HQ of 1 for any scenario.

Excess cancer risk estimates for the direct sediment exposure scenarios were much lower than those for the seafood consumption scenarios. With the exception of the tribal clamming RME scenario and the tribal clamming 183-day-per-year scenario, all excess cancer risk estimates for direct sediment exposure scenarios were less than or equal to 5×10^{-5} (i.e., only 1.7% of the risks from the adult tribal RME seafood consumption scenario based on Tulalip intake data) (Table 6-6). Total excess cancer risk from the tribal clamming RME scenario was 1×10^{-4} (excluding PCB TEQ), which is 3.3% of the risks from the adult tribal RME seafood consumption scenario based on Tulalip data and 2×10^{-4} (excluding PCB TEQ) for the tribal clamming 183-day-per-year scenario. Total excess cancer risk estimates were greater than 1×10^{-6} for the netfishing scenarios and between 5×10^{-6} and 5×10^{-5} for the beach play RME scenarios. Risk estimates associated with specific beach play areas are also presented in Map 6-1. The chemicals contributing the most to direct sediment excess cancer risk estimates were dioxins and furans, PCBs, arsenic, and cPAHs. No HQs were greater than 1 for any of the direct sediment exposure scenarios.

Table 6-4. Summary of estimated excess cancer risks for the seafood consumption scenarios

Chemical	Adult Tribal RME (Tulalip Data)	Adult Tribal CT (Tulalip Data)	Child Tribal RME (Tulalip Data)	Child Tribal CT (Tulalip Data)	Adult Tribal (Suquamish Data)	Adult API RME	Adult API CT	Adult One Meal per Month			
								Benthic Fish	Clam	Crab	Pelagic Fish
Arsenic (inorganic)[a]	1×10^{-3}	6×10^{-5}	3×10^{-4}	3×10^{-5}	2×10^{-2} [b]	7×10^{-4}	1×10^{-5}	4×10^{-7}	1×10^{-4}	3×10^{-6}	6×10^{-6}
BEHP	6×10^{-6}	2×10^{-7}	1×10^{-6}	7×10^{-8}	4×10^{-5}	2×10^{-6}	3×10^{-8}	8×10^{-7}	8×10^{-8}	8×10^{-8} [c]	1×10^{-6}
cPAHs[d]	7×10^{-5}	4×10^{-6}	7×10^{-5}	8×10^{-6}	8×10^{-4}	3×10^{-5}	8×10^{-7}	2×10^{-7}	7×10^{-6}	2×10^{-7}	3×10^{-7}
Dioxin and furan TEQ[e]	na	na	na	na	na	na	na	na	na	na	na
PCB TEQ	1×10^{-3}	6×10^{-5}	2×10^{-4}	2×10^{-5}	7×10^{-3}	4×10^{-4}	7×10^{-6}	8×10^{-5}	2×10^{-5}	2×10^{-5}	2×10^{-4}
Total PCBs	2×10^{-3}	6×10^{-5}	3×10^{-4}	3×10^{-5}	1×10^{-2} [b]	5×10^{-4}	8×10^{-6}	1×10^{-4}	5×10^{-5}	2×10^{-5}	2×10^{-4}
Pentachlorophenol[a]	9×10^{-5} [f]	2×10^{-6} [f]	2×10^{-5} [f]	7×10^{-7} [f]	5×10^{-4} [f]	2×10^{-5}	3×10^{-7}	2×10^{-5} [c]	1×10^{-6} [c]	2×10^{-6} [c]	1×10^{-5}
Subtotal (excluding PCB TEQ)	**3×10^{-3}**	**1×10^{-4}**	**7×10^{-4}**	**7×10^{-5}**	**3×10^{-2}**	**1×10^{-3}**	**2×10^{-5}**	**1×10^{-4}**	**2×10^{-4}**	**3×10^{-5}**	**2×10^{-4}**
Subtotal (excluding total PCBs)	**2×10^{-3}**	**1×10^{-4}**	**6×10^{-4}**	**6×10^{-5}**	**3×10^{-2}**	**1×10^{-3}**	**2×10^{-5}**	**1×10^{-4}**	**1×10^{-4}**	**3×10^{-5}**	**2×10^{-4}**
Tentatively Identified Chemicals (JN-qualified)											
Aldrin	5×10^{-5} [f]	1×10^{-6} [f]	9×10^{-6} [f]	6×10^{-7} [f]	2×10^{-4}	1×10^{-5}	2×10^{-7}	3×10^{-6} [c]	8×10^{-7} [c]	3×10^{-6} [c]	3×10^{-6}
alpha-BHC	2×10^{-5} [f]	5×10^{-7} [f]	3×10^{-6} [f]	2×10^{-7} [f]	6×10^{-5}	3×10^{-6}	6×10^{-8}	1×10^{-6}	1×10^{-7}	1×10^{-6} [c]	1×10^{-6}
beta-BHC	6×10^{-6} [f]	3×10^{-7} [f]	1×10^{-6} [f]	1×10^{-7} [f]	3×10^{-5}	1×10^{-6}	3×10^{-8}	3×10^{-7}	1×10^{-7}	3×10^{-7} [c]	6×10^{-7}
Carbazole	5×10^{-5}	1×10^{-6}	8×10^{-6}	4×10^{-7}	2×10^{-4}	1×10^{-5}	8×10^{-8}	1×10^{-6} [c]	9×10^{-8} [c]	1×10^{-6} [c]	1×10^{-5}
Total chlordane	6×10^{-6}	2×10^{-7}	1×10^{-6}	9×10^{-8}	3×10^{-5}	2×10^{-6}	3×10^{-8}	3×10^{-7}	7×10^{-8}	7×10^{-8}	1×10^{-6}
Total DDTs	2×10^{-5}	1×10^{-6}	4×10^{-6}	4×10^{-7}	1×10^{-4}	6×10^{-6}	1×10^{-7}	1×10^{-6}	2×10^{-7}	4×10^{-7}	4×10^{-6}
Dieldrin	1×10^{-4}	3×10^{-6}	2×10^{-5}	1×10^{-6}	1×10^{-3}	5×10^{-5}	4×10^{-7}	3×10^{-6} [c]	9×10^{-6}	3×10^{-6}	3×10^{-6} [c]
gamma-BHC	6×10^{-6}	1×10^{-7}	1×10^{-6}	5×10^{-8}	3×10^{-5}	1×10^{-6}	1×10^{-8}	2×10^{-7} [c]	1×10^{-7}	2×10^{-7}	1×10^{-7}
Heptachlor	1×10^{-5} [f]	4×10^{-7} [f]	3×10^{-6} [f]	2×10^{-7} [f]	6×10^{-5}	3×10^{-6}	4×10^{-8}	7×10^{-7} [c]	1×10^{-7} [c]	7×10^{-7} [c]	2×10^{-6}
Heptachlor epoxide	3×10^{-5}	1×10^{-6}	6×10^{-6}	5×10^{-7}	2×10^{-4}	9×10^{-6}	1×10^{-7}	1×10^{-6} [c]	6×10^{-7}	9×10^{-7}	4×10^{-6}
Hexachlorobenzene	1×10^{-5}	2×10^{-7}	2×10^{-6}	1×10^{-7}	4×10^{-5}	2×10^{-6}	3×10^{-8}	6×10^{-7}	6×10^{-8}	6×10^{-7}	9×10^{-7}
Subtotal	**3×10^{-4}**	**9×10^{-6}**	**6×10^{-5}**	**4×10^{-6}**	**2×10^{-3}**	**1×10^{-4}**	**1×10^{-6}**	**1×10^{-5}**	**1×10^{-5}**	**1×10^{-5}**	**3×10^{-5}**
Total excess cancer risk (excluding PCB TEQ)	**3×10^{-3}**	**1×10^{-4}**	**8×10^{-4}**	**7×10^{-5}**	**3×10^{-2}**	**1×10^{-3}**	**2×10^{-5}**	**1×10^{-4}**	**2×10^{-4}**	**4×10^{-5}**	**2×10^{-4}**
Total excess cancer risk (excluding total PCBs)	**2×10^{-3}**	**1×10^{-4}**	**7×10^{-4}**	**6×10^{-5}**	**3×10^{-2}**	**1×10^{-3}**	**2×10^{-5}**	**1×10^{-4}**	**1×10^{-4}**	**4×10^{-5}**	**2×10^{-4}**

[a] No mussel data were available for this chemical. When calculating the chronic daily intake and risk values, the portion of seafood consumption that had been assigned to mussels was divided proportionally among the remaining consumption categories.

[b] Because the excess cancer risk is greater than or equal to 0.01, risk was calculated using the exponential equation in EPA (1989).

[c] No detected values in this seafood category. Chronic daily intake and risk estimate are based on one-half the maximum reporting limit.

[d] cPAH concentrations are based on benzo(a)pyrene equivalents. Data used in the risk characterization are from only 2004 because of high reporting limits in historical data. All cPAH data are analyzed in the uncertainty analysis (Appendix B, Section B.6). Because of the potential for increased susceptibility of children to carcinogens with mutagenic activity, as described in EPA guidance (EPA 2005e), the risk estimate for children for cPAHs is based on dose adjustments across the 0-to-6-year age range of children. See Appendix B, Section B.5.1, for more information.

[e] Tissue data for dioxins and furans were not collected. Thus, the calculated risk total, which does not include risks from dioxins and furans, is underestimated to an unknown degree.

[f] Greater than 50% of the risk associated with this chemical is derived from seafood categories with no detected values.

API – Asian and Pacific Islander
BEHP – bis(2-ethylhexyl) phthalate
BHC – benzene hexachloride
cPAH – carcinogenic polycyclic aromatic hydrocarbon
CT – central tendency
na – not available
PCB – polychlorinated biphenyl
RME – reasonable maximum exposure
TEQ – toxic equivalent

Table 6-5. Summary of estimated non-cancer hazards for the seafood consumption scenarios

Chemical	Adult Tulalip RME (Tulalip Data)	Adult Tribal CT (Tulalip Data)	Child Tribal RME (Tulalip Data)	Child Tribal CT (Tulalip Data)	Adult Tribal (Suquamish Data)	Adult API RME	Adult API CT	Adult One Meal per Month			
								Benthic Fish	Clam	Crab	Pelagic Fish
Arsenic[a, b]	3	0.3	7	0.7	38	3	0.2	0.002	0.7	0.01	0.03
Chromium	0.2	0.02	0.3	0.04	2	0.1	0.01	0.002	0.03	0.006	0.007
Mercury	0.5	0.07	1	0.1	2	0.3	0.02	0.06	0.02	0.07	0.04
Total PCBs	40	4	86	8	274	29	2	6	3	1	10
TBT (as ion)	1	0.2	3	0.3	15	1	0.1	0.002	0.3	0.02	0.06
Vanadium	0.8	0.1	2	0.2	9	0.8	0.07	0.01	0.2	0.01	0.06
Hazard Indices by Effect[c]											
HI for cardiovascular endpoint[d]	**4**	**0.4**	**9**	**0.9**	**47**	**4**	**0.3**	**0.01**	**0.9**	**0.02**	**0.09**
HI for developmental endpoint[e]	**41**	**4**	**87**	**8**	**276**	**29**	**2**	**6**	**3**	**1**	**10**
HI for hematologic endpoint[f]	**0.2**	**0.03**	**0.5**	**0.05**	**2**	**0.2**	**0.01**	**0.006**	**0.03**	**0.01**	**0.009**
HI for immunological endpoint[g]	**41**	**4**	**89**	**8**	**289**	**30**	**2**	**6**	**3**	**1**	**10**
HI for kidney endpoint[h]	**0.4**	**0.05**	**1.0**	**0.1**	**2**	**0.3**	**0.02**	**0.03**	**0.03**	**0.04**	**0.04**
HI for liver endpoint[i]	**1**	**0.1**	**3**	**0.3**	**7**	**0.8**	**0.05**	**0.1**	**0.1**	**0.09**	**0.3**
HI for neurological endpoint[j]	**41**	**4**	**87**	**8**	**276**	**29**	**2**	**6**	**3**	**1**	**10**
HI for dermal endpoint[k]	**3**	**0.3**	**7**	**0.7**	**38**	**3**	**0.2**	**0.01**	**0.7**	**0.02**	**0.06**

[a] No mussel data were available for this chemical. When calculating the risk values, the portion of seafood consumption that had been assigned to mussels was divided proportionally among the remaining consumption categories.

[b] Arsenic risk estimates are based on inorganic arsenic.

[c] HIs include risks associated with all COPCs by endpoint. However, only those COPCs with a hazard quotient greater than or equal to 1 for at least one scenario are listed in this table.

[d] Cardiovascular endpoint is for arsenic and vanadium.

[e] Developmental endpoint is for PCBs and mercury.

[f] Hematologic endpoint is for antimony and zinc.

[g] Immunological endpoint is for PCBs and TBT.

[h] Kidney endpoint is for 4-methylphenol, cadmium, copper, gamma-BHC, and pentachlorophenol.

[i] Liver endpoint is for 4-methylphenol, aldrin, alpha-BHC, beta-BHC, BEHP, butyl benzyl phthalate, chlordane, copper, total DDTs, dieldrin, endrin, endrin aldehyde, gamma-BHC, heptachlor, heptachlor epoxide, hexachlorobenzene, and pentachlorophenol.

[j] Neurological endpoint is for 4-methylphenol, mercury, and total PCBs.

[k] Dermal endpoint is for 4-methylphenol and arsenic.

API – Asian and Pacific Islander
BEHP – bis(2-ethylhexyl) phthalate
BHC – benzene hexachloride
COPC – chemical of potential concern
cPAH – carcinogenic polycyclic aromatic hydrocarbon
CT – central tendency
HI – hazard index
PCB – polychlorinated biphenyl
RME – reasonable maximum exposure
TBT – tributyltin

Table 6-6. Summary of estimated excess cancer risks for direct sediment exposure scenarios

Chemical	Netfishing		Beach Play RME								Clamming		
	RME	CT	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Tribal – 183 Days per Year	Tribal RME	7 Days per Year
Arsenic	6×10^{-6}	1×10^{-6}	5×10^{-6}	7×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-5}	2×10^{-5}	3×10^{-7}
cPAHs[a]	1×10^{-6}	2×10^{-7}	1×10^{-5}	4×10^{-5}	3×10^{-5}	8×10^{-6}	5×10^{-6}	5×10^{-6}	1×10^{-6}	4×10^{-6}	8×10^{-6}	5×10^{-6}	1×10^{-7}
Dioxin and furan TEQ	2×10^{-5}	4×10^{-6}	na	na	na	1×10^{-5}	8×10^{-8}	na	6×10^{-8}	na	2×10^{-4}	1×10^{-4}	8×10^{-7}
PCB TEQ	4×10^{-6}	6×10^{-7}	4×10^{-9}	3×10^{-7}	na	9×10^{-6}	1×10^{-7}	3×10^{-7}	3×10^{-8}	8×10^{-8}	5×10^{-5}	3×10^{-5}	2×10^{-7}
Total PCBs	2×10^{-6}[b]	3×10^{-7}[b]	7×10^{-8}	1×10^{-7}	1×10^{-7}	6×10^{-6}	1×10^{-7}	5×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-5}[b]	8×10^{-6}[b]	9×10^{-8}
Subtotal (excluding PCB TEQ)	**3×10^{-5}**	**6×10^{-6}**	**2×10^{-5}**	**5×10^{-5}**	**3×10^{-5}**	**3×10^{-5}**	**8×10^{-6}**	**9×10^{-6}**	**5×10^{-6}**	**7×10^{-6}**	**2×10^{-4}**	**1×10^{-4}**	**1×10^{-6}**
Subtotal (excluding total PCBs)	**3×10^{-5}**	**6×10^{-6}**	**2×10^{-5}**	**5×10^{-5}**	**3×10^{-5}**	**3×10^{-5}**	**8×10^{-6}**	**8×10^{-6}**	**5×10^{-6}**	**7×10^{-6}**	**3×10^{-4}**	**2×10^{-4}**	**1×10^{-6}**
Tentatively Identified Chemicals (JN-qualified)													
Toxaphene	2×10^{-6}	3×10^{-7}	1×10^{-8}	7×10^{-9}	2×10^{-8}	2×10^{-7}	1×10^{-7}	1×10^{-8}	1×10^{-8}	1×10^{-8}	9×10^{-6}	6×10^{-6}	2×10^{-8}
Total risk (excluding PCB TEQ) across both exposure routes)[c]	**3×10^{-5}**	**5×10^{-6}**	**2×10^{-5}**	**5×10^{-5}**	**3×10^{-5}**	**3×10^{-5}**	**8×10^{-6}**	**9×10^{-6}**	**5×10^{-6}**	**7×10^{-6}**	**3×10^{-4}**	**1×10^{-4}**	**1×10^{-6}**
Total risk (excluding total PCBs) across both exposure routes)[c]	**3×10^{-5}**	**6×10^{-6}**	**2×10^{-5}**	**5×10^{-5}**	**3×10^{-5}**	**3×10^{-5}**	**8×10^{-6}**	**8×10^{-6}**	**5×10^{-6}**	**7×10^{-6}**	**3×10^{-4}**	**2×10^{-4}**	**1×10^{-6}**

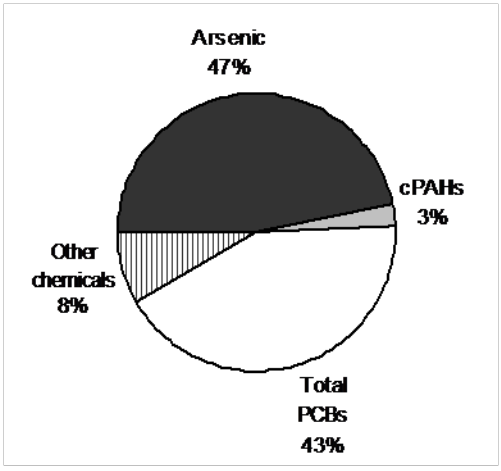
[a] cPAH concentrations are based on benzo(a)pyrene equivalents. Because of the potential for increased susceptibility of children to carcinogens with mutagenic activity, as described in EPA guidance (2005e), the risk estimate for beach play RME for cPAHs is based on dose adjustments across the 0-to-6-year age range of children. See Appendix B, Section B.5.1, for more information.

[b] The EPC used for this risk estimate was based on an arithmetic UCL, which is expected to overestimate exposure because of spatially biased sampling. The arithmetic mean was greater than the spatially-weighted mean (developed using Thiessen polygons) by a factor of approximately 5.

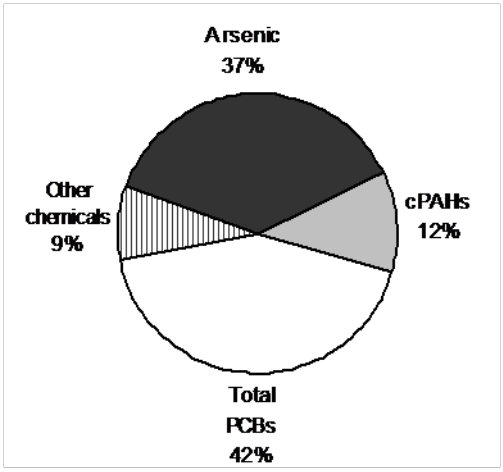
[c] Total risk values include the risks associated with all COPCs. However, only those COPCs with an excess cancer risk greater than or equal to 1×10^{-6} for at least one scenario are listed in this table.

COPC – chemical of potential concern
cPAH – carcinogenic polycyclic aromatic hydrocarbon
CT – central tendency
EPC – exposure point concentration
na – not available
PCB – polychlorinated biphenyl
RME – reasonable maximum exposure
SWAC – spatially weighted average concentration
TEQ – toxic equivalent

A small number of chemicals were responsible for the majority of the estimated health risks, and the highest risk estimates were associated with seafood consumption. The distributions of cancer risks by chemical are shown in Figure 6-2 for both the adult and child seafood consumption scenarios. The average percent contribution of different chemicals is shown for the adult scenarios because there was little variability in relative chemical contribution among the different scenarios (i.e., adult tribal RME based on Tulalip data, adult API RME, and adult tribal based on Suquamish data). Approximately 85 to 90% of health risks were associated with only two or three chemicals (i.e., arsenic, PCBs, or cPAHs), and almost all the risks in the "other chemicals" category were attributed to tentatively identified pesticides. Cancer risks from cPAHs represented a higher fraction of total cancer risks for children as compared with adults because the risk characterization method used assigns higher cPAH toxicity to children as compared with adults. Note that Figure 6-2 does not show risks for dioxins and furans, which were not analyzed in tissue. The majority of the non-cancer hazards associated with seafood consumption were contributed by total PCBs (> 80% of the total developmental, neurological, and immunological hazard indices). The total PCB HQ for all seafood consumption scenarios, except the adult one-meal-per-month crab scenario, exceeded 1.



a) Average total cancer risk (excluding PCB TEQ) for adult seafood consumption scenarios



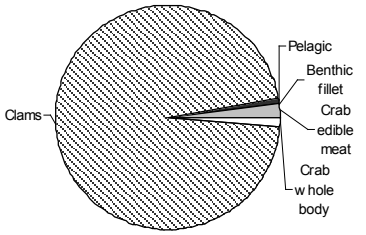
b) Average total cancer risk (excluding PCB TEQ) for child seafood consumption scenarios

Figure 6-2. Seafood consumption scenario risks by chemical

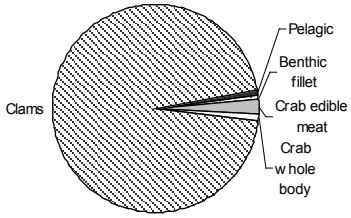
An incremental risk evaluation was performed for arsenic in tissue because arsenic is a an element found in the sediments of central and northern Puget Sound as result of natural sources (see Appendix B, Section B.5.5.1). Tissue samples for several species were collected from background locations and analyzed for arsenic. To estimate the incremental arsenic risk associated with the consumption of LDW seafood, arsenic risk calculated for consumption of seafood from background areas was subtracted from arsenic risk calculated for consumption of seafood from the LDW. Consideration of arsenic background risk did not appreciably affect LDW risk estimates associated with

clam consumption. However, the incremental arsenic risk associated with the LDW was negligible for all other seafood categories assessed.

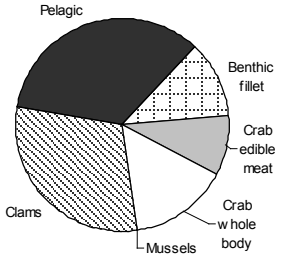
Elevated risk estimates associated with cPAHs and arsenic in seafood were largely attributed to consumption of clams (Figure 6-3). In contrast, risks from total PCBs through the consumption of seafood were more evenly divided among the seafood consumption categories (Figure 6-3, Panels c, f, and i), with pelagic fish and clams as dominant contributors. There were relatively small differences between the three scenarios (i.e., adult tribal RME based on Tulalip data, adult API RME, and adult tribal based on Suquamish data) for arsenic and cPAHs. For total PCB risks, the proportional contributions of all fish compared with all shellfish were similar across the three scenarios. However, within the shellfish group, the types of shellfish contributing the most to total PCB excess cancer risk differed across the three groups, reflecting differences in shellfish consumption patterns across the scenarios.



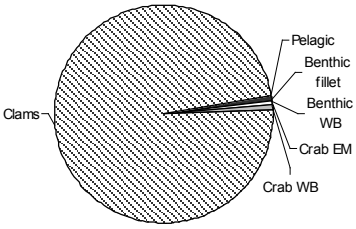
a) Arsenic cancer risks by seafood category for the adult tribal RME seafood consumption scenario based on Tulalip data



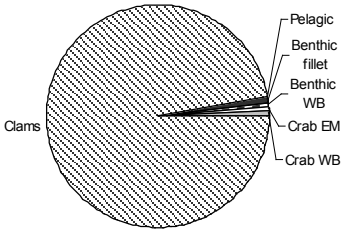
b) cPAH cancer risks by seafood category for the adult tribal RME seafood consumption scenario based on Tulalip data



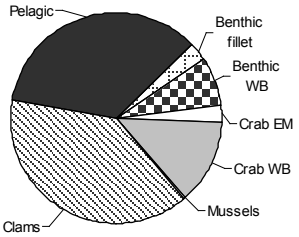
c) Total PCB cancer risks by seafood category for the adult tribal RME seafood consumption scenario based on Tulalip data



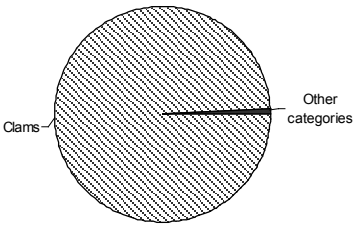
d) Arsenic cancer risks by seafood category for the API RME seafood consumption scenario



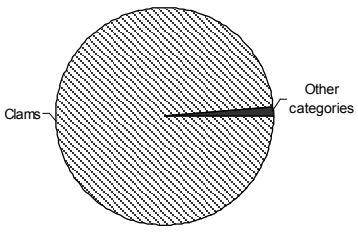
e) cPAH cancer risks by seafood category for the API RME seafood consumption scenario



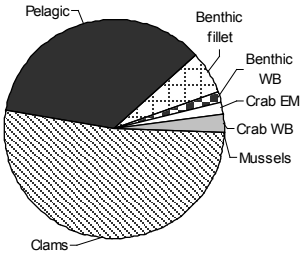
f) Total PCB cancer risks by seafood category for the API RME seafood consumption scenario



g) Arsenic cancer risks by seafood category for the adult tribal seafood consumption scenario based on Suquamish data



h) cPAH cancer risks by seafood category for the adult tribal seafood consumption scenario based on Suquamish data

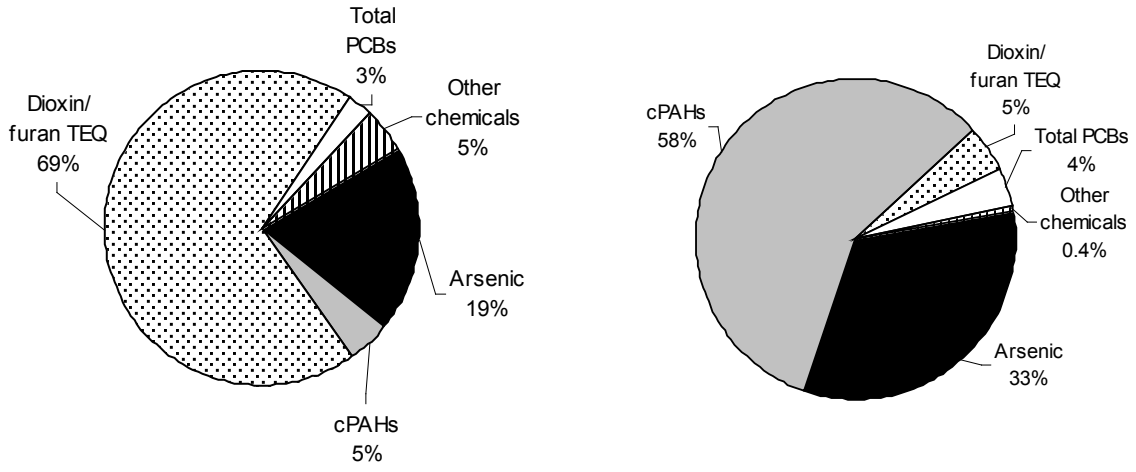


i) Total PCB cancer risks by seafood category for the adult tribal seafood consumption scenario based on Suquamish data

Figure 6-3. Excess cancer risks by seafood category for the adult seafood consumption scenarios

The risk contribution by chemical was different for direct sediment exposure scenarios than for seafood consumption exposure scenarios. The direct sediment exposure risk estimates were also quite different between the adult (i.e., netfishing and clamming) and child (i.e., beach play) scenarios. Dioxin and furan risks contributed the majority (average of 69%) of the risks for the adult sediment scenarios, followed by arsenic (average of 19%) (Figure 6-4, Panel a). For the beach play scenarios, cPAHs were responsible for the majority of the estimated risks (average of 58%) and dioxins and furans were much less important to the overall risk estimate (average of 5%), primarily because the highest concentrations of dioxins and furans in the LDW were not in

beach play areas, and there were fewer data available, so risks associated with these chemicals could not be evaluated for some areas (Figure 6-4, Panel b). In addition, the risk characterization method used for cPAHs assigns higher cPAH toxicity to children as compared with adults, so cPAH cancer risk estimates for the beach play scenario represented a much higher fraction of the total cancer risk as compared with the adult scenarios. In areas where dioxin and furan data were lacking, estimates of their contribution to risk could not be made.



a) Average total cancer risk estimate for the two netfishing and three clamming scenarios

b) Average total cancer risk estimate for the eight beach play RME scenarios

Figure 6-4. Excess cancer risks by chemical for direct-contact sediment exposure scenarios

In addition to estimating the risks for each exposure scenario separately, risks for multiple scenarios were summed to represent possible exposure of the same individuals to LDW chemicals from different activities, as shown in Table 6-7. The sum of excess cancer risk estimates for each of these four sets of scenarios is the same as the estimates for their seafood consumption components alone after rounding to one significant figure, as recommended by EPA (1989). This analysis demonstrates that the contributions of netfishing, clamming, beach play, and swimming are relatively small in comparison to seafood consumption risk estimates and highlights the significance of the seafood-consumption exposure pathways for all users of the LDW. Summing child beach play and swimming increased the risk estimate only slightly over that of beach play alone. Overall, swimming was the least important exposure pathway.

Table 6-7. Excess cancer risk estimates across related scenarios

ACTIVITY	EXCESS CANCER RISK[a]
Adult Tribal Scenarios	
Adult tribal netfishing RME[b]	3×10^{-5}
Swimming[c]	$< 1 \times 10^{-6}$
Adult tribal RME seafood consumption (Tulalip data)	3×10^{-3}
Total	**3×10^{-3}**
Child Scenarios[d]	
Beach play RME – Area 2[e]	5×10^{-5}
Swimming[c]	$< 1 \times 10^{-6}$
Subtotal for beach play and swimming	**5×10^{-5}**
Child tribal RME seafood consumption (Tulalip data)	8×10^{-4}
Total	**9×10^{-4}**
Adult Low-End Clamming Scenarios	
Clamming – 7 days per year	1×10^{-6}
Swimming[c]	$< 1 \times 10^{-6}$
Clam consumption – one meal per month	2×10^{-4}
Total	**2×10^{-4}**
Adult Tribal RME Clamming Scenarios	
Tribal clamming RME (120 days per year)	1×10^{-4}
Swimming[c]	$< 1 \times 10^{-6}$
Adult tribal RME seafood consumption based on Tulalip data	3×10^{-3}
Total	**3×10^{-3}**

[a] All non-swimming risk estimates are presented in Appendix B; total excess cancer risk estimates excluding PCB TEQ were used because these were equal to or higher than total excess cancer risk estimates excluding total PCBs.

[b] Although EPA guidance generally discourages summing risk estimates from multiple RME scenarios, risks for the netfishing RME scenario, rather than the netfishing CT scenario, were added to the seafood consumption RME scenario to account for the fact that RME seafood consumption and RME netfishing may be practiced by tribal members simultaneously.

[c] Adult and child swimming risk estimates as reported by King County for Elliott Bay and the Duwamish River for medium exposure assumptions (12 events per year for adults or children aged 1 to 6) (King County 1999c). Exposure pathways consisted of dermal contact and incidental sediment ingestion of water during swimming. Risks were estimated based on total PCB concentrations of 0.0144 µg/L in the LDW originally modeled by King County (King County 1999c). PCB congener data from samples collected from the LDW by King County in 2005 indicate that this modeled estimate is likely an overestimate of actual total PCB concentrations, which were no greater than 0.0314 µg/L during low-flow sampling conducted in August 2005 (Mickelson and Williston 2006). These results indicate that the risk estimates for the swimming scenario presented by King County in the water quality assessment (King County 1999c) are also likely overestimated.

[d] Child scenarios include the child tribal RME seafood consumption estimate based on 40% of the total adult tribal RME consumption based on Tulalip data, which is considered protective of non-tribal children.

[e] Beach play Area 2 is included because it had the highest risk estimate of the beach play scenarios.

CT – central tendency

PCB – polychlorinated biphenyl

RME – reasonable maximum exposure

6.4 UNCERTAINTY ANALYSIS

There are many uncertainties associated with the risk estimates for each exposure scenario in the baseline HHRA. To be health-protective of all members of the general public, the risk estimates presented in the baseline HHRA were intended to avoid underestimation of risks for the RME individual, and thus are likely to overestimate risks for most individuals for the chemicals that were evaluated. Although risk estimates were highest for the seafood consumption scenarios, the uncertainties associated with those risk estimates were also very high. There is considerable uncertainty about the applicability of some of the seafood consumption rates to this HHRA under current uses of the site, particularly for clams, given the quality and quantity of shellfish habitat in the LDW. These risk estimates were intended to provide information to risk managers involved in remedial planning at the site but may not reflect actual risks to people currently consuming LDW seafood.

Another important uncertainty is in the methods used to characterize the excess cancer risks associated with exposures to PCBs. Two methods were used in the baseline HHRA, one method based on total PCB data and the cancer SF for total PCBs and a second method based on dioxin-like PCB congener data and the cancer SF for TCDD. Because both of these methods account for the potential carcinogenic effects of PCBs, the excess cancer risk estimates from these two methods were not summed in estimating cumulative risks in order to avoid double-counting PCB excess cancer risks. Hence, the risk estimates for the two methods were presented separately in the baseline HHRA. Although this approach avoids the double-counting of PCB-related excess cancer risks, it is possible that each method for quantifying PCB excess cancer risks on its own underestimates the overall PCB cancer health risk. The issues associated with assessing risks posed by environmental PCB mixtures, various approaches for addressing double-counting, and quantitative risk estimates derived using these approaches are discussed in detail in the baseline HHRA uncertainty analysis section (Appendix B, Section B.6.3.1).

Dioxins and furans were not analyzed in seafood samples. This lack of data contributes to an underestimation of risk because these chemicals were not included in the risk assessment for the seafood consumption scenarios.

The final risk estimates also reflect uncertainties associated with using data and assumptions from multiple sources; the combined effect of those uncertainties on risk estimates cannot be quantified. However, the risk assessment tended to overestimate risks more than underestimate them, consistent with the health-protective nature of risk assessment. All or any of the uncertainties are relevant to the risk estimates. In spite of these uncertainties, the baseline risk characterization for the LDW site is considered to be health-protective and sufficient to support risk management decisions.

6.5 SUMMARY AND SELECTION OF HUMAN HEALTH RISK DRIVERS

The baseline HHRA identified risk driver chemicals (referred to as indicator hazardous substances in the MTCA program [WAC 173-340-703]). The risk drivers from both the HHRA and the ERA will be the focus of remedial analyses in the FS. The starting point for designating risk drivers was to identify COCs. Chemicals with excess cancer risk estimates greater than 1×10^{-6} or an HQ greater than 1 for any RME exposure scenario were designated COCs. Nineteen chemical were identified as seafood consumption COCs.[120] Eighteen chemicals were identified as seafood consumption COCs based on an exceedance of one or both of these risk thresholds for at least one seafood RME consumption scenario. Dioxins and furans were also included as a COC for seafood consumption, even though no quantitative risk estimates were made. It was assumed that dioxin and furan excess cancer risk estimates for seafood consumption scenarios would have been greater than 1×10^{-6}. Five chemicals were identified as direct sediment exposure COCs[121] based on excess cancer risk estimates greater than 1×10^{-6} for at least one RME scenario. Note that none of the direct sediment contact scenarios had HQs greater than 1; thus, no chemicals were designated as COCs based on non-cancer risk for the direct-contact scenarios.

Organochlorine pesticides were identified as COCs for several seafood consumption and direct sediment scenarios. However, as discussed previously, there may have been analytical interference from PCBs that affected their identification and quantification. Because there is no known source of organochlorine pesticides in the LDW, health risks associated with organochlorine pesticides in the LDW would not be expected to differ from those for other, similar urban or industrial waterway environments.

Chemicals selected as risk drivers were a subset of the COCs. The relative percentage of the total human health risk posed by these COCs was considered in designating a risk driver. Other factors that were also considered included the criteria identified in WAC 173-340-703 for designating an indicator hazardous substance: (a) toxicological characteristics that influence its ability to adversely affect human health or the environment relative to the concentration of the hazardous substance at the site, (b) tendency to persist in the environment, (c) tendency to move into and through environmental media, (d) preliminary natural background concentrations, (e) thoroughness of testing, (f) detection frequency, and (g) chemicals that readily break down into less toxic byproducts (see Appendix B, Section B.7, for more details). Based on this analysis, four risk drivers were identified for both seafood consumption and

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[120] The COCs based on seafood consumption scenarios were PCBs, arsenic, cPAHs, dioxins and furans, aldrin, BEHP, alpha-BHC, beta-BHC, carbazole, total chlordane, total DDTs, dieldrin, gamma-BHC, heptachlor, heptachlor epoxide, hexachlorobenzene, pentachlorophenol, TBT, and vanadium.

[121] The COCs based on direct sediment exposure were PCBs, arsenic, cPAHs, dioxins and furans, and toxaphene.

direct sediment exposure: PCBs, arsenic, cPAHs, and dioxins and furans. The direct-contact risk estimate for dioxins and furans was driven by high concentrations in surface sediments at a small number of sampling locations within the LDW.

COCs not selected as risk drivers in the baseline HHRA will be addressed through focused evaluation in the FS; these chemicals may also be considered in remedial design for specific areas in or near the LDW, and included in the post-remedial monitoring program that is part of the 5-year review that EPA conducts at all Superfund sites where hazardous substances, pollutants, or contaminants remain in place after cleanup is completed.

7 Preliminary Background Concentrations of Risk Driver Chemicals

This section presents concentrations of selected risk driver chemicals (i.e., PCBs, arsenic, cPAHs, and dioxins and furans) in sediment, tissue, and water collected from locations within and outside of the LDW. Understanding background concentrations of these risk driver chemicals is important because it provides a context for both the ecological and human health RBTCs, which are discussed in Section 8. The datasets and summary statistics presented in this section represent information available at the time of the RI; additional data for use in evaluating background are being collected and evaluated. The specific data and summary statistics presented in this section are preliminary; the final background values considered in setting preliminary remediation goals (PRGs) and assessing remedial alternatives will be presented in the FS. EPA and Ecology will select the remediation goals and the final background concentrations to be considered in the derivation of cleanup levels in the Record of Decision (ROD).

Preliminary background concentrations of PCBs, arsenic, cPAHs, and dioxins and furans are presented in this section because some of the risk-based threshold concentrations (RBTCs; see Section 8) for these chemicals are lower than concentrations in areas outside of the LDW. RBTCs for other risk-driver chemicals based on the SQS and CSL appear to be higher than these concentrations and thus are not presented in this section.

MTCA (WAC 173-340-200) defines natural background as concentrations of hazardous substances that are consistently present in an environment that has not been influenced by localized human activities. Thus, under MTCA, natural background values can be defined for man-made compounds (e.g., PCBs) that may not occur naturally. MTCA also discusses area background, which is a term used to represent those concentrations that are consistently present in the environment in the vicinity of the site as a result of human activities unrelated to releases from the site.

CERCLA uses different definitions for background. Under CERCLA guidance, anthropogenic background refers to natural and human-made substances that are present in the environment as a result of human activities, but that are not specifically related to CERCLA releases at the site (EPA 2002d). Natural background refers to substances that are naturally present in the environment in forms that have not been influenced by human activity (e.g., naturally occurring metals). Under both the CERCLA and MTCA programs, anthropogenic or area background concentrations are generally higher than natural background concentrations.

This section is intended to provide initial background information to provide a preliminary context for the site characterization data and RBTCs presented elsewhere in the RI report. Some additional datasets that are relevant to background exist; this

compilation is not exhaustive. The exclusion of a dataset from these discussions does not necessarily exclude those data from being considered in the future as background evaluations continue, and some data included in this summary may be eliminated in future background evaluations. Additional sampling studies are underway and will be providing new datasets relevant to LDW background determinations. The presentation of information provided in this section is not intended to be interpreted as the development of background-based PRGs or cleanup levels in the RI.

Background-related information may be relevant for multiple chemicals and for multiple environmental media. As noted above, there are also several terms for "background" (e.g., natural, anthropogenic, area), which are based on different concepts and usually require different datasets for characterizing each type of background concentration. For any single chemical, environmental medium, and type of background, repeated sampling may produce different sets of results. Therefore, final background determinations by EPA and Ecology may be based on a (statistical) distribution of values and not a single value. Statistical evaluations of background datasets can become complex. For the purpose of providing preliminary information in this section, the focus is on presenting relatively simple summary statistics. Further background assessments and the development of background-based PRGs and cleanup levels will involve detailed statistical evaluations, as appropriate.

An evaluation of background requires an assessment of the quality of the various potential datasets before deciding how to evaluate the data statistically. The general term "representativeness" can be used to reflect multiple considerations, such as sampling and analysis protocols, possible changes over time, spatial differences, the potential influence of other sources, and the specific relevance of the data, as collected and analyzed, to the LDW. The selection of datasets to serve as the basis for background determinations for the LDW will consider such representativeness issues but is not attempted in this section. If more than one dataset is selected, background determinations will consider combining the data versus performing separate evaluations of each dataset and then assessing the multiple results (e.g., as independent "lines of evidence"). These detailed considerations and dataset combinations are not addressed for this RI summary but will be addressed in future background analyses. Consistent with the intent of this section to provide only an initial context related to background, the general approach is simple and descriptive rather than complex and interpretive.

Section 7.1 presents sediment data for selected risk driver chemicals from samples collected from areas that are not believed to have been influenced by localized human activities. These data are relevant for consideration of natural background concentrations.

Section 7.2 discusses concentrations of chemicals in sediments collected upstream of the LDW and in sediments that have been deposited in the Upper Turning Basin of the LDW. Area and anthropogenic background concentrations in sediment have not been

formally defined for the LDW. Sediment transported from upstream of the LDW is likely to significantly influence the future quality and characteristics of sediment within the LDW (see Section 3). Therefore, multiple sediment datasets are presented in Section 7.2 along with a discussion of associated physical properties that may affect their chemistry. Section 7.2 also discusses upstream water quality data and estimates chemical concentrations in suspended sediment in the water column. These data provide a range of relevant chemical concentrations that will be considered in the FS in the assessment of PRGs and the evaluation of remedial alternatives.

Section 7.3 provides additional context for the data presented in Sections 7.1 and 7.2 by presenting urban sediment data from Seattle and other Puget Sound locations.

Tissue data from Puget Sound are presented in Section 7.4. Most of the available tissue data for total PCBs from Puget Sound have been characterized as either near-urban or non-urban (West et al. 2001). Available arsenic data were categorized according to whether or not the sampling location was likely to have been impacted by emissions from the former Asarco smelter located in Ruston, Washington. Tissue data are presented to show the general range of concentrations in areas outside the influence of site-related activities.

7.1 SEDIMENT DATASETS TO BE CONSIDERED FOR NATURAL BACKGROUND

This section provides a summary of available sediment data from reference areas in the Puget Sound region. Summary statistics are provided for each reference area or specific study; combined preliminary natural background concentrations were not derived. These data are considered to be representative of non-urban, non-localized concentrations in the Puget Sound region that exist as a result of natural processes and/or the large-scale distribution of chemicals from anthropogenic sources.

7.1.1 Data sources

Ten areas in Puget Sound have been identified as reference areas by the Battelle Marine Research Laboratory (Battelle) (1986) or WSDOH (1995) (Table 7-1; Maps 7-1, 7-2, and 7-3). Sediment data from these 10 reference areas were obtained from four sources: 1) a study by NOAA and Ecology on sediment quality in Puget Sound conducted from 1997 to 1999 (NOAA and Ecology 1999, 2000, 2002), 2) Washington State's SEDQUAL database (Ecology 2004c), 3) a Battelle survey of eight bays (1986), and 4) Ecology's Environmental Information Management (EIM) System database (Ecology 2007c). Data were obtained for total PCBs, arsenic, and cPAHs from this search. Data were processed to the extent possible using data management procedures described in Appendix E, although the data from these datasets were generally used as reported in the above sources without further data quality reviews. In addition, sampling and analytical methods used to produce these datasets varied from study to study and potentially from year to year within a given study. Thus, while these data provide a general indication of chemical concentrations in these reference areas, they should not be viewed as a single dataset with consistent methodology.

Table 7-1. Reference areas identified for consideration of natural background concentrations of total PCBs, arsenic, and cPAHs

Reference Area	Sources Used to Identify Reference Areas
Carr Inlet	WSDOH (1995)
Case Inlet	Battelle (1986)
Dabob Bay	WSDOH (1995); Battelle (1986)
Discovery Bay	WSDOH (1995)
Rich Passage	WSDOH (1995)
Samish Bay	WSDOH (1995); Battelle (1986)
Saratoga Passage	WSDOH (1995)
Sequim Bay	WSDOH (1995); Battelle (1986)
West Beach	WSDOH (1995)
Wollochet Bay	WSDOH (1995)

Battelle – Battelle Marine Research Laboratory
cPAH – carcinogenic polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
WSDOH – Washington State Department of Health

In addition to the data from the reference areas identified above, additional data were obtained from the following studies:

- **Rayonier, Inc., RI –** Samples were collected and analyzed for dioxin, furan, and PCB congeners from two areas outside the influence of localized human activities (Dungeness Bay and Freshwater Bay) as part of the RI at the Rayonier, Inc., mill site near Port Angeles, Washington (Map 7-1) (Malcolm Pirnie 2007b).
- **Puget Sound 2008 Survey –** Samples were collected and analyzed from 14 reference areas throughout Puget Sound at established reference sites and locations distant from known sources of contamination (Map 7-4) (Liebman 2008). Five samples were collected from each reference area for a total of 70 samples. Samples were analyzed for PCBs (Aroclors and PCB congeners), arsenic, cPAHs, and dioxins and furans, in addition to other analytes.

In the following sections, data from individual studies are summarized separately. The Puget Sound 2008 survey data are summarized as a combined dataset from multiple areas because sampling and analytical methods were consistent in the 14 areas sampled throughout Puget Sound.

The DMMP has compiled a set of dioxin and furan data representing background in Puget Sound, but these data were not available for inclusion in the RI (USACE 2009). The DMMP's data compilation includes the Puget Sound 2008 survey data as well as additional data from the Anderson-Ketron open-water disposal site, Ecology's EIM,

and a reference sample associated with a recent dredge project sediment characterization.

7.1.2 Arsenic surface sediment datasets to be considered for natural background

Arsenic was frequently detected in samples from all 10 reference areas in Puget Sound and was detected in all of the samples from the Puget Sound 2008 survey (Figure 7-1). The arsenic concentrations included in the datasets ranged from 0.5 mg/kg dw in Carr Inlet to 27 mg/kg dw in Sequim Bay (Table 7-2). Detection frequencies in individual areas ranged from 48 to 100%. Sampling locations are shown on Maps 7-2 and 7-3. Percent fines ranged from 1 to 98.5% in the Puget Sound 2008 survey, with a mean of 47.4%.

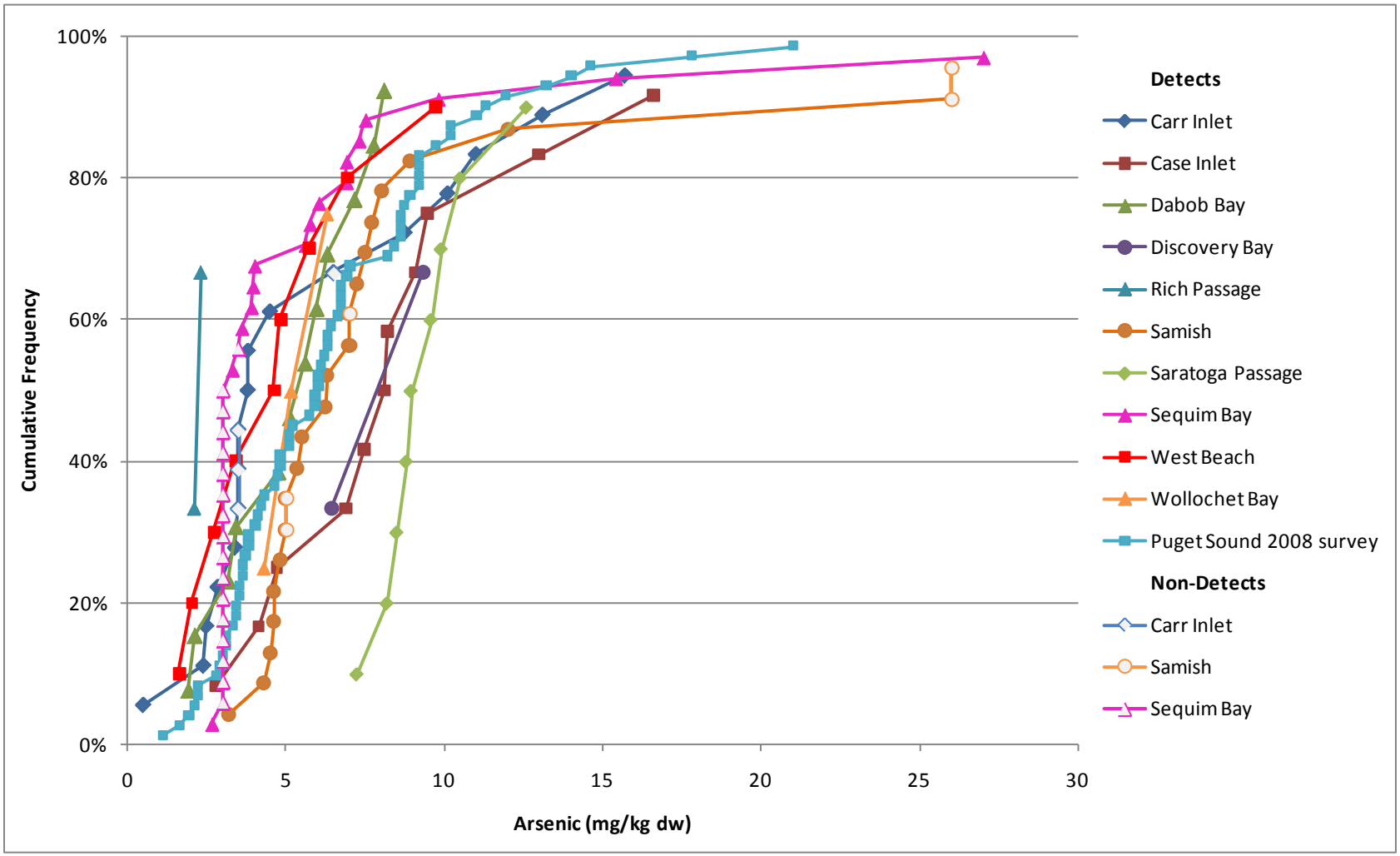


Figure 7-1. Cumulative frequency of arsenic concentrations in surface sediment collected from Puget Sound reference areas and the 2008 survey

Table 7-2. Summary of arsenic datasets to be considered for natural background

Sampling Location	Sampling Period	Detection Frequency	Concentration (mg/kg dw)								UCL Type
			Minimum Detect	Maximum Detect	Mean Detect	Minimum RL	Maximum RL	50TH Percentile[a]	90TH Percentile[a]	95% UCL[b]	
Reference Areas											
Carr Inlet	1972 – 2000	13/17	0.500	15.7	6.34	7.0	13.0	3.8	13.6	7.59	95% KM (t) UCL
Case Inlet	1972 – 1999	11/11	2.8	16.6	8.2	na	na	8.1	15.9	10.4	95% Student's-t UCL
Dabob Bay	1995 – 1999	12/12	1.90	8.1	5.11	na	na	5.4	8.0	6.2	95% Student's-t UCL
Discovery Bay	1986 – 1994	2/2	6.43	9.3	7.87	na	na	7.9	9.3	9.3	maximum detect
Rich Passage	1998	2/2	2.10	2.3	2.2	na	na	2.2	2.3	2.3	maximum detect
Samish	1989	17/22	3.20	12.0	6.34	10	52	6.3	12.0[c]	7.16	95% KM (t) UCL
Saratoga Passage	1972 – 1997	9/9	7.2	13	9.36	na	na	9.0	12.6	10.3	95% Student's-t UCL
Sequim Bay	1994 – 1997	16/33	2.65	27.0	7.47	6.0	7.0	3.0	8.9	7.2	95% KM (% bootstrap) UCL
West Beach	1986 – 1990	9/9	1.6	9.7	4.6	na	na	4.6	9.7	6.2	95% Student's-t UCL
Wollochet Bay	1982 – 1996	3/3	4.30	6.3	5.25	na	na	5.2	6.3	6.3	maximum detect
Puget Sound 2008 Survey											
Puget Sound	2008	70/70	1.1	21	6.5	na	na	6.0	11	7.3	95% approximate gamma UCL

Note: Multiple datasets have been collected over time, there were no consistent temporal trends in the data.

[a] Percentiles were calculated using detected values and one-half the RL for samples in which arsenic was not detected. Percentiles are non-parametric percentiles calculated using methods presented in the *National Institute of Standards and Technology Handbook of Statistical Methods* (NIST and SEMATECH 2006).

[b] UCLs were calculated using ProUCL 4 statistical software (EPA 2007e), which accounts for non-detect values in the calculation of UCLs.

[c] Maximum detected value presented; the 90th percentile value was higher than the maximum detect because of elevated RLs.

dw – dry weight
KM – Kaplan-Meier
na – not applicable
RL – reporting limit
t – Student's t distribution
UCL – upper confidence limit on the mean

7.1.3 PCB surface sediment datasets to be considered for natural background

Total PCB concentrations were calculated either by summing detected PCB Aroclors or by summing detected PCB congeners. The analytical method used for PCB Aroclors had a much higher RL than the analytical method used for PCB congeners. Thus, PCBs as Aroclors were detected in only 11 of 140 samples that were analyzed using the Aroclor method, while at least one of the 209 PCB congeners was detected in every sample analyzed using the PCB congener method, resulting in 100% detection (Figure 7-2; Table 7-3). In the 70 samples collected for the Puget Sound 2008 survey, the calculated mean concentration of total PCBs as Aroclor sums was 11 µg/kg dw (based on a mean of the total PCB concentration in the six samples with at least one detected Aroclor), compared with 1.2 µg/kg dw for the mean concentration as PCB congener sums (based on a mean of the total PCB concentration in all 70 samples with at least one detected PCB congener). Reference locations with PCB sediment data are presented on Maps 7-1 and 7-2. TOC content in the 70 samples from the Puget Sound 2008 survey ranged from 0.2 to 4.0%, with a mean of 1.3%. When the total PCB data from the Puget Sound 2008 survey were normalized for organic carbon content, concentrations ranged from 0.0056 to 0.85 mg/kg OC, with a mean of 0.11 mg/kg OC (Table 7-3).

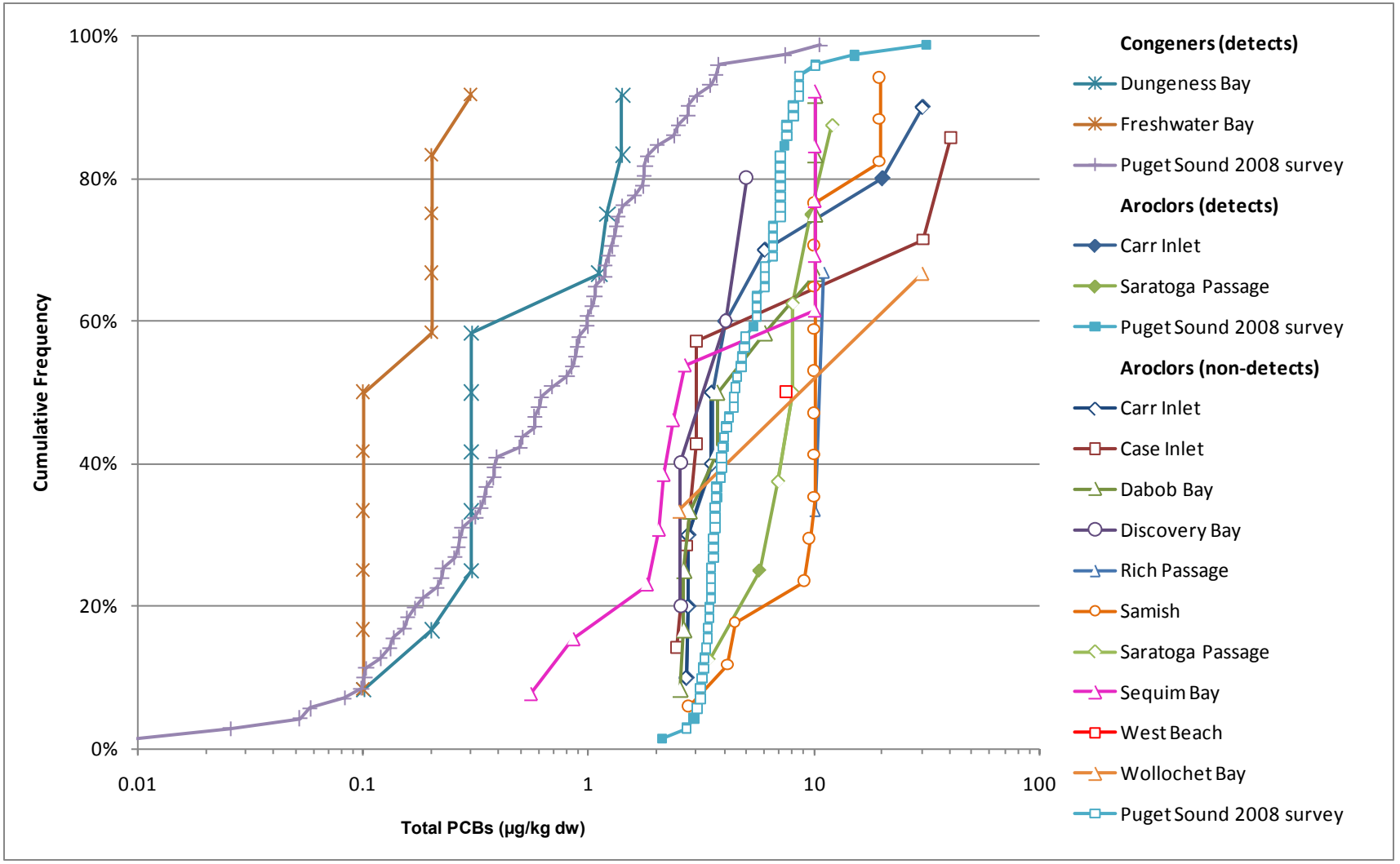


Figure 7-2. Cumulative frequency of total PCB concentrations in surface sediment collected from Puget Sound reference areas and the 2008 survey

Table 7-3. Summary of total PCB datasets to be considered for natural background

Sampling Location	Sampling Period	Analtye	Unit	Concentration[a]									UCL Type
				Detection Frequency	Minimum Detect	Maximum Detect	Mean Detect	Minimum Non-Detect[b]	Maximum Non-Detect[b]	50TH Percentile[c]	90TH Percentile[c]	95% UCL[d]	
Reference Areas													
Carr Inlet	1984 – 2000	PCB Aroclors	µg/kg dw	2/9	4.0	19.9	11.5	5.4	60	3.5	19.9[e]	19.9	maximum detect
Case Inlet	1999	PCB Aroclors	µg/kg dw	0/6	na	na	na	4.9	80	nc	nc	nc	nc
Dabob Bay	1995 – 1999	PCB Aroclors	µg/kg dw	0/11	na	na	na	5.1	20	nc	nc	nc	nc
Discovery Bay	1994 – 2002	PCB Aroclors	µg/kg dw	0/4	na	na	na	5.1	10	nc	nc	nc	nc
Dungeness Bay	2006	PCB congeners	µg/kg dw	11/11	0.2	1.4	0.63	na	na	0.3	1.4	1.4	maximum detect
Freshwater Bay	2006	PCB congeners	µg/kg dw	11/11	0.1	0.3	0.15	na	na	0.1	0.2	0.19	95% Modified-t UCL
Rich Passage	1998	PCB Aroclors	µg/kg dw	0/2	na	na	na	20	22	nc	nc	nc	nc
Samish	2000 – 2004	PCB Aroclors	µg/kg dw	0/16	na	na	na	5.5	39	nc	nc	nc	nc
Saratoga Passage	1996 – 1997	PCB Aroclors	µg/kg dw	3/7	5.7	9.7	7.4	6.8	24	8.0	9.7	9.7	maximum detect
Sequim Bay	1994 – 2002	PCB Aroclors	µg/kg dw	0/12	na	na	na	1.1	20	nc	nc	nc	nc
West Beach	1994	PCB Aroclors	µg/kg dw	0/1	na	na	na	15	15	nc	nc	nc	nc
Wollochet Bay	1996 – 1999	PCB Aroclors	µg/kg dw	0/2	na	na	na	5	60	nc	nc	nc	nc
Puget Sound 2008 Survey													
Puget Sound	2008	PCB Aroclors	µg/kg dw	6/70	2.1	31	11	5.4	20	4.4	8.0	6.5	95% KM (percentile bootstrap) UCL

Sampling Location	Sampling Period	Analtye	Unit	Concentration[a]									UCL Type
				Detection Frequency	Minimum Detect	Maximum Detect	Mean Detect	Minimum Non-Detect[b]	Maximum Non-Detect[b]	50TH Percentile[c]	90TH Percentile[c]	95% UCL[d]	
Puget Sound	2008	PCB Aroclors	mg/kg OC	5/59[f]	0.21	3.0	0.99	0.36	1.97	0.39	0.63	3.0	maximum detect
Puget Sound	2008	PCB congeners	µg/kg dw	70/70	0.010	11	1.2	na	na	0.65	2.8	1.5	95% approximate gamma UCL
Puget Sound	2008	PCB congeners	mg/kg OC	59/59[f]	0.0056	0.85	0.11	na	na	0.054	0.21	0.16	95% H-UCL

Note: Multiple datasets have been collected over time; there were no consistent temporal trends in the data.

[a] For PCB Aroclors, the total PCB concentration represents the sum of detected concentrations of nine individual PCB Aroclors for a given sample. For samples in which none of the individual Aroclors were detected, the maximum RL for an individual PCB Aroclor in that sample is used as the concentration. For PCB congeners, the total PCB concentration represents the sum of the detected PCB congener concentrations for a given sample.

[b] Non-detected concentrations for samples in which none of the individual PCB Aroclors were detected were calculated as described in Footnote a.

[c] Percentiles are non-parametric percentiles calculated using methods presented in the *National Institute of Standards and Technology Handbook of Statistical Methods* (NIST and SEMATECH 2006). Percentiles were calculated using both detected and non-detected total PCB concentrations (see Footnote a).

[d] UCLs were calculated using ProUCL 4 statistical software (EPA 2007e), which accounts for non-detect values in the calculation of UCLs.

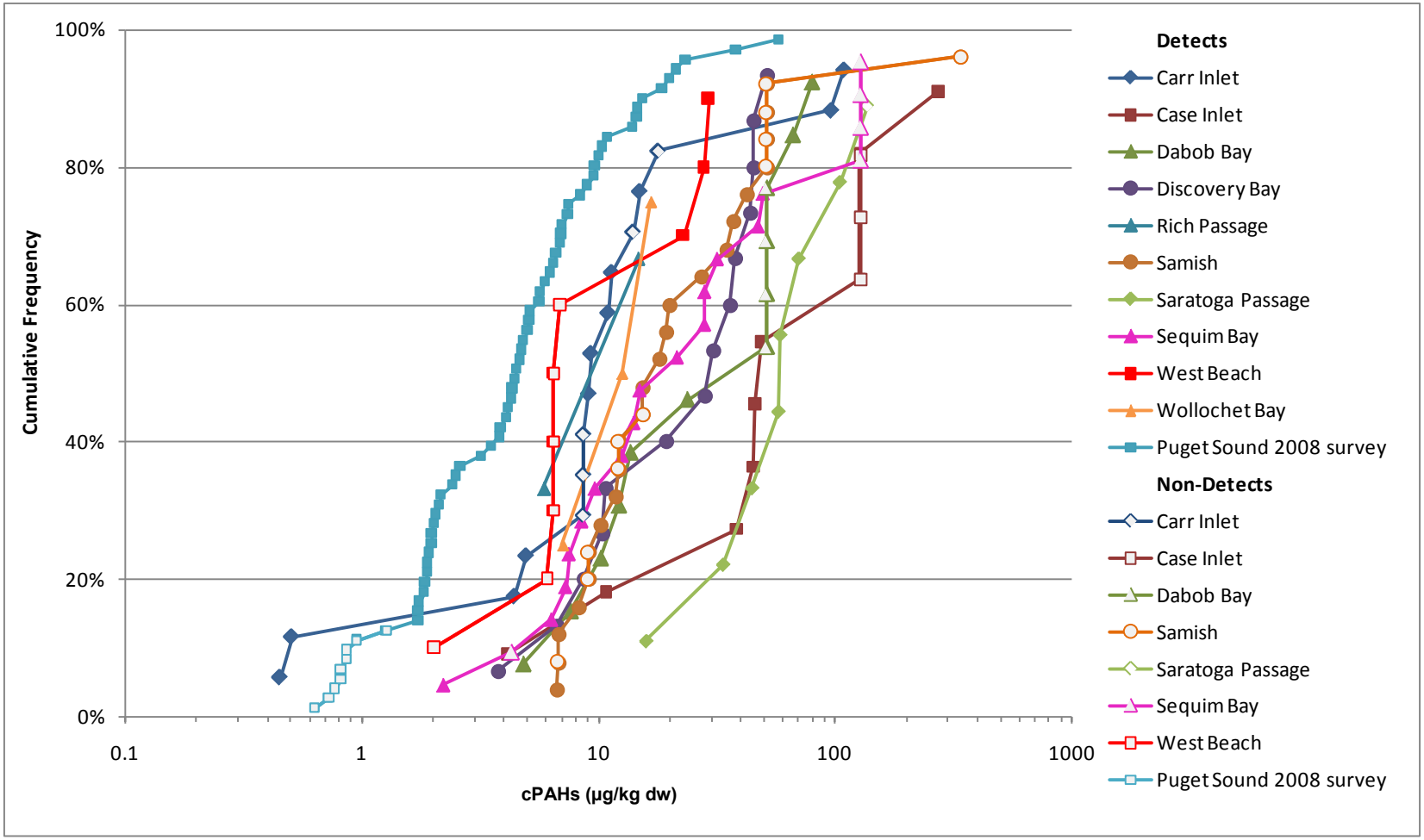
[e] Maximum detected value presented; the 90th percentile value was higher than the maximum detected value because of elevated RLs.

[f] OC-normalized concentrations were not calculated for 11 samples that had TOC contents ≤ 0.5% and ≥ 4%.

dw – dry weight
H – Land's H statistic
KM – Kaplan Meier
na – not available
nc – not calculated
PCB – polychlorinated biphenyl
RL – reporting limit
TOC – total organic carbon
UCL – upper confidence limit on the mean

7.1.4 cPAH surface sediment datasets to be considered for natural background

At least one cPAH compound was detected in the majority of samples from the 10 reference areas in Puget Sound and the Puget Sound 2008 survey (Figure 7-3). The cPAH concentrations ranged from 0.45 µg/kg dw in Carr Inlet to 274 µg/kg dw in Case Inlet (Table 7-4). Detection frequencies in individual areas ranged from 33 to 100%, although the detection frequency for individual cPAH compounds was sometimes as low as 0%. For samples from the Puget Sound 2008 survey, OC-normalized cPAH concentrations ranged from 0.11 to 2.8 mg/kg OC, with a mean concentration of 0.56 mg/kg OC (Table 7-4). Sampling locations for the cPAH samples are shown on Maps 7-3 and 7-4.



Note: Total cPAHs were calculated by summing the products of concentrations and compound-specific PEFs for individual cPAH compounds, as discussed in detail in Appendix E.

Figure 7-3. Cumulative frequency of cPAH concentrations in surface sediment collected from Puget Sound reference areas and the 2008 survey

Table 7-4. Summary of cPAH datasets to be considered for natural background

Sampling Location	Sampling Period	Concentration (µg/kg dw)[a]									UCL Type
		Detection Frequency	Minimum Detect	Maximum Detect	Mean Detect	Minimum Non-Detect[b]	Maximum Non-Detect[b]	50TH Percentile[c]	90TH Percentile[c]	95% UCL[d]	
Reference Areas											
Carr Inlet	1984 – 2000	11/16	0.450	108	24.5	17.2	35.4	9.1	99.2	33.9	95% KM (BCA) UCL
Case Inlet	1992 – 1999	8/11	4.14	274	59.9	256	256	46.0	244.7	154.5	95% KM (Chebyshev) UCL
Dabob Bay	1995 – 1999	8/12	4.78	79.2	27.1	102	102	37.3	75.2	43.1	95% KM (BCA) UCL
Discovery Bay	1994 – 2003	14/14	3.75	51.5	26.9	na	na	29.3	48.5	34.9	95% Student's-t UCL
Rich Passage	1998	2/2	5.84	14.7	10.3	na	na	10.3	14.7	14.7	maximum detect
Samish	1989	13/24	6.63	41.9	19.8	13.4	102	16.7	41.9[e]	21.6	95% KM (t) UCL
Saratoga Passage	1996 – 1997	7/8	15.9	105	55	272	272	58	105[e]	75.3	95% KM (t) UCL
Sequim Bay	1994 – 2002	15/20	2.20	49.4	19.2	8.5	256	18.1	49.4[e]	24.7	95% KM (percentile bootstrap) UCL
West Beach	1986 – 1990	3/9	22.7	29.2	26.6	4.0	13.7	6.4	29.2	29.2	maximum detect
Wollochet Bay	1982 – 1996	3/3	7.00	16.6	12	na	na	12.5	16.6	16.6	maximum detect
Puget Sound 2008 Survey											
Puget Sound	2008	61/70	1.7	58	7.9	1.3	2.5	4.5	15	9.2	95% KM (BCA) UCL
Puget Sound 2008 Survey (mg/kg OC)											
Puget Sound	2008	53/59	0.11	2.8	0.56	0.11	2.8	0.29	1.2	0.81	95% KM (Chebyshev) UCL

Note: Multiple datasets have been collected over time; there were no consistent temporal trends in the data.

[a] Total cPAHs were calculated by summing the products of individual PAH concentrations and compound-specific PEFs for the seven individual cPAH compounds (benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, benzo(k) fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene), as discussed in Appendix E. Total cPAHs were considered detected if one or more of the individual cPAH compounds were detected. For non-detected compounds, one-half the RL was multiplied by the PEF when calculating cPAH concentrations.

[b] Non-detected values for samples in which none of the individual cPAH compounds were detected were calculated as described in Footnote a.

[c] Percentiles are non-parametric percentiles calculated using methods presented in the *National Institute of Standards and Technology Handbook of Statistical Methods* (NIST/SEMATEC 2009). For samples in which none of the cPAHs were detected, one-half the calculated cPAH concentration was used (see Footnote a).

[d] UCLs were calculated using ProUCL 4 statistical software (EPA 2007e), which accounts for non-detect values in the calculation of UCLs.

[e] The 90th percentile value was higher than the maximum detected value because of elevated RLs.

BCA – bias-corrected accelerated
cPAH – carcinogenic polycyclic aromatic hydrocarbon
KM – Kaplan Meier
na – not applicable
PEF – potency equivalency factor
RL – reporting limit
TEQ – toxic equivalent
UCL – upper confidence limit on the mean

7.1.5 Dioxins and furans sediment datasets to be considered for natural background

The Puget Sound 2008 survey provides a robust reference dataset for dioxins and furans; prior to this survey relatively few reference data were available for dioxins and furans. At least one dioxin or furan congener was detected in every sample collected as part of the 2008 survey and in the other two Puget Sound locations sampled (Maps 7-1 and 7-2). Among all of the datasets, dioxin and furan TEQs ranged from 0.067 ng/kg dw in a sample collected from Freshwater Bay to 12 ng/kg dw in a sample collected from the South Sound (Figure 7-4; Table 7-5). For samples from the Puget Sound 2008 survey, OC-normalized dioxin and furan TEQs ranged from 0.028 to 0.30 µg/kg OC, with a mean concentration of 0.10 µg/kg OC (Table 7-5).

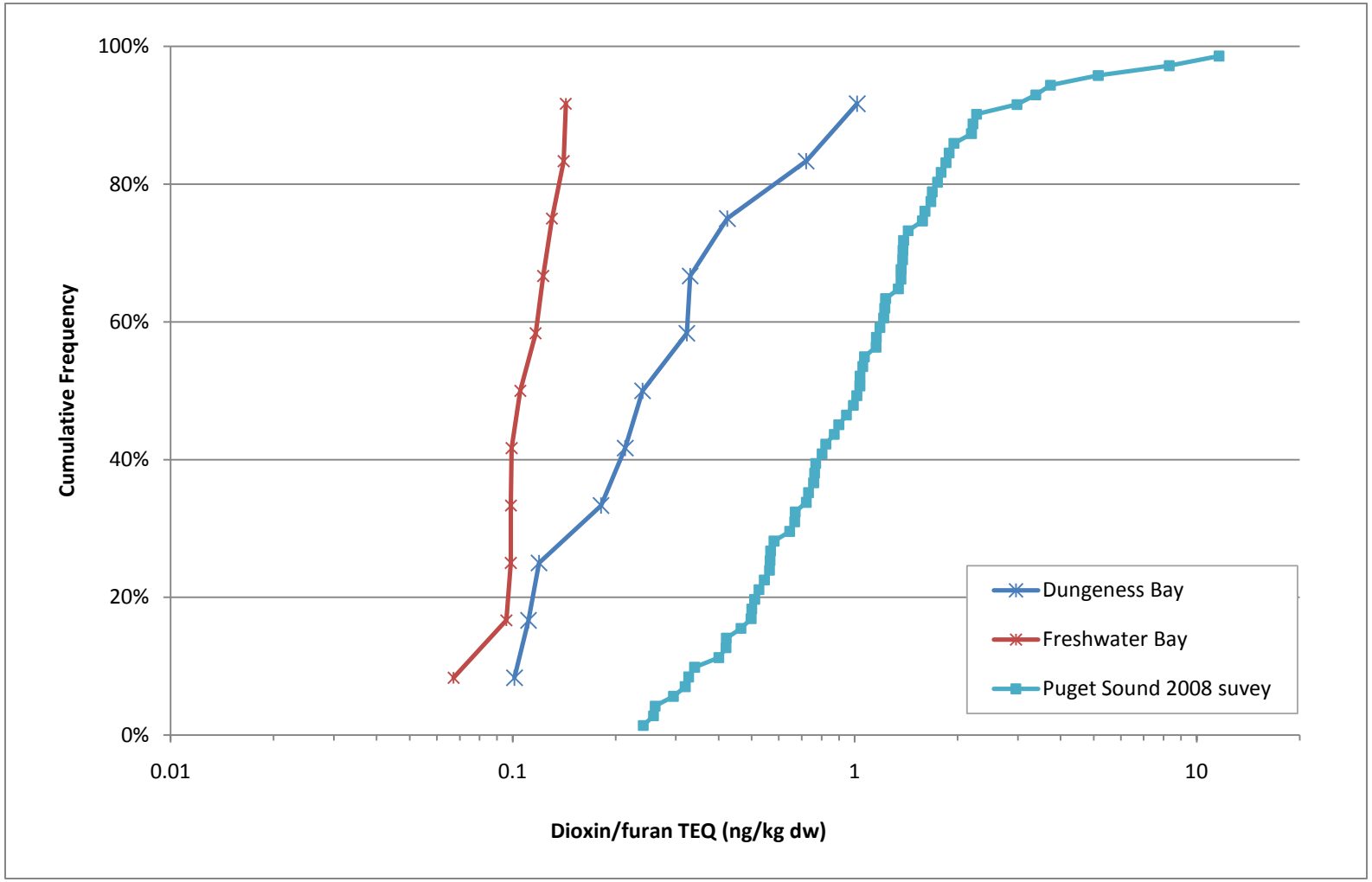


Figure 7-4. Cumulative frequency of dioxin and furan TEQs in surface sediment collected from two Puget Sound locations and as part of the 2008 survey

Table 7-5. Summary of dioxin and furan TEQ datasets to be considered for natural background

Sampling Location	Sampling Period	Concentration (ng/kg dw)[a]							UCL Type
		Detection Frequency	Minimum Detect	Maximum Detect	Mean Detect	50TH Percentile[b]	90TH Percentile[b]	95% UCL[c]	
Dungeness Bay	2006	11/11	0.101	1.02	0.344	0.24	0.721	0.542	95% Approximate gamma UCL
Freshwater Bay	2006	11/11	0.067	0.143	0.111	0.105	0.141	0.123	95% Student's-t UCL
Puget Sound	2008	70/70	0.24	12	1.4	1.0	2.3	1.6	95% H-UCL
TOC-normalized dioxin and furan TEQ data (µg/kg OC)									
Puget Sound	2008	59/59	0.028	0.30	0.10	0.088	0.19	0.12	95% H-UCL

[a] Dioxin and furan TEQs were calculated by summing the products of individual congener concentrations and congener-specific TEFs, as discussed in Appendix E. A dioxin and furan TEQ value was considered detected if one or more of the congeners were detected. For non-detected congeners, the TEF was multiplied by one-half the RL.

[b] Percentiles are non-parametric percentiles calculated using methods presented in the *National Institute of Standards and Technology Handbook of Statistical Methods* (NIST/SEMATEC 2009).

[c] UCLs were calculated using ProUCL 4 statistical software (EPA 2007e), which accounts for non-detect values in the calculation of UCLs.

dw – dry weight
H – Land's H statistic
na – not applicable
nc – not calculated
RL – reporting limit
TEF – toxic equivalency factor
TEQ – toxic equivalent
UCL – upper confidence limit on the mean

7.2 UPSTREAM AND UPPER TURNING BASIN DATA

This section presents concentrations of PCBs, arsenic, cPAHs, and dioxins and furans in surface sediment samples that were collected upstream of the LDW, as well as in subsurface sediment samples that were collected in the Upper Turning Basin of the LDW. Various data were considered as separate lines of evidence. The following three types of data are presented in this section:

- Surface sediment data collected upstream of RM 5.0
- Sediment core data collected between RM 4.0 and RM 4.75 by USACE for dredged material characterization
- Estimated chemical concentrations in upstream suspended solids based on Green/Duwamish River water chemistry and total suspended solids data

The types of data listed above were collected for various purposes; thus, each line of evidence may have uncertainties and biases with respect to characterizing chemical concentrations in sediment likely to deposit within the LDW. Therefore, all lines of evidence will be evaluated as part of the overall background assessment in the FS, wherein the uncertainties and biases for each of the lines of evidence will be discussed and evaluated in detail.

Section 7.2.1 provides a brief overview of sediment transport processes to provide additional context for the different lines of evidence. The data sources and methods for evaluation of each of these datasets are presented in Sections 7.2.2 through 7.2.4.

7.2.1 Review of sediment transport processes and sediment physical properties

As summarized in Section 3, extensive analysis of sediment transport processes has been conducted in recent years, primarily through the use of the STM. One important conclusion reached through the application of the STM is that approximately 99% of the total external sediment load to the LDW comes from the Green River, upstream of the LDW. About 50% of this total load settles in the LDW. The remaining load, comprised mostly of finer silt-clay particles, is transported out of the LDW because these particles have slower settling velocities and thus travel greater distances than coarser particles prior to deposition. Approximately 10% of the fine silt-clay particles that enter the LDW system, either from upstream or lateral sources, are deposited in the LDW. In contrast, 76, 96, and > 99% of the other particle classes (medium-coarse silt, fine sand, and medium-coarse sand, respectively) from upstream or lateral sources are deposited in the LDW.

Twenty-four percent of the total sediment load entering the upstream end of the STM study area (defined as RM 4.75) is bedload,[122] which primarily settles in the Upper

[122] Bedload is that portion of sediment that can be transported by intermittent contact with the streambed by rolling, sliding, and bouncing.

Turning Basin (RM 4.5 to RM 4.75) (QEA 2008). The remainder of the total sediment load entering the STM study area (76%) is suspended material. This material generally consists of finer fractions (i.e., clay, silt, and fine sand) with lower settling velocities compared with bedload sand, and therefore, is generally transported greater distances in the LDW. These finer fractions may have higher chemical concentrations than the coarser bedload (i.e., medium and coarse sand) because of the affinity of chemicals (such as hydrophobic PCBs, cPAHs, and dioxins and furans) to sorb to finer sediments with high surface area-to-volume ratios and higher TOC (Hedges and Keil 1995). Potential differences in chemical concentrations between larger-size-fraction bedload and smaller-size-fraction suspended materials may also be mirrored by differences in chemical concentrations among the various size fractions of the suspended materials themselves. As noted in Section 3, much of the finest particulate matter from upstream may be carried through the LDW without depositing to LDW sediments, and chemical concentrations may increase as particle size decreases. These issues related to representativeness of potential background datasets will be evaluated in further background analyses and determinations but are not assessed in this section. All representativeness issues and sources of potential bias in candidate background datasets will be discussed in detail in the FS.

As a result of the sediment transport processes described above, sediments sampled in various locations tend to have differing physical properties. Table 7-6 summarizes the TOC content and percent fines (sum of silt and clay fractions) of the upstream sediment data (i.e., surface sediment data from RM 5.0 to RM 7.0), subsurface sediment data from the navigation channel between RM 4.0 and RM 4.75, and surface sediment data from the LDW up to RM 4.0. The subsurface sediment chemistry data were further subdivided to reflect longitudinal differences between the Upper Turning Basin and sediments collected closer to RM 4.0.

The TOC and percent fines values for available surface sediment samples upstream of RM 5.0 were much lower than those values for surface sediments below RM 4.0. These results are consistent with the observation that suspended solids, which primarily consist of fine particles with relatively higher TOC content (compared with sand) are transported from upstream regions (above RM 5.0) throughout the LDW. The subsurface sediment data from RM 4.0 to RM 4.4 were similar to data from surface sediment in RM 0.0 to RM 4.0 (Table 7-6). In contrast, the data close to and within the Upper Turning Basin more closely resembles the surface sediment data from upstream of RM 5.0. These results are consistent with the observation that coarser bedload fractions from upstream regions are preferentially deposited within and near the Upper Turning Basin compared with more downstream locations.

Table 7-6. Total organic carbon and percent fines data for upstream sediment datasets compared with LDW surface sediment from RM 0.0 to RM 4.0

PARAMETER	SURFACE SEDIMENT (RM 0.0 to RM 4.0)	SUBSURFACE SEDIMENT (RM 4.0 TO RM 4.4)[a]	SUBSURFACE SEDIMENT (RM 4.4 TO RM 4.75)[a]	SURFACE SEDIMENT (RM 5.0 TO RM 7.0)
Total Organic Carbon (%)				
Average	1.97	1.94	1.26	0.83
Minimum	0.05	0.60	0.03	0.068
Maximum	11.5	2.80	3.10	2.31
10th percentile	0.91	1.41	0.44	0.08
90th percentile	2.89	2.60	2.74	1.93
Percent Fines				
Average	52.8	58.2	17.0	24.1
Minimum	1.6	23.0	2.6	0.01
Maximum	100	78.0	36.7	65.0
10th percentile	13.5	49.0	6.0	0.01
90th percentile	85.8	69.0	34.2	57.0

[a] The subsurface sediment samples collected from the navigation channel between RM 4.0 and 4.75 generally represent composite samples from sediment cores that start at the mudline and therefore include sediment from the surface interval (i.e., the top 10 cm).

LDW – Lower Duwamish Waterway

RM – river mile

7.2.2 Upstream surface sediment data – RM 5.0 to RM 7.0

Data were compiled for total PCBs, arsenic, cPAHs, and dioxins and furans in both suspended matter and bedded sediments upstream of the LDW (RM 5.0 to RM 7.0); sampling locations are shown on Map 7-5.[123] These data were evaluated to assess the quality of sediment potentially being transported into the LDW from the Green/Duwamish River system. Table 7-7 presents a statistical summary of the data. Dioxins and furans and cPAHs were calculated as TEQs using methods described in Appendix E, Sections E.3.6 (dioxins and furans) and E.3.7 (cPAHs).

Relatively few upstream surface sediment locations were sampled for dioxins and furans (4 locations) compared with 37, 24, and 16 locations for total PCBs, arsenic, and cPAHs, respectively (Table 7-8). Mean and 90th percentile concentrations were 23 and 40 µg/kg dw for total PCBs, 6.8 and 11 mg/kg dw for arsenic, and 55 and 135 µg/kg dw for cPAH, respectively (Table 7-7). The mean dioxin and furan TEQ was 2.0 ng/kg

[123] Because of the small number of dioxin and furan samples collected between RM 5.0 and RM 7.0 (three), one sample collected from Springbrook Creek (which enters the Duwamish River through the Black River at approximately RM 10.2) was included in the dioxin and furan dataset.

dw (Table 7-7); percentiles were not calculated for dioxins and furans because of the small sample size.

Ecology conducted a study investigating chemical concentrations in bedded sediments between RM 4.9 and RM 6.5, and the data resulting from that study will also be considered in the FS when they are available. The Ecology study was conducted to reduce the uncertainty in the characterization of chemical conditions in upstream sediments, which is currently based on a relatively small number of samples relative to the number of sediment samples in the LDW study area, and to assess whether there are any point sources in this upstream area. The existing upstream surface sediment data were collected for various purposes and may not provide an unbiased representation of chemical concentrations in upstream areas.

Table 7-7. Summary statistics for upstream datasets and USACE cores in the Upper Turning Basin of the LDW

Chemical and Data Type	No. of Samples	Detection Frequency (%)	Concentration					Percentile[b]		95% UCL[c]	UCL Type[c]
			Minimum Detect	Maximum Detect	Minimum Non-Detect[a]	Maximum Non-Detect[a]	Mean[b]	50TH	90TH		
Total PCBs (µg/kg dw)[d]											
Upstream surface sediment[e]	37	49	1.6	140	0.6	40	23	19	40	21	95% KM (BCA) UCL
RM 4.0 to RM 4.75 – USACE cores[f]	37	81	10.8	300	20	52	56	38	86	96	95% KM (BCA) UCL
Upstream suspended solids[g, h]	22	100	2.8	367	na	na	50	21	107	82	95% Approximate Gamma UCL
Total PCBs (mg/kg OC)											
Upstream surface sediment[e, i]	20	55	0.23	10.5	0.1	3.7	2.1	1.0	3.7	5.6	97.5% KM (Chebyshev) UCL
RM 4.0 to RM 4.75 – USACE cores[f, i]	35	86	0.86	15.8	1.1	6.8	3.3	2.1	6.2	5.4	95% KM (Chebyshev) UCL
Upstream suspended solids[g, i, j]	18	100	0.06	2.7	na	na	0.5	0.2	1.3	1.5	97.5%Chebyshev UCL
Arsenic (mg/kg dw)											
Upstream surface sediment[e]	24	100	3.3	22	na	na	6.8	5.4	11	8.0	95% Approximate Gamma UCL
RM 4.0 to RM 4.75 – USACE cores[f]	35	97	3.0	15	9.4	9.4	7.6	6.5	13	8.4	95% KM (BCA) UCL
Upstream suspended solids[g, h]	100	100	0.50	133	na	na	37	29	73	47	95% Chebyshev UCL
cPAHs (µg/kg dw)											
Upstream surface sediment[e]	16	44	36	260	9	18	55	18	135	100	95% KM (t) UCL
RM 4.0 to RM 4.75 – USACE cores[f, k]	36	97	14.6	270	14	14	117	107	201	137	95% KM (t) UCL
Upstream suspended solids[g,h,]	18	67	29	408	22	244	151	74	354	269	95% KM (Chebshev) UCL
cPAHs (mg/kg OC)											
Upstream surface sediment[e, i]	7	86	1.8	20	1.8	1.8	7.1	2.5	18	20	95% KM (Chebshev) UCL
RM 4.0 to RM 4.75 – USACE cores[f, i, k]	34	97	0.64	21	0.4	0.4	7.3	6.6	12	8.7	95% KM (BCA) UCL
Upstream suspended solids[g,i, j]	15	60	0.77	6.8	1.2	6.5	2.8	1.9	5.5	3.0	95% KM (t) UCL
Dioxins and furan TEQ (ng/kg dw)											
Upstream surface sediment[e]	4	100	1.1	2.6	na	na	2.0	1.7	nc	nc	nc

Chemical and Data Type	No. of Samples	Detection Frequency (%)	Concentration					Percentile[b]		95% UCL[c]	UCL Type[c]
			Minimum Detect	Maximum Detect	Minimum Non-Detect[a]	Maximum Non-Detect[a]	Mean[b]	50TH	90TH		
Dioxin and furan TEQ (µg/kg OC)											
Upstream surface sediment[e, i]	2	100	0.1	0.2	na	na	0.2	nc	nc	nc	nc

Source: AECOM (Rodriguez Lattuada 2010)

[a] For arsenic, non-detect values are equal to the full RL. For total PCBs, cPAHs, and dioxin and furans, non-detects indicate that no individual components of the calculated total or TEQ were detected. For total PCBs, the total was calculated as the sum of detected values for the individual components, and the non-detect value is the maximum RL for an individual Aroclor. For cPAH and dioxin and furan TEQs, non-detect values were calculated using the full the RL for non-detected components multiplied by the PEF or TEF, respectively.

[b] The mean and percentile concentrations were calculated using statistical software ProUCL 4.00.04 (EPA 2007e), with non-detects set at full reporting limit.

[c] UCLs were calculated using ProUCL 4 statistical software (EPA 2007e), which accounts for non-detect values in the calculation of UCLs. Selected UCL is the recommended UCL value by ProUCL.

[d] Seventeen samples were analyzed for PCB Aroclors and twenty samples were analyzed using the NOAA method described in Section 4.1.3.3.

[e] Upstream surface sediment samples from 1994 to 2006.

[f] USACE core (RM 4.0 to 4.75) samples from 1990 to 2003.

[g] Upstream suspended solids samples from 2001 to 2008 (King County whole water samples). King County surface water data normalized to solid fractions by dividing by the TSS in the individual sample. All detected arsenic concentrations associated with TSS were calculated as the difference between whole-water (i.e., unfiltered) and filtered sample data.

[h] Concentrations of chemicals on suspended solids were estimated as described in Section 7.2.4 (in units of µg/kg TSS for total PCBs and cPAHs and mg/kg TSS for arsenic).

[i] Some samples were not OC-normalized because the TOC was ≤ 0.5 or ≥ 4%. Therefore, the sample size for the OC-normalized data is smaller than the sample size for the dry weight data.

[j] Data were normalized to the POC content in water. The POC was calculated as the difference between the TOC and the DOC. Only samples with both types of data and where the TOC was greater than the DOC were used. Therefore, the sample size for the OC-normalized data is smaller than the sample size for the TSS normalized data.

[k] One sample concentration (1,052 µg/kg dw) was excluded from the cPAH dataset because it was an outlier (as determined by outlier tools in ProUCL software).

BCA – bias-corrected accelerated
cPAH – carcinogenic polycyclic aromatic hydrocarbon
DOC – dissolved organic carbon
dw – dry weight
KM – Kaplan-Meier
LDW – Lower Duwamish Waterway
na – not applicable
nc – not calculated
OC – organic carbon
PCB – polychlorinated biphenyl
PEF – potency equivalency factor
POC – particulate organic carbon
RL – reporting limit
RM – river mile
TEF – toxic equivalency factor
TEQ – toxic equivalent
TOC – total organic carbon
TSS – total suspended solids
UCL – upper confidence limit on the mean
USACE – US Army Corps of Engineers

Table 7-8. Surface sediment sampling events conducted upstream of the LDW

Sampling Event (Event Code)	Year Conducted	River Mile	Number of Samples (number of detects)				Source
			PCBs	Arsenic	cPAHs	Dioxins and Furans	
LDW RI: surface sediment sampling for chemical analyses and toxicity testing (LDWRI-SurfaceSediment Round2)	2005	5.1 – 5.8	6 (0)	6 (6)	6 (4)	0	Windward (2005d)
LDW RI: surface sediment sampling for chemical analyses and toxicity testing (LDWRI-SurfaceSediment Background)	2005	5.3 (PCBs) 6.1 – 7.0 (arsenic) 5.3 and 10.2 (dioxins and furans)[a]	1 (0)	8 (8)	0	2 (2)	Windward (2005i)
EPA site inspection: Lower Duwamish River (EPA SI)	1998	5.3 – 5.5	5 (0)	5 (5)	5 (0)	2 (2)	Weston (1998)
Duwamish Waterway Phase 1 site characterization (Boeing SiteChar; upstream reference samples)	1997	6.1	3 (0)	3 (3)	3 (2)	0	Exponent (1998)
Duwamish Waterway sediment characterization study (NOAA SiteChar)	1997	5.2 – 6.0	20 (18)	0	0	0	NOAA (1997, 1998)
Norfolk CSO sediment cleanup study – Phase 1 (Norfolk-cleanup1)	1994	5.4 – 5.5	2 (0)	2 (2)	2 (1)	0	King County (1996)
Total numbers of samples			**37 (18)**	**24 (24)**	**16 (7)**	**4 (4)**	

[a] This sample was collected in Springbrook Creek, which enters the Duwamish River at approximately RM 10.2.

cPAH – carcinogenic polycyclic aromatic hydrocarbon
CSO – combined sewer overflow
EPA – US Environmental Protection Agency
LDW – Lower Duwamish Waterway
NOAA – National Oceanographic and Atmospheric Administration
PCB – polychlorinated biphenyl
RI – remedial investigation
SI – site investigation

7.2.3 USACE dredged material

The Seattle District USACE has been characterizing sediments in the Upper Turning Basin and in the navigation channel immediately downstream of the Upper Turning Basin as part of their on-going navigation maintenance dredging responsibilities. The area between RM 4.3 and RM 4.75 is dredged approximately every 2 years, while the section between RM 4.0 and RM 4.3 is dredged approximately every 4 years. The material dredged from this area over the past 15 years has been deemed acceptable for open-water disposal by the USACE under the DMMP program. Data from this portion of the navigation channel provides another line of evidence for characterizing the potential contribution of upstream sediment to the LDW because they represent relatively recent material deposited from upstream of the LDW. There are

uncertainties in the use of this dataset for characterizing this contribution, primarily related to the partitioning between coarse and fine-grained material in this region, and because of the unknown contribution from sources within the LDW (Table 7-6). The suitability of these data for characterizing background will be discussed in the FS.

USACE provided chemical and physical data for subsurface sediment samples collected between RM 4.0 and RM 4.75 from 1990 to 2003 (Fox 2007) based on a database query of the Dredged Analysis Information System (DAIS). Subsurface sediment samples were also collected in this area in 2008 and 2009, although data were not available for inclusion in this evaluation. For the purposes of dredged sediment characterization, the USACE has been compositing sediment cores for characterization both vertically (generally 0-to-4-ft intervals but occasionally as deeper intervals, up to 10 ft), and in some cases, horizontally (compositing two or more cores collected across the basin or navigation channel). Figures 7-5, 7-6, and 7-7 present the total PCB, arsenic, and cPAH concentrations, respectively, as a function of time relative to dredging events. The sampling locations are shown on Map 7-6.

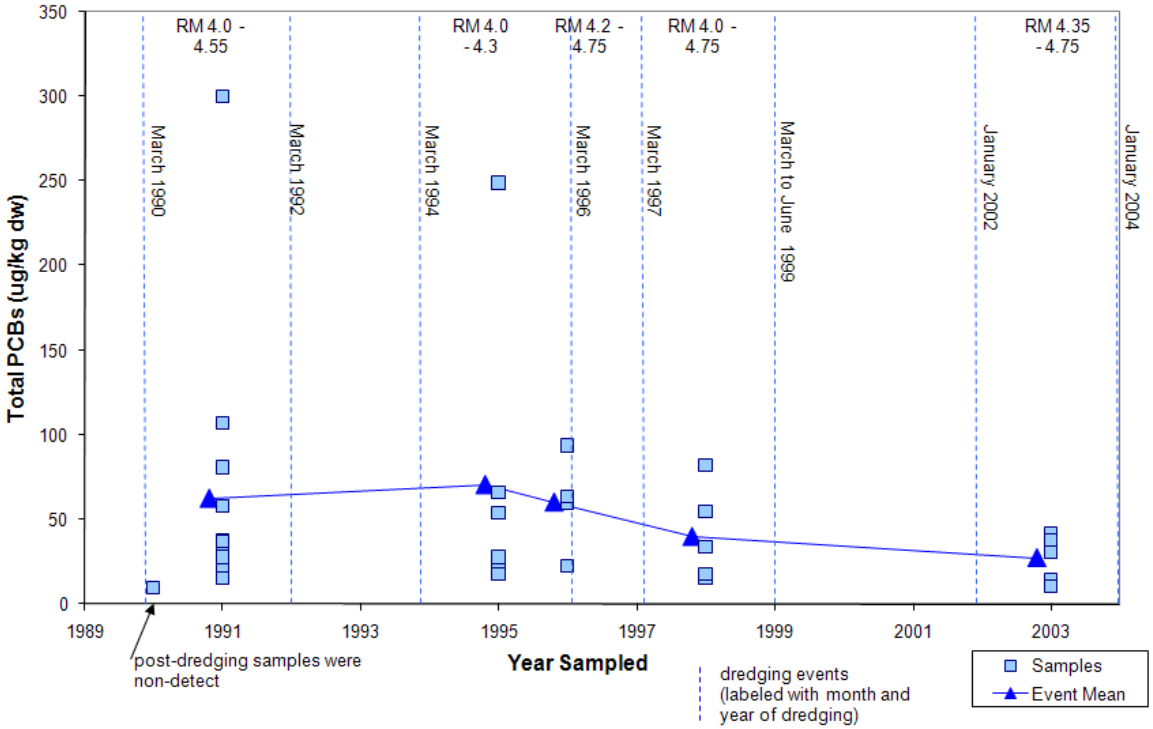


Figure 7-5. Total PCB concentrations in cores collected for dredged material characterization from RM 4.0 to RM 4.75 over time

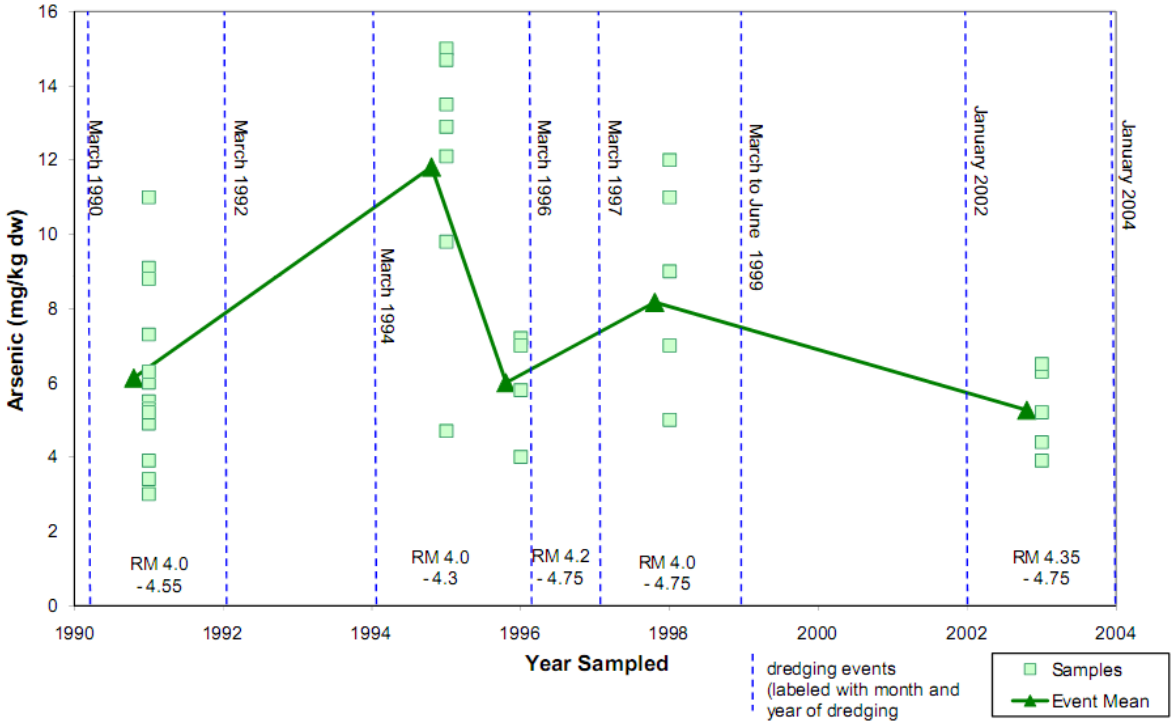
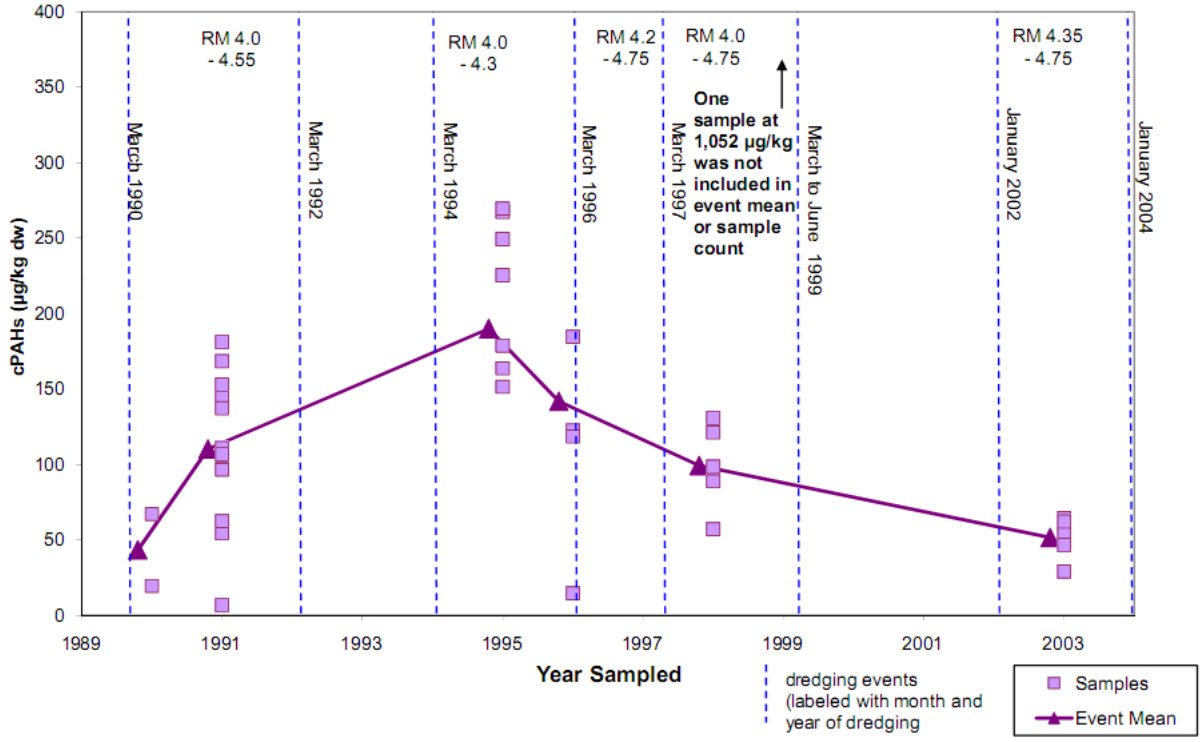


Figure 7-6. Arsenic concentrations in cores collected for dredged material characterization from RM 4.0 to RM 4.75 over time



Note: Total cPAHs were calculated by summing the products of concentrations and compound-specific PEFs for individual cPAH compounds, as discussed in detail in Appendix E, Section E.3.

Figure 7-7. cPAH concentrations in cores collected for dredged material characterization from RM 4.0 to RM 4.75 over time

The mean and 90th percentile concentrations for data collected between 1990 and 2003 were 56 and 86 µg/kg dw for total PCBs, 7.6 and 13 mg/kg dw for arsenic, and 117 and 201 mg/kg dw for cPAH (Table 7-7). One sample concentration (1,052 µg/kg dw) was excluded from the cPAH dataset because it was an outlier (as determined by outlier tools in ProUCL software). Additional analysis of potential outliers will be conducted in the FS.

7.2.4 Water quality data

As discussed in Section 7.2.1, solids may be transported through bedload processes or in suspension in the water column. Suspended solids typically have higher proportions of finer particles, such as silt and clay, compared with material transported by bedload processes, which typically consists of sands. By using chemical data for whole water (i.e., unfiltered) samples and the TSS concentrations for those same samples, an estimate of the chemical concentration in the suspended solids can be generated.

There are a number of uncertainties and potential biases associated with these estimates to characterize chemical concentrations on upstream solids that settle in the LDW. These uncertainties include:

- Greater temporal variation in water quality vs. sediment quality (grab samples vs. integrated sampling technique)
- Small number of storm events sampled with moderate to high TSS, when much of the sediment transport occurs
- Assumptions regarding the extent of partitioning of PCBs and cPAHs in unfiltered water samples to particles
- The relevance of these data with respect to deposition of sediment within the LDW (e.g., potential influence of particle size fraction on chemical concentrations, and differential deposition and transport throughout the LDW)

These factors will be discussed and evaluated further in the FS. In addition, Ecology is currently conducting a study investigating the chemical concentrations associated with suspended solids in high-volume water samples upstream of the LDW (Ecology 2008b). The Ecology data will also be considered in the FS when they are available.

King County water quality data from the lower Green/Duwamish Rivers were used to estimate the concentrations of total PCBs (as a sum of PCB congeners), arsenic, and cPAHs associated with suspended solids in samples collected upstream of the LDW. The King County sampling events for which data are available for this analysis are summarized in Table 7-9. Two stations have been sampled by King County in the lower Green and Duwamish Rivers upstream of the LDW: the Duwamish River at E Marginal Way S (RM 6.3) and the Green River at Fort Dent (~RM 10.5 to RM 11.0; Map 7-7). Whole-water concentrations of PCBs and cPAHs were normalized to the sample-specific TSS concentration and expressed as µg/kg TSS. Solids-associated

arsenic concentrations were calculated as the difference between total and filtered sample results, normalized to the sample-specific TSS and expressed as mg/kg TSS.

Table 7-9. Available water quality data from the Lower Green/Duwamish Rivers upstream of the LDW

Analyte	Sampling Location	Type of Data	Sampling Years	Study and Reference
PCB congeners[a]	Green River – Fort Dent	grab samples; total (unfiltered)	2005	Duwamish River/Elliott Bay/Green River water column PCB congener survey (Mickelson and Williston 2006)
			2007 – 2008	unpublished data from King County; (2002b, 2007f)
	Duwamish River at E Marginal Way S		2007	unpublished data from King County (2002b, 2007f)
Arsenic	Green River – Fort Dent	grab samples; total (unfiltered) and dissolved (filtered)	2001 – 2003	Green-Duwamish Watershed water quality assessment (Herrera 2004b, 2005).
			2004 –2006	unpublished data from King County (King County 2002b, 2007f)
cPAHs[a]	Green River – Fort Dent	grab samples; total (unfiltered)	2008	unpublished data from King County (King County 2002b, 2007f)
	Duwamish River at E Marginal Way S			

Note: Each sample summarized above was also analyzed for TSS.

[a] King County analyzed unfiltered water samples collected from the Green River location in 2001 to 2003 for PAHs and PCBs as Aroclors, but these compounds were not detected in any samples (Herrera 2004b, 2005).

cPAH – carcinogenic polycyclic aromatic hydrocarbon

LDW – Lower Duwamish Waterway

PCB – polychlorinated biphenyl

TSS – total suspended solids

The following subsections present the results of King County water quality data for PCBs, arsenic, and cPAHs.

7.2.4.1 PCB congeners

King County collected unfiltered surface water samples from the Green River at Fort Dent from 2001 to 2003 for analyses of total PCBs (as Aroclors) (Map 7-7). PCBs were not detected in any of these samples at detection limits ranging from 0.04 to 0.06 µg/L (Herrera 2004b, 2005).

Thus, in order to achieve lower detection limits, King County analyzed a total of 21 upstream water samples in 2005 and 2007/2008 for all 209 PCB congeners using EPA Method 1668. Unfiltered surface water samples were collected from the same location at Fort Dent four times in 2005 (August to December), nine times in 2007 (March to December), and once in 2008 (June) and analyzed for PCB congeners and TSS (Mickelson and Williston 2006) (Table 7-10). Two of the 2007 samples and the June

2008 sample were collected as part of King County's wet weather event streams sampling program, and thus were collected during storm events. Surface water samples were also collected from the Duwamish River at the E Marginal Way S Bridge at S 155th Street (RM 6.3) seven times in 2007 (March to December) and analyzed for PCB congeners and TSS (Map 7-7) (Axys 2008).

Table 7-10. Total PCB and TSS concentrations in upstream surface water samples and estimated total PCB concentrations associated with suspended solids

Data Type	Daily Average Flow (cfs)[a]	Surface Water				Suspended Solids (estimated)	
		Total PCB (µg/L)[b]		TSS (mg/L)		Total PCBs (µg/kg TSS)	
		Green River at Fort Dent	Duwamish River at E Marginal Way S	Green River at Fort Dent	Duwamish River at E Marginal Way S	Green River at Fort Dent	Duwamish River at E Marginal Way S
Individual Events							
August 22, 2005	277	0.000222	no data	5.2	no data	43	no data
September 26, 2005	378	0.0007839	no data	8.0	no data	98	no data
November 28, 2005	1,060	0.000442[c]	no data	3.6[c]	no data	110[d]	no data
December 19, 2005	550	0.00004084	no data	2.0 U	no data	20	no data
March 7, 2007	1,680	0.0001286	0.0005144	14.7	9.6	8.7	53.6
April 4, 2007	1,620	0.0001012[c]	0.00009948	35.8[c]	10	2.8[d]	9.9
May 9, 2007	1,460	0.00003845	0.0000762[c]	5.8	2.1[c]	6.6	36[d]
May 21, 2007 – storm[e]	985	0.001543	no data	4.2	no data	370	no data
June 6, 2007	840	0.0000491[c]	0.0001460	4.3[c]	3.5	11[d]	42
October 10, 2007	941	0.0000542[c]	0.0000711	7.8[c]	9.3	7.0[d]	7.6
November 7, 2007	539	0.00004046	0.0000603[c]	1.8	1.5[c]	23	41[d]
December 3, 2007 – storm[e]	2,550	0.002395[c]	no data	71.1[c]	no data	34.0[d]	no data
December 12, 2007	1,200	0.000057[c]	0.0000699	10.8[c]	7.4	5.3[d]	9.4
June 3, 2008 – storm[e]	2,190	0.000240	no data	21.8	no data	9.3	no data
August 20, 2008 – storm[e]	321	0.0015	no data	9.24	no data	162	no data
Summary Statistics							
Number of samples	na	22		22		22	
Detection frequency	na	22 / 22		22 / 22		22 / 22	
Mean	1,162	0.000392		11		50[f]	
Minimum	277	0.0000385		1.5		2.8	
Maximum	2,550	0.002395		71.1		367	
RL or range of RLs	na	na		na		na	
25th Percentile	547	0.000056		3.5		8.2[f]	
50th Percentile	1023	0.000100		6.9		21[f]	
75th Percentile	1635	0.000460		13.6		42[f]	

Data Type	Daily Average Flow (cfs)[a]	Surface Water				Suspended Solids (estimated)	
		Total PCB (µg/L)[b]		TSS (mg/L)		Total PCBs (µg/kg TSS)	
		Green River at Fort Dent	Duwamish River at E Marginal Way S	Green River at Fort Dent	Duwamish River at E Marginal Way S	Green River at Fort Dent	Duwamish River at E Marginal Way S
90th Percentile	2,370	0.001530		25.3		107[f]	

[a] Flow data are from the USGS station 12113000 at Auburn, Washington.

[b] Total PCB concentrations were calculated as the sum of detected PCB congeners, which is consistent with the totaling method used for total PCBs based on Aroclors.

[c] Field replicates were collected for these samples; the average total PCB and TSS concentrations shown represent averages of the original and field replicates.

[d] Field replicates were collected for these samples. The average TSS-normalized total PCB concentrations were first calculated separately for the original and the field replicate, and then the two concentrations were averaged.

[e] A storm was a targeted event with at least 0.25-in. rainfall over 24 hours, with a minimum of 24 hours antecedent dry. The other sampling events were conducted during routine monthly monitoring and may or may not correspond to storm events.

[f] The mean and percentile concentrations were calculated using statistical software ProUCL 4.00.04 (EPA 2007e), with non-detects set at full reporting limit.

cfs – cubic feet per second
dw – dry weight
na – not applicable
PCB – polychlorinated biphenyl
RL – reporting limit
TSS – total suspended solids

Summary statistics were calculated for total PCB concentrations (sum of detected PCB congeners) in surface water and estimated total PCB concentrations in suspended solids.[124] Total PCB concentrations in surface water samples ranged from 0.00003845 to 0.002395 µg/L, with mean and 90th percentile concentrations of 0.000340 and 0.001391 µg/L, respectively. The mean and 90th percentile concentrations for total PCBs in suspended solids were estimated to be 50 and 107 µg/kg dw TSS, respectively (Table 7-10). The highest concentrations of total PCBs were detected during two of the three sampled storm events (May 2007 and December 2007); at lower flow rates there does not appear to be any correlation between total PCB concentration and flow rate (Figure 7-8), although the relationship was not evaluated statistically. Total PCB concentrations during the third storm event (June 2008) were lower than during the other two storm events and some of the other sampling events. The other sampling events for PCBs and other analytes were conducted during routine monthly monitoring and may or may not correspond to rainfall events. Also, the duration and extent of the wet weather events were not evaluated when making this observation.

[124] TSS-normalized total PCB concentrations are conservative estimates of particulate-associated PCB concentrations because unfiltered samples likely include dissolved PCBs as well as PCBs associated with solids.

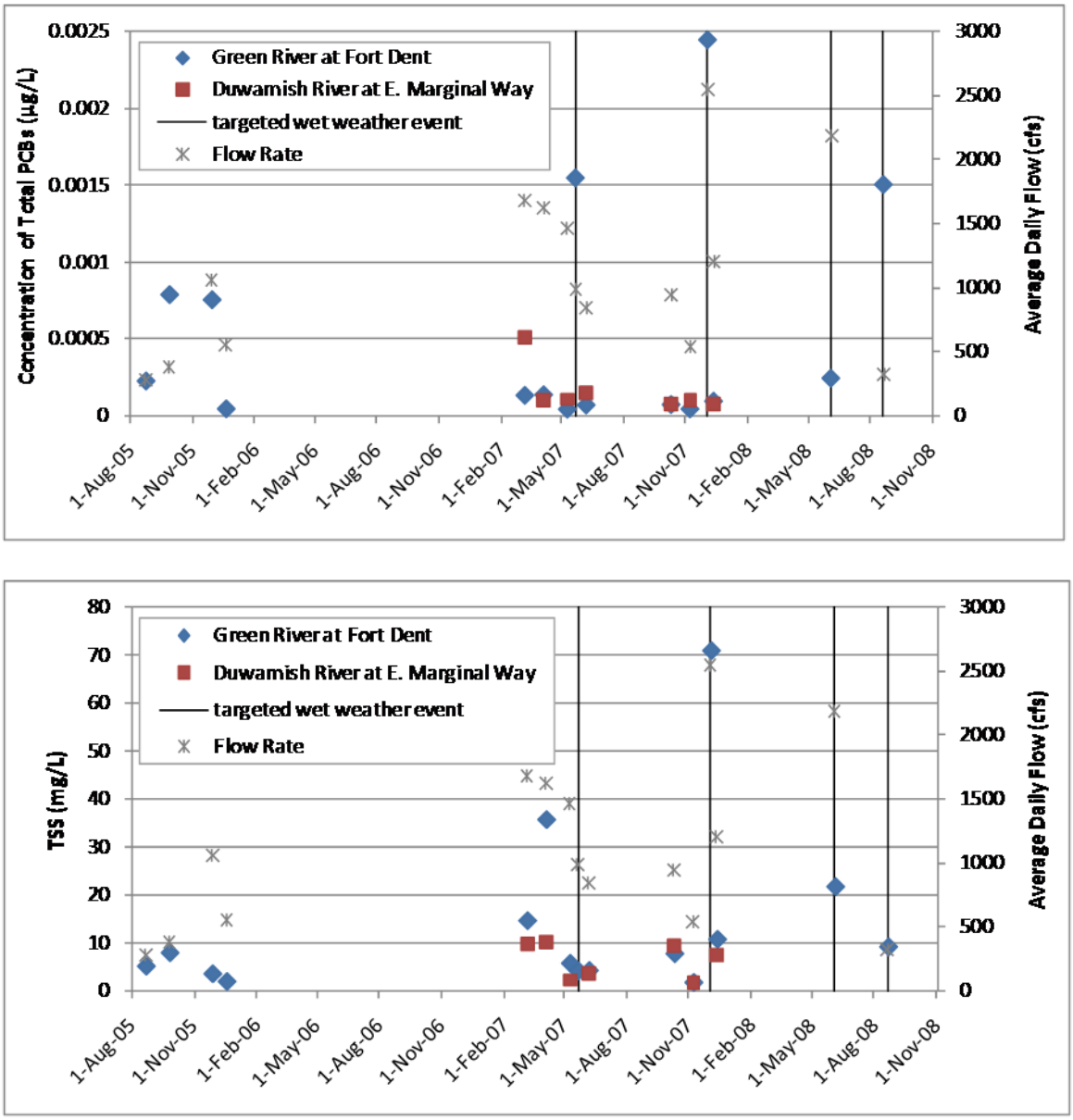


Figure 7-8. Total PCB and TSS concentrations in surface water at upstream Green /Duwamish River locations

For comparative purposes, total PCB concentrations in surface water from the LDW were also normalized using TSS concentrations to evaluate the PCB concentrations associated with total solids (Table 7-11). The highest flow rate was associated with the lowest TSS-normalized total PCB concentration at each location and depth, with a similar pattern for total PCB concentrations. The lowest flow rate was associated with the highest TSS-normalized total PCB concentration at two of the four locations and depths (RM 0.0 at 1 m above the bottom and RM 3.3 at 1 m below the surface).

Table 7-11. Total PCB and TSS concentrations in LDW surface water samples and estimated total PCB concentrations associated with suspended solids

Date	Daily Average Flow (cfs)[a]	Surface Water				Suspended Solids (estimated)	
		Total PCB (µg/L)[b]		TSS (mg/L)		Total PCBs (µg/kg TSS)	
		LDW at RM 0.0	LDW at RM 3.3	LDW at RM 0.0	LDW at RM 3.3	LDW at RM 0.0	LDW at RM 3.3
August 22, 2005							
1 m below the surface	277	0.001796	0.001592 J	4.80	3.40	370	470
1 m above the bottom		0.001814	0.003211	3.1	11.1	590	290
September 26, 2005							
1 m below the surface	378	0.001024	0.001452 J	6.00	5.00	170	290
1 m above the bottom		na	0.001883 J	3.7	5.8	na	320
November 28, 2005							
1 m below the surface	1,060	0.000591	0.000398	4.20	4.30	140	93
1 m above the bottom		0.00025	0.000132	2.0	4.20	130	31
December 19, 2005							
1 m below the surface	550	0.001947 J	0.001122	5.05	4.34	390	260
1 m above the bottom		0.000599	0.001341	2.9	3.7	210	360

[a] Flow data are from the USGS station 12113000 at Auburn, Washington.

[b] Total PCB concentrations were calculated as the sum of detected PCB congeners, which is consistent with the totaling method used for total PCBs based on Aroclors.

cfs – cubic feet per second
dw – dry weight
LDW – Lower Duwamish Waterway
na – not available
PCB – polychlorinated biphenyl
RM – river mile
TSS – total suspended solids

7.2.4.2 Arsenic

King County collected surface water samples from the Green River at Fort Dent from 2001 to 2006 for arsenic analysis (Map 7-7). Only samples with paired total and dissolved arsenic and TSS data, and with total arsenic concentrations greater than dissolved arsenic concentrations, were used to estimate arsenic concentrations associated with suspended solids. Particulate arsenic concentrations in water were calculated by subtracting (on a per-sample basis) dissolved arsenic from total arsenic concentrations in water. If, in a given sample, total arsenic was detected but dissolved arsenic was not, one half the method detection limit (MDL) for the dissolved arsenic was subtracted from the detected total arsenic concentration. The resulting particulate arsenic value was then normalized to the sample-specific TSS concentrations to estimate the arsenic concentrations in suspended solids.

Summary statistics were calculated for total and dissolved arsenic concentrations in surface water and for estimated arsenic concentrations associated with suspended solids. The mean and 90th percentile concentrations of total arsenic were 0.87 and 1.2 µg/L, respectively; the mean and 90th percentile concentrations of dissolved arsenic

were 0.52 and 0.71 µg/L, respectively (Table 7-12). The mean and 90th percentile concentrations of arsenic normalized to suspended solids were 37 and 73 mg/kg dw TSS, respectively (Table 7-12).[125] The relatively high arsenic concentrations (compared with other arsenic concentrations summarized in Table 7-7) associated with suspended solids in water samples may be a reflection of high arsenic concentrations on very fine particulates distributed throughout the drainage basin by atmospheric deposition from the Asarco smelter in Ruston, Washington. The highest concentration of total arsenic was detected during the highest flow sampled, but there does not appear to be any significant relationship between arsenic concentration and flow in the rest of the dataset (Figures 7-9 through 7-11).

Table 7-12. Arsenic and TSS concentrations in upstream surface water samples and estimated arsenic concentrations associated with suspended solids

Data Type	Daily Average Flow (cfs)[a]	Surface Water – Green River at Fort Dent				Suspended Solids (estimated)
		Total Arsenic (µg/L)	Dissolved Arsenic (µg/L)	Particulate Arsenic (total arsenic minus dissolved arsenic) (µg/L)[b]	TSS (mg/L)	Arsenic (mg/kg TSS)[c]
Individual Events						
April 30, 2001 – storm[d]	2,250	0.76	0.5 U	0.51	11.7	**44**
June 11, 2001 – storm[d]	1,290	0.9	0.63	0.27	9.2	29
November 14, 2001 – storm[d]	3,800	1.1	0.62	0.48	27	18
January 24, 2002 – storm[d]	2,220	0.576	0.44	0.14	7.3	19
February 13, 2002	1,370	0.69	0.5 U	0.44	3.82	**120**
		0.68	0.5 U	0.43	3.75	**110**
		0.65	0.5 U	0.40	4.62	**87**
February 21, 2002 – storm[d]	2,030	0.72	0.71	0.01	20.1	0.50
		0.77	0.67	0.10	16.6	6.0
February 22, 2002 – storm[d]	3,700	1.1	0.81	0.29	53	5.5
		1.3	0.79	0.51	53.6	9.5
		0.84	0.85	na[b]	39.3	na
		0.5 U	0.79	na[b]	25.2	na
March 11, 2002 – storm[d]	1,200	0.76	0.54	0.22	8.4	26
March 25, 2002	1,550	0.75	0.53	0.22	7.11	31
		0.74	0.54	0.20	5.8	34
March 26, 2002	1,520	0.75	0.53	0.22	12.4	18

[125] Summary statistics for TSS-normalized arsenic concentrations were calculated using ProUCL with non-detects set at full reporting limit if dissolved arsenic was not detected. Using MTCAStat, the 90th percentile concentration of TSS-normalized arsenic would have been 56 mg/kg dw TSS if the full MDL had been used or 88 mg/kg dw TSS if zero had been used for non-detected dissolved arsenic concentrations.

Data Type	Daily Average Flow (cfs)[a]	Surface Water – Green River at Fort Dent				Suspended Solids (estimated)
		Total Arsenic (µg/L)	Dissolved Arsenic (µg/L)	Particulate Arsenic (total arsenic minus dissolved arsenic) (µg/L)[b]	TSS (mg/L)	Arsenic (mg/kg TSS)[c]
April 24, 2002	2,030	0.64	0.5 U	0.39	8.79	**44**
		0.63	0.5 U	0.38	10.8	**35**
April 25, 2002	1,880	0.59	0.5 U	0.34	9.89	**34**
June 12, 2002	1,700	0.5 U	0.5 U	na[b]	7.47	na
		0.5 U	0.5 U	na[b]	6.49	na
		0.57	0.5 U	0.32	8.02	**40**
June 28, 2002 – storm[d]	952	0.73	0.55	0.18	6.2	29
		0.86	0.54	0.32	11	29
		0.65	0.51	0.14	5.1	27
June 29, 2002 – storm[d]	1,210	0.68	0.56	0.12	5.8	21
		0.72	0.52	0.20	11.5	17
		0.72	0.51	0.21	10	21
		0.75	0.55	0.20	8.3	24
		0.75	0.54	0.21	9.4	22
		0.71	0.53	0.18	6.2	29
June 30, 2002 – storm[d]	1,390	0.74	0.56	0.18	8.9	20
August 6, 2002	294	0.933	0.741	0.19	3.4	56
October 23, 2002	244	0.98	0.78	0.20	2.27	88
November 6, 2002 – storm[d]	209	0.91	0.62	0.29	4.9	59
		0.91	0.65	0.26	4.24	61
November 7, 2002 – storm[d]	207	0.85	0.65	0.20	2.5	80
		0.79	0.6	0.19	2.6	73
November 12, 2002 – storm[d]	264	0.98	0.66	0.32	3	110
December 3, 2002	197	0.71	0.55	0.16	1.2	130
December 4, 2002	195	0.76	0.55	0.21	2.3	91
December 11, 2002 – storm[d]	213	0.72	0.54	0.18	4.29	41
		0.65	0.51	0.14	4.3	33
December 12, 2002 – storm[d]	371	1.1	0.57	0.53	12.4	43
		0.88	0.55	0.33	11.3	29
		0.67	0.61	0.060	5.05	12
		0.71	0.52	0.19	4.79	40
		0.76	0.53	0.23	6.38	36
		0.67	0.54	0.13	5.06	26
December 13, 2002 – storm[d]	816	1.1	0.58	0.52	9.9	53
January 3, 2003 – storm[d]	1,220	1.2	0.64	0.56	21.6	26

Data Type	Daily Average Flow (cfs)[a]	Surface Water – Green River at Fort Dent				Suspended Solids (estimated)
		Total Arsenic (µg/L)	Dissolved Arsenic (µg/L)	Particulate Arsenic (total arsenic minus dissolved arsenic) (µg/L)[b]	TSS (mg/L)	Arsenic (mg/kg TSS)[c]
January 4, 2003 – storm[d]	1,150	1	0.62	0.38	14.9	26
		0.98	0.67	0.31	13.1	24
		1.2	0.53	0.67	18.6	36
		1.1	0.63	0.47	16.1	29
		1	0.63	0.37	19.6	19
		1.2	0.59	0.61	21.2	29
January 5, 2003 – storm[d]	1,420	1	0.67	0.33	15.8	21
		1	0.69	0.31	17.7	18
		1	0.64	0.36	16.4	22
January 21, 2003 – storm[d]	646	0.71	0.53	0.18	4.5	40
		0.71	0.51	0.20	4.4	45
		0.78	0.5 U	0.53	6.79	**78**
January 22, 2003 – storm[d]	1,040	0.89	0.58	0.31	11.8	26
		0.8	0.56	0.24	9.85	24
		0.78	0.5	0.28	8.98	31
		0.76	0.5	0.26	7.88	33
		0.73	0.5 U	0.48	6.3	**76**
January 23, 2003 – storm[d]	1,320	0.95	0.63	0.32	13.8	23
January 27, 2003 – storm[d]	5,210	1.6	0.5 U	1.4	52.4	**26**
February 12, 2003	1,220	0.65	0.5 U	0.40	7.94	**50**
		0.71	0.5 U	0.46	15.6	**29**
February 13, 2003	1,110	0.63	0.5 U	0.38	8.37	**45**
March 8, 2003 – storm[d]	1,130	0.68	0.53	0.15	6.9	22
		0.69	0.57	0.12	6.18	19
		0.68	0.52	0.16	5.24	31
March 9, 2003 – storm[d]	1,340	0.71	0.53	0.18	10.4	17
		0.64	0.5 U	0.39	6.8	**57**
		0.66	0.55	0.11	5.39	20
		0.71	0.54	0.17	10.4	16
		0.73	0.52	0.21	10.4	20
		0.73	0.51	0.22	10	22
March 10, 2003 – storm[d]	2,040	0.77	0.52	0.25	14.3	17
April 28, 2003	1,540	0.57	0.5 U	0.32	8.12	**39**
		0.53	0.5 U	0.28	17	**16**
April 29, 2003	1,400	0.57	0.5 U	0.32	7.22	**44**
June 8, 2003	662	0.91	0.62	0.29	10.4	28
		0.93	0.67	0.26	7.84	33
June 9, 2003	655	0.85	0.7	0.15	12	13

Data Type	Daily Average Flow (cfs)[a]	Surface Water – Green River at Fort Dent				Suspended Solids (estimated)
		Total Arsenic (µg/L)	Dissolved Arsenic (µg/L)	Particulate Arsenic (total arsenic minus dissolved arsenic) (µg/L)[b]	TSS (mg/L)	Arsenic (mg/kg TSS)[c]
August 26, 2003	234	1.1	0.81	0.29	6.63	44
		1.1	0.8	0.30	6.4	47
August 27, 2003	230	1.2	0.84	0.36	6.1	59
October 16, 2003 – storm[d]	546	1.1	0.61	0.49	12.9	38
October 17, 2003 – storm[d]	1,050	1.5	0.58	0.92	28.2	33
November 17, 2003 – storm[d]	1,200	0.85	0.5 U	0.60	15.8	**38**
November 18, 2003 – storm[d]	3,650	1.6	0.5 U	1.4	67	**20**
May 26, 2004 – storm[d]	957	0.82	0.53	0.29	7.6	38
September 13, 2004 – storm[d]	682	1.0	0.69	0.31	11.9	26
January 18, 2005 – storm[d]	6,050	1.6	0.61	0.99	63.2	16
October 31, 2005 – storm[d]	1,070	0.72	0.57	0.15	6.6	23
January 9, 2006 – storm[d]	4,540	0.99	0.5 U	0.74	34.4	**22**
September 19, 2006 – storm[d]	297	1.0	0.69	0.31	9.8	32
November 7, 2006 – storm[d]	10,200	4.16	0.5 U	3.9	312	**13**
Summary Statistics[f]						
Number of samples	55	104	104	100	104	100
Detection frequency	na	101/104	80/104	na[e]	104/104	100/100
Mean	1,580	0.87	0.52	0.37	15	37[g]
Minimum	195	0.25	0.25	0.01	1.2	0.50[g]
Maximum	10,200	4.2	0.85	3.9	312	130[g]
RL or range of RLs	na	0.5	0.5	na	na	na
25th Percentile	646	0.70	0.48	0.19	5.5	21[g]
50th Percentile	1,200	0.76	0.55	0.29	9.6	29[g]
75th Percentile	1,700	0.99	0.63	0.39	17	43[g]
90th Percentile	3,740	1.2	0.71	0.56	28	73[g]

[a] Flow data are from the USGS station 12113000 at Auburn, Washington.

[b] If, in a given sample, total arsenic was detected but dissolved arsenic was not, one-half the MDL for the dissolved arsenic was subtracted from the total arsenic concentration to estimate the particulate arsenic concentration. Particulate arsenic concentrations could not be calculated for four samples because: 1) the dissolved concentration was greater than the total concentration (two samples on February 22, 2002), or 2) neither total nor dissolved arsenic was detected (two samples on June 12, 2002).

[c] Arsenic concentrations associated with suspended solids (in mg/kg TSS) were calculated as follows:

$$\frac{As_{Total}\left(\frac{\mu g}{L}\right) - As_{Dissolved}\left(\frac{\mu g}{L}\right)}{TSS\left(\frac{mg}{L}\right)}\left(1{,}000{,}000\,\frac{mg}{kg}\right)\left(\frac{mg}{1000\,\mu g}\right) = As\left(\frac{mg}{kg}\,TSS\right)$$

[d] A storm was a targeted event with at least 0.25-in. rainfall over 24 hours and a preceding minimum dry period of 24 hours. The other sampling events were conducted during routine monthly monitoring and may or may not correspond to storm events.

[e] Detection frequency is not applicable for particulate arsenic because it is a calculated concentration using one-half the MDL if dissolved arsenic was not detected (see Footnote b).

[f] To evaluate the influence of non-detected dissolved arsenic concentrations in the calculation of the suspended solid arsenic concentrations, summary statistics were also calculated using MTCAStat assuming non-detects were equal to 0, non-detects were equal to the full MDL, and non-detects were excluded from the dataset, as shown below:

	Arsenic concentration (mg/kg TSS)			Percentiles for arsenic concentrations (mg/kg TSS)			
Treatment of NDs	Minimum	Maximum	Mean	25th	50th	75th	90th
ND = 1/2 MDL	0.50	130	37	21	29	43	76
ND = 0	0.50	180	43	22	30	56	88
ND = full MDL	0.50	130	30	18	26	36	56
Excluding ND data	0.50	130	33	20	28	38	59

The maximum concentration of 180 mg/kg TSS was calculated using data from the first sample collected on February 13, 2002, and zero for non-detects.

[g] The mean and percentile concentrations were calculated using statistical software ProUCL 4.00.04 (EPA 2007e), with non-detects set at full reporting limit.

cfs – cubic feet per second
dw – dry weight
MDL – method detection limit
na – not applicable
ND – non-detect value
TSS – total suspended solids
U – not detected at reporting limit shown

Bold identifies TSS-normalized arsenic concentrations that were calculated using non-detected dissolved arsenic concentrations assuming one-half the MDL for those values.

For comparative purposes, Table 7-13 presents TSS-normalized arsenic concentrations in surface water from the LDW. These concentrations were calculated by subtracting (on a per-sample basis) dissolved arsenic from total arsenic concentrations in surface water. The resulting particulate arsenic concentration was then divided by the sample-specific TSS concentration. TSS-normalized arsenic concentrations ranged from 0.5 to 340 mg/kg TSS in the LDW, with means for the three locations ranging from 12 to 25 mg/kg TSS.

Table 7-13. Summary of estimated arsenic concentrations associated with suspended solids in LDW surface water

	Detection Frequency[b]		Arsenic Concentration (mg/kg TSS)			TSS Concentration (mg/L)		
Location ID[a]	Ratio	%	Minimum	Maximum	Mean	Minimum	Maximum	Mean
BRN (RM 1.1)	60/60	100	0.5	340	25	2.6	69	11
SWM (RM 1.9)	59/59	100	2.3	100	20	5.5	31.3	15
NFK (RM 4.9)	22/22	100	3.8	29	12	2.6	48.7	11

[a] BRN, SWM, and NFK are located in the LDW near the Brandon, SW Michigan, and Norfolk CSOs, respectively.

[b] TSS-normalized arsenic concentrations were calculated for surface water samples that were analyzed for both dissolved and total arsenic, In those samples, both dissolved and total arsenic were always detected.

CSO – combined sewer overflow
dw – dry weight
ID – identification
LDW – Lower Duwamish Waterway
RM – river mile
TSS – total suspended solids

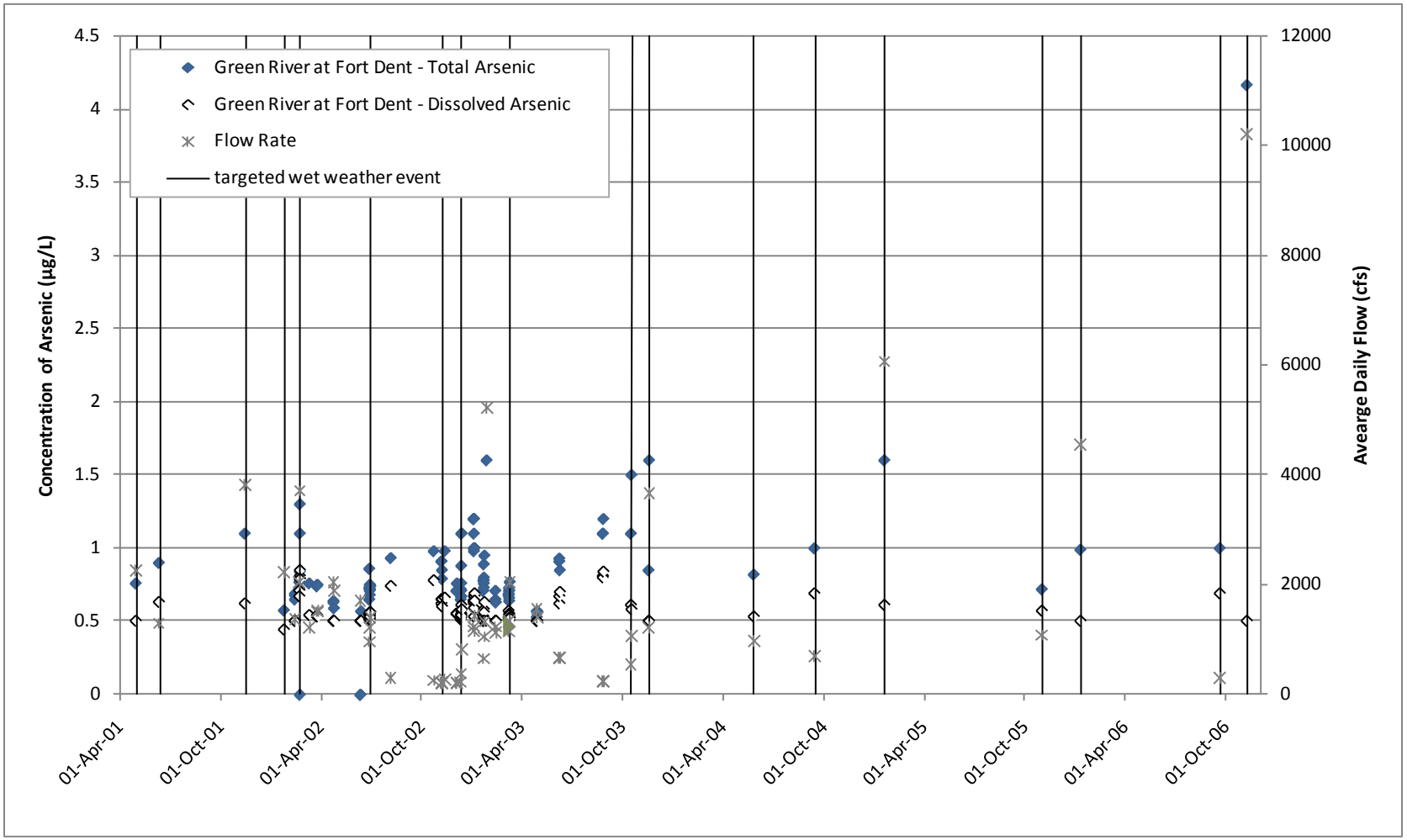


Figure 7-9. Arsenic concentrations in surface water at the upstream Green River at Fort Dent location

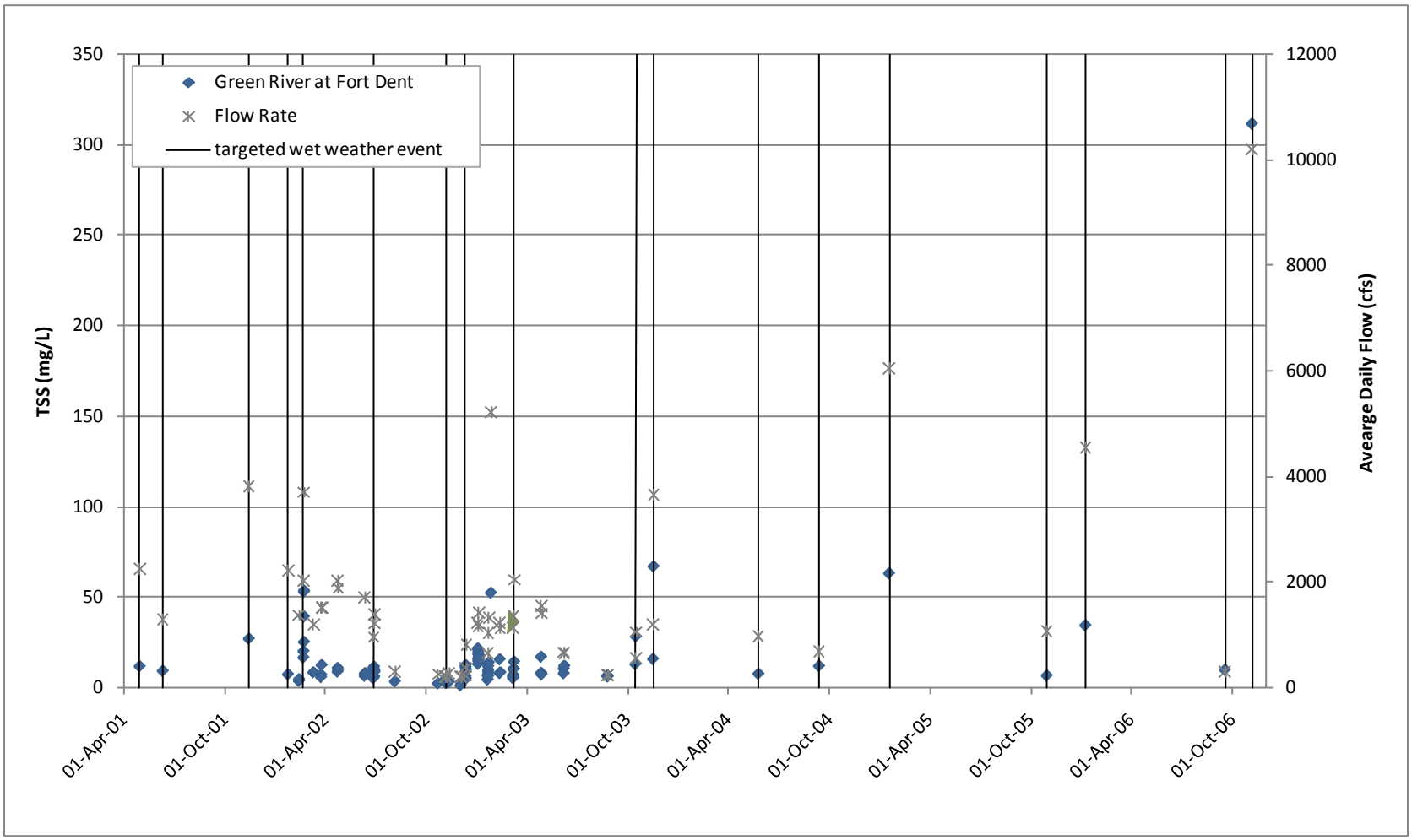


Figure 7-10. TSS concentrations in surface water at the upstream Green River at Fort Dent location

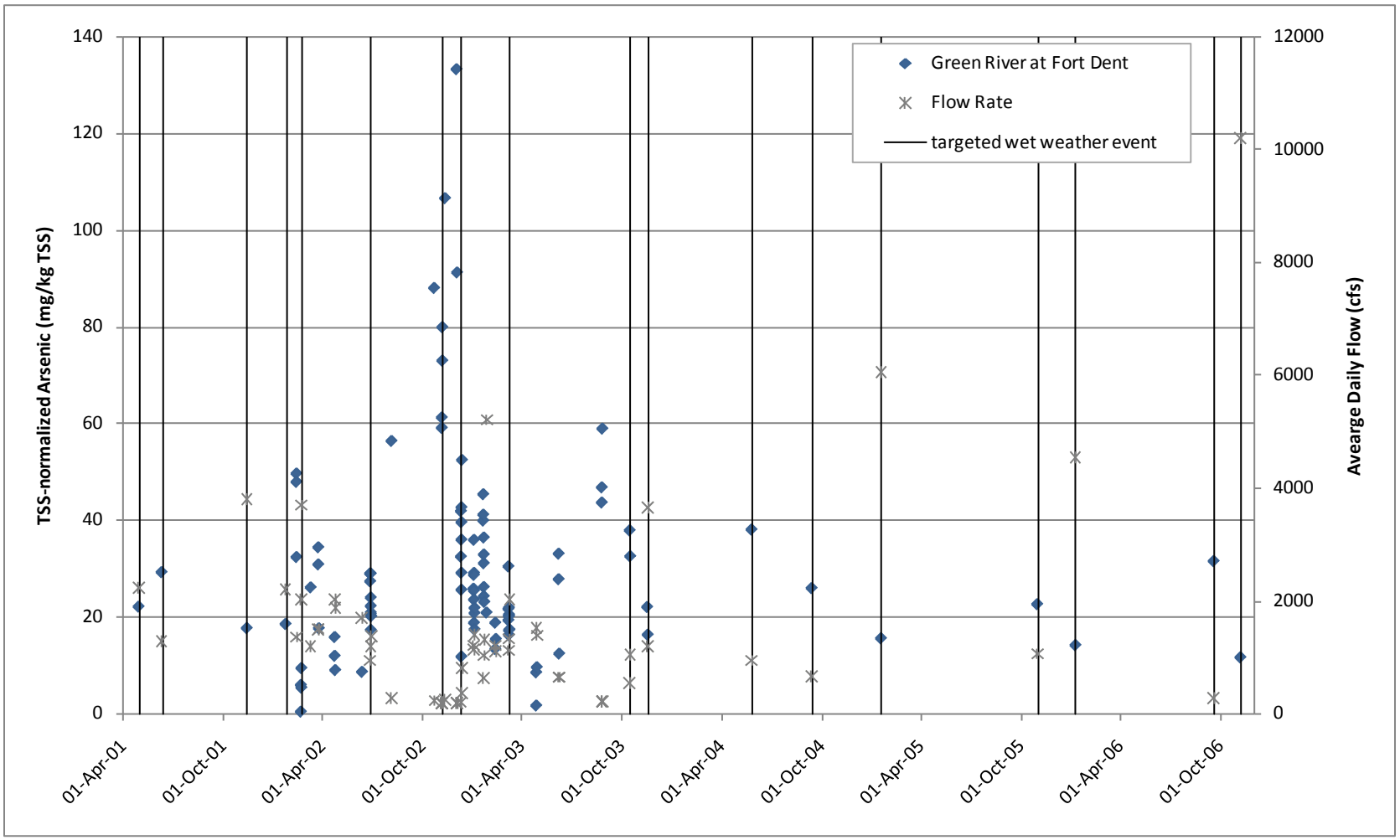


Figure 7-11. TSS-normalized arsenic concentrations in surface water at the upstream Green River at Fort Dent location

7.2.4.3 cPAHs

From 2001 through 2003, King County collected unfiltered surface water samples for PAH analysis from the Green River at Fort Dent (Map 7-7). PAHs were not detected in these samples (Herrera 2004b, 2005). In 2008, King County collected unfiltered surface water samples from the Green River at Fort Dent and from the Duwamish River at the E Marginal Way S Bridge (at S 155th Street, RM 6.3) monthly from February through August 2008. In addition, samples were also collected during two storm events (June and August) from the Green River at Fort Dent (Table 7-14; Map 7-7). These samples were analyzed using a method with lower reporting limits for PAHs (EPA Method 8270D-SIM); TSS was also analyzed in these samples.

Table 7-14. cPAH and TSS concentrations in upstream surface water samples and estimated cPAH concentrations associated with suspended solids

Data Type	Daily Average Flow (cfs)[a]	Surface Water				Suspended Solids (estimated)	
		cPAH (µg/L)[b]		TSS (mg/L)		cPAH (µg/kg TSS)[c]	
		Duwamish River at E Marginal Way S	Green River at Fort Dent	Duwamish River at E Marginal Way S	Green River at Fort Dent	Duwamish River at E Marginal Way S	Green River at Fort Dent
Individual Events							
February 6, 2008	837	0.0016	0.0011[d]	3.9	5.2[d]	408	220[e]
March 5, 2008	1,810	0.00045 U[b, d]	0.00045 U[b]	8.5[d]	9.8	nc[e]	nc
March 17, 2008	1,850	0.00049[d]	0.00051	7.7[d]	9.6	64[e]	53
April 9, 2008	1,180	0.0010	0.0005[d]	4.0	4.2[d]	239	117[e]
May 7, 2008	2,470	0.00104[d]	0.0011	19.3[d]	20.8	53.8[e]	53.2
June 3, 2008 – storm[f]	2,190	no data	0.0027[d]	no data	21.8[d]	no data	122[e]
June 12, 2008	3,570	0.00045 U[b]	0.00046[d]	20.4	15.9[d]	nc	29[e]
July 9, 2008	1,330	0.00045 U[b,d]	0.00045 U[b]	1.9[d]	6.1	nc[e]	nc
August 6, 2008	341	0.00048	0.00045 U[b,d]	1.4	2.5[d]	346	nc`
August 20, 2008 – storm[f]	321	no data	0.0035[d]	no data	9.2[d]	no data	384[e]
Summary Statistics							
Number of samples	na	18		18		18	
Detection frequency	na	12/18		18/18		12/18	
Mean detect	1,590	0.0012		9.6		151[h]	
Minimum detect	321	0.00046		1.4		29	
Maximum detect	3,570	0.0035		21.8		408	
25th Percentile	713	0.00049[g]		4.0[g]		53[h]	
50th Percentile	1,520	0.0010[g]		8.1[g]		74[h]	
75th Percentile	2,260	0.0015[g]		17[g]		229[h]	
90th Percentile	3,460	0.0032[g]		21[g]		354[h]	

[a] Flow data are from the USGS Station 12113000 at Auburn, Washington.

[b] cPAH was calculated as the sum of each individual cPAH concentration multiplied by the corresponding PEF, as discussed in more detail in Appendix E, Section E.3. When the individual cPAH component concentration was reported as

non-detected, then the PEF was multiplied by half the MDL. A U-qualifier indicates that no individual cPAH components were detected.

[c] TSS-normalized cPAHs were calculated by dividing the cPAH concentration (in µg/L) by the TSS concentration (in kg/L). TSS-normalized cPAHs were not calculated for samples with only U-qualified cPAH results.

[d] Field replicates were collected for these samples; the average cPAH and TSS concentrations shown represent averages of the original and field replicates.

[e] Field replicates were collected for these samples. The average TSS-normalized cPAH concentrations were first calculated separately for the original and the field replicate, and then the two concentrations were averaged.

[f] A storm was a targeted event with at least 0.25-in. rainfall over 24 hours, with a minimum 24-hour antecedent dry. The other sampling events were conducted during routine monthly monitoring and may or may not correspond to storm events.

[g] Percentiles were calculated using methods presented in the National Institute of Standards and Technology Handbook of Statistical Methods ((NIST and SEMATECH 2006).

[h] The mean and percentile concentrations were calculated using statistical software ProUCL 4.00.04 (EPA 2007e), with non-detects set at full reporting limit.

cPAH – carcinogenic polycyclic aromatic hydrocarbon
cfs – cubic feet per second
MDL – method detection limit
na – not applicable
nc –not calculated
PEF – potency equivalency factor
TSS – total suspended solids
U – not detected at given concentration

Summary statistics were calculated for cPAH in surface water and estimated for cPAH associated with suspended solids. Detected cPAH concentrations in surface water samples ranged from 0.0005 to 0.0035 µg/L. The mean and 90th percentile cPAH concentrations normalized to TSS were 151 and 354 µg/kg dw TSS, respectively (Table 7-14).[126] There does not appear to be any significant relationship between cPAH concentration and flow in the dataset (Figure 7-12). cPAH concentrations associated with suspended solids could not be calculated for surface water from the LDW because the LDW cPAH surface water data were calculated from SPMD samples (without corresponding TSS data).

[126] When the six surface water samples with no detected cPAHs were excluded from the calculations, the mean and 90th percentile cPAH concentrations normalized to TSS were 159 and 388 µg/kg dw TSS using the National Institute of Standards and Technology Handbook of Statistical Methods (NIST and SEMATECH 2006).

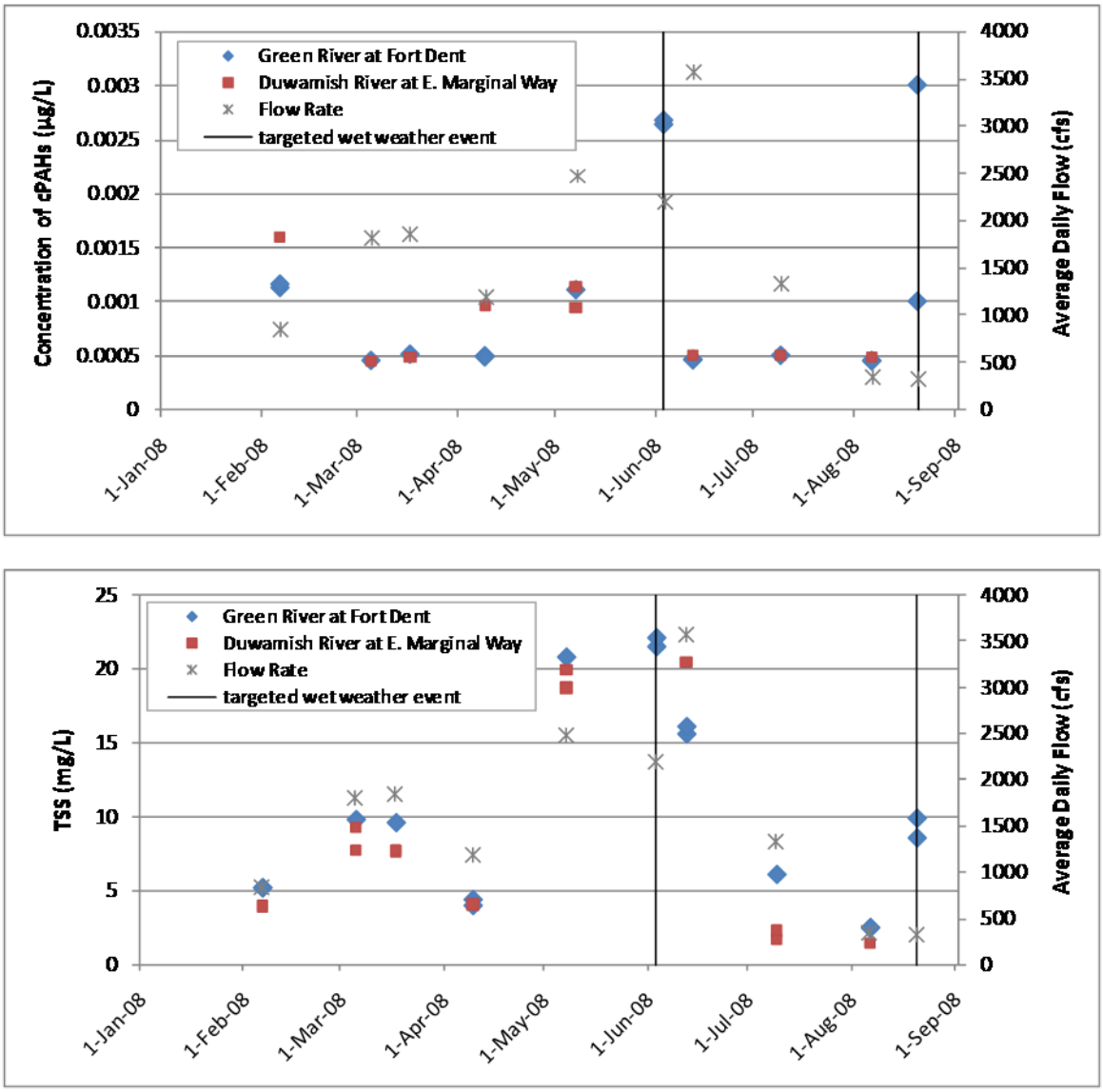


Figure 7-12. Carcinogenic PAH and TSS concentrations in surface water at upstream Green River/Duwamish locations

7.3 URBAN BACKGROUND SEDIMENT DATA

To provide additional context for the sediment concentrations presented in Sections 7.1 and 7.2, this section presents concentrations of total PCBs, arsenic, cPAHs, and dioxins and furans from locations outside the Green/Duwamish watershed. These data are being presented only for informational purposes (i.e., they are not being used to define background for deriving sediment cleanup values).

7.3.1 PCBs, arsenic, and cPAHs

Surface sediment data for total PCBs, arsenic, and cPAHs within the following major urban bays and lakes were extracted from Ecology's EIM system: Elliott Bay,

Bellingham Bay, Commencement Bay, Lake Washington, and Lake Sammamish. These data include the results from many individual studies. As noted in the introduction to Section 7, detailed evaluations of dataset representativeness were not performed.

Prior to the calculation of statistics, these data were screened to exclude the following types of samples:

- Samples collected as part of a CERCLA or MTCA cleanup study prior to any sediment remediation (post-remediation monitoring data from any such sites were retained)
- Samples collected as part of routine onsite monitoring of the DMMP open-water dredged material disposal sites

Although data from the open-water dredged material disposal sites may be representative of regional sediment quality, these data were excluded because of the difficulty in attributing the sediment characteristics of the dredged material to the original location from which the sediments were dredged.

Elliott Bay locations were divided into an inner Elliott Bay dataset and an outer Elliott Bay dataset. The inner and outer datasets were defined by drawing a north-south line from the Duwamish head to Pier 91/92. Three locations near the middle and east of the line were included in the outer Elliott Bay dataset because the water depths were greater than 140 m. The Elliott Bay datasets include data collected from 1991 to 1998 but do not include post-cap monitoring samples from Pier 52/53 and Denny Way. Inner Elliott Bay data are included in Tables 7-15 through 7-17 for informational purposes but are excluded from the summary ranges discussed in this section and in Section 7.5 because inner Elliott Bay receives discharge from the LDW and may be influenced by other known point sources of contamination. Additional screening steps were applied with the objective of generating a single result per chemical for each location, which involved averaging field duplicates, field replicates, and laboratory replicates, as described in Appendix E. In addition, for locations monitored repeatedly over time, only the most recent result was included. Although additional screening steps were discussed and evaluated with EPA and Ecology (RETEC 2007a, b, c), only those steps discussed above were ultimately conducted to derive the datasets presented in this section.

The summary statistics for each urban bay or lake were evaluated individually (Tables 7-15, 7-16, and 7-17). The available data for each water body from studies not specifically designed as background evaluations may not be representative of overall conditions (or that portion that might be deemed to reflect background) in that water body. Differences in available datasets from one water body to another may also affect the comparability of results across different areas. In addition, aside from the initial screening discussed above, these data were not thoroughly screened to ensure that all data that might be associated with hazardous waste sites or other point sources of contamination were removed. Therefore, the data summarized in this section are presented only for informational purposes.

Table 7-15. Total PCB concentrations in surface sediment samples collected in urban bays and lakes, excluding cleanup and disposal sites

Area	Detection Frequency	PCB Concentration (µg/kg dw)							
		Minimum Detect	Maximum Detect	Mean	95% UCL	50th Percentile	90th Percentile	Minimum Non-Detect	Maximum Non-Detect
Inner Elliott Bay	28/37	33	800	190	255	99	576	18	59
Outer Elliott Bay	7/28	8.1	138	38	53	17	82	10	844
Bellingham Bay	6/61	8.0	425	76	164	25	114	15	850
Commencement Bay	49/71	4.0	1,104	61	127	21	64	12	350
Lake Sammamish	25/25	16	88	40	49	34	73	na	na
Lake Washington	1/17	26	26	87	137	47	217	9.5	285

Note: Mean and percentile values were calculated using both detected and non-detected concentrations, where non-detects were set equal to one-half the non-detect concentration. The 95% UCL values were calculated in ProUCL v. 4.0, using both detect and non-detect concentrations.

dw – dry weight

na – not applicable

PCB – polychlorinated biphenyl

UCL – upper confidence limit on the mean

Table 7-16. Arsenic concentrations in surface sediment samples collected in urban bays and lakes, excluding cleanup and disposal sites

Area	Detection Frequency	Arsenic Concentration (mg/kg dw)							
		Minimum Detect	Maximum Detect	Mean	95% UCL	50th Percentile	90th Percentile	Minimum RL	Maximum RL
Inner Elliott Bay	25/34	4.7	27	8.6	10.4	7.4	16	6.0	11
Outer Elliott Bay	19/31	2.4	14	5.1	6.4	4.1	9.8	2.9	18
Bellingham Bay	160/162	1.5	19	9.2	9.6	9.2	13	3.3	7.5
Commencement Bay	131/133	1.4	45	9.6	12	8.7	17	13	13
Lake Washington	25/29	2.0	27	7.2	8.9	6.3	13	4.0	20
Lake Sammamish	29/29	1.8	72	15	59	8.7	38	na	na

Note: Mean and percentile values were calculated using both detected and non-detected concentrations, where non-detects were set equal to one-half the RL. The 95% UCL values were calculated in ProUCL v. 4.0, using both detect and non-detect concentrations.

dw – dry weight

na – not applicable

RL – reporting limit

UCL – upper confidence limit on the mean

Table 7-17. cPAH concentrations in surface sediment samples collected in urban bays and lakes, excluding cleanup and disposal sites

Area	Detection Frequency	cPAH Concentration (µg/kg dw)							
		Minimum Detect	Maximum Detect	Mean	95% UCL	50th Percentile	90th Percentile	Minimum Non-Detect	Maximum Non-Detect
Inner Elliott Bay	64/66	14	4,780	583	1,080	269	1,410	34	36
Outer Elliott Bay	15/21	22	327	116	152	79	292	20	39
Bellingham Bay	53/64	5.8	593	76	108	32	185	15	26
Commencement Bay	45/45	8.8	1,700	223	345	115	527	na	na
Lake Washington	30/33	43	5,290	374	635	216	904	49	855
Lake Sammamish	11/20	57	1,870	234	407	92	574	41	453

Note: Total cPAHs were calculated by summing the products of concentrations and compound-specific PEFs for individual cPAH compounds, as discussed in detail in Appendix E, Section E.3. Mean and percentile values were calculated using both detected and non-detected concentrations, where non-detects were set equal to one-half the non-detect concentration. The 95% UCL values were calculated in ProUCL v. 4.0, using both detect and non-detect concentrations.

cPAH – carcinogenic polycyclic aromatic hydrocarbons

dw – dry weight

na – not applicable

PEF – potency equivalency factor

UCL – upper confidence limit on the mean

Excluding the data from inner Elliott Bay, the mean total PCB concentrations for sediments in urban bays and lakes ranged from 38 to 87 µg/kg dw. The mean concentrations from these water bodies were within or higher than the range of mean total PCB concentrations from the three datasets evaluated in Section 7.2, which ranged from 17 to 51 µg/kg dw (Table 7-7). The 90th percentiles of the total PCB data in urban bays and lakes ranged from 64 to 217 µg/kg dw, with the exclusion of data from inner Elliott Bay (Table 7-15), compared with 46 to 120 µg/kg dw in the three datasets in Section 7.2.

The mean arsenic concentrations in urban bays and lakes ranged from 5.1 to 15 mg/kg dw. These means are within the range of arsenic means from the three datasets evaluated in Section 7.2 (7 to 37 mg/kg dw) (Table 7-7). The 90th percentiles of the arsenic data in urban bays and lakes ranged from 9.8 to 38 mg/kg dw (Table 7-16) compared with 11 to 76 mg/kg dw in the three datasets in Section 7.2.

Excluding the data from inner Elliott Bay, the mean cPAH concentrations in urban bays and lakes ranged from 76 to 374 µg/kg dw. The mean concentrations from these water bodies were within or higher than the range of cPAH means from the three datasets evaluated in Section 7.2, which ranged from 51 to 125 µg/kg dw (Table 7-7). The 90th percentiles of the cPAH data in urban bays and lakes ranged from 185 to 904 µg/kg dw, with the exclusion of data from inner Elliott Bay (Table 7-17), compared with 209 to 340 µg/kg dw in the three datasets in Section 7.2.

7.3.2 Dioxins and furans

Surface sediment sampling for dioxins and furans in the greater Seattle metropolitan area was conducted as part of the RI sampling event in 2005 (Windward 2005d). This Seattle-area study was designed to collect sediment samples and provide dioxin and furan TEQ results near storm drains and other areas receiving runoff associated with typical urban sources. Dioxins and furans from these sources are distributed throughout urban areas via atmospheric deposition followed by stormwater runoff. The total number of samples was relatively small; conclusions drawn from these results for urban levels should be considered in this context.

The criteria used to select sampling areas representative of LDW background were as follows: 1) the area must receive drainage from basins with land uses similar to the LDW, 2) the area must not be located near known industrial point sources of dioxins and furans, 3) the area must represent a range of receiving water environments, and 4) the area must represent a range of stormwater discharge frequencies, volumes, and types similar to those in the LDW. The sampling locations that met these four criteria are shown on Map 7-8. In order to assess the potential influence of outfall proximity on dioxin and furan TEQs in sediment, two samples, one between 30 and 50 ft from the outfall and a second between 100 and 120 ft from the outfall, were collected at each of four of these locations: Elliott Bay (Terminal 91), Lake Union (I-5 bridge), Lake Washington (Renton), and the Ship Canal (Salmon Bay).

Individual dioxin and furan congener data were converted to a dioxin and furan TEQ using concentrations of detected congeners, one-half the RLs for congeners that were not detected in a given sample, and mammalian TEFs (Van den Berg et al. 2006). Data were reviewed to determine the appropriate dataset to represent urban conditions expected for areas with stormwater runoff, such as the LDW. The dioxin and furan TEQ results for all individual samples are provided in Table 7-18. TEQs ranged from 5.46 ng/kg dw (Lake Union) to 187 ng/kg dw (in Salmon Bay). Most of the TEQs were less than 30 ng/kg dw. The two samples collected during this study from upstream of the LDW in the Green River, as shown on Map 7-8, are included in the discussion of upstream sediment sampling (Section 7.2.2).

Table 7-18. Dioxin and furan TEQs in surface sediment samples collected from areas near storm drains and from other areas receiving runoff in the greater Seattle metropolitan area

Location	Location ID	Dioxin and Furan TEQ (ng/kg dw)	Values Included in Calculation of Statistics (ng/kg dw)
Elliott Bay (Terminal 91)[a]	EB-SS2a	13.7 J	16.3
	EB-SS2b	18.9 J	
Lake Union (I-5 bridge)[a]	LU-SS9a	5.46 J	15.8
	LU-SS9b	26.1 J	
Lake Washington (Bothell)	LW-SS3	13.2 J[b]	13.2
Lake Washington (Bellevue)	LW-SS4	14.7 J	14.7
Lake Washington (Renton)[a]	LW-SS5a	14.1 J	14.3
	LW-SS5b	14.5 J	
Ship Canal (Salmon Bay)[a]	SC-SS1a	187 J	-
	SC-SS1b	63.1 J	-
Union Bay (Laurelhurst)	UB-SS8	53.4 J	-
Statistics for greater Seattle area locations (excluding samples from the Ship Canal and Union Bay)			**mean – 14.9**
			90th percentile – 16.3
			95% UCL – 16.0

[a] Two samples were collected, one approximately 30 to 50 ft from the outfall and the other approximately 100 to 120 ft from the outfall.

[b] Reported concentration is the average of two field samples.

dw – dry weight
ID – identification
J – estimated concentration
na – not applicable
TEQ – toxic equivalent
UCL – upper confidence limit on the mean

The summary statistics presented in Table 7-18 include two adjustments to the set of individual results. The data for the Ship Canal and Union Bay sampling locations are not included because the TEQs were higher than the national range of 0.12 to 16.3

ng/kg dw (EPA 2000b).[127] Three of the sampled locations had two samples each. The results of the two samples collected at different distances from the outfall at each of these three locations (Elliott Bay, Lake Union, Lake Washington/Renton) were averaged before calculating summary statistics. Averaging was intended to provide a representation of conditions in the general vicinity of the outfalls. The mean dioxin and furan TEQ for this reduced dataset was 14.9 ng/kg dw, higher than the average from EPA's (2000b) national summary (which included both urban and rural locations), but within the range.

7.4 TISSUE DATA FROM PUGET SOUND

This section presents the ranges of total PCB and arsenic concentrations in tissue samples from non-urban and near-urban areas in Puget Sound.

Relatively few tissue data were available for dioxins and furans and cPAHs. Dioxins and furans were identified as a seafood consumption risk driver based on an assumption of unacceptable risk (no LDW tissue data were available); thus, the limited background tissue data available are not presented. For cPAHs, limited background tissue data were available from King County (King County 1999e). However, cPAHs were rarely detected.[128] Thus, these cPAH data are not presented.

7.4.1 PCBs

A search was conducted to identify available PCB tissue data from background areas in the greater Puget Sound area. The first step included a general online search, including the Web sites for WDFW, the King County Department of Natural Resources (KCDNR), Ecology, and WSDOH. A search was also conducted of the EIM database on Ecology's Web site (Ecology 2007c). In addition, both WDFW and WSDOH were contacted to confirm that all available data had been located.

A summary of available tissue data is provided in Table 7-19. Total PCBs were calculated as the sum of detected Aroclors, unless total PCB concentrations were provided in the individual data sources, in which case the reported value for total PCBs was used. If no individual Aroclors were detected in a sample, the total PCB concentration was reported as undetected at the highest RL for an individual Aroclor.

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[127] The range of dioxin and furan TEQs in sediments of 11 lakes and reservoirs throughout the United States, which were selected to represent background conditions in areas removed from known sources, was 0.12 to 16.3 ng/kg dw (EPA 2000b), with an arithmetic mean of 5.3 ng/kg dw.

[128] The detection limit for the available background samples (King County 1999e) was higher than that achieved in the LDW, further reducing the benefit of using such samples to characterize background.

Table 7-19. Total PCB concentrations in fish, crab, and clam composite tissue collected from non-urban and near-urban areas of the Puget Sound

Species	Tissue Type	Sampling Location	Sampling Year(s)	Detection Frequency	Individuals per Composite (Average)	Total PCB Concentration (µg/kg ww)			Source
						Mean[a]	Minimum	Maximum	
Rockfish									
Copper rockfish	fillet	PSAMP – non-urban[b]	1989 – 1999	1/1	5	4.5	4.5 J	4.5 J	West et al. (2001)
Copper rockfish	fillet	PSAMP – near-urban[b]	1989 – 1999	17/17	3.6	9.9	3.9 J	22.5 J	West et al. (2001)
Quillback rockfish	fillet	PSAMP – non-urban[b]	1989 – 1999	42/79	2.6	12.2	2.0 J	124.4 J	West et al. (2001)
Quillback rockfish	fillet	PSAMP – near-urban[b]	1989 – 1999	42/42	2.4	40.3	4.1 J	140.4 J	West et al. (2001)
Yelloweye rockfish	fillet	PSAMP non-urban[b]	1989 – 1999	2/2	1	32.3	16.3 J	48.2 J	West et al. (2001)
Sole									
English sole	fillet	Case Inlet/ Dana Passage	2005	2/3	4.67	7.2	5.6 J	13.2 J	Era-Miller (2006)
English sole	fillet	Pickering Passage	2005	0/2	5	2.8	5.5 U	5.6 U	Era-Miller (2006)
English sole	fillet	South Puget Sound	2005	2/2	20	6.5	6.1 J	6.8 J	Era-Miller (2006)
English sole	fillet	PSAMP – non urban[b]	1989 – 1999	117/189	15.2	11.6	1.3 J	50.8 J	West et al. (2001)
English sole	fillet	PSAMP – near urban[b]	1989 – 1999	66/78	15.1	16.2	2.0 J	79.9 J	West et al. (2001)
English sole	na	Discovery Bay	1982	1/1	na	13	13	13	Gahler et al. (1982), as cited in cited in Cubbage (1992)
Flathead sole	na	Discovery Bay	1982	0/1	na	5	10 U	10 U	Gahler et al. (1982), as cited in cited in Cubbage (1992)
Rock sole	fillet	Budd Inlet	2005	0/1	5	2.7	5.4 U	5.4 U	Era-Miller (2006)
Rock sole	fillet	Carr Inlet	2005	0/2	5	2.3	5.5 U	5.5 U	Era-Miller (2006)
Rock sole	fillet	Case Inlet/ Dana Passage	2005	0/1	5	2.3	5.5 U	5.5 U	Era-Miller (2006)
Rock sole	fillet	Hale Passage	2005	0/2	5	2.7	5.1 U	5.5 U	Era-Miller (2006)

Species	Tissue Type	Sampling Location	Sampling Year(s)	Detection Frequency	Individuals per Composite (Average)	Total PCB Concentration (µg/kg ww)			Source
						Mean[a]	Minimum	Maximum	
Crab									
Dungeness crab	hepato-pancreas	Dungeness Bay[c]	2006	7/7	1	25.0	13.1	49.5	Malcolm Pirnie (2007a)[d]
Dungeness crab	hepato-pancreas	Freshwater Bay[c]	2006	8/8	1	17.8	8.80	32.3	Malcolm Pirnie (2007a)[d]
Dungeness crab	edible meat	Dungeness Bay[c]	2006	7/7	1	1.02	0.46	1.92	Malcolm Pirnie (2007a)[d]
Dungeness crab	edible meat	Freshwater Bay[c]	2006	8/8	1	0.62	0.43	0.99	Malcolm Pirnie (2007a)[d]
Dungeness crab	edible meat	Padilla/Fidalgo Bay	1999	1/3	5	1.2	1.2J	2.6U	Ecology (2000)
Dungeness crab	edible meat	Samish Island	1999	1/1	5	1.4	1.4J	1.4J	Ecology (2000)
Dungeness crab	calculated whole body[e]	Dungeness Bay[c]	2006	7/7	1	8.44	4.39	16.05	Malcolm Pirnie (2007a)[d]
Dungeness crab	calculated whole body[e]	Freshwater Bay[c]	2006	8/8	1	5.96	3.03	10.71	Malcolm Pirnie (2007a)[d]
Clams									
Geoduck	tissue	Freshwater Bay[c]	2006	8/8	1	0.64	0.24	1.43	Malcolm Pirnie (2007a)[d]
Geoduck	visceral cavity	Freshwater Bay[c]	2006	5/5	1	1.35	0.92	2.10	Malcolm Pirnie (2007a)[d]
Horse clam	tissue	Dungeness Bay[c]	2006	8/8	1	0.12	0.09	0.14	Malcolm Pirnie (2007a)[d]
Horse clam	tissue	Freshwater Bay[c]	2006	8/8	1	0.14	0.10	0.23	Malcolm Pirnie (2007a)[d]
Horse clam	visceral cavity	Dungeness Bay[c]	2006	5/5	1	1.06	0.35	1.49	Malcolm Pirnie (2007a)[d]
Horse clam	visceral cavity	Freshwater Bay[c]	2006	5/5	1	1.66	1.35	2.14	Malcolm Pirnie (2007a)[d]
Butter clam	soft parts	Samish Island	1999	0/1	50	1.25	2.5 U	2.5 U	Ecology (2000)
Butter clam	soft parts	various locations[f]	1994 – 1998	1/66	na	na	3.5[g]	3.5[g]	King County
Littleneck clam	soft parts	Padilla/Fidalgo Bay	1999	1/3	50	2.8	2.3 U	3.6	Ecology (2000)

[a] Mean concentrations were calculated using one-half the highest RL for an individual Aroclor for samples in which no Aroclors were detected.

[b] PSAMP data are from various sites around Puget Sound (Maps 7-9 through 7-11).

[c] Dungeness Bay and Freshwater Bay were the reference sites used in the Rayonier Mill RI near Port Angeles, Washington (Malcolm Pirnie 2007a).

[d] The total PCB concentrations in this study were calculated as the sum of all detected PCB congeners.

[e] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Total PCB concentrations in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data). Detection frequencies were not calculated for these samples because they do not represent individually analyzed samples.

[f] Locations include Edmonds, Point Wells, Carkeek Park, Golden Gardens, West Point, Alki Point, Vashon Island, and Normandy Park. Data for clams collected by King County were compiled from five King County reports (1995, 2000e, 2001b, 2005j, 2006f).

[g] One detected concentration was reported for a single Aroclor (1254) in a single sample. Other Aroclors were not detected, and RLs were not reported for the other samples.

J – estimated concentration

na – not available

PCB – polychlorinated biphenyl

PSAMP – Puget Sound Ambient Monitoring Program

U – not detected

ww – wet weight

Tissue background numbers are presented in this section to provide context for the tissue RBTCs presented in Section 8. It should be noted that sampling and analytical methods used to produce these datasets varied from study to study. Thus, while these data provide a general indication of chemical concentrations in these reference areas, they should not be viewed as a single dataset with consistent methodology. Furthermore, because of differences in methods and the potential for spatial bias,[129] averages or UCL concentrations on a species-specific tissue basis across all background locations were not derived. The results of various studies are presented only for informational purposes.

Background tissue data were obtained from numerous locations around Puget Sound (Maps 7-9, 7-10, and 7-11). The primary sources of background data for fish were a PSAMP report (West et al. 2001) and a study conducted by Ecology (Era-Miller 2006). The PSAMP study area encompassed the Puget Sound region from Georgia Basin to the South Sound, including over 2,300 km^2 of aquatic habitat and over 2,100 km of shoreline (West et al. 2001) (Maps 7-9 and 7-10). Locations throughout the study area were sampled intermittently over a 10-year period from 1989 through 1999 such that all locations were sampled at least once, but not all locations were sampled every year. The species analyzed included English sole, copper rockfish, quillback rockfish, yelloweye rockfish, and adult salmon[130] (both chinook and coho species).

The study conducted by Ecology (Era-Miller 2006) was designed to augment the PSAMP data, and thus some of the locations were co-located with those in the PSAMP monitoring effort. The sampling locations included eight sites in south Puget Sound (Map 7-9). The species sampled during this investigation were English sole and rock sole (see Table 7-19). Limited information on two fish samples was also found in a report by Cubbage (1992) regarding a study conducted by Gahler et al. (1982). This study presented total PCB data from samples collected in Discovery Bay.

The primary source of crab and clam data was the remedial investigation (RI) for the Rayonier mill site near Port Angeles (Malcolm Pirnie 2007a). This investigation included tissue sampling at Freshwater and Dungeness Bays; the locations were selected to represent background conditions for that RI (Map 7-11). Species collected in background locations for the Rayonier Mill RI included Dungeness crabs, horse clams, and geoducks.

As part of another study, conducted by Ecology (2000), shellfish tissue samples, including Dungeness crabs, butter clams, and littleneck clams, were collected and

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[129] An example of spatial bias is one location having a larger number of samples compared to another location.

[130] Adult salmon data were not included in Table 7-5 because their exposure to chemicals in LDW sediment is not anticipated to significantly influence the concentrations in their tissues, primarily because of the very small portion of their lives spent in the LDW.

analyzed. In addition, King County analyzed shellfish samples for PCBs as part of their water quality assessment surveys (King County 1995, 2000e, 2001b, 2005j, 2006f). Out of the 66 samples collected by King County from various locations around Puget Sound (including Edmonds, Point Wells, Carkeek Park, Golden Gardens, West Point, Alki Point, Vashon Island, Normandy Park), PCBs (Aroclor 1254) were detected in only one sample.

In general, total PCB concentrations ranged from non-detect to 140.4 µg/kg ww in fish tissue samples (Table 7-19; Figure 7-13). Rock sole had the lowest total PCB concentrations, followed by copper rockfish, English sole, yelloweye rockfish, and quillback rockfish. Total PCB concentrations in whole-body Dungeness crabs ranged from 3.03 to 16.05 µg/kg ww. For all species for which both near and non-urban data were available, the non-urban samples consistently had lower mean total PCB concentrations than near-urban samples. Total PCB concentrations in clam tissue samples ranged from non-detect to 3.6 µg/kg ww, and thus were the lowest of the background tissue types measured. Total PCB concentrations in shellfish tissue ranged from non-detect to 3.6 µg/kg ww.

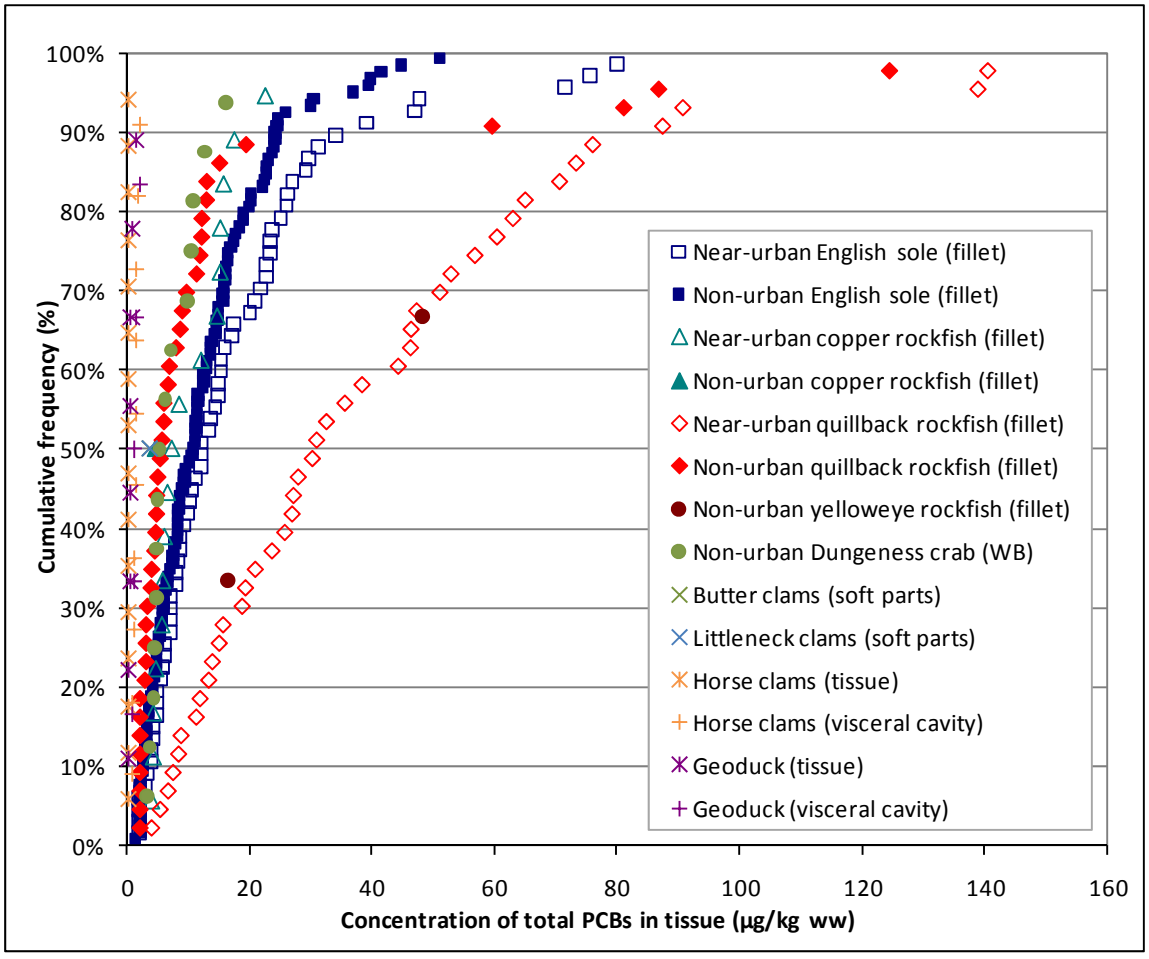

Figure 7-13. Detected total PCB concentrations in tissue samples collected at non-urban and near-urban locations in greater Puget Sound

PCBs have been detected in many types of food other than seafood, such as butter, chicken, steak, eggs and baked goods (WSDOH 2006). The concentrations reported in supermarket foods were similar to those detected in background fish samples, and ranged from non-detect to 70 µg/kg ww.

7.4.2 Arsenic

Data were collected as part of the RI to assess background concentrations of arsenic (both total and inorganic) in tissue (Windward 2005a, b, 2006b). Samples were collected from locations both within and outside of the region thought to be impacted by aerial emissions from the former Asarco smelter in Tacoma, Washington (Area-Wide Soil Contamination Task Force 2003), as noted in Table 7-20 and shown on Map 7-12. This smelter is known have been an important source of arsenic to areas within the smelter plume and has been the focus of an extensive soil study conducted by Ecology in south King County (Ecology 2001b).

The concentrations of inorganic arsenic are of greater interest because inorganic arsenic is more toxic and because EPA has derived a cancer slope factor for inorganic arsenic but not for total or organic arsenic. Therefore, only inorganic arsenic data are summarized. Clams were collected from background areas in both 2004 and 2005 and fish and crabs were collected in 2004 as part of the RI (Table 7-20 and Map 7-12). The only other study in Puget Sound that analyzed inorganic arsenic in tissue was conducted by Ecology (2002a), but the results from that study were not relevant because samples were collected only from urban bays.

In 2004, fish and crabs were collected from the East Passage (Asarco-influenced) and Blake Island (non-Asarco-influenced) and combined to create 61 composite tissue samples, as presented in Table 7-20 (Windward 2005b). The 2004 tissue dataset also included 12 composite clam tissue samples, 6 from a beach in Seahurst Park (Asarco-influenced) and 6 from a beach on Bainbridge Island (non-Asarco-influenced) (Windward 2005a). Because the clams collected in 2004 were not *Mya arenaria* (the type of clam predominantly found in the LDW) further sampling was conducted in 2005 to collect *Mya arenaria* from other background locations for the analysis of inorganic and total arsenic. In the 2005 sampling event, 12 additional composite *Mya arenaria* samples were formed, 6 from beaches on Vashon Island (Asarco-influenced) and 6 from the Dungeness National Wildlife Refuge (NWR) (non-Asarco-influenced) (Windward 2006).

Table 7-20. Inorganic arsenic concentrations in clam, fish, and crab tissue composite samples collected from Puget Sound locations outside of urban areas

Area	Tissue Type	Sampling Year	Detection Frequency	Inorganic Arsenic (mg/kg ww)			Source
				Mean[a]	Minimum	Maximum	
Clams							
Vashon Island (Asarco influenced) – *Mya arenaria*	whole body	2005	6/6	0.143	0.0930	0.227	Windward (2006b)
Seahurst Park (Asarco influenced) – various species[b]	whole body	2004	6/6	0.443	0.0980 J	0.616 J	Windward (2005a)
Dungeness NWR (non-Asarco influenced) – *Mya arenaria*	whole body	2005	6/6	0.0645	0.0470	0.117	Windward (2006b)
Bainbridge Island (non-Asarco influenced) – various species[b]	whole body	2004	6/6	0.201	0.0440 J	0.485 J	Windward (2005a)
Perch (shiner surfperch, pile perch, and striped perch)							
East Passage (Asarco influenced)	whole body	2004	2/3	0.008	0.005 U	0.01 J	Windward (2005b)
Blake Island (non-Asarco influenced)	whole body	2004	6/6	0.02	0.01	0.03	Windward (2005b)
Crabs (Dungeness crab and slender crab)							
East Passage (Asarco influenced)	edible meat	2004	6/6	0.018	0.010 J	0.040	Windward (2005b)
	hepatopancreas	2004	2/2	0.08	0.08	0.08	Windward (2005b)
	calculated whole body[c]	2004	6/6	0.037	0.032 J	0.052	Windward (2005b)
Blake Island (non-Asarco influenced)	edible meat	2004	6/6	0.023	0.020	0.030	Windward (2005b)
	hepatopancreas	2004	2/2	0.31	0.27	0.34	Windward (2005b)
	calculated whole body[c]	2004	6/6	0.11	0.10	0.13	Windward (2005b)
Benthic fish (English sole and starry flounder)							
East Passage (Asarco influenced)	fillet	2004	1/6	0.002	0.002 U	0.004 J	Windward (2005b)
	whole body	2004	6/6	0.01	0.007 J	0.02	Windward (2005b)
Blake Island (non-Asarco influenced)	fillet	2004	2/6	0.003	0.002 U	0.005 U	Windward (2005b)
	whole body	2004	6/6	0.02	0.01	0.03	Windward (2005b)

[a] Means were based on one-half RL for non-detect.

[b] Composite clam tissue samples from Seahurst Park and Bainbridge Island included multiple species (*Saxidomus giganteus, Clinocardium nuttallii, Macoma nasuta, Macoma secta, Tresus capax*, and *Protothaca staminea*).

[c] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Arsenic concentrations in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data). Detection frequencies were not calculated for these samples because they do not represent individually analyzed samples.

NWR – National Wildlife Refuge

J – estimated concentration

U – not detected

ww – wet weight

Inorganic arsenic concentrations in clam, fish, and crab tissue samples ranged from non-detect to 0.616 mg/kg ww. Inorganic arsenic concentrations were generally higher in clams (0.0440 to 0.616 mg/kg ww) than in the other tissue types (non-detect to 0.34 mg/kg ww). In clams, most of the inorganic arsenic concentrations in Asarco-influenced samples were higher than concentrations in non-Asarco-influenced samples, although there was some overlap in concentrations and two samples from Bainbridge Island (non-Asarco-influenced) had relatively high concentrations (Figure 7-14). No statistical analyses were conducted to evaluate whether the difference was significant.

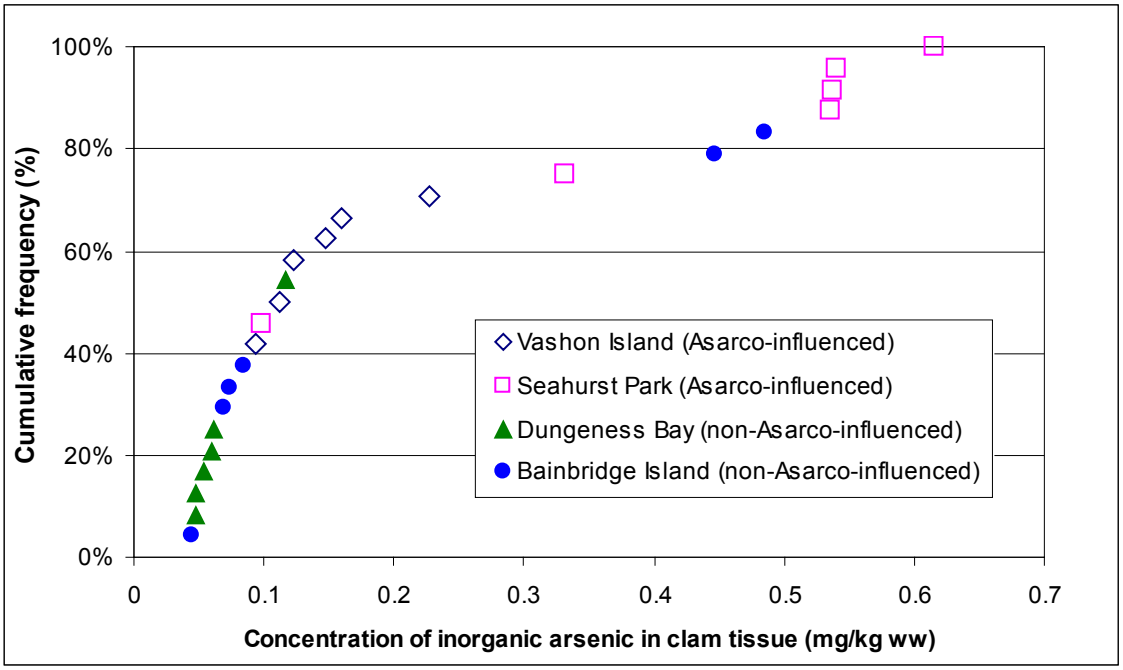

Figure 7-14. Comparison of inorganic arsenic concentrations in clam tissues collected from Puget Sound

7.5 SUMMARY

This section presents an initial summary of data for total PCBs, arsenic, cPAHs, and dioxins and furans from areas outside of the LDW and for cores collected from the Upper Turning Basin of the LDW. These data provide context for information presented elsewhere in the RI and will be useful in future background determinations. These datasets include surface sediment data from Puget Sound reference areas and other recent data that are potentially relevant for natural background concentrations; data from the Green River (upstream of the LDW), including surface sediment concentrations and TSS-normalized concentrations in water; data from sediment core samples from the Upper Turning Basin; and tissue data for various species collected from the greater Puget Sound region. Information on urban sediment concentrations from multiple areas is also presented to provide additional context.

Individual datasets address some or all of the four primary chemicals for which background values are of interest: PCBs, arsenic, cPAHs, and dioxins and furans. Detailed evaluations of background datasets and determinations of background-based PRGs will be addressed in continuing assessments to be documented in the FS or separate technical memoranda. Additional sampling studies, which are providing new data relevant to background, are in progress and will be considered in future evaluations. The information presented here is therefore preliminary.

Although single "point" concentrations may be used to summarize potential background datasets, as is done in this summary, background is properly viewed as a statistical distribution of values. A final statistical approach for determining background values for cleanup decisions, or for evaluating compliance with background-based cleanup levels, has not yet been selected. Statistical evaluations within this section are limited to estimating simple summary statistics. Some data representativeness issues are mentioned as datasets are described, primarily to illustrate some of the factors to be reviewed, but with no attempt to be comprehensive. Both statistical and data representativeness issues will be further evaluated as background assessments continue.

Concentrations of PCBs, arsenic, cPAHs, and dioxins and furans in surface sediment were summarized for reference areas throughout Puget Sound as an indication of the concentrations of these chemicals in non-urban areas. Specific natural background concentrations or concentration ranges were not derived; these concentrations may be developed in the future by EPA and Ecology. Data from the Puget Sound 2008 survey conducted by the DMMP became available in January 2009. That study provided additional data for PCB congeners and dioxins and furans.

Based on currently available data, the estimated 90th percentile concentrations[131] from each of the reference areas and the Puget Sound 2008 survey ranged from 2.3 to 15.9 mg/kg dw for arsenic, from 0.2 to 19.9 µg/kg dw for PCBs, from 14.7 to 244.7 µg/kg dw for cPAHs, and from 0.141 to 2.3 ng/kg dw for dioxin and furan TEQs.

Sediment and water quality data from upstream areas and core data from the LDW Upper Turning Basin were compiled to assess the range of chemical concentrations in sediments entering the LDW from upstream. Table 7-7 summarizes the means, medians, 90th percentiles, and UCLs for each dataset that was evaluated. For PCBs, the range of 90th percentile concentrations was 40 to 107 µg/kg dw. The lowest 90th percentile was associated with relatively coarse-grained surface sediment samples collected upstream of RM 5.0. The highest 90th percentile concentration was an estimated concentration associated with fine suspended solids in the water column upstream of the site. The upstream 90th percentile concentrations were within the

[131] The 90th percentile concentration ranges are presented as one point of comparison only for informational purposes. Estimated 90th percentile values that reflect non-detected results have been replaced with maximum detected values.

range but generally lower than the 90th percentile values for sediments in urban bays and lakes, which ranged from 64 to 217 µg/kg dw, with the exclusion of the inner Elliott Bay data.

For arsenic, the 90th percentile concentrations in sediment calculated from the individual datasets ranged from 11 to 73 mg/kg dw. The lowest 90th percentile concentration was associated with relatively coarse-grained surface sediment samples collected upstream of the site, whereas the highest 90th percentile concentration was an estimated concentration associated with fine suspended solids in the water column upstream of the site. The 90th percentile arsenic concentrations for sediments in urban bays and lakes ranged from 9.8 to 38 mg/kg dw.

For cPAHs, the 90th percentile concentrations in sediment calculated for the individual datasets ranged from 135 to 354 µg/kg dw, with the lowest 90th percentile concentration associated with relatively coarse-grained surface sediment samples collected upstream of RM 5.0 and the highest 90th percentile concentration associated with suspended solids from upstream of the LDW. The 90th percentile cPAH concentration for sediments in urban bays and lakes ranged from 185 to 904 µg/kg dw, with the exclusion of the inner Elliott Bay data.

There were fewer data available for dioxins and furans. The mean dioxin and furan TEQ from sediment upstream of RM 5.0 was 2.0 ng/kg dw, which was lower than the 90th percentile dioxin and furan TEQ for samples collected near storm drains and other areas receiving runoff from the greater Seattle metropolitan area (16.3 ng/kg dw). Because only four samples were available from upstream, no 90th percentile value was estimated for dioxins and furans.

Total PCB and inorganic arsenic concentrations in tissue samples collected outside of urban areas were presented to provide a context for PCB and inorganic arsenic tissue RBTCs presented in Section 8. Total PCB concentrations in fish fillets and crab tissue ranged from non-detect to 140.4 µg/kg ww among the species. Total PCB concentrations in clams were generally lower than in fish and crabs, ranging from non-detect to 3.6 µg/kg ww. Inorganic arsenic concentrations in clam tissue ranged from 0.0440 to 0.616 mg/kg ww. Inorganic arsenic concentrations in fish and crabs (whole body) were generally lower (non-detect to 0.13 mg/kg ww).

EPA and Ecology will set final background concentrations for consideration of cleanup levels in the ROD. The preliminary information on background presented in this section, based on available datasets, will be supplemented by additional datasets as they become available. Further detailed evaluations of background are planned. This initial compilation of potential background data provides a context for the LDW site characterization data (Section 4) and RBTCs (Section 8).

8 Risk-Based Threshold Concentrations

This section presents the derivation of RBTCs, which represent the concentrations that equate to specific risk thresholds. RBTCs for human health were developed for excess cancer risk thresholds of 1×10^{-4}, 1×10^{-5} and 1×10^{-6} and HQs equal to 1. These thresholds are important in both the CERCLA and MTCA programs, as discussed in the HHRA (Appendix B). RBTCs have been estimated for exposure through direct sediment contact and ingestion of seafood items. RBTCs were developed for chemicals that were identified as risk driver chemicals in either the ERA (Appendix A) or the HHRA (Appendix B). RBTCs are an important component in the derivation of PRGs in the FS. The RBTCs derived in this section are not the same as cleanup levels or cleanup goals. EPA and Ecology will select final cleanup values in the ROD. It should also be noted that although SWACs are discussed in this section, PRGs will be compared with 95% UCLs on the SWACs in the FS.

In the HHRA (Appendix B, Section B.7), PCBs, arsenic, cPAHs, and dioxins and furans were identified as risk driver chemicals for both seafood consumption and direct sediment contact scenarios (Table 8-1). In the ERA (Appendix A, Section A.7), PCBs were identified as a risk driver chemical for river otter based on risks associated with ingestion of PCBs in prey.[132] In addition, 41 chemicals were identified as risk driver chemicals for the benthic invertebrate community based on detected exceedances of SMS criteria.

Table 8-1. Summary of risk driver chemicals from the HHRA and ERA

Exposure Scenario	PCBs	Arsenic	Dioxins and Furans	cPAHs	Other Chemicals
Human health – direct sediment contact	X	X	X	X	ns
Human health – seafood consumption	X	X	X[a]	X	ns
River otter prey ingestion	X	na[b]	ne	na[c]	na[b]
Benthic invertebrate sediment exposure	X	X	ne	na[c]	X[d]

[a] Dioxins and furans were assumed to be risk drivers for human health seafood consumption (see Appendix B) even though tissue data were not available for the risk assessment. Because tissue data and risk estimates are not available, RBTCs cannot be calculated for dioxins and furans for the seafood consumption scenarios.

[b] Arsenic and other chemicals were not identified as risk drivers because they were not COCs for otter.

[c] cPAHs (as a TEQ) were evaluated only for human health risks. Other approaches (e.g., assessment of individual PAH compounds) were used in the ecological assessment of PAHs.

[d] In addition to arsenic and total PCBs, risk driver chemicals identified for the benthic invertebrate community, based on one or more surface sediment samples with exceedances of the SQS, include cadmium, chromium, copper, lead, mercury, silver, zinc, acenaphthene, anthracene, benz(a)anthracene, benzo(a)pyrene,

[132] In the ERA (Appendix A), direct exposure to sediments was explicitly evaluated for fish and wildlife receptors as a component of the overall diet (i.e., incidental sediment ingestion). No risk drivers were identified for fish or wildlife receptors based solely on direct contact with sediments because the majority of the risk is associated with ingestion of dietary items, not direct contact with sediment. Therefore, the PCB RBTC for river otter is based only on ingestion of prey items.

benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3,-c,d)pyrene, naphthalene, phenanthrene, pyrene, total benzofluoranthenes, HPAH, LPAH, BEHP, butyl benzyl phthalate, dimethyl phthalate, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, 2-methylnaphthalene, 4-methylphenol, 2,4-dimethylphenol, benzoic acid, benzyl alcohol, dibenzofuran, hexachlorobenzene, n-nitrosodiphenylamine, pentachlorophenol, and phenol.

BEHP – bis(2-ethylhexyl) phthalate
cPAH – carcinogenic polycyclic aromatic hydrocarbon
COC – chemical of concern
ERA – ecological risk assessment
HHRA – human health risk assessment
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
na – not applicable
ne – not evaluated (in risk assessment)
ns – not selected (as a risk driver)
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SQS – sediment quality standards
TEQ – toxic equivalent

Various approaches were used to derive the RBTCs for the risk driver chemicals in Table 8-1. Mathematical equations based on risk assessment assumptions were used to derive sediment RBTCs for the human health direct sediment contact scenarios (Section 8.1) and tissue RBTCs for the seafood ingestion scenarios (human [Section 8.2] and otter [Section 8.4]). Sediment RBTCs for the benthic invertebrate community were based on SMS criteria (Section 8.5).

To develop RBTCs for sediment for seafood consumption scenarios, a relationship was needed between chemicals concentrations in tissues and sediment. Different types of models were used to estimate this relationship, depending on data type. For PCBs, a FWM was developed to relate total PCB concentrations in sediment to concentrations in fish, crabs, and clams, which were all relevant for RBTC development (Section 8.3.1). Co-located sediment and clam tissue data were used to evaluate regression models for arsenic and cPAHs to determine if the derivation of sediment RBTCs was appropriate (Sections 8.3.2 and 8.3.3).

The FWM developed for PCBs could not be used to relate arsenic concentrations in clam tissue and sediment and was not used to relate cPAHs in sediment and clam tissue. The FWM could not be used for arsenic because the Gobas-type FWM was designed to model bioaccumulation of hydrophobic organic chemicals. The FWM was not used for cPAHs because application of the model to a toxicity equivalent mixture of compounds is complicated, and would have required certain input parameters that are not readily available (such as a K_{OW} value weighted to account for differences in toxicity of the various cPAH congeners and cPAH concentrations in water). Also, the FWM was not calibrated for PAH compounds.

8.1 SEDIMENT RBTCS FOR HUMAN DIRECT SEDIMENT CONTACT

Sediment RBTCs were determined for direct sediment contact scenarios evaluated in the HHRA (Appendix B). RBTCs are important in the evaluation of remedial action objectives (RAOs); RBTCs developed for RME scenarios will be used in evaluating

cleanup alternatives.[133] RBTCs for non-RME direct sediment contact scenarios were also estimated to aid in risk management and risk communication.

The RME scenarios for direct sediment contact evaluated in the HHRA (Appendix B) included beach play, netfishing, and tribal clamming (120 days per year). Non-RME scenarios included netfishing (central tendency) and clamming scenarios with lower (i.e., 7 days per year, provided for informational purposes) and higher (i.e., 183 days per year) exposure frequencies than the RME clamming scenario. Key parameters used to estimate risks associated with direct sediment contact are summarized in Tables 8-2 and 8-3. Detailed descriptions of the direct sediment contact scenarios and risk results are presented in the HHRA (Appendix B) in Sections B.3 and B.5, respectively. Detailed exposure information for the direct sediment contact scenarios is presented in Tables B.3-15 through B.3-26, EPCs are summarized in Table B.3-44, chemical toxicity information is presented in Tables B.4-1 and B.4-2, and risk estimates for direct sediment contact scenarios are presented in Tables B.5-23 through B.5-48.

Table 8-2. Summary of input parameters for RME direct sediment contact exposure scenarios

Direct Sediment Contact Scenario for Which RBTCs Were Derived	Incidental Sediment IR (g/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Skin Surface Area Exposed (cm^2)
Netfishing RME	0.05	119	44	3,600
Child beach play RME[a]	0.2	65	6	varies with age
Tribal clamming RME (120 days per year)	0.1	120	64	6,040

[a] For the beach play scenarios, the LDW was divided into eight sections to assess risks associated with different areas of the LDW. Exposure of children was evaluated from the time of birth to 6 years of age.

IR – ingestion rate

RBTC – risk-based threshold concentration

RME – reasonable maximum exposure

Table 8-3. Summary of input parameters for non-RME direct sediment contact exposure scenarios

Direct Sediment Contact Scenario for Which RBTCs Were Derived	Incidental Sediment IR (g/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Skin Surface Area Exposed (cm^2)
Netfishing CT	0.05	63	29	3,600
Clamming (7 days per year)	0.1	7	30	6,040
Tribal clamming upper bound (183 days per year)	0.1	183	70	6,040

CT – central tendency

IR – ingestion rate

RBTC – risk-based threshold concentration

RME – reasonable maximum exposure

[133] In accordance with EPA guidance (Section 6.1.2 of EPA 1989), RME scenarios are used to formulate RAOs and evaluate cleanup alternatives at Superfund sites.

8.1.1 Methods for calculating sediment RBTCs for human direct sediment contact

Sediment RBTCs for direct sediment contact scenarios were derived for each of the risk driver chemicals according to Equation 8-1 (for carcinogenic effects). The first term in the denominator addresses dermal exposure; the second term addresses incidental ingestion.

$$RBTC = \frac{TR}{\left[\left[\left(\frac{ABS \times SA \times AF \times FC \times EF \times ED \times CF_1}{BW \times AT_C}\right) + \left(\frac{IR \times FC \times EF \times ED \times CF_2}{BW \times AT_C}\right)\right] \times SF\right]} \quad \textbf{Equation 8-1}$$

Where:

RBTC	=	risk-based threshold concentration in sediment (mg/kg dw)
TR	=	target risk (i.e., 1×10^{-6}, 1×10^{-5}, 1×10^{-4}) (unitless)
ABS	=	absorption factor (unitless)
SA	=	skin surface area (cm^2)
AF	=	adherence factor (mg/cm^2-day)
FC	=	fraction from contaminated site (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
CF_1	=	conversion factor, kg to mg (0.000001)
BW	=	body weight (kg)
AT_c	=	averaging time, cancer (days)
SF	=	cancer slope factor $(mg/kg\text{-}day)^{-1}$
AT_n	=	averaging time, non-cancer (days)
IR	=	incidental sediment ingestion rate (g/day)
CF_2	=	conversion factor, kg to g (0.001)

RBTCs were not estimated for non-cancer hazards for direct-contact scenarios because none of the RME scenarios had HQs for an individual chemical greater than 1 or generated endpoint-specific HIs in excess of 1 (Appendix B, Section B.5.6). Equation 8-1 is simply a rearrangement of the equation used in the HHRA to estimate excess cancer risk. In this case, rather than inserting a maximum or 95% UCL sediment concentration into the equation and solving for risk, as was done in the HHRA (Appendix B), the target risk is set and the equation is solved for a corresponding sediment concentration.

8.1.2 Results of sediment RBTC calculations for human direct sediment contact

Sediment RBTCs for the direct sediment contact RME scenarios are shown in Table 8-4; those for non-RME scenarios are presented in Table 8-5. The non-RME RBTCs are presented for informational purposes only, and are not intended for use in setting clean up levels. The remedial decision-making process will focus primarily on the RME scenarios, although some non-RME scenarios will also be considered as lower- and upper- bound estimates of risk. The RBTCs for the tribal clamming RME

scenario were lower than the RBTCs for the other two RME scenarios at a given target risk level, except for cPAHs. The beach play RME RBTCs were lowest for cPAHs because the beach play scenario was specifically designed to be protective of children. Because cPAHs have a mutagenic mode of action, EPA guidance (2005e) recommends that the dose estimates be adjusted upwards in the risk calculation to account for the potential greater susceptibility of children from 0 to 6 years of age compared with older children and adults. This approach resulted in approximately a five-fold increase in the cancer risk estimate for cPAHs for children (Appendix B, Section B.5, Equation 5.2), with a corresponding lowering of the cPAH RBTC. Considerations relevant to the application of these RBTCs are discussed in Section 8.6.

Table 8-4. Sediment RBTCs for RME direct sediment contact human health scenarios

Risk Driver	Target Risk	Sediment RBTCs Based on Direct-Contact RME Scenarios		
		Netfishing RME	Beach Play RME	Tribal Clamming RME (120 days/year)
Arsenic (mg/kg dw)	1×10^{-6}	3.7	2.8	1.3
	1×10^{-5}	37	28	13
	1×10^{-4}	370	280	130
cPAHs (µg/kg dw)[a]	1×10^{-6}	380	90	150
	1×10^{-5}	3,800	900	1,500
	1×10^{-4}	38,000	9,000	15,000
Dioxin/furan TEQ (ng/kg dw)	1×10^{-6}	37	28	13
	1×10^{-5}	370	280	130
	1×10^{-4}	3,700	2,800	1,300
Total PCBs (µg/kg dw)	1×10^{-6}	1,300	1,700	500
	1×10^{-5}	13,000	17,000	5,000
	1×10^{-4}	130,000	170,000	50,000

[a] cPAH concentrations are expressed in terms of benzo(a)pyrene equivalents. Because of the potential for increased susceptibility of children to carcinogens with mutagenic activity, as described in EPA guidance (2005e), the risk estimate for children for cPAHs is based on dose adjustments across the 0-to-6-year age range of children (see Appendix B, Section B.5.1, for more information).

cPAH – carcinogenic polycyclic aromatic hydrocarbon
CT – central tendency
dw – dry weight
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration
RME – reasonable maximum exposure
TEQ – toxic equivalent

Table 8-5. Sediment RBTCs for non-RME direct sediment contact human health scenarios

Risk Driver	Target Risk	Sediment RBTCs Based on Non-RME Direct-Contact Scenarios		
		Clamming (7 days/year)	Netfishing CT	Clamming (183 days/year)
Arsenic (mg/kg dw)	1×10^{-6}	43	11	0.80
	1×10^{-5}	430	110	8.0
	1×10^{-4}	4,300	1,100	80
cPAHs (µg/kg dw)[a]	1×10^{-6}	4,700	1,100	87
	1×10^{-5}	47,000	11,000	870
	1×10^{-4}	470,000	110,000	8,700
Dioxin/furan TEQ (ng/kg dw)	1×10^{-6}	220	110	7.98
	1×10^{-5}	2,200	1,100	79.8
	1×10^{-4}	22,000	11,000	798
Total PCBs (µg/kg dw)	1×10^{-6}	16,000	9,500	300
	1×10^{-5}	160,000	95,000	3,000
	1×10^{-4}	1,600,000	950,000	30,000

[a] cPAH concentrations are expressed in terms of benzo(a)pyrene equivalents.

cPAH – carcinogenic polycyclic aromatic hydrocarbon
CT – central tendency
dw – dry weight
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration
RME – reasonable maximum exposure
TEQ – toxic equivalent

8.2 TISSUE RBTCS FOR HUMAN SEAFOOD CONSUMPTION

Several different human seafood consumption scenarios were evaluated in the HHRA (Appendix B). EPA's application of the tribal framework to the LDW states that the tribal scenarios based on Tulalip data are the most appropriate scenarios for representing RME exposure in the LDW because of the quality and quantity of shellfish habitat that will be present post–remediation (EPA 2005a, 2007d). Therefore, RBTCs associated with the tribal adult and child RME seafood consumption scenarios based on Tulalip consumption data will be used in the evaluation of cleanup alternatives based on both the application of the tribal framework(EPA 2005a) and more recent communication from EPA (2007b). Because it provides another RME estimate, the adult API RME seafood consumption scenario may also be used in the evaluation of cleanup alternatives.

In addition to the RBTCs for the RME scenarios, RBTCs were developed for the other seafood consumption scenarios to aid in risk management and risk communication efforts. Thus, RBTCs were derived for adult tribal (Suquamish data), adult and child tribal CT (Tulalip data), adult API CT, and adult one-meal-per-month scenarios.

Key assumptions for each of the seafood consumption scenarios are summarized in Table 8-6. The seafood consumption scenarios and risk results are presented in the HHRA (Appendix B), in Sections B.3 and B.5, respectively. Detailed exposure information for the seafood consumption scenarios is presented in Tables B.3-7 through B.3-14, EPCs are summarized in Table B.3-39, chemical toxicity information is presented in Tables B.4-1 and B.4-2, and risk estimates are presented in Tables B.5-1 through B.5-16.

Table 8-6. Summary of key assumptions in the seafood consumption scenarios

Seafood Consumption Scenario for which RBTCs Were Derived	Ingestion Rate (g/day)					Exposure Duration (yrs)
	Pelagic Fish	Benthic Fish	Crabs	Other Shellfish[a]	Total	
Adult tribal RME (Tulalip data)	8.1	7.5	37.7[c]	44.2[c]	97.5	70
Child tribal RME (Tulalip data)	3.2	3.0	15.1[c]	17.7[c]	39.0	6
Adult API RME	4.9	2.4	10.6	33.6	51.5	30
Adult tribal CT (Tulalip data)	1.3	1.2	5.8[c]	6.7[c]	15.0	30
Child tribal CT (Tulalip data)	0.52	0.48	2.4[c]	2.64[c]	6.0	6
Adult tribal (Suquamish data)	56	29.2[d]	55[d]	444[d]	584.2[d]	70
Adult API CT	0.5	0.24	1.1	3.5	5.3	12
Adult one meal per month[b]	7.5	7.5	7.5	7.5	na	30

[a] Other shellfish represents both clam and mussel consumption categories.

[b] Adult one-meal-per-month consumption was evaluated for individual seafood categories independently to reflect different seafood consumption practices.

[c] Consumption rates based on the Tulalip Tribes survey (Toy et al. 1996) have been updated according to the correction provided by EPA (2009), in which the relative apportionment of shellfish between crab and other shellfish was reversed (although the total consumption did not change). These values differ from those presented in Table 6-2 (which contains the values previously provided by EPA and used in the LDW HHRA, Appendix B).

[d] Totals of benthic fish and shellfish categories (and overall total) differ slightly from values provided by EPA (2007d) because of significant figure and rounding issues when total consumption was allocated to more specific consumption categories. The overall total listed here is slightly higher than the corresponding value provided by EPA (2007d).

API – Asian and Pacific Islander

CT – central tendency

na – not applicable

RBTC – risk-based threshold concentration

RME – reasonable maximum exposure

Tissue RBTCs were estimated for total PCBs, arsenic, and cPAHs according to the methods described in Section 8.2.1. The primary use of these RBTCs will be to evaluate post-cleanup monitoring data for risk driver chemicals in seafood tissue. It should be noted that sediment RBTCs were not derived directly from tissue RBTCs; sediment RBTCs were derived as described in Section 8.3. Tissue RBTCs were not estimated for

dioxins and furans because tissue data for these chemicals have not been collected from the LDW.

8.2.1 Methods for calculating tissue RBTCs for human seafood consumption

Tissue RBTCs associated with the human seafood consumption scenarios were estimated for total PCBs, arsenic, and cPAHs using Equation 8-2 (for carcinogenic effects) or Equation 8-3 (for non-carcinogenic effects; only PCBs and arsenic). The values for these parameters are presented in the HHRA (Section 3, Appendix B).

$$\text{Tissue RBTC} = \frac{TR}{\left[\left[\frac{IR \times FC \times EF \times ED \times CF}{BW \times AT_C}\right] \times SF\right]} \qquad \textbf{Equation 8-2}$$

$$\text{Tissue RBTC} = \frac{THQ}{\left[\left[\frac{IR \times FC \times EF \times ED \times CF}{BW \times AT_n}\right] \times \frac{1}{RfD}\right]} \qquad \textbf{Equation 8-3}$$

Where:

RBTC	=	risk-based threshold concentration in seafood items (mg/kg ww)
TR	=	target risk (i.e., 1×10^{-6}, 1×10^{-5}, 1×10^{-4}) (unitless)
IR	=	ingestion rate (g/day)
FC	=	fraction from contaminated site (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
CF	=	conversion factor, kg to g (0.001)
BW	=	body weight (kg)
AT_c	=	averaging time, cancer (days)
SF	=	cancer slope factor $(mg/kg\text{-}day)^{-1}$
THQ	=	target hazard quotient (1) (unitless)
AT_n	=	averaging time, non-cancer (days)
RfD	=	reference dose (mg/kg-day)

RBTCs based on carcinogenic risks were estimated for three risk threshold levels, 1×10^{-6}, 1×10^{-5}, and 1×10^{-4}; for non-cancer hazards, the RBTCs corresponding to an HQ of 1 were estimated.

8.2.2 Results of tissue RBTC calculations for human seafood consumption

Tissue RBTCs corresponding to the RME seafood consumption scenarios are presented in Table 8-7; tissue RBTCs corresponding to the non-RME scenarios are presented in Table 8-8. RBTCs for non-RME scenarios are presented only for informational purposes. The remedial decision-making process will focus primarily on the RME scenarios, although some non-RME scenarios will also be considered as lower- and upper- bound estimates of risk. Tissue RBTCs for the seafood consumption scenarios

represent the ingestion-weighted average concentration in tissue that results in a certain risk threshold for each scenario. For example, the RBTC for total PCBs for the adult tribal RME seafood consumption scenario based on Tulalip data was 4.2 µg/kg ww at the 1×10^{-5} excess cancer risk level. Thus, consumption of 97.5 g/day (adult tribal RME daily ingestion rate based on Tulalip data) of any tissue type with a total PCB concentration of 4.2 µg/kg ww for 70 years would result in a 1×10^{-5} excess cancer risk. Consumption of numerous types of seafood, such as crabs, clams, and fish (as specified in the adult tribal RME exposure parameters based on Tulalip data) would also result in a 1×10^{-5} excess cancer risk as long as the ingestion-weighted average of the various tissue concentrations consumed was 4.2 µg/kg ww. For the three risk driver chemicals evaluated, the tissue RBTCs for the adult tribal RME scenario based on Tulalip data were lower than all other scenarios for a given risk threshold (Table 8-7).

Table 8-7. Tissue RBTCs estimated from HHRA RME seafood consumption scenarios

Chemical	Seafood Consumption Scenario	Unit (ww)	Tissue RBTC[a]			
			Excess Cancer Risk			Non-Cancer Hazard
			1×10^{-6}	1×10^{-5}	1×10^{-4}	HQ = 1
Arsenic (inorganic)	adult tribal RME (Tulalip data)	mg/kg	0.00056	0.0056	0.056	0.25
	child tribal RME (Tulalip data)	mg/kg	0.0030	0.030	0.30	0.12
	adult API RME	mg/kg	0.0019	0.019	0.19	0.37
Total PCBs	adult tribal RME (Tulalip data)	µg/kg	0.42	4.2	42	17
	child tribal RME (Tulalip data)	µg/kg	2.3	23	230	7.8
	adult API RME	µg/kg	1.4	14	140	24
cPAHs[b]	adult tribal RME (Tulalip data)	µg/kg	0.11	1.1	11	na
	child tribal RME (Tulalip data)[c]	µg/kg	0.12	1.2	12	na
	adult API RME	µg/kg	0.39	3.9	39	na

[a] Tissue RBTCs represent ingestion-weighted average concentrations across different seafood categories. Tissue concentrations in individual seafood categories may be higher or lower than the tissue RBTC, but the average concentration in all resident seafood consumed must equal the tissue RBTC in order to result in the specified risk threshold.

[b] cPAH concentrations are expressed in terms of benzo(a)pyrene equivalents.

[c] Because of the potential for increased susceptibility of children to carcinogens with mutagenic activity, as described in EPA guidance (2005e), the risk estimate for children for cPAHs is based on dose adjustments across the 0-to-6-year age range of children (see Appendix B, Section B.5.1, for more information).

API – Asian and Pacific Islander
cPAH – carcinogenic polycyclic aromatic hydrocarbon
EPA – US Environmental Protection Agency
HHRA – human health risk assessment
HQ – hazard quotient
na – not applicable
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration
RME – reasonable maximum exposure
ww – wet weight

Table 8-8. Tissue RBTCs estimated from HHRA non-RME seafood consumption scenarios

Chemical	Seafood Consumption Scenario	Unit (ww)	Tissue RBTC[a]			
			Excess Cancer Risk			Non-Cancer Hazard
			1×10^{-6}	1×10^{-5}	1×10^{-4}	HQ = 1
Arsenic (inorganic)	adult tribal CT (Tulalip data)	mg/kg	0.0085	0.085	0.85	1.6
	child tribal CT (Tulalip data)	mg/kg	0.020	0.20	2.0	0.76
	adult API CT	mg/kg	0.062	0.62	6.2	3.6
	adult tribal (Suquamish)	mg/kg	0.000088	0.00088	0.0088	0.040
	adult one meal per month[b]	mg/kg	0.015	0.15	1.5	2.9
Total PCBs	adult tribal CT (Tulalip data)	µg/kg	6.4	64	640	110
	child tribal CT (Tulalip data)	µg/kg	15	150	1,500	51
	adult API CT	µg/kg	46	460	4,600	240
	adult tribal (Suquamish)	µg/kg	0.066	0.66	6.6	2.6
	adult one meal per month[b]	µg/kg	11	110	1,100	190
cPAHs[c]	adult tribal CT (Tulalip data)	µg/kg	1.7	17	174	na
	child tribal CT (Tulalip data)[d]	µg/kg	0.76	7.6	76	na
	adult API CT	µg/kg	13	130	1,300	na
	adult tribal (Suquamish)	µg/kg	0.018	0.18	1.8	na
	adult one meal per month[b]	µg/kg	3.1	31	310	na

[a] Tissue RBTCs represent ingestion-weighted average concentrations across different seafood categories. Tissue concentrations for individual seafood categories may be higher or lower than the tissue RBTC, but the average concentration in all resident seafood consumed must equal the tissue RBTC in order to match the specified risk threshold.

[b] The adult one-meal-per-month value represents the tissue RBTC that corresponds to consumption of any type of seafood at a rate of one meal per month (7.5 g/day or 0.25 ounces/day).

[c] cPAH concentrations are expressed in terms of benzo(a)pyrene equivalents.

[d] Because of the potential for increased susceptibility of children to carcinogens with mutagenic activity, as described in EPA guidance (2005e), the risk estimate for children for cPAHs is based on dose adjustments across the 0-to-6-year age range of children (see Appendix B, Section B.5.1, for more information).

API – Asian and Pacific Islander
cPAH – carcinogenic polycyclic aromatic hydrocarbon
CT – central tendency
EPA – US Environmental Protection Agency
HHRA – human health risk assessment
HQ – hazard quotient
na – not applicable
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration
ww – wet weight

For total PCBs, Table 8-9 presents a comparison of tissue RBTCs to empirical LDW and background tissue data for Puget Sound. The tissue RBTC represents an average concentration in seafood associated with a particular diet and a specific consumption rate. Therefore, the tissue RBTC, which are based on a diet of multiple species, and concentrations in a single species are not strictly comparable. Total PCB concentrations in the three species from the LDW were greater than the tissue RBTCs for all risk levels. Total PCB concentrations in tissue from Puget Sound background locations

were generally greater than tissue RBTCs at the 1×10^{-6} risk level for clams and crabs. For English sole, total PCB concentrations in tissue collected from Puget Sound background locations were generally greater than the tissue RBTC at the 1×10^{-5} risk level (Table 8-9).

Table 8-9. Total PCB concentrations in LDW and background tissue compared with tissue RBTCs

EPC or RBTC	Total PCB Concentration (µg/kg ww)		
	English Sole	Clam	Dungeness and Slender Crabs
LDW-wide UCL	1,200	600	200
LDW-wide mean	700	140	170
Background (range of mean values)[a]	2.8 – 16	0.12 –- 2.8	0.62 – 1.4
1 x 10^{-4} RBTC (Tulalip RME)	42	42	42
1 x 10^{-5} RBTC (Tulalip RME)	4.2	4.2	4.2
1 x 10^{-6} RBTC (Tulalip RME)	0.42	0.42	0.42

[a] Range of mean total PCB concentrations from various studies and non urban sampling areas in the Puget Sound, as presented in Table 7-19.

EPC – exposure point concentration
LDW – Lower Duwamish Waterway
PCB – polychlorinated biphenyl
RME – reasonable maximum exposure
RBTC – risk-based threshold concentration
UCL – upper confidence limit on the mean
ww – wet weight

8.3 Sediment RBTCs for Human Seafood Consumption

Methods for deriving sediment RBTCs for human seafood consumption varied by risk driver. For PCBs, a mechanistic FWM was developed to derive sediment RBTCs (Section 8.3.1). However, such a model is not appropriate for arsenic and cPAHs, so regression models were evaluated for those risk drivers (Sections 8.3.2 and 8.3.3, respectively).

Dioxins and furans were identified as a risk driver for human seafood consumption based on an assumption of unacceptable risk, although no tissue data were available when the risk assessments were conducted. Because estimating sediment RBTCs for the seafood consumption pathway requires modeling the relationship between empirical sediment and tissue concentrations, sediment RBTCs for dioxins and furans could not be estimated for the seafood consumption pathway (sediment RBTCs for dioxins and furans based on direct contact were derived in Section 8.1). Remedial decision-making for dioxins and furans by EPA and Ecology will be based on appropriate guidance and regulations, including those specifically related to the role of background concentrations in the CERCLA and MTCA processes (EPA 2002a; Ecology 2001a).

8.3.1 PCB sediment RBTCs for human seafood consumption

8.3.1.1 Methods for calculating total PCB sediment RBTCs for human seafood consumption

For PCBs, the FWM was used to estimate sediment RBTCs. Information regarding the specific input parameters, calibration, and performance of the FWM is presented in Appendix D (Section D.9), which describes how the FWM was used to derive sediment RBTCs. A best-fit RBTC was estimated using the FWM parameter set that most closely fit the empirical PCB tissue data for all species combined. In addition, a range of sediment RBTCs for total PCBs was estimated for each seafood exposure scenario. The RBTC range represents the range of estimates generated by the FWM while still meeting the FWM performance criterion, which required that the estimated concentrations in tissues be within a factor of 2 of the empirical data for all of the target species. A full discussion of the sources of uncertainty in the FWM is presented in Appendix D, Section D.6.

8.3.1.2 Results of total PCB sediment RBTC calculations for human seafood consumption

Sediment RBTCs were calculated to represent the total PCB concentrations in sediment that correspond to a range of excess cancer risk thresholds (1×10^{-4}, 1×10^{-5}, and 1×10^{-6}) for each of the HHRA scenarios evaluated (Tables 8-10 and 8-11 for the RME and non-RME scenarios, respectively). Sediment RBTCs were estimated to be < 1 µg/kg dw at the 1×10^{-5} or 1×10^{-6} target risk levels for the adult and child tribal RME scenarios and for the adult API RME scenario because the water concentrations assumed in the model (0.0006 to 0.0012 µg/L; see Appendix D, Section D.9) resulted in estimated tissue concentrations greater than the tissue RBTCs in Table 8-7, even in the absence of any contribution from sediment.

Table 8-10. Sediment RBTCs for total PCBs based on excess cancer risks in HHRA RME seafood consumption scenarios

Scenario	Risk Level	Sediment RBTC (µg/kg dw)[a]		
		Lower Bound[b]	Best Fit	Upper Bound[b]
Adult tribal RME (Tulalip data)	1×10^{-4}	< 1	7.3	25
Child tribal RME (Tulalip data)		109	185	301
Adult API RME		67	100	167
Adult tribal RME (Tulalip data)	1×10^{-5}	< 1	< 1	< 1
Child tribal RME (Tulalip data)		< 1	< 1	< 1
Adult API RME		< 1	< 1	< 1
Adult tribal RME (Tulalip data)	1×10^{-6}	< 1	< 1	< 1
Child tribal RME (Tulalip data)		< 1	< 1	< 1
Adult API RME		< 1	< 1	< 1

[a] For RBTCs presented as < 1 µg/kg dw, a sediment RBTC could not be calculated; even if the total PCB concentration in sediment was set equal to 0 µg/kg dw, FWM-estimated total PCB concentrations in tissue would be greater than the tissue RBTC for the applicable risk level because of the contribution of PCBs from water alone.

[b] Upper and lower bounds were calculated using estimates from parameter sets that met the FWM performance criterion (i.e., empirical data were within a factor of 2 of FWM-estimated concentrations for all species) (see Section D.9).

API – Asian and Pacific Islander
dw – dry weight
FWM – food web model
HHRA – human health risk assessment
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration
RME – reasonable maximum exposure

Table 8-11. Sediment RBTCs for total PCBs based on excess cancer risks in the non-RME HHRA seafood consumption scenarios

Scenario	Risk Level	Sediment RBTC (µg/kg dw)[a, b]		
		Lower Bound[c]	Best Fit	Upper Bound[c]
Adult tribal CT (Tulalip data)	1×10^{-4}	370	> 380	> 380
Child tribal CT (Tulalip data)		> 380	> 380	> 380
Adult API CT		> 380	> 380	> 380
Adult tribal (Suquamish data)		< 1	< 1	< 1
Adult one meal per month of benthic fish		220	320	> 380
Adult one meal per month of pelagic fish		170	250	> 380
Adult one meal per month of crabs		> 380	> 380	> 380
Adult one meal per month of clams		> 380	> 380	> 380
Adult tribal CT (Tulalip data)	1×10^{-5}	13	29	62
Child tribal CT (Tulalip data)		68	100	181
Adult API CT		260	> 380	> 380
Adult tribal (Suquamish data)		< 1	< 1	< 1
Adult one meal per month of benthic fish		9	13	23
Adult one meal per month of pelagic fish		< 1	< 1	< 1
Adult one meal per month of crabs		100	220	> 380
Adult one meal per month of clams		270	350	> 380
Adult tribal CT (Tulalip data)	1×10^{-6}	< 1	< 1	< 1
Child tribal CT (Tulalip data)		< 1	< 1	< 1
Adult API CT		0.2	10	28
Adult tribal (Suquamish data)		< 1	< 1	< 1
Adult one meal per month of benthic fish		< 1	< 1	< 1
Adult one meal per month of pelagic fish		< 1	< 1	< 1
Adult one meal per month of crabs		< 1	< 1	< 1
Adult one meal per month of clams		< 1	2	8

[a] For RBTCs presented as < 1 µg/kg dw, a sediment RBTC could not be calculated; even if the total PCB concentration in sediment was set equal to 0 µg/kg dw, FWM-estimated total PCB concentrations in tissue

would be greater than the tissue RBTC for the applicable risk level because of the contribution of PCBs from water alone.

[b] A sediment RBTC of > 380 µg/kg dw indicates that even under current conditions in the LDW, excess cancer risks are estimated to be less than the target risk level.

[c] Upper and lower bounds were calculated using estimates from parameter sets that met the FWM performance criterion (i.e., empirical data were within a factor of 2 of FWM-estimated concentrations for all species) (see Section D.9).

API – Asian and Pacific Islander
CT – central tendency
dw – dry weight
FWM – food web model
HHRA – human health risk assessment
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration
RME – reasonable maximum exposure

At the 1×10^{-4} target risk level, sediment RBTCs were 7.3 and 185 µg/kg dw for the adult and child tribal RME scenarios, respectively, and ranged from < 1 to 25 µg/kg dw for the adult tribal RME scenario and from 109 to 301 µg/kg dw for the child tribal RME scenario (Table 8-10). Sediment RBTCs for the non-RME (informational) scenarios ranged from < 1 µg/kg dw for the adult tribal scenario based on Suquamish data to > 380 µg/kg dw for a number of scenarios at the 1×10^{-4} target risk level (Table 8-11). A sediment RBTC of > 380 µg/kg dw indicates that even under current conditions in the LDW, [134] excess cancer risks are estimated to be less than the target risk level. For RBTCs presented as < 1 µg/kg dw, a sediment RBTC could not be calculated; even if the total PCB concentration in sediment was set equal to 0 µg/kg dw, FWM-estimated total PCB concentrations in tissue would be greater than the tissue RBTC for the applicable risk level because of the contribution of PCBs from water alone. This issue arises even at total PCB concentrations in water (0.0003 µg/L) that are similar to the total PCB concentrations in the Green River, upstream of the site (see Table 7-10). Further explanation is provided in Appendix D, Section D.9.

Sediment RBTCs for total PCBs corresponding to non-cancer hazards for RME scenarios with a target HQ of 1 were also estimated; all were < 1 µg/kg dw (Table 8-12). Best-fit RBTCs for the non-RME scenarios ranged from < 1 to > 380 µg/kg dw (Table 8-13).

[134] A sediment SWAC of 380 µg/kg dw was used in the FWM because it reflected the most current sediment interpolation at the time of model calibration. A subsequent interpolation (with a new IDW parameterization and the inclusion of Round 3 sediment data) resulted in a SWAC of 350 µg/kg dw for the LDW. Appendix D, Section D.6.2.3, presents an analysis of the FWM sensitivity to the SWAC; the average SPAF for all target species was 1.1 regardless of whether the SWAC was 350 or 380 µg/kg dw.

Table 8-12. Sediment RBTCs for total PCBs for the RME HHRA seafood consumption scenarios based on non-cancer hazard quotient of 1

Scenario	Sediment RBTC (µg/kg dw)[a]		
	Lower Bound[b]	Best Fit	Upper Bound[b]
Adult tribal RME (Tulalip data)	< 1	< 1	< 1
Child tribal RME (Tulalip data)	< 1	< 1	< 1
Adult API RME	< 1	< 1	< 1

[a] Sediment RBTCs were presented as < 1 µg/kg dw because they could not be calculated; even if the total PCB concentration in sediment was set equal to 0 µg/kg dw, FWM-estimated total PCB concentrations in tissue would be greater than the tissue RBTC for the applicable risk level because of the contribution of PCBs from water alone.

[b] Upper and lower bounds were calculated using estimates from parameter sets that met the FWM performance criterion (i.e., empirical data were within a factor of 2 of FWM-estimated concentrations for all species) (see Section D.9).

API – Asian and Pacific Islander
dw – dry weight
FWM – food web model
HHRA – human health risk assessment
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration
RME – reasonable maximum exposure

Table 8-13. Sediment RBTCs for total PCBs for the non-RME HHRA seafood consumption scenarios based on non-cancer hazard quotient of 1

Scenario	Sediment RBTC (µg/kg dw)[a, b]		
	Lower Bound[c]	Best Fit	Upper Bound[c]
Adult tribal CT (Tulalip data)	43	76.9	116
Child tribal CT (Tulalip data)	3	15.1	39
Adult API CT	117	193	304
Adult tribal (Suquamish data)	< 1	< 1	< 1
Adult one meal per month of benthic fish	27	40	63
Adult one meal per month of pelagic fish	5	20	27
Adult one meal per month of crabs	211	> 380	> 380
Adult one meal per month of clams	> 380	> 380	> 380

[a] For RBTCs presented as < 1 µg/kg dw, a sediment RBTC could not be calculated; even if the total PCB concentration in sediment was set equal to 0 µg/kg dw, FWM-estimated total PCB concentrations in tissue would be greater than the tissue RBTC for the applicable risk level because of the contribution of PCBs from water alone.

[b] A sediment RBTC of > 380 µg/kg dw indicates that even under current conditions in the LDW, excess cancer risks are estimated to be less than the target risk level.

[c] Upper and lower bounds were calculated using estimates from parameter sets that met the FWM performance criterion (i.e., empirical data were within a factor of 2 of FWM-estimated concentrations for all species) (see Section D.9).

API – Asian and Pacific Islander
CT – central tendency
dw – dry weight
FWM – food web model
HHRA – human health risk assessment
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration

8.3.2 Arsenic sediment RBTCs for human seafood consumption

As discussed in the HHRA (Appendix B), 96% of inorganic arsenic exposure, and hence, 96% of arsenic risk associated with seafood consumption is from consumption of clams. Consequently, the relationship between inorganic arsenic concentrations in clams and sediment is of considerable importance. Tissue chemistry data were collected in 2004 for the Eastern soft-shell clam (*Mya arenaria*). This species was selected for sampling because it is the most abundant clam in the LDW within the size range of interest from a human seafood consumption perspective. Clams in the size range appropriate for human consumption were defined as being over 2 cm long, measured at the widest diameter across the shell (anterior to posterior) (Harbo 2001), or heavier than 16 g with the shell on.[135] Also, *M. arenaria* can tolerate lower salinity environments better than can other native species, such as butter clams (*Saxidomus giganteus*) and native littleneck clams (*Protothaca staminea*). *M. arenaria* are filter feeders, like many other commercially important Puget Sound clam species, such as butter clams and Manila clams (*Tapes philippinarum*). *M. arenaria* can process large quantities of water (4 to 6 L/hr) while feeding on suspended particulates in the water column (Brown et al. 1994).

Given the feeding behavior of *M. arenaria*, water and suspended material in the water are likely to be important sources of bioaccumulated arsenic (Abraham and Dillon 1986). Arsenic was analyzed in hundreds of surface water samples in Elliott Bay, both East and West Waterways, and in the LDW as part of the King County WQA conducted from 1996 to 1997 (King County 1999e). Arsenic was also analyzed in numerous water samples collected in the Green/Duwamish River upstream of the site by King County (2002b, 2007f) (see Section 7.2.4.2 for more details). Mean arsenic concentrations in water at RM 1.0 and RM 2.0 were higher than those at RM 5.0 (Table 8-14). The downstream arsenic concentrations were similar to arsenic concentrations in Elliott Bay; arsenic concentrations in the water at RM 5.0 were similar to those in water collected from RM 10.5 (see Section 7.2.4.2 for more details).

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[135] *M. arenaria* clams were the largest clams collected in the LDW (mean total wet weight of 15.2 g in the 2003 clam survey) (Windward 2004c). This species also had the widest range in weight (0.3 to 54 g). During the 2003 clam survey, 20% of the clams collected in the LDW were *M. arenaria.* Over half the clams collected in the LDW during the 2003 clam survey were identified as *Macoma balthica* (60%), and 18% of the clams were *Macoma nasuta*. Other less common *Macoma* species included *Macoma inquinata* and *Macoma secta* (both < 1%). *M. balthica* were the smallest clams collected on all beaches, with a mean total wet weight of 0.7 g (range of < 0.1 to 3.4 g); whereas *M. nasuta* were on average larger in size (mean total wet weight of 5.2 g, range of 0.3 to 16 g) but too small for human consumption. *M. inquinata* and *M. secta* were similar in size to *M. balthica*.

Table 8-14. Arsenic concentrations in water collected from the LDW and surrounding water bodies

Location	Dissolved Arsenic (µg/L)				Total Arsenic (µg/L)			
	Number of Detects/ Number of Samples	Range	Mean	Median	Number of Detects/ Number of Samples	Range	Mean	Median
Elliott Bay								
North end of waterfront	32/32	0.79 – 1.5	1.1	1.1	79/79	0.27 – 1.5	1.1	1.1
Outer Elliott Bay	22/22	0.96 – 1.5	1.2	1.2	52/52	0.19 –1.5	1.2	1.2
South end of waterfront	72/72	0.68 – 1.5	1.2	1.2	167/167	0.16 – 1.5	1.1	1.2
East and West Waterway								
West Waterway	72/72	0.30 – 1.5	0.98	1.1	165/165	0.30 – 1.5	0.97	1.0
East Waterway	71/71	0.51 – 1.4	1.1	1.2	168/168	0.29 – 1.5	1.1	1.2
LDW								
RM 1.0	72/72	0.24 – 1.5	0.86	0.97	167/167	0.29 – 1.5	0.93	0.89
RM 2.0	72/72	0.22 – 1.4	0.81	0.97	167/167	0.28 – 1.6	0.88	0.77
RM 5.0	24/24	0.18 – 0.46	0.32	0.33	56/56	0.18 – 0.87	0.49	0.48
Upstream of LDW[a]								
Green River at Fort Dent (~RM 10.5 to RM 11.0)	80/104	0.25 – 0.85	0.52	0.54	101/104	0.25 – 4.2	0.87	0.76

Source: King County (1999e)

[a] Upstream water data were collected across a range of conditions, including storms (King County 2002b, 2007f) (see Section 7.2.4.2 for more details).

LDW – Lower Duwamish Waterway

RM – river mile

There is no clear relationship between the arsenic concentration in water and the arsenic concentration in clam tissue samples collected throughout the LDW (i.e., total arsenic concentrations in clams were similar throughout the waterway except for samples collected in the embayment between RM 1.4 and RM 1.5 and in Slip 4, where concentrations were higher in clam tissue). Thus, although filter-feeding clams are likely exposed to arsenic in water (Abraham and Dillon 1986), it is not clear whether the arsenic concentration in water contributes significantly to differences in the arsenic concentration in LDW clam tissues.

Co-located sediment samples were collected in 2004 with the *M. arenaria* clam samples (Windward 2005a); these sediment samples were analyzed for a number of analytes, including total arsenic, grain size, and TOC. Relationships between arsenic concentrations in clam tissues and these co-located sediment samples were investigated; however, studies in the literature suggest that the relationship between the arsenic concentrations in co-located sediment samples and *M. arenaria* tissues is

probably tenuous. For example, Foster et al. (1987) conducted an experiment using sediment from Chesapeake Bay to evaluate the bioaccumulation of sediment-sorbed chemicals in a filter-feeding clam (*M. arenaria*) and a deposit-feeding clam (*Macoma balthica*). The *Macoma* clams bioaccumulated the chemicals (naphthalene, diphenyl ether, di-n-octyl phthalate, 4,4'-DDT, and chrysene) at measurable rates over the 12-day exposure period, whereas *Mya* did not show bioaccumulation of any of the sediment chemicals (Foster et al. 1987). These data suggest that a significant relationship between chemical concentrations in bedded sediment and *M. arenaria* in the LDW may be unlikely.

Nevertheless, the relationship between arsenic in clams and sediment collected from the LDW was evaluated using a regression model. Empirical regressions are commonly used to describe the relationship between chemical concentrations in sediment and biota at contaminated sites. Regression models are considered superior to simple uptake factors (e.g., biota-sediment accumulation factors, bioaccumulation factors, bioconcentration factors) because of their ability to address thresholds and other non-linear properties associated with bioaccumulation (Suter 2007).

Because *M. arenaria* are filter feeders, the appropriate areal extent of the source of suspended particulates is likely to be greater than the single co-located composite sediment sample that was collected with the clams. Thus, the regression relationship between the concentrations of inorganic arsenic in clam tissue and total arsenic in sediment was evaluated at three spatial scales. A linear regression model was developed using log -10 transformed concentrations of individual sediment samples as the independent variable and co-located tissue concentrations as the dependent variable. The second regression evaluated the relationship between SWACs of arsenic in sediment from the intertidal areas where clams were collected and the clam tissue concentrations from these areas. The third regression evaluated the SWACs for larger areas surrounding the intertidal areas (e.g., buffer areas, defined as approximately two times the intertidal area itself). Clam tissue sampling locations are shown on Map 8-1 along with the co-located sediment exposure areas over which SWACs were calculated. Only data from exposure areas with detected arsenic concentrations in tissue were used in the analysis (i.e., only 8 of 15 areas were included).

For all of the regression analyses, inorganic arsenic tissue concentrations, rather than total arsenic tissue concentrations, were used to evaluate the relationship between arsenic concentrations in clam tissue and total arsenic concentrations in sediment because the excess risk estimates for seafood consumption were based on the toxicity of inorganic arsenic. Table 8-15 presents the results of the regression analyses for the various tissue/sediment combinations for clams collected in 2004. Additional regression results (including paired data, regression results, and residual tests) are presented in Appendix E, Section E-5. Arsenic was also analyzed in clams collected in 2007. The 2007 data are discussed further in Section 8.3.2.5.

Table 8-15. Results of arsenic regression analyses

Sediment Dataset	n[a]	Regression Equation	R^2 Value	Significance of Regression
Co-located sediment (2004 clam data, including highest value)	8	tissue = [2.6 x (Log(sediment))] - 0.86	0.76	p = 0.005
Co-located sediment (2004 clam data, excluding highest value)	7	tissue = [6.5 x (Log(sediment))] - 3.5	0.71	p = 0.02
Intertidal area SWAC[b]	8	tissue = [2.8 x (Log(sediment))] - 1.4	0.68	p = 0.01
Intertidal area plus buffer SWAC[b]	8	tissue = [3.8 x (Log(sediment))] - 2.75	0.61	p = 0.02

[a] All paired data in which arsenic was detected in both clams and sediment were included.

[b] The SWAC was calculated using the 2008 IDW layer for arsenic.

IDW – inverse distance weighting

n – number of data pairs

SWAC – spatially weighted average concentration

Overall, these data explorations illustrate the uncertainty in the relationship between inorganic arsenic concentrations in clams and total arsenic concentrations in various sediment exposure areas. The regression statistics for the larger intertidal areas were similar to those for the co-located samples. Because expanding the clam exposure areas did not improve the regression relationship, the co-located sediment and tissue data were selected for use in the detailed evaluation of an arsenic regression model.

When developing a regression model, certain assumptions must be met for summary statistics (regression coefficients, R^2) and significance results (p values) to be interpreted exactly. These assumptions include: 1) the relationship between the two variables is linear (or can be made linear using transformations), 2) the residuals around the model (the distribution of the empirical Y data around the regression line) are normally distributed, and 3) the variance of the residuals around the model is homogeneous across the range of predicted values. The assumption requiring normality of the residuals is often relaxed as long as the variance of the residuals is homogeneous. Quantitative tests may also be performed to determine the effect of individual data pairs on the regression coefficients (e.g., "Cook's Distance"). When any of the assumptions of a regression are not met, the validity of a linear model should be investigated and inference about regression results should be drawn with care.

Simple visual diagnostics are often adequate for determining if the assumptions are met, and, if they do not appear to be, whether transformation of one or both variables could help the data to meet test assumptions. The arithmetic arsenic data did not meet the assumption of residual homogeneity of variance, and the distance between the highest data point and the majority of the data was approximately an order of magnitude. Both of these characteristics of the data suggested that a log-transformation would help to linearize the sediment-tissue relationships and equalize variance of the residuals along the line.

After a log-transformation was applied, a significant positive relationship ($R^2 = 0.76$, $p = 0.005$) was found between the eight inorganic arsenic concentrations in LDW clam tissue and the total arsenic concentrations in the eight co-located sediment samples. Figure 8-1 presents the regression model, and Figure 8-2 presents the data on an arithmetic scale.

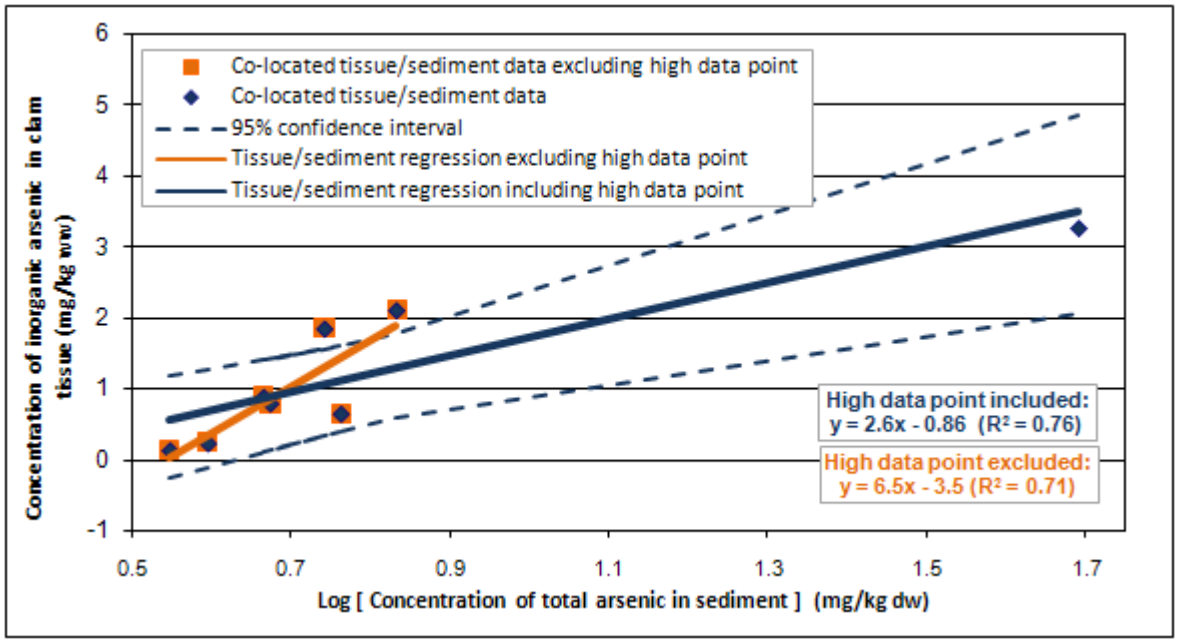

Figure 8-1. Logarithmic regression of inorganic arsenic concentrations in LDW clam tissue relative to total arsenic concentrations in co-located sediment samples using arithmetic tissue and log[sediment] data

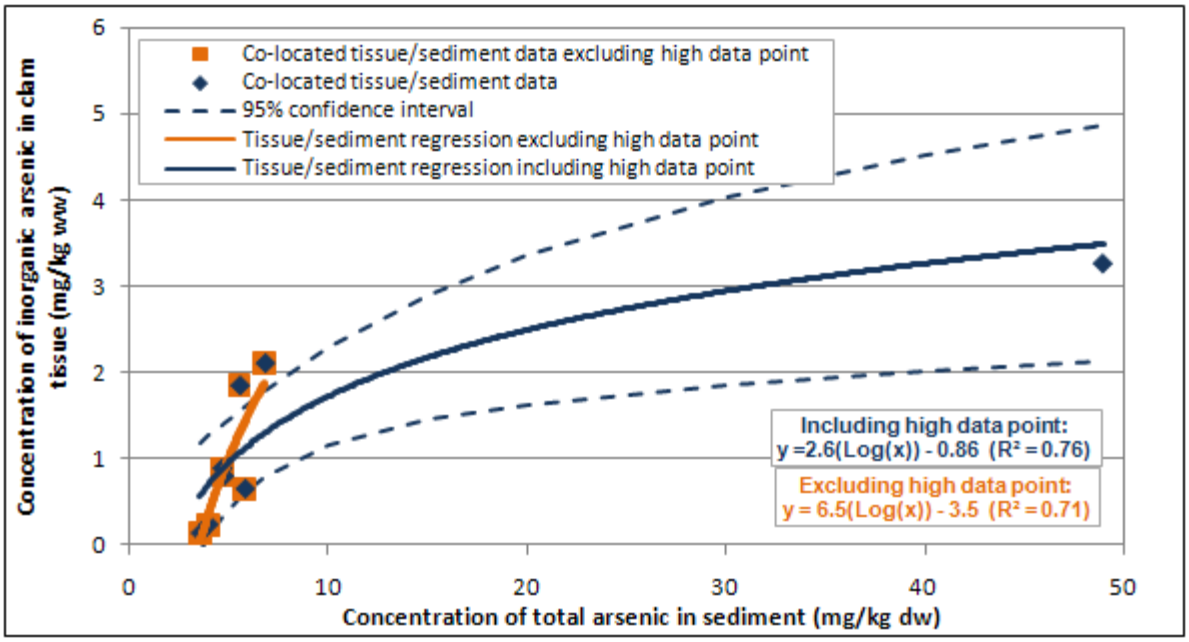

Figure 8-2. Logarithmic regression of inorganic arsenic concentrations in LDW clam tissue relative to total arsenic concentrations in co-located sediment samples presented on arithmetic scale

8.3.2.1 Uncertainties associated with the regression

Although the relationship between the concentration of arsenic in sediment and tissue is significant and positive based on the regression, there are a number of sources of uncertainty that make it imprudent to use a regression model with this dataset to estimate the tissue-sediment relationship for arsenic for the purpose of remedial decision-making. These sources of uncertainty include the:

- Influence of the highest data point on the regression, including the impact of the highest data point on the shape of the regression curve and on the range across which the regression may be applied
- Broad width of the confidence intervals

Each of these sources of uncertainty is described in more detail below.

Uncertainties Associated with the Highest Tissue-Sediment Data Point

The highest sediment concentration is almost an order of magnitude higher than the second highest sediment concentration, but its paired tissue concentration is not similarly higher than the second highest tissue concentration. A regression relationship based on sediment-tissue pairs with sediment concentrations less than or equal to the second-highest sediment concentration would predict a much higher tissue concentration at the highest sediment concentration. The lack of fit of the empirical tissue concentration to its expected value based on the other data creates some uncertainties about the kind of relationship that exists between concentrations in clam tissue and concentrations in sediment. Based on the results of several statistical

analyses, the highest tissue-sediment data point had a larger effect than would be expected by chance on: 1) the extent to which the data met the assumptions required to construct a valid linear model, 2) the slope and intercept parameters of the best-fit linear model, and 3) the predictions of tissue concentrations at high sediment concentrations. These findings raise some concerns about which model is correct and how results of a final model should be used.

For example, a primary assumption that must be met for regression significance levels and parameter estimates to be valid is that regression residuals must be normally distributed. One measure of the normality of regression residuals is the correlation between residual values and their expected normal scores. The coefficient of determination between residuals and normal scores for this dataset (0.82) was slightly lower than the threshold (0.90) used by MTCAStat (Ecology 1997) to consider data to be normal, and a Shapiro-Wilks test of the standardized residuals indicated that the residuals may not be normal ($p = 0.032$). Another assumption of a linear regression model is that the model must fit the data along the full range of the data. Several statistical tests indicated that the highest data point may not be part of the same population as the other data points and, consequently, the linear regression model does not fit the entire dataset well. For example, the highest data point's sediment and tissue concentration both qualified as "outliers" with respect to the rest of the values in the dataset.[136] In addition, the sediment and tissue concentrations for the highest data point had a larger than expected influence on the estimated tissue concentration for the highest sediment concentration.[137] Additional statistical analyses indicated that the highest data point also had a greater than expected effect on the estimate of the intercept, the slope, and the regression coefficients.[138]

Although the regression relationship was significant both with and without the highest point, and a high proportion of the variance in tissue concentrations was explained by both regressions ($R^2 > 70\%$ for both regressions; Figure 8-2), the slope of

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[136] The distance between the high sediment concentration and the mean sediment concentration (its leverage value) was 0.82, which is much larger than what would be considered moderate (0.2 to 0.5) or even extreme (> 0.5) leverage values for small datasets (Neter et al. 1990). The high tissue concentration also qualifies as an outlier. Its Studentized deleted residual value of 4.18 is significantly greater than the expected value of 2.6 for this model ($p = 0.009$).

[137] The number of standard deviations between the estimated tissue value using a model with the data point and the estimated tissue concentration using a model without the data point, the DFFit value, was 3.95 compared to an expected DFFit of 1.00.

[138] The standardized difference between the intercepts based on models with and without the data pair, DFbeta0, was 2.67, compared to an expected DFbeta0 of < 1. The standardized difference between the slopes based on models with and without the data point, DFbeta1, was 3.9, compared to an expected DFbeta1 of < 1. Cook's Distance, an overall measure of combined impact of a data point on both regression coefficients, was 25.36, significantly greater than the expected value of 3.5 for this model ($p = 0.001$).

the regression equation was much higher when the highest data point was excluded. In addition, the difference between the slopes of the two regressions had a large effect on the estimated concentration in clam tissue at the highest sediment concentration. If the regression equation using all data was applied, the estimated tissue concentration would have been 3.5 mg/kg ww, while the regression equation excluding the high value would have resulted in an estimated tissue concentration of 7.5 mg/kg ww. This difference in tissue concentrations corresponds to a more than two-fold difference in risk estimates. Although tissue concentrations at lower sediment concentrations might be estimated more accurately using a regression without the highest data point, tissue concentrations at higher sediment concentrations might be greatly overestimated. In addition, excluding the highest data point would limit the range of sediment values across which the regression could be applied (to between 3.5 and 6.8 mg/kg dw) because extrapolation beyond the range of data used to create a regression is not valid.

The distance between the highest data point and the second highest data point and the strong influence of the highest data point on the slope and intercept of the regression equation make it difficult to determine if a linear model is valid or if other explanatory variable(s) (e.g., water concentrations, grain size) are needed in the model to provide more accurate predictions. Inasmuch as all data were collected using the same protocol, there is no substantive reason to exclude the high data point from the dataset; it provides information about areas with higher-than-average arsenic concentrations that may exist in a smaller percentage of the total LDW than do areas with lower concentrations (see Figure 4-21).

Uncertainties Associated with Wide Confidence Intervals

The width of the 95% confidence intervals calculated for the arsenic regression affects the confidence in the estimate of the sediment RBTC from the tissue RBTC. Ideally, the confidence intervals shown on Figure 8-1 could be used to estimate a range of sediment RBTCs at a given tissue RBTC. However, because the sample size is small and the highest sediment concentration is an order of magnitude higher than the mean sediment concentration (sediment concentrations are skewed), the width of the confidence intervals is quite large, especially at higher sediment concentrations. These wide confidence limits, along with the relatively shallow slope of the regression, lead to high uncertainty in inverse predictions of sediment concentrations from risk-based tissue concentrations. For example, given the wide confidence intervals, a sediment concentration of 5 mg/kg dw could be associated with a tissue concentration between 0.4 and 1.6 mg/kg ww with 95% certainty. Assuming an individual consumed only clams at the adult tribal RME seafood consumption rate (97.5 g/day), the excess cancer risks would range from 7×10^{-4} to 3×10^{-3}.

8.3.2.2 Other efforts to understand the arsenic data

Analytical results for the clam samples collected in 2004 were presented in a data report finalized in June 2005 (Windward 2005a). The proportions of total arsenic consisting of inorganic arsenic in LDW clams were substantially higher than expected

based on data from the literature and other sites in Puget Sound (Ecology 2002a). Therefore, additional studies were conducted to further investigate this finding.

Comparison of Results from Different Laboratories

Although the laboratory QA results did not suggest problems with the analyses, a second laboratory was asked to re-analyze a subset of archived clam tissue samples for total and inorganic arsenic to confirm the results. The samples that were analyzed as a result of this request were splits of composite clam tissue samples collected from the LDW in 2004 (LDW-C1-T, LDW-C4-T, LDW-C5-T, and LDW-C6-T), which had been archived frozen. Columbia Analytical Services, Inc. (CAS), analyzed the original samples for total arsenic, and Brooks Rand conducted the analyses for inorganic arsenic. Battelle analyzed the four archived clam sample splits for both total and inorganic arsenic using the same methods used by CAS (EPA 6020) and Brooks Rand (EPA 1632). These four samples were sent to Battelle in May 2005, and the analyses were conducted in June 2005. The differences in sample holding times for these different analyses would not be expected to affect the results.

The concentrations of both total arsenic and inorganic arsenic reported by CAS and Brooks Rand were similar, but consistently higher, than the corresponding concentrations reported by Battelle (Table 8-16). However, the results were not sufficiently different to cast doubt on the original results. Regardless of the laboratory, the proportions of total arsenic consisting of inorganic arsenic were still much higher than those that have typically been identified elsewhere.

Table 8-16. Total and inorganic arsenic concentrations in LDW clam samples analyzed by multiple laboratories

	Total Arsenic Concentration (mg/kg ww)			Total Inorganic Arsenic Concentration (mg/kg ww)		
Sample ID	CAS	Battelle	Percent Difference	Brooks Rand	Battelle	Percent Difference
LDW-C1-T	1.30	0.817[a]	37%	0.132	0.106[a]	20%
LDW-C4-T	5.87	3.29	44%	3.27	2.676	18%
LDW-C5-T	2.28	1.41	38%	0.795	0.512	36%
LDW-C6-T	2.73	2.15	21%	1.85	1.371	26%

[a] Average of two laboratory replicates.
CAS – Columbia Analytical Services, Inc.
ID – identification
LDW – Lower Duwamish Waterway
ww – wet weight

EPA also analyzed splits of three other LDW clam tissue samples at their Manchester laboratory. Total arsenic was analyzed using ICP-MS, which is the same method that was used to analyze LDW samples. Inorganic arsenic and other arsenic species were analyzed using an experimental method that is being developed by EPA, which involves a significantly different extraction. Total arsenic concentrations were very

similar between the Brooks Rand and Manchester laboratories (Table 8-17). Inorganic arsenic concentrations were higher for the Brooks Rand results compared with the Manchester results, resulting in a much higher percentage of inorganic arsenic for the clam composite samples collected from other locations. These samples contained various species of clams; clam composite samples from the LDW were composed of *Mya arenaria*, as discussed below.

Table 8-17. Inorganic and total arsenic concentrations in split clam samples

Sample (Location)	Manchester			Brooks Rand		
	Concentration (mg/kg ww)		% of Total Arsenic that is Inorganic	Concentration (mg/kg ww)		% of Total Arsenic that is Inorganic
	Inorganic Arsenic	Total Arsenic		Inorganic Arsenic	Total Arsenic	
SP-C-T4 (Seahurst Park)	0.30	2.02	14.6	0.536	2.04	26.2
LDW-C2-T2 (LDW)	0.31	1.76	17.4	na	1.87	na
BI-C-T6 (Bainbridge Island)	0.21	2.14	9.91	0.331	1.89	17.4

EPA – US Environmental Protection Agency
LDW – Lower Duwamish Waterway
na – not analyzed
ww – wet weight

Analysis of Clams from Other Puget Sound Locations

In 2004, 12 composite clam tissue samples were collected from Seahurst Park (Asarco-influenced background) and Bainbridge Island (outside the area believed to have been affected by the Asarco plume) and analyzed for both total and inorganic arsenic (Windward 2005a) for comparison to the LDW clam data. Because the clam species collected in 2004 from background locations were not the same as the clam species for which arsenic data were available from the LDW, a second background clam sampling event was conducted in 2005. In 2005, 12 composite tissue samples of soft-shell clams (*Mya arenaria,* the same species collected in the LDW) were collected from Vashon Island (Asarco-influenced background) and the Dungeness National Wildlife Refuge (NWR) (outside the area believed to have been affected by the Asarco plume) and analyzed for both total and inorganic arsenic (Windward 2006b).

The relationship between inorganic arsenic in clam tissue and total arsenic in sediment for background *Mya arenaria* samples (collected from Dungeness NWR and Vashon Island) was negative (i.e., inorganic arsenic concentrations in clam tissue decreased with increasing total arsenic concentrations in sediment)(Figure 8-3). Data from species other than *M. arenaria* (collected from Bainbridge Island and Seahurst Park data) also had an inverse relationship between clam tissue and sediment (Figure 8-3), which is the opposite of the relationship noted in LDW clams at higher sediment concentrations (Figures 8-1 and 8-2). The difference in the relationship between

inorganic arsenic in LDW clam tissue and total arsenic in sediment compared with clams from other areas of Puget Sound suggests that there may be fundamental differences in the exposure at these locations or in the bioaccumulation dynamics at these lower concentrations. Furthermore, the ratio of inorganic to total arsenic concentrations in clams from these background locations was much lower than that in clams from the LDW, similar to the ratio in clams from other Puget Sound locations. The background *M. arenaria* samples had inorganic arsenic fractions that ranged from 6 to 19%, with a mean of 10%; the other species of clams had a range of 2 to 27%, with a mean of 13% inorganic arsenic. Ratios of total to inorganic arsenic in LDW clams are presented in Table 8-18.

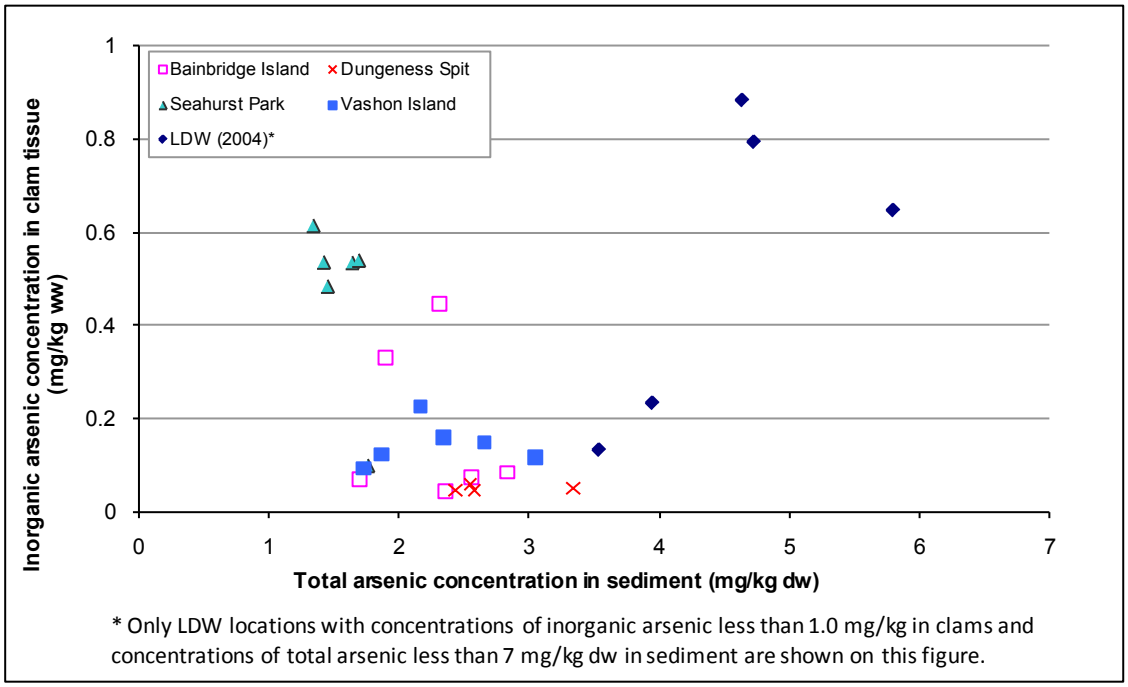

Figure 8-3. Concentrations of inorganic arsenic in a subset of clams from the LDW compared with concentrations in clams from background areas as a function of total arsenic concentrations in co-located sediment

Table 8-18. Comparison of arsenic concentrations in LDW tissue and sediment samples from the 2004 and 2007 collection efforts

Station	Non-Depurated Sample Concentrations										Depurated Sample Concentrations			Non-Depurated Sample Concentrations Divided by Depurated Sample Concentrations (2007 data only)	
	2004 Data				2007 Data				2007 Data Divided by 2004 Data		2007 Data				
	Sediment	Clam Tissue			Sediment	Clam Tissue			Tissue	Sediment	Tissue			Tissue	
	Total Arsenic (mg/kg dw)	Total Arsenic (mg/kg ww)	Inorganic Arsenic (mg/kg ww)	Inorganic Arsenic (% of Total)	Total Arsenic (mg/kg dw)	Total Arsenic (mg/kg ww)	Inorganic Arsenic (mg/kg ww)	Inorganic Arsenic (% of Total)	Inorganic Arsenic	Total Arsenic	Total Arsenic (mg/kg ww)	Inorganic Arsenic (mg/kg ww)	Inorganic Arsenic (% of Total)	Total Arsenic	Inorganic Arsenic
C1	3.53	1.30	0.132	10%	4.88	2.23	0.690	31%	5.2	1.4	2.35	0.720	31%	0.9	1.0
C2-1	5.79	1.84	0.648	35%	4.53	4.97	2.75	55%	4.2	0.78	3.58	1.13	32%	1.4	2.4
C2-2	3.13	1.88	no data	no data	3.57	4.02	1.73	43%	no data	1.1	2.48	0.920	37%	1.6	1.9
C3-1	4.63	2.01	0.885	44%	5.30	3.91	2.22	57%	2.5	1.1	4.88	1.70	35%	0.8	1.3
C3-2	3.62	4.64	no data	no data	5.27	3.24	1.58	49%	no data	1.5	5.40	2.34	43%	0.6	0.7
C4	49.0	5.87	3.27	56%	172	9.29	6.65	72%	2.0	3.5	12.4	7.60	61%	0.7	0.9
C5	4.72	2.28	0.795	35%	14.1	3.44	1.82	53%	2.3	3.0	4.24	2.17	51%	0.8	0.8
C6	5.52	2.73	1.85	68%	22.4	4.68	4.41	94%	2.4	4.1	7.05	5.72	81%	0.7	0.8
C7-1	6.17	2.82	no data	no data	10.1	6.48	6.40	99%	no data	1.6	11.5	9.30	81%	0.6	0.7
C7-2	6.80	3.86	2.11	55%	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data
C8	10.5	5.44	no data	no data	27.7	5.50	4.10	75%	no data	2.6	8.27	6.25	76%	0.7	0.7
C9	3.94	1.48	0.23	16%	5.62	4.87	2.78	57%	12	1.4	6.76	2.47	37%	0.7	1.1
C10-1	11.9	4.07	no data	no data	37.5	5.13	2.68	52%	no data	3.1	4.67	2.61	56%	1.1	1.0
C10-2	10.8	2.81	no data	no data	7.66	3.56	2.08	58%	no data	0.71	6.27	3.26	52%	0.6	0.6
C11	no data	no data	no data	no data	22.3	2.66	1.37	52%	no data	no data	2.49	1.01	41%	1.1	1.4
C12	no data	no data	no data	no data	67.6	15.2	11.3	74%	no data	no data	19.7	3.28	17%	0.8	3.4
Average	**9.29**	**3.07**	**1.24**	**40%**	**27.4**	**5.28**	**3.50**	**61%**	**4.4**	**2.0**	**6.80**	**3.37**	**49%**	**0.9**	**1.2**

dw – dry weight LDW – Lower Duwamish Waterway ww – wet weight

Collection of Additional Data in the LDW in 2007

In order to further assess inorganic arsenic concentrations in clam tissues, assess the potential effect of depuration, and determine whether or not the high percentage of inorganic arsenic documented in 2004 clam samples was reproducible, 15 additional co-located clam tissue and sediment samples were collected in late summer 2007 and analyzed at Brooks Rand.[139] The concentrations of total arsenic in sediment and inorganic arsenic in clam tissue were higher, on average, in the 2007 data than in the 2004 data (Table 8-18). The percentage of inorganic arsenic remained high.

Half of the clams collected in 2007 were depurated prior to analysis to determine whether depuration could have affected the ratio of inorganic to total arsenic in clam tissue and, if so, if depuration could have affected the relationship between tissue and sediment concentrations. Clams analyzed as part of the 2004 or 2005 RI studies and as part of previous Puget Sound studies (Ecology 2002a) were not depurated. The results of the depuration study are presented in Table 8-18. Although the percentage of inorganic arsenic was generally lower in the depurated samples, no consistent relationship was found between depuration and the ratio of inorganic arsenic to total arsenic in LDW clams.

The 2007 data did not improve the fit of the linear relationship between arsenic concentrations in sediment and clam tissue, as evidenced by lower R^2 values in both the 2007 regression and the regression using 2004 and 2007 data combined (Figure 8-4). The low R^2 value for the combined 2004 and 2007 dataset indicates that a linear regression model does not estimate the relationship between the concentration of inorganic arsenic in tissue and total arsenic in sediment with good precision and thus should not be relied upon for remedial decision-making.[140] Confidence intervals around the regression line provide an indication of the amount of uncertainty in the relationship based on 2004 and 2007 data (Figure 8-5), which is particularly high for extrapolations from a given tissue concentration (e.g., tissue RBTC) to a given sediment concentration.

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[139] In 2007, Softshell clams (*Mya arenaria)* were collected from a total of 15 locations, with one non-depurated and one depurated sample analyzed for each location. *Mya arenaria* weights ranged from 16 to 162 g (average of 53 g) and clam lengths ranged from 45 to 106 mm (average of 74 mm).

[140] The scatter in the data points is particularly pronounced at the low end of the sediment range, where sediment clean-up goals may be set (based on direct–contact sediment RBTCs for arsenic [Table 8-3] and background concentrations presented in Section 7).

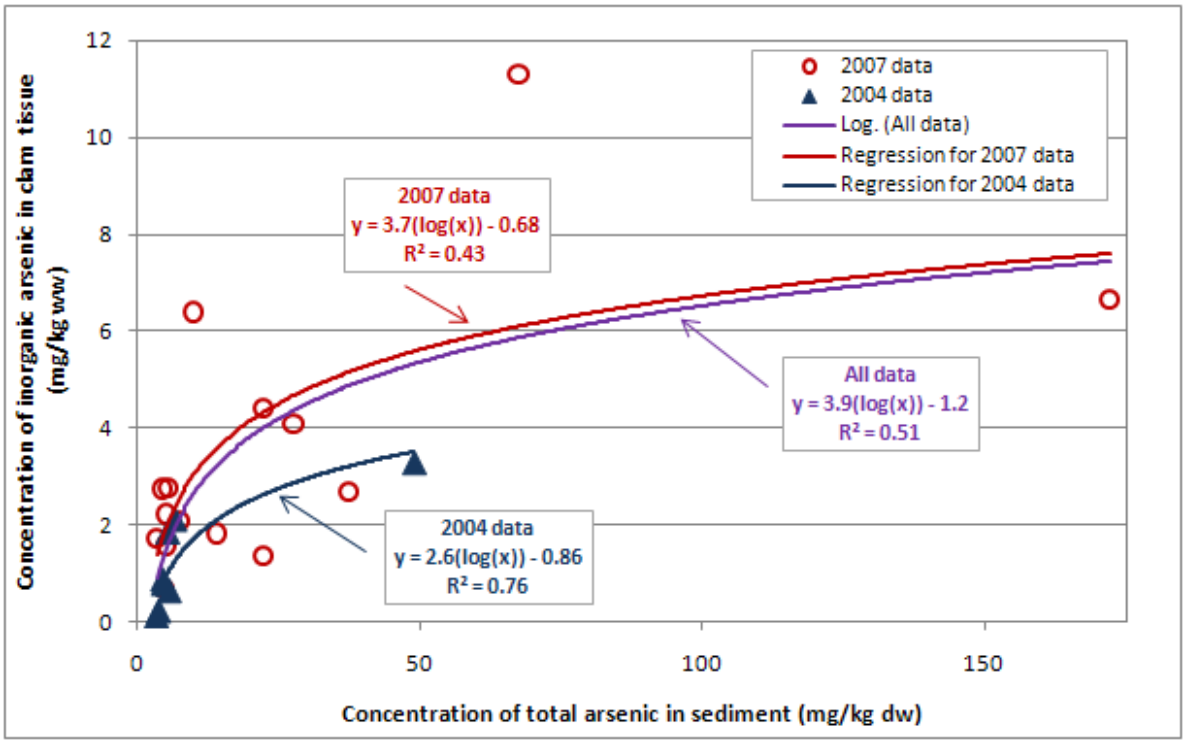


Figure 8-4. Logarithmic regression of inorganic arsenic concentrations in LDW clam tissue relative to total arsenic concentrations in co-located sediment using 2004 and 2007 data

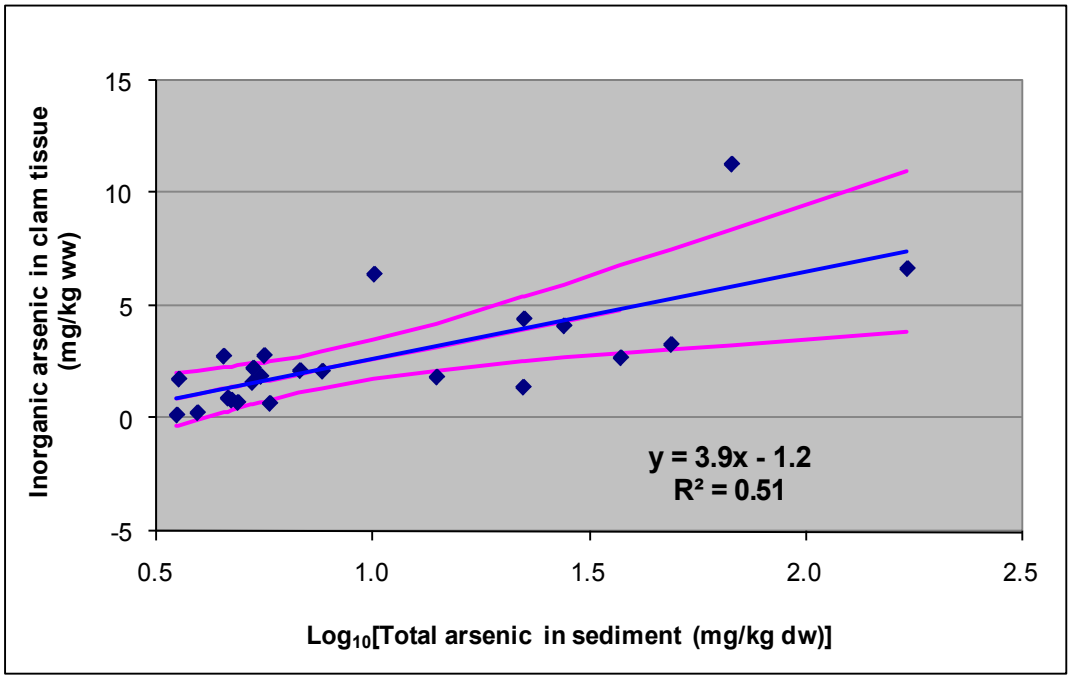


Figure 8-5. Regression relationship for inorganic arsenic in clam tissue and total arsenic in sediment using 2004 and 2007 data

Because the goal of most modeling efforts is to find the simplest model to describe the data, a logarithmic regression was the logical choice for this model application given the premise that the rate of change in the bioaccumulation response generally decreases as the sediment concentration increases (Suter 2007). However, because of the poor logarithmic fit, other statistical models were considered in an attempt to better explain the relationship between inorganic arsenic in tissue and total arsenic in sediment. A log-log regression was computed but did not improve the fit. A quadratic model was not considered appropriate because it would predict decreasing tissue concentrations above an intermediate, but still relatively low, sediment concentration. Other model types that could have been applied to the data (e.g., hockey stick regression) would also have been driven by the high data point. Although the linear model with log transformed sediment was able to explain only 51% of the variance in tissue concentrations, it was the most parsimonious model to describe the data.

8.3.2.3 Development of sediment RBTCs for arsenic and seafood consumption

Based on the information discussed above, LDWG, EPA, and Ecology agree that the clam tissue-to-sediment relationships for arsenic are too uncertain to develop sediment RBTCs. Variables other than sediment concentrations are likely to be important, based on the filter-feeding behavior of *M. arenaria*, and thus any potential effect of sediment remediation on concentrations of inorganic arsenic in clam tissue is highly uncertain. More information, from efforts such as long-term monitoring following sediment remediation and source control, may be needed to determine whether decreases in total arsenic concentrations in sediment affect inorganic arsenic concentrations in clam tissue and, if so, to what extent.

Nevertheless, at the request of EPA, the regression relationship (for the combined 2004 and 2007 dataset) was used to "back-calculate" the sediment concentrations that corresponded to the tissue RBTCs presented in Table 8-7. Because the regressions are not expected to be predictive given the feeding behavior of *M. arenaria*, the development of these sediment concentrations may falsely raise expectations regarding the potential success of sediment cleanup in reducing seafood consumption risks for arsenic. Therefore, this exercise should be viewed as only informational.

Sediment concentrations of total arsenic that corresponded to tissue RBTCs for the RME seafood consumption scenarios (for excess cancer risks between 1×10^{-6} and 1×10^{-4}, and a non-cancer hazard quotient [HQ] < 1) were all between 2.1 and 2.6 mg/kg dw, even though the tissue RBTCs spanned 3 orders of magnitude and the corresponding confidence intervals spanned an order of magnitude. All of the estimated sediment arsenic concentrations (and even the upper confidence limits) were below the range of 90th percentile arsenic concentrations in upstream surface sediment and Upper Turning Basin subsurface sediments (see Section 7.2). See Appendix E, Section E.7, for more details regarding the back-calculation.

8.3.3 cPAH sediment RBTCs for human seafood consumption

As discussed in the HHRA (Appendix B), 95% of cPAH exposure, and hence, 95% of cPAH risk associated with seafood consumption is from consumption of clams. As discussed in Section 8.3.2, given the feeding behavior of *M. arenaria*, water and suspended particulates in the water are likely to be important sources of bioaccumulated chemicals for this species (Abraham and Dillon 1986). Foster et al. (1987) did not report uptake of PAHs by *M. arenaria* in their study, where the clams "appeared to remain isolated from exposure to contaminated sediment." Nonetheless, the clam tissue/sediment relationship was evaluated to assess the potential to calculate sediment RBTCs for cPAHs associated with seafood consumption in the LDW using site-specific data.

As with arsenic, various regression models were investigated in an attempt to relate site-specific concentrations of cPAHs in composite clam tissue samples and co-located or nearby sediment samples. Multiple spatial scales were evaluated. The performance of the regression model described below was not improved using sediment concentrations averaged over larger spatial areas. The sediment exposure areas evaluated in the cPAH regressions are shown on Map 8-2, and results are presented in Table 8-19.

Table 8-19. Results of cPAH regression analyses

Sediment Dataset	n[a]	Regression Equation	R^2 Value	Significance of Regression
Co-located sediment (including highest value)	14	tissue = [12.8 x (Log(sediment))] - 13.5	0.59	p = 0.001
Co-located sediment (excluding highest value)	13	tissue = [4.89 x (Log(sediment))] + 2.50	0.12	p = 0.02
Intertidal area SWAC	14	tissue = [14.8 x (Log(sediment))] - 23.8	0.49	p = 0.005
Intertidal area plus buffer SWAC	14	tissue = [15.05 x (Log(sediment))] - 24.6	0.36	p = 0.02

[a] All paired data in which cPAHs were detected in both clams and sediment were included.

cPAH – carcinogenic polycyclic aromatic hydrocarbon
n – number of data pairs
SWAC – spatially weighted average concentration

Overall, these data explorations illustrate the uncertainty in the relationship between cPAH concentrations in clams and cPAH concentrations in various sediment exposure areas. Because expanding the clam exposure area and otherwise manipulating the data did not improve the regression relationship, the co-located sediment and tissue data were selected for use in the detailed evaluation of a cPAH regression model.

A logarithmic regression of the co-located data was significant (p = 0.001) and explained 59% of the variance in tissue concentrations when all data were included in the regression. The residuals were normally distributed (fit-R^2 of residuals against

expected normal scores = 0.95); however, the variance of the residuals increased with concentration and the pattern of the residuals was not uniform along the range of sediment and tissue concentrations. In addition, a single high data point was responsible for the significance of the regression, as shown in Figure 8-6. The removal of the highest data point reduced the R^2 value to 0.12. The data and the regression model are presented in Figure 8-6 on a logarithmic scale; Figure 8-7 presents the data and regression on an arithmetic scale. Additional regression results are presented in Appendix E, Section E.5 (including paired data, regression results for co-located sediment-tissue model, and analyses of regression residuals).

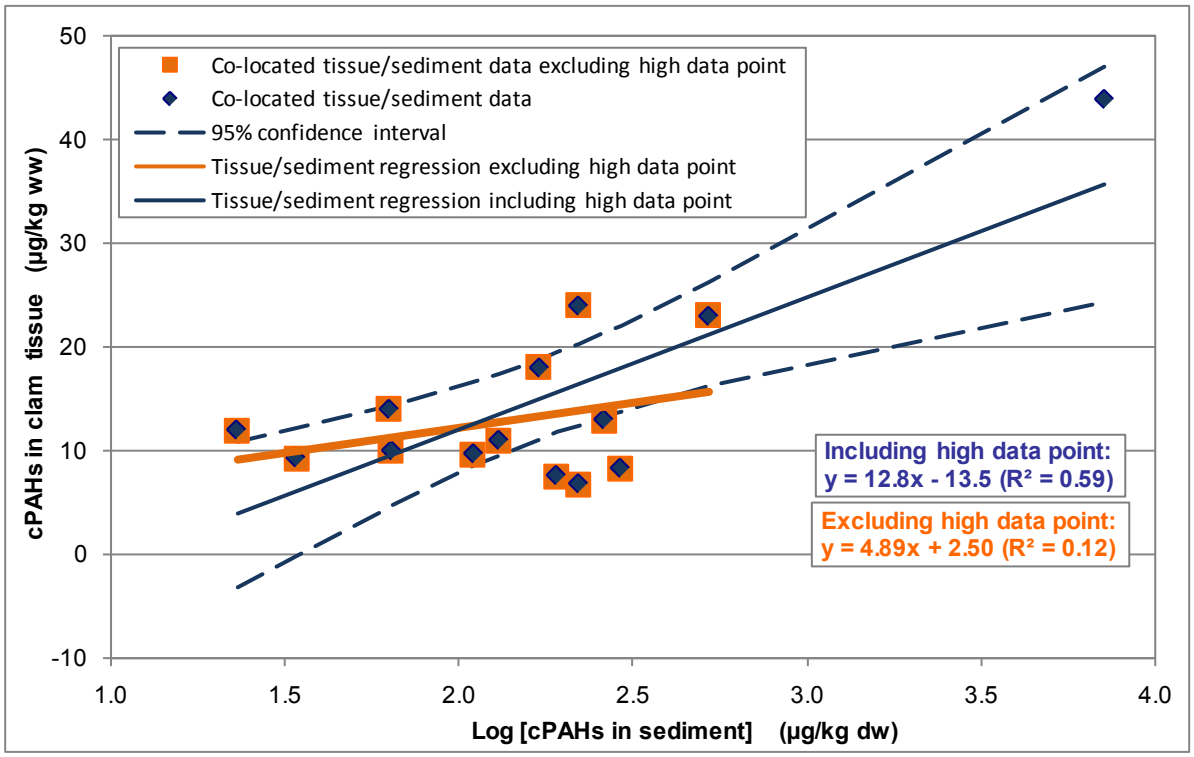


Figure 8-6. Logarithmic regression of cPAH concentrations in LDW clam tissue relative to concentrations in co-located sediment using arithmetic tissue data and log[sediment] data

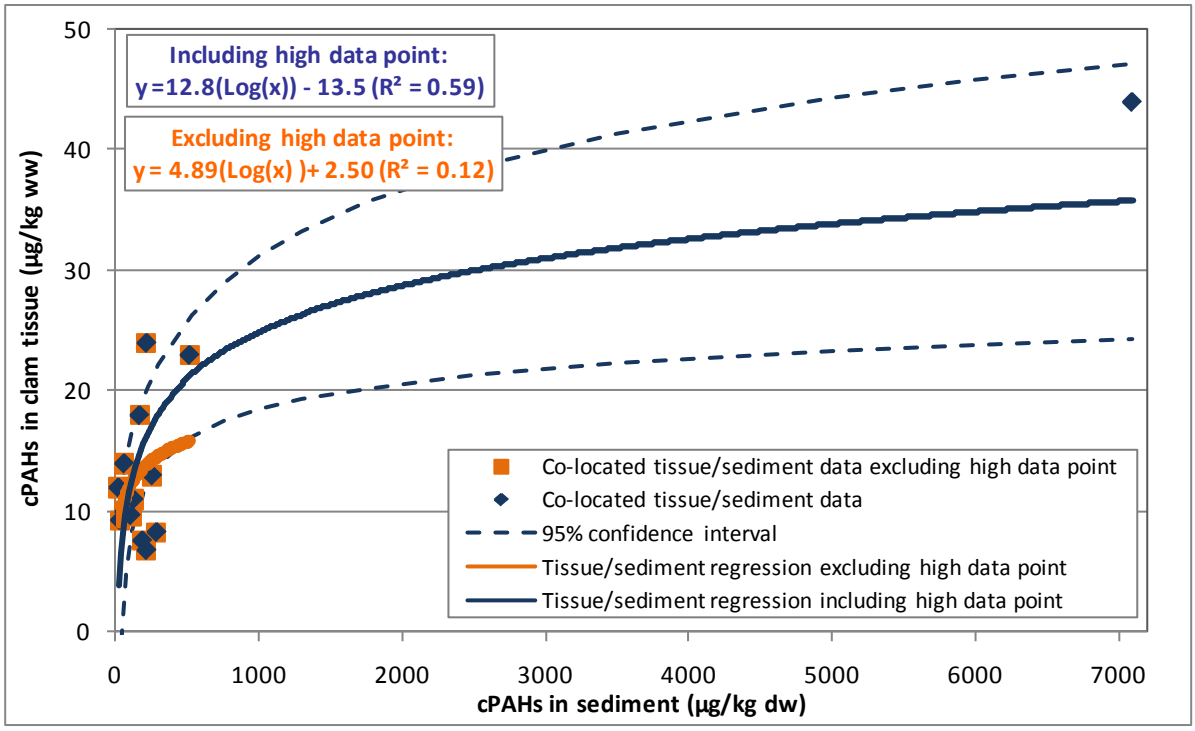


Figure 8-7. Logarithmic regression of cPAH concentrations in LDW clam tissue relative to concentrations in co-located sediment presented on arithmetic scale

As with arsenic, a number of uncertainties make the regression model unsuitable for the purpose of remedial decision-making, including the:

- Impact of the highest data point on the shape and the significance of the regression curve
- Low percent variance explained by the regression (which suggests that other variables may be important)
- Broad width of the confidence intervals

Each of these sources of uncertainty is described in more detail below.

Several outlier diagnostics indicated that the highest tissue-sediment data point had a strong effect on the regression equation. The high data point can be considered an outlier in terms of its sediment concentration (Leverage value = 0.56) and its tissue concentration (Studentized deleted residual = 22.67, $p < 0.0005$). It can also be considered "influential" in its effect on the estimated tissue concentration at its sediment concentration (DFFit = 14.39), its effect on the estimate of the intercept (DFbeta0 = 16.04), and its effect on the estimate of the slope (DFbeta1 = 7.90). The overall influence of the high data point on the regression coefficients was significant at alpha = 0.10 (Cook's Distance = 3.77, $p = 0.074$). Four other data points also met the criteria defining outliers for both sediment and tissue concentrations. Although these data points did not have the same degree of influence on fitted values or the overall

regression equation as the highest data point, they contributed to the irregular pattern in the residuals.

When the highest data point was removed, the regression was no longer significant (R^2 =0.12, p = 0.25). As with arsenic, the highest data point had a large influence on the regression relationship (in this case, it changes not only the slope but also the significance of the relationship), and estimates from one regression would differ greatly from estimates based on the other. Also, removal of the high value would lead to a regression that could only be applied for sediment cPAH concentrations between 23 and 520 µg/kg dw.

In addition to the weaknesses of the cPAH regression model described above, the percent of variance explained by the regression relationship (R^2) is low (particularly when the highest data point is removed). Although the residuals appeared to be normally distributed (Shapiro-Wilks test on standardized residuals p = 0.40), their irregular pattern and increasing magnitude with increasing tissue concentration indicates that other factors besides sediment could be affecting tissue concentrations.

The width of the confidence intervals of the tissue-sediment relationship (Figure 8-6) generates considerable uncertainty in the estimation (i.e., using an inverse prediction) of sediment concentrations from risk-based tissue concentrations, particularly at the low end of the sediment range. Because of the wide confidence intervals, a single sediment concentration may correspond to tissue concentrations that vary by approximately half an order of magnitude (e.g., a sediment concentration of 220 µg/kg dw could correspond to a tissue concentration range of 6.8 to 24 µg/kg ww). Such differences in tissue concentrations correspond to differences in risk estimates of just under an order of magnitude. Assuming an individual consumed only clams at the adult tribal RME seafood consumption rate (97.5 g/day), this range of tissue concentrations would result in excess cancer risks that vary from 3×10^{-5} to 1×10^{-4}. Estimating sediment concentrations that correspond to specific tissue concentrations is equally problematic. For example, according to the regression equation that includes all data, a cPAH concentration of 11 µg/kg ww (the tissue RBTC for adult tribal RME seafood consumption) corresponds to a sediment concentration of 200 µg/kg dw. However, the uncertainty bounds around that concentration range from 40 to > 250 µg/kg dw based on the confidence intervals. The fact that the range of sediment cPAH concentrations that corresponds to a tissue cPAH concentration of 11 µg/kg ww spans nearly an order of magnitude clearly demonstrates the uncertainty in the clam tissue-sediment relationship.

As with the arsenic sediment tissue relationship, more complicated models (e.g., a log-log regression model, hockey stick regression model) were considered. However, for the same reasons discussed in Section 8.3.2.5, a more complicated model was not appropriate for cPAHs based on the data.

Based on the information discussed above, LDWG, EPA, and Ecology agree that the clam tissue-to-sediment relationships for cPAHs are too uncertain to develop RBTCs

for sediment. Variables other than sediment concentrations are likely to be important, based on the filter-feeding behavior of *M. arenaria*, and thus any potential effect of sediment remediation on concentrations of cPAHs in clam tissue is highly uncertain; long-term clam tissue monitoring following sediment remediation and source control may be needed to determine whether decreases in cPAH concentrations in sediment affect cPAH concentrations in clam tissue and, if so, to what extent.

Nevertheless, at the request of EPA, the regression relationship was used to "back-calculate" the sediment concentrations that corresponded to the tissue RBTCs presented in Table 8-7. Because the regressions are not expected to be predictive given the feeding behavior of *M. arenaria*, the development of these sediment concentrations may falsely raise expectations regarding the potential success of sediment cleanup in reducing seafood consumption risks for cPAHs. Therefore, this exercise should be viewed as only informational.

cPAH concentrations in sediment (as TEQs) that corresponded to clam tissue RBTCs for the RME seafood consumption scenarios (for excess cancer risks between 1×10^{-6} and 1×10^{-5}) ranged from 12 to 23 µg/kg dw and the corresponding confidence limits spanned 2 orders of magnitude. Sediment concentrations that corresponded to 1×10^{-4} tissue RBTCs for the adult and child tribal RME scenarios were 83 and 100 µg/kg dw, respectively, with corresponding confidence limits that spanned 1 order of magnitude. All of these sediment TEQs are less than or equal to the range of 90th percentile concentrations in upstream surface sediments and Upper Turning Basin subsurface sediments (see Section 7.2). The sediment concentration for the 1×10^{-4} adult Asian and Pacific Islander (API) RME seafood consumption scenario (13,000 µg/kg dw) was much higher than the range of upstream concentrations and the baseline LDW-wide spatially weighted average concentration (SWAC) for cPAHs (380 µg/kg dw). See Appendix E, Section E.7, for more details regarding the back-calculation.

8.4 RBTCs Based on River Otter Prey Ingestion

PCBs were identified as a risk driver chemical for river otter in the ERA (Appendix A). This section presents the derivation of both tissue and sediment RBTCs for this receptor. Both types of RBTCs were calculated because although remediation goals will be sediment-based, tissue RBTCs are relevant for risk communication.

8.4.1 Tissue RBTCs for river otter prey ingestion

Tissue RBTCs were estimated for total PCBs for river otter according to Equation 8-4. To estimate a tissue RBTC corresponding to a HQ of 1, the exposure dose was set equal to the LOAEL that was identified in the ERA (0.26 mg/kg body weight/day). Body weight and food ingestion rate values for river otter were derived from the literature, as described in the ERA (Appendix A, Section A.5.1.2.4). The site use factor was assumed to be 1. PCB dose contributions from water ingestion and incidental sediment ingestion were assumed to be negligible.

$$\text{Tissue RBTC} = \frac{ED \times BW}{SUF \times FIR} \qquad \textbf{Equation 8-4}$$

Where:

RBTC	=	risk-based threshold concentration in prey tissue (mg PCBs/kg food dw)
ED	=	exposure dose set equal to the LOAEL (mg/kg body weight/day)
BW	=	body weight (kg)
SUF	=	site use factor (unitless); fraction of time that river otter spend foraging in the LDW relative to the entire home range
FIR	=	food ingestion rate (kg food dw/day)

The tissue RBTC for river otter for a LOAEL-based HQ of 1 was 2.7 mg/kg food dw or 540 µg/kg ww (assuming 80% moisture). River otter ingest various fish and shellfish species. The estimated tissue RBTC represents the weighted average concentration of all prey types that could be ingested by river otter.

8.4.2 Sediment RBTCs for river otter prey ingestion

A range of sediment RBTCs for total PCBs was estimated for river otter using the FWM and the same general approach described for the human health consumption scenarios (Section 8.3.1). Section D.9 of Appendix D describes the how the FWM was used to derive sediment RBTCs.

A range of sediment RBTCs for total PCBs was estimated for two dietary scenarios. The range of RBTCs reflects the model performance criterion, which required that the estimated concentrations in tissues were within a factor of 2 of the empirical data for all of the target species. In addition, a best-fit RBTC was estimated using the model parameter set that most closely fit the empirical PCB tissue data for all modeled species combined.

Dietary studies on the river otter indicate that they eat primarily adult fish, although their diet is variable. Because of the possibility that river otter may also consume some juvenile fish, and because juvenile fish were included in the FWM, two dietary scenarios were used to calculate RBTCs: one in which only adult fish were consumed and one in which juvenile fish were consumed along with adults (Table 8-20). Note that the ERA included juvenile chinook salmon as a portion of the river otter's diet as a surrogate for larger salmon. In addition, river otters were assumed to consume crab and bivalves in the ERA. Although there are some differences in the dietary assumptions used in the ERA and those used to derive RBTCs, the RBTCs are considered to be conservative because fish generally had higher total PCB concentrations than crab or bivalves (Section 4.2.3.4).

Table 8-20. Dietary fractions of prey items used in the two river otter dietary scenarios for calculation of RBTCs for total PCBs

Receptor of Concern	Dietary Scenario	Fraction of Prey Item in Diet (by weight)					
		Clam[a]	Juvenile Fish	Crab	Pacific Staghorn Sculpin	Shiner Surfperch	English Sole
River otter	including juvenile fish	0.02	0.22	0.1	0.22	0.22	0.22
	excluding juvenile fish	0.02	na	0.1	0.29	0.29	0.29

[a] In the ERA, clams and mussels were assumed to be 1% of the river otter's diet. Because mussels were not modeled in the FWM, clams were assumed to contribute 2% of the river otter's diet for RBTC calculations.

ERA – ecological risk assessment

na – not applicable

PCB – polychlorinated biphenyl

RBTC – risk-based threshold concentration

Best-fit sediment RBTCs for river otter corresponding to a LOAEL-based HQ of 1 were 159 and 128 µg/kg dw with and without inclusion of juvenile fish in the diet, respectively (Table 8-21). When juvenile fish were excluded from the river otter diet, the sediment RBTCs were slightly lower (ranging from 91 to 217 µg/kg dw) than when juvenile fish were included (ranging from 100 to 250 µg/kg dw). Because total PCB concentrations in juvenile chinook salmon and estimated total PCB concentrations in juvenile fish were lower than total PCB concentrations in Pacific staghorn sculpin, shiner surfperch, and English sole, the overall PCB exposure concentration was lower when juvenile fish were included in the otter diet. Consequently, the corresponding sediment RBTC was higher when juvenile fish were included in the otter diet than when otter were assumed to eat only adult fish.

Table 8-21. Sediment RBTCs for total PCBs for prey consumption by river otter

Scenario	RBTCs for Total PCBs in Sediment (µg/kg dw)		
	Lower Bound	Best Fit	Upper Bound
Inclusion of juvenile fish in diet	100	159	250
Exclusion of juvenile fish from diet	91	128	217

dw – dry weight

PCB – polychlorinated biphenyl

RBTC – risk-based threshold concentration

8.5 RBTCs Based on Benthic Invertebrate Exposure

In the ERA, 41 chemicals were identified as risk drivers for the benthic invertebrate community because they had at least one detected exceedance of the SQS in surface sediment. Because SMS are applicable promulgated standards at the site, sediment RBTCs for these 41 chemicals were set equal to the SQS and the CSL numerical chemical criteria (Table 8-22). Toxicity test data for locations with SMS exceedances must also be considered in the application of these RBTCs because toxicity test

information overrides chemical data as part of the SMS. Toxicity test data are presented in Section 4.2.1, and the interpretation of SMS exceedances and site-specific toxicity data are discussed in the ERA (Appendix A). According to the SMS (WAC 173-204-310), locations with all chemical concentrations less than or equal to the SQS are defined as having no acute or chronic adverse effects on biological resources, locations with any chemical concentrations between the SQS and CSL are defined as having minor adverse effects, and locations with any chemical concentration greater than the CSL are defined as having more pronounced adverse effects, pending confirmatory designation via biological testing (WAC 173-204-310-2).

Table 8-22. SMS chemical criteria for risk driver chemicals identified for the benthic invertebrate community

CHEMICAL	UNIT	SQS	CSL
Metals			
Arsenic	mg/kg dw	57	93
Cadmium	mg/kg dw	5.1	6.7
Chromium	mg/kg dw	260	270
Copper	mg/kg dw	390	390
Lead	mg/kg dw	450	530
Mercury	mg/kg dw	0.41	0.59
Silver	mg/kg dw	6.1	6.1
Zinc	mg/kg dw	410	960
PAHs			
2-Methylnaphthalene	mg/kg OC	38	64
Acenaphthene	mg/kg OC	16	57
Anthracene	mg/kg OC	220	1,200
Benzo(a)anthracene	mg/kg OC	110	270
Benzo(a)pyrene	mg/kg OC	99	210
Benzo(g,h,i)perylene	mg/kg OC	31	78
Total benzofluoranthenes	mg/kg OC	230	450
Chrysene	mg/kg OC	110	460
Dibenzo(a,h)anthracene	mg/kg OC	12	33
Dibenzofuran	mg/kg OC	15	58
Fluoranthene	mg/kg OC	160	1,200
Fluorene	mg/kg OC	23	79
Indeno(1,2,3-cd)pyrene	mg/kg OC	34	88
Naphthalene	mg/kg OC	99	170
Phenanthrene	mg/kg OC	100	480
Pyrene	mg/kg OC	1,000	1,400
Total HPAH	mg/kg OC	960	5,300

CHEMICAL	UNIT	SQS	CSL
Total LPAH	mg/kg OC	370	780
Phthalates			
BEHP	mg/kg OC	47	78
Butyl benzyl phthalate	mg/kg OC	4.9	64
Dimethyl phthalate	mg/kg OC	53	53
Other SVOCs			
1,2,4-Trichlorobenzene	mg/kg OC	0.81	1.8
1,2-Dichlorobenzene	mg/kg OC	2.3	2.3
1,4-Dichlorobenzene	mg/kg OC	3.1	9.0
2,4-Dimethylphenol	µg/kg dw	29	29
4-Methylphenol	µg/kg dw	670	670
Benzoic acid	µg/kg dw	650	650
Benzyl alcohol	µg/kg dw	57	73
Hexachlorobenzene	mg/kg OC	0.38	2.3
n-Nitrosodiphenylamine	mg/kg OC	11	11
Pentachlorophenol	µg/kg dw	360	690
Phenol	µg/kg dw	420	1,200
PCBs			
Total PCBs	mg/kg OC	12	65

BEHP – bis(2-ethylhexyl) phthalate
CSL – cleanup screening level
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
OC –organic carbon
PCB – polychlorinated biphenyl
SMS – Washington State Sediment Management Standards
SQS – sediment quality standard
SVOC – semivolatile organic compound

8.6 APPLICATION OF RBTCS

The RBTCs derived in this section are an important consideration in the derivation of PRGs in the FS. Three issues related to application of RBTCs are discussed here: spatial considerations (Section 8.6.1), consideration of cumulative and aggregate risk (Section 8.6.2), and considerations of assumptions regarding current and future use (Section 8.6.3).

8.6.1 Spatial considerations

Appropriate application of RBTCs requires explicit consideration of spatial scale. Some RBTCs are appropriate for application on a point-by-point basis, while most others should be applied only at a larger scale. For example, RBTCs based on the protection of benthic invertebrates (see Section 8.5) should be applied on a point-by-point basis because of the small home ranges of these animals and the regulatory framework described in the SMS. All other RBTCs (Sections 8.1 through 8.4) are most

appropriately applied at larger spatial scales. RBTCs for seafood consumption should be applied at an LDW-wide spatial scale because risks were evaluated at this scale.

RBTCs derived for direct sediment contact scenarios should be applied to appropriate exposure areas. The exposure area for the netfishing RME scenario included all of the intertidal and subtidal areas of the LDW. For the beach play RME scenario, eight separate intertidal areas were selected in the HHRA as exposure areas where children are most likely to contact sediment (Map 6-1). These areas could change in the future if, for example, a new park with access to intertidal areas were to be constructed. The exposure area for the RME clamming included all intertidal areas where clamming could occur because such areas are potentially accessible either from a boat or from shore (Map 6-2).

8.6.2 Consideration of cumulative and aggregate excess cancer risk

Following both EPA and Ecology guidance for conducting HHRAs, cumulative excess cancer risk estimates were calculated in the HHRA by summing risk estimates for individual COCs. Cumulative excess cancer risk should also be given consideration during the application of RBTCs in the FS. In practice, cumulative carcinogenic risk can be considered in the application of RBTCs in specific areas by summing the risks for individual chemicals within a given exposure area to ensure that they do not result in an unacceptable cumulative target risk. Cumulative risk for non-cancer hazards can only be evaluated if the chemicals affect the same target organs or have the same endpoint effects.

For example, if the target excess cancer risks for four individual risk drivers were all set to 1×10^{-6} for calculation of individual chemical RBTCs, the cumulative target risk would be no greater than 4×10^{-6}. In this example, if the acceptable target cumulative risk was 1×10^{-5}, then meeting each individual RBTC that was based on a target risk of 1×10^{-6} would result in an acceptable cumulative risk estimate for that area because 4×10^{-6} is less than 1×10^{-5}.

8.6.3 Consideration of assumptions regarding current and future LDW use

The human health RBTCs presented in the RI, particularly those for RME scenarios, are based on exposure assumptions that are intended to be health-protective of both current and future uses of the LDW. There is limited site-specific data available on the amount of resident seafood organisms currently being harvested and consumed from the LDW, and no site-specific data on the degree to which people may currently be exposed via beach play or clamming activities. Consequently, the data used to establish the exposure parameters for these RME scenarios were based on other sources, including tribal seafood consumers and clam diggers from other areas of Puget Sound and beach users from King County lakes. The tribal netfishing scenario, on the other hand, reflects exposure conditions that could occur under current tribal fishing activities within the LDW.

The exposure assumptions for the RME scenarios for tribal seafood consumption and clam digging are likely overestimates of current behavior in the LDW because current use is likely depressed as a result of the fish advisory and local knowledge of contamination. With respect to seafood consumption, WSDOH has issued health advisories for LDW fish and crab, warning the public that any seafood consumption from the LDW is unsafe because of elevated PCB concentrations in these species (WSDOH 2005). WSDOH (Office of Food Safety and Shellfish) and Public Health – Seattle & King County advise against consumption of clams in the LDW because of pathogens from urban sewage releases (WSDOH 2005). Environmental quality, and consequently seafood resources, is expected to improve in the future, but it is not known if future site use will reach the RME exposure levels assumed in the HHRA (Appendix B).

A creel study (in which fishermen were observed and surveyed while fishing) was conducted by King County to assess the amount of fishing activity that occurred in Elliott Bay and the LDW in 1997 (King County 1999c). The study included surveys at eight locations (Table 8-23) within the LDW on 30 different days during the summer of 1997 (between June 22 and August 30), including 10 Saturdays, 10 Sundays, and 10 weekdays. Sites were visited repeatedly between 5 a.m. and 8 p.m. (weekends) and from 5 a.m. to 11 a.m. and 4 p.m. to 10 p.m. (weekdays).

Table 8-23. Locations and number of fishermen identified in the King County creel survey

Fishing Location Within LDW	Number of Individuals Observed Fishing[a]
Spokane Street S Bridge[b]	192
T-105	10
Diagonal Avenue S	2
Duwamish Waterway Park	1
Kellogg Island	0
Muckleshoot 1st Avenue. boat ramp	0
8th Avenue, street end	0
Boeing office building access	0
8th Avenue S and S Portland Street	0

Source: King County (1999c)

[a] Surveys were conducted within the LDW on 30 different days during the summer of 1997 (between June 22 and August 30), including 10 Saturdays, 10 Sundays, and 10 weekdays. Sites were visited repeatedly between 5 a.m. and 8 p.m. (weekends) and from 5 a.m. to 11 a.m. and 4 p.m. to 10 p.m. (weekdays).

[b] The Spokane Street S Bridge is 755 ft north of the LDW study area boundary. Because the home ranges of resident fish and crabs within the LDW have not been explicitly defined, individuals fishing at this location may catch and consume fish and crabs that may have been exposed to LDW-related contamination.

LDW – Lower Duwamish Waterway

T-105 – Terminal 105

Very few individuals were observed fishing in the LDW compared with Elliott Bay (13 in the LDW and over 1,000 in Elliott Bay), and seafood was caught at only one of the eight locations (two crabs and one sole were caught at T-105). Although fishing was documented to be infrequent within the LDW, one of the most popular fishing locations in the survey was the Spokane Street S Bridge, which is 755 ft north of the study area, from which people can fish in the East Waterway. Persons fishing from this bridge may catch and consume seafood that may have been exposed to LDW contamination because fish collected from this location may use LDW habitat to an unknown extent. Although this survey did not evaluate the frequency of fishing from boats, people have been observed using boats to fish for salmon in the LDW.

Future remedial and restoration actions could increase the frequency of fishing and other recreational activities, particularly kayaking and canoeing. Although the LDW is expected to remain an industrial corridor for the foreseeable future, remedial and other actions could result in a reduction in or suspension of some fish advisories, thereby increasing the use of the LDW as a fishing resource. Increased public access and habitat restoration activities may not only expand the areas where people currently access the river, but also increase the frequency with which they do so. Consequently, the potential overestimation of current risks in the exposure scenarios is intended to be protective of future uses as well.

8.7 SUMMARY

RBTCs in sediment were derived for consideration in the development of PRGs in the FS. RBTCs were derived for human direct sediment contact scenarios for arsenic, cPAHs, dioxins and furans, and total PCBs (Table 8-24; Figure 8-8). Tissue RBTCs (Table 8-25) were also derived for risk communication purposes. Sediment RBTCs based on the seafood consumption scenarios were estimated for total PCBs using the FWM. Regression models for relating concentrations of inorganic arsenic and cPAHs in clams to concentrations of arsenic and cPAHs in co-located sediment were evaluated and found to be unsuitable for developing RBTCs. No sediment RBTC based on seafood consumption was estimated for dioxins and furans because dioxin and furan tissue data from the LDW were not available when the risk assessments were conducted to support such a derivation. RBTCs were also estimated for total PCBs in both tissue and sediment for prey consumption by river otter. Sediment RBTCs for benthic invertebrates were set equal to SMS criteria.

Table 8-24. Summary of sediment RBTCs for risk drivers

Risk Driver Chemical and SMS Criteria (if available)	Risk Level	Sediment RBTC for Direct-Contact Scenarios			Sediment RBTC for Human Seafood Consumption Scenarios			Sediment RBTC for Ecological Receptor[a]
		Netfishing RME	Beach Play RME	Tribal Clamming RME	Adult Tribal RME (Tulalip Data)	Child Tribal RME (Tulalip Data)	Adult API RME	River Otter Prey Consumption
Arsenic (mg/kg dw) SQS = 57, CSL = 93	1×10^{-6}	3.7	2.8	1.3	nc[b]	nc[b]	nc[b]	na[c]
	1×10^{-5}	37	28	13	nc[b]	nc[b]	nc[b]	na[c]
	1×10^{-4}	370	280	130	nc[b]	nc[b]	nc[b]	na[c]
	HQ = 1	nc[d]	nc[d]	nc[d]	nc[b]	nc[b]	nc[b]	na[e]
cPAHs (µg/kg dw)	1×10^{-6}	380	90	150	nc[b]	nc[b]	nc[b]	na[c]
	1×10^{-5}	3,800	900	1,500	nc[b]	nc[b]	nc[b]	na[c]
	1×10^{-4}	38,000	9,000	15,000	nc[b]	nc[b]	nc[b]	na[c]
	HQ = 1	nc[d]	nc[d]	nc[d]	nc[b]	nc[b]	nc[b]	na[f]
Dioxin/furan TEQ (ng/kg dw)	1×10^{-6}	37	28	13	ne[g]	ne[g]	ne[g]	ne[g]
	1×10^{-5}	370	280	130	ne[g]	ne[g]	ne[g]	ne[g]
	1×10^{-4}	3,700	2,800	1,300	ne[g]	ne[g]	ne[g]	ne[g]
	HQ = 1	nc[d]	nc[d]	nc[d]	ne[g]	ne[g]	ne[g]	ne[g]
Total PCBs (µg/kg dw) SQS = 12 mg/kg OC, CSL = 65 mg/kg OC	1×10^{-6}	1,300	1,700	500	<1[h]	< 1[h]	<1[h]	na[c]
	1×10^{-5}	13,000	17,000	5,000	< 1[h]	< 1[h]	<1[h]	na[c]
	1×10^{-4}	130,000	170,000	50,000	7.3 (< 1 – 25)[i]	185 (109 – 301)[i]	100 (67 – 167)[i]	na[c]
	HQ = 1	nc[d]	nc[d]	nc[d]	< 1[h]	< 1[h]	< 1[h]	128 – 159[j]

[a] Sediment RBTCs for the remaining 39 risk driver chemicals identified for the benthic invertebrate community were presented in Table 8-22.

[b] Regression models for relating concentrations of arsenic and cPAHs in clams to concentrations of these chemicals in co-located sediment were evaluated and found to be unsuitable for developing RBTCs.

[c] Tissue RBTCs for excess cancer risk were developed only for human health.

[d] Sediment RBTCs for direct-contact scenarios were estimated only for excess cancer risks. Sediment RBTCs were not estimated for non-cancer hazards for direct-contact scenarios because none of the RME scenarios had HQs for an individual chemical > 1 or generated endpoint-specific HIs in > 1 (Appendix B, Section B.5.6).

[e] Tissue RBTCs for arsenic were not developed for otter because arsenic was not a COC for otter.

[f] Tissue RBTCs for cPAHs were not developed for otter because cPAHs were evaluated only for human health; PAHs were evaluated as individual PAH compounds for otter in the ERA and were not a COPC.

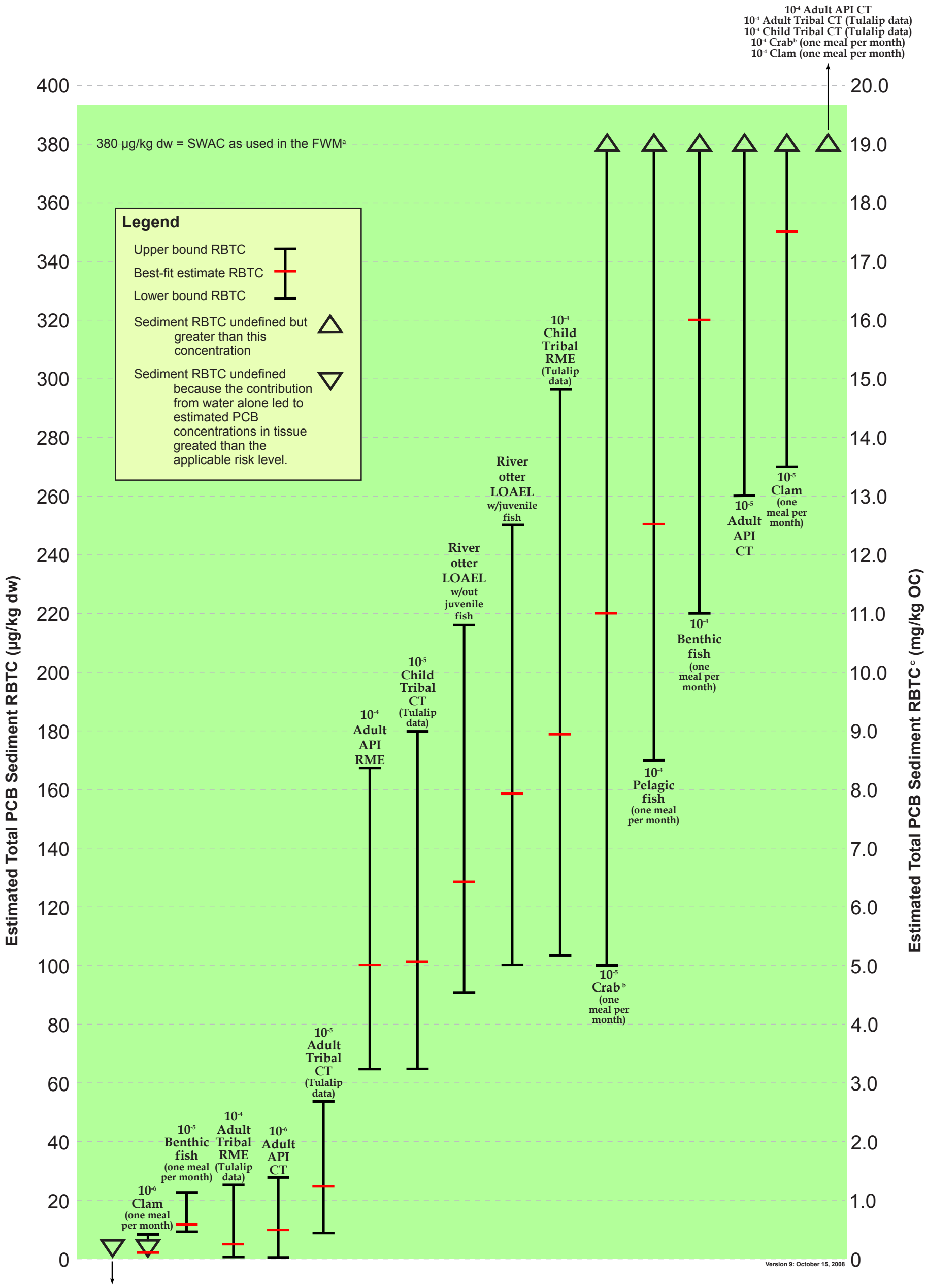
[g] RBTCs, other than those for direct sediment contact human health scenarios, could not be calculated because there were no dioxin and furan tissue data available for the risk assessments.

[h] For RBTCs presented as < 1 µg/kg dw, a sediment RBTC could not be calculated; even if the total PCB concentration in sediment was set equal to 0 µg/kg dw, FWM-estimated total PCB concentrations in tissue would be greater than the tissue RBTC for the applicable risk level because of the contribution of PCBs from water alone.

[i] The RBTC represents best-fit estimate from the FWM and the upper- and lower-bound estimates from FWM parameter sets that met the model performance criterion of estimates for all target species within a factor of 2 of empirical data.

[j] Represents best-fit estimates from the FWM for two different dietary scenarios, as described in Section 8.4.

API – Asian and Pacific Islander
cPAH – carcinogenic polycyclic aromatic hydrocarbon
CSL – cleanup screening level
dw – dry weight
FWM – food web model
HI – hazard index
HQ – hazard quotient
LDW – Lower Duwamish Waterway
na – not applicable
nc – not calculated
ne – not evaluated
ns – not selected (as a risk driver for this receptor)
OC – organic carbon
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration
RME – reasonable maximum exposure
SMS – Washington State Sediment Management Standards
SQS – sediment quality standards
TEQ – toxic equivalent



10-4 Adult Tribal (Suquamish data)
All other 10-5 human seafood consumption risks:
- 10-5 Adult Tribal RME (Tulalip data)
- 10-5 Child Tribal RME (Tulalip data)
- 10-5 Adult API RME
- 10-5 Adult Tribal (Suquamish data)
- 10-5 Pelagic fish (one meal per month)

All other 10-6 human seafood consumption risks:
- 10-6 Adult Tribal RME (Tulalip data)
- 10-6 Child Tribal RME (Tulalip data)
- 10-6 Adult API RME
- 10-6 Adult Tribal CT (Tulalip data)
- 10-6 Child Tribal CT (Tulalip data)
- 10-6 Adult Tribal (Suquamish data)
- 10-6 Benthic fish, pelagic fish, crabs[b], or clams (one meal per month)

Note: Ranges shown incorporate results from the final ERA and final HHRA, results from FWM Calibration 2, and the ranges associated with two different diet assumptions for river otter.

[a] A sediment SWAC of 380 µg/kg dw was used in the FWM because it reflected the most current sediment interpolation at the time of model cal bration. However, subsequent interpolation (with a new IDW parameterization and inclusion of Round 3 sediment data) resulted in a SWAC of 350 µg/kg dw.

[b] Crab one-meal-per-month scenario included consumption of equal portions of slender crabs and Dungeness crabs.

[c] Sediment RBTCs estimated from the FWM were on a dry-weight basis; for the sake of comparison, the dry-weight sediment RBTCs were converted to approximate OC-normalized sediment RBTCs, assuming 2% organic carbon.

Figure 8-8. Summary of sediment RBTCs for total PCBs for selected human seafood consumption and river otter prey consumption scenarios

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Table 8-25. Summary of tissue RBTCs for risk drivers

Risk Driver Chemical	Risk Level	Tissue RBTCs for Human Seafood Consumption Scenarios			Tissue RBTCs for Ecological Receptor
		Adult Tribal RME	Child Tribal RME	Adult API RME	River Otter Prey Consumption
Arsenic (mg/kg ww)	1×10^{-6}	0.00056	0.0030	0.0019	na[a]
	1×10^{-5}	0.0056	0.030	0.019	na[a]
	1×10^{-4}	0.056	0.30	0.19	na[a]
	HQ = 1	0.25	0.120	0.37	na[b]
cPAHs (µg/kg ww)	1×10^{-6}	0.11	0.12	0.39	na[a]
	1×10^{-5}	1.1	1.2	3.9	na[a]
	1×10^{-4}	11	12	39	na[a]
	HQ = 1	na	na	na	na[c]
Total PCBs (µg/kg ww)	1×10^{-6}	0.42	2.3	1.4	na[a]
	1×10^{-5}	4.2	23.0	14	na[a]
	1×10^{-4}	42	230	140	na[a]
	HQ = 1	17	8	24	540

[a] Tissue RBTCs for excess cancer risk were developed only for human health.

[b] Tissue RBTCs for arsenic were not developed for otter because arsenic was not a COC for otter.

[c] Tissue RBTCs for cPAHs were not developed for otter because cPAHs were evaluated only for human health; PAHs were evaluated as individual PAH compounds for otter in the ERA and were not a COPC.

API – Asian and Pacific Islander
cPAH – carcinogenic polycyclic aromatic hydrocarbon
HQ – hazard quotient
na – not applicable
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration
RME – reasonable maximum exposure
ww – wet weight

Sediment RBTCs for total PCBs under the various human seafood consumption scenarios and for prey consumption by river otters are compared in Figure 8-8. This figure facilitates a visual comparison of the RBTC ranges for the different seafood consumption scenarios. It also shows that across the range of total PCB concentrations of interest in sediment (0 to 380 µg/kg dw), RBTCs range from < 1 µg/kg dw to greater than 380 µg/kg dw, depending upon the seafood consumption scenario and target risk level. The appropriate application of RBTCs to sediment in the LDW must consider the specific exposure areas identified in the HHRA for direct-contact scenarios and for seafood consumption RBTCs.

9 Potential Pathways, Source Identification, and Source Control Efforts

Source control is the process of identifying and preventing or reducing releases of chemicals into the environment. The goal of an effective source control strategy is to minimize the potential for sediment to become recontaminated to levels of concern after remediation has been completed. Since 2001, source identification and control programs in the LDW have been established by regulatory authorities including the City of Seattle, King County, Ecology, and EPA. The goal of these efforts has been to identify potential sources of chemicals to the LDW and to implement cleanup plans and source control strategies.

The LDW and its adjacent upland areas have been used for industrial, commercial, and shipping operations for nearly a century. During this time, chemicals associated wFith those practices have entered the LDW through various pathways. Forty-one chemicals have been detected in sediment from the LDW at concentrations exceeding SMS criteria, including PCBs, PAHs, metals, phthalates, and other SVOCs; dioxins and furans, which do not have SMS criteria, were also elevated in some areas. Many private and agency-led environmental investigations have been conducted both in the LDW and on adjacent upland properties to further characterize the nature and extent of contamination in the LDW and to identify potential sources of chemicals that could continue to enter the LDW.

Ecology, as the lead source control agency, formed the LDW Source Control Work Group (SCWG) in 2002. The SCWG is composed primarily of public agencies responsible for source control, including Ecology, the City of Seattle, the City of Tukwila, King County, the Port of Seattle, and EPA. Public agencies with the authority to regulate source control in the LDW use stormwater programs, permits, hazardous waste management and pollution prevention programs, inspection and maintenance programs, water quality compliance and spill response programs, environmental and pathways assessments, and other regulatory programs in an effort to control sources of contamination. The SCWG is discussed further in Section 9.2.

In 2004, Ecology developed a source control strategy for the LDW (2004b). The basic approach for the LDW source control strategy is to identify and manage sources of sediment contamination in coordination with the LDW-wide RI, as well as more localized, site-specific investigations. The strategy provides the basis for Ecology to identify priority areas through a tiered process and to develop "summary of existing information and data gaps reports" (hereafter referred to as data gaps reports) and detailed area-specific source control action plans (SCAPs) for each priority area. The status of the reports for the various areas is discussed in Sections 9.2.2 and Appendix I.

This section describes the potential migration pathways through which chemicals can enter the LDW (Section 9.1), discusses the overall LDW source control strategy and

SCWG efforts (Section 9.2), identifies the various potential historical and ongoing sources to the LDW (Section 9.3), and discusses the ongoing source identification and control efforts being implemented in the LDW (Section 9.4). The information in this section was compiled using readily available data; historical records and documents; and information from EPA, Ecology, the City of Seattle, the City of Tukwila, the Port of Seattle, The Boeing Company, and King County.

Source control is an ongoing, iterative process that continually produces new information. The summary of source control information provided in this report reflects information that was available at the time of document preparation. Information in this report does not supersede or replace information provided by the SCWG through their source control strategy implementation, including SCAPs, data gaps reports, source control status reports, or other SCWG products. These sources should be referred to for the most up-to-date and complete source control documentation.

The source information presented in this section for the greater LDW drainage basins (Map 9-1) is useful in the development of a CSM for the LDW and will assist in the remedial alternative decision-making process.

9.1 POTENTIAL PATHWAYS

Chemicals released to media such as air, soil, groundwater, and surface water or to impervious surfaces may migrate to the LDW through various potential pathways. As shown in Figure 9-1, potential pathways include atmospheric deposition; surface water inputs; direct discharge into the LDW (e.g., CSOs, storm drains); chemical spills and/or leaks to the ground, surface water, or directly into the LDW; groundwater migration; and bank erosion. This section briefly highlights the potential pathways to the LDW. In-depth information is provided in Sections 9.3 and 9.4.

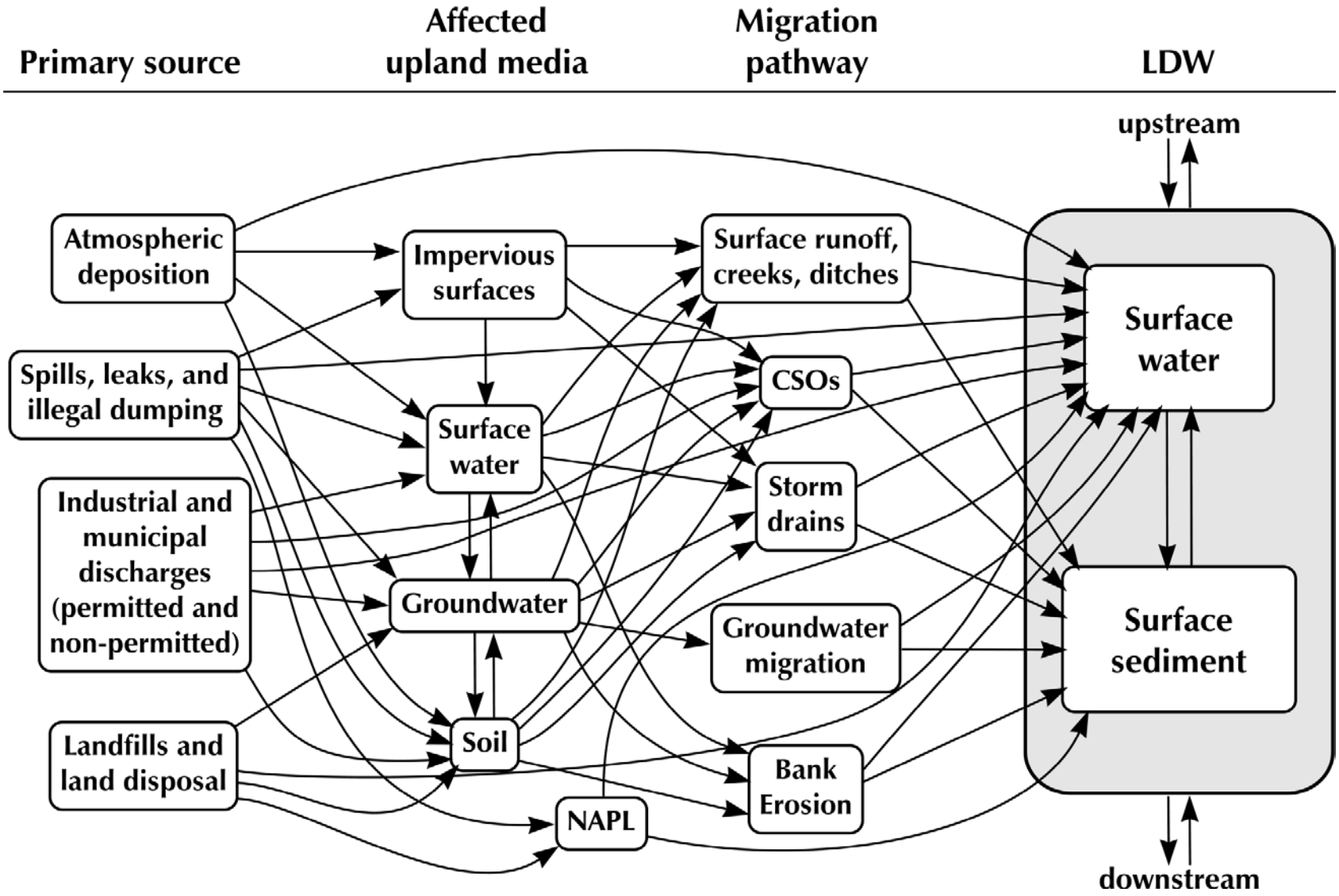

Figure 9-1. Conceptual model of chemical sources and potential pathways to the LDW

9.1.1 Atmospheric deposition

Chemicals are emitted to the air from both point and non-point sources. Point sources include various industrial facilities (EPA 2001). Non-point sources include mobile emissions from motor vehicles, marine vessels, and trains, as well as common materials (e.g., plastics) through off-gassing. Chemicals emitted to the air may be transported over long distances, generally in the direction of the area's prevailing winds. They can be deposited from the atmosphere to land and water surfaces through wet deposition (precipitation) or dry deposition (as particles).

Air pollutants can enter water bodies through either direct or indirect deposition. Direct deposition occurs when particulates with adsorbed chemicals are deposited onto the surface of a water body and then settle to the bottom, becoming part of the sediment. Indirect deposition occurs when chemicals are first deposited on land or other water bodies in the watershed and then transported to the water body via surface water or stormwater runoff, either in dissolved form or adsorbed to solids in the runoff, which is discharged to the water body and ultimately transported to bottom sediments. Many air pollutants deposited through direct or indirect atmospheric deposition in aquatic systems, such as the LDW, have the potential to contaminate sediment because they are hydrophobic and tend to adhere to sediment particles (PSCAA 2003). The potential sources of chemicals to the LDW through atmospheric deposition are discussed in further detail in Sections 9.3.2.4 and 9.4.2.

9.1.2 Surface water inputs

Potentially contaminated surface waters and suspended sediment may be transported to the LDW from the upper reaches of the Green/Duwamish River, tributary creeks, and through open-channel drainage ditches. The inputs from these sources vary greatly during the year; the upper Green/Duwamish system is variable because it can be influenced by a large area of mixed industrial, commercial, residential, and agricultural lands. Accidental spills and leaks (e.g., hazardous material releases from fuel storage tanks, automobiles, or other equipment) that occur upriver or along its tributaries also have the potential to enter the LDW in areas lacking collection systems, through which spills and leaks can flow directly over impervious surfaces and drain into the LDW. Surface water inputs into the LDW are discussed in further detail in Section 9.4.3.

9.1.3 Direct discharges

In general, direct discharge systems include municipal or other publicly owned drainage systems, privately owned and managed drainage systems, and sanitary/combined sewer systems. Since 2003, over 250 individual discharge points (e.g., pipes) into the LDW study area have been identified (Herrera 2004a). These individual points, often referred to as outfalls, are defined here as locations of discharge of storm water and/or industrial wastewaters transported via a collection system; though most industrial discharges are now routed through the sanitary sewer

and no longer discharge directly to the waterway. The classifications of direct discharges include CSOs, emergency overflows (EOFs), and public and private storm drain systems. Direct discharge systems and the various types of outfalls are discussed in further detail in Section 9.4.4 and Appendix H.

9.1.4 Spills and leaks

Chemicals released through spills and leaks to soil, other ground surfaces (such as roadways), surface water, or groundwater have the potential to migrate to the LDW. Leaks can occur from various sources including pipes and storage tanks, industrial or commercial equipment, and process operations. Spills can occur accidentally during vehicle fueling and maintenance, or purposefully in the case of illegal dumping. The US Coast Guard (USCG), Ecology, and the City of Seattle each have programs to record and clean up reported spills and leaks of hazardous materials. These programs are discussed further in Section 9.4.5.

9.1.5 Groundwater migration

Groundwater flow in the greater Duwamish Basin is generally towards the LDW, although the direction varies locally depending on the nature of subsurface materials, hydrostratigraphy, and proximity to the LDW (see Section 2.5). Near the LDW, tidal action can greatly alter groundwater flow directions, rates, and water quality. The determination of whether a chemical identified in groundwater will reach sediment and surface water in the LDW study area is a complex process. Groundwater issues in the LDW area are discussed further in Sections 9.4.6, and an overview of monitoring information for select facilities is presented in Appendix I.

9.1.6 Bank erosion

Shoreline banks are susceptible to erosion by vessel wakes, wind waves, surface water runoff, tidal exchange, and groundwater discharge. Shoreline armoring and vegetation reduce, but do not eliminate, bank erosion. Bank slope and bank soil properties are also major factors in the susceptibility of bank areas to erosion; steeper banks are more susceptible for a given grain size. Currently, the majority of the LDW shoreline is armored with constructed steel, wood, concrete bulkheads, sheet pile walls, and riprap revetments, which reduce the potential for bank erosion in most areas. Unarmored areas exist along the banks of Kellogg Island, the shoreline east of the island, and areas to the south near the Upper Turning Basin. Although the unarmored areas are more susceptible to erosion, armored areas are also susceptible, under some circumstances. In addition, shoreline armoring is generally not designed to be completely impervious to water; groundwater and surface water are allowed to pass through the bank materials for structural stability. This seepage has the potential to entrain soil from the bank, although properly designed armoring systems would include appropriate geotechnical filters to minimize or prevent the transport of soil through the armoring system. Along the LDW, armoring systems that are not properly designed or maintained (and that have underlying soil contamination) could result in

the transport of contaminated bank soils to the LDW. In addition, if chemicals are present in shoreline bank soils that have a low affinity for sorption to soil, these chemicals may dissolve into groundwater as it passes through the bank materials.

Erosion of contaminated bank material has been identified as a potential pathway to LDW sediments in a few areas along the LDW shoreline, as discussed in Section 9.4.7. Appendix I presents available bank soil data that have been collected from several properties along the LDW. Bank erosion could also be a potential pathway to LDW sediments in other areas; however, because bank material along much of the LDW shoreline has not been well characterized, the importance of this pathway from an LDW-wide perspective is not well known. Therefore, the extent of bank contamination is a potential data gap for site-specific source control evaluations in the LDW.

9.2 LDW SOURCE CONTROL ACTIVITIES

Ecology is the lead entity for implementing source control in the LDW. Ecology works in cooperation with local jurisdictions and EPA (together forming the SCWG, which is discussed in Section 9.2.1) and conducts several different source control activities within the LDW. Source control investigations assess the potential sources and pathways of chemicals in a specific area. Ecology's overall source control strategy for the LDW is discussed in Section 9.2.2. The purpose of the LDW source control program is to control sources of chemicals to LDW sediments in coordination with sediment remediation (Ecology 2004b). Ecology's source control investigation findings and their plans for implementing source control activities are documented in data gaps reports and SCAPs (see Section 9.2.3).

9.2.1 Source Control Work Group activities

Ecology works with several other entities to create and implement source control strategies and prioritize cleanup efforts in the LDW. In 2002, these entities formed the LDW SCWG. As discussed in Section 9, the members of the SCWG are public agencies responsible for source control in the LDW, including Ecology, the City of Seattle, the City of Tukwila, King County, the Port of Seattle, and EPA. The purpose of the SCWG is to share information, discuss strategies, develop action plans, jointly implement source control measures, and share progress reports on source control activities in the LDW area. Other public entities with related source control responsibilities include PSCAA and Seattle-King County Department of Public Health. Both of these entities actively coordinate with the SCWG.

9.2.2 Ecology's source control strategy

Ecology is the lead agency responsible for source control in the LDW. In January 2004, Ecology issued the final *Lower Duwamish Waterway Source Control Strategy* (Ecology 2004b). This strategy is consistent with sediment source control protocols described in EPA guidance (2002c) and the SMS (Ecology 1995). The strategy describes the process and timing for implementing source control, the roles of various regulatory agencies

responsible for conducting source control (e.g., SCWG) and those providing enforcement, and Ecology's methods for tracking and documenting source control progress in the LDW.

The focus of Ecology's source control strategy for LDW sediment is to meet sediment cleanup goals and to prevent post-remediation recontamination to levels that exceed the SMS or other LDW sediment cleanup goals that will be established in the ROD (Ecology 2004b). The strategy was designed to identify and manage sources of chemicals that could contaminate LDW sediments, and it serves as the basis for the development of a series of detailed SCAPs for priority action areas.[141] Although not explicitly addressed in the SMS, Ecology is also evaluating VOCs in porewater as part of source control efforts because if VOCs are present in sufficiently high concentrations, they can cause adverse effects to benthic organisms.

The source control strategy established the priority for source control activities in the LDW according to the following four tiers (Ecology 2004b):[142]

- **Tier One –** Source control work associated with the identified EAAs
- **Tier Two –** Source control work associated with sediment cleanup areas identified for final or long-term cleanup through the RI process or in the EPA ROD
- **Tier Three –** Source control work associated with drainage basins discharging to LDW sediments that have not been identified for Tier One or Tier Two source control activities through the RI/FS process
- **Tier Four –** Source control work associated with sediment areas that have been remediated and were subsequently recontaminated above SMS criteria or LDW cleanup goals based on post-cleanup monitoring

In 2003, seven sediment areas were identified as candidate sites to be given priority for investigation and potential cleanup in the LDW because of the relatively high chemical concentrations in sediment (Windward 2003e) (Table 9-1, Map 9-2). These seven areas (candidate EAAs) were subsequently adopted as the areas included in the Tier One classification. These sediment areas were identified based on both risk- and management-based criteria and are discussed in a LDWG technical memorandum (Windward 2003e) that identified the candidate sites for early action. Risk-based criteria were based on CSL exceedances or the top 95th percentile of PCBs based on the

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[141] Ecology and EPA may revise the source control strategy in the future. Newer versions would supersede previous versions of the strategy.

[142] As of February 2008, Ecology identified 23 source control areas for evaluation in the LDW. These areas were defined in part based on drainage to the LDW. At this point, source control areas encompass almost all of the properties immediately adjacent to the LDW study area and their associated sub-drainage basins.

results of the Phase 1 risk assessments. Management-based criteria included: 1) consistency with methods used by EPA and Ecology to identify contaminated sites requiring remediation, 2) ability to prevent unacceptable recontamination at the site, and 3) consistency between potential early action cleanup methods and remedial alternatives that are likely to be evaluated for the LDW (Windward 2003e).

Table 9-1. Candidate EAAs identified in 2003

Early Action Area No.	Associated Name	River Mile	Side of LDW
EAA 1	Duwamish/Diagonal	0.4 to 0.6	east
EAA 2	Early Action Area 2 (RM 2.2)	2.2	west
EAA 3	Slip 4	2.8 to 2.9	east
EAA 4	Boeing Plant 2/ Jorgensen Forge	2.9 to 3.7	east
EAA 5	Terminal 117	3.5 to 3.7	west
EAA 6	Early Action Area 6 (RM 3.8)	3.8	east
EAA 7	Norfolk	4.8 to 5.0	east

Source: Windward (2003e)
EAA – early action area
RM – river mile

Some of the EAA sediment boundaries shown on Map 9-2 and subsequent maps are preliminary and have not been finalized by EPA and Ecology. The Duwamish/Diagonal and Norfolk boundaries represent the areas where removal and capping actions have been completed by King County (in both EAAs) (King County 1999g; King County et al. 2005a) and by Boeing (in the Norfolk EAA only). The T-117 boundary was identified in the draft T-117 engineering evaluation/cost analysis (EE/CA) as the removal area; the final boundary is contingent on supplemental sampling (Windward et al. 2008). The Slip 4 boundary represents the final sediment removal area delineated in the Slip 4 EE/CA (Integral 2006) and finalized in EPA's action memo (EPA 2006a). The in-water boundary adjacent to Boeing Plant 2 represents the final sediment removal area identified under RCRA (Geomatrix and Floyd|Snider 2008) for Boeing's portion of the Boeing Plant 2/Jorgensen Forge EAA. The in-water boundary adjacent to Jorgensen Forge represents the proposed sediment removal area identified under CERCLA (EPA 2008b) for the Jorgensen Forge portion of the Boeing Plant 2/Jorgensen Forge EAA. The EAA 2 and RM 3.8 boundaries are preliminary and have not been finalized by EPA or Ecology. Detailed information on these EAAs is included in Appendix I.

The seven candidate EAAs proposed by LDWG were the basis for the designation of the Tier One source control areas (SCAs) established by Ecology; however, Ecology's SCAs encompass a larger area adjacent to and upland of the LDW (Map 9-3). The SCAs associated with the EAA boundaries include the drainage basins that drain to these areas.

In 2007, Ecology identified eight additional SCAs for priority evaluation (Map 9-2) (Ecology 2007j). Identification of the eight additional SCAs was based on surface sediment data and general knowledge about the upland areas draining to those particular areas, including drainage infrastructure and facilities operating within them (Ecology 2007j). The sediment areas associated with SCAs shown on Map 9-2 correspond only to upland source control drainage areas, and do not correspond to areas that have been identified for in-water remediation. Sediment management areas will be mapped and evaluated in the FS for cleanup with final determinations by EPA and Ecology documented in the ROD.

In February 2008, Ecology expanded the boundaries of many of the 15 previously identified areas and added 8 additional SCAs (Map 9-3) (Ecology and SAIC 2008). The updated boundaries established for the 23 SCAs were developed to ensure that source control would be conducted for the entire study site. These areas were delineated based on storm drainage sub-basins and upland property boundaries. The two northernmost SCA boundaries extend beyond the northern boundary of the LDW study area because of upland drainage features relevant to source control in those areas. For many of the SCAs, a determination of whether remediation will be required for the sediments adjacent to the boundary of the SCA has not been made.

Upland parcels and drainage areas in association with these 23 SCAs have been identified by Ecology; the upland parcels associated with these SCAs are identified on Map 9-3 and in Appendix I. The 23 SCAs currently established by Ecology within the LDW are listed in Table 9-2 along with the status of the SCAP for each area. As source control investigations within these areas continue, Ecology may revise the SCA boundaries (Good 2008). Where an individual SCA falls under Ecology's tiered classification (as established by Ecology's source control strategy) will not be determined until the RI/FS is complete and the necessary level of remediation has been established (Ecology and SAIC 2008).

Table 9-2. Ecology's 23 SCAs and the SCAP status

Property Name or Description[a]	Approximate Location	Status of SCAP	Final SCAP Publication Date[b]
Spokane Street to Kellogg Island	RM 0 to RM 1.0 west	TBD	TBD
Kellogg Island to Lafarge Cement[c]	RM 1.0 to RM 1.3 west	TBD	TBD
Glacier Bay	RM 1.3 to RM 1.6 west	completed	November 2007
Terminal 115[c]	RM 1.6 to RM 2.1 west	TBD	TBD
Trotsky Inlet (EAA 2)[c]	RM 2.1 to 2.2 west	completed	June 2007
Riverside Drive	RM 2.2 to RM 3.4 west	TBD	TBD
Terminal 117 (EAA 5)	RM 3.4 to RM 3.8 west	completed	July 2005
Sea King Industrial Park[c]	RM 3.8 to RM 4.2 west	TBD	TBD
Restoration areas	RM 4.2 to RM 4.8 west	TBD	TBD
Spokane Street to Ash Grove Cement[c]	RM 0 to RM 0.1 east	completed	June 2009

Property Name or Description[a]	Approximate Location	Status of SCAP	Final SCAP Publication Date[b]
Duwamish/Diagonal Way (EAA 1)	RM 0.1 to RM 0.9 east	completed	December 2004
Slip 1	RM 0.9 to RM 1.0 east	completed	May 2009
King County lease parcels[c]	RM 1.0 to RM 1.2 east	TBD	TBD
St. Gobain to Glacier Northwest[c]	RM 1.2 to RM 1.7 east	completed	June 2009
Slip 2 to Slip 3	RM 1.7 to RM 2.0 east	completed	June 2009
Slip 3 to Seattle Boiler Works[c]	RM 2.0 to RM 2.3 east	completed	April 2009
Seattle Boiler Works to Slip 4[c]	RM 2.3 to RM 2.8 east	completed	June 2009
Slip 4 (EAA 3)	RM 2.8 east	completed	July 2006
Boeing Plant 2/Jorgensen Forge[c] (EAA 4)	RM 2.8 to RM 3.7 east	completed	November 2007
Boeing Isaacson/Central KCIA (EAA 6)[c]	RM 3.7 to RM 3.9 east	completed	March 2009
Slip 6	RM 3.9 to RM 4.3 east	completed	September 2008
Boeing Developmental Center[c]	RM 4.3 to RM 4.9 east	TBD	TBD
Norfolk CSO/SD (EAA 7)[d]	RM 4.9 east	completed	September 2007

Sources: Ecology and SAIC (2008), (Good 2008), (Good 2009)

[a] List of SCAs and associated names are from Ecology; some of the EAA names have been altered since the EAAs were originally selected in 2003.

[b] SCAP schedule taken from the LDW source controls status report for July 2007 to March 2008 and updated based on personal communications from Ecology (Ecology and SAIC 2008) and modified with updated information received from Ecology (Good 2008).

[c] Company names are used only to designate areas and are not necessarily included in the cleanup area or necessarily responsible for contamination in these areas.

[d] A City pump station EOF also discharges through this outfall.

CSO – combined sewer overflow
EAA – early action area
KCIA – King County International Airport
RM – river mile
SCA – source control area
SCAP – source control action plan
SD – storm drain
TBD – to be determined

Ecology is in the process of evaluating each SCA for potential pathways and sources of contamination to the LDW. Ecology assesses the status of and need for source control within each SCA by reviewing existing information, identifying data gaps, and then developing a SCAP for each area.

9.2.3 Data gaps reports and source control action plans

Data gaps reports are prepared by Ecology to summarize available information that may have implications for source control for each of the SCAs.[143] Elements of these reports include:

- Location and physical characteristics of the SCAs

[143] Instead of data gaps reports, a series of property assessments were prepared for EAA-1, EAA-3, and EAA-5.

- Documentation of readily available information with implications for sediment recontamination
- Identification of potential COCs for source control evaluation and assessment of potential pathways
- Identification of critical data gaps that need to be addressed prior to sediment cleanup

Once the existing information and data gaps are identified for an SCA, Ecology then develops a SCAP for that area. Ecology is producing SCAPs for all 23 SCAs. The SCAP for each of these areas identifies potential chemical sources and actions needed to control them and evaluates whether ongoing sources could recontaminate sediments after cleanup. In addition, the SCAPs describe source control actions that are planned or currently underway and sampling and monitoring activities that will be conducted to identify additional sources.

Ecology has completed or is in the process of developing detailed SCAPs and data gaps reports for the SCAs.[144] As they are completed, the data gaps and SCAPs are provided to EPA, the SCWG, and stakeholders. After the source control actions identified in a SCAP have been implemented, the success of the plan will be evaluated by Ecology through a series of source control effectiveness and completeness determinations (Ecology 2004b). These evaluations will then be provided to EPA for comment and concurrence, at which time a final determination of completeness will be issued.

9.3 HISTORICAL SOURCES AND PRACTICES IN THE LDW

In the course of over 100 years of growth and development, industrial practices and waste streams have contributed chemicals to the LDW. Understanding these various historical practices is important to identify, characterize, and control sources of sediment contamination. The following section provides an overview of the industrial development of the waterway, including the dynamic reshaping of the river and the manufacturing and commercial operations that were established along its shores. The section also discusses some of the manufacturing and waste handling and disposal practices prevalent in the earlier history of the waterway. This type of information is important to consider in source identification and control effects.

Maps 9-4a through 9-4d provide information on some of the historical operations identified in the LDW study area. The majority of source information used to prepare the maps was compiled from Foster (1945) and the Pollution Control Commission (1955). Some historical information, at a more limited level, was obtained from other

[144] At the time of this RI, a separate data gaps report had not been prepared for the Duwamish/Diagonal Way SCA; the information typically provided in data gaps reports is included in the SCAP for this SCA.

source documents, including the data gaps reports and SCAPs. The locations of the historical operations presented on the maps are the approximate locations based on available information; in many cases, the exact locations were unknown. These maps are intended to give general locations of historical operations relative to the LDW and should not be used to associate these operations with individual parcels.

Information in this section was based on readily available resources, most notably Foster (1945) and Sweet Edwards (1985). Other sources include Ecology's data gaps reports and SCAPs, other summaries of source information, and an Environmental Data Resources, Inc. (EDR), document that was prepared in 2006 for the LDW (EDR 2006b). None of the resource information has been independently verified beyond the citations noted, and LDWG cannot verify the completeness or accuracy of source documentation. Furthermore, the primary data have had varying levels of QC and data validation, which have not generally been documented in the literature reviewed. Therefore, information included in this section should not be relied upon as complete. Ecology, the lead agency for source control, may require additional site-specific information or determine that a more thorough evaluation of the data is needed. It is expected that more thorough evaluations of the data will be conducted in the course of further source control investigations.

9.3.1 Industrial development of the LDW

Historically, land adjacent to the Duwamish was accessed using the river as a transportation route. By 1874, Seattle's first railroad had been established, allowing further access to and development of lands along the river. Between 1901 and 1913, the LDW, the East and West Waterways, and Harbor Island were all developed through dredging, filling, and channelization of the Duwamish River and its delta (Section 2.2). Filling of mudflats and wetlands along the LDW created additional land that was available for development, and dredging and channelization of the LDW allowed oceangoing ships and barges access to the LDW. A steam plant used for electric power generation was built along the LDW in 1906.

Shipyards, airplane manufacturing, cement manufacturing, food processing, and cold storage were early industries along the LDW that became increasingly important with the onset of World War I (Sato 1997). Other common industries at this time included lumber storage and milling yards, metal fabrication, and equipment manufacturing (Sato 1997; Ecology 2006a). Residential areas in Georgetown and South Park began to grow with the increase in job opportunities and improved transportation; the South Park neighborhood area increased by more than 66 ac after channelization of the river, and the new land was claimed by farmers (Wilma 2001b).

The aviation industry continued to develop when Boeing Field (now KCIA), Seattle's first municipal airport, was opened in 1928 (Wilma 2001a). Thousands of B-17 and B-29 bombers were produced at Boeing Plant 2 during World War II (King County 2005c). Boeing has had several other facilities near the LDW at various times. World War II also resulted in an increased need for shipyards and maintenance docks for the

US Navy. Harbor Island became home to several ship-building, salvaging, and maintenance companies, and it became an important port for economic trade. A lead smelter was also built on the island in 1937 (Tetra Tech 1988b).

Construction and cement companies, slaughterhouses, meat packing facilities, and a cannery were also located along the LDW in the 1930s and 1940s (Foster 1945). By 1945, industrial facilities were prevalent along the LDW. Lumber production continued to develop, including the use of pole treating and wood preserving processes (Foster 1945). Metal working facilities, machine shops, shipyards, cement and asphalt companies, manufacturing facilities, and meat packing companies were all common industries during the World War II era and following years. Lime and concrete plants and chemical manufacturing (including paint, glue, resin, and wood preservatives) were also established in the LDW at this time. Industrial development resulted in an increased need for waste disposal, and many casual dumping sites were created. Eventually, some dumping sites became official landfills that received industrial waste, though most remained small informal landfills used by neighboring properties for their waste disposal.

Continuing through the 1950s and 1960s, metal working facilities along the LDW included metal manufacturers and recyclers, galvanization plants, and foundries. Steel, tin, aluminum, titanium, nickel, and lead (at the Harbor Island smelter) were all used in various metal-working industries. With an increase in demand for fuel products along the LDW, several petroleum storage facilities and storage tank farms were established on Harbor Island. From the 1950s to the 1970s, several smaller companies and landfill sites along the LDW were closed and redeveloped as parking lots or other commercial and industrial facilities.

By the 1980s, much of the land adjacent to the LDW was occupied by industry. Aviation industries and Port of Seattle operations, including cargo storage and transport, continued to expand during this time. Harbor Island was still used largely for shipyard activities and petroleum storage. Other metal-working industries remained on Harbor Island and along the LDW during this time period (Sweet Edwards 1985). Wood preserving, chemical processing (including used oil and antifreeze), and other types of manufacturing continued throughout the 1980s. Industry to the south of Harbor Island near Kellogg Island was primarily related to cement and gypsum manufacturing and included an upland waste disposal site (Sweet Edwards 1985). In 1998, the Harbor Island lead smelter was permanently closed.

Many of the industries that were present along the LDW in the past are still in operation today. Currently aviation facilities used for the construction, maintenance, and operation of aircraft, Port-owned and privately owned terminals used for cargo shipping and receiving, motor vehicle and marine vessel maintenance, cement production, manufacturing plants, and various other industries all operate along the

LDW. Maps 9-4a through 9-4d show approximate locations of selected historical operations along the LDW.

9.3.2 Historical discharge sources

Historically, chemical disposal practices were not regulated as they are today. In many cases, chemicals and other wastes were discharged directly to the LDW or disposed of on upland properties without sufficient containment (Foster 1945; Seattle-King County Department of Public Health 1984). This section provides an overview of information regarding historical sources to the LDW.

9.3.2.1 Historical industrial discharges

Potential sources of contamination along the LDW were documented in several historical reports (Foster 1945; Sweet Edwards 1985; Tetra Tech 1988b). In the report by Foster (1945), the river was divided into three sections for assessment: the Duwamish Waterway, which received predominantly industrial waste, the Green River below the City of Palmer (south-central King County), which received primarily domestic sewage and agricultural waste, and the upper Green River, which received little contaminated discharge of any type at that time.

Wastes generated during the development and ongoing industrial history of the LDW had the potential to be discharged into the waterway. Wastes were transported to the LDW directly through storm drainage systems, as a component of the discharge from sanitary sewer systems, through atmospheric deposition, or direct disposal along the shoreline. Sanitary sewer systems serviced large industrial areas along the LDW. Information on sewer system discharges are discussed in Section 9.3.2.2.

Historically, many industrial facilities used unlined, open-air waste ponds for pre-treatment of slurries and other waste water (Sweet Edwards 1985; Foster 1945). Often the ponds and lagoons were located along the LDW shoreline and contained chemicals that could enter area soil and/or groundwater and eventually enter the LDW. Waste slurries derived from routine maintenance and cleaning of tanks and equipment were often dumped directly into the LDW or into wastewater ponds on a daily to yearly basis, depending on the industry (Foster 1945).

Several lumber yards were located along the LDW in the past, particularly at the upstream reach of the LDW near the Upper Turning Basin. Prior to 1945, considerable amounts of sawdust were disposed of in the LDW (Foster 1945); after that time, sawdust became valued as a fuel product and was kept by most mills. Waste products from lumber mills and sand and gravel companies were sources of solids (in addition to ongoing inputs from the Upper Duwamish/Green River) to the LDW in the past. Additional wastes associated with lumber processing included creosote used in pole dipping, and arsenic and sulfate salts of copper and zinc used to preserve logs. Creosote is known to contain PAHs. Other wood preservatives and resins may have contained TBT (EPA 2003).

Historically, oil and fuel were discharged to the LDW from various industrial activities including ship-building and repair facilities, ship salvaging companies, brick manufacturing, machine shops, pole treating facilities, and hydraulic equipment manufacturing (Foster 1945). Oily wastes were observed seeping from facilities located along the LDW shoreline in the past (Sweet Edwards 1985). The storage, transport, and use of fuel at aviation, railway, motor vehicle, and fuel storage/tank farm facilities were also historical sources of petroleum product wastes that may have reached the LDW through both direct discharge (spills and dumping), transport through storm drain networks, and indirect discharge (migration through soil or groundwater). Historically, recycled or waste oils sometimes contained PCBs from electrical or hydraulic equipment and other sources directly containing PCBs or due to mixing or cross-contamination with PCB oil from those sources (ATSDR 2000). Recycling of these oils often resulted in oil spills (Sweet Edwards 1985).

In the late 1970s, the EPA issued regulations banning the manufacture of PCBs. The use of PCB-containing equipment began to be phased out at this time. The presence of PCBs in waste oils might have diminished after these regulations were introduced in the late 1970s. However, the timing and amount of the reduction of PCBs in waste oils are uncertain.

Significant uses of PCBs were as a dielectric fluid in transformers and as a component of hydraulic oils; releases to the environmental associated with both of these uses have been well documented. PCBs have also been used in many other products, such as capacitors, heat transfer systems, inks and carbonless copy paper, the ballasts of some fluorescent light fixtures, and paints. PCB contamination along the LDW has also been documented in connection with the waste oil used as fuel in asphalt manufacturing (Ecology 2005a; Windward et al. 2005b), as well as associated with caulking and sealant materials used on pavement and asphalt (SAIC 2007e).

Industrial waste discharges originating from manufacturing and metalworking companies often contained various chemicals. Acidic solutions were among the most widely reported chemical releases associated with these industries (Sweet Edwards 1985; Foster 1945). Other wastes included metal scraps, sodium borate, cyanide, and zinc salts (Foster 1945). Chromium, copper, cadmium, and nickel are associated with electroplating (Sweet Edwards 1985). In addition, the Harbor Island and Asarco smelters emitted lead, arsenic, and other metals to the atmosphere (Huey 2002; Ecology 2007b; Area-Wide Soil Contamination Task Force 2003) (Section 9.3.2.4).

Shipbuilding and marine vessel maintenance is another industry that has been present in the LDW for many years. Metals (including arsenic, chromium, copper, lead, and zinc) and petroleum products were common waste products produced by shipyards activities (Tetra Tech 1988b). Anti-fouling paint applied to boats often contained TBT, copper, mercury, and other metals (SAIC 2007d). Sandblasting, painting, boat repair, and other maintenance activities also had the potential to contribute metals and various petroleum products to the LDW. In addition, solvents, acids, various types of

paint, antifreeze, and other chemicals have also been associated with shipyards (SAIC 2007d).

Several waste products are associated with the aviation industry, including alkaline carbide wastes from acetylene generators (Foster 1945), petroleum products used for fuel, and metal wastes produced in the manufacture of aircraft (Foster 1945; Ecology 2006a). Solvents and paints were also associated with aircraft maintenance.

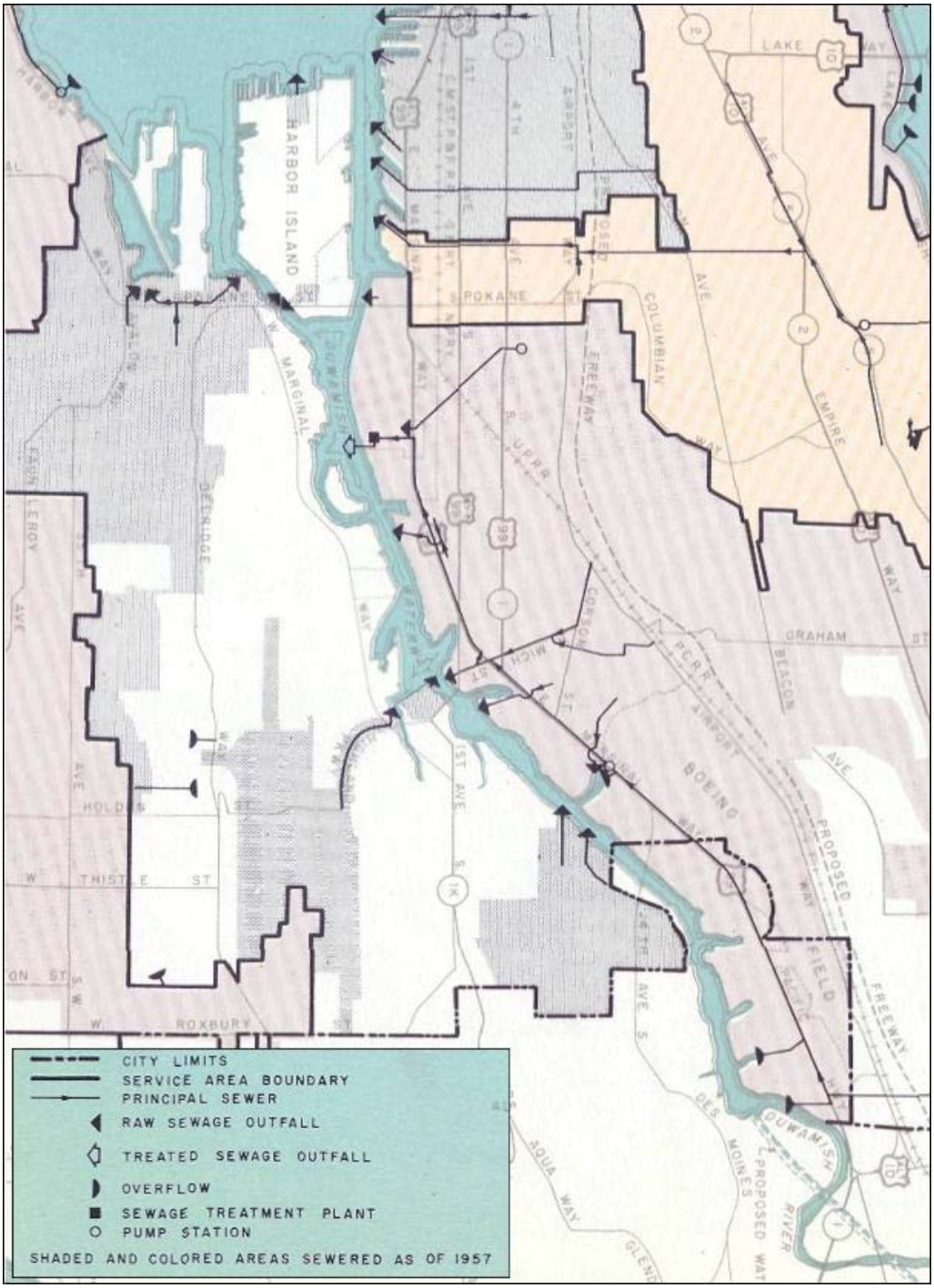
Chemical manufacturing has produced various wastes that entered the LDW through a number of pathways in the past (Sweet Edwards 1985). Used antifreeze is generally known to contain lead and cadmium, and production of adhesives, water-soluble glues, formaldehyde, and wood-preserving resins produced phenol formaldehyde and pentachlorophenol waste (SAIC 2007d). Dioxins and furans are known to be a by-product of pentachlorophenol production and fires and incineration of both chlorinated and non-chlorinated organic compounds. Copper was a waste product associated with the production of vanillin and wood preserving resins (Sweet Edwards 1985). Cement and asphalt manufacturing produced several waste products, such as cement kiln dust, which were often disposed of at casual landfill sites (Sweet Edwards 1985).

Organic wastes originating from various operations were also commonly discharged directly to the LDW in the past. Agricultural operations, slaughterhouses, meat packing facilities, and raw sewage discharges were all sources of organic wastes, including blood, manure, and grease (Foster 1945). Historical sewage discharges are discussed further in Section 9.3.2.2.

9.3.2.2 Historical sewer system discharges

Prior to the creation of Metro (now the King County Wastewater Treatment Division) in 1958, local sewer systems along the waterway discharged raw sewage directly into the LDW. These raw sewage discharges potentially contained mixed industrial wastes originating from facilities along the waterway. Although the LDW is currently served by a combination of separated, partially separated, and combined sewer systems, historically, most of the LDW area was served by a combined storm/sanitary sewer system. Some small areas in unincorporated King County along the river remain on septic systems. The extent to which industry along the river uses septic systems is unknown.

As shown on Figure 9-2, approximately seven of these combined sewer/sanitary outfalls (raw sewage outfalls) and five CSOs (overflows) discharged to the LDW in 1958. The combined sewer/sanitary outfalls discharged raw sewage, stormwater, and industrial waste streams directly to the waterway in areas not served by a wastewater treatment plant. CSOs discharged similar wastewater but only when the capacities of the treatment plants or their conveyance systems were exceeded.



Source: Brown and Caldwell (1958)

Figure 9-2. Outfalls that historically discharged raw sewage to the LDW

The Henderson-E Marginal Way S system collected stormwater runoff and municipal/industrial wastewater from approximately 5,900 ac (on the east side of the waterway and conveyed flow to the Diagonal Avenue S wastewater treatment plant (WWTP). The Diagonal Avenue S WWTP operated from 1938 until approximately 1969 when the plant was closed and flows were diverted to the West Point WTTP. In

1958, the total population served by the Diagonal Avenue S WWTP was about 30,000 (Brown and Caldwell 1958). Two of the combined raw sewer outfalls and all five of the CSOs in the LDW identified on Figure 9-2 were associated with the Henderson-E Marginal Way S system. The last sanitary sewer outfall of this system was connected to the West Point system in 1976.

In 1958, the West Seattle system served an area of about 1,950 ac located along the west side of the LDW (Brown and Caldwell 1958). At that time, none of the raw sewage, stormwater, or potential industrial waste streams from this system was treated. Four raw sewage outfalls discharged to the LDW study area and another three outfalls discharged outside the LDW in the vicinity of West Waterway (see Figure 9-2). In addition to the areas served by the West Seattle system, large areas on the west side of the river, stretching from the southern tip of Harbor Island to approximately RM 2.8, were not connected to the City of Seattle's sanitary sewer system as of 1958 (Brown and Caldwell 1958). These areas relied on onsite systems (e.g., septic tanks and drain fields) to infiltrate wastewater into the underlying soil in order to dispose of sanitary and industrial waste. However, some private systems used dry wells or directly discharged to roadside ditches or into surface water bodies (Brown and Caldwell 1958).

As mentioned previously, the first WWTP along the LDW, the Diagonal Avenue S WWTP, was built by the City of Seattle in 1938 near RM 0.6, approximately 1,200 ft south of the current location of the Diagonal Avenue S CSO/SD (Brown and Caldwell 1958). The Diagonal Avenue S WWTP provided primary treatment for sanitary wastewater, industrial waste streams, and stormwater collected from the Rainier Beach neighborhood near Lake Washington and the industrial district along E Marginal Way S from the Diagonal Avenue S WWTP south to the Upper Turning Basin (the area previously identified as the Henderson-E Marginal Way S system). Industrial facilities along the LDW were not required to redirect industrial waste discharges to this system until the early 1950s.

The Diagonal Avenue S WWTP had a design capacity of 8 million gal. per day (mgd). Regulating stations were installed in the collection system (e.g., at the present location of the Norfolk CSO/SD and the present location of the E Marginal Way S pump station in Slip 4) to keep the WWTP from overloading. In 1956, the dry weather flow to the Diagonal Avenue S WWTP ranged from 2.5 to 5.0 mgd. However, up to 90% of the wet weather flow was bypassed directly to the LDW because of limited capacity at the WWTP and the fact that the interceptor sewers were too small to convey the required flow from the trunk lines (Brown and Caldwell 1958).

The principal source of organic waste to the LDW was raw sewage that originated from industrial facilities and residential areas along the LDW (Foster 1945). This type of waste was usually routed through the City's sewer system into the Diagonal Avenue S WWTP for example; however, many of the industrial properties along the LDW were too low in elevation for effective use of the gravity fed sewer lines and raw

sewage and industrial waste streams in these locations were either stored temporarily in open ponds or discharged untreated to the LDW (Brown and Caldwell 1958).

By the late 1950s, industries that discharged wastewater (industrial or sanitary waste) to the public sewer system or directly to a nearby receiving water body were required to obtain a wastewater discharge permit from the Pollution Control Commission. At that time, 150 industries in the City of Seattle had industrial discharge permits. A sewerage and drainage survey conducted in 1957 indicated that industrial waste streams that discharged directly into the LDW without pre-treatment could potentially reach a volume of about 33,900 gal. per day (gpd). The majority of this industrial waste (63%) was associated with metal-related industries (Brown and Caldwell 1958). The study indicated that the wastes from metal-plating industries were particularly hazardous and required separate pretreatment.

In the same survey, a total of 14 industries that discharged industrial wastewater (at a rate of approximately 2,500 gpd) into networks that would be treated at the Diagonal Avenue S WWTP were also identified (Brown and Caldwell 1958). Industrial discharges that passed through the Diagonal Avenue S WWTP originated from adhesives and chemical plants, metal plating facilities, beverage bottling operations, cement handling and production, compressed gas operations, food canning, sawmill and wood-working related industries, steel plants, and truck manufacturing operations (Brown and Caldwell 1958).

In 1962, Metro assumed operation of the Diagonal Avenue S WWTP until its closure in 1969, when the Elliott Bay Interceptor (EBI) was brought on-line and flow was diverted to the West Point WWTP, which discharges treated wastewater to Puget Sound. The evolution of the wastewater permit programs required industrial properties along the waterway to upgrade their systems and interconnect with the interceptor line.

Starting in 1969, large portions of the public and private sewer lines were connected into the EBI line, and subsequent system overflows were eventually limited to the current King County and City of Seattle CSO locations (see Section 9.4.4.4). Some connections required complex infrastructure improvements; thus, raw sewage was discharged for several years after 1969, including through the Henderson/E Marginal Way S system. The raw sewage outfall into Slip 4 continued to discharge until 1976 (City of Seattle 1998).

9.3.2.3 Significant known historical spills

In 1974, a spill occurred at the GSA dock when a transformer was dropped and cracked while being loaded onto a barge in Slip 1, resulting in the release of approximately 980 L (260 gal.) of high-concentration PCB dielectric fluid (primarily Aroclor 1242) into the LDW (EPA 1975a). Two separate dredging operations were conducted to address the sediment contamination that resulted from the spill. An

initial cleanup by EPA in 1974 was estimated to recover approximately 300 L (80 gal.) of PCBs.

A second dredging attempt by EPA and the USACE in 1976 was required to recover PCBs that had spread throughout Slip 1 and into the river channel, in part because of a 20-yr flood that occurred in the winter of 1975-1976. The second cleanup involved hydraulic dredging of sediments containing PCBs in the northwest corner of Slip 1. About 38 million L (10 million gal.) of PCB-contaminated slurry was piped to settling lagoons on the Chiyoda Property (formerly the Diagonal Avenue S WWTP property and currently the location of the Port of Seattle's T-108 (Map 9-4a). Most of the slurry was deposited in one of the lagoons located closest to the LDW, while the second lagoon received overflow water from the first lagoon. Water pumped from the lagoons was filtered through a sand and charcoal filter to remove suspended particles and PCBs before discharge to the LDW. It was estimated that the second dredging removed another 640 L (170 gal.) of the 980-L (260-gal.) spill (EPA 1975a).

Two other known significant historical spills were documented in the Washington State Pollution Control Commission (WPCC) Progress reports (WPCC 1945-1957, as cited in Dexter et al. 1985)**.** Dexter et al. (1985) did not report the exact years of the spills, but both were reported to the WPCC between 1945 and 1957. The Duwamish Manufacturing Company reportedly spilled 5,000 gal. of crude oil from a valve left open on a tank (the exact date and location of the spill is unknown). The Duwamish Manufacturing Company was located near RM 3.5 W (Map 9-4c). The site was subsequently cleaned, but most of the leaking oil had already entered the LDW. Another reported incident occurred at the Duwamish/Diagonal Avenue S SD, which is located at approximately RM 0.7 E (Map 9-4a). A large amount (quantity not reported) of oil was found entering the LDW from the SD. The oil had come from the Union Pacific Railroad roundhouse where drained oil had overflowed from a sump, which was intended to prevent the oil from reaching the sewer (WPCC 1945-1957, as cited in Dexter et al. 1985).

9.3.2.4 Atmospheric sources

Historical atmospheric sources may have contributed to sediment contamination in the LDW in the past. Sources of these discharges included regional smelter facilities, fossil fuel combustion by motor vehicles and industrial facilities, cement manufacturing plants, and other industrial and urban practices. Air emissions were not commonly monitored or regulated prior to the establishment of the Clean Air Act (CAA) in the 1970s.

Regional Smelter Facilities

The LDW is located in an area that has been designated as having potential soil contamination caused by historical smelter emissions (Area-Wide Soil Contamination Task Force 2003). Two historical regional smelter facilities were potential sources to the LDW. The Asarco copper smelter operated from 1890 to 1985 in Ruston,

Washington, northwest of Tacoma. A lead smelter was also located on Harbor Island from the 1930s until 1998, though operations were greatly reduced in the mid-1980s.

Smokestack emissions from the Asarco smelter contained arsenic and lead, and were likely a historical source of these metals to the LDW (Ecology 2002c). Prevailing winds are a large factor in determining the spread of smelter emissions (Ecology 2001b); for much of the year, prevailing winds in the LDW are from the south (PSCAA 2007c) where the Asarco smelter was located. Heavy metals were distributed through atmospheric deposition to over 1,000 square miles of the Puget Sound basin from the Asarco smelter. Map 9-5 provides information on the aerial size and extent of the arsenic plume footprint from the Asarco smelter and ranges of arsenic contamination in surface soil (Ecology 2007b).

Since the closure of the Asarco smelter, Ecology and several local health departments have initiated studies to outline the extent of the plume "footprint" by testing arsenic and lead concentrations in area soils. Soil samples collected to date show that arsenic concentrations in the LDW drainage basin range from 17 to 30 mg/kg dw (Ecology 2001b). Lead concentrations ranged from 37 to 200 mg/kg dw. MTCA Method A soil cleanup levels for unrestricted land uses for arsenic and lead are 20 and 250 mg/kg dw, respectively. Soil characterization within the plume footprint is still ongoing (Ecology 2007k).

It is estimated that the Harbor Island lead smelter deposited lead through atmospheric deposition over at least 640 ac of land (Area-Wide Soil Contamination Task Force 2003). Emissions from the smelter contributed to lead contamination of the soil on Harbor Island, leading to its listing as an NPL site in 1983 (EPA 1993b). Emissions from the smelter were also likely deposited into the LDW through direct and indirect atmospheric deposition. An air monitoring station formerly located on Harbor Island was used to collect samples to analyze for lead concentrations in the air. Prior to the smelter's closure, lead was often detected in air samples at concentrations above federal standards. Quarterly average lead concentrations over 10.5 $\mu g/m^3$ were reported by PSCAA for the 1981 monitoring year (PSCAA 2006a). By 1998, all operations at the Harbor Island smelter ceased and lead concentrations in air dropped below the Quarterly Federal Standard of 1.5 $\mu g/m^3$. Air monitoring on Harbor Island was discontinued in 1999.

It is likely that both the Asarco smelter and the Harbor Island smelter contributed metals, particularly arsenic and lead, to the LDW through direct and indirect atmospheric deposition in the past. The contribution of metals to the LDW from historical smelter emissions compared with other sources has not been determined and is difficult to assess.

Historical Urban Atmospheric Sources

In addition to smelter facilities, other historical urban atmospheric sources have potentially contributed to sediment contamination in the LDW, such as wood burning,

industrial processes for heating, burning of fossil fuels including emissions from motor vehicles, power generating facilities, wood treatment, waste incineration, and cement kilns.

Air pollutants commonly associated with urban activities in the past included particulate matter (PM), metals, PAHs, PCBs, and dioxins and furans. PM and PAHs were emitted from the burning of fossil fuels such as coal and oil, used in various industrial processes and for domestic purposes such as transportation and heat. Wood burning and waste incineration were other historical practices that emitted PM, PAHs, dioxins and furans, and metals (PSCAA 2003).

In the past, large quantities of lead were emitted to the atmosphere from the use of leaded gasoline, which was used primarily from the early 1920s through the 1990s, though it was largely phased out by the mid-1970s because of health concerns (Ecology 2001b). Chromium and nickel emissions are also associated with the burning of fossil fuels (PSCAA 2006a).

Other industrial processes that were common in the LDW in the past also may have contributed air pollutants. Arsenic is often emitted to the atmosphere through wood treatment processes and distillate oil combustion, and chromium is emitted by chrome electroplaters (PSCAA 2006a). Cement kiln emissions can contain chromium, mercury, lead, and zinc, as well as dioxins and dioxin-like compounds, PCBs, and PAHs (EPA 2007f). Several of the historical atmospheric sources are still present near the LDW today, though most emissions are now registered and regulated by PSCAA and EPA.

9.3.2.5 Waste disposal, fill areas, and abandoned landfills

Source information from upland disposal or abandoned landfills sites is generally not well characterized because information on the current conditions of these sites is either largely unavailable or has not been thoroughly investigated. This section summarizes readily available information that pertains to upland waste disposal and abandoned landfills in the vicinity of the LDW.

Waste Disposal and Fill Areas

Historical waste disposal and fill areas in the LDW are discussed in Sweet Edwards (1985) (Map 9-6). The focus of this report was to identify potential sources of contamination to groundwater through the leaching of wastes from these areas. Prior to the 1970s, it was common practice for industries to store or bury waste products on their property or on nearby vacant lots. Filling of the old Duwamish River and grading of new sites along the LDW occurred from approximately 1910 until the 1960s (Sweet Edwards 1985). Potential contamination from the fill material is uncertain, because the quality and source of fill material used during this time period is undocumented and largely unknown. Fill was assumed to be primarily dredge spoils from the main channel, and fill sites were likely located near dredge sites to keep transportation costs low (Sweet Edwards 1985).

Shoreline Banks

The LDW shoreline banks were used as areas for fill and refuse disposal in the past. This practice was used to dispose of wastes and reclaim land; it is likely that the majority of the LDW shoreline was used to dispose of fill material and other wastes during construction of the waterway. Currently, bank conditions range from exposed slopes of varying grade to vertical grades with armoring with constructed steel, wood, concrete bulkheads, sheet pile walls, and riprap revetments, which reduce the potential for bank erosion in most areas. Bank soil characterization data are not available for the majority of the properties along the LDW shoreline, although data exist for some properties, such as Rhône-Poulenc, Boeing Plant 2, Jorgensen Forge, Slip 4, Industrial Container Services/Trotsky property, Douglas Management Company, T-108, and T-117. Bank soil information for several properties along the LDW is discussed in Appendix I.

With the amount of data currently available, the correlation between bank soil conditions and intertidal sediment quality is not well understood. However, it is recognized that bank soils could potentially affect sediment quality directly through erosion or indirectly through tidal exchange or groundwater interactions. Indirect effects were investigated during the seep study (see Section 9.4.6) (Windward 2004b). Bank soil, in both armored and unarmored shoreline areas, could erode and potentially affect nearshore sediment quality or groundwater quality in some areas.

Abandoned Landfills

Upland landfill disposal represents another type of waste disposal practice commonly used in the past. Prior to the establishment of municipal waste dumps, from the 1800s into the first half of the 1900s, residential and industrial solid wastes in the Seattle area were commonly dumped in low-lying and wet areas. As with the shoreline areas, waste disposal in these areas served the dual purpose of providing dumping grounds for garbage and other debris while reclaiming low-lying land, including former slips within the LDW (Map 9-6), for future development. Even after the establishment of municipal waste landfills, localized landfilling at industrial and residential properties continued along the LDW. Most of the small-scale sites associated with the historical practice of landfilling are undocumented.

Burning was a common practice for the handling of disposed wastes at private residences, industrial facilities, and at some landfills, and accidental fires sometimes occurred (Seattle-King County Department of Public Health 1984).

An unknown number of such waste sites underlie portions of the city historically comprising Elliott Bay and Duwamish tidelands. These areas were used to dispose of solid and liquid wastes and dredge spoils (Map 9-6). As a consequence, there are likely numerous smaller undocumented landfills, in addition to documented municipal landfills, that are located in the LDW drainage area.

In 1984, the Seattle-King County Department of Public Health (1984) conducted a survey of some of the larger and better-documented former landfills in the city to assess public health risks at these sites. This survey concluded that in most cases abandoned landfill sites were adequately capped and not likely to pose a direct-contact risk to people. However, the survey noted a potential for exposure to leachate that has migrated via groundwater into underground piping networks or building excavations. The survey also stated that degradation could occur at abandoned landfills through the generation of methane gas as wastes decompose.

In 1986, the department followed up with a toxicity hazard assessment of some of these landfills (Seattle-King County Department of Public Health 1986). The four landfills reviewed in the LDW drainage basin included the Judkins Park Landfill, the Sick's Stadium Landfill, the 6th Avenue S Landfill, and the South Park Landfill (Map 9-6). Surface water runoff, surface soils, and subsurface gases where assessed for the presence of chemicals that could pose a risk to public health or site workers. The study reported that no significant environmental health problems were identified at the Judkins Park and Sick's Stadium Landfills, and no further study was recommended. No conclusions or recommendations were made for the 6th Avenue S Landfill, the boundaries of which are not known, because of the limited amount of information available for that site. The assessment recommended that groundwater and stream sampling be conducted at the South Park Landfill.

King County implemented an independent remedial investigation and a quarterly groundwater monitoring program at the South Park Landfill in 1997. Long-term monitoring indicated that vinyl chloride was the only COC present in downgradient wells located approximately 2,000 ft from the LDW, but that concentrations rarely exceeded MTCA Method B surface water cleanup standards. Vinyl chloride readily degrades under aerobic conditions, and with precipitation infiltration and the tidal-mixing effect expected during transport through groundwater, it is highly unlikely that vinyl chloride from the site would reach the LDW at concentrations that could influence sediment conditions (Windward 2003c).

The South Park Landfill has been a MTCA site since 1988. An agreed order is being negotiated by the City of Seattle, King County, and South Park Property Development, a private business group that owns a portion of the former landfill, to conduct an RI/FS at the South Park Landfill (Wang 2008). The RI/FS will be conducted to delineate the nature and extent of contamination at the site; this information will be used to establish the MTCA site boundary. The RI/FS process will also determine whether additional measures beyond typical landfill closure practices are necessary at the site to confirm that the former landfill will not be a source of contamination to the LDW.

Although previous investigations of abandoned municipal landfills in the LDW drainage basin have assessed these sites for risks to public health, they have not assessed the potential for these areas to act as sources of contamination to LDW

sediments. In addition, smaller, undocumented landfill areas haven't been assessed for their potential to contribute chemicals to the LDW. The potential for abandoned landfills in the LDW drainage basin to affect sediment quality in the LDW is not known, and few data are available to assess the potential impacts from abandoned landfills (Sato 2008). Environmental investigations are ongoing at the South Park Landfill; abandoned landfill sites would need to be investigated in order to determine whether or not they are potential sources of contamination to the LDW.

9.4 SOURCE IDENTIFICATION AND CONTROL EFFORTS

The previous section discussed the sources and pathways of historical contamination that have the potential to affect the quality of the environment in the LDW. Identification of current and ongoing sources is equally important to promote the effective implementation of remediation strategies while ensuring that areas being remediated are not recontaminated after cleanup is complete. This section provides a detailed discussion of the known sources of contamination that could potentially affect sediment quality in the LDW.

This section discusses the ongoing source control work being carried out by various agencies as they implement many different regulatory programs. The various regulatory and public entities currently doing source control work in the LDW include the City of Seattle, the City of Tukwila, King County, the Port of Seattle, Ecology, and EPA. The different source control methods and tools being used by these entities to identify, characterize, and control sources include permits, enforcements, regulations, pollution prevention programs, inspection and maintenance programs, environmental investigations, pathway assessments, and cleanups.

9.4.1 Available source information

Numerous documents and resources were reviewed and evaluated during completion of the RI to help identify potential sources of contamination in the LDW. These resources included various federal, state, and local environmental databases that document a range of information including suspected site contamination, investigative status, and past cleanup activities. Agency and SCWG representatives provided clarification and additional updated information on the status of sites along the LDW, as necessary. The following section presents an overview of these various resources and the results of the review.

9.4.1.1 Historical documents and available reports

A considerable number of regional and site-specific source investigations and associated control actions have been performed in the LDW study area under a wide range of RCRA, CWA, and MTCA actions. Chemical loadings, sources, pathways, and control efforts within the LDW were initially compiled and reviewed by Metro in 1983 (Harper-Owes 1983) based on a synthesis of numerous investigations conducted from 1960 to 1982. The purpose of the study was to assess the water quality and sediment

problems in the Duwamish estuary and to determine how these problems affected the beneficial uses of the river. A more recent data compilation was prepared by King County as part of the 1999 WQA for the Duwamish River and Elliott Bay (King County 1999e). The focus of the WQA study was to assess the risks in the LDW and identify the effects of CSO discharges into the LDW and Elliott Bay on those risks.

As discussed in Section 9.2, Ecology has published a source control strategy for the LDW (Ecology 2004b). That document outlines the major components of the source control program and describes the roles of the regulatory agencies participating in the LDW SCWG. The goal of the strategy is to meet SQS and to prevent future exceedances of SMS criteria and sediment cleanup goals established in an LDW ROD.

9.4.1.2 Environmental databases

Information on upland facilities within the LDW drainage basin was collected from regulatory databases maintained by EPA, Ecology, King County, the City of Seattle, and the Puget Sound Clean Air Agency (PSCAA). Much of the information was from a database search prepared by EDR in 2006 for the LDW study area.

Tables 9-2 and 9-3 list the various regulatory databases identified in the EDR report (EDR 2006b); information provided in the databases identified in Table 9-2 is summarized in Appendix G. The documentation provided by EDR included information on numerous facilities located within several miles of the LDW study area. Databases were selected for inclusion in the RI based primarily on their potential relevance to LDW source control. Tables 9-3 and 9-4 further summarize the rationale for determining the inclusion or exclusion of database information included in Appendix G.

Table 9-3. Databases used to identify facility information on potential ongoing sources to the LDW as detailed in Appendix G

Location in Appendix G	Database	Description	Rationale for Inclusion in Report	Source
Tables G-1 through G-3	National Pollutant Discharge Elimination System Permits	Permits are issued for industrial, municipal, and large construction area discharges to surface water bodies by Ecology under the NPDES program.	Facilities discharge directly to the LDW or upriver of the LDW.	Ecology's Water Quality Permit Life Cycle database (Ecology 2007g, f; EDR 2006b)
Table G-4	King County Industrial Waste Program Permits	King County issues permits or discharge authorizations for industries discharging into its wastewater treatment system.	Facilities discharge directly to the LDW through King County and SPU CSOs.	King County (Tiffany 2006a, b)
Table G-5	Large-Quantity Generators	EPA database that tracks facilities that generate over 1,000 kg of hazardous waste or over 1 kg of acutely hazardous waste per month.	Given the volume of potential hazardous waste generated, LQGs have the potential to be a source of contamination to the LDW.	EDR (2006b) from Ecology database
Table G-6	Confirmed and Suspected Contaminated Sites List	This list is a database used by Ecology's Toxic Cleanup Program to track progress on all confirmed and suspected contaminated sites in Washington State.	Sites with toxic chemicals present or suspected to be present in various environmental media in the vicinity of the LDW.	EDR (2006b) from Ecology database
Table G-7	Leaking Underground Storage Tank; cleanup in progress	Inventory of active LUST incident reports maintained by Ecology.	LUST sites with soil and/or groundwater contamination in the vicinity of the LDW.	EDR(2006b) from Ecology database
Table G-8	Leaking Underground Storage Tank; remediation reported as complete	Inventory of inactive (remediated) LUST reports maintained by Ecology.	LUST sites may have provided a source of contamination prior to site cleanup.	EDR (2006b) from Ecology database
Table G-9	Solid Waste Facility/Landfill	Inventory of solid waste disposal facilities or landfills, both active and inactive, or open dumps that failed to meet RCRA Subtitle D Section 4004 criteria for solid waste landfills or disposal sites.	Releases of toxic waste from disposed materials at SWF/LF facilities in the vicinity of the LDW.	EDR (2006b) from Ecology SWF/LF database
Table G-10	Lists of active and inactive drycleaners	Ecology-maintained list of registered (i.e., active) and inactive drycleaners.	Drycleaners can generate hazardous waste that can contaminate groundwater and soil in the vicinity of the LDW.	EDR (2006b) from Ecology databases

LOCATION IN APPENDIX G	DATABASE	DESCRIPTION	RATIONALE FOR INCLUSION IN REPORT	SOURCE
Table G-11	Brownfields	Federal and state lists of Brownfield sites (i.e., abandoned, idle, or underused commercial or industrial properties, where expansion or redevelopment is hindered by real or perceived contamination). EPA and Ecology maintain separate lists of Brownfields sites.	Sites with toxic chemicals present in various environmental media in the vicinity of the LDW.	EDR (2006b) from EPA and Ecology databases
Table G-12	Toxics Release Inventory System	TRIS facilities are registered with EPA and identified as facilities that release toxic chemicals to the air, water, and land in reportable quantities under the Superfund Amendments and Reauthorization Act, Title III, Section 313.	Facilities with toxic chemical releases to various environmental media in the LDW surface drainage area.	EDR (2006b) from EPA database
Table G-13	PSCAA's Registered Air Emission Sources	A list of sites registered with the PSCAA as producing emissions of air pollutants.	Facilities with registered air emissions in the vicinity of the LDW.	PSCAA (Nehen 2007)
Table G-14	Ecology Spills Program[a]	Spills reported to Ecology's Environmental Report Tracking System.	Spills in the LDW drainage basin.	EDR (2006b) from Ecology database
Table G-15	Seattle Public Utilities Spill Response Program Records[a]	SPU maintains a record of hazardous material spills involving the city's infrastructure.	Spills in the LDW drainage basin.	Schmoyer (2007b)

[a] Databases include only a partial list of spill information maintained by the USCG.

CSCSL – Confirmed and Suspected Contaminated Sites List
CSO – combined sewer outfall
Ecology – Washington State Department of Ecology
EDR – Environmental Data Resources, Inc.
EPA – US Environmental Protection Agency
ERTS – Environmental Report Tracking System
LDW – Lower Duwamish Waterway
LUST – leaking underground storage tank
NPDES – National Pollutant Discharge Elimination System
PSCAA – Puget Sound Clean Air Agency
RCRA – Resource Conservation and Recovery Act
SARA – Superfund Amendments and Reauthorization Act
SD – storm drain
SPU – Seattle Public Utilities
SWF/LF – solid waste facility/landfill
TRIS – Toxics Release Inventory System
USCG – US Coast Guard
UST – underground storage tank

Table 9-4. Databases used to identify facility information on potential sources to the LDW but excluded from Appendix G

DATABASE	DESCRIPTION	RATIONALE FOR EXCLUSION FROM THE REPORT	SOURCE
Comprehensive Environmental Response, Compensation, and Liability Information System	EPA-maintained database that contains information on potentially hazardous waste sites as reported by states, local municipalities, and private entities under Section 103 of CERCLA.	Facilities with toxic chemical releases to various environmental media in the vicinity of the LDW. The seven facilities identified on this database are either included previously on other database listings or are outside the LDW drainage basin.	EDR (2006b) from EPA database
Resource Conservation and Recovery Act – treatment, storage, and disposal facilities	EPA-maintained database that provides selective information on sites that store, transport, treat, or dispose of hazardous materials as defined by RCRA.	No RCRA-TSD sites were identified within the LDW drainage basin.	EDR (2006b) from EPA database
National Priorities List	EPA's list of Superfund sites is a subset of CERCLIS that identifies priority sites for cleanup under the Superfund program.	The NPL list is a subset of CERCLIS. The three NPL listed sites included the LDW, Harbor Island, and Pacific Sound Resources (located to the west of the mouth of the West Waterway)	EDR (2006b) from EPA database
Corrective Action Sites	Database maintained by EPA that tracks hazardous waste handlers with RCRA corrective action activity.	Entries in the CORRACTS database primarily include administrative compliance issues and do not have direct implications for source control.	EDR (2006b) from EPA database
RCRA small-quantity waste generators	EPA database that tracks facilities producing between 100 and 1,000 kg of hazardous waste per month (small-quantity waste generators).	Over 1,000 facilities within the EDR search radius were identified as being RCRA SQGs. Operations and chemical use/storage at facilities with SQG classifications vary greatly; an SQG listing provides little information relevant to potential LDW source control concerns. Therefore, tabularized summation of the SQG information was not completed. Other databases were relied upon to identify potential sources of contamination. In addition, SPU business inspections, which are discussed in this section, have focused on a more in-depth assessment of small-quantity waste generators in the LDW.	EDR (2006b) from EPA database
Emergency Response Notification System	Database maintained by the National Response Center, US Coast Guard to track reported releases of oil and hazardous substances.	Ecology and SPU databases were relied upon to identify hazardous materials spills information.	EDR(2006b) from National Response Center database
Hazardous Sites List	Database maintained by Ecology listing a subset of CSCSL sites ranked by the Washington Ranking Method.	The HSL is a subset of the CSCSL; CSCSL sites within the summation area are summarized in Table G-6.	EDR (2006b) from Ecology database
Voluntary Cleanup Program sites	List of sites maintained by Ecology that tracks sites that have entered either the VCP or the Independent Remedial Action Program.	Sites listed in the VCP database that are still undergoing cleanup or investigation are also listed on the CSCSL, dry cleaners, or LUST databases, all of which are summarized in Appendix G.	EDR (2006b) from Ecology database

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS – Comprehensive Environmental Response, Compensation, and Liability Information System
CORRACTS – Corrective Action Sites
CSCSL – Confirmed and Suspected Contaminated Sites List
Ecology – Washington State Department of Ecology
EDR – Environmental Data Resources, Inc.
EPA – US Environmental Protection Agency
ERNS – Emergency Response Notification System
HSL – Hazardous Sites List
IRA – independent remedial action
LDW – Lower Duwamish Waterway
LQG – large-quantity generator
LUST – leaking underground storage tank
NPL – National Priorities List
RCRA – Resource Conservation and Recovery Act
SPU – Seattle Public Utilities
SQG – small-quantity generator
TSD – treatment, storage, and disposal
USCG – US Coast Guard
VCP – Voluntary Cleanup Program
WARM – Washington Ranking Method

Appendix G consists of lists of sites from various databases as provided in agency files. These lists are intended to provide a general indication of the scope and complexity of the source control environment of the LDW, and not to identify specific sources. The inclusion or exclusion of a facility on one of these lists does not infer that it is or is not a potential source of contamination to the LDW. In addition, none of the resource information has been independently verified beyond the citations noted, and LDWG cannot verify the completeness or the accuracy of the information.

Furthermore, much of the primary data have had varying levels of quality control and data validation, which have not generally been documented in the resource materials reviewed. Therefore, information included in Appendix G should not be relied upon as complete and factual. Additional evaluations of the data would be required in order to use the data quantitatively or as an inference to identify potential sources. In many cases, the most recent database information available for a facility is considered outdated, and likely does not represent the current status or condition of the site.

In order to focus the tabularized summation of the EDR presentation, the following geographic parameters were used to identify which property reviews were most relevant to source control in the LDW:

- Facilities located within the LDW surface drainage basin, as defined by King County and the City of Seattle (King County and SPU 2005)
- Facilities within 1 mi of the shoreline of the LDW study area
- Facilities within 1 mi upriver of the Upper Turning Basin

Facilities meeting these criteria and included in the EDR documentation are summarized in tables in Appendix G; Tables 9-3 and 9-4 summarize the types of information in each environmental database, their relevance to source control in the LDW, and the rationale for their inclusion. Listed facilities identified include those on Ecology's Confirmed and Suspected Contaminated Sites List (CSCSL), RCRA- and CERCLA-listed properties, registered Brownfield properties, and leaking underground storage tank (LUST) sites. In addition to the databases provided by EDR, business inspection programs conducted by King County and Seattle Public Utilities (SPU) also provided information about potential sources; these programs are described in Section 9.4.4.5.

9.4.1.3 Agency and Source Control Work Group information

The final source of information used to evaluate potential ongoing sources to the LDW included work products and personal communications from Ecology, the City of Seattle, King County, the Port of Seattle, PSCAA, USACE, and EPA. Information on upland sites is available in existing SCAPs, data gaps reports, property reviews, and other regulatory information sources (such as the databases listed in Table 9-3), along with direct discussions with Ecology, SCWG, and EPA representatives.

Other readily available information used to summarize the status of source control in the LDW included sediment sampling in CSO/SD systems and road rights-of-way (ROWs) conducted by the City (in conjunction with Boeing at some locations), business inspections conducted by the City and County, a street sweeping pilot program conducted by the City, atmospheric deposition and water quality sampling conducted by the County, air quality information provided by PSCAA and Ecology, and information on the sources, fate, and transport of phthalates gathered by the Sediment Phthalates Work Group (SPWG). Readily available information was reviewed, and agency personnel were contacted for additional information when necessary.

9.4.2 Atmospheric loading and assessment programs

Common air pollutants with the ongoing potential to affect LDW sediments through deposition include metals, PCBs, PAHs, dioxins and furans, and phthalates (EPA 2001; Floyd|Snider 2007a). PSCAA records show that over 200 businesses in the Duwamish Valley are registered as active sources of air pollution (listed in Appendix G) (PSCAA 2007a). Motor vehicle traffic on Interstate 5 (I-5) and local roads also produces nitrous oxide, black carbon, and other emissions through the burning of fossil fuels (PSCAA 2006a).

Air quality and atmospheric deposition information has been collected in the vicinity of the LDW by several groups, including the PSCAA, Ecology, and King County. Efforts are also underway to research the sources, transport, and fate of air pollutants and to reduce emissions through regulations and voluntary programs. Air emissions monitoring and assessment programs are discussed in Section 9.4.2.2, and emission reduction programs and additional regulations are discussed in Section 9.4.2.5.

9.4.2.1 Particulate matter

PM refers to solid particulates and liquid droplets suspended in the air. There are two size classes of PM: fine particulate matter (FPM), which refers to particles less than 2.5 μm in diameter ($PM_{2.5}$), and coarse particulate matter (CPM), which includes particles between 2.5 and 10 μm in diameter (PM_{10}) (EPA 2008a). Fine PM (less than 2.5 μm in diameter) is of primary concern in the Puget Sound region (PSCAA 2006a). Particles greater than 10 μm in diameter can be generated by grinding activities and through dust re-suspension. Although particles of this size generally do not travel great distances, they can be a potential source of some metals (e.g., copper and zinc) and other chemicals in localized areas, such as along high-traffic roadways.

FPM is generated through the burning of wood, fossil fuels, and other materials and can also be formed when pollutant gases react in the atmosphere (King County and SPU 2005; PSCAA 2006d). In the Puget Sound region, FPM is the air pollutant of greatest concern for human health (PSCAA 2006d); it can also provide a pathway for the transport of chemicals, such as metals, PCBs, dioxins and furans, phthalates, and cPAHs (Floyd|Snider 2007a, b; EPA 2001; King County and SPU 2005). At some stations, atmospheric deposition flux data for some PAHs collected by King County also showed

a correlation with FPM concentration data in the atmosphere (King County 2008b). FPM has the potential to affect sediment quality in the LDW if chemicals released to the atmosphere attach to the fine particles that are then deposited through direct or indirect atmospheric deposition to the LDW. Once in the LDW, FPM and associated chemicals have the potential to accumulate in bottom sediments. The 3-year average 98th percentile daily concentrations of FPM in the Duwamish area were approximately 34 µg/m^3 (as reported in 2001) and 29 µg/m^3 (as reported in 2005) (PSCAA 2006a).

9.4.2.2 Toxic air pollutant monitoring and assessment

Toxic air pollutants, as classified by EPA, are those that have the potential to adversely affect human health (EPA 2007a). They include PAHs, PCBs, phthalates, dioxins and furans, and several metals. Common emission sources of toxic air pollutants include industrial facilities, chemical manufacturing plants, solid waste incinerators, motor vehicles, marine vessels, trains, and wood smoke (PSCAA 2006b, c). Use of solvents, paints, degreasers, and other chemicals can also release toxic air pollutants (EPA 2007a). Ecology monitors concentrations of these pollutants at Beacon Hill in Seattle. This is done as part of EPA's national air toxics trends site network. Other temporary (1-year) monitoring studies have been conducted in Seattle, Tacoma, Spokane, and Longview. These studies characterize air emissions and identify toxic air pollutants that could pose risks to human health (PSCAA 2003). These pollutants have the potential to affect sediment quality if they migrate to the LDW through direct or indirect atmospheric deposition.

WSDOH conducted a health consultation to assess potential health risks from air pollution in the South Park and Georgetown neighborhoods of South Seattle (WSDOH 2008b). The study used a model to estimate risks to human health from air emissions from various sources, and several estimates were made using the model. Emission sources included in the model were point sources (facilities registered with PSCAA), mobile sources including motor vehicles, and wood stove emissions. Emissions from railways, aircraft, and ships were not included in the inventory because estimates of these emissions were not available.

The study concluded that on-road mobile sources (e.g., cars and trucks) posed the greatest health risks from air pollution in South Seattle. Seventy-four percent of the theoretical cancer risk from on-road sources was attributed to diesel PM (which consists of both CPM and FPM). Point sources were also found to contribute to health risks, primarily because of chromium compound emissions. Wood stove and fireplace use was also found to contribute to health risks from air pollution. The Puget Sound Air Toxics Evaluation (PSCAA 2003) also concluded that the majority of cancer risk associated with air pollutants comes from diesel exhaust. The study used both Ecology monitoring data and an analysis and comparison with modeling results from EPA's national air toxics assessment.

King County has collected two phases of atmospheric deposition data in the LDW basin to provide information for source control. Four rounds of data were collected in Phase 1

of sampling, which was conducted between January and May 2005.[145] Deposition flux values were calculated for phthalates and PAHs based on these data. Sixteen rounds of data were collected in Phase 2 of sampling, which was conducted between October 2005 and April 2007. Deposition flux values were calculated for PCB Aroclors in addition to phthalates and PAHs based on the Phase 2 data. No dioxin and furan monitoring has been conducted as part of this program (King County 2008b).

Four stations were used during Phase 1 monitoring: Beacon Hill (BW), Duwamish Valley/E Marginal Way S (CE), Georgetown (DZ), South Park Community Center (SPCC) (Map 9-7) (King County 2008b). In Phase 2, (KCIA was added, and Beacon Hill and Duwamish Valley stations were relocated (BWR and CER, respectively) to areas thought to be more representative of neighborhood-scale atmospheric conditions. The Duwamish (CE/CER), Georgetown (DZ), and South Park Community Center (SPCC) stations are most representative of the Duwamish industrial basin, the Beacon Hill (BW/BWR) station is most representative of Seattle urban-scale conditions, and the KCIA station represents a location impacted by mobile sources (fuel combustion from aircraft). Atmospheric deposition samples were collected using a passive atmospheric deposition sampler that samples for "dry" and "wet" deposition combined. Atmospheric deposition flux values indicating mass deposition/area/time were provided for each chemical. The minimum, maximum, mean, median, 25th percentile, and 75th percentile results by chemical are provided for the Duwamish industrial basin stations (CE/CER, DZ, and SPCC), the Seattle urban-scale station (BW/BWR), and the airport station (KCIA) (Table 9-5).

[145] The Phase 1 atmospheric deposition sampling was conducted primarily as a pilot study; the sampler was redesigned for the Phase 2 study. Data presented in this section are from the Phase 2 study.

Table 9-5. Summary results for King County's Phase 2 atmospheric deposition data

Chemical	Sample Count	Count of Detected Values	Detection Frequency (%)	Detected Deposition Flux Values (µg/m^2/day)						Deposition Flux Values With ND = 0[a]		
				Min	Max	Mean	Median	25TH percentile	75TH percentile	Min	Max	Mean
Duwamish Industrial Basin Stations (CE/CER, DZ, SPCC)												
PAHs												
Benzo(a)anthracene	47	38	81	0.003	0.243	0.063	0.051	0.024	0.077	0	0.243	0.051
Benzo(a)pyrene	47	29	62	0.008	0.265	0.095	0.072	0.052	0.135	0	0.265	0.059
Benzo(b)fluoranthene	47	40	85	0.010	0.317	0.119	0.103	0.082	0.154	0	0.317	0.102
Benzo(g,h,i)perylene	47	40	85	0.010	0.323	0.121	0.104	0.062	0.155	0	0.323	0.103
Benzo(k)fluoranthene	47	36	77	0.009	0.317	0.101	0.084	0.057	0.131	0	0.317	0.077
Chrysene	47	46	98	0.037	0.464	0.146	0.123	0.093	0.178	0	0.464	0.142
Dibenzo(a,h)anthracene	47	17	36	0.020	0.170	0.042	0.030	0.022	0.043	0	0.170	0.015
Indeno(1,2,3-cd)pyrene	47	34	72	0.005	0.232	0.078	0.060	0.046	0.100	0	0.232	0.056
Pyrene	47	46	98	0.088	0.831	0.241	0.192	0.136	0.271	0	0.831	0.235
Phthalates												
BEHP	47	47	100	0.261	12.240	2.940	2.255	1.396	3.609	na	na	na
BBP	47	47	100	0.163	7.007	0.950	0.599	0.299	1.063	na	na	na
Diethyl phthalate	47	42	89	0.007	0.447	0.165	0.142	0.076	0.217	0	0.447	0.147
Dimethyl phthalate	47	34	72	0.029	0.153	0.068	0.061	0.049	0.080	0	0.153	0.049
Di-n-butyl phthalate	47	39	83	0.002	0.678	0.177	0.093	0.034	0.249	0	0.678	0.147
Di-n-octyl phthalate	47	27	57	0.037	2.874	0.658	0.329	0.159	0.748	0	2.874	0.378
PCBs												
Total PCBs	30	6	20	0.014	0.065	0.039	0.042	0.019	0.039	0	0.065	0.008
Seattle Urban-Scale Stations (BW/BWR)												
PAHs												
Benzo(a)anthracene	12	6	50	0.019	0.030	0.023	0.022	0.021	0.023	0	0.030	0.011
Benzo(a)pyrene	12	5	42	0.021	0.026	0.023	0.021	0.021	0.025	0	0.026	0.009

Table 9-5, cont. Summary results for King County's Phase 2 atmospheric deposition data

Chemical	Sample Count	Count of Detected Values	Detection Frequency (%)	Detected Deposition Flux Values (µg/m^2/day)						Deposition Flux Values With ND = 0[a]		
				Min	Max	Mean	Median	25TH percentile	75TH percentile	Min	Max	Mean
Benzo(b)fluoranthene	12	10	83	0.033	0.072	0.047	0.046	0.038	0.049	0	0.072	0.039
Benzo(g,h,i)perylene	12	8	67	0.033	0.070	0.047	0.043	0.038	0.057	0	0.070	0.031
Benzo(k)fluoranthene	12	7	58	0.025	0.054	0.037	0.035	0.031	0.040	0	0.054	0.021
Chrysene	12	12	100	0.023	0.090	0.055	0.051	0.038	0.074	na	na	na
Dibenzo(a,h)anthracene	12	1	8	0.012	0.012	na	na	na	na	0	0.012	0
Indeno(1,2,3-cd)pyrene	12	5	42	0.025	0.059	0.034	0.027	0.025	0.033	0	0.059	0.014
Pyrene	12	12	100	0.035	0.157	0.090	0.086	0.073	0.110	na	na	na
Phthalates												
BEHP	12	12	100	0.955	3.479	1.640	1.457	1.151	1.993	na	na	na
BBP	12	12	100	0.193	0.980	0.498	0.495	0.271	0.686	na	na	na
Diethyl phthalate	12	11	92	0.092	0.658	0.209	0.135	0.094	0.276	0	0.658	0.191
Dimethyl phthalate	12	11	92	0.022	0.104	0.039	0.034	0.028	0.035	0	0.104	0.035
Di-n-butyl phthalate	12	7	58	0.015	0.143	0.081	0.070	0.037	0.130	0	0.143	0.047
Di-n-octyl phthalate	12	5	42	0.096	0.165	0.128	0.137	0.099	0.144	0	0.165	0.053
PCBs												
Total PCBs	8	0	0	nd	nd	nd	nd	na	na	0	0	0
KCIA												
PAHs												
Benzo(a)anthracene	16	16	100	0.185	1.473	0.928	0.976	0.679	1.180	na	na	na
Benzo(a)pyrene	16	16	100	0.234	2.225	1.324	1.419	0.947	1.691	na	na	na
Benzo(b)fluoranthene	16	16	100	0.375	3.410	2.082	2.123	1.619	2.656	na	na	na
Benzo(g,h,i)perylene	16	16	100	0.259	2.494	1.373	1.517	0.983	1.591	na	na	na
Benzo(k)fluoranthene	16	16	100	0.310	2.774	1.596	1.664	1.248	1.976	na	na	na
Chrysene	16	16	100	0.347	3.078	1.958	2.063	1.474	2.590	na	na	na
Dibenzo(a,h)anthracene	16	16	100	0.072	0.579	0.391	0.418	0.305	0.507	na	na	na
Indeno(1,2,3-cd)pyrene	16	16	100	0.228	2.149	1.228	1.312	0.879	1.521	na	na	na

Table 9-5, cont. Summary results for King County's Phase 2 atmospheric deposition data

Chemical	Sample Count	Count of Detected Values	Detection Frequency (%)	Detected Deposition Flux Values (µg/m^2/day)						Deposition Flux Values With ND = 0[a]		
				Min	Max	Mean	Median	25TH percentile	75TH percentile	Min	Max	Mean
Pyrene	16	16	100	0.574	4.652	2.712	2.814	1.891	3.440	na	na	na
Phthalates												
BEHP	16	16	100	0.268	6.144	1.719	1.512	1.159	1.941	na	na	na
BBP	16	16	100	0.187	2.913	0.843	0.585	0.257	0.922	na	na	na
Diethyl phthalate	16	15	94	0.026	0.472	0.236	0.217	0.128	0.355	0	0.472	0.221
Dimethyl phthalate	16	11	69	0.031	0.100	0.053	0.052	0.040	0.059	0	0.100	0.036
Di-n-butyl phthalate	16	14	88	0.033	0.630	0.211	0.109	0.054	0.321	0	0.630	0.185
Di-n-octyl phthalate	16	7	44	0.057	0.651	0.193	0.125	0.094	0.166	0	0.651	0.084
PCBs												
Total PCBs	10	2	20	0.043	0.045	0.044	0.044	na	na	0	0.045	0.009

Source: (King County 2008b)

[a] Calculations were performed with only detected values.

BEHP – bis(2-ethylhexyl) phthalate
BBP – butyl benzyl phthalate
KCIA – King County International Airport
na – not applicable
nd – not detected
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl

During the Phase 2 monitoring, the detection frequencies for individual PAHs ranged from 36% to 98% at the Duwamish industrial area stations, and from 8% to 100% at the Beacon Hill station, which represents urban neighborhood conditions (Table 9-5). All individual PAHs analyzed were detected in 100% of the samples from the KCIA station. The prevalence of PAHs at the KCIA station is attributed to mobile sources (i.e., aircraft) (King County 2008b). Mobile combustion sources (i.e., cars and trucks) are also thought to be important sources of PAHs at the Duwamish industrial area stations. Pyrene had the highest concentration at all three monitoring station groups. The highest pyrene flux was 0.831 $\mu g/m^2/day$ at the Duwamish industrial area stations, 0.157 $\mu g/m^2/day$ at the Beacon Hill station, and 4.652 $\mu g/m^2/day$ at the KCIA station.

The ranges of detection frequencies for phthalates were similar at all three monitoring station groups, although the minimum detection frequency was highest for the Duwamish industrial area stations (Table 9-5). BEHP and BBP were detected in 100% of samples from all three monitoring station groups. The highest BEHP and BBP fluxes were detected at the Duwamish industrial area stations (12.24 $\mu g/m^2/day$ and 7.007 $\mu g/m^2/day$, respectively).

PCBs were detected in 20% of the samples collected from the Duwamish industrial area stations and in 20% of the samples collected from the KCIA station. PCBs were not detected in any of the samples collected from the Beacon Hill station, which represents urban neighborhood conditions. MDLs for PCBs corresponded to deposition flux values that ranged from 0.011 to 0.063 $\mu g/m^2/day$. The highest detected total PCB atmospheric deposition flux result was 0.065 $\mu g/m^2/day$ and the lowest detected total PCB atmospheric deposition flux result was 0.014 $\mu g/m^2/day$ (both detected at the Duwamish industrial area stations).

The LDW atmospheric deposition flux data collected by King County were compared with data collected by EPA and Ecology from stations near the LDW, and to data collected from other areas (the Georgia Basin of British Columbia, Denmark, the greater Puget Sound area, and the Great Lakes region) by other entities (King County 2008b). A comparison of deposition flux values among studies for BBP, BEHP, PAHs, and total PCBs can be made using average values from each study (Table 9-6). In general, the results from the LDW appear to be similar to those from other urban environments; however, some differences were noted (Table 9-6). Differences in LDW deposition flux values and those from other studies are likely the result of variations in sampling methods and intervals, among other study-specific factors (King County 2008b).

Table 9-6. Average atmospheric deposition flux values for the LDW compared with those from other studies

Study or Program	Study Location	Types of Deposition Measured in Study[a]	Average Atmospheric Deposition Flux Value (µg/m^2/day)			
			BBP	BEHP	PAHs	Total PCBs
King County Lower Duwamish Waterway Passive Atmospheric Deposition Sampling	LDW (Duwamish industrial basin stations)[b, c]	wet and dry deposition	0.95[d, e]	2.94 [d, e]	0.24 (pyrene) 0.1 (benzo(a)pyrene) 0.11 (all PAHs included in study)[d, e, f]	0.037[d, e]
Environment Canada Georgia Basin/ Puget Sound Airshed study	Georgia Basin (Chilliwack station, mixed rural/urban land use)	dry deposition	0.063[g]	0.615[g]	0.063[d, g]	na
Phthalates and Nonylphenols in Roskilde Fjord	Roskilde Fjord	deposition type not reported	0.047	0.625	na	na
Washington State Department of Ecology Air Quality Program	Puget Sound Region (Beacon Hill station)[c]	dry deposition and gas phase absorption	na	na	0.207 (pyrene)[g]	na
	Puget Sound Region (Georgetown station)[c]				0.346 (pyrene)[g]	
US. EPA/ Environment Canada Integrated Atmospheric Deposition Network	Great Lakes Region (IIT/Chicago station, urban land use)	wet and dry deposition and gas phase absorption	na	na	0.085 – 0.261[g] (benzo(a)pyrene)	0.128 – 0.654[h]
New Jersey Atmospheric Deposition Network	New Jersey (Camden station, urban/industrial land use)	wet and dry deposition	na	na	0.154 (pyrene) 0.069 (benzo(a)pyrene)	0.096
	New Jersey (Jersey City station, urban/industrial land use)		na	na	0.270 (pyrene) 0.113 (benzo(a)pyrene)	0.034

Sources: King County and SPU (2005) and King County (2008b)

[a] Data from different studies are directly comparable only when the same types of atmospheric deposition were measured. The LDW passive atmospheric deposition study sampled wet and dry deposition. Some of the comparison studies did not include wet deposition, and others included measures of gas phase absorption in addition to wet and/or dry deposition. Different chemicals are deposited through different modes of deposition. As an example, studies that include gas phase sampling measure lower molecular weight PCB congeners, which are primarily deposited through gas phase absorption. Results for total PCBs from studies that include gas phase absorption measurements will generally have higher total PCB results because of the addition of lower molecular weight PCB congeners.

[b] The Duwamish industrial basin stations include the Duwamish station (CE/CER), the Georgetown station (DZ), and the South Park Community Center station (SPCC).

[c] King County and Ecology used some of the same monitoring stations (including the Georgetown and Beacon Hill stations) in their studies.

[d] Average calculations were made using only Phase 2 data because the deposition sampler design was changed between the Phase 1 and Phase 2 sampling events.

[e] Average calculations include only detected deposition flux values.

[f] Value presented for all PAHs is an average of the average deposition flux values provided for seven individual cPAHs and two additional individual PAHs (benzo(g,h,i)perylene and pyrene).

[g] This study presented results as air concentrations; the average deposition flux values were calculated using an atmospheric deposition velocity value of 0.2 cm/second.

[h] Represents a range of averages.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
EPA – US Environmental Protection Agency
IIT – Illinois Institute of Technology
LDW – Lower Duwamish Waterway
na – not available
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl

Differences in study methodology also introduce uncertainty in the comparison of LDW flux values to flux values from other studies (King County 2008b). Because the atmospheric deposition monitoring conducted in the LDW did not include gas absorption, some chemicals such as LPAHs may have been underestimated. Data collected by Environment Canada, Ecology, and EPA/ Environment Canada Integrated Atmospheric Deposition Network were reported as average air concentration values and were converted to average atmospheric deposition flux values using a deposition velocity value of 0.2 cm/s. This conversion introduces uncertainty into the comparison of values from various studies.

Results of the atmospheric deposition monitoring for the LDW basin indicate atmospheric deposition may contribute phthalates, PAHs, and PCBs to the LDW; however, the relative contribution of atmospheric deposition compared with other sources was not evaluated for the LDW. A comparison of chemical loadings from direct atmospheric deposition to loadings from other pathways was made in the study of toxic chemical loadings to Puget Sound conducted in 2007 (Hart Crowser et al.). This study used the atmospheric deposition data collected in the LDW by King County as well and data from other studies. Information provided in this study can be applied to the LDW for a general understanding of the potential for atmospheric deposition to contribute toxic pollutants to LDW sediments.

The study of toxic chemical loadings to Puget Sound reported that direct atmospheric deposition appears to be a significant pathway to Puget Sound for some chemicals (Hart Crowser et al. 2007). Loading estimates for direct atmospheric deposition were compared with loading estimates for surface water runoff; surface water runoff was identified as the pathway that transported the majority of toxic chemicals to Puget Sound. For PAHs, direct atmospheric deposition represented an equal or greater loading source than surface water runoff. For other chemicals, such as BEHP, DDT, dioxins and furans, and PCBs, direct atmospheric deposition represented a small percent (approximately 4 to 7%) of the loading estimate for the surface water runoff pathway. For metals, loading estimates from atmospheric deposition were between 5 and 35% of estimates for surface water runoff. The report acknowledged the

uncertainty associated with these loading estimates because of limited atmospheric deposition data (Hart Crowser et al. 2007).

Gas absorption may be the primary mechanism for atmospheric deposition of SVOCs, including LPAHs (Hart Crowser et al. 2007). No gas absorption rates were available for the SVOCs identified as chemicals of concern to Puget Sound. Therefore, estimates of LPAH loading via this pathway likely had a high degree of uncertainty.

King County currently has no plans for additional monitoring of atmospheric deposition in the Duwamish Valley (Tiffany 2007). The PSCAA, in coordination with Ecology and under a grant from EPA, will conduct an air toxics monitoring study at a monitoring station in the Duwamish Valley and at three stations in Tacoma (Himes 2008). Results from the study will be available in 2010. The sampling program will provide information on spatial and temporal trends in air toxics concentrations, and provide data for comparison of air toxics concentrations between cities (Seattle and Tacoma) and between local areas and national trends.

Ecology also has plans to continue air monitoring at the Beacon Hill station under the National Air Toxics program, and to conduct a deposition study in the Puget Sound in association with the Puget Sound Partnership (Williamson 2008). The deposition study began in the fall of 2008; data will be collected for approximately one year. Monitoring stations are located throughout the Puget Sound region, and all monitors are located in shoreline areas. The study is using similar sampling methods to the King County study.

9.4.2.3 Sediment Phthalates Work Group

The SPWG was a voluntary work group that included representatives from the City of Seattle, the City of Tacoma, King County, Ecology, and EPA (Ecology 2007m). The categories of information the SPWG studied were phthalate occurrence, phthalate risk and receptors, source identification, source control and treatment, and federal and state regulations relevant to phthalate contamination in sediments (Floyd|Snider 2007a). As stated in the Letter of Agreement for the work group, the goals of the SPWG were to "work together to summarize and evaluate existing information regarding phthalate sediment contamination issues, identify data gaps and provide recommendations on how to address these phthalate sediment contamination dilemmas in the short-term" and to "make recommendations for further study and describe possible frameworks to address sediment phthalate issues for the longer term" (Sediment Phthalates Work Group 2006). An additional goal of the SPWG's was to provide recommendations for preventing phthalate recontamination of the LDW after cleanup (Floyd|Snider 2007a).

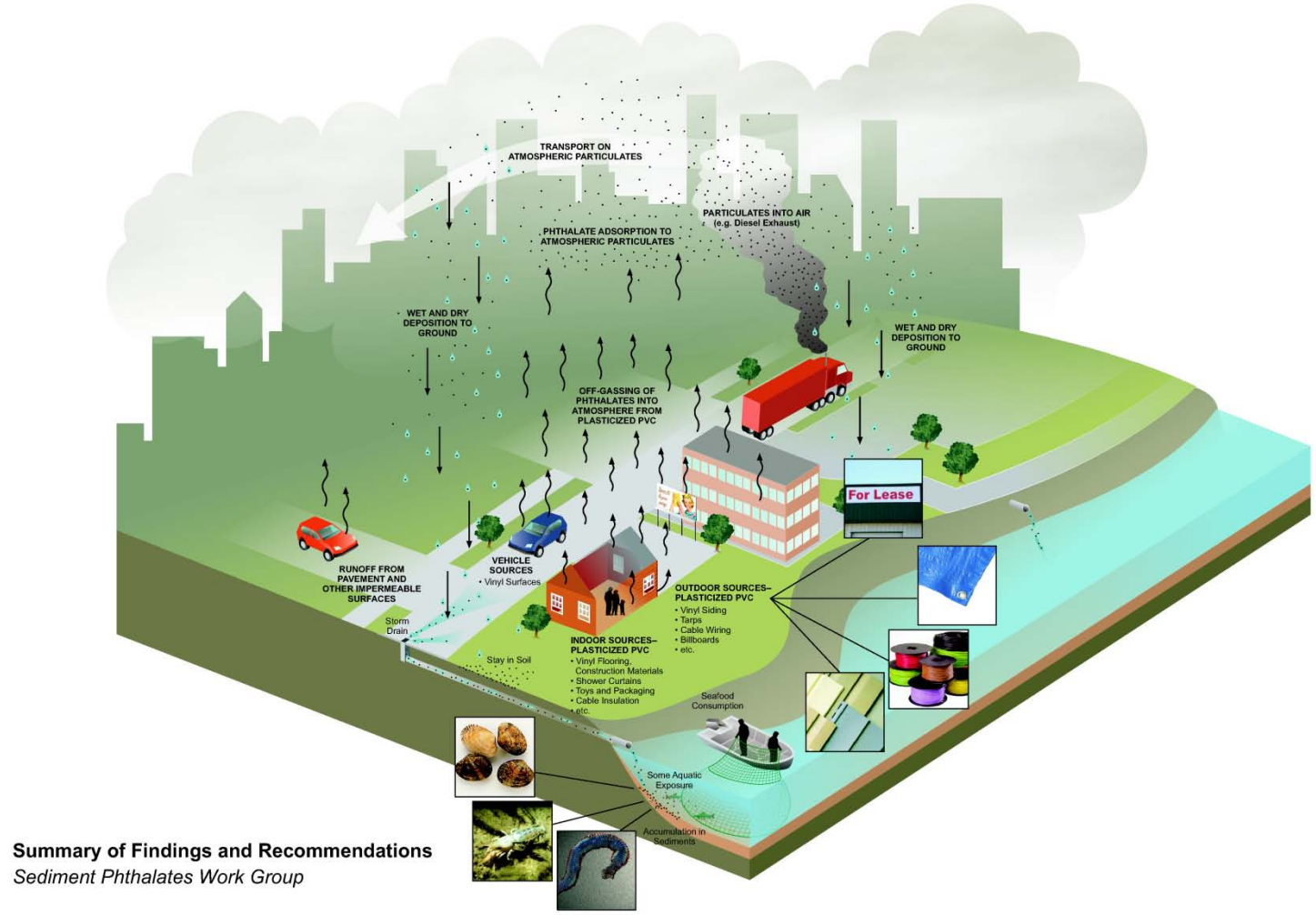
The SPWG developed a basic working model of how phthalates from non-point sources may reach the LDW sediments (Floyd|Snider 2007b). This model has not been peer-reviewed or otherwise validated. The basic premise is that phthalates initially enter the environment primarily through off-gassing from manufactured products. Once in the atmosphere, they attach to PM and are distributed to land and water surfaces. They are transported to water bodies like the LDW through stormwater runoff. Numerous

sources of phthalates exist. An earlier phthalate source sampling project conducted in 2003 identified some common products that contain phthalates (Section 9.4.2.4). The 2003 study of possible phthalate-bearing material was not comprehensive or definitive; it was simply aimed at identifying common materials with high concentrations of phthalates in hopes of finding easily controlled sources to sediments.

The SPWG concluded that phthalates are widespread in urban and other developed environments and that they are ubiquitous in water, soil, sediment and air (Floyd|Snider 2007a). Figure 9-3 presents a visual summary of the SPWG's conceptual model of how phthalates move through the environment from various sources into sediments. This figure was presented with the SPWG's recommendations and findings (Floyd|Snider 2007a).

Phthalates from non-point sources can accumulate in sediment through both direct and indirect atmospheric deposition, and atmospheric deposition has been identified as the pathway most likely contributing the majority of phthalates to sediments (Floyd|Snider 2007a). However, point sources of phthalates (i.e., direct discharges from industrial processes or wastes) may also exist. Based on its studies, the SPWG did not identify any single, large, easily controllable source of phthalates to sediments, although a few such sources have been identified in the past. For example, a facility called Janco-United, Inc., formerly located in the 4400 block of 4th Avenue S, disposed of degreasing compounds and other wastes associated with janitorial supply operations that allegedly contained phthalates. These wastes were initially discharged directly to the ground and then through an SD that discharged to the LDW; the discharges occurred for several years in the early 1980s.

The two phthalates most frequently detected in Puget Sound sediments, BEHP and BBP, are commonly attached to PM in the air. When indirect atmospheric deposition occurs, phthalates deposited on surfaces throughout an entire watershed can be carried through surface water run-off (including CSO and SD discharges) to discrete sediment areas where they then accumulate (Floyd|Snider 2007a). Although atmospheric deposition and surface water runoff are the pathways by which phthalates reach sediments, the concentrations of phthalates in these media do not generally trigger regulatory responses based on human or ecological health risks. In sediment, however, phthalates can accumulate at concentrations above sediment cleanup standards.



Source: Floyd|Snider (2007b)

Figure 9-3. Sediment Phthalates Work Group conceptual model

Build-up of phthalates in sediment can be toxic to benthic invertebrates; organisms at higher trophic levels (i.e., humans) metabolize phthalates and excrete them and do not appear to be at risk (Floyd|Snider 2007b). The SPWG concluded that phthalates in sediments presented little additional human health risk compared with other chemicals and so recommended that sediment cleanup actions not be delayed because of the potential for phthalate recontamination. The group suggested that phthalates continue to be addressed through long-term operation and maintenance programs (Floyd|Snider 2007b). Methods for reducing and controlling sources of phthalates include using substitutes for phthalates in plasticized goods, removing particulates from the atmosphere, and reducing stormwater flow runoff by increasing pervious surfaces within watersheds.

As stated in the SPWG summary of findings and recommendations report (Floyd|Snider 2007b):

> "During the 10-month process, the Work Group collected, summarized, and evaluated existing information to:
>
> - Document where phthalates are found and identify potential sources
> - Define phthalate contamination concerns within current regulations
> - Place sediment phthalate concerns in perspective with other sediment contamination risks and within the broader issue of phthalate risks from other exposure pathways
> - Identify potential source control and treatment options
> - Provide recommendations on next steps
> - Share findings with the public"

The SPWG made several recommendations (Floyd|Snider 2007b), including:

- Phthalate recontamination at sediment cleanup sites should be managed with site-specific operation and maintenance plans.
- Other contaminants that are transferred through the air to stormwater to sediment pathway should be studied in order to further validate the SPWG's understanding of this pathway and to reduce additional contaminants (beyond phthalates) that reach sediments through this pathway.

9.4.2.4 Phthalate source studies

Atmospheric deposition is one likely source of phthalate compounds to the LDW. In 2003, as part of their compliance with their CERCLA AOC for the Thea Foss/Wheeler-Osgood Waterway, the City of Tacoma conducted a phthalate source study to investigate whether phthalates in stormwater solids varied with land use and to

investigate particular materials (e.g., automotive fluids, tires, and packing peanuts) for phthalates. King County and the City of Seattle joined the effort to investigate materials for phthalates, and each entity looked at a separate set of materials for their phthalate content. The City of Tacoma analyzed automotive fluids and other automotive products and packing peanuts. The City of Seattle analyzed tires, belts, and roadway materials. King County conducted a study of air particulates and re-analyzed some of the materials the City of Tacoma had analyzed earlier (e.g., different types of fluids and brands of products). King County and City of Tacoma laboratories found high concentrations of BEHP in some automotive belts, brake pads, and tires (King County and SPU 2005). Liquid products generally contained lower concentrations of BEHP. Analytical results from product testing were reported in the City/County source control progress report from 2004 (King County and SPU 2004). The literature review suggested that some vehicle fuel products, such as diesel, contain BEHP that may be released into the atmosphere in exhaust (King County and SPU 2005, citing California Air Resources Board, 1997).

Dust samples were also collected during two sampling rounds from the roof of the Tacoma Dome as part of the phthalate source studies. The first round of sampling was conducted in May 2003 prior to roof washing, and the second round of sampling was conducted in July 2003 immediately after the roof was washed. BEHP was detected at 600 µg/ft^2 in the first round sample, and at 42 µg/ft^2 in the second round sample (King County and SPU 2004).

9.4.2.5 Air emissions reduction programs

EPA regulates air pollutants through the CAA (42 USC § 7401 et seq.), and local regulations include the Washington CAA (WAC 173-401) and PSCAA Regulations I, II, and III. PSCAA's regulations provide acceptable source impact levels (ASILs) for approximately 650 chemicals, which are used to evaluate the potential for a single emission source to impact air quality. PSCAA requires dischargers of toxic air pollutants to use best available control technology (BACT), described in their regulations, to minimize emissions of these chemicals and protect human health. Currently the Puget Sound region is in compliance with federal air quality standards (PSCAA 2007b). Except for FPM and ozone, concentrations of criteria air pollutants in Puget Sound have been in compliance with regulatory standards for nearly a decade (PSCAA 2006a).

Current regulations on air quality are generally based on protecting human health and may not be adequate to address source control concerns associated with atmospheric deposition. Several local groups have initiated emissions reduction programs that go beyond regulatory requirements to further control the release of atmospheric pollutants.

The Port of Seattle is helping to lead the Puget Sound Maritime Air Forum (PSMAF), an organization of private and public entities with regulatory responsibilities related to air emissions. The PSMAF is working to identify, quantify, and reduce maritime sources of

air pollutants (PSMAF 2007). The primary goals of the forum are to ensure that the Georgia Basin-Puget Sound area continues to meet ambient air quality standards and to reduce port-related air quality impacts on human health and climate change (PSMAF 2007). Through the use of cleaner burning fuels, cleaner engines, and other technology, PSMAF is working to reduce FPM emitted by ships at berth by 70% by 2010. The group is also working to reduce emissions from trucks, trains, and other harbor craft used in Port activities. A reduction in fuel-burning emissions would result in a reduction in air pollutant loading, and a reduction in FPM could also potentially result in a reduction in transport of chemicals such as metals, phthalates, and PAHs to LDW sediments through direct and indirect atmospheric deposition.

The PSMAF has completed an air emissions inventory to identify air pollutants originating from diesel equipment used in maritime operations in the Puget Sound region (Starcrest Consulting Group 2007). PM and VOCs were two types of pollutants included in the inventory. The emissions inventory estimated that 1,270 tons per year (tpy) of VOCs are emitted from maritime sources, while 19,200 tpy are emitted from non-maritime sources; 220 tpy FPM are emitted through maritime emissions, while 3,600 tpy are emitted from non-maritime emissions; and 170 tpy diesel particulate matter (a type of FPM) are emitted through maritime emissions, while 260 tpy are emitted through non-maritime emissions (Starcrest Consulting Group 2007). Data provided in the inventory will be used to prioritize pollution reduction efforts.

The PSMAF is part of PSCAA's Diesel Solutions Program, which was initiated in 2001. The program works to reduce diesel emissions from numerous sources, including the construction industry, railways, and transit vehicles (PSCAA 2007b). Reducing diesel emissions will reduce FPM and can play a role in the reduction of other air pollutants that are transported through the atmosphere when they adsorb to FPM.

9.4.3 Surface water inputs

The Green/Duwamish River drainage area is approximately 1,466 km^2 (566 mi^2) and is part of WRIA 9 (Kerwin and Nelson 2000). According to information on WRIA 9, the Green/Duwamish River flows through four subwatersheds: the upper Green River, the middle Green River, the lower Green River, and the Duwamish Estuary (Map 2-2). The LDW is located within the Duwamish Estuary subwatershed. The flow of water to the LDW from upriver provides a potential source of chemicals to the study area. Upstream data are presented in Section 7.

Tributary creeks within the LDW drainage basin and direct surface water runoff are also potential sources of chemical inputs to the system. Two main creeks within the Duwamish River Estuary subwatershed, Puget Creek and Hamm Creek, drain into the LDW. The following sections discuss the potential upriver sources, tributary inputs, and direct surface water runoff to the LDW.

9.4.3.1 Upper Duwamish/Green River

Both historical and current land use practices in the Green/Duwamish River watershed provide the potential for pollutants to enter the river upstream of the LDW study area. These potential upstream sources include:

- Fecal coliform bacteria from human sewage discharges and animal wastes (both domestic and wild) (Herrera 2006)
- Pesticide and fertilizer runoff from agricultural operations
- Chemicals from various sources, including but not limited to roadways, industrial and commercial facilities, and surface water runoff from mining operations
- Chemicals deposited by atmospheric deposition
- Contaminated sediment from logging and sawmill operations and urban development throughout the watershed

Historically, the Duwamish/Green River watershed consisted almost entirely of forests, wetlands, and floodplain sloughs (Collins and Sheikh 2005). With the arrival of settlers, towns and agricultural operations were established throughout the river valley in the mid 1800s (Sato 1997; King County 2005k). Logging, sawmill, and mining operations were scattered throughout the Green River watershed, particularly in the upper and middle Green Rivers. Meat packing industries were located along the middle Green River, and manure, blood, and floor washings were often discharged directly into the river (Foster 1945). Sedimentation from logging and mining operations, as well as human sewage, dairy farm drainage, and household garbage were also sources of contamination to the Green/Duwamish River (Collins and Sheikh 2005; Foster 1945).

Mines and mining towns, including the town of Black Diamond, the Royal Reward Mine, and the St. Helens mining district, were established in the upper and middle Green River watersheds. Though most of these mines are either no longer in use or are mined only to a limited degree, mine drainage containing copper, arsenic, mercury, and iron may enter tributaries to the Green River and still has the potential to contaminate water and sediment in the Green River (Ecology 2002b).

The upper Green River watershed is protected under a watershed management plan as the drinking water supply for the City of Tacoma (Tacoma Water 2007); forestry remains the primary land use in this watershed (King County 2004a). In the middle Green River watershed, major land uses include forested land (approximately 27%), residential land (approximately 50%), and agricultural land (approximately 12%) (King County 2005k). In the lower Green River watershed, expansive urban development has been the most significant land use change from historical conditions, with approximately 50% of the land now residential, and 27% of the land developed for commercial and industrial use (King County 2005k). Agriculture, mixed land use, and park areas make up the remainder of the lower Green River watershed.

Although the upper and middle Green Rivers generally have good water quality, the lower Green River frequently exceeded Class A standards[146] for water quality (temperature, dissolved oxygen, and fecal coliform bacteria) (Washington Environmental Hearings Office 1996). Mercury had previously exceeded WQS for the Lower Green River but currently meets Category 2 standards; the Duwamish River currently meets Category 1 standards. Water bodies listed in Category 1 meet all of the tested standards, and water bodies listed in Category 2 are waters of concern.

Water bodies are listed under Category 5 if Ecology has data indicating that WQS have been violated, and there is no TMDL or pollution control plan. Water bodies in this category require TMDLs and are placed on the 303(d) list. The lower Green River and the LDW have been placed on Ecology's biannual Category 5 list under Section 303(d) of the federal CWA for fecal coliform bacteria, dissolved oxygen, and temperature (Ecology 2008e).

In 2003, King County conducted a WQA of the Green and Duwamish Rivers (Herrera 2005). The study spanned the area from the Howard Hanson Dam in the upper Green River watershed to the mouth of the Duwamish River at Elliott Bay, and included locations in the main river system and in selected tributaries. One sampling station was located in the upper Green River subwatershed, nine were located in the middle Green River subwatershed, six were located in the lower Green River subwatershed, one was located at the lower Green River/Duwamish River boundary, and one was located in the Duwamish River Estuary subwatershed. This assessment included analyses of nutrients, metals, and organic analytes (Herrera 2005).

Total and dissolved concentrations of arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc in the Green River watershed were compared with Washington State WQS for freshwater (Herrera 2005). Only mercury and zinc concentrations were above state standards at some stations. Of the 86 samples collected during base flow, the concentration of dissolved mercury was above the chronic standard in one sample each from the Duwamish River subwatershed and the lower Green River subwatershed. The concentration of dissolved mercury was less than the standard during storm flow at all sampling locations. Of the 58 samples analyzed for dissolved zinc, the concentration of zinc was above acute WQS in one storm-flow event sample from the Mill/Springbrook Creek (tributary entering at the lower Green River/Duwamish River boundary) (Herrera 2005). The concentration of dissolved zinc was less than the standard during base flow at all sampling locations.

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[146] The Washington 1997 WQS used a class-based system that separated each water body into a specific "class" depending on the beneficial use of that water body (EPA 2006a). The four classes in the system are Class AA, Class A, Class B, and Lake Class. Class A standards are protective of salmon and trout spawning and non-core rearing and migration (EPA 2006b). The Washington 1997 WQS were revised in 2003 and no longer consist of a class-based system.

During this study, aluminum, dissolved arsenic, cadmium, chromium, lead, mercury, dissolved nickel, and zinc concentrations did not vary significantly among upriver and downstream locations (Herrera 2005). Concentrations of total arsenic were statistically higher in downstream locations relative to upriver locations within the Green-Duwamish system. Dissolved copper and total nickel concentrations also increased significantly with distance downstream during storm flow conditions, but not during base flow conditions; the increased copper and nickel concentrations remained below applicable WQS (Herrera 2005). Although not reported as part of the 2003 WQA, a previous water quality investigation conducted in the Green/Duwamish River system between 2001 and 2002 had indicated a trend of increasing total aluminum, copper, lead, and zinc concentrations with distance downstream, and decreasing dissolved aluminum concentrations with distance downstream during storm flow conditions (Herrera 2005).

Nutrient and metal samples were collected using autosequential and autocomposite methods and occasionally as grab samples. Samples analyzed for organic compounds were collected only as grab samples, and therefore, less information is available compared with metals and nutrients (Herrera 2005). Organic compounds analyzed included PCB Aroclors, SVOCs (including PAHs and phthalates), VOCs, organophosphate pesticides, and chlorinated herbicides. VOCs and PCB Aroclors were never detected; however, the detection limits for PCB Aroclors were noted to be greater than the Washington State chronic WQS for freshwater for total PCBs (detection limits ranged from 0.04 to 0.06 µg/L, whereas the chronic freshwater quality standard is 0.014 µg/L).

Phenol was detected at low concentrations (less than 0.09 to 0.67 µg/L) at all sampling locations except for one location in the lower Green River where phenol was not detected. Phthalates and many PAHs were rarely detected; detection limits were not identified in source documentation. Multiple PAHs were detected in at least three samples from the Black River (a tributary that enters at the lower Green River/Duwamish River boundary). Organophosphate pesticides were not detected, though the detection limits were greater than the Washington State chronic WQS for freshwater for some pesticides (detection limits for organophosphate pesticides ranged from 0.29 to 0.52 µg/L). Of the chlorinated herbicides, atrazine was detected in one sample (0.98 µg/L in a storm flow sample) from Newaukum Creek (a tributary to the middle Green River), 2,4-D was detected in two samples from Springbrook Creek, a tributary to the lower Green River (0.1 µg/L in base flow and 0.37 µg/L in a storm flow sample) and in two samples from Newaukum Creek (0.08 µg/L and 0.19 µg/L in a storm flow sample), and dichlorprop was detected in one sample from Newaukum Creek (detection limits for chlorinated herbicides ranged from 0.015 to 0.046 µg/L) (Herrera 2005).

Water quality index scores for the Green River decreased from upriver to downstream, and concentrations of most analytes increased from upriver to downriver (Herrera 2005). The water quality index is a number intended to rank the water quality in certain

areas. A higher water quality index score indicates better water quality (Herrera 2005). Water quality index scores were calculated for each of the Green/Duwamish River tributaries. Many of the tributaries were ranked as being of high concern for water quality, primarily because of high total nitrogen, total phosphorus, and fecal coliform bacteria concentrations, and because of low dissolved oxygen concentrations. Urban, residential, and agricultural land uses in the drainage basins of these creeks and streams were directly associated with the reduced water quality index scores (Herrera 2005). The water quality index at the Duwamish River Estuary subwatershed sampling station (Hamm Creek) was ranked as being of moderate concern.

King County performed water quality statistical and pollutant loading analyses on the data collected in 2002 and 2003. The loading analyses were used to derive correlations between constituent loadings and land use patterns in the Green River drainage basin (Herrera 2007). The loading analyses showed a correlation between agricultural land use and copper loading. Forested lands were not correlated with metals loading during base flow conditions but storm events could influence metals loading within those areas. The loading analyses also indicated that there was a correlation between the presence of roads and impervious surfaces and zinc and fecal coliform bacteria loading. Commercial areas were positively correlated with metals loading. Loading from low-density residential areas was highly variable, but negatively correlated with metals loading. Within the developed basins, metals loading was correlated with storm water. In general, the ratio of median storm-to-base flow concentrations of metals was greater than or equal to 1, but the ratios for dissolved metals were particularly high in Hamm Creek (4.5 for copper, 5.0 for mercury, and 4.0 for zinc) (Herrera 2007).

9.4.3.2 Creeks

Hamm Creek and Puget Creek are two significant open-channel systems that discharge to the LDW (Map 2-1). The creeks drain upland areas and have the potential to provide a pathway for chemicals to reach the LDW.

Puget Creek is a surface water body that drains primarily residential land, along with a small amount of commercial land (the Seattle Community College campus). The creek includes three convergent forks. The Puget Creek natural drainage area is approximately 294 ac; however, additional stormwater conveyances (e.g., ditches) increase the drainage area to approximately 430 ac (Rheaume 2007). There is generally year-round base flow to the north of Brandon Street, but the upper reaches are typically seasonal (Rheaume 2007). The creek primarily drains runoff from the surrounding residential neighborhood before it enters the SD system at W Marginal Way SW and flows into the LDW near T-105. Of the five risk driver chemicals discussed in Section 4 in more detail, only PCBs had sediment concentrations exceeding SMS criteria near the mouth of Puget Creek. The concentration of PCBs in surface sediment exceeded the SQS, but not the CSL, in at least one sample. No other exceedances of SMS criteria were detected.

Hamm Creek is a seasonal tributary to the LDW and has four forks: the north fork, the south fork, the middle fork, and the lost fork. Historically, the creek meandered through an intertidal marsh before discharging to the LDW. However, the creek was eventually connected to a piped system, which discharges to the LDW near S 96th St. The middle fork converges with the north fork near S 96th Street, west of Highway 99 and continues to discharge to the LDW via the S 96th Street storm drain outfall. In 2000, King County completed a habitat restoration project which rerouted the south fork to the waterway through a newly constructed stream channel (NOAA 2009a). The lost fork does not appear on maps in the RI because it is largely a piped system. In addition, Ecology determined that the lost fork of Hamm Creek is actually Durham Creek (Wood 2007). Durham Creek discharges to the waterway via the City's 7th Ave S storm drain outfall.

All four forks together drain approximately 1,408 ac (Kerwin and Nelson 2000) of residential, commercial, and industrial land. The north fork basin is more industrialized than the basin drained by the south fork (Herrera 2005). Hamm Creek flows through urban residential and portions of the West Duwamish Greenbelt before discharging to the LDW at approximately RM 4.2 (Kerwin and Nelson 2000).

The Hamm Creek drainage basin (including all of the forks mentioned above) is primarily residential (850 ac), with 316 ac of open space, including both the Rainier Golf and Country Club and Glen Acres Golf and Country Club. Open space is also occupied by public ROWs and some second-growth forest. The lower portions of the creek are heavily impacted commercial and industrial areas (242 ac). Water quality in all three forks of Hamm Creek has shown evidence of degradation (Kerwin and Nelson 2000). During base flow conditions, elevated pH values have been reported. These pH values are thought to be related to a cement kiln dust pile near S 96th Street and 10th Avenue (Kerwin and Nelson 2000). None of the chemicals analyzed in surface sediment near the mouth of Hamm Creek exceeded the SQS.

9.4.4 Direct discharge system information

This section presents an overview of direct discharges to the LDW, including permit requirements, management, and site-specific data. For the purposes of this report, direct discharge systems are defined as those that enter the LDW via a distinct pipe or outfall. In general, direct discharge systems include municipal or other publicly owned storm drain systems, municipal sanitary and combined sewer systems, and privately owned and managed storm drain systems. The main classifications of direct discharges include CSOs, EOFs, and public and private SDs.

In the area of the LDW, these discharge systems transport stormwater collected from industrial, commercial, and residential neighborhoods. These discharge systems also have the potential to transport treated wastewaters (from private industrial pre-treatment systems) and raw sewage during heavy rainfall events.

In May 2003, SPU conducted a low-tide outfall survey for the LDW study area to locate, inspect, and collect data on the horizontal and approximate vertical locations of

apparent outfalls in the LDW. No attempt was made, however, to verify whether each and every pipe observed during the survey was in fact an active outfall. For example, some identified outfall locations have later been determined to be former water intake or pressure relief pipes and not outfalls. The survey also collected information on the size and composition of the outfall piping and estimated the rate of the flow (in gpm) exiting the pipe at the time of the survey, when feasible. The survey area included the east and west shorelines of the LDW from the south end of Harbor Island to approximately RM 5.0 (near the Norfolk CSO/SD) (Herrera 2004a).

For completion of the RI, the most up-to-date and readily available outfall-specific information was synthesized, including information on discharges identified in the Phase 1 RI, the 2003 outfall survey, and updated outfall information from Ecology, EPA, City of Seattle, City of Tukwila, Boeing, Port of Seattle, and King County records. Through this effort, 244 individual outfalls were identified within the LDW study area. To assist in this effort, Boeing also conducted an internal records review to further evaluate the current status and ownership of the outfalls on their properties along the LDW. Boeing completed an in-field inspection of the shoreline along Boeing Plant 2 to identify and confirm outfall locations noted in the 2003 survey. During this effort, Boeing identified additional outfall locations that had not been reported in the 2003 survey and noted other locations that were either abandoned or improperly classified as outfalls by Herrera (2004a).

Based on this information, the current status, use, and ownership of the outfalls discharging to the LDW were identified. These outfalls were identified and categorized using the classification nomenclature presented in Table 9-7. Maps 9-8a through 9-8f present the identified outfall locations, their classification, and ownership status. Detailed outfall-specific information is included in Appendix H.

Improvements and upgrades to stormwater networks and outfalls is a continuous process in the LDW basin. The outfall information discussed in this section and in Appendix H represents the best knowledge available from the resource documentation cited at the time that the outfall survey was conducted and reviewed. Some discrepancies exist between the outfall information from the LDW outfall survey and outfall information discussed in Ecology's SCAPs and data gaps reports. These discrepancies are generally the result of recent changes in outfall configuration or differences in the source documentation used to generate the information. Discrepancies between the LDW outfall survey and outfall information provided in SCAPs and data gaps reports for several of the SCAs are discussed in Appendix I.

Table 9-7. Outfall nomenclature and descriptions

NOMENCLATURE	DESCRIPTION
CSO	Overflow point on a publicly owned and maintained combined sewer system. Combined sewers convey both wastewater (residential and industrial) and stormwater runoff. Overflows generally occur only during large storm events when the capacity of the combined sewer is exceeded and not all flow can be successfully conveyed to a treatment plant. Under these conditions, excess flow is discharged to a nearby receiving water body to prevent sewage backups.
EOF[a]	Overflow point on a combined or sanitary sewer, generally located at a pump station. Discharges are not storm related. Overflows occur as a result of mechanical failure, pipe obstruction, or power failure. Pump stations in LDW are equipped with backup generators.
CSO/SD or EOF/SD	Shared outfall that serves as both a combined sewer overflow or emergency overflow and storm drain system.
Public storm drain	Storm drains that are required to have coverage under an NPDES municipal stormwater permit (i.e., City of Seattle, King County, Port of Seattle, and WSDOT).
Private storm drain	Storm drains that collect storm and surface waters from areas in addition to those mentioned above. Discharges from these facilities may be covered under the general industrial NPDES permit, individual stormwater permits, or other site-specific requirements governing discharge to surface water bodies.
Stream, channel, or swale	Locations of open-air, convergent discharges into the waterway.
Abandoned outfall	Outfalls that are plugged or have existing documentation to show that the upland pipe has been disconnected.
Not an outfall	Location previously identified as an outfall in the 2003 survey; subsequent in-field investigation or identification of historical information led to a determination that the location was not an outfall (e.g., water intake or pressure release pipes).
Pipe of unresolved origin and/or use	Pipe identified as an outfall by Herrera (2004a) but with an undetermined origin and/or use.

[a] This designation is also used to identify an overflow feature from a reservoir, as appropriate. Reservoir overflows are not associated with discharges from the combined or sanitary sewer system.

CSO – combined sewer overflow
EOF – emergency overflow
LDW – Lower Duwamish Waterway
NPDES – National Pollutant Discharge Elimination System
SD – storm drain
WSDOT – Washington State Department of Transportation

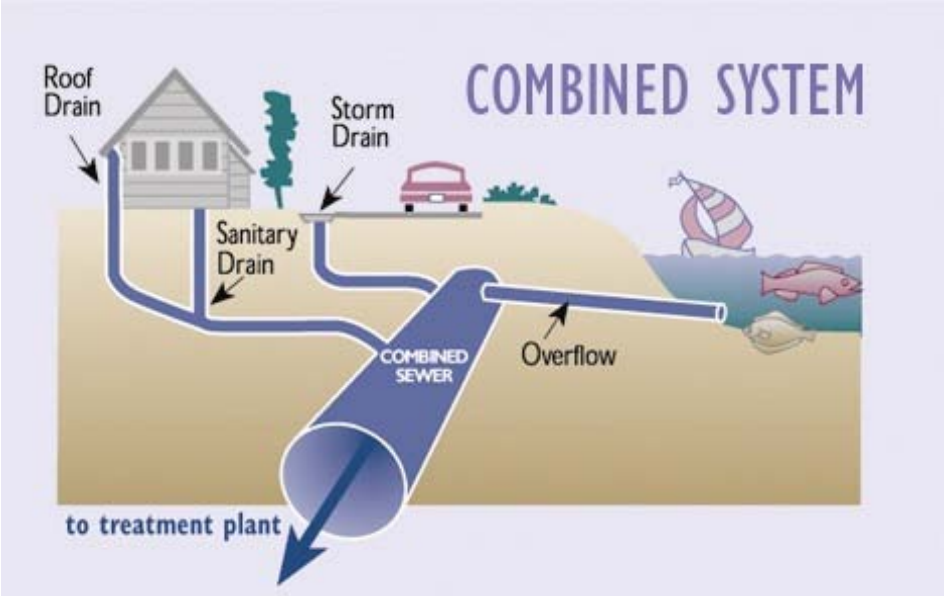
9.4.4.1 Combined sewer overflows and emergency overflows

Discharges from CSOs occur during rainfall events when the CSO system capacity is insufficient to transport the volume of both sanitary wastewater and stormwater flows. When this capacity is exceeded, excess flow is discharged to the LDW through an overflow structure (Figure 9-4). This flow can consist of a combination of untreated residential and industrial wastewater and stormwater runoff. CSOs are a recognized source of water pollution as a result of temporary increases in bacterial counts in the LDW, aesthetic degradation of the shoreline, and public health concerns in areas where human contact with the discharged water is possible.

An EOF is a discharge that can occur from either the combined or sanitary sewer systems that is not necessarily related to storm conditions and/or system capacity limitations. EOF discharges typically occur as a result of mechanical issues (e.g., pump station failures) or when transport lines are blocked. Pressure relief points are provided

in the network to discharge flow under emergency conditions to prevent sewer backups. Pump stations are operated by both the City of Seattle and King County.

The total area of the combined CSO/SD basin for the LDW is 28,700 ac (Schmoyer 2009b). The City of Seattle and King County can potentially discharge combined untreated residential and industrial wastewater and stormwater runoff through CSOs to the LDW study area during these storm events. The City of Seattle owns and operates the local sanitary sewer collectors and trunk lines, while King County owns and operates the larger interceptor lines that transport flow from the local systems to the West Point WWTP.



Source: King County (2006a)

Figure 9-4. Schematic diagram of CSO system

Infrastructure improvements have greatly improved system storage capacity and reduced the number of discharges from the combined sewer systems (those that may include contributions of stormwater, sewage, and industrial waste streams). These combined systems are still in operation in some areas adjacent to the LDW, but their existence is very limited.

9.4.4.2 Storm drain systems

The LDW study area is also served by a combination of public and private storm drain systems. Many of the privately owned storm drain systems interconnect with public systems (including the combined sewer systems) before discharging to the LDW. In some cases, primarily for properties adjacent to the waterfront, private storm drain networks discharge directly to the LDW. The City of Seattle and King County have general knowledge of the location of these remaining systems; infrastructure upgrades are ongoing. The majority of the current volume of sanitary wastewater within the LDW basin is routed via public and private systems to the West Point WWTP.

For the purpose of this document, a public storm drain is defined as any system that is required to have coverage under a National Pollutant Discharge Elimination System (NPDES) municipal stormwater permit (i.e., systems owned and operated by the City of Seattle, Port of Seattle, King County, and the Washington State Department of Transportation [WSDOT]). All other drainage systems are classified as private.

During periods of rainfall, urban stormwater runoff may enter the LDW directly from roadways or properties adjacent to the waterway (i.e., direct stormwater runoff) or through these storm drain systems. Urban areas have the potential to accumulate particulate materials, dust, oil, asphalt, rust, rubber, metals, pesticides, detergents, and other chemicals resulting from urban activities. Chemicals present on pervious and impervious surfaces (e.g., roadways, parking lots, residential yards, industrial yard areas) can then be flushed into storm drains during wet weather and transported to the LDW in dissolved or particulate form. These drainage networks also provide a pathway for spills and leaks to reach the LDW.

An estimated 8,936 ac of land drain to the LDW via storm drains. Land use in the basin is summarized in Table 9-8. Table 9-9 presents LDW basin statistics based on geographic area and system ownership. Recent analyses by the City of Seattle and King County estimated approximately 4,000 mgy in discharges (including flow from Hamm and Puget Creeks) into the LDW through the storm drain and natural drainage networks (SPU 2008).

Table 9-8. Land use in the LDW drainage basin

Land Use	Area (ac)	Percentage of Total Area
Commercial	529.0	5.9
Industrial	2,580.6	28.9
Multi-family residential	255.7	2.9
Schools	170.2	1.9
Parks, open space	1,306.7	14.6
Single family residential	1,773.8	19.8
Right-of-way	2,320.0	26.0
Total	**8,936**	**100.0**

Source: Schmoyer (2008d)
LDW – Lower Duwamish Waterway

Table 9-9. Relative size of sub-basin discharges to the LDW

SUB-BASIN	AREA (ac)	PERCENTAGE OF TOTAL AREA
City of Seattle municipal storm drain system	5,458	61
Public storm drains outside of City of Seattle[a]	1,865	21
Other storm drain systems and waterfront discharges within the Seattle city limits[b]	1,108	12
Private storm drain systems and waterfront discharges outside of Seattle city limits[c]	505	6
Totals	**8,936**	**100**

Source: Schmoyer (2008d)

[a] Includes storm drains owned and operated by the City of Tukwila and other public drainage networks in unincorporated King County.

[b] Storm drains located within Seattle that do not connect to the City of Seattle's municipal storm drain network (including systems owned by King County, the Port of Seattle, and other private owners along the LDW.

[c] Storm drains outside Seattle serving areas immediately adjacent to the waterfront, owned and operated by waterfront property owners.

LDW – Lower Duwamish Waterway

Annual stormwater discharge volumes are usually substantially higher than annual CSO discharge volumes because storm drains discharge whenever it rains, and CSOs only discharge during larger storm events. Annual stormwater discharges to the LDW have been estimated at approximately 4,000 mgy compared with less than 65 mgy historically from the county CSOs and less than 10 mgy from the city CSOs (Huber 2002; Schmoyer 2002; SPU 2007).

Private storm drain systems usually support smaller drainage basins (often less than 5 ac. In the LDW drainage basin, these smaller areas are usually immediately adjacent to the LDW and are located primarily on commercial and industrial use properties. An estimated 1,613- ac discharge to the LDW through these private systems associated with industrial facilities. In contrast, Seattle's municipal system drains about 5, 458 ac, and the publicly managed system outside of Seattle's basin (including the Hamm Creek drainage and the City of Tukwila's network) drains approximately 1,865 ac (SPU 2007).

9.4.4.3 Discharge permit programs

Wastewater and stormwater discharges from industrial facilities, public systems, and construction sites are each potential sources of contamination to the LDW. In general, discharge permit programs have been established by federal and state governments to help reduce the impact to water quality from these types of discharges. Both the state NPDES program and King County's Industrial Waste Program (IWP) regulate discharges to the LDW. Wastewater discharges are regulated by the NPDES and IWP programs; the NPDES program also regulates stormwater discharges from municipal separated storm drains, industrial sites, and construction sites. The following section discusses these various permit programs and how they apply to discharges to the LDW.

NPDES Programs

The NPDES program was established in 1972 under Section 402 of the CWA and requires a permit to discharge chemicals from any point source into waters of the United States. The NPDES program is administered by Ecology and regulates both wastewater and stormwater discharges to surface waters. Toxic chemicals, such as metals and man-made organics, as well as conventional parameters (5-day biological oxygen demand [BOD], TSS, pH, fecal coliform bacteria, and oil and grease) may be regulated under NPDES permits. Non-conventional parameters, including ammonia, phosphorus, chemical oxygen demand, and toxicity may also be regulated under the NPDES program (EPA 2002b).

There are two basic types of NPDES permits issued: individual and general. Facilities with similar operations, wastes, effluent limits, or monitoring requirements can be covered under general permits (EPA 2002b). Facilities with the same stormwater point source can also be covered under a general permit. NPDES general industrial stormwater permits, which are by far the most common, currently set limits for only a few parameters and chemicals (e.g., turbidity, pH, oil and grease, copper, and zinc). Under the CWA, all NPDES permits are issued for 5-year terms, and applications for renewal/reissuance are required not less than 180 days prior to the expiration of the current permit. NPDES-permitted discharges to the LDW include municipal stormwater (Phase 1 and Phase 2 municipal permits), general industrial stormwater, construction projects, boatyards, shipyards, CSOs, individual industrial wastewater (e.g., LaFarge, Seattle Iron and Metals), and sand and gravel operations.

King County and City of Seattle CSO discharges are permitted under individual NPDES permits. All King County CSOs located in the LDW are covered under the West Point WWTP permit (NPDES No. WA-002918-1) (Ecology 2005b). The City of Seattle's two CSOs are regulated under the NPDES permit No. WA-003168-2 (Ecology 2005c). City of Seattle and King County EOF events are reported to Ecology via Ecology's Environmental Report Tracking System (ERTS). Dry weather overflows (prohibited in NPDES permits), pump station failures, and blocked lines resulting from fats, oils, and grease; ragging;[147] or other reasons are routinely reported to Ecology's Water Quality Program.

Ecology has issued three types of general NPDES permits relevant to discharges to the LDW: one for sand and gravel operations, a second for boatyards, and a third for industrial stormwater operations at several facilities (Ecology 2007h). The general stormwater permit is also subdivided into three subcategories: municipal, industrial, and construction stormwater permits (Ecology 2007e).

[147] Ragging is the build up of raggy components of raw sewage.

Sand and gravel general permits cover discharges of process water, stormwater, and mine-dewatering water (Ecology 2007p). Boatyard general permits are issued to commercial businesses that maintain, construct, or repair small vessels (Ecology 2007h).

There are two types of municipal stormwater permits defined under the CWA (40 CFR 122.26), based on the size of the municipality's population. Ecology's Phase 1 permits cover discharges from large and medium municipal separate stormwater sewer systems, except for municipal separate storm sewers owned or operated by WSDOT. The City of Seattle, the Port of Seattle, and King County are all covered under Phase 1 permits (Ecology 2007p). The first Phase 1 municipal stormwater permit did not require stormwater quality monitoring; however, monitoring of stormwater discharges is required under the new 2007 Phase 1 permit. Under the new permit, Phase 1 permittees are now required to monitor stormwater at three locations in their systems representing different land uses (i.e., low- and high-density residential, commercial, industrial for cities and commercial, low density residential, and high density residential for counties). Samples are required to be analyzed for a number of chemicals and parameters including many of the sediment COCs identified in the LDW, as well as for toxicity. The new Phase 1 permit also requires that permittees collect an in-line sediment sample at each monitoring location once each year during the monitoring program (Ecology 2007p).

Industrial general stormwater NPDES permits regulate stormwater discharges from industrial facilities. These facilities are required to monitor total copper, total lead, total zinc, oils and grease, turbidity, BOD, ammonia, nitrate-nitrite nitrogen, total phosphorus, and pH from at least one outfall location. All industrial facilities with industrial general stormwater permits are required to conduct quarterly monitoring of authorized discharges to surface water (Ecology 2007e).

Construction general stormwater NPDES permits are required for clearing, grading and excavation activities that affect 1 or more acres and that will discharge into surface water. Permits are also required if Ecology determines that an activity may potentially contaminate surface waters or if a water quality standard is expected to be violated (Ecology 2007a).

Facilities that do not qualify for a general permit must apply for an individual permit. Individual permits regulate the discharge of pollutants associated with a particular industrial or municipal facility. Individual permits have been issued to the City of Seattle and King County for CSO discharges (EPA 2002b).

A search was conducted to identify NPDES permitted discharges to the LDW. This search included a review of Ecology's Water Quality Permit Life Cycle System (Ecology 2007o). The system included facility addresses for each permittee but did not have information on outfall locations. A facility was assumed to potentially discharge to the LDW if the facility was within the LDW surface water drainage basin (according to the City's geographic information system [GIS] shape file). Six sand and gravel, sixty-seven industrial general, three construction general, three boatyard general, and five

individual permitted facilities were identified within the LDW surface water drainage basin (see Table G-1).

NPDES Permits in the Vicinity of the LDW Study Area

It is possible that facilities discharging to the Duwamish River upstream of the LDW could also affect the water quality within the LDW. Table G-2 provides a summary of the facilities with an NPDES permit in the Black River, Duwamish River, lower Green River-East or lower Green River-West drainage basins (according to Washington State Department of Natural Resources GIS shape files). Sound Transit Light Rail also holds an individual NPDES permit for outfalls that discharge to the Duwamish River during construction (including areas upstream of and within the LDW). Only one of these outfall locations is within the LDW. A summary of the other Sound Transit Light Rail outfall locations is presented in Table G-3.

King County Industrial Waste Program

Under the CWA, local wastewater collection and treatment facilities were granted local pretreatment authority to regulate the types and amounts of chemicals discharged to their sanitary sewer systems. In April 1981, Ecology authorized Metro as the local pretreatment authority in Seattle and surrounding areas; this authority later shifted to King County through a series of changes in local government. King County established an IWP in 1969, through which permits could be issued to facilities that discharge to the sanitary sewer system. This program became an EPA-delegated program consistent with the requirements of the CWA in 1981.

The IWP enforces local discharge limits and regulates the discharge of industrial wastewater through the issuance and enforcement of discharge permits. The activities of the IWP serve to reduce industrial loading to the sewer system and to CSOs in the event of discharges to the LDW. Requirements may include pretreatment before discharge and/or best management practices (BMPs). King County enforces both federal standards and local limits, whichever are more stringent. Local limits were established to protect sewer facilities and treatment processes, public health and safety, and waters receiving the discharge to enable King County to comply with its own NPDES permits. Regulated materials include heavy metals; flammable materials; sulfides; cyanide; pH; fats, oils, and grease; and organic compounds. Since it began, the program has achieved significant improvements in the quality of wastewater received by King County's WWTPs and thus also in CSO discharges (King County 2006c).

The IWP issues industrial wastewater discharge permits and authorizations to companies that have industrial processes with the potential to adversely affect King County's WWTPs. Permits almost always require companies to monitor their own discharges. Waste discharge permits are issued to federally regulated industries or to facilities with discharge volumes greater than 25,000 gpd. Major discharge authorizations are issued for discharges between 5,000 gpd and 25,000 gpd. Minor discharge authorizations are issued for discharges between 1,000 and 5,000 gpd. Letters

of authorization are issued for discharges less than 1,000 gpd. A list of industrial facilities that currently hold industrial waste discharge permits and authorizations governed under the IWP is provided in Table G-4 in Appendix G.

In support of this program, King County staff inspect facilities with discharge permits at least once per year and sample wastewater from all permitted companies at least twice per year. Follow-up inspections and wastewater sampling are conducted to verify that identified conditions causing violations are corrected and eliminated. King County bases the enforcement response to each violation on a number of factors, including the severity and duration of the violation and the discharge and enforcement history of the facility or business (King County 2006b). Facilities demonstrating compliance with the County's permit can be issued discharge authorizations, which reduce the sampling regularity. King County inspects companies with discharge authorizations at least once every 5 years, but does not regularly sample them, relying instead on self-monitoring at these companies.

Hazardous Waste Management Inspection Programs

The regional Hazardous Waste Management Program (HWMP) complements King County's IWP by educating local residents and small businesses on methods to reduce hazardous waste and prevent water pollution. The program is a cooperative effort among King County's Department of Natural Resources and Parks (the Solid Waste and Water and Land Resources Divisions), Public Health, SPU, and 38 cities throughout King and Snohomish Counties. The program implements the local HWMP adopted in 1990 by King County and all of the regional cities.

The regional HWMP targets industry groups and geographic areas to provide technical assistance. Program staff make site visits to small businesses throughout King County and all of its incorporated cities to observe operating practices. When problem materials, such as lead, mercury, and solvent-based paints, are found to be disposed of in the sanitary sewer, program staff advise the company on correct practices. When necessary, staff can refer the matter to the IWP for regulatory action. In 2000, more than 3,000 businesses were inspected. Follow-up inspections indicated that 75 to 80% of businesses made at least one positive change in hazardous waste management or environmental practices as a result of the initial visit (King County 2002c citing Galvin 2001). The LDW area is included in the general coverage of the program; additional efforts in the LDW targeted auto body and repair shops, machine shops, photo laboratories, and dry cleaners in the basin.

The regional HWMP will conduct follow-up activities in the Duwamish/Diagonal drainage basin to support the early action cleanup for the Duwamish/Diagonal EAA consistent with the LDW source control strategy. For example, a list of businesses previously inspected is being compared with a list of current businesses in the Diagonal CSO/SD drainage basin to identify any new inspections that need to be made. This information will be used to identify the need for new site visits and to coordinate with the inspection data from both the stormwater and industrial waste inspection programs.

Current efforts are focusing on visits to new (and previously visited) businesses within the Diagonal CSO/SD drainage basin or businesses in the drainage basins of other EAAs.

Local Construction Stormwater Management Programs

In addition to the NPDES construction stormwater permits described above, local municipalities also regulate the discharge of stormwater and water from excavated soils (i.e., groundwater that "dewaters" from soils moved about or removed from a construction site). Surface water management is an important aspect of most construction operations. Depending on the size and complexity of the effort, large volumes of stormwater runoff can collect at a construction site that can be very high in TSS and can potentially contain chemical contaminants. This surface water may have to be temporarily stored and potentially pretreated prior to discharge to the storm drain network or sanitary sewer.

In the City of Seattle, the Department of Planning and Development (DPD) regulates discharges from construction sites to the storm drain and combined sewer systems per the stormwater, grading, and drainage control code (Seattle Municipal Code 22.800), which requires developers to control soil erosion and runoff from all construction projects. Depending on the size of the construction site, developers are required to either implement standard erosion and control procedures or submit a temporary erosion and sediment control plan for DPD review. Projects that will conduct a significant amount of excavation dewatering are also required to submit a dewatering plan for review and approval. Construction dewatering involves the removal of groundwater and accumulated stormwater encountered during excavation activities. This water can be contaminated depending on the environmental conditions of the site. Depending on the location of the project, stormwater and dewatering water may be treated and discharged to the storm drain system or discharged directly to the combined sewer system. Discharges to the combined sewer must obtain a Side Sewer Permit from the City of Seattle and comply with King County's IWP requirements.

In unincorporated King County, the King County Department of Development and Environmental Services regulates construction discharges (King County 2006b). Most construction runoff is discharged to nearby storm drain systems or directly to adjacent surface waters. Although there are separate departments responsible for regulation within the city and county limits, the City of Seattle and King County work together to regulate discharges during construction because the systems are interconnected.

King County's IWP regulates construction discharges when those discharges will enter the sanitary or the combined sewer system. A temporary dewatering permit is required for excavations greater than 12 ft deep, projects that disturb more than 1 ac, projects that encounter surface and/or subsurface water during construction, projects in an environmentally critical area, and disposal of contaminated surface and/or subsurface water. Water from dewatering operations can only be discharged to the public sewer system if authorized by the County. All dewatering discharges must meet County

permitting requirements regardless of the discharge volume and period of discharge (King County 2006b). Stormwater discharged into the sanitary or combined sewer systems must contain less than 7 mL/L of settleable solids to prevent sewer lines from becoming restricted or blocked. The discharge of materials such as ashes, sand, grass, and gravel to the sewer system is prohibited, and entities that discharge these or other solids to the public sewer system are liable for any damages caused (King County 2006b).

Large-volume dischargers of construction-related water to the sanitary or combined sewer systems (i.e., more than 25,000 gpd) must find other means of disposal during the "wet months" (November through April) when the sewer system can be at full capacity. Discharges of construction-related water to the sewer system are not prohibited during the "dry months" (May through October).

9.4.4.4 King County/City of Seattle CSO management and permit compliance

An important element of source control is the use of discharge permits issued by regulatory agencies. These permits provide clear and enforceable requirements for controlling the frequency, volume, and duration of CSO discharges, and the chemical concentrations in those discharges. As part of the City of Seattle and King County NPDES permits, Ecology requires "the greatest reasonable reduction of combined sewer overflows at the earliest possible date" (WAC 173-245-010). Ecology also requires that CSO planning documents specify the means for complying with the regulations.

Under their permits, both King County and the City of Seattle are required to monitor the frequency, volume, and duration of CSO discharges, and the magnitude of storm events at the time of CSO discharges. Monitoring information is then submitted to Ecology in monthly discharge monitoring reports and annual CSO reports. The annual reports provide information on the annual frequency and volume of CSO discharges, discuss accomplishments achieved in reducing CSO discharges, and explain additional CSO reduction efforts that will be made in the coming year (WAC 173-245-090(1)). King County's NPDES permit also requires sediment monitoring but only at the West Point WWTP.

In addition to discharge monitoring reports and annual CSO reporting requirements, both the City of Seattle and King County's NPDES permits require the maintenance of long-term control plans and submittal of amendments to CSO reduction plans at the time of NPDES permit renewal. Management practices and policies, called the Nine Minimum Controls, detailed in both the City of Seattle and King County permits, must also be implemented in order to reduce CSO frequency, volume, duration, and pollutant loads. The Nine Minimum Controls require:

1. Implementation of operation and maintenance programs for the combined sewer systems
2. Maximized use of the storage capacity of the wastewater collection system to reduce CSO discharges

3. Use of CSO controls (City of Seattle) and pretreatment programs (King County) to minimize nondomestic discharges to CSOs
4. Maximization of wastewater flow to wastewater treatment plants during wet-weather events
5. Prohibition of CSO discharges during dry weather, with reporting requirements in the event of a dry weather CSO discharge
6. Control of solid and floatable materials in combined sewer system wastewater
7. Implementation of pollution prevention plans
8. Public notification of CSO events
9. Monitoring of CSO outfalls for discharges

King County's CSO control plan is periodically updated to incorporate current technologies and BMPs, and to integrate CSO control with other Wastewater Treatment Division capital improvement programs in order to monitor and reduce CSO discharges. Strategies incorporated into the control plans include managing pollution at its source, maximizing the use of existing system capacity, monitoring and modeling flows in the system, and constructing new CSO control facilities.

King County routes combined sewer flows that would otherwise be discharged during CSO events to the regional plants for secondary treatment or CSO (primary) treatment, when possible, in order to provide the highest level of treatment. In some areas of the system where flows cannot be conveyed to the regional plants, the flows are either conveyed to satellite CSO treatment facilities for treatment prior to discharge or they overflow at various CSO outfalls in the collection system. Flow control is achieved with the use of an automated control system that manages flows through the conveyance system so that during storm events, the maximum amount of wastewater is contained in pipelines and storage facilities until it can be conveyed to a treatment plant. CSOs discharge untreated wastewater only when flows exceed the capacity of these systems (King County 2006b).

Construction of King County CSO control facilities in the region began in the late 1970s. So far, about $320 million has been spent to control CSO frequency, volume, duration, and quality, and another $383 million is planned to implement the CSO control projects throughout King County over the next 25 years. Early projects involved sewer separation, flow diversion, and storage tunnels. Current and future projects involve construction of conveyance improvements, storage tanks, and additional treatment facilities. These new treatment facilities will provide preliminary treatment to remove large objects, sand, gravel, and other inorganic material; primary treatment to remove suspended solids; secondary treatment to remove soluble material and fine suspended solids; and disinfection to kill pathogens (King County 2008a).

King County plans to reduce volumes at six CSOs discharging to the LDW (Hanford at Rainier [Hanford No. 1], E Michigan, S Brandon Street, 8th Avenue W, W Michigan, and

Terminal 115 [T-115]). The plans include conveyance expansion, increased storage capacity, and treatment (such as the storage and treatment tanks included in the Norfolk CSO/SD and the S Brandon St CSO systems) (King County 2006b).

Since 1988, when monitoring and measuring of CSO flows began, flow control efforts have reduced CSO volumes from an estimated 2.4 billion gal. per year to approximately 900 mgy system-wide. Examples of King County CSO management projects that have either decreased CSO volumes or discharge frequencies include: 1) replacement of the pipe that leads from the Brandon Street Regulator Station to the EBI, providing some reduction in the volume of overflows, and 2) installation of portable monitoring within the Duwamish and West Seattle pump stations to better characterize conditions at the pump stations and siphons to improve flow and system capacity management (King County 2006b).

The City of Seattle's permit also requires completion of a CSO supplemental characterization study and a sediment survey report. The supplemental characterization study is to be completed for a subset of the City's permitted CSOs, and will involve collecting whole-water samples of the discharges from the subset of CSOs and analyzing those samples for conventional and priority pollutants. Solids samples will not be collected as a part of this study (Taylor Associates 2007). The final report is due to Ecology in December of 2009. The sediment survey report will use available sediment data collected in the vicinity of the permitted CSO outfalls to assess sediment quality and determine whether additional sampling is needed.

The City of Seattle has also made progress in controlling the volume, frequency, and duration of CSOs. Since 1980 (the baseline for City CSO modeling), the City has reduced the annual volume of CSOs from approximately 306 million gal per year to about 214 million gal per year (estimated average for years 1998 through 2007) (Lee 2009). In its 2001 CSO reduction plan update, SPU identified the Diagonal Avenue S CSO/SD as one of the six priority outfalls in the city; no other uncontrolled CSOs have been identified in the LDW (City of Seattle 2002; CTE 2001). In 2005, SPU replaced an undersized pipe on the largest overflow point in this system (Diagonal Avenue S CSO/SD No.111 D) to allow more water to enter the King County sanitary sewer system. The Diagonal Avenue S CSO/SD system is currently being monitored to determine whether additional storage capacity is needed to adequately control overflows.

9.4.4.5 Compliance and inspection programs

Compliance and inspection programs are conducted by various agencies and NPDES permit holders to identify and manage potential sources of chemicals that are typically generated from business practices within the LDW drainage basin. Ecology NPDES inspections assess compliance with permit requirements, which may include BMPs. Inspections conducted under the joint SPU/KC program note NPDES issues but also consider stormwater, spill control/response, industrial waste, and hazardous waste issues. Local inspectors work with businesses to implement appropriate corrective actions necessary to comply with local stormwater and wastewater codes. In addition to

these broader, programmatic compliance issues, SCWG members such as the City of Seattle, the City of Tukwila, the Port of Seattle, and King County use these programs to bring additional focus to source control concerns in the LDW. Most of their compliance and inspection programs pertain to discharges to the storm drain and /combined sewer systems. The measures implemented jointly or by each member are described in greater detail below.

Business Inspection Programs

In 2001, SPU began a city-wide business inspection program to enforce the source control requirements of the City of Seattle's stormwater, grading, and drainage control code (SMC 82.200). Business inspections for the LDW source control program, which began in 2003, are part of the City's overall source control program, but focus on a wider range of pollution-generating activities, including hazardous waste and industrial wastewater management. Prior to 2001, the City conducted periodic stormwater inspections for specific projects in Elliott Bay and the Duwamish River to control sources of chemicals entering city-owned storm drains. Business inspection locations are shown on Map 9-9.

One of the earliest inspection efforts in the LDW occurred in the mid 1990s under a Centennial Clean Water Fund grant from Ecology (She 1997). Approximately 100 businesses in the LDW were inspected. The study focused on outdoor activities to minimize the presence of chemicals used or generated by onsite activities that could come in contact with stormwater runoff. Inspectors worked with local businesses to improve their pollution prevention practices and developed information bulletins for businesses to promote BMPs, including disposal/storage activities, landscape maintenance, and housekeeping practices, and to increase local awareness of the importance of protecting water quality. A number of measurable actions by businesses were noted as a result of the inspections, including movement of barrels indoors, improvement of housekeeping practices, reducing or diverting contaminated water entry away from storm drains, and other similar actions.

In 2001, SPU inspected 200 businesses in the western portion of the Diagonal drainage basin (109 drive-by inspections and 91 complete onsite inspections). A total of 81 of the businesses inspected were not in compliance with City stormwater source control requirements. Most of the problems were related to inadequate maintenance of onsite storm drainage systems (33%) and inadequate spill response programs (47%). SPU inspectors worked with the business owners to improve their stormwater pollution prevention practices.

In 2003, SPU and King County initiated a joint inspection program to support LDW source control efforts. The joint program addressed various potential pollution-generating activities, including stormwater management, hazardous waste management, and industrial waste disposal. This joint program was designed to minimize the disruption to businesses by conducting a single inspection that covered all of the municipal environmental regulations rather than having representatives from

each program conduct individual inspections. All inspections were conducted under the existing code authorities of each jurisdiction. Inspectors from King County and SPU conducted joint inspections to cross-train inspectors from the various King County/City of Seattle programs about each other's program requirements. Later, each inspector worked independently. Since 2005, SPU has assumed all inspection duties for the LDW program, with King County providing technical assistance, as needed. King County also continues to conduct routine inspections as part of its ongoing programs (e.g., industrial waste).

As of June 2008, a total of 1,175 businesses in the LDW study area have been inspected (882 full onsite inspections and 293 screening inspections). In addition, over 826 follow-up inspections have been conducted to confirm that property owners have implemented the necessary corrective actions (Schmoyer 2008b).

Corrective actions were required at 540 of the 882 sites (61%) where full inspections were conducted. Inadequate maintenance of onsite drainage facilities was the most common problem (57% of the corrective actions). Problems related to spill control, containment, and response were the most common problem (42% of the corrective actions). Approximately 38% of the corrective actions required were associated with stormwater practices (e.g., illicit discharges/connections, structures that require cleaning or repair, improper storage of materials, poor housekeeping practices), The other problems identified during the inspections involved improper storage, handling, or disposal of hazardous materials and products (19% of the corrective actions) (Schmoyer 2008c).

To date, SPU has inspected businesses in the Duwamish/Diagonal Way EAA, the Slip 4 EAA, the T-117 EAA, the Norfolk EAA, the Trotsky Inlet EAA, the Slip 1 SCA, the St. Gobain to Glacier NW SCA, the Slip 2 to Slip 3 SCA, the Slip 3 to Seattle Boiler Works SCA, the Seattle Boiler Works to Slip 4 SCA, the Glacier Bay SCA, and the Riverside Drive SCA. The business inspection program has focused on reaching businesses that discharge to the LDW via the publicly owned storm drain or the combined sewer systems.

In 2009, SPU will continue conducting follow-up inspections in the Diagonal/Duwamish, Norfolk, Glacier Bay, Trotsky Inlet areas, as needed, focusing on higher-priority businesses. In addition, inspections will also expand into other areas to support sediment remediation efforts and Ecology's development of SCAPs for the remaining SCAs. In 2009, the City of Seattle expects to begin inspecting areas on the west side of the LDW that have not yet been inspected (Schmoyer 2009a). The City of Seattle will continue conducting business inspections to support the LDW source control program and will refer identified source control issues to King County and Ecology, as appropriate.

City of Tukwila and King County

The City of Tukwila has jurisdiction over a portion of the drainage in the southeast part of the LDW study area. King County has jurisdiction over a very small strip of land adjacent to the southwest part of the LDW study area. These entities will be brought in as appropriate to conduct any necessary stormwater source control activities consistent with the source control strategy. In 2007, the City of Seattle signed a memorandum of agreement with the City of Tukwila to allow the City of Seattle to inspect five high-priority sites in the Norfolk drainage basin that are in Tukwila's jurisdiction.

Port of Seattle

The Port of Seattle is implementing a tenant audit and inspection program for its approximately 30 tenants, aimed at minimizing the potential for stormwater impacts. Tenant activities include container storage and handling, shipping, fishing vessel moorage, barge loading, and marina operations. The Port will use inspection opportunities to observe activities that can affect stormwater discharges and oversee the implementation and operation of appropriate BMPs. These inspections will also allow Port inspectors to observe any hazardous/dangerous waste-generating activities, inspect usage and storage of hazardous materials, and investigate any other environmental concerns, including air quality, noise, and impacts on neighbors and surrounding communities.

As part of their lease, the Port of Seattle requires tenants to apply for and obtain their own permits for stormwater management and air discharges and to write their own plans for industrial discharges to King County sewers and any spill prevention, control, and countermeasures. The Port of Seattle reviews all the permits and plans for adequacy and implementation to protect the Port from potential liabilities and to ensure that appropriate environmental/public health concerns have been addressed. The Port of Seattle also communicates with federal, state, and local agencies to make sure that any potential concerns or actions are addressed.

The Port of Seattle has a multi-phased tenant compliance program that includes an environmental review of all new and renewed tenant leases, a walk-through of all new tenant facilities upon occupancy and exit, and depending on their activity, periodic inspections (weekly, monthly or annual). Most Port tenants do not have industrial activities that require a formal intensive checklist and environmental audit by the Port. The Port has a cooperative compliance program through which they communicate potential concerns with tenants, including responsiveness and technical assistance. For each tenant inspection, the Port of Seattle completes a tenant inspection form. The information on the completed form is entered into the Port of Seattle's electronic database for compliance tracking. The information in this database is not published as an independent report and was not available for summation in this document.

Ecology's Urban Waters Initiative

The LDW is one of three areas in the state selected in 2007 by the legislature under the new Urban Waters Initiative. The initiative is designed to provide resources to state and local agencies to control sources of pollution to selected areas. The goal of the initiative is to develop effective lines of communication with business owners and managers to help in the battle against pollution in the state's waterways (Ecology 2008d).

As part of this initiative, Ecology and local agencies have built upon the original SPU/King County joint program and been able to assign more inspectors to work with businesses in areas that affect the LDW. Inspectors under this initiative include Ecology's Hazardous Waste and Water Quality Programs, King County's Wastewater Treatment Division's IWP, and SPU. These coordinated inspections evaluate commercial and industrial properties for compliance with necessary permits and established regulations. The inspections determine if source control measures should be implemented and whether site-specific source tracing samples should be collected (Ecology 2008d).

9.4.4.6 CSO and storm drain inputs and loading information

As mentioned in the previous sections, the City of Seattle and King County are required by their NPDES permit to conduct monitoring to support overall permit compliance requirements. In some instances, other parameters are also monitored to aid in CSO program management with the goal of reducing the potential for CSO events and chemical contributions to the waterway. The following section presents the available data for both CSO and storm drain discharges in the LDW basin.

CSO/EOF Inputs to the LDW

Several CSO/EOF outfalls are located within the LDW study area (Maps 9-8a through 9-8f). The City of Seattle owns and operates two CSOs (S Brighton St CSO and Diagonal Avenue S CSO) and three EOFs (EOF 117/pump station 44, formerly the Slip 4 EOF, EOF 156/pump station 78, formerly the Isaacson EOF, and EOF 178/pump station 17, which discharges to the LDW at the Norfolk outfall). The City's two CSOs also operate as storm drains, which regularly discharge stormwater during rainfall events. The City's Diagonal Avenue S CSO/SD outfall carries overflows from both County and City CSOs and receives overflows from nine separate overflow points, including the County's Hanford No. 1 CSO. Map 9-1 shows the basin boundaries for the area served by sanitary and combined sewers that have the potential to discharge to the LDW through a CSO, EOF, or CSO/SD outfall location.

Table 9-10 presents the 1999-2005 annual overflow volumes and flow frequencies available for King County's CSO/EOFs plus the contributions of the County's Hanford No. 1 CSO to the City's Diagonal Avenue S CSO/SD outfall (Map 9-8a). Table 9-10 also presents information on annual sediment load information for King County and City of Seattle CSOs. The City of Seattle's Diagonal Avenue S CSO is the only city CSO with significant discharges. The other city CSO (S Brighton St) discharges only during

extreme storm events, generally once every 5 yrs (Tetra Tech 1988a). SPU records show that the S Brighton Street CSO has not overflowed since monitoring began in March 2000 (King County and SPU 2005). King County uses the period between 1981 and 1983 as the baseline for measuring progress in controlling CSOs; baseline volumes were determined using computer modeling (King County 2006a).

Table 9-10. CSO/EOF volumes, frequency of discharge, and annual sediment load information

CSO/EOF	Discharge No.	Map ID	Owner	Annual Average Volume (mgy)		Annual Average Frequency (events/yr)		Annual Sediment Load (MT/yr)[a]
				Baseline (1981 – 1983)	June 1999 – May 2005	Baseline (1981 – 1983)	June 1999 – May 2005	
8th Avenue S	040	2107	King County	8	0.00	6	0	nr
S Brandon Street	041	2223	King County	64	30.96	36	26.3	15.0
Diagonal Avenue S[b, c]	111	2155	City of Seattle	nr	8.64[d]	nr	20	3.4
Duwamish pump station West	034	na	King County	< 1	0.58	<1	1.0	0.1
Duwamish pump station East[e]	035	2153	King County	nr	0.67	<1	0.17	1.0
Hanford No. 1[f]	031	2155[e]	King County	nr	10.36	nr	5.50	4.9
E Marginal Way S pump station[e]	043	na	King County	< 1	0.00	< 1	0	nr
E Michigan	039	2502	King County	190	19.01	34	8.14	9.0
W Michigan	042	2506	King County	2	0.98	5	3.57	0.5
Norfolk[c]	044	2095	King County	39	0.28	20	1.14	0.1
Terminal 115	038	na	King County	2	3.17	4	2.00	1.5

Source: King County (2006b), Nairn (2007), SPU (2007), and Schmoyer (2007a), (QEA 2008)

[a] Information provided in the STM report (QEA 2008).

[b] Volume/frequency include only contributions from the City-owned system.

[c] Combined CSO/SD.

[d] Annual average calculation does not include 59 million gal. discharge event that occurred October 20 and 21, 2003. Annual average volume calculation with that single event included is approximately 15.84 mgy.

[e] Emergency overflow.

[f] Hanford No. 1 discharges through the City's Diagonal Avenue S SD outfall, which also discharges the City's Diagonal Avenue S CSO.

CSO – combined sewer overflow
EOF – emergency overflow
MT/yr – metric tons per year
mgy – million gallons per year
na – not available
nr – not reported

As shown in Table 9-10, the E Michigan CSO, S Brandon Street CSO, and Hanford No. 1 (discharging via the City's Diagonal Avenue S CSO/SD) outfalls had the highest annual average overflow volumes between 1999 and 2005. In 2004, the Duwamish West pump station was reactivated under King County's NPDES permit because of concerns that it could overflow; monitoring of this pump station is now in place. The E Marginal Way S Pump Station and Duwamish East CSO/EOF are considered to be controlled (i.e., they meet Ecology's standard of one overflow event per year based on a 5-yr average) (King County 2006b).

King County's E Marginal Way S outfall is a pump station EOF; discharge at this station occurs only under emergency conditions (i.e., power or mechanical failure). King County has no record of an overflow event ever occurring at this location. The Duwamish East CSO/EOF also functions as an emergency bypass for a pump station; there has not been an emergency overflow since 1989 (King County 2006b). However, this location has the potential to overflow if the input volume from the siphon carrying combined sewage from the western bank of the LDW and the West Seattle area is too high (King County 2006b).

Whole-Water Sampling of CSOs

As part of two different studies, whole-water samples were collected from King County CSO discharges to the Duwamish River (King County 1999e). Samples were collected from the Norfolk CSO once in 1995 as part of the pilot study for the King County WQA and four times in 1997 as part of the Henderson/MLK CSO control project. The S Brandon Street CSO was sampled in 1996-1997 during 15 different CSO events (with more than one sample collected per event) for the King County WQA. Both of these CSOs discharge into the LDW study area; Tables 9-11 and 9-12 summarize the data collected from the Norfolk and S Brandon St CSOs (Williston 2008).

In the whole-water samples collected from the Norfolk and S Brandon Street CSOs between 1995 and 1997, six metals (i.e., arsenic, chromium, copper, lead, nickel, and zinc) were detected in 100% of the samples. Other constituents regularly detected included other metals, phthalates, and several PAHs. Other organic compounds, including PCBs and DDTs, were not detected in any of these CSO whole-water samples (Williston 2008). Surface sediment data for areas near these outfalls are discussed in relation to the SQS in Section 4.2.1 (Maps 4-14a through 4-14f). Source tracing samples collected within the Norfolk CSO/SD drainage basin (i.e., ROW catch basin, onsite catch basin, in-line sediment grab) are presented in Section 9.4.4.7.

Table 9-11. Chemical concentrations in Norfolk CSO discharge

Parameter[a]	Detection Frequency	Number of Samples	RLs for Non-Detected Concentrations (µg/L)		Number of Detections	Detected Concentrations (µg/L)				
			Minimum	Maximum		Minimum	Maximum	Mean	Median	Standard Deviation
Antimony (total)	100%	3	na	na	3	0.56	1.2	0.87	0.85	0.32
Arsenic (total)	100%	3	na	na	3	4.1	4.9	4.6	4.7	0.43
Barium (total)	100%	3	na	na	3	21	57	44	49	20
Cadmium (total)	67%	3	0.20	0.20	2	0.28	0.31	0.30	0.30	0.021
Chromium (total)	100%	3	na	na	3	1.4	11.3	7.8	9.2	5.5
Cobalt (total)	100%	3	na	na	3	0.5	3	2.1	2.4	1.3
Copper (total)	100%	3	na	na	3	13	30	21	21	8.8
Lead (total)	100%	3	na	na	3	4.2	29	19	21	13
Mercury (total)	50%	4	0.20	0.20	2	0.21	0.25	0.2	0.23	0.03
molybdenum (total)	67%	3	0.50	0.50	2	0.59	0.98	0.79	0.79	0.28
Nickel (total)	100%	3	na	na	3	3.5	12	8.4	9.3	4.3
Silver (total)	33%	3	0.30	0.30	1	0.88	0.88	0.88	0.88	na
Vanadium (total)	100%	2	na	na	2	2.3	14	7.9	7.9	8.0
Zinc (total)	100%	3	na	na	3	38	95	71	75	29
Chrysene	20%	5	0.14	0.28	1	0.2	0.2	0.2	0.2	Na
Fluoranthene	60%	5	0.14	0.28	3	0.2	0.27	0.2	0.22	0.038
Phenanthrene	60%	5	0.14	0.28	3	0.17	0.33	0.2	0.20	0.09
Pyrene	60%	5	0.14	0.28	3	0.18	0.27	0.2	0.23	0.04
BBP	80%	5	0.14	0.14	4	0.26	1.23	0.58	0.51	0.44
BEHP	20%	5	0.28	1.71	1	4.7	4.7	4.7	4.7	Na
Diethyl phthalate	100%	5	na	na	5	0.28	2.2	1.2	1.2	0.73
1,4-Dichlorobenzene	100%	5	na	na	5	0.38	0.83	0.51	0.44	0.18
4-Methylphenol	60%	5	0.24	0.27	3	0.25	2.9	1.4	1.2	1.4
Benzoic acid	60%	5	0.94	0.95	3	1.2	2.5	2.1	2.3	0.75
Benzyl alcohol	40%	5	0.24	0.47	2	0.33	0.38	0.36	0.36	0.04

Table 9-11, cont. Chemical concentrations in Norfolk CSO discharge

Parameter[a]	Detection Frequency	Number of Samples	RLs for Non-Detected Concentrations (µg/L)		Number of Detections	Detected Concentrations (µg/L)				
			Minimum	Maximum		Minimum	Maximum	Mean	Median	Standard Deviation
Coprostanol	80%	5	1.90	1.90	4	15	67	32	30	25
TOC	100%	4	na	na	4	8.8	16	13	13	3.2
TSS	100%	5	na	na	5	51	167	110	105	55

Source: (Williston 2008)

Note: Tentatively identified compounds and select conventional parameters were excluded from this table.

[a] All other compounds analyzed (including PCBs, 15 PAHs, 41 other SVOCs, 3 phthalates, and 10 metals) were not detected in these CSO samples.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
CSO – combined sewer overflow
na – not applicable
PCB – polychlorinated biphenyl
RL – reporting limit
TOC – total organic carbon
TSS – total suspended solids

Table 9-12. Chemical concentrations in S Brandon Street CSO discharge

Parameter[a]	Unit	Detection Frequency	Number of Samples[b]	RLs for Non-Detected Concentrations		Number of Detections	Detected Concentrations (µg/L)				
				Minimum	Maximum		Minimum	Maximum	Mean	Median	Standard Deviation
Antimony (total)	mg/L	100%	41	na	na	41	0.0012	2.3	0.0585	0.00205	0.36
Arsenic (total)	mg/L	100%	41	na	na	41	0.0014	3.5	0.089423	0.00284	0.55
Barium (total)	mg/L	100%	41	na	na	41	0.023	38	0.962273	0.0397	5.85
Cadmium (total)	mg/L	100%	41	na	na	41	0.00034	1	0.016492	0.00084	0.10
Chromium (total)	mg/L	100%	41	na	na	41	0.0045	7.9	0.207454	0.0104	1.23
Cobalt (total)	mg/L	100%	40	na	na	40	0.00095	2.3	0.060111	0.00227	0.36
Copper (total)	mg/L	100%	41	na	na	41	0.022	46	1.167466	0.0376	7.13
Iron (total)	mg/L	100%	24	na	na	24	2.66	5590	239.4925	5.435	1139.66
Lead (total)	mg/L	100%	41	na	na	41	0.019	48.8	1.244124	0.0407	7.61
Magnesium (total)	mg/L	100%	1	na	na	1	1.08	1.08	1.08	1.08	na
Manganese (total)	mg/L	100%	1	na	na	1	0.051	0.051	0.0513	0.0513	na
Mercury (total)	mg/L	15%	41	0.00	0.20	6	0.0002	0.00108	0.00046	0.00037	0.00
Mercury (total) (by CVAF)[c]	mg/L	100%	5	na	na	5	1.2E-07	8.56E-05	4.32E-05	3.15E-05	0.00
Molybdenum (total)	mg/L	100%	41	na	na	41	0.0032	4.38	0.115128	0.00672	0.68
Nickel (total)	mg/L	100%	41	na	na	41	0.0069	10.4	0.29568	0.0126	1.63
Selenium (total)	mg/L	29%	41	0.00	0.00	12	0.001	1.3	0.109508	0.0013	0.37
Silver (total)	mg/L	66%	41	0.00	0.00	27	0.00039	0.34	0.013655	0.00093	0.07
Sodium (total)	mg/L	100%	1	na	na	1	4.7	4.7	4.7	4.7	na
Tin (total)	mg/L	100%	4	na	na	4	0.0026	0.0035	0.00322	0.00339	0.00
Vanadium (total)	mg/L	100%	35	na	na	35	0.0031	6.74	0.199622	0.00684	1.14
Zinc (total)	mg/L	100%	41	na	na	41	0.12	156	4.023098	0.173	24.33
Butyltin (total)	µg/L	100%	1	na	na	1	4	4	4	4	na
Mono-n-butyltin (as monobutyltin ion)	µg/L	100%	1	na	na	1	4	4	4	4	na
2-Methylnaphthalene	µg/L	19%	32	0.38	0.80	6	0.39	1.7	0.76	0.64	0.49

Table 9-12, cont. Chemical concentrations in S Brandon Street CSO discharge

Parameter[a]	Unit	Detection Frequency	Number of Samples[b]	RLs for Non-Detected Concentrations		Number of Detections	Detected Concentrations (µg/L)				
				Minimum	Maximum		Minimum	Maximum	Mean	Median	Standard Deviation
Acenaphthene	µg/L	6%	32	0.09	0.20	2	0.12	0.19	0.155	0.155	0.05
Benzo(a)anthracene	µg/L	13%	32	0.14	0.30	4	0.15	0.3	0.18575	0.165	0.05
Chrysene	µg/L	75%	32	0.14	0.14	24	0.15	0.54	0.251083	0.234	0.08
Fluoranthene	µg/L	97%	32	0.14	0.14	31	0.15	0.72	0.308871	0.32	0.13
Fluorene	µg/L	16%	32	0.14	0.30	5	0.14	0.40	0.233	0.236	0.11
Phenanthrene	µg/L	81%	32	0.14	0.14	26	0.19	0.762	0.346692	0.284	0.14
Pyrene	µg/L	97%	32	0.14	0.14	31	0.15	0.812	0.321742	0.321	0.12
BBP	µg/L	34%	32	0.14	2.30	11	0.65	24	3.405545	1.14	6.82
BEHP	µg/L	78%	32	2.53	3.95	25	3.52	8.4	5.4328	5.21	1.10
Diethyl phthalate	µg/L	84%	32	0.24	0.24	27	0.26	1.6	0.654667	0.51	0.39
Dimethyl phthalate	µg/L	75%	32	0.09	0.20	24	0.096	0.31	0.158833	0.13	0.07
Di-n-butyl phthalate	µg/L	63%	32	0.24	0.60	20	0.32	18	1.9982	0.7215	3.91
Di-n-octyl phthalate	µg/L	100%	32	na	na	32	0.68	3.3	1.460438	1.2	0.63
1,4-Dichlorobenzene	µg/L	97%	32	0.15	0.15	31	0.15	2.69	0.516355	0.45	0.48
2,4-Dimethylphenol	µg/L	6%	32	0.24	0.50	2	0.37	0.42	0.395	0.395	0.04
2-Methylphenol	µg/L	38%	32	0.24	0.50	12	0.25	22	2.223333	0.37	6.17
4-Chloro-3-methylphenol	µg/L	22%	32	0.47	1.00	7	0.53	1.1	0.76	0.65	0.21
4-Methylphenol	µg/L	56%	32	0.24	0.50	18	0.25	26	2.984778	0.976	5.87
4-Nitrophenol	µg/L	59%	32	0.47	0.50	19	0.48	2.5	1.287368	0.96	0.73
Benzoic acid	µg/L	91%	32	0.94	0.94	29	0.96	23	5.328621	2.63	5.99
Benzyl alcohol	µg/L	47%	32	0.24	0.71	15	0.31	3.2	0.873467	0.504	0.85
Caffeine	µg/L	100%	32	na	na	32	1.23	29	6.700938	3.735	6.23
Coprostanol	µg/L	100%	32	na	na	32	8.5	96	31.60406	22.55	22.66
Isophorone	µg/L	13%	32	0.24	0.50	4	0.27	0.46	0.3675	0.37	0.08
Pentachlorophenol	µg/L	81%	32	0.24	0.50	26	0.25	0.597	0.370192	0.35	0.09
Phenol	µg/L	25%	32	0.94	2.00	8	1.2	16.1	3.92625	2.28	5.03

Table 9-12, cont. Chemical concentrations in S Brandon Street CSO discharge

Parameter[a]	Unit	Detection Frequency	Number of Samples[b]	RLs for Non-Detected Concentrations		Number of Detections	Detected Concentrations (µg/L)				
				Minimum	Maximum		Minimum	Maximum	Mean	Median	Standard Deviation
TOC	µg/L	100%	36	na	na	36	5.0	33	13	11	6.5
TSS	µg/L	100%	23	na	na	23	44	771	127	75	156
Ammonia nitrogen	mg/L	100%	35	na	na	35	0.053	3.1	0.605791	0.371	0.67
Nitrite + nitrate nitrogen	mg/L	94%	16	0.05	0.05	15	0.085	0.331	0.164267	0.134	0.08

Source: Williston (2008)

Note: Tentatively identified compounds and select conventional parameters were excluded from this table.

[a] Detection frequency was less than 5% for naphthalene; all other compounds analyzed (including PCBs,10 PAHs, 34 other SVOCs, 19 pesticides, 14 metals, and 2 organometals) were not detected in these CSO samples.

[b] Fifteen events were sampled, with most having multiple samples per event. Samples were first averaged per event (by date) and then summary statistics were calculated. For purposes of this summary table, all samples were used in the mean and median calculations and not combined per event.

[c] Five samples were analyzed for mercury using ultra trace level sampling techniques and analyzed by cold vapor atomic fluorescence.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
CSO – combined sewer overflow
CVAF – cold vapor atomic fluorescence
na – not applicable
PCB – polychlorinated biphenyl
RL – reporting limit
TOC – total organic carbon
TSS – total suspended solids

Lateral Loads Analysis for the LDW

In 2007, SPU estimated the lateral loads to the LDW for use in the STM that has been developed for the FS. The STM tracks the movement of sediment through the LDW from three primary sources: lateral loads, Duwamish/Green River contributions at the upstream boundary of the LDW, and re-suspension of in-waterway sediment. For the purposes of the STM, lateral loads are defined as the sediment contributions from small streams, storm drains, and CSOs along the LDW. The information used in the STM provides a general, large-scale perspective on lateral solids loading and transport in the LDW. These preliminary lateral load estimates may be refined in the FS.

The LDW drainage basin was divided into sub-basins for the lateral load analysis. The sub-basins were delineated based on City of Seattle GIS information as well as site-specific drainage plans (SPU 2007). In 2008, SPU updated the lateral loads analysis to incorporate source tracing data through December 2007 and updated sub-basin boundaries (see Map 9-10). Table 9-13 summarizes the updated TSS concentrations and stormwater discharge volumes estimated as part of the lateral load analysis (SPU 2008).

In order to estimate the volume of stormwater discharged to the LDW, the Hydrologic Simulation Program-Fortran was used to estimate runoff volumes for various combinations of land use, soil type, and slope within the drainage basin (SPU 2008). Data from CSO flow monitoring programs (1999 to 2005) were used to estimate discharge volume for CSOs. Flow estimates were calculated for a typical wet year (2002), dry year (1993) and an average year (1986) (SPU 2008). Rainfall data used in the model were collected at SPU's gauge station at E Marginal Way S and 13th Avenue S.

TSS concentrations in stormwater were estimated based on TSS data from 24 locations in Seattle, Bellevue, Tacoma, Issaquah, and Everett. Average TSS concentration calculations accounted for different types of land use. The TSS concentration was calculated based on the percentage of land use within each sample area (Table 9-8). Land-use weighted averages were multiplied by the calculated runoff volume for each land use category. TSS concentrations in CSO discharges were estimated using King County data from samples collected from 1995 to 1997 from five major CSO outfalls (Brandon, Chelan, Hanford, Connecticut, and King) (SPU 2008).

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Table 9-13. LDW storm drain estimated lateral load information

Outfall No.[a]	Name	Outfall ID	Drainage Basin Area (ac)	Runoff Volume			TSS Load		
				Low Water Year (mgy)	Med Water Year (mgy)	High Water Year (mgy)	Low Water Year (MT/yr)	Med Water Year (MT/yr)	High Water Year (MT/yr)
1	Diagonal Avenue S CSO/SD storm drain basin	2155	2,620	797	1,045	1,372	241	316	414
2	Norfolk CSO/SD storm drain basin	2095	826	317	416	545	91	124	162
3	Slip 4 SD drainage basin	2048	495	242	314	401	74	97	124
4	7th Avenue S SD drainage basin	2112	232	83	108	138	24	33	42
5	Seattle municipal storm drain (SW Idaho Street)	2147	655	158	211	285	42	62	83
6	Seattle municipal storm drain (SW Kenny/Glacier Bay)	2127	164	39	53	71	11	15	21
7	Seattle municipal storm drain (SW Highland Park Drive)	2125	491	118	159	214	42	62	83
8	Hamm Creek	2205	721	245	325	438	46	86	116
9	King County Airport storm drain No. 2 at former Slip 5	2062	236	119	154	196	35	48	61
10	King County Airport storm drain No. 1 at slip 6	2080	64	32	42	53	9	13	17
11	Remaining Seattle municipal storm drains (east side of LDW)	no number[b]	226	109	142	180	34	44	57
12	S 96th St SD	2100A	996	348	457	604	87	128	169
13	1st Avenue S channel	no number[b]	328	79	106	143	21	31	41
WF-1	Waterfront Area 1	na	46	23	30	38	7	9	12
WF-2	Waterfront Area 2	na	71	36	46	59	11	14	18
WF-3	Waterfront Area 3	na	43	22	28	35	6	9	11
WF-4	Waterfront Area 4	na	210	107	138	176	33	43	55
WF-5	Waterfront Area 5	na	101	50	64	82	14	20	26

Outfall No.[a]	Name	Outfall ID	Drainage Basin Area (ac)	Runoff Volume			TSS Load		
				Low Water Year (mgy)	Med Water Year (mgy)	High Water Year (mgy)	Low Water Year (MT/yr)	Med Water Year (MT/yr)	High Water Year (MT/yr)
WF-6	Waterfront Area 6	na	94	27	38	52	6	11	15
WF-7	Waterfront Area 7	na	37	17	23	29	5	7	9
WF-8	Waterfront Area 8	na	56	29	37	47	9	12	15
WF-9	Waterfront Area 9	na	47	24	30	39	7	9	12
WF-10	Waterfront Area 10	na	58	27	35	45	8	11	14
WF-11	Waterfront Area 11	na	120	49	65	86	13	18	24
Storm drain totals			8,936	3,096	4,065	5,328	878	1,224	1,600

[a] Waterfront areas represent sections of the LDW shoreline that were previously not identified as a component of the first 13 listed sub-basins. Waterfront areas were delineated by the City of Seattle. Although each waterfront area includes multiple outfalls, the loading analysis combined the contribution from each area as a single discharge for loading estimating purposes (SPU 2008).

[b] Outfall was not found during the 2003 outfall survey; no corresponding number is available (Herrera 2004a).

CSO – combined sewer overflow

LDW – Lower Duwamish Waterway

mgy – million gallons per year

MT/yr – metric tons per year

na – not applicable

SD – storm drain

TSS – total suspended solids

9.4.4.7 Storm drain source tracing information and control programs

Various source control efforts to identify and characterize potential sources of contamination have been implemented to minimize the potential for sediment recontamination in the LDW. As part of these efforts, source identification is being conducted in the LDW drainage basin. This source identification effort includes the collection of the following types of samples:

- Sediment from catch basins located on private property and within the public ROW
- Sediment from in-line sediment traps installed in the storm drain system
- In-line grab samples of sediment accumulated within storm drain lines collected from maintenance holes on the storm drain trunk lines
- Catch basin samples are grab samples of material that has accumulated in the catch basin sump. Catch basins are part of the stormwater collection system and collect runoff from a fairly small catchment area (< 1 ac). These structures are equipped with a small sump to capture sediment and other large debris before it can enter the stormwater conveyance system. The sediment that accumulates in catch basins provides a qualitative measure of the solid-phase stormwater load coming from a drainage system and may not reflect actual total loading to the waterway (whole water plus solids). Catch basin samples are collected either from a specific site or property (onsite) or from the streets (ROWs).

In-line sediment traps consist of a sample bottle mounted inside the collection system pipe. Traps are typically installed for a period of about 6 months to passively collect suspended particulates that pass by the sampling station. Sampling stations are selected to isolate specific drainage sub-basins or entire drainage basins (generally greater than 50 ac). SPU has installed in-line sediment traps in the storm drain systems that discharge to the Duwamish/Diagonal (6 traps) and Slip 4 (10 traps) EAAs (Map 9-2). In 2007, SPU also installed five in-line sediment traps in the Norfolk drainage system. However, the results from these traps were not available at the time this report was prepared.

In-line grab samples of sediment are samples of material that has accumulated within storm drain lines in quiescent areas where there is sufficient sediment present for chemical analysis. Like sediment traps, in-line grab samples also represent contributions on a basin-wide or sub-basin scale.

From January 2002 through December 2007, source tracing sediment samples have been collected from 171 onsite catch basins and 74 ROW catch basins in the LDW drainage basin. In addition, 130 in-line sediment grab samples and 102 in-line sediment trap samples have been collected (Schmoyer 2008a). Samples from onsite catch basins have primarily been collected from sites where business inspections were conducted and at sites where sufficient sediment was available for chemical analysis (see Map 9-11 for

source tracing sampling locations through December 2007). Most of the catch basin samples have been collected in the Duwamish/Diagonal and Slip 4 drainage basins, but samples have also been collected from the Norfolk area, and from other sub-basins outside the Duwamish/Diagonal and Slip 4 drainages.

Samples from three catch basins, six manholes, one street dirt area at the western edge of the 16th Avenue S ROW, and one settling tank located upstream of an oil-water separator at the Basin Oil facility were also analyzed for dioxins (Integral 2008). These samples, which were analyzed for dioxin and furan congeners, were collected in 2004 and 2005 to support ongoing source tracing efforts in the LDW. Sample locations were selected to target areas with relatively high total PCB concentrations in source tracing samples previously collected (Integral 2008). TEQs were calculated using the mammalian TEFs as provided by van den Berg et al. (2006). Concentrations of individual congeners that were not detected were estimated at one-half the RL.

Dioxins and furans were detected in all 11 samples. TEQs in the three catch basin samples ranged from 11.3 ng/kg dw to 25.6 ng/kg dw, and TEQs in the manhole samples ranged from 6.2 ng/kg dw to 26.3 ng/kg dw (Integral 2008). The sample collected from the settling tank near Basin Oil had a TEQ of 15.2 ng/kg dw and the street dirt sample had a TEQ of 90.5 ng/kg dw. These data are not evaluated further in this section.

No regulatory standards exist for in-line storm drain sediment. Chemical concentrations in storm drain sediment were compared in this section to the SMS criteria and MTCA Method A cleanup standards for informational purposes only (MTCA methods were used for comparison of TPH values only). This comparison provides an estimate of storm drain sediment quality. TOC information was not available for all samples with detected concentrations. Detection frequencies were based on the total number of samples collected in each sub-basin per media type. For organic compounds with OC-normalized SMS criteria, percentages of samples with concentrations above the SQS and the CSL were based on the number of detected samples for which TOC information was available.

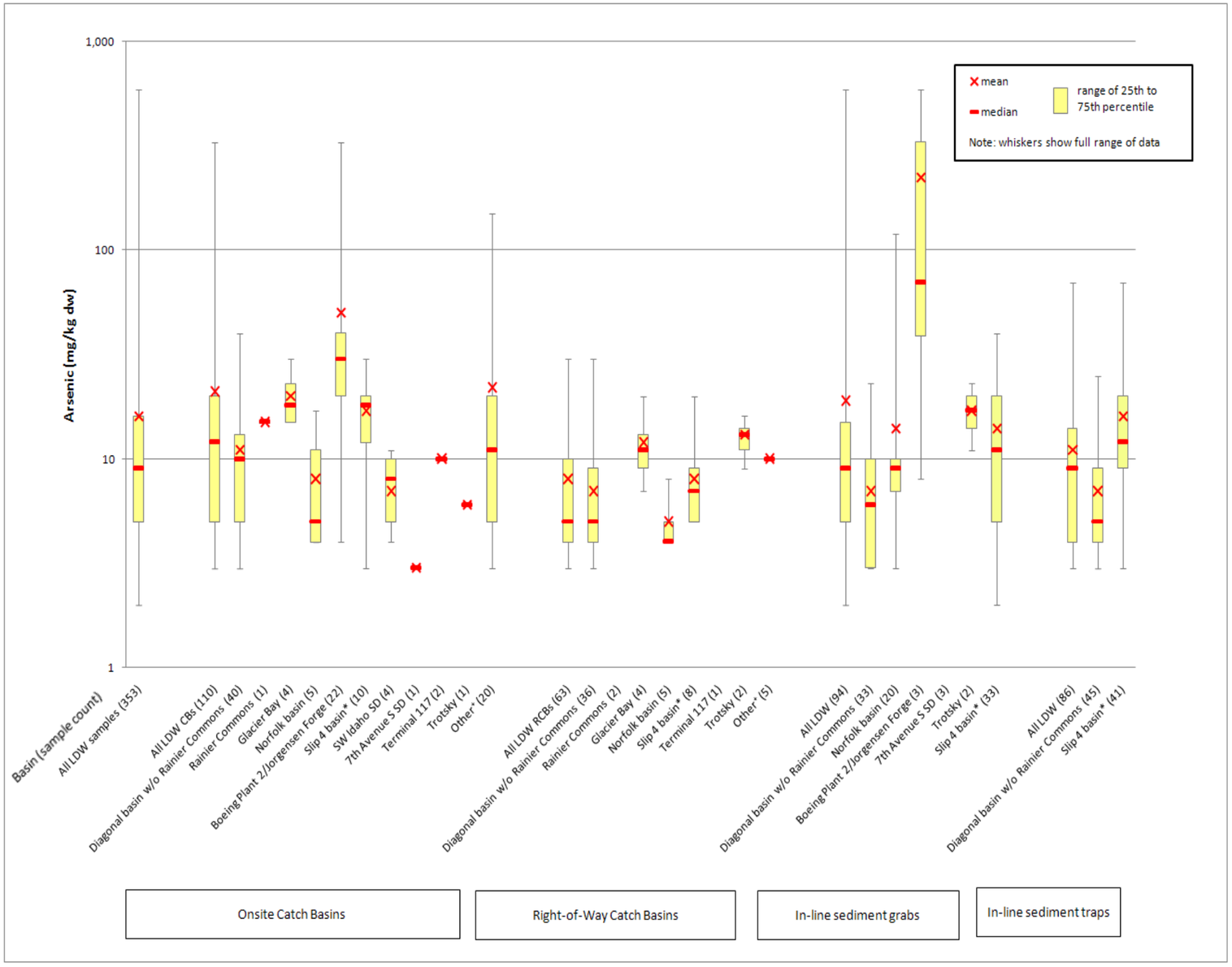
If storm drain sediment samples are below the SQS, it is likely that LDW sediment in outfall discharge areas would not be re-contaminated to levels above the SQS as a result of outfall discharges. In contrast, an exceedance of the SQS in storm drain samples may indicate a potential for sediment recontamination, but additional source investigations would be necessary to determine if recontamination above the SQS might occur. This section summarizes results from the source tracing sampling efforts.

Overall trends and conclusions from the source tracing information collected for all LDW drainages through December 2007 are as follows:

- Chemical concentrations in the four different types of samples were variable.
- Chemicals that frequently had concentrations greater than the CSL included zinc, BEHP, and BBP.

- Other chemicals that had concentrations greater than the SQS in at least one sample included total PCBs, arsenic, copper, lead, mercury, PAHs, di-n-octylphthalate, benzoic acid, 1,2-dichlorobenzene, 1,4-dichlorobenzene, hexachlorobenzene, dibenzofuran, 2-methylnaphthalene, n-nitrosodiphenylamine, and bis(2-chloroethoxy)methane.
- Chemical concentrations were generally higher in samples collected from onsite catch basins than from ROW catch basin, likely because most onsite catch basin sampling stations were selected based on source control problems identified during business inspections.
- Total PCBs were frequently detected in all sample types (70 to 100%, depending on sample type). The majority of higher total PCB concentrations were collected from a few locations in the LDW drainage basin. Elevated total PCB concentrations have generally been associated with specific sources, including PCB-contaminated exterior building paint, paving caulk, or historical activities.
- BEHP and PAHs were detected in most of the samples collected in the LDW drainage basin.
- Arsenic was detected in 38 to 52% of the source tracing samples, depending on sample type; arsenic concentrations were greater than the CSL in six source tracing samples.

Figures 9-5 through 9-10 summarize the results of source tracing samples for arsenic, total PCBs, BBP, BEHP, total LPAHs, and total HPAHs, respectively. General statistical information on chemicals for which source tracing data is available are summarized in Table 9-14. All data have been provided by the City of Seattle (Schmoyer 2008e); an independent QA/QC of the raw data was not performed as part of the RI. Surface sediment data collected near the various drainages referred to in Table 9-14 are discussed in relation to the SQS in Section 4.2.1. Maps 9-12 through 9-14 provide a spatial presentation of source tracing information for total PCBs, mercury, and BEHP concentration ranges, respectively.

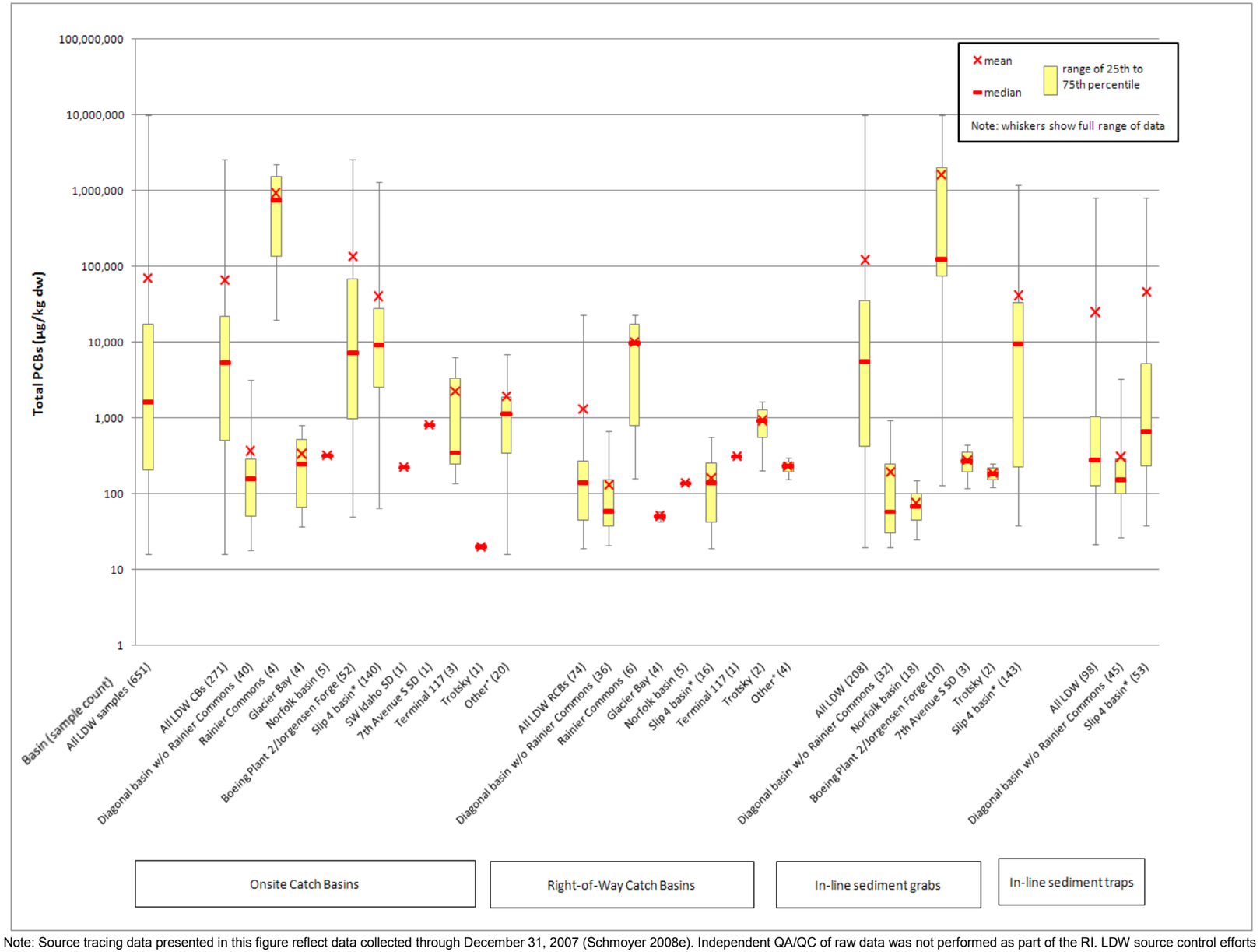


Note: Source tracing data presented in this figure reflect data collected through December 31, 2007 (Schmoyer 2008e). Independent QA/QC of raw data was not performed as part of the RI. LDW source control efforts are ongoing.

* Data from sub-basins within the Slip 4 drainage basin (i.e., Slip 4, NBF, KCIA, I-5, and adjacent properties) have been combined to calculate summary statistics (e.g., ranges, medians). Chemical concentrations within the sub-basins vary greatly. Maps 9-12 through 9-14 provide a spatial presentation of total PCBs, mercury, and BEHP concentrations, respectively.

+ Other samples include source tracing information associated with Slip 5, Slip 6, T-115, and the Chemithon Corporation property.

Figure 9-5. Arsenic source-tracing sample results

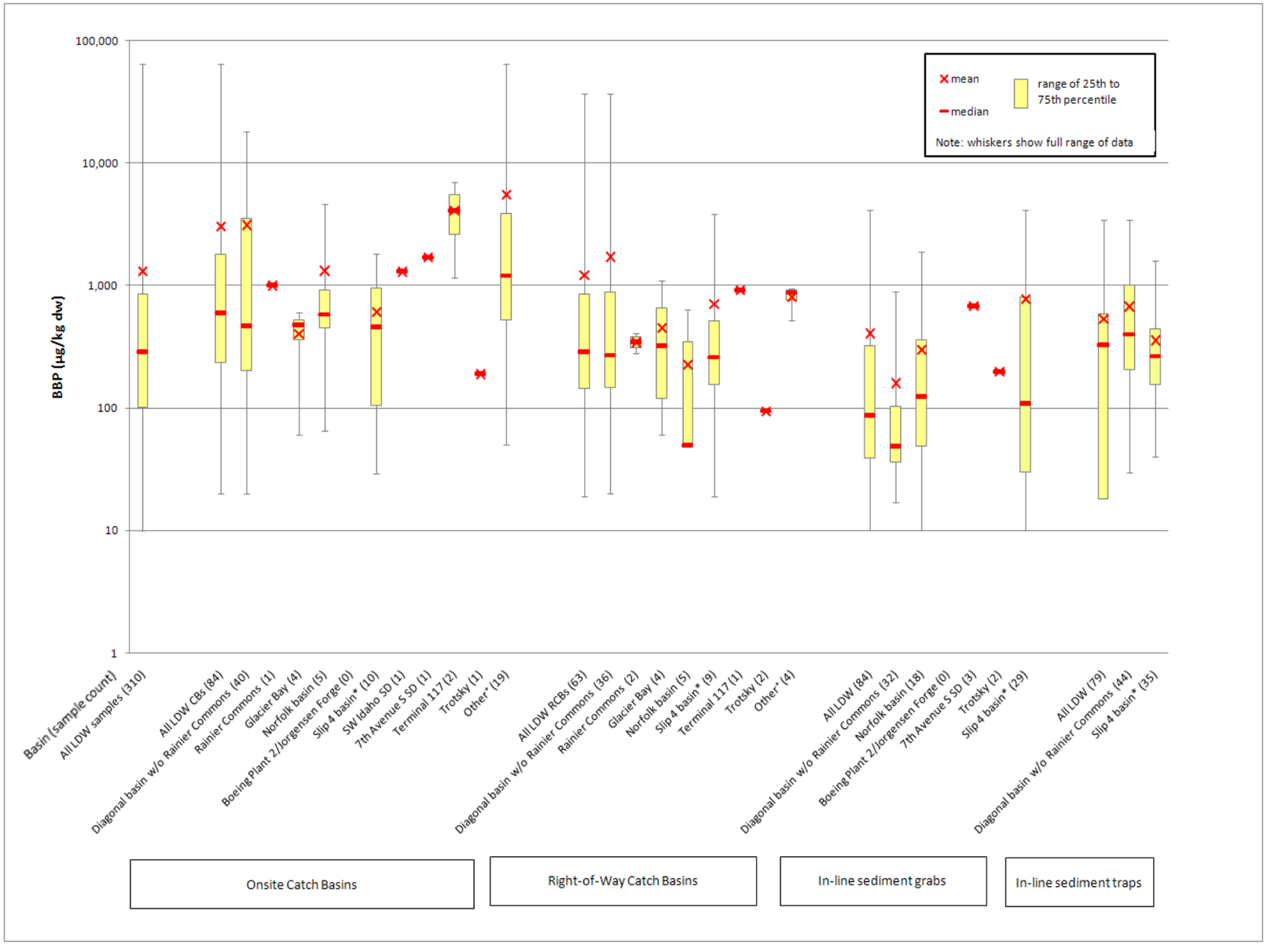


Note: Source tracing data presented in this figure reflect data collected through December 31, 2007 (Schmoyer 2008e). Independent QA/QC of raw data was not performed as part of the RI. LDW source control efforts are ongoing.

* Data from sub-basins within the Slip 4 drainage basin (i.e., Slip 4, NBF, KCIA, I-5, and adjacent properties) have been combined to calculate summary statistics (e.g., ranges, medians). Chemical concentrations within the sub-basins vary greatly. Maps 9-12 through 9-14 provide a spatial presentation of total PCBs, mercury, and BEHP concentrations, respectively.

+ Other samples include source tracing information associated with Slip 5, Slip 6, T-115, and the Chemithon Corporation property.

Figure 9-6. Total PCB source-tracing sample results

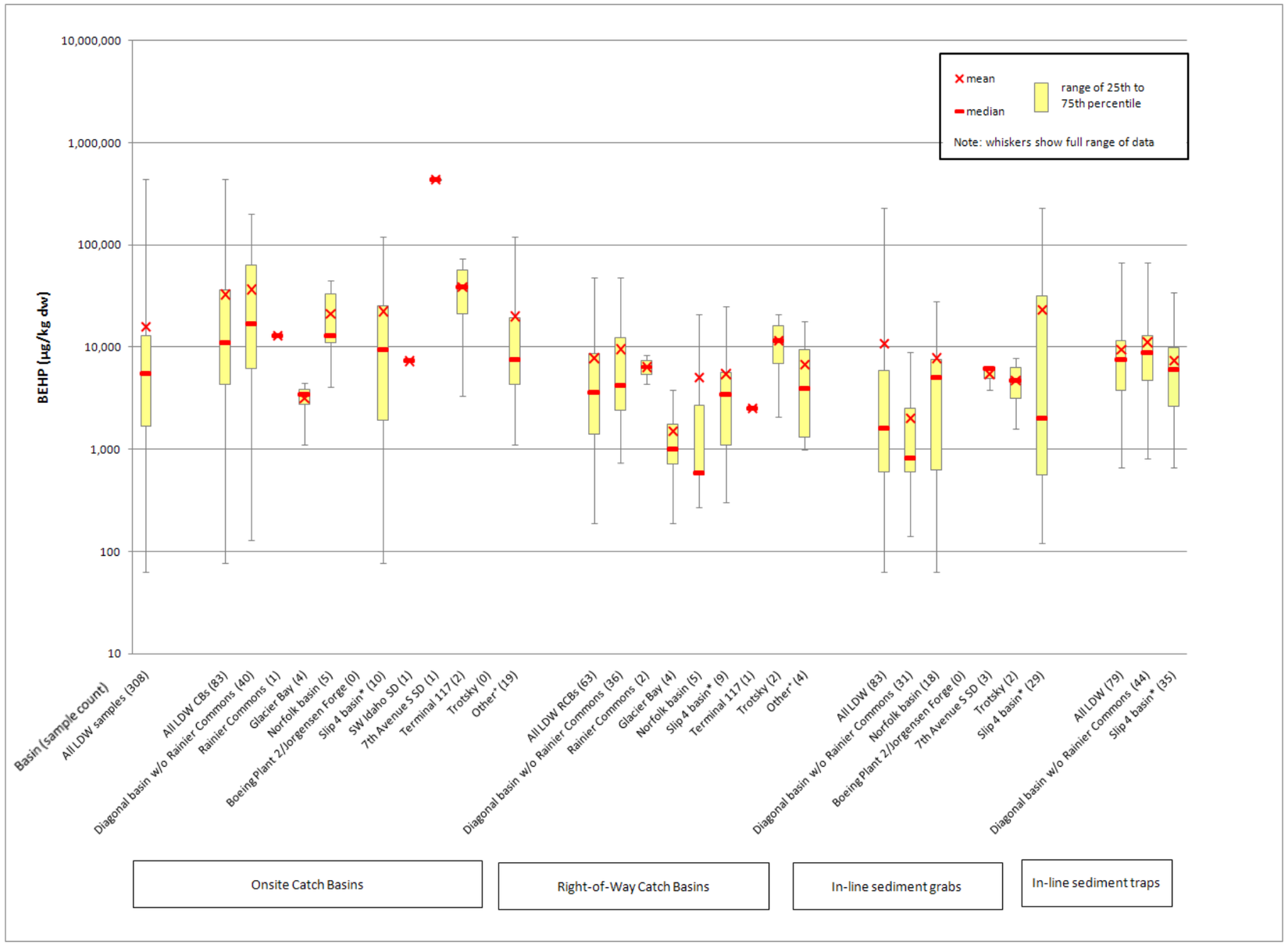


Note: Source tracing data presented in this figure reflect data collected through December 31, 2007 (Schmoyer 2008e). Independent QA/QC of raw data was not performed as part of the RI. LDW source control efforts are ongoing.

* Data from sub-basins within the Slip 4 drainage basin (i.e., Slip 4, NBF, KCIA, I-5, and adjacent properties) have been combined to calculate summary statistics (e.g., ranges, medians). Chemical concentrations within the sub-basins vary greatly. Maps 9-12 through 9-14 provide a spatial presentation of total PCBs, mercury, and BEHP concentrations, respectively.

+ Other samples include source tracing information associated with Slip 5, Slip 6, T-115, and the Chemithon Corporation property.

Figure 9-7. BBP source-tracing sample results

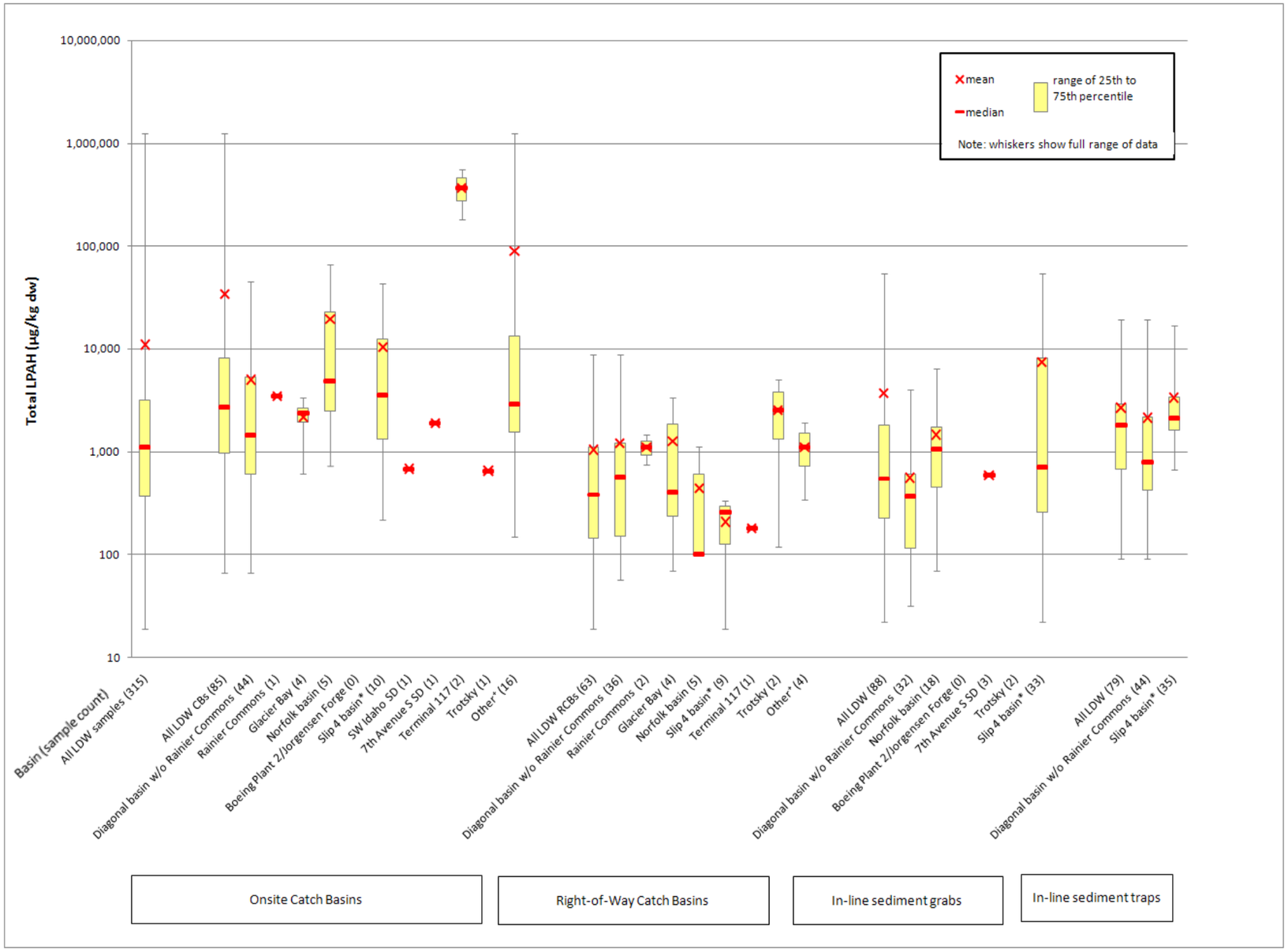


Note: Source tracing data presented in this figure reflect data collected through December 31, 2007 (Schmoyer 2008e). Independent QA/QC of raw data was not performed as part of the RI. LDW source control efforts are ongoing.

* Data from sub-basins within the Slip 4 drainage basin (i.e., Slip 4, NBF, KCIA, I-5, and adjacent properties) have been combined to calculate summary statistics (e.g., ranges, medians). Chemical concentrations within the sub-basins vary greatly. Maps 9-12 through 9-14 provide a spatial presentation of total PCBs, mercury, and BEHP concentrations, respectively.

+ Other samples include source tracing information associated with Slip 5, Slip 6, T-115, and the Chemithon Corporation property.

Figure 9-8. BEHP source-tracing sample results

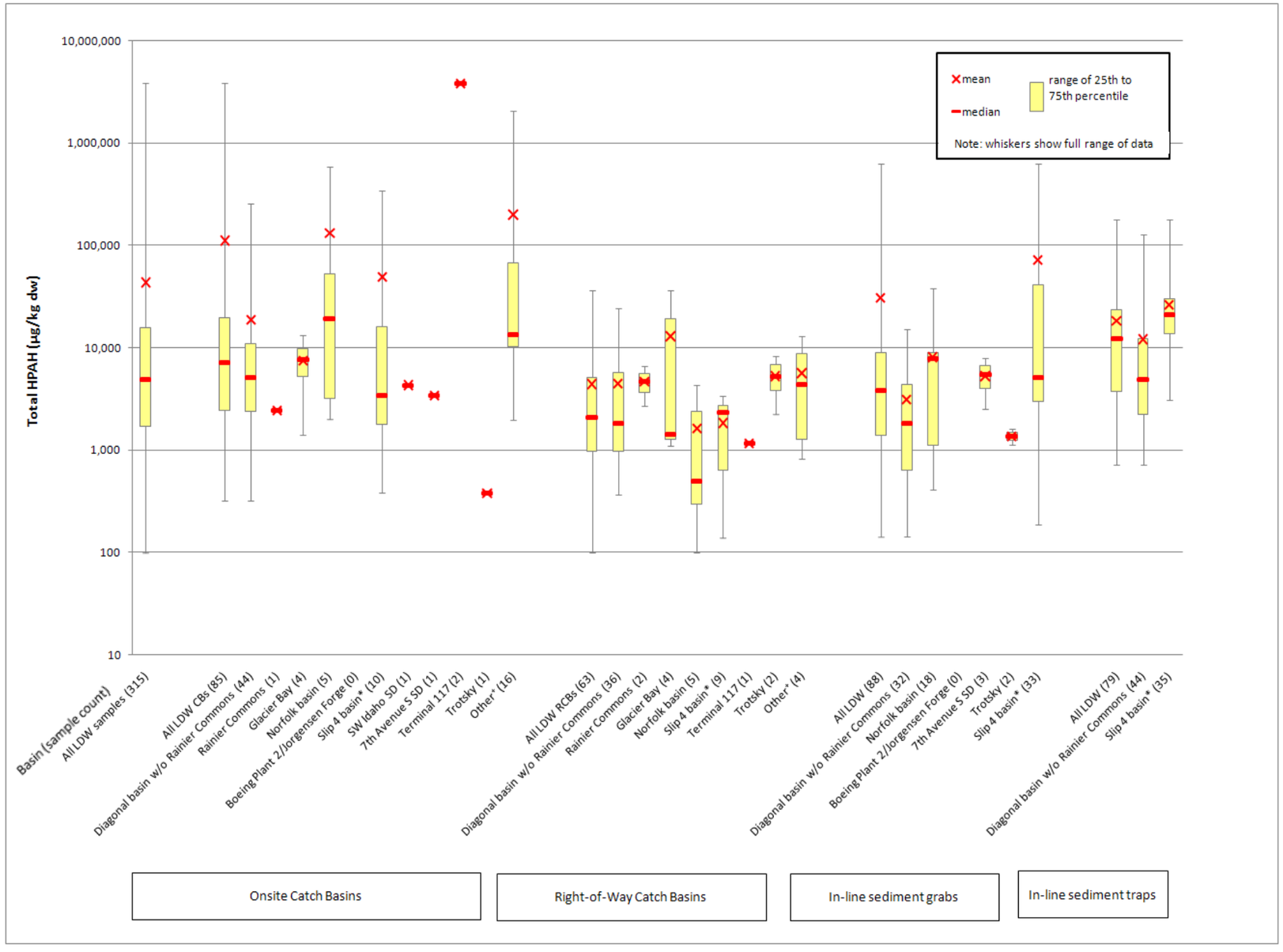


Note: Source tracing data presented in this figure reflect data collected through December 31, 2007 (Schmoyer 2008e). Independent QA/QC of raw data was not performed as part of the RI. LDW source control efforts are ongoing.

* Data from sub-basins within the Slip 4 drainage basin (i.e., Slip 4, NBF, KCIA, I-5, and adjacent properties) have been combined to calculate summary statistics (e.g., ranges, medians). Chemical concentrations within the sub-basins vary greatly. Maps 9-12 through 9-14 provide a spatial presentation of total PCBs, mercury, and BEHP concentrations, respectively.

+ Other samples include source tracing information associated with Slip 5, Slip 6, T-115, and the Chemithon Corporation property.

Figure 9-9. Total LPAH source-tracing sample results



Note: Source tracing data presented in this figure reflect data collected through December 31, 2007 (Schmoyer 2008e). Independent QA/QC of raw data was not performed as part of the RI. LDW source control efforts are ongoing.

* Data from sub-basins within the Slip 4 drainage basin (i.e., Slip 4, NBF, KCIA, I-5, and adjacent properties) have been combined to calculate summary statistics (e.g., ranges, medians). Chemical concentrations within the sub-basins vary greatly. Maps 9-12 through 9-14 provide a spatial presentation of total PCBs, mercury, and BEHP concentrations, respectively.

* Other samples include source tracing information associated with Slip 5, Slip 6, T-115, and the Chemithon Corporation property.

Figure 9-10. HPAH source-tracing sample results

Table 9-14. Summary of data for a subset of chemicals in source tracing samples by sample type and basin

Chemical[a]	Units	Sample Count[b]	Detection Frequency (%)	Range of Detected Concentrations	Percent > SQS and ≤ CSL[c]	Percent > CSL[c]
Onsite Catch Basins						
All LDW Onsite Catch Basins (82 to 271 samples)						
Arsenic	mg/kg dw	110	52%	3 – 330	1%	4%
Copper	mg/kg dw	84	100%	30 – 6,320	21%	0%
Lead	mg/kg dw	110	99%	10 – 15,300	5%	18%
Mercury	mg/kg dw	110	74%	0.02 – 49	3%	23%
Zinc	mg/kg dw	84	100%	55 – 3,940	49%	24%
Total PCBs	µg/kg dw	271	89%	16 – 2,600,000	9%	8%
BBP	µg/kg dw	84	71%	20 – 64,000	50%	13%
BEHP	µg/kg dw	83	100%	77 – 440,000	22%	61%
TPH-Oil	mg/kg dw	82	100%	52 – 390,000	na	na
Total LPAH	µg/kg dw	85	87%	67 – 1,253,000	5%	6%
Total HPAH	µg/kg dw	85	93%	320 – 3,830,000	12%	2%
Diagonal without Rainier Commons Onsite Catch Basins (39 to 44 samples)						
Arsenic	mg/kg dw	40	38%	3 – 40	0%	0%
Copper	mg/kg dw	40	100%	30 – 1,520	13%	0%
Lead	mg/kg dw	40	98%	10 – 5,830	5%	15%
Mercury	mg/kg dw	40	65%	0.02 – 2.05	3%	15%
Zinc	mg/kg dw	40	100%	55 – 3,940	47%	18%
Total PCBs	µg/kg dw	40	73%	18 – 3,200	5%	3%
BBP	µg/kg dw	40	70%	20 – 18,000	45%	15%
BEHP	µg/kg dw	40	100%	130 – 200,000	0%	88%
TPH-Oil	mg/kg dw	39	100%	52 – 250,000	na	na
Total LPAH	µg/kg dw	44	80%	67 – 44,860	2%	0%
Total HPAH	µg/kg dw	44	91%	320 – 256,800	5%	0%
Diagonal with Rainier Commons Onsite Catch Basins (1 to 4 samples)						
Arsenic	mg/kg dw	1	0%	15	0%	0%
Copper	mg/kg dw	1	100%	362	0%	0%
Lead	mg/kg dw	1	100%	430	0%	0%
Mercury	mg/kg dw	1	100%	1.51	0%	100%
Zinc	mg/kg dw	1	100%	1,810	0%	100%
Total PCBs	µg/kg dw	4	100%	19,800 – 2,200,000	0%	100%
BBP	µg/kg dw	1	100%	1,000	100%	0%
BEHP	µg/kg dw	1	100%	13,000	0%	100%
TPH-Oil	mg/kg dw	1	100%	3,400	na	na
Total LPAH	µg/kg dw	1	100%	3,451	0%	0%
Total HPAH	µg/kg dw	1	100%	2,436	0%	0%
Glacier Bay Onsite Catch Basins (4 samples)						
Arsenic	mg/kg dw	4	50%	15 – 30	0%	0%
Copper	mg/kg dw	4	100%	234 – 1,730	75%	0%
Lead	mg/kg dw	4	100%	10 – 120	0%	0%

Table 9-14, cont. Summary of data for a subset of chemicals in source tracing samples by sample type and basin

Chemical[a]	Units	Sample Count[b]	Detection Frequency (%)	Range of Detected Concentrations	Percent > SQS and ≤ CSL[c]	Percent > CSL[c]
Mercury	mg/kg dw	4	75%	0.02 – 0.07	0%	0%
Zinc	mg/kg dw	4	100%	167 – 1,360	50%	25%
Total PCBs	µg/kg dw	4	100%	37 – 810	25%	25%
BBP	µg/kg dw	4	100%	60 – 600	75%	0%
BEHP	µg/kg dw	4	100%	1,100 – 4,500	0%	75%
TPH-Oil	mg/kg dw	4	100%	410 – 2,100	na	na
Total LPAH	µg/kg dw	4	100%	604 – 3,370	0%	0%
Total HPAH	µg/kg dw	4	100%	1,390 – 13,190	25%	0%
Norfolk Basin Onsite Catch Basins (4 to 5 samples)						
Arsenic	mg/kg dw	5	40%	4 – 17	0%	0%
Copper	mg/kg dw	5	100%	44 – 164	0%	0%
Lead	mg/kg dw	5	100%	23 – 295	0%	0%
Mercury	mg/kg dw	5	40%	0.03 – 0.2	0%	0%
Zinc	mg/kg dw	5	100%	121 – 1,980	40%	20%
Total PCBs	µg/kg dw	5	20%	320	0%	0%
BBP	µg/kg dw	5	80%	65 – 4,600	40%	0%
BEHP	µg/kg dw	5	100%	4,100 – 45,000	40%	60%
TPH–Oil	mg/kg dw	4	100%	1,700 – 14,000	na	na
Total LPAH	µg/kg dw	5	100%	730 – 66,230	20%	0%
Total HPAH	µg/kg dw	5	100%	2,010 – 585,400	20%	0%
Boeing Plant 2/Jorgensen Forge Onsite Catch Basins (0 to 52 samples)						
Arsenic	mg/kg dw	22	77%	4 – 330	4%	14%
Copper	mg/kg dw	0	na	na	na	na
Lead	mg/kg dw	22	100%	14 – 15,300	9%	59%
Mercury	mg/kg dw	22	95%	0.03 – 49	9%	68%
Zinc	mg/kg dw	0	na	na	na	na
Total PCBs	µg/kg dw	52	94%	50 – 2,600,000	na[e]	na[e]
BBP	µg/kg dw	0	na	na	na	na
BEHP	µg/kg dw	0	na	na	na	na
TPH-Oil	mg/kg dw	0	na	na	na	na
Total LPAH	µg/kg dw	0	na	na	na	na
Total HPAH	µg/kg dw	0	na	na	na	na
Slip 4 Basin Onsite Catch Basins (10 to 140 samples)[d]						
Arsenic	mg/kg dw	10	80%	3 – 30	0%	0%
Copper	mg/kg dw	10	100%	52 – 6,320	20%	0%
Lead	mg/kg dw	10	100%	29 – 481	10%	0%
Mercury	mg/kg dw	10	90%	0.03 – 0.34	0%	0%
Zinc	mg/kg dw	10	100%	268 – 3,530	60%	30%
Total PCBs	µg/kg dw	140	96%	66 – 1,310,000	10%	0%
BBP	µg/kg dw	10	60%	29 – 1,800	40%	10%
BEHP	µg/kg dw	10	100%	77 – 120,000	0%	50%
TPH-Oil	mg/kg dw	10	100%	210 – 13,000	na	na
Total LPAH	µg/kg dw	10	80%	220 – 43,000	10%	0%
Total HPAH	µg/kg dw	10	100%	380 – 344,400	30%	0%

Table 9-14, cont. Summary of data for a subset of chemicals in source tracing samples by sample type and basin

Chemical[a]	Units	Sample Count[b]	Detection Frequency (%)	Range of Detected Concentrations	Percent > SQS and ≤ CSL[c]	Percent > CSL[c]
SW Idaho SD Onsite Catch Basins (0 to 4 samples)						
Arsenic	mg/kg dw	4	50%	4 – 11	0%	0%
Copper	mg/kg dw	0	na	na	na	na
Lead	mg/kg dw	4	100%	36 – 127	0%	0%
Mercury	mg/kg dw	4	50%	0.03 – 0.13	0%	0%
Zinc	mg/kg dw	0	na	na	na	na
Total PCBs	µg/kg dw	1	100%	223	0%	0%
BBP	µg/kg dw	1	100%	1,300	100%	0%
BEHP	µg/kg dw	1	100%	7,300	0%	100%
TPH-Oil	mg/kg dw	1	100%	1,700	na	na
Total LPAH	µg/kg dw	1	100%	680	0%	0%
Total HPAH	µg/kg dw	1	100%	4,310	0%	0%
7th Avenue S SD Onsite Catch Basins (1 sample)						
Arsenic	mg/kg dw	1	0%	na	0%	0%
Copper	mg/kg dw	1	100%	285	0%	0%
Lead	mg/kg dw	1	100%	40	0%	0%
Mercury	mg/kg dw	1	100%	0.05	0%	0%
Zinc	mg/kg dw	1	100%	392	0%	0%
Total PCBs	µg/kg dw	1	100%	810	0%	0%
BBP	µg/kg dw	1	100%	1,700	0%	0%
BEHP	µg/kg dw	1	100%	440,000	0%	100%
TPH-Oil	mg/kg dw	1	100%	390,000	na	na
Total LPAH	µg/kg dw	1	100%	1,900	0%	0%
Total HPAH	µg/kg dw	1	100%	3,400	0%	0%
Terminal 117 Onsite Catch Basins (2 to 3 samples)						
Arsenic	mg/kg dw	2	0%	10	0%	0%
Copper	mg/kg dw	2	100%	134 – 173	0%	0%
Lead	mg/kg dw	2	100%	98 – 428	0%	0%
Mercury	mg/kg dw	2	50%	0.04 – 0.11	0%	0%
Zinc	mg/kg dw	2	100%	711 – 830	100%	0%
Total PCBs	µg/kg dw	3	100%	140 – 6300	0%	0%
BBP	µg/kg dw	2	0%	1,150 – 7,000	100%	0%
BEHP	µg/kg dw	2	100%	3,300 – 74,000	0%	50%
TPH-Oil	mg/kg dw	2	100%	19,000 – 77,000	na	na
Total LPAH	µg/kg dw	2	100%	183,000 – 556,000	0%	100%
Total HPAH	µg/kg dw	2	50%	3,830,000	0%	50%
Trotsky Onsite Catch Basins (0 to 1 samples)						
Arsenic	mg/kg dw	1	0%	6	0%	0%
Copper	mg/kg dw	1	100%	146	0%	0%
Lead	mg/kg dw	1	100%	25	0%	0%
Mercury	mg/kg dw	1	0%	na	0%	0%
Zinc	mg/kg dw	1	100%	111	0%	0%
Total PCBs	µg/kg dw	1	100%	20	0%	0%
BBP	µg/kg dw	1	100%	190	100%	0%

Table 9-14, cont. Summary of data for a subset of chemicals in source tracing samples by sample type and basin

Chemical[a]	Units	Sample Count[b]	Detection Frequency (%)	Range of Detected Concentrations	Percent > SQS and ≤ CSL[c]	Percent > CSL[c]
BEHP	µg/kg dw	0	na	na	na	na
TPH-Oil	mg/kg dw	1	100%	4,600	na	na
Total LPAH	µg/kg dw	1	100%	650	0%	0%
Total HPAH	µg/kg dw	1	100%	380	0%	0%
Other Onsite Catch Basins (16 to 20 samples)[f]						
Arsenic	mg/kg dw	20	55%	3 – 150	5%	5%
Copper	mg/kg dw	20	100%	79 – 1,820	40%	0%
Lead	mg/kg dw	20	100%	47 – 1,760	0%	5%
Mercury	mg/kg dw	20	75%	0.03 – 9.4	5%	15%
Zinc	mg/kg dw	20	100%	271 – 3,290	50%	35%
Total PCBs	µg/kg dw	20	60%	16 – 7000	16%	21%
BBP	µg/kg dw	19	74%	50 – 64,000	53%	21%
BEHP	µg/kg dw	19	95%	1,100 – 120,000	5%	79%
TPH–Oil	mg/kg dw	19	100%	650 – 25,000	na	na
Total LPAH	µg/kg dw	16	100%	150 – 1,253,000	7%	20%
Total HPAH	µg/kg dw	16	94%	1,952 – 2,062,000	20%	7%
ROW Catch Basins						
All LDW ROW Catch Basins (62 to 73 samples)						
Arsenic	mg/kg dw	63	38%	3 – 30	0%	0%
Copper	mg/kg dw	62	100%	30 – 751	3%	0%
Lead	mg/kg dw	63	100%	10 – 1,370	0%	3%
Mercury	mg/kg dw	63	44%	0.02 – 1.46	0%	5%
Zinc	mg/kg dw	62	100%	73 – 966	27%	2%
Total PCBs	µg/kg dw	73	70%	19 – 23,000	2%	1%
BBP	µg/kg dw	63	75%	19 – 37,000	48%	3%
BEHP	µg/kg dw	63	98%	190 – 48,000	16%	43%
TPH-Oil	mg/kg dw	63	100%	360 – 18,000	na	na
Total LPAH	µg/kg dw	63	87%	19 – 8,900	0%	0%
Total HPAH	µg/kg dw	63	92%	99 – 36,520	0%	0%
Diagonal without Rainier Commons ROW Catch Basins (36 samples)						
Arsenic	mg/kg dw	36	31%	3 – 30	0%	0%
Copper	mg/kg dw	36	100%	38 – 751	3%	0%
Lead	mg/kg dw	36	100%	19 – 1,370	0%	3%
Mercury	mg/kg dw	36	44%	0.02 – 1.17	0%	6%
Zinc	mg/kg dw	36	100%	85 – 966	25%	3%
Total PCBs	µg/kg dw	36	61%	21 – 670	0%	0%
BBP	µg/kg dw	36	78%	20 – 37,000	41%	6%
BEHP	µg/kg dw	36	100%	740 – 48,000	8%	56%
TPH–Oil	mg/kg dw	36	100%	480 – 14,000	na	na
Total LPAH	µg/kg dw	36	92%	57 – 8,900	0%	0%
Total HPAH	µg/kg dw	36	94%	364 – 24,290	0%	0%
Diagonal with Rainier Commons ROW Catch Basins (2 to 6 samples)						
Arsenic	mg/kg dw	2	0%	na	0%	0%
Copper	mg/kg dw	2	100%	59 – 113	0%	0%

Table 9-14, cont. Summary of data for a subset of chemicals in source tracing samples by sample type and basin

Chemical[a]	Units	Sample Count[b]	Detection Frequency (%)	Range of Detected Concentrations	Percent > SQS and ≤ CSL[c]	Percent > CSL[c]
Lead	mg/kg dw	2	100%	61 – 62	0%	0%
Mercury	mg/kg dw	2	0%	na	0%	0%
Zinc	mg/kg dw	2	100%	189 – 213	0%	0%
Total PCBs	µg/kg dw	6	100%	160 – 23,000	0%	50%
BBP	µg/kg dw	2	100%	280 – 410	100%	0%
BEHP	µg/kg dw	2	100%	4,400 – 8,300	0%	100%
TPH-Oil	mg/kg dw	2	100%	1,200 – 3,500	na	na
Total LPAH	µg/kg dw	2	100%	750 – 1,448	0%	0%
Total HPAH	µg/kg dw	2	100%	2693 – 6,600	0%	0%
Glacier Bay ROW Catch Basins (4 samples)						
Arsenic	mg/kg dw	4	100%	7 – 20	0%	0%
Copper	mg/kg dw	4	100%	36 – 183	0%	0%
Lead	mg/kg dw	4	100%	11 – 402	0%	0%
Mercury	mg/kg dw	4	25%	0.09	0%	0%
Zinc	mg/kg dw	4	100%	78 – 635	25%	0%
Total PCBs	µg/kg dw	4	50%	43 – 58	0%	0%
BBP	µg/kg dw	4	75%	60 – 1,100	75%	0%
BEHP	µg/kg dw	4	100%	190 – 3,800	75%	0%
TPH-Oil	mg/kg dw	4	100%	370 – 1,700	na	na
Total LPAH	µg/kg dw	4	75%	69 – 3,320	0%	0%
Total HPAH	µg/kg dw	4	75%	1100 – 36,520	0%	0%
Norfolk Basin ROW Catch Basins (5 samples)						
Arsenic	mg/kg dw	5	20%	4 – 8	0%	0%
Copper	mg/kg dw	5	100%	29 – 98	0%	0%
Lead	mg/kg dw	5	100%	20 – 126	0%	0%
Mercury	mg/kg dw	5	0%	0.03 – 0.05	0%	0%
Zinc	mg/kg dw	5	100%	73 – 305	0%	0%
Total PCBs	µg/kg dw	5	20%	138	0%	0%
BBP	µg/kg dw	5	40%	50 – 640	20%	0%
BEHP	µg/kg dw	5	100%	270 – 21,000	0%	20%
TPH-Oil	mg/kg dw	5	100%	360 – 1,500	na	na
Total LPAH	µg/kg dw	5	60%	99 – 1,120	0%	0%
Total HPAH	µg/kg dw	5	100%	99 – 4,300	0%	0%
Slip 4 Basin ROW Catch Basins (8 to 16 samples)[d]						
Arsenic	mg/kg dw	8	63%	5 – 20	0%	0%
Copper	mg/kg dw	10	100%	38 – 720	10%	0%
Lead	mg/kg dw	9	100%	10 – 179	0%	0%
Mercury	mg/kg dw	9	67%	0.02 – 0.11	0%	0%
Zinc	mg/kg dw	9	100%	93 – 593	44%	0%
Total PCBs	µg/kg dw	16	100%	19 – 570	0%	0%
BBP	µg/kg dw	9	78%	19 – 3,800	56%	0%
BEHP	µg/kg dw	9	100%	300 – 25,000	34%	22%
TPH-Oil	mg/kg dw	9	100%	400 – 8,000	na	na
Total LPAH	µg/kg dw	9	89%	19 – 330	0%	0%

Table 9-14, cont. Summary of data for a subset of chemicals in source tracing samples by sample type and basin

Chemical[a]	Units	Sample Count[b]	Detection Frequency (%)	Range of Detected Concentrations	Percent > SQS and ≤ CSL[c]	Percent > CSL[c]
Total HPAH	µg/kg dw	9	100%	140 – 3,380	0%	0%
Terminal 117 ROW Catch Basins (1 sample)						
Arsenic	mg/kg dw	1	0%	na	0%	0%
Copper	mg/kg dw	1	100%	51	0%	0%
Lead	mg/kg dw	1	100%	22	0%	0%
Mercury	mg/kg dw	1	0%	na	0%	0%
Zinc	mg/kg dw	1	100%	237	0%	0%
Total PCBs	µg/kg dw	1	100%	310	0%	0%
BBP	µg/kg dw	1	100%	920	100%	0%
BEHP	µg/kg dw	1	100%	2,500	0%	0%
TPH-Oil	mg/kg dw	1	100%	4,100	na	na
Total LPAH	µg/kg dw	1	100%	180	0%	0%
Total HPAH	µg/kg dw	1	100%	1,160	0%	0%
Trotsky ROW Catch Basins (2 samples)						
Arsenic	mg/kg dw	2	100%	9 – 16	0%	0%
Copper	mg/kg dw	2	100%	141 – 254	0%	0%
Lead	mg/kg dw	2	100%	115 – 547	0%	50%
Mercury	mg/kg dw	2	100%	0.13 – 1.46	0%	50%
Zinc	mg/kg dw	2	100%	592 – 655	100%	0%
Total PCBs	µg/kg dw	2	100%	203 – 1650	50%	0%
BBP	µg/kg dw	2	50%	95	0%	0%
BEHP	µg/kg dw	2	100%	2,100 – 21,000	0%	50%
TPH-Oil	mg/kg dw	2	100%	4,600 – 18,000	na	na
Total LPAH	µg/kg dw	2	100%	120 – 4,990	0%	0%
Total HPAH	µg/kg dw	2	100%	2,266 – 8,320	0%	0%
Other ROW Catch Basins (2 to 5 samples)[f]						
Arsenic	mg/kg dw	5	20%	10	0%	0%
Copper	mg/kg dw	2	100%	85 – 157	0%	0%
Lead	mg/kg dw	4	100%	70 – 145	0%	0%
Mercury	mg/kg dw	4	75%	0.03 – 0.2	0%	0%
Zinc	mg/kg dw	3	100%	329 – 781	33%	0%
Total PCBs	µg/kg dw	4	50%	158 – 303	0%	0%
BBP	µg/kg dw	4	75%	520 – 950	75%	0%
BEHP	µg/kg dw	4	75%	1,000 – 18,000	25%	25%
TPH-Oil	mg/kg dw	4	100%	450 – 9,100	na	na
Total LPAH	µg/kg dw	4	75%	340 – 1,900	0%	0%
Total HPAH	µg/kg dw	4	100%	820 – 13,000	0%	0%
In-Line Sediment Grabs						
All LDW In-Line Sediment Grabs (81 to 208 samples)						
Arsenic	mg/kg dw	94	52%	2 – 590	1%	2%
Copper	mg/kg dw	91	100%	13 – 3,960	3%	0%
Lead	mg/kg dw	94	100%	10 – 47,200	2%	9%
Mercury	mg/kg dw	94	53%	0.01 – 3.3	2%	10%
Zinc	mg/kg dw	87	100%	40 – 9,980	26%	13%

Table 9-14, cont. Summary of data for a subset of chemicals in source tracing samples by sample type and basin

Chemical[a]	Units	Sample Count[b]	Detection Frequency (%)	Range of Detected Concentrations	Percent > SQS and ≤ CSL[c]	Percent > CSL[c]
Total PCBs	µg/kg dw	208	86%	20 – 10,000,000	10%	10%
BBP	µg/kg dw	84	40%	10 – 4,090	30%	1%
BEHP	µg/kg dw	83	100%	63 – 232,000	19%	47%
TPH-Oil	mg/kg dw	81	100%	61 – 81,000	na	na
Total LPAH	µg/kg dw	88	84%	22 – 53,560	5%	1%
Total HPAH	µg/kg dw	88	98%	143 – 629,900	13%	2%
Diagonal Basin In-Line Sediment Grabs (31 to 33 samples)						
Arsenic	mg/kg dw	33	12%	3 – 23	0%	0%
Copper	mg/kg dw	33	100%	22 – 340	0%	0%
Lead	mg/kg dw	33	100%	15 – 4,910	0%	9%
Mercury	mg/kg dw	33	18%	0.01 – 3.3	0%	9%
Zinc	mg/kg dw	33	100%	85 – 718	18%	0%
Total PCBs	µg/kg dw	32	44%	20 – 940	3%	0%
BBP	µg/kg dw	32	34%	17 – 900	25%	0%
BEHP	µg/kg dw	31	100%	140 – 8,900	25%	52%
TPH-Oil	mg/kg dw	32	100%	110 – 13,000	na	na
Total LPAH	µg/kg dw	32	84%	32 – 4,000	0%	0%
Total HPAH	µg/kg dw	32	97%	143 – 15,300	6%	0%
Norfolk Basin In-Line Sediment Grabs (16 to 20 samples)						
Arsenic	mg/kg dw	20	70%	3 – 120	0%	5%
Copper	mg/kg dw	20	100%	20 – 3,960	5%	0%
Lead	mg/kg dw	20	100%	16 – 700	0%	5%
Mercury	mg/kg dw	20	55%	0.02 – 0.4	0%	0%
Zinc	mg/kg dw	20	100%	90 – 9,980	35%	15%
Total PCBs	µg/kg dw	18	78%	25 – 150	0%	0%
BBP	µg/kg dw	18	33%	10 – 1,900	33%	0%
BEHP	µg/kg dw	18	100%	63 – 28,000	0%	56%
TPH-Oil	mg/kg dw	16	100%	180 – 5,300	na	na
Total LPAH	µg/kg dw	18	78%	70 – 6,390	0%	0%
Total HPAH	µg/kg dw	18	94%	410 – 37,790	0%	0%
Boeing Plant 2/Jorgensen Forge In-Line Sediment Grabs (0 to 10 samples)						
Arsenic	mg/kg dw	3	100%	8 – 590	34%	33%
Copper	mg/kg dw	0	na	na	na	na
Lead	mg/kg dw	3	100%	52 – 47,200	0%	67%
Mercury	mg/kg dw	3	100%	1.37 – 3.24	0%	100%
Zinc	mg/kg dw	0	na	na	na	na
Total PCBs	µg/kg dw	10	100%	130 – 100,00,000	nc[e]	nc[e]
BBP	µg/kg dw	0	na	na	na	na
BEHP	µg/kg dw	0	na	na	na	na
TPH-Oil	mg/kg dw	0	na	na	na	na
Total LPAH	µg/kg dw	0	na	na	na	na
Total HPAH	µg/kg dw	0	na	na	na	na
7th Avenue S SD In-Line Sediment Grabs (3 samples)						
Arsenic	mg/kg dw	3	100%	20 – 30	0%	0%

Table 9-14, cont. Summary of data for a subset of chemicals in source tracing samples by sample type and basin

Chemical[a]	Units	Sample Count[b]	Detection Frequency (%)	Range of Detected Concentrations	Percent > SQS and ≤ CSL[c]	Percent > CSL[c]
Copper	mg/kg dw	3	100%	129 – 175	0%	0%
Lead	mg/kg dw	3	100%	119 - 151	0%	0%
Mercury	mg/kg dw	3	100%	0.17 - 0.2	0%	0%
Zinc	mg/kg dw	3	100%	515 - 575	100%	0%
Total PCBs	µg/kg dw	3	100%	119 - 440	0%	0%
BBP	µg/kg dw	3	33%	680	33%	0%
BEHP	µg/kg dw	3	100%	3,800 – 6,400	0%	67%
TPH-Oil	mg/kg dw	3	100%	1,900 – 3,100	na	na
Total LPAH	µg/kg dw	3	33%	590	0%	0%
Total HPAH	µg/kg dw	3	100%	2,530 - 7,880	0%	0%
Trotsky In-Line Sediment Grabs (2 samples)						
Arsenic	mg/kg dw	2	100%	11 - 23	0%	0%
Copper	mg/kg dw	2	100%	99 - 105	0%	0%
Lead	mg/kg dw	2	100%	87 - 113	0%	0%
Mercury	mg/kg dw	2	50%	0.06	0%	0%
Zinc	mg/kg dw	2	100%	394 - 444	50%	0%
Total PCBs	µg/kg dw	2	100%	122 - 250	0%	0%
BBP	µg/kg dw	2	50%	200	0%	0%
BEHP	µg/kg dw	2	100%	1,600 – 7,800	0%	50%
TPH-Oil	mg/kg dw	2	100%	3,100 – 3,900	na	na
Total LPAH	µg/kg dw	2	0%	na	0%	0%
Total HPAH	µg/kg dw	2	100%	1,130 – 1,600	0%	0%
Slip 4 Basin In-Line Sediment Grabs (28 to 143 samples)[d]						
Arsenic	mg/kg dw	33	70%	2 – 40	0%	0%
Copper	mg/kg dw	33	100%	13 – 1,550	6%	0%
Lead	mg/kg dw	33	100%	10 – 744	6%	6%
Mercury	mg/kg dw	33	79%	0.02 – 1.7	6%	9%
Zinc	mg/kg dw	29	100%	40 – 1,880	20%	28%
Total PCBs	µg/kg dw	143	95%	38 – 1,200,000	21%	27%
BBP	µg/kg dw	29	52%	10 – 4,090	31%	3%
BEHP	µg/kg dw	29	100%	120 – 232,000	28%	34%
TPH-Oil	mg/kg dw	28	100%	61 – 81,000	na	na
Total LPAH	µg/kg dw	33	100%	22 – 53,560	12%	3%
Total HPAH	µg/kg dw	33	100%	185 – 629,900	27%	6%
In-Line Sediment Traps						
All LDW In-Line Sediment Traps (68 to 98 samples)						
Arsenic	mg/kg dw	86	40%	3 – 70	1%	0%
Copper	mg/kg dw	86	100%	4 – 640	5%	0%
Lead	mg/kg dw	86	100%	4 – 1,070	1%	5%
Mercury	mg/kg dw	86	71%	0.02 – 8.3	1%	20%
Zinc	mg/kg dw	86	100%	30 – 2,460	45%	12%
Total PCBs	µg/kg dw	98	96%	22 – 800,000	14%	5%
BBP	µg/kg dw	79	70%	30 – 3,400	41%	0%
BEHP	µg/kg dw	79	100%	670 – 67,000	13%	63%

Table 9-14, cont. Summary of data for a subset of chemicals in source tracing samples by sample type and basin

Chemical[a]	Units	Sample Count[b]	Detection Frequency (%)	Range of Detected Concentrations	Percent > SQS and ≤ CSL[c]	Percent > CSL[c]
TPH-Oil	mg/kg dw	68	100%	120 – 7,500	na	na
Total LPAH	µg/kg dw	79	97%	90 – 19,350	1%	0%
Total HPAH	µg/kg dw	79	100%	720 – 180,300	3%	0%
Diagonal Basin In-Line Sediment Traps (42 to 45 samples)						
Arsenic	mg/kg dw	45	22%	3 – 25	0%	0%
Copper	mg/kg dw	45	100%	7 – 597	4%	0%
Lead	mg/kg dw	45	100%	29 – 360	0%	0%
Mercury	mg/kg dw	45	62%	0.03 – 2.8	0%	4%
Zinc	mg/kg dw	45	100%	162 – 1,930	42%	7%
Total PCBs	µg/kg dw	45	96%	27 – 3,250	0%	2%
BBP	µg/kg dw	44	80%	30 – 3,400	48%	0%
BEHP	µg/kg dw	44	100%	820 – 67,000	13%	73%
TPH-Oil	mg/kg dw	42	100%	120 – 7,500	na	na
Total LPAH	µg/kg dw	44	95%	90 – 19,350	0%	0%
Total HPAH	µg/kg dw	44	100%	720 – 127,580	2%	0%
Slip 4 Basin In-Line Sediment Traps (26 to 53 samples)[d]						
Arsenic	mg/kg dw	41	59%	3 – 70	2%	0%
Copper	mg/kg dw	41	100%	4 – 640	5%	0%
Lead	mg/kg dw	41	100%	4 – 1,070	2%	10%
Mercury	mg/kg dw	41	80%	0.02 – 8.3	2%	37%
Zinc	mg/kg dw	41	100%	30 – 2,460	49%	17%
Total PCBs	µg/kg dw	53	96%	38 – 800,000	15%	33%
BBP	µg/kg dw	35	57%	40 – 1,600	31%	0%
BEHP	µg/kg dw	35	100%	670 – 34,000	12%	51%
TPH–Oil	mg/kg dw	26	100%	410 – 7,500	na	na
Total LPAH	µg/kg dw	35	100%	668 – 16,700	4%	0%
Total HPAH	µg/kg dw	35	77%	3,084 – 180,300	4%	0%

Note: Source tracing data presented in this table reflect data collected through December 31, 2007 (Schmoyer 2008e). Independent QA/QC of raw data was not performed as part of the RI LDW source control efforts are on-going.

[a] Total PCBs, total LPAH, and total HPAH concentrations were calculated using detected concentrations only.

[b] Number of samples per sample type may vary because of insufficient sample volume (i.e., not all samples per sample type were analyzed for all listed chemicals).

[c] For organic compounds with OC-normalized SMS criteria, percentages of samples with concentrations above the SQS and the CSL were based on the number of detected samples for which TOC information was available. Detection frequencies were based on the total number of samples collected in each sub-basin per media type.

[d] Data from sub-basins within the Slip 4 drainage basin (i.e., Slip 4, NBF, KCIA, I-5, and adjacent properties) have been combined to calculate summary statistics (e.g., ranges, medians). Chemical concentrations within the sub-basins vary greatly. Maps 9-12 through 9-14 provide a spatial presentation of total PCBs, mercury, and BEHP concentrations, respectively.

[e] TOC information not available for comparison with SMS.

[f] Other samples include those collected in association with Slip 5, Slip 6, T-115, and the Chemithon corporation property.

BEHP – bis(2-ethylhexyl) phthalate
BBP – butyl benzyl phthalate
CSL – cleanup screening level
HPAH – high molecular weight polycyclic aromatic hydrocarbon
LDW – Lower Duwamish Waterway
LPAH – low molecular weight polycyclic aromatic hydrocarbon
na – not applicable
nc – not calculated
NBF – North Boeing Field
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
ROW – right-of-way
SD – storm drain
SQS – sediment quality standards
T-115 – Terminal 115

Catch Basin Cleaning and Performance Results

In addition to sampling catch basins, the City of Seattle has a maintenance program that routinely cleans catch basins in the public ROWs. Street dirt can contain chemicals such as metals, petroleum hydrocarbons, and other organic chemicals associated with motor vehicles. These chemicals often adsorb onto particulate material and are transported along with suspended solids present in stormwater runoff.

Although catch basins are primarily designed to prevent storm drains from becoming plugged by trapping large debris and solids, some of the particulate-bound chemicals can also be removed in catch basins. At the start of the LDW source control effort, SPU prioritized cleaning of catch basins in the Diagonal Avenue S CSO/SD drainage basin (shown in Map 9-1). In 2006, SPU cleaned catch basins and jetted the storm drain lines located in the public ROW in the 7th Avenue S storm drain system located in the South Park neighborhood (see Maps 9-1 and 9-10). SPU cleaned all the ROW catch basins in the Diagonal Avenue S CSO/SD storm drain basin between August 2007 and March 2008.

Diagonal Avenue S CSO/SD Cleanout Program Performance

In 2002, SPU collected in-line sediment samples from the Diagonal Avenue S CSO/SD as part of an agreement with the Elliott Bay Duwamish Restoration Panel to characterize sediment discharged from this system to the LDW. Sampling was conducted in the lower part of the drainage system, below 4th Avenue S (Map 9-15). Concentrations of lead, mercury, zinc, BEHP, BBP, and PAHs in sediment collected from the main-line on Diagonal Avenue S were greater than the SQS in one or more samples. Concentrations of lead, mercury, zinc, BEHP, BBP, and PCBs in sediment collected from the drainage laterals of the system were greater than the SQS in one or more samples.

From 2002 to 2004, the City of Seattle cleaned portions of the Diagonal Avenue S CSO/SD main-line as well as several of the lateral lines. Approximately 6,200 linear feet (LF) of pipe were cleaned and an estimated 300 cubic yards (cy) of sediments were removed. Since the cleaning was completed, SPU has collected four in-line sediment grabs and six in-line sediment trap samples from a station located on the main-line at the lower end of the drainage system (location M1 on Map 9-15).

In the in-line sediment grab samples, BEHP concentrations were lower than in samples collected prior to cleanout; however, concentrations were still greater than the SQS in three of the four samples. The concentration of BBP was greater than the SQS in one of the grab samples, and the concentration of dimethyl phthalate was greater than the CSL in one sample. The 1,4-dichlorobenzene concentration was greater than the CSL in the first grab sample collected after the pipe was cleaned, but subsequent samples had concentrations below the SQS.

Chemical concentrations in the in-line sediment traps remained fairly consistent from 2003 through 2007 (before and after the cleanout). With the exception of zinc, metals concentrations have been relatively low and generally less than the SQS. Zinc concentrations were greater than the SQS in about half of the sediment trap samples, and greater than the CSL in three samples. BEHP concentrations continue to be above SMS criteria in the trap samples, with concentrations greater than the SQS in about 70% of the in-line trap samples. PAH concentrations in the traps remain low, with HPAH concentrations greater than the SQS in one sample, and LPAH concentrations lower than the SQS in all samples. One of the 45 sediment trap samples collected to date exceeded the SQS criterion for total PCBs.

Storm drain lines and catch basins on the Rainier Commons property[148] (which is within the Diagonal Avenue S CSO/SD basin) were cleaned in 2008 after SPU traced the presence of PCBs in a catch basin to the property in 2004. The source of the PCBs was identified as the exterior building paint that contained approximately 2,300 mg/kg dw PCBs (Vernon Environmental 2006). The buildings were pressure washed and repainted, and the storm drain lines and catch basins on the property were subsequently cleaned. At the same time, SPU cleaned the drain lines on Airport Way S immediately downstream of the property to remove any residual PCB contamination. SPU plans to resample the catch basins in the area after sufficient sediment has accumulated, to confirm whether the source of PCBs has been adequately controlled.

Norfolk CSO/SD Cleanout Program Performance

SPU collected in-line sediment samples in the Norfolk system along Martin Luther King, Jr., Way S before and after the drain lines and catch basins (Map 9-16) were cleaned in the summer of 2005 to remove accumulated sediment in advance of drainage improvements. The initial in-line sediment samples were collected in 2003 and 2005, and were used to evaluate sediment disposal options for the cleaning project. Of the 11 in-line sediment samples, the zinc concentrations were greater than the SQS and the CSL in 8 and 4 samples, respectively. BEHP concentrations were greater than the CSL in 6 of the 14 samples.

RoseWater (2007) collected additional in-line samples in 2007 as part of an investigation to determine the cause of the high rate of sediment deposition observed in the lines. The samples contained lower concentrations of zinc (105 to 603 mg/kg) than did the samples prior to cleanout, but continued to have elevated concentrations of BEHP.

Boeing Plant 2 Storm Drain Cleanout Program

In 2005, Boeing adopted a systematic approach to source control, beginning with an evaluation of the chemical quality of the suspended solids in stormwater discharged

[148] The Rainier Commons property is occupied by Tully's Coffee.

to the LDW via the Boeing Plant 2 storm water system. Based on sampling of catch basin solids, the evaluation in 2005 identified storm drains with the potential to discharge suspended solids with PCBs and/or SMS metals at concentrations above the CSL. In response to high concentrations of PCBs in two of the storm drains, Boeing removed contaminated solids from these storm drains and blocked further discharge of stormwater to them. The two inactive storm drains (X and Y) were fully decommissioned in 2006.

Between late 2006 and early 2008, Boeing completed two "wet season" rounds of in-line sampling of suspended solids in the five remaining storm drains that were identified as being of interest. The sampling was conducted by pumping and filtering large quantities of stormwater as it passed through downgradient manhole locations prior to discharge. The collection and analyses of the solids was conducted in accordance with EPA-approved work plans. Depending on chemical concentrations in the collected solids, further source control measures would be implemented to control potential sources of contamination. Total PCB concentrations in the solids collected from four of the five storm drains were greater than the 2AET,[149] with an average concentration of 2.8 mg/kg dw. Concentrations of metals were variable, with some CSL exceedances of copper, cadmium, chromium, lead, mercury, and zinc.

During summer 2008, Boeing began cleaning a majority of the Plant 2 storm drain systems that primarily drain pavement areas. As of mid-October 2008, approximately 21,600 LF of pipe and 343 catch basins and manholes had been cleaned, an estimated 80 cy of sediments had been removed, and 231 geotextile inserts had been installed in catch basins to reduce the amount of sediment entering the systems. Weather permitting, storm drain cleaning will likely be completed during November 2008, at which time a total of approximately 27,000 LF of pipe and 400 catch basins and manholes will have been cleaned, and 270 geotextile inserts will have been installed. Round 3 of source control sampling is scheduled to begin in November 2008.

North Boeing Field Storm Drain System Cleanout Information

Regular inspection and cleaning of the storm drain system at North Boeing Field (NBF), including manholes, catch basins, and oil/water separators, is conducted by Boeing, usually on an annual basis. In addition, the storm drain system, including piping, has been cleaned on at least three occasions since the mid-1980s.

As a result of the discovery of PCBs in the Georgetown Steam Plant flume and in portions of the storm drain system at NBF, portions of the storm drain system at NBF near the Georgetown Steam Plant were cleaned in 1985 by Seattle City Light (Seattle City Light 1985). Additional storm drain system cleaning was performed in this area by Boeing in 1986 (The Boeing Company 1986).

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[149] TOC was not analyzed, so comparison with the CSL, which is expressed on an OC-normalized basis, was not possible.

In 1992, approximately 60% of the 7 mi of storm drain system piping, 90 percent of the over 400 manholes, and 81 percent of the over 400 catch basins of the NBF storm drain system were cleaned by Boeing. Problems encountered during the cleaning process, including excess water, blockage problems, and obstructed access, prevented the cleaning of the remainder of the storm drain system (Landau Associates 1993).

Another major storm drain system cleaning event was conducted by Boeing between 2005 and 2008. Storm drain system piping, catch basins, and manholes were pressure washed, an oil/water separator near the Georgetown Steam Plant was decommissioned, and portions of the storm drain system were replaced or were lined with cured-in-place pipe.

Sediment traps installed at seven locations at NBF in 2005 have been sampled periodically by Boeing. Concentrations of PCBs in sediment trap samples collected in 2008 have decreased substantially compared with prior sediment trap samples. In March 2008, total PCB concentrations in the solids collected within these seven sediment traps ranged from 0.42 to 16 mg/kg dw.

Boeing Developmental Center South Storm Drain Cleanout Program

The south storm drain from the Boeing Developmental Center discharges near the Norfolk CSO/SD. PCBs were detected in surface sediments on the cap placed offshore of the Norfolk CSO/SD during post-removal monitoring and raised concerns regarding the potential for recontamination of the clean cap material. Subsequent sampling events and source control evaluations conducted by King County, Ecology, and Boeing indicated that surface sediment in a small area inshore of the Norfolk cap and near the south storm drain outfall had PCB concentrations above SMS criteria and there was concern that erosion of these sediments could potentially contribute to recontamination of the Norfolk cap. Under the MTCA Voluntary Cleanup Program (VCP), Boeing completed sediment sampling to define the extent of PCBs above the SMS criteria and performed sediment removal work in this area (near the south storm drain). As part of this overall project, Boeing conducted source control investigation and elimination efforts within the upland areas of the south storm drain system. Source control for the project has been implemented in sequential phases, beginning with sampling and characterization of upland areas in the southern portion of the Boeing Developmental Center, followed by cleanout of the south storm drain system, installation of a sediment trap/oil-water separator located above the storm drain outfall, and performance monitoring.

Sampling of construction materials in the upland area (including samples of paint, roofing materials, catch basin solids, joint caulking compounds, and other materials in the immediate area) did not identify any materials that could provide an ongoing source of PCBs to the storm drain (Project Performance Corporation 2001).

Given the PCB concentrations detected in selected side-wall samples from the south storm drain, Boeing decided to implement the storm drain cleanout project, which was

completed in August 2002 (Project Performance Corporation 2002; as cited in Ecology and Environment 2007a). Approximately 500 ft of 24-in.-diameter concrete pipe was cleaned by jet-rodding. The jet-rod cleaning provides multiple (~15) radial water jets at ~ 2,000 psi to remove sidewall scum from the pipe interior. The quantity of sludge removed was estimated at less than 3 cy. Following completion of the drain system cleaning, a video camera was run through the storm drain line. The video inspection indicated that the pressure-washing technique was effective in removing all of the material from the storm drain pipe, including the side-wall scum accumulated on pipe interior walls, except in one section of the pipe, which was subsequently cleaned at the same time as installation of the stormwater treatment vault. A Vortechs® 9000 unit (stormwater treatment vault) was installed in August 2003 (Landau 2004). The Vortechs® 9000 unit is approved by Ecology as a pretreatment technology for removal of total suspended solids from stormwater runoff (Ecology 2007d). Following installation of the sediment trap, Boeing completed a sediment removal action in the area of the south storm drain outfall in September 2003 (Project Performance Corporation 2003); contaminated sediments were first removed and the area was then capped with clean fill material.

Subsequent to the work noted above, Boeing has completed annual monitoring of both surface sediments on the cap placed just offshore of the south storm drain (2004 to 2009) and solids in the storm drain (2004 to 2008) (CALIBRE 2005, 2006, 2007, 2008, 2009). Total PCB concentrations in surface sediments on the cap have remained consistently low from 2004 through 2009 (all represent samples collected after cleanout of the storm drain) and have generally been below the SQS (16 out of 20 samples were below the SQS, and the maximum was less than 2 times the SQS, over 5 years of sampling); total PCBs were undetected at all three cap stations in the most recent round of sampling. Total PCB concentrations in solids collected from a filter bag deployed in a manhole downstream of the Vortechs® 9000 unit have decreased from a maximum of 12.6 mg/kg dw in 2005 to 2.28 mg/kg dw in 2007 (no sample was collected downstream of the Vortechs® 9000 unit in 2008 because the filter bag had become detached and washed away). The mass loading of total PCBs from this source to the LDW has been estimated to be $\leq$0.55 g/year in each of the 5 years with data (CALIBRE 2009).

Key Manhole Sampling

King County regularly samples wastewater at key locations in the sewer system that lead to the wastewater treatment plant. Week-long composite sampling is conducted twice per year (during a wet season and a dry season) at three pump stations in the LDW drainage basin: W Marginal Way SW, Duwamish, and E Marginal Way S (near Slip 4). In 2003, King County began analyzing samples for phthalates in addition to metals in wastewater samples. Data are available for samples collected in September 2003 (dry season), April 2004 (wet season), and September 2004 (dry season) for phthalates. Key conclusions for the phthalates were (King County and SPU 2005):

- Concentrations of BEHP (2 to 14 µg/L) in the wet season samples collected from the E Marginal Way S and Duwamish pump stations in April of 2004, were within the range of concentrations typically detected in stormwater samples (1 to 16 µg/L).
- In September 2003, samples collected from the W Marginal Way SW pump station contained a significantly higher BEHP concentration (148 µg/L) than the other two stations (mean ~ 5 µg/L).
- Other phthalates detected in the key manhole samples included BBP (100% of samples), diethylphthalate (97% of samples), di-n-butylphthalate (25% of samples), and dimethylphthalate (1% of samples).

Street Sweeping Pilot Program

In 2006, the City of Seattle implemented a pilot project to evaluate street sweeping as a tool to reduce the amount of pollutants discharged to area receiving water bodies (SPU and Herrera 2009). The pilot test was conducted using regenerative air sweepers at two residential test sites (West Seattle and Southeast Seattle-Columbia City) and one industrial site in the Diagonal/Duwamish drainage basin. Testing began in the residential areas in June 2006 and concluded in June 2007. In the industrial area, testing began in November 2006 and concluded in June 2007. At each site, a 10 to 25 block area was divided into a control area and a test area. In the test area, each side of the street was swept on alternating weeks, but the control area was not swept. Catch basin sediment, sweeper waste, and street dirt accumulations were measured every month from the test and control areas to determine the quantity of material removed by the sweeping effort. Samples of each media type (e.g., catch basin sediment, sweeper waste, and street dirt) were also collected every month and composited each quarter for chemical analysis of metals, SVOCs, PCBs, grain size, and organic carbon.

Test results showed that street sweeping was effective in removing about 2,200 to 3,100 pounds of material per acre of street swept per year. The largest amount of sediment was removed in the Diagonal/Duwamish test site. Similarly, sweeping was effective in reducing the amount of dirt present on the street. Average monthly reductions in street dirt mass were 74, 90, and 48% at the West Seattle, Southeast Seattle, and Diagonal/Duwamish test sites, respectively.

Concentrations of most chemicals (metals, petroleum hydrocarbons, phthalates, and PCBs) were higher in the catch basin samples than in the street dirt and sweeper waste. The highest concentrations were generally detected in the catch basin samples collected from the Diagonal/Duwamish test site. Overall, PCBs were detected in less than 50% of all the samples, with most detections occurring in samples collected from the Diagonal/Duwamish site (SPU and Herrera 2009).

In addition to measuring mass removal rates and quantities, the pilot test was also conducted to evaluate whether street sweeping reduces the rate of sediment accumulation in catch basins, and thereby reduces the frequency that catch basins need to be cleaned. The results indicate that catch basins are relatively ineffective in removing sediment. Over the course of the pilot test, the mass of sediment accumulated in the catch basins accounted for only about 5 to 15% of the total mass removed from the streets. Sweeping did not significantly affect the amount or rate of sediment accumulation in catch basins. The final report (SPU and Herrera 2009) is available on SPU's website.

9.4.5 Spills and leaks

Spills and leaks may enter the LDW through various pathways. This section provides information on data resources for leaks and spills in the LDW drainage basin.

9.4.5.1 Available spill data

Ecology receives spill reports, which are tracked through ERTS, and placed on the Spills Program database. Records of spills in the LDW drainage area currently listed on Ecology's Spills database are listed in Table G-14 in Appendix G. In addition to responding to spills, Ecology regularly refers reports of spills within the LDW area to SPU or the USCG for response.[150] Records of SPU spill responses are included in Table G-15 in Appendix G.

Three significant known historical spills have been reported. One spill occurred at the Duwamish/Diagonal SD. This spill was reportedly an oil spill that originated at a sump at the Union Pacific Railroad. The Duwamish Manufacturing Company also spilled crude oil into the LDW. The site was cleaned but a large portion of the oil had already reached the LDW (WPCC 1945-1957, as cited in Dexter et al. 1985).

In 1974, a spill of high-concentration PCB dielectric fluid occurred in Slip 1 (EPA 1975a). As a result of two separate dredging events, most of the PCBs spilled were recovered, although sampling results indicated that PCBs had spread prior to cleanup (EPA 1975b). Recent sediment samples have detected PCB concentrations in Slip 1 that

[150] USCG also maintains a database of oil and chemical spills into water bodies that are reported directly to the USCG (i.e., without first being reported to Ecology). The USCG spill database is available through the National Response Center website). The USCG database is organized by year of report and is not geographically coded.

exceed the SQS in surface sediment and the CSL in subsurface sediment (Windward and RETEC 2007).

9.4.5.2 Leaks

Leaks can occur from various sources such as pipes and storage tanks or from industrial or commercial equipment and process operations. Ecology currently regulates and monitors active and inactive LUSTs. The LUST list includes confirmed and suspected leaking tanks owned and operated by entities such as gas stations, manufacturing industries, commercial properties, and government agencies. The LUST list contains sites that have been cleaned up and sites currently in the process. Currently, about 70 of the LUST sites on Ecology's active LUST list are located in the LDW drainage area (EDR 2006b). The records for active and inactive LUST sites are summarized in Tables G-7 and G-8 in Appendix G, respectively.

9.4.5.3 Spill prevention and cleanup programs

Ecology maintains a spill prevention, preparedness, and response program whose goal is to protect public health, safety, and the environment from accidental releases of oil and other hazardous materials (Ecology 2006b). In addition, Ecology provides 24-hr emergency response units statewide and investigates hazardous material incidents in order to identify practices that will reduce the number of future spills. Ecology has the authority to issue fines or require changes in operations at facilities that violate spills regulations.

Ecology partnered with EPA, the USCG, and other state and local agencies from Oregon and Idaho to produce the Northwest Area Contingency Plan. The plan provides guidelines for response actions to spill incidents, and, in Washington State, it functions as the statewide master response plan for oil and hazardous substance releases (EPA and USCG 2006). Regulations calling for a regional response plan capable of responding to hazardous materials spills and other releases are contained in 40 CFR 300.

SPU inspectors routinely respond to water quality complaints throughout the city of Seattle. Complaints are received from a number of sources, including the City's hotline number, staff reports, and referrals from other City departments and agencies. In addition to identifying and controlling the causes of a complaint, City inspectors also provide technical assistance to local residents and businesses regarding BMPs for reducing pollution. SPU also maintains a coordinator network to respond to spills affecting City infrastructure on a 24-hour basis, seven days a week. SPU maintains an on-call contractor to provide emergency cleanup services. Records from the SPU spill coordinator program are provided in Appendix G.

9.4.6 Groundwater

Numerous studies that provide information on groundwater conditions have been conducted in the LDW basin. Groundwater monitoring has been conducted at many facilities adjacent to and nearby the LDW (Map 9-17). Although most of those studies were conducted to assess conditions at specific facilities, they provide data that are useful in evaluating groundwater conditions in the greater LDW basin. Multiple seep and porewater sampling events have also been conducted in the LDW (see Maps 4-11a and 4-12a, respectively). A review of existing groundwater data was conducted for 12 facilities identified by EPA and Ecology in 2003, based on information available at the time, as part of the Phase 1 RI (Groundwater Pathway Assessment, Appendix G [Windward 2003a]) (Map 9-17). This preliminary assessment evaluated the potential for chemicals in groundwater at these 12 facilities to reach sediment in the LDW through groundwater discharge based on data that were available at that time.

Table 9-15 provides a summary of groundwater information for the 12 facilities discussed in Appendix G of the Phase 1 RI as well as numerous other facilities. Additional facilities were selected for inclusion in the table if they were shoreline properties associated with one of the 11 SCAs discussed in Appendix I[151] or if they were identified by Ecology as being sites of interest for groundwater (Hiltner 2008). As part of their source control program, Ecology is also assessing groundwater at upland facilities associated with the SCAs, many of which are not included in Table 9-15. The SCAP and data gaps reports present available groundwater information for all of the facilities associated with the SCAs.

[151] Of the properties associated with the 11 SCAs discussed in Appendix I, only the shoreline properties were included in Table 9-15. Ecology is evaluating groundwater at several upland facilities associated with these 11 SCAs as part of their source control program. For groundwater information on upland facilities associated with the 11 SCAs that are not included in Table 9-15, see Ecology's SCAPs and data gaps reports.

Table 9-15. Summary of available information for groundwater sites in the LDW

LDW RM	Facility	SCA	Chemicals Above SQS In the RI Baseline Surface Sediment Dataset within the Associated Sediment Area[a]	Chemicals Detected in Groundwater[b]	Chemicals Detected in Seeps	Chemicals Detected in Porewater	Groundwater Program Details and Fate and Transport Information, if Available	Sources of Additional Information
Shoreline Properties								
0.3 – 0.5 E	T-106 (northern portion of parcel, formerly referred to as T-106 W)	Duwamish/ Diagonal Way	cadmium, chromium, lead, mercury, silver, zinc, 2-methylnaphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, total HPAHs, total LPAHs, BEHP, BBP, dimethyl phthalate, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol, n-nitrosodiphenylamine, phenol, total PCBs, dioxins and furans[c, d]	arsenic ,lead, toluene, petroleum-related compounds	No seep data were reported.	No porewater data were reported.	Groundwater sampling was conducted as part of an environmental site assessment in 2007; these investigations assessed UST locations and an area of historical cement kiln dust disposal.	Pinnacle Geosciences (2005, 2007)
0.3 – 0.5 E	T-106 (southern portion of parcel, formerly referred to as T-106 SW)	Duwamish/ Diagonal Way	cadmium, chromium, lead, mercury, silver, zinc, 2-methylnaphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, total HPAHs, total LPAHs, BEHP, BBP, dimethyl phthalate, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol, n-nitrosodiphenylamine, phenol, total PCBs, dioxins and furans[c, d]	arsenic, lead, petroleum hydrocarbons	No seep data were reported.	No porewater data were reported.	Groundwater sampling was conducted in the 1990s as part of LUST investigations and at a compressor area and a steam cleaning area.	Pinnacle Geosciences (2005)
0.5 – 0.7 E	T-108 (former Chiyoda property)	Duwamish/ Diagonal Way	cadmium, chromium, lead, mercury, silver, zinc, 2-methylnaphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, total HPAHs, total LPAHs, BEHP, BBP, dimethyl phthalate, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol, n-nitrosodiphenylamine, phenol, total PCBs, dioxins and furans[c, d]	arsenic, cadmium, chromium, copper, lead, nickel, zinc, 1-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, chrysene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene, total HPAHs, total LPAHs, PCBs, benzene, ethylbenzene, toluene, xylenes	No seep data were reported.	No porewater data were reported.	Numerous soil and groundwater investigations have been conducted at the facility over the past 20 years as part of site assessments and PCB disposal site investigations. A groundwater sampling program was implemented in 2006 and 2007 in accordance with an Ecology approved work plan. Based on the results, it was recommended that additional groundwater monitoring at the facility was not necessary.	Pacific Groundwater Group (2006, 2007), Windward (2003a)
0.7 – 0.9 E	Federal Center South	Duwamish/ Diagonal Way	cadmium, chromium, lead, mercury, silver, zinc, 2-methylnaphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, total HPAHs, total LPAHs, BEHP, BBP, dimethyl phthalate, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol, n-nitrosodiphenylamine, phenol, total PCBs, dioxins and furans[c, d]	benzene, ethylbenzene, toluene, xylene, petroleum hydrocarbons	arsenic, cadmium, copper, lead, mercury, nickel, silver, zinc	No porewater data were reported.	Groundwater monitoring in 2000 identified a gasoline plume.	Ecology (2004a), Windward (2004b)
1.4 E	St. Gobain Containers (former St. Gobain Glass)	St. Gobain to Glacier Northwest[e]	zinc, chrysene, benzyl alcohol, phenol, total PCBs[c]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater monitoring program is in place.	

Table 9-15, cont. Summary of available information for groundwater sites in the LDW

LDW RM	Facility	SCA	Chemicals Above SQS In the RI Baseline Surface Sediment Dataset within the Associated Sediment Area[a]	Chemicals Detected in Groundwater[b]	Chemicals Detected in Seeps	Chemicals Detected in Porewater	Groundwater Program Details and Fate and Transport Information, if Available	Sources of Additional Information
1.5 E	Longview Fibre Paper and Packaging	St. Gobain to Glacier Northwest[e]	zinc, chrysene, benzyl alcohol, phenol, total PCBs[c]	PAHs, SVOCs, petroleum hydrocarbons	No seep data were reported.	No porewater data were reported.	Groundwater monitoring took place in 2003 after remediation of a LUST; details were not available. It is unclear whether the groundwater monitoring is ongoing.	EDR (2006a)
1.6 E	BPB Gypsum/Old James Hardy Gypsum	St. Gobain to Glacier Northwest[e]	zinc, chrysene, benzyl alcohol, phenol, total PCBs[c]	No groundwater data were reported.	arsenic, cadmium, copper, lead, nickel, mercury, zinc, carbon disulfide, TPH (diesel)	No porewater data were reported.	No groundwater monitoring program is in place.	Windward (2004b)
1.75 E (northern parcel) and 1.9 E (southern parcel)	Duwamish Marine Center	Slip 2 to Slip 3[e]	total PCBs[c]	non-halogenated solvents, PCBs, petroleum hydrocarbons	arsenic, cadmium, copper, lead, mercury, nickel, silver, zinc	aluminum, arsenic, barium, cadmium, calcium, iron, lead, magnesium, manganese, potassium, sodium, vanadium, tributyltin as ion	Groundwater sampling conducted as part of site assessment related to CSCSL record; no record of formal groundwater monitoring program identified during assessment.	Cargill and Thomas (2007), EDR (2006b), Weston (1999a)
2.1 E	SCS Refrigerated Services	Slip 3 to Seattle Boiler Works	arsenic, benzyl alcohol[c]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No fate and transport or groundwater program information was available.	
2.1 – 2.3 E	Glacier Marine Services	Slip 3 to Seattle Boiler Works	arsenic, benzyl alcohol[c]	No groundwater data were reported.	No seep data were reported.	aluminum, arsenic, barium, cadmium, calcium, copper, iron, lead, magnesium, manganese, potassium, silver, sodium, vanadium, zinc, dibutyltin as ion, tributyltin as ion	No fate and transport or groundwater program information was available.	Weston (1999a)
2.1 – 2.3 E	Seattle Distribution Center	Slip 3 to Seattle Boiler Works	arsenic, benzyl alcohol[c]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No fate and transport or groundwater program information was available.	
2.2 – 2.25 E	Bunge Foods/Guimont Parcel (Dawn Food Products)	Slip 3 to Seattle Boiler Works, Seattle Boiler Works to Slip 4	arsenic, mercury, fluoranthene, total PCBs, benzyl alcohol[c]	No groundwater data were reported.	1,2-DCE, vinyl chloride[f]	No porewater data were reported.	No fate and transport or groundwater program information was available.	
2.3 E	Seattle Boiler Works	Seattle Boiler Works to Slip 4	mercury, fluoranthene, total PCBs[c]	No groundwater data were reported.	1,1-dichloroethane, 1,2-dichloroethane, 1,2-DCE, cis-1,2-DCE, trans-1,2-DCE, 1,2-dichloropropane, acetone, benzene, chloride, chlorobenzene, PCE, TCE, toluene, vinyl chloride, total xylenes[f]	1,1-dichloroethane, cis-1,2-DCE, trans-1,2-DCE, carbon disulfide, PCE, TCE, vinyl chloride[f]	No groundwater monitoring program is in place.	
2.4 E	Seattle Iron & Metals Corporation	Seattle Boiler Works to Slip 4	mercury, fluoranthene, total PCBs[c]	No groundwater data were reported.	1,1,1-trichloroethane, 1,1-dichloroethane, 1,2-dichloroethene, cis-1,2-DCE, 1,2,4-trimethylbenzene, acetone, PCE, TCE, vinyl chloride[f]	1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,1-DCE, 1,1-dichloroethane, carbon disulfide, chlorobenzene, cis-1,2-dichloroethene, isopropylbenzene, toluene, trans-1,2-dichloroethene, vinyl chloride[f]	No groundwater monitoring program is in place.	
2.6 E	Puget Sound Truck Lines	Seattle Boiler Works to Slip 4	mercury, fluoranthene, total PCBs[c]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater monitoring program is in place.	
2.7 E	Seattle City Light	Seattle Boiler Works to Slip 4	mercury, fluoranthene, total PCBs[c]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater monitoring program is in place.	

Table 9-15, cont. Summary of available information for groundwater sites in the LDW

LDW RM	Facility	SCA	Chemicals Above SQS In the RI Baseline Surface Sediment Dataset within the Associated Sediment Area[a]	Chemicals Detected in Groundwater[b]	Chemicals Detected in Seeps	Chemicals Detected in Porewater	Groundwater Program Details and Fate and Transport Information, if Available	Sources of Additional Information
2.8 E	Crowley Marine Services	Seattle Boiler Works to Slip 4, Slip 4	mercury, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, total HPAHs, BBP, BEHP, total PCBs[c]	arsenic, copper, 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, chrysene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene BEHP, cis-1,2-DCE, acetone, dichloromethane	total PCBs	arsenic, barium, cadmium, lead, vanadium[g]	Groundwater sampling conducted in the 1980s and 1990s as part of site assessment; samples were collected from 12 wells and analyzed for metals, VOCs, SVOCs, TPH, chlorinated phenols, pesticides, and PCBs. There are plans for an additional groundwater investigation to be conducted on the facility.	SAIC (2006, 2007a, 2008a)
2.95 E	First South Properties	Slip 4	mercury, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, total HPAHs, BBP, BEHP, total PCBs[c]	arsenic, copper, zinc, TPH, 2-methylnaphthalene, acenaphthene, fluorene, phenanthrene, pyrene	mercury, copper	No porewater data were reported.	Groundwater sampling conducted in the 1980s and 1990s as part of site assessment and UST removals; samples were collected from 7 wells and analyzed for metals, VOCs, SVOCs, TPH, and PCBs. The site was granted an NFA in 1997 and groundwater monitoring was terminated in 1998. No record of an ongoing groundwater monitoring program was identified during this assessment.	Ecology (2006a), SAIC (2007a), Windward (2004b)
2.9 – 3.6 E	Boeing Plant 2	Slip 4, Boeing Plant 2/ Jorgensen Forge	cadmium, chromium, copper, lead, mercury, silver, zinc, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, Indeno(1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, BBP, BEHP, phenol, total PCBs, dioxins and furans[c, d]	aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, zinc, naphthalene, BEHP, di-n-buytlphthalate, 2,4-dimethylphenol, 2-methylphenol, 4-chloro-3-methylphenol, 4-methylphenol, phenol, methyl isobutyl ketone, total PCBs, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1,2-trichloro-trifluoroethane, 1,1-DCE,1,1-dichloroethane, 1,2-dichloroethane, cis-1,2-DCE, trans-1,2-DCE, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, 4-isopropyltoluene,acetone, benzene, bromodichloromethane, carbon disulfide, carbon tetrachloride, chlorobenzene, chloroethane, chloroform, chloromethane, ethylbenzene, isopropylbenzene, n-butylbenzene, n-propylbenzene, PCE, sec-butylbenzene, TCE, tert-butylbenzene, toluene, trichlorofluoromethane, vinyl chloride, m,p-xylene, o-xylene, TPH (diesel, gasoline, and motor oil), 2-butanone, cyanide, methylene chloride	arsenic, chromium, copper, lead, mercury, selenium, zinc, fluoranthene, phenanthrene, total PCBs, cis-1,2-DCE, benzene, TCE, vinyl chloride	1,1-dichloroethene, cis-1,2-DCE, TCE, vinyl chloride[h]	Weston's (1998) mass loading analysis indicated no predicted accumulation in sediments for metals following bank removal. V PCBs were detected in seeps. The likely source of PCBs in seeps is sediment. VOC concentrations detected in porewater samples were less than toxicity thresholds for benthic invertebrates. Groundwater monitoring is on-going.	Ecology (2006a), Ecology and Environment (2007b), Environmental Partners (2008), SAIC (2007b), Weston (1998), Windward (2003a, 2006a)
3.6 – 3.7 E	Jorgensen Forge	Boeing Plant 2/Jorgensen Forge	cadmium, chromium, copper, lead, mercury, silver, zinc, acenaphthene, benzo(a)anthracene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, Indeno(1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, BBP, BEHP, phenol, total PCBs, dioxins and furans[c, d]	cadmium, benzene, ethylbenzene, toluene, vinyl chloride, xylenes, TPH (diesel)	arsenic, cadmium, copper, lead, mercury, nickel, silver, zinc	1,1-dichloroethene, cis-1,2-DCE, TCE, vinyl chloride[h]	No formal groundwater monitoring program is in place. Groundwater sampling was conducted as part of site investigations and/or tank removal.	Ecology and Environment (2007b), Environmental Partners (2008), Windward (2004b)
3.7-3.8 E	Boeing Isaacson	Boeing Isaacson/ Central KCIA	arsenic, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, BEHP, BBP, benzoic acid total PCBs[c]	arsenic, cadmium, chromium, copper, lead, zinc	arsenic, cadmium, copper, lead, mercury, nickel, silver and zinc[i, j]	No porewater data were reported.	Several groundwater investigations have been conducted, including a hydrogeologic investigation in 2000. Apparent natural attenuation was noted based on a comparison of data from well pairs. Groundwater sampling was conducted in September 2007 and future sampling is planned.	Ecology (2008a), SAIC (2008b), Windward (2003a)
3.8 E	Boeing Thompson	Boeing Isaacson/ Central KCIA	arsenic, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, BEHP, BBP, benzoic acid, total PCBs[c]	arsenic	arsenic[j]	No porewater data were reported.	Groundwater sampling was conducted between 1988 and 2007. Additional groundwater sampling is planned.	Ecology (2008a), SAIC (2008b), Windward (2003a)

Table 9-15, cont. Summary of available information for groundwater sites in the LDW

LDW RM	Facility	SCA	Chemicals Above SQS In the RI Baseline Surface Sediment Dataset within the Associated Sediment Area[a]	Chemicals Detected in Groundwater[b]	Chemicals Detected in Seeps	Chemicals Detected in Porewater	Groundwater Program Details and Fate and Transport Information, if Available	Sources of Additional Information
3.9 – 4.0 E	PACCAR (former Kenworth Truck Co.)	Slip 6	lead, BBP, total PCBs[k]	arsenic, barium, chromium, copper, nickel, selenium, zinc, benzo(g,h,i,)perylene, chrysene, BEHP, benzyl alcohol, fluoranthene, total PCBs, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1-DCE,1,1-dichloroethane, 1,2-dichloroethane, cis-1,2-DCE, trans-1,2-DCE, acetone, benzene, chloroethane, chloroform, dichloromethane, methylene chloride, PCE, TCE, vinyl chloride, TPH (diesel, gasoline, and motor oil), glycols	arsenic, copper, lead	No porewater data were reported.	VOCs and TPH are likely attenuated, and arsenic is in the range of background concentrations. Groundwater monitoring for VOCs occurred between 1986 and 2002. Two rounds of groundwater monitoring were completed in 2006.	Ecology and Environment (2008b), Windward (2003a)
4.0 -4.2 E	Former Rhône-Poulenc facility	Slip 6	mercury, acenaphthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, total HPAHs, BEHP, benzoic acid, phenol, total PCBs[k]	arsenic, beryllium, cadmium, chromium, copper, lead, mercury, selenium, silver, thallium, vanadium, zinc, benzo(a)pyrene, chrysene, BEHP, 2-methylphenol, 4-methylphenol, bis(2-chloroethyl)ether, PCP, 1,1-dichloroethane, acetone, benzene, dichloromethane, ethylbenzene, formaldehyde, toluene, xylenes	aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, magnesium, mercury, nickel, vanadium, zinc, BEHP, formaldehyde	antimony, arsenic, chromium, barium, cadmium, copper, iron, lead, magnesium, manganese, mercury, vanadium, zinc, tributyltin, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, fluoranthene, pyrene, BEHP, diethylphthalate, 1,1-biphenyl, caprolactam	Groundwater investigations at the site began in 1985. As of 2007, over 10 years of quarterly groundwater monitoring has been conducted on the site. Toluene contamination in groundwater is still being investigated by EPA.	Ecology and Environment (2008b), EPA (2005d), Rhône-Poulenc (1996), Weston (1999a), Windward (2003a)
4.2 – 4.8 E	Boeing Developmental Center	Slip 6, Norfolk CSO/SD	lead, acenaphthene, total PCBs[k]	aluminum, arsenic, barium, calcium, cobalt, copper, iron, lead, magnesium, molybdenum, nickel, zinc, naphthalene, 1,1,1-trichloroethane, 1,1,2-trichloro-1,2,2-trifluoroethane, 1,1-dichloroethane, 1,2,4-trimethylbenzene, cis-1,2-DCE,1,3,5-trimethylbenzene, 2-hexanone, benzene, bromomethane, cis-1,3-dichloropropene, ethylbenzene, m,p-xylene, o-xylene, PCE, toluene, TCE, vinyl chloride, TPH (diesel, gasoline)	No seep data were reported.	No porewater data were reported.	Plumes of chlorinated solvents are reported to be locally contained and to not extend to the LDW. Natural attenuation expected for hydrocarbons and benzene (500 ft from LDW). Groundwater monitoring occurred as part of an Ecology NFA finding in 2001. Groundwater monitoring was discontinued in 2004.	Ecology and Environment (2007a, 2008b), Windward (2003a)
4.6 E	Boeing Military Flight Center	Norfolk CSO/SD	fluoranthene, BBP, BEHP, 1,4-dichlorobenzene, total PCBs[c]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater monitoring program is in place.	
1.28 W	Alaskan Marine Lines	Glacier Bay	arsenic, copper, lead, mercury, zinc, acenaphthene, benzo (g,h,i) pyrene, chrysene, fluoranthene, indeno (1,2,3-cd) pyrene, phenanthrene, total HPAHs, BBP, BEHP, PCP, total PCBs, dioxin and furans[c, d]	1-methylnaphthylene, 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene, pyrene, benzene, xylenes (total), TPH (diesel, gasoline, motor oil)	No seep data were reported.	No porewater data were reported.	Groundwater sampling has been conducted as part of site assessment and UST investigations; no formal groundwater monitoring program is in place.	SAIC (2007d), Ecology (2007i)
1.35 W	Duwamish Shipyard	Glacier Bay	arsenic, copper, lead, mercury, zinc, acenaphthene, benzo (g,h,i) pyrene, chrysene, fluoranthene, indeno (1,2,3-cd) pyrene, phenanthrene, total HPAHs, BBP, BEHP, PCP, total PCBs, dioxin and furans[c, d]	arsenic, chromium, lead, benzo(a)pyrene, benzene, vinyl chloride	No seep data were reported.	No porewater data were reported.	No formal groundwater monitoring program is in place. Groundwater information collected from borings not completed as monitoring wells.	SAIC (2007d), Ecology (2007i)
1.45 W	Glacier NW (former Reichhold Chemical)	Glacier Bay	arsenic, copper, lead, mercury, zinc, acenaphthene, benzo-(g,h,i) -pyrene, chrysene, fluoranthene, indeno (1,2,3-cd)-pyrene, phenanthrene, total HPAHs, BBP, BEHP, PCP, total PCBs, dioxin and furans[c, d]	arsenic, silver, naphthalene, 2,4,6-trichlorophenol, 2,4-dicholorpohenol, 2-chloropheonol, PCP	arsenic, copper, lead, mercury, silver, and zinc	No porewater data were reported.	Three wells installed in perched groundwater zone near former Reichhold waste pits; exact locations unknown. No formal groundwater monitoring program is in place.	SAIC (2007d), Ecology (2007i)
1.5 W	MRI Corporation	Glacier Bay	arsenic, copper, lead, mercury, zinc, acenaphthene, benzo (g,h,i) pyrene, chrysene, fluoranthene, indeno (1,2,3-cd) pyrene, phenanthrene, total HPAHs, BBP, BEHP, PCP, total PCBs, dioxin and furans[c, d]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater monitoring program is in place; however, the Port of Seattle is entering this site into Ecology's VCP program, and a new site investigation including groundwater will begin soon.	SAIC (2007d), Ecology (2007i)
2.2 W	Douglas Management Company	Trotsky Inlet	lead, mercury, zinc, BBP, BEHP, total PCBs, dioxins and furans[c, d]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater program is in place.	Ecology (2007h), SAIC (2007b, c), Windward (2004b)

Table 9-15, cont. Summary of available information for groundwater sites in the LDW

LDW RM	Facility	SCA	Chemicals Above SQS In the RI Baseline Surface Sediment Dataset within the Associated Sediment Area[a]	Chemicals Detected in Groundwater[b]	Chemicals Detected in Seeps	Chemicals Detected in Porewater	Groundwater Program Details and Fate and Transport Information, if Available	Sources of Additional Information
2.2 W	Trotsky (former Northwest Cooperage, present-day Industrial Container Services)	Trotsky Inlet	lead, mercury, zinc, BBP, BEHP, total PCBs, dioxins and furans[c, d]	antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, zinc, 2-methylnapthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzofuran, fluoranthene, fluorene, ideno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, BBP, BEHP, di-n-octyl phthalate,1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 2,4-dimethylphenol, 2-methylphenol, 4-chloro-m-cresol, 4-methylphenol, benzoic acid, hexachlorobenzene, n-nitrosodiphenylamine, PCP, phenol, phenols (total), methyl isobutyl ketone, total PCBs, 2,4′-DDE, 2,4′-DDT, 4,4′-DDD, 4,4′-DDE, 4,4′-DDT, cis-chlordane, gamma-chlordane, lindane, 1,1-dichloroehtane, trans-1,2-dichloroethylene, acetone, benzene, dichloromethane, ethylbenzene, toluene, vinyl chloride, xylenes, TPH (diesel and gasoline), cyanide	arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, zinc, benzo(a)anthracene, fluoranthene, naphthalene, pyrene, diethylphthalate, dimethylphthalate, di-N-buytlphthalate, pentachlorophenol, 1,2-dichlorobenze, 1,3-dichlorobenzene, 1,4-dichlorobenzene, total PCBs, 2,4′-DDD, 4,4′-DDD, 4,4′-DDE, 4,4′-DDT, lindane, carbon disulfide, chlorobenzene, TPH (diesel)	No porewater data were reported.	Groundwater samples were collected as part of Phase I, II, and III soil and groundwater assessments; samples were collected from monitoring wells in 2007.	Ecology (2007h), SAIC (2007b, c)
2.3 W	Boyer Towing properties (three parcels)	Trotsky Inlet	lead, mercury, zinc, BBP, BEHP, total PCBs, dioxins and furans[c, d]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater program is in place.	
3.0 – 3.1 W (inland and shoreline portions)	Long Painting	none[l]	PCBs, hexachlorobenzene[k]	arsenic, barium, chromium, lead, 1,1,1-trichloroethane, PCE	arsenic, cadmium, copper, lead, mercury, nickel, silver, zinc	tributyltin	Groundwater sampling has been conducted at the facility; however, no information was available regarding ongoing or future groundwater monitoring. No plume was identified on site, but groundwater data were insufficient. Metal groundwater COCs have not accumulated to concentrations above the SQS in adjacent sediments. The two VOC COCs were not detected in the single sediment sample analyzed for VOCs.	SEA (1998), Windward (2003a, 2004b)
3.4 – 3.5 W	South Park Marina	Terminal- 117	2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno (1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, benzyl alcohol, phenol, total PCBs[c]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater program is in place.	
3.5 – 3.7 W	T-117	Terminal- 117	2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno (1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, benzyl alcohol, phenol, total PCBs[c]	arsenic, cadmium, chromium, copper, lead, silver, zinc, 1-methylnaphthalene, acenaphthene, benzo(a)anthracene, total Benzofluoranthenes, chrysene, fluorene, naphthalene, total HPAHs, total LPAHs, BEHP, total PCBs, cis-1,2-dichloroethene, acetone, chlorobenzene, tetrachloroethene, trichloroethene, o-xylene, m,p-xylene, total xylenes, TPH (diesel, lube oil, and motor oil)	chromium, copper, zinc, BEHP, total PCBs	No porewater data were reported.	Quarterly sampling was conducted in 1997-1998. Several groundwater investigations have been conducted from 1991 to 2006. Groundwater monitoring is ongoing.	Windward (2003a) Windward et al. (2005a; 2008)
3.67 – 3.91 W	Boeing South Park	Terminal- 117	2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno (1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, benzyl alcohol, phenol, total PCBs[c]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater program is in place.	

Table 9-15, cont. Summary of available information for groundwater sites in the LDW

LDW RM	Facility	SCA	Chemicals Above SQS In the RI Baseline Surface Sediment Dataset within the Associated Sediment Area[a]	Chemicals Detected in Groundwater[b]	Chemicals Detected in Seeps	Chemicals Detected in Porewater	Groundwater Program Details and Fate and Transport Information, if Available	Sources of Additional Information
Inland Properties								
0.7 – 0.9 E	Union Pacific Railroad Argo fueling site	Duwamish/ Diagonal Way	cadmium, chromium, lead, mercury, silver, zinc, 2-methylnaphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, total HPAHs, total LPAHs, BEHP, BBP, dimethyl phthalate, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol, n-nitrosodiphenylamine, phenol, total PCBs, dioxins and furans[c, d]	TPH (diesel)	No seep data were reported.	No porewater data were reported.	Groundwater monitoring wells were installed to monitor a diesel plume present beneath the facility. The plume migrates to the west. Groundwater remediation operations, including pumping and air sparging, were conducted between 2001 and 2004; over 38,000 gal. of diesel were recovered.	Ecology (2004a), SAIC (2007j)
1.4 E	Philip Services Corp./ Burlington Environmental	none[l]	mercury, zinc, chrysene, total PCBs, benzyl alcohol, phenol[k]	barium, cadmium, chromium, copper, lead, manganese, nickel, selenium, silver, vanadium, benzo(a)anthracene, benzofluoranthenes (total), benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, benzoic acid, 1,1-DCE, 1,1-dichloroethane, 1,1,1-trichloroethane, 1,2-DCE, cis-1,2-DCE, trans-1,2-DCE, 1,2,4-trimethylbenzene, benzene, chlorobenzene, chloroethane, dichloromethane, ethylbenzene, PCE,TCE, toluene, vinyl chloride, xylenes, petroleum hydrocarbons, 2-butanone, ethane, methane	arsenic, cadmium, copper, lead, mercury, nickel, silver, zinc, TPH-diesel range, TPH	aluminum, arsenic, barium, lead, manganese, vanadium, tributyltin	Site-wide FS completed in 2006 concluded that chlorinated ethenes, 1,4-dioxane and possibly vinyl chloride, could reach the LDW at concentrations greater than the surface water protection criteria.[m] As of 2002, quarterly groundwater monitoring was ongoing. In 2004, a subsurface barrier wall and groundwater recovery system were installed at the facility. As of 2006, this system was still being monitored.	PSC (2001a, b, 2002a, b, c), Geomatrix (2006)
2.35 E	Great Western International (Fox Avenue Buildings)	Seattle Boiler Works to Slip 4	total PCBs[k]	aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, zinc, 2-chloronaphthalene, 2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, chrysene, dibenzofuran, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene, BEHP, diethylphthalate, dimethyl phthalate, di-n-butyl phthalate, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 2,3,5-trichlorophenol, 2,4,5-trichlorophenol, 2,4-dichlorophenol, 2,4-dimethylphenol, 2-methylphenol, 4,6-dinitro-2-methylphenol, 4-chloro-3-methylphenol, 4-methylphenol, benzoic acid, benzyl acid, carbazole, isophorone, n-nitro-di-n-propylamine, n-nitroso-di-n-propylamine, PCP, phenol, 1,1,1,2-trichloroethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-DCE, 1,2-DCE, cis-1,2-dichloroethane, cis-1,2-DCE, trans-1,2-DCE, 1,2,4-trimethylbenzene, 1,2-dichloropropane, 1,3,5-trimethylbenzene, acetone, benzene, carbon disulfide, chloroform, DCE, ethane, ethene, ethylbenzene, iso-propyl benzene, iso-propyl toluene, n-butyl benzene, n-propyl benzene, PCE, sec-butyl benzene, styrene, TCE, tetrachlorophenols (total), toluene, trichlorofluoromethane, vinyl chloride, m,p- xylene, total xylenes, TPH (diesel and gasoline), 1,2-propanediol, 2-butanone, 2-propanol, 4-methyl-2-pentanone, diethylene glycol, ethylene glycol, methane, methanol, methylene chloride, sulfate	acenaphthene, total LPAH, total PAH, 1,1,1-trichloroethane, 1,1-DCE, 1,1-dichloroethane, 1,2,4-trimethylbenzene, 1,2-dichlorobenzene, 1,2-DCE (total), cis-1,2-DCE, trans-1,2-DCE, 1,2-dichloroethane, 1,2-dichloropropane, acetone, benzene, chlorobenzene, PCE, toluene, total xylenes, TCE, vinyl chloride, o-xylene	1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,1-DCE, 1,1-dichloroethane, 1,2-dichloroethane, cis-1,2-DCE, trans-1,2-DCE, 1,2-dichloropropane, benzene, carbon disulfide, chlorobenzene, isopropylbenzene, PCE, TCE, toluene, vinyl chloride	Fate and transport analyses for VOCs indicated extensive degradation prior to discharge. In 2004, an underground injection control cleanup program was implemented at the site. As of 2006, the cleanup was still being conducted and its effectiveness was under evaluation. It was not specified whether these evaluations include a groundwater monitoring program. All VOC concentrations in porewater were less than toxicity thresholds for benthic invertebrates except for two cis1,2-DCE concentrations in the high intertidal, which were greater than the no-effect threshold but less than the effect threshold.	SAIC (2008a), Terra Vac and Floyd & Snider (2000), Windward (2003a), Windward (2006a)
2.7 E	Georgetown Steam Plant	Slip 4	mercury, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, total HPAHs, BBP, BEHP, total PCBs[c]	PCBs, trichloroethylene	No seep data were reported.	No porewater data were reported.	Five groundwater monitoring wells were installed and quarterly groundwater monitoring (to continue for one year) was initiated in August 2006.	Ecology (2007j), SAIC (2007a)
2.7 – 3.35 E	North Boeing Field	Slip 4	mercury, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, total HPAHs, BBP, BEHP, total PCBs[c]	antimony, arsenic, beryllium, chromium, copper, lead, nickel, zinc, BEHP, total PCBs, cis-1,2-DCE, acetone, benzene, dichloromethane, ethylbenzene, PCE, TCE, toluene, vinyl chloride, total xylenes, TPH	No seep data were reported.	No porewater data were reported.	Groundwater monitoring has been conducted at several locations on NBF as part of previous site investigations. Ongoing semi-annual groundwater monitoring is occurring at two VOC locations and two TPH locations: nine wells are monitored for VOCs (cis-1,2-DCE, PCE, TCE, vinyl chloride), and six wells are monitored for TPH and BTEX.	SAIC (2007e)

Table 9-15, cont. Summary of available information for groundwater sites in the LDW

LDW RM	Facility	SCA	Chemicals Above SQS In the RI Baseline Surface Sediment Dataset within the Associated Sediment Area[a]	Chemicals Detected in Groundwater[b]	Chemicals Detected in Seeps	Chemicals Detected in Porewater	Groundwater Program Details and Fate and Transport Information, if Available	Sources of Additional Information
2.6 W	South Park Landfill	none[l]	acenapthene, anthracene, benzo(a)anthracene, chrysene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, BBP, BEHP, benzyl alcohol, benzoic acid, PCBs, hexachlorobenzene[k]	aluminum, arsenic, barium, calcium, copper, iron, magnesium, manganese, potassium, selenium, cis-1,2-DCE, chlorobenzene, and vinyl chloride	arsenic, cadmium, copper, lead, mercury, nickel, silver, zinc	No porewater data were reported.	Vinyl chloride not expected to discharge at concentrations of concern because of relatively low concentrations and distance to LDW. Several rounds of groundwater monitoring have been conducted since 1997 and additional monitoring will likely be conducted in the future as part of a planned RI/FS at the site.	Windward (2003a, 2004b)
3.6 W	Basin Oil	Terminal- 117	2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno (1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, benzyl alcohol, phenol, total PCBs[c]	aluminum, antimony, barium, beryllium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silver, thallium, vanadium, zinc, PCBs, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1-DCE, 1,1-dichloroethane, cis-1,2-DCE, trans-1,2-DCE, acetone, chloroform, chloromethane, chloroform, DCE, PCE, TCE, cyanide	See the seep information provided for T-117. Basin Oil is located adjacent to T-117; groundwater from the two facilities likely discharges to the LDW in approximately the same zone.	No porewater data were reported.	Quarterly sampling was conducted in 1997-1998. Two single groundwater sampling events were conducted in 1991 and 1994.	Windward et al. (2003)
4.1 W	Advance Electroplating	none[l]	no exceedances within the zone of potential groundwater discharge[k]	aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, zinc, acetone, chloroform, chloromethane, PCE, TCE, (and their daughter products), cyanide	No seep data were reported.	arsenic, barium, copper, lead, manganese, vanadium	The site is a significant distance from LDW but may discharge to Hamm Creek first. Biodegradation and volatilization of VOCs is expected between the site and the LDW. No information was identified regarding an ongoing groundwater monitoring program; the most recent groundwater monitoring data are from February 1999.	Windward (2003a)

Note: Information was provided in the groundwater pathway assessment (Appendix G in Windward 2003a), the seep (Windward 2004b) and porewater (Windward 2006a) studies conducted for the RI, additional seep and porewater studies conducted as part of other investigations, documents prepared by Ecology as part of their LDW source control program, including SCAPs and data gap reports, and in additional source documents provided by LDWG members.

[a] Most of the chemical lists are based on SQS exceedances of RI baseline surface sediment data within the administrative SCA surface sediment boundaries established by Ecology in February 2007; however, some are based on SQS exceedances within the zones of potential groundwater discharge estimated for facilities in the groundwater pathway assessment (Appendix G in Windward 2003a). Footnotes c and k specify which lists were generated using the SCA administrative boundaries and which were generated using the zones of potential groundwater discharge.

[b] Includes chemicals detected in historical samples and more recent samples.

[c] The list of chemicals is based on SQS exceedances of RI baseline surface sediment data within the administrative SCA surface sediment boundaries established by Ecology in February 2007. Chemical lists for facilities associated with more than one SCA include all chemicals detected above the SQS in both SCAs. The lists of chemicals detected above the SQS in surface sediment for T-108, Boeing Plant 2, Boeing Isaacson, and T-117 are based on exceedances within the administrative SCA surface sediment boundaries established by Ecology in February 2007, even though zones of potential groundwater discharge were established for these facilities in the groundwater pathway assessment (Appendix G in Windward 2003a). The SCA boundaries were used because they covered approximately the same area as the zones of potential groundwater discharge (Appendix G in Windward 2003a).

[d] SMS criteria do not exist for dioxins and furans. Dioxins and furans were included because they are a risk driver chemical with highly elevated concentrations (i.e., TEQ > 100 ng/kg dw) in surface sediment in the associated SCA.

[e] The St. Gobain to Glacier Northwest and Slip 2 to Slip 3 SCAs were two of the 23 SCAs identified by Ecology, but they are not included among the 11 SCAs discussed in Appendix I. The rationale for the selection of the 11 SCAs is discussed in Appendix I. Facilities within these two SCAs are included in the table because they were identified by Ecology as facilities of interest for groundwater.

[f] The seep and porewater samples collected near the Bunge Foods/Guimont Parcel (Dawn Food Products) shoreline, the Seattle Iron and Metals shoreline, and the Seattle Boiler Works shoreline (see seep sampling locations between RM 2.2 and RM 2.5 E on Maps 4-11a and 9-17 and porewater sampling locations between RM 2.3 and RM 2.45 E on Maps 4-12a and 9-17) were collected as part of investigations to characterize the Great Western International facility. These samples are also included in the information for the Great Western International (Fox Avenue Buildings) facility.

[g] Porewater sample was collected near the middle of Slip 4 (sample DR181 on Map 4-12a).

[h] Porewater samples were collected near the Boeing Plant 2 and Jorgensen Forge property boundary (see sampling locations near RM 3.6 E on Map 4-12a and Map 9-17). Data from these samples are presented for both facilities.

[i] The seep sample in which arsenic, cadmium, copper, lead, mercury, nickel, silver, and zinc were detected was collected along the Jorgensen Forge shoreline (sample SP-20 on Map 4-11a) near the property boundary between Jorgensen Forge and Boeing Isaacson. Data for this seep sample are presented for both facilities.

[j] One seep sample was collected near the Boeing Isaacson and Boeing Thompson property boundary (sample Seep-1 on Map 4-11a). Data from this sample are presented in the table for both facilities.

[k] The lists of chemicals detected above the SQS in surface sediment for these facilities are based on exceedances within the zone of potential groundwater discharge estimated for each facility in the groundwater pathway assessment (Appendix G in Windward 2003a).

[l] Facility has not yet been associated with an SCA by Ecology.

[m] The final RI cleanup levels selected for Philip Services Corp. for the water table, shallow, and intermediate groundwater were the minimum concentrations based on the following: calculated MTCA Method B groundwater cleanup levels based on an Asian and Pacific Islander exposure scenario for the consumption of fish for the groundwater-to-surface water exposure pathway; AWQC based only on the human health consumption of organisms (Section 304 of the federal CWA); ERA surface water screening levels protective of aquatic biota in surface water; AWQC freshwater and marine criteria maximum concentration, criteria continuous concentration, and organoleptic effects (Section 304 of the federal CWA); Washington State freshwater and marine acute and chronic effects criteria; and MTCA Method A cleanup levels (Geomatrix 2006).

Shading identifies the 12 facilities specifically discussed in Section 9.4.6.

AWQC – ambient water quality criteria
BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
COC – chemical of concern
CSCSL – Confirmed and Suspected Contaminated Sites List
CSO – combined sewer overflow
DCE – dichloroethene
DDD– dichlorodiphenyldichloroethane
DDE –dichlorodiphenyldichloroethylene
DDT– dichlorodiphenyltrichloroethane
dw – dry weight
FS – feasibility study
GWI – Great Western International
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LDW – Lower Duwamish Waterway
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
LUST – leaking underground storage tank
NBF – North Boeing Field
NFA – no further action
PCB – polychlorinated biphenyl
PCE – tetrachloroethene
PCP –pentachlorophenol
PSC – Phillip Services Corporation
RI – remedial investigation
RM – river mile
SAIC – Science Applications International Corporation
SCA – source control area
SCAP – source control action plan
SD – storm drain
SQS – sediment quality standards
SRI – supplemental remedial investigation
SVOC – semivolatile organic compound
T-108 – Terminal 108
T-117 – Terminal 117
TCE – trichloroethene
TPH – total petroleum hydrocarbon
UST – underground storage tank
VOC – volatile organic compound

Information in Table 9-15 was provided in the seep (Windward 2004b) and porewater (Windward 2006a) studies performed as part of the RI,[152] additional seep and porewater studies conducted as part of other investigations, documents prepared by Ecology as part of their LDW source control program, or in additional source documents provided by LDWG. Table 9-15 lists chemicals detected in groundwater, seeps, and porewater, when available, for each of the facilities. Table 9-15 also includes a list of chemicals that were detected above the SQS in surface sediment samples in the baseline dataset within the administrative boundary of the associated SCA or within the zone of potential groundwater discharge for the 12 facilities evaluated as part of the groundwater pathway assessment (Appendix G in Windward 2003a).[153] Fate and transport and groundwater program information is also provided when available. Key references are listed for additional information. The information presented in Table 9-15 and in this section is not intended to be a complete assessment of the chemical contamination in groundwater at the listed facilities or the potential for chemicals in groundwater to present a risk to sediment-dwelling organisms. It is intended to be a summary of information available at the time this report was drafted on chemicals present in groundwater.

It is important to note that additional reference documents containing groundwater data and other information exist for many of the facilities listed in Table 9-15; therefore, the summary may not be complete. The information in Table 9-15 is presented to provide a snap-shot of the state of groundwater investigations in the area of the LDW. Concentration ranges for selected chemicals detected in groundwater, seeps, and porewater are provided in Appendix I, as available, for many of the facilities listed in Table 9-15.[154] In-depth analyses have not been conducted as part of the RI for any of the facilities in Table 9-15; however, a preliminary assessment of 12 facilities was conducted as part of the groundwater pathway assessment in 2003 (Appendix G in Windward 2003a), based on data available at the time. Groundwater

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[152] The RI seep survey(Windward 2004b) was conducted over the entire LDW. In consultation with EPA and Ecology, some of the seeps observed were selected for sampling during the seep study. The RI porewater study (Windward 2006a) was conducted near the Great Western International and Boeing Plant 2/Jorgensen Forge properties because these properties were identified as having the greatest potential for VOC-contaminated porewater as a result of groundwater discharge, based on information available at that time.

[153] For facilities that were not included in the Phase 1 RI groundwater pathways assessment, the administrative SCA sediment boundaries provided by Ecology in February 2007 (Ecology 2007j) were used to produce the list of chemicals detected above the SQS. Those boundaries were established only for administrative purposes and are based on the extent of the adjacent upland LDW sub-drainage basins of the SCAs; the boundaries are not intended to delineate potential sediment cleanup boundaries.

[154] Additional information is provided in Appendix I for facilities located within one of the 11 SCAs selected for summation.

pathway analysis is dependent on an assessment of a number of factors, including site-specific hydrogeology characteristics and chemical-specific fate and transport parameters. EPA and Ecology will continue to evaluate chemicals in groundwater and seeps as part of their continued source control efforts. Information on the hydrogeology of the LDW, including geology, physical properties, and groundwater systems, is included in Section 2.5.

Section 9.4.6.1 Phase 1 groundwater pathway assessment

The groundwater pathway assessment summarized information available through 2002 for 12 upland facilities identified by EPA and Ecology as preliminary sites of interest with respect to groundwater. These facilities were Advance Electroplating, Boeing Developmental Center, Boeing Isaacson, Boeing Plant 2, GWI, Long Painting, T-117 (former Malarkey Asphalt), PACCAR (former Kenworth Truck Co.), Philip Services/Burlington Environmental, the former Rhône-Poulenc facility, the South Park Landfill, and T-108 (former Chiyoda property) (Appendix G in Windward 2003a). The locations of these facilities are shown on Map 9-17.

The following information was evaluated in the groundwater pathway assessment for each of the 12 facilities:

- Site operations and regulatory status
- Site-specific aquifer characteristics, groundwater flow direction, and rates of flow
- Chemicals identified as groundwater COCs (different criteria were used to select COCs for different facilities)
- COC concentrations in groundwater samples collected from monitoring wells located nearest to the LDW, as well as chemical contour or plume maps, when available
- COC concentrations in groundwater seeps or sediment in the LDW near potential areas of groundwater discharge
- Available fate and transport information

Based on various screening criteria used at each of the facilities, COCs identified in groundwater included chlorinated solvents and their breakdown products, metals, BTEX compounds, TPH, PCBs, PAHs, and a few other organic compounds at a few facilities. The most common groundwater COCs were metals and chlorinated solvents, both of which were COCs at over half of the facilities. Groundwater COC lists for individual facilities may be updated by EPA or Ecology based on ongoing environmental investigations and source control work.

As part of the groundwater pathway assessment (Appendix G in Windward 2003a), zones of potential groundwater discharge were estimated for each of the 12 facilities, and surface sediment data available at that time within that zone were reviewed to

identify detections of groundwater COCs in sediment at concentrations above SMS criteria or DMMP guidelines.[155] This comparison of sediment data to the SQS criteria or DMMP guidelines is intended only as a preliminary assessment; chemicals in groundwater may also pose a risk to sediment-dwelling organisms through porewater exposure. The groundwater discharge zones were estimated based on the direction of groundwater flow from each facility to the LDW; additional investigations would be necessary to formally delineate the zone of potential groundwater discharge for each facility. Additional source analyses may be conducted prior to remediation for specific facilities as part of cleanup-related activities.

Limitations of the groundwater pathway assessment were associated with the type of data used for the analysis and uncertainties associated with the data. Uncertainties included: 1) all potential sources of groundwater contamination, such as the presence of uncharacterized fill material, may not have been addressed; 2) few groundwater samples were available for facilities on the west side of the LDW; and 3) SMS criteria or DMMP guidelines were unavailable for some chemicals. The preliminary results provided in the groundwater pathway assessment for each of the 12 facilities are summarized below and have been updated based on groundwater, seep, and porewater information collected or identified since completion of the assessment in 2003. Groundwater information is still being collected at several facilities in the LDW drainage basin and reviewed by EPA and Ecology. EPA and Ecology will make the final pathway determinations based on their continuing source control evaluations.

9.4.6.2 Seep study conducted for the LDW RI

In 2004, a seep study was conducted as part of the RI to evaluate whether seeps contributed significant chemical inputs to the LDW, to determine whether additional seeps should be sampled in the future as part of the RI or to provide source control information, and to determine whether additional surface sediment sampling was needed in seep areas (Windward 2004b). A reconnaissance survey that resulted in the visual identification of 82 seep locations throughout the LDW was conducted; 18 of these locations were selected in consultation with EPA and Ecology for sample collection and chemical analysis. Seeps were selected for analysis based on the seep's proximity to potentially contaminated upland properties according to groundwater information available at the time, seep flow, and any visual or olfactory indications (e.g., oily or colored seep water or intertidal sediment) that might suggest the potential presence of chemicals in the seep. Two of the 18 seeps selected for chemical analysis were not sampled because they were dry at the time of sampling. The locations of the 16 seeps sampled during the LDW seep study are shown on Map 4-11a.

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[155] Sediment information provided in Table 9-15 and discussed in this section is based on the RI baseline surface sediment dataset, which includes sediment data collected since the groundwater pathway assessment was completed.

Seeps have also been sampled as part of several other investigations in the LDW. Information on these sampling events is provided in Section 4.1.2.5 (Table 4-11 and Map 4-11a). The results of the seep sampling conducted for the RI and as part of other investigations are presented in multiple places throughout the RI: Maps 4-11b through 4-11e, Section 4.2 (where seep results are described in detail by chemical group), Table 4-21 (where seep data are compared with WQC), Table 9-15 (where chemicals detected in the seep samples are listed by facility), and the following sections where seep data associated with the 12 facilities included in the groundwater pathway assessment are discussed. Seep data are also presented in Appendix I for the facilities located within the 11 SCAs selected for summarization. EPA and Ecology may further evaluate seeps as part of their continuing source control efforts.

9.4.6.3 Porewater study conducted for the LDW RI

A porewater study was conducted as part of the RI in 2005 to determine whether VOCs in porewater posed a risk to benthic invertebrates (Windward 2006a). Although VOCs rarely accumulate in sediment, organisms such as benthic invertebrates could be exposed to VOCs in areas downgradient from upland areas with high VOC concentrations in groundwater. Porewater samples were collected from areas adjacent to upland properties where VOCs had historically been detected in groundwater (Map 4-12a). The GWI and Boeing Plant 2/Jorgensen Forge facilities were selected for the porewater investigation because existing data indicated that these areas had the greatest potential to have VOC-contaminated porewater as a result of groundwater discharge (i.e., maximum concentrations of some VOCs were at least an order of magnitude higher at these facilities than at any of the other 12 facilities evaluated[156] (Windward 2005h)).

Porewater sampling has also been conducted as part of several other investigations in the LDW. Information on porewater sampling events is provided in Section 4.1.2.6 (Table 4-12 and Map 4-12a). The results of the porewater sampling conducted for the RI and as part of other investigations are presented in multiple places throughout the RI: Maps 4-12b through4-12d, Section 4.2 (where porewater results are described in further detail by chemical group), Table 4-22 (where porewater data are compared with WQC), Table 9-15 (where chemicals detected in the porewater samples are listed by facility), and the following sections where porewater data associated with the 12 facilities included in the groundwater pathway assessment are discussed. Porewater data are also presented in Appendix I for the facilities located within the 11 SCAs

[156] One possible exception was trichloroethene at Advance Electroplating, according to EPA's summary of other data collected from seven onsite wells by Hart Crowser in 2000 (Sanga 2002). The high concentrations of trichloroethene (200,000 µg/L) in one of the site wells suggest that non-aqueous phase liquid (NAPL) may be present beneath the site, although it was not detected in the 104 borings drilled to 13 ft by Ecology & Environment, or in the seven monitoring wells installed by Hart Crowser (Sanga 2002). The highest trichloroethene concentration documented in follow-up work was 2,600 µg/L.

selected for summarization. Ecology and the SCWG may further evaluate chemicals in porewater as part of their continued source control efforts.

9.4.6.4 Groundwater, seep, and porewater study information for the 12 facilities included in the Phase 1 groundwater pathway assessment

This section presents a summary of groundwater, seep, and porewater information available for each of the 12 facilities evaluated in the groundwater pathway assessment (Appendix G in Windward 2003a). Information collected or identified since the completion of that assessment is also included.

Advance Electroplating

Advance Electroplating is located approximately 3,300 ft to the west of the LDW at RM 4.1 (Map 9-17). The facility was used for chrome plating operations from the mid-1960s to the early 1990s. A time-critical removal action (TCRA) under RCRA was conducted at the facility in the mid-1990s (Appendix G in Windward 2003a). Chemicals identified as groundwater COCs that were evaluated in the groundwater pathway assessment included 10 metals (antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc) and 2 VOCs (tetrachloroethene and trichloroethene).[157]

The zone of potential groundwater discharge for Advance Electroplating was estimated to be between RM 4.1 and RM 4.2 (on the west side of the LDW) (Appendix G in Windward 2003a); however, groundwater discharge zones for this facility have not been formally delineated. This zone was identified because it is the area where Hamm Creek discharges; it is probable that the Advance Electroplating facility's shallow groundwater discharges to a local ditch or other surface water drainage (e.g., Hamm Creek) before discharging to the LDW, given the relative elevation difference between the site and the LDW elevation, and the surface water drainage systems between the site and the LDW (Appendix G in Windward 2003a). Additional groundwater investigations would be needed to formally delineate the groundwater discharge zone for this facility.

Water quality data are available for Hamm Creek (Herrera 2004b, 2005) and were used in a pollutant loading analysis conducted for the Green-Duwamish watershed (Herrera 2007). The pollutant loading analysis included a calculation of loading values for Hamm Creek for total and dissolved copper, total and dissolved mercury, and total and dissolved zinc. This area was also included in the lateral loads analysis discussed in Sections 3.2.5.1 and 9.4.4.6. Based on a review of the baseline surface sediment data collected from the zone of potential groundwater discharge, none of the potential

[157] Chemicals were selected as groundwater COCs for Advance Electroplating in the groundwater pathway assessment if they were detected in groundwater and if SMS criteria or DMMP guidelines were available (Windward 2003a).

groundwater COCs identified for the Advance Electroplating facility were detected above the SQS.[158]

Two porewater samples (unfiltered) were collected from the zone of potential groundwater discharge as part of an EPA SI (Weston 1999a) (Map 9-17). Arsenic, barium, lead, manganese, and vanadium were detected in both porewater samples; copper was detected in one porewater sample. All of these chemicals were also detected in site groundwater (Table 9-15). VOCs were not analyzed in the porewater samples. No seep data from the zone of potential groundwater discharge were identified.

The groundwater quality within the deeper alluvium has not been evaluated. The clay layer identified above the alluvium by Ecology and Environment (1997) may have restricted downward COC migration. EPA's emergency action removed most of the contaminated soils from the facility in 1995 and 1996 (Ecology and Environment 1997).

Boeing Developmental Center

The BDC is located on the east side of the LDW between RM 4.2 and RM 4.8 (Map 9-17). One hundred and fifty-seven solid waste management units (SWMUs) and five areas of concern (AOC) were identified and investigated at the facility under RCRA (Ecology and Environment 2007a). All but two of the SWMUs (SWMU-17, SWMU-20) were determined to not represent a threat to human health or the environment and were clean-closed in accordance with RCRA requirements (Appendix G in Windward 2003a; Ecology and Environment 2007a). Of the SWMUs and AOCs that required further monitoring, three areas required additional groundwater investigation: SWMU-17, SWMU-20, and AOC 05. These areas are all located on the southern portion of the BDC.

Chemicals detected in groundwater at the BDC that were evaluated in the groundwater pathway assessment were arsenic, copper, lead, nickel, benzene, tetrachloroethene, and TPH.[159] The zone of potential groundwater discharge for the BDC was estimated to be the east side of the LDW between RM 4.4 and RM 4.8 (Appendix G in Windward 2003a); however, groundwater discharge zones for this facility have not been formally delineated. Of the groundwater COCs for which SMS criteria exist, only lead was detected in surface sediments above the SQS (i.e., one CSL exceedance was detected near the southern end of the zone of potential groundwater

[158] All of the potential groundwater COC metals were analyzed for in all of the surface sediment samples collected from the estimated groundwater discharge zone; the two VOCs were only analyzed in one sample.

[159] Chemicals were selected as groundwater COCs for the BDC in the groundwater pathway assessment if they had been detected since 1998 in groundwater above MTCA Method B marine surface water cleanup levels (Appendix G in Windward 2003a).

discharge). No seep or porewater data have been collected from within the zone of potential groundwater discharge for this facility.

Remedial actions at SWMU-17, SWMU-20, and AOC 05 have been conducted under RCRA corrective action authority. Pump and treat groundwater remediation was conducted at SWMU-20 from 1993 to 2001, and an electron donor injection was performed in 2004.[160] Groundwater monitoring conducted in May 2006 indicated that chemical concentrations at SWMU-20 have decreased since the initiation of groundwater treatment (Ecology and Environment 2007a). The groundwater monitoring data from SWMU-20 showed that concentrations of chlorinated VOCs decreased downgradient of the former degreaser pit and that concentrations also decreased with depth so that the downgradient extent of chlorinated solvent detection was limited to within 200 ft of the original source area. The LDW is another 500 ft from the downgradient extent of the detected VOC plume (Appendix G in Windward 2003a).

At AOC 05, an oxygen release compound was injected into groundwater in 2002, and pilot testing of a bioremediation groundwater remediation system was initiated in 2007 (Ecology and Environment 2007a) to address TPH and benzene contamination.[161] Groundwater monitoring is ongoing at SWMU-17, SWMU-20, and AOC 05.

The data reviewed for the BDC as part of the groundwater pathways assessment indicated that the residual COC plumes are contained locally around the source areas. In the case of AOC 05, the UST source has been removed (Landau 2001), and the existing monitoring data indicate a very limited extent of residual hydrocarbon concentrations in groundwater (Appendix G in Windward 2003a). Given the ongoing cleanup activities at SWMU-20 and AOC 05, and the distance from SWMU-17, SWMU-20, and AOC 05 to the LDW (over 700 ft), attenuation through biodegradation could be expected to reduce the residual hydrocarbon constituent concentrations before discharge to the LDW.

Additional information on the BDC is included in both the Slip 6 and Norfolk CSO/SD SCA summaries in Appendix I (Sections I.4.7 and I.4.8).

Boeing Isaacson

The Boeing Isaacson facility is located on the east side of the LDW between RM 3.7 and RM 3.8 (Map 9-17). Several remedial actions and environmental investigations have been conducted at the facility (Appendix G in Windward 2003a) (also see

[160] SWMU-20 is approximately 0.25 ac in size.

[161] Toluene, enthylbenzene, and xylene are being remediated at AOC 05 by oxygen release compound injection and the bioremediation system.

Appendix I). Chemicals detected in Boeing Isaacson groundwater that were evaluated in the groundwater pathway assessment were arsenic, chromium, lead, and zinc.[162]

The zone of potential groundwater discharge for Boeing Isaacson was estimated to be between RM 3.7 and RM 3.9 on the east side of the LDW (Appendix G in Windward 2003a); however, groundwater discharge zones for this facility have not been formally delineated. With the exception of arsenic, none of the chemicals identified in the groundwater pathway assessment were detected above the SQS in surface sediments in this area. Arsenic was detected above the CSL in two samples and above the SQS in one sample collected within the zone of potential groundwater discharge (see Map 4-14e and Appendix I, Section I.4.6).

One seep sample was collected in support of a request for a groundwater NFA determination at the Boeing Isaacson facility (ERM and Exponent 2000). Dissolved arsenic was detected in the sample. An additional seep location (SP-20) along the Jorgensen Forge shoreline near the Jorgensen Forge and Boeing Isaacson property boundary was sampled in 2004 (Windward 2004b). Arsenic, cadmium, copper, lead, mercury, nickel, silver, and zinc were detected in both filtered and unfiltered samples collected from this seep location.

Additional sampling was conducted in 2006 and 2007, and samples were analyzed for total and dissolved arsenic (SAIC 2008b). Data from these sampling events are summarized in Appendix I (Section I.4.6).

A comparison of arsenic concentrations in groundwater samples collected in the 1990s near the shoreline relative to samples collected from upgradient wells located slightly inland from the shoreline identified an apparent attenuation process occurring in groundwater at Boeing Isaacson (Appendix G in Windward 2003a). These wells are screened within the same aquifer zone and indicated at least an order of magnitude reduction in arsenic concentrations within 100 ft of downgradient flow (Appendix G in Windward 2003a). The potential for arsenic in groundwater to contaminate LDW sediments is being investigated at this site by Ecology (Ecology 2008a). Groundwater sampling was conducted in 2007 and additional sampling is planned (Ecology 2008a).

Ecology is still assessing groundwater at this facility as part of their source control program for the LDW. Ecology is negotiating an Agreed Order with Boeing to conduct a MTCA RI/FS at the Boeing Isaacson site and the adjacent Boeing Thompson site. Under this order, Boeing will conduct: 1) additional soil sampling on these properties to characterize concentrations of arsenic and other COCs in surface and subsurface soils, and 2) additional groundwater sampling at selected wells on these properties during both wet and dry seasons to characterize concentrations of arsenic and other

[162] Chemicals were selected as groundwater COCs for Boeing Isaacson in the groundwater pathway assessment if they were detected in the 1988 sampling event above either their freshwater or marine AWQC (Appendix G in Windward 2003a).

COCs in groundwater. If COCs in soil or groundwater are present at sufficiently high concentrations, and there is demonstrated to be a pathway to the LDW that could result in unacceptable levels of sediment contamination, Boeing will develop a plan for controlling these contaminant sources.

Boeing Plant 2

The Boeing Plant 2 facility is located on the east side of the LDW between approximately RM 2.9 and RM 3.6 (Map 9-17). Environmental investigations and corrective actions have been conducted at Boeing Plant 2 under RCRA since 1994 (see Appendix I, Section I.4.5). Groundwater data collected as part of several site investigations (Weston 1996, 1998, 2001a, b, c, 2002a; Weston Solutions 2002) were evaluated in the groundwater pathway assessment (Appendix G in Windward 2003a). Chemicals that were identified as groundwater COCs in the groundwater pathway assessment were arsenic, cadmium, chromium, copper, lead, nickel, selenium, silver, thallium, zinc, PCBs, 1,1-dichloroethene, cis-1,2-dichloroethene, trichloroethene, and vinyl chloride.[163] Shoreline groundwater monitoring at Boeing Plant 2 is ongoing. Nine VOCs, thirteen metals, and PCBs were detected in samples from a recent semi-annual monitoring event (Environmental Partners 2008). Data gaps investigations have also recently been completed for upland areas at Boeing Plant 2 (Environmental Partners and Golder Associates 2007a, c, b; Ecology and Environment 2007b). Recent data are presented in Appendix I.

Based on groundwater flow information, the zone of potential groundwater discharge for Boeing Plant 2 was estimated as extending from RM 2.8 to RM 3.6 on the east side of the LDW (Appendix G in Windward 2003a); however, groundwater discharge zones for this facility have not been formally delineated. A review of the baseline surface sediment dataset (see Appendix I, Section I.4.5) indicates that of the groundwater COCs for which SMS criteria are available,[164] PCBs and all of the metals except for arsenic were detected in some areas at concentrations above the CSL in the zone of potential groundwater discharge.

In 1995, 21 seep samples (some filtered and some unfiltered) were collected from 18 locations along the Boeing Plant 2 and adjacent Jorgensen Forge facility shoreline as part of the Plant 2 RFI (Weston 1998) (see Map 4-11a). Of the VOCs identified as groundwater COCs in the groundwater pathway assessment (Appendix G in Windward 2003a), cis-1,2-dichloroethene, trichloroethene, vinyl chloride, copper (total and dissolved), zinc (total), and total PCBs were detected in the seep samples.

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[163] The chemicals selected in the groundwater pathway assessment as the groundwater COCs for the Boeing Plant 2 facility were those detected in boundary wells above preliminary media cleanup levels (Appendix G in Windward 2003a).

[164] SMS criteria are not available for nickel, selenium, thallium, 1,1-dichloroethene, cis-1,2-dichloroethene, or vinyl chloride.

In 2005, as part of the LDW RI (Windward 2006a), 14 porewater samples were collected from locations adjacent to the Boeing Plant 2 and Jorgensen Forge facilities (see Map 4-12a) and analyzed for VOCs. Four VOCs (vinyl chloride, 1,1-dichloroethene, cis-1,2-dichloroethene, and trichloroethene) were detected in porewater samples collected using peepers. At least one VOC was detected in samples collected from five of the eight locations at this site, with concentrations ranging from 0.2 µg/L (cis-1,2-dichloroethene and trichloroethene) to 13 µg/L (vinyl chloride).

A roughly 15-ac area of intertidal and subtidal sediments (referred to as the Duwamish Sediments Other Area [DSOA]) along the Plant 2 shoreline has been delineated for dredging and backfilling/capping remedial actions (Ecology and Environment 2007b) (see Appendix I, Section I.4.5). The approval and design of the dredging and backfilling/capping interim measure are currently in progress (Ecology and SAIC 2008). Further investigation is being planned to more fully characterize the depth of sediment contamination adjoining the navigation channel. As part of the planning for sediment remediation, Weston conducted a mass loading analysis and an equilibrium-partitioning model analysis to evaluate whether metals in groundwater had the potential to recontaminate sediment in the remediation area (Weston 2002b). The analyses indicated that after remediation, groundwater from the facility would not contaminate the sediment area at concentrations that would exceed the SQS within a reasonable time frame (i.e., hundreds of years). EPA has not expressed an opinion on the conclusions reached in any of Boeing's reports regarding groundwater as a source of contaminants to the LDW, and EPA has not yet decided whether there will be any need for further control of groundwater.

Great Western International

GWI is located on the east side of the LDW approximately 400 ft to the northeast of the Myrtle Street embayment at RM 2.4 (Map 9-17). An RI/FS was initiated at the facility in 1991 to address soil and groundwater contamination associated with site operations (Appendix G in Windward 2003a). In 2004, an underground injection control cleanup program was implemented. As of 2006, cleanup was still being conducted and its effectiveness was still under evaluation (Ecology and Environment 2008a). The groundwater pathway assessment used groundwater data obtained from the supplemental remedial investigation (SRI)/FS (Terra Vac and Floyd & Snider 2000). Chemicals that were identified as groundwater COCs were tetrachloroethene, trichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, vinyl chloride, 1,1-dichloroethane, and methylene chloride.[165]

Based on groundwater flow information, the zone of potential groundwater discharge for GWI was estimated to be between RM 2.3 and RM 2.4 (Appendix G in Windward

[165] A chemical was identified in the SRI/FS as a COC for GWI if it was detected in monitoring wells located closest to the LDW above MTCA Method B cleanup levels.

2003a); however, the groundwater discharge zone for this facility has not been formally delineated. One of the four surface sediment samples collected from within the zone of potential groundwater discharge was analyzed for VOCs, including all of the groundwater COCs, except methylene chloride. None of the groundwater COCs that were analyzed for in sediment were detected.

As part of the SRI/FS, 43 water samples were collected from sediment in the Myrtle Street embayment using absorbent screening modules called Gore-Sorbers® (Terra Vac and Floyd & Snider 2000). Two of the water samples contained detectable quantities of tetrachloroethene breakdown products. Seep samples were also collected in 1998 and 1999 as part of the SRI/FS (see Map 4-11a); it is not known whether the seep samples were filtered or unfiltered. All of the groundwater COCs, with the exception of methylene chloride, were detected in the seep samples.

The key findings of the Myrtle Street embayment study (Terra Vac and Floyd & Snider 2000) were as follows:

- Groundwater discharge to the LDW at the Myrtle Street embayment was found to occur as discrete seep discharges in the intertidal zone. Generalized groundwater upwelling was not observed in the Myrtle Street embayment based on the Gore-Sorber study using VOCs as chemical markers.
- PCE and/or its degradation products were detected in Gore-Sorber modules placed in seep-face sediments along the eastern edge of the Myrtle Street embayment. This seep face was further delineated in a second sampling event and found to have a moderately long horizontal extent. The seeps were bounded in elevation (vertical extent) and found to occur between approximately -1 and -3 ft MLLW.

Porewater samples were collected from the zone of potential groundwater discharge for GWI as part of the RI (Windward 2006a) (see Map 4-12a). Piezometers were used to collect porewater samples in deeper areas, and peepers (porous diffusion samplers) were used in shallower areas. The samples were analyzed for all of the groundwater COCs identified for GWI, with the exception of methylene chloride. None of the groundwater COCs were detected in porewater samples collected using piezometers, consistent with the results of the Gore-Sorber study and the conceptual site model (Windward 2005h). In samples collected using peepers, all of the groundwater COCs analyzed were detected in two or more samples. Cis-1,2-dichloroethene and vinyl chloride were detected in every peeper sample collected from the zone of potential groundwater discharge for GWI. The VOC results for porewater are discussed further in Section 4.2.11.4.

Based on groundwater, seep, Gore-Sorber®, and surface sediment data available at the time, the SRI/FS (Terra Vac and Floyd & Snider 2000) presented a fate and transport analysis of ethenes and ethanes. That analysis indicated that groundwater COCs were extensively degraded through reductive dechlorination.

Ecology is continuing to assess the GWI facility under MTCA and as part of their source control program for the LDW (SAIC 2008a; Ecology 2009). Ecology and the GWI property owner (the facility is now called the Fox Avenue Building LLC site) are entering into an Agreed Order under MTCA for additional site investigation and cleanup. An interim cleanup action to address contaminant migration to the LDW is included in the Scope of Work under the Agreed Order for GWI.

Long Painting

The Long Painting facility is located on the west side of the LDW between approximately RM 3.0 and RM 3.1 (Map 9-17). A portion of the facility is adjacent to the LDW, and a portion is inland. Site investigations conducted in 1997 and 2000 (Kleinfelder 2000) included groundwater sampling (Appendix G in Windward 2003a). Groundwater data collected in 2000 were used in the groundwater pathway assessment. Chemicals in groundwater that were identified as COCs were arsenic, chromium, lead, 1,1,1-trichloroethane, and tetrachloroethene.[166]

The zone of potential groundwater discharge for Long Painting was estimated to be between RM 2.9 and RM 3.1 on the southwest side of the LDW, based on groundwater flow information (Appendix G in Windward 2003a); however, the groundwater discharge zone for this facility has not been formally delineated. None of the metals were detected above the SQS in the surface sediment samples collected from the zone of potential groundwater discharge in which they were analyzed (see Map 4-14d). The VOCs were not detected in the single sediment sample analyzed in this zone (Appendix G in Windward 2003a).

One porewater sample was collected just outside the zone of potential groundwater discharge for Long Painting; this sample was collected within the navigation channel at approximately RM 3.05 as part of the PSDDA sediment characterization of the LDW navigation channel (SEA 1998). None of the groundwater COCs for Long Painting were analyzed in the porewater sample.

One seep sample was collected from the zone of potential groundwater discharge as part of the RI (Windward 2004b). Of the groundwater COCs for this facility, arsenic and lead were detected in the seep sample. Neither 1,1,1-trichloroethane nor tetrachloroethene was analyzed in this sample.

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[166] The metals identified as COCs were selected in the groundwater pathway assessment for the Long Painting facility because they were detected in groundwater above MTCA Method A or B groundwater cleanup levels and in the monitoring well closest to the LDW (Appendix G in Windward 2003a). The two VOCs were not detected above MTCA cleanup levels in any of the wells but were selected because it was not clear if the downgradient monitoring wells would capture a potential chlorinated solvent plume.

The groundwater pathway assessment concluded that there were insufficient groundwater data (i.e., representation of depth and location) to fully evaluate the potential for groundwater contamination on the Long Painting site.

T-117 (Former Malarkey Asphalt)

T-117 is the location of the former Malarkey Asphalt facility, which manufactured roofing asphalt and other petroleum-based products from 1937 to 1993. The site is located on the west side of the LDW, between approximately RM 3.5 and RM 3.7 (Map 9-17). Several environmental investigations and remedial actions have been conducted at the T-117 facility; and a non-time-critical removal action (NTCRA) for the remediation of soil, sediment, and adjacent streets is planned. Additional information on the background of and plans for the T-117 facility is included in the groundwater pathway assessment (Appendix G in Windward 2003a) and Appendix I, Section I.4.11.

Groundwater data were collected from the site between 2003 and 2008 as part of the draft EE/CA for the NTCRA (Windward et al. 2008). Total PCBs, TPH, and chrysene were selected as the groundwater COCs for the T-117 facility in the EE/CA (Windward et al. 2008). As stated in the draft EE/CA, these groundwater COCs are expected to be addressed through the NTCRA removal of contaminated soil, which is the likely source of contamination to the groundwater (Windward et al. 2008).

The zone of potential groundwater discharge for the T-117/former Malarkey Asphalt facility was estimated to be the sediment area adjacent to the site, extending from RM 3.5 to RM 3.7, based on the proximity of the facility to this area and groundwater flow information (Appendix G in Windward 2003a); however, the groundwater discharge zone for this facility has not been formally delineated. PCBs and several individual PAHs have been detected above the CSL in numerous sediment samples collected from the zone of potential groundwater discharge (see Appendix I, Section I.4.11).

In 2003, seep samples were collected from three locations within the zone of potential groundwater discharge for T-117 as part of the NTCRA investigation (Windward et al. 2005a). Total PCBs were detected in one of the three seep samples. This seep was re-sampled because it was suspected that the detected PCB concentration of 0.94 J µg/L may have been associated with suspended solids in the water sample. The second sample was centrifuged and analyzed, and PCBs were not detected at a reporting limit of 0.033 µg/L. No other groundwater COCs were detected in the seep samples. No porewater data have been collected.

Groundwater data have been collected at T-117 since 1991. Historical (pre-2003) groundwater conditions are summarized in the data gaps report (Windward et al. 2003). Groundwater monitoring has been conducted at T-117 periodically since 2003. Nine wells are currently located on the upland portion of the T-117 facility. Six wells are located along the shoreline (25 to 70 ft from the LDW), and three wells are

upgradient (ENSR|AECOM 2008). Recent groundwater data for T-117 are summarized in Appendix I (Section I.4.11).

PCBs have been detected in 11 out of 35 unfiltered groundwater samples collected between 2005 and 2008 in shoreline and upgradient wells at concentrations ranging from 0.010 to 2.0 µg/L (Windward et al. 2005a; 2008). TPH was detected in 4 out of 19 samples ranging from 0.5 to 7.5 mg/L. Chrysene was detected in one sample at 0.50 µg/L.

In 2004, five shoreline wells were sampled. PCBs and chrysene were not detected. Samples collected from shoreline wells in 2005 were analyzed for PCBs and TPH. PCBs were detected in one shoreline well at a concentration of 0.040 µg/L, and TPH was detected in another shoreline well at a concentration of 0.5 mg/L. In January 2006, the well with the PCB detection was re-sampled to confirm the 2005 result. PCBs were detected in the 2006 sample at 0.32 µg/L.

In August 2006, six shoreline wells were sampled. PCBs were detected in four of the shoreline wells, TPH was detected in one shoreline well at 0.94 mg/L, and no PAHs were detected.

In March 2008, groundwater samples were collected from the six shoreline wells and the three upgradient wells. PCBs were detected in four wells and TPH and PAHs were detected in two wells. TPH concentrations were 0.70 mg/L in a shoreline well and 7.5 mg/L in an upgradient well. Chrysene was detected in one well. Groundwater monitoring is still being conducted at T-117 as part of a quarterly groundwater monitoring investigation.

Although PCBs were detected in shoreline wells, PCBs have very low solubility and mobility in groundwater, except in the presence of a co-solvent such as petroleum fuel. Trace amounts of LNAPL (i.e., a sheen < 0.01 ft thick) were observed in two of the monitoring wells (MW-2 and MW-7) on one occasion during the 2005 tidal study. During the most recent groundwater monitoring event in February 2008 (ENSR|AECOM 2008), no LNAPL was observed in any of the wells monitored. Concentrations of petroleum hydrocarbons (TPH-oil) were detected during quarterly groundwater sampling.

Groundwater in these wells is typically turbid, indicating the likelihood that low concentrations of PCBs present in the fine silts surrounding the well screens may be leaching into the wells during well purging. Thus, PCB detections in the groundwater were likely the result of suspended soil particles (Windward et al. 2008).

As stated in the draft EE/CA for the upland NTCRA, collectively, these data suggest that a majority of the PCBs detected in sediment near T-117 are most likely the result of past releases of surface water runoff, spillage from the upland area, or erosion of

contaminated soil in the shoreline bank(Windward et al. 2008).[167] Seep monitoring data collected to date indicate that seep discharges to the LDW do not appear to be a source to the sediment because chemicals detected in the seep samples (metals and BEHP) do not exceed the SQS in sediment and were not identified as site COCs (Windward et al. 2008). PCBs and chrysene were not detected in the seep samples (after centrifugation). However, PCBs have been detected in groundwater samples. The draft EE/CA (Windward et al. 2008) for the upland NTCRA is under review by Ecology. The goal of the upland cleanup is to remove most of the contamination from the upland site.

PACCAR (Former Kenworth Truck Co.)

The PACCAR facility (a former Kenworth Truck Co. manufacturing facility) is located on the east side of the LDW between RM 3.9 and RM 4.0 (Map 9-17). Environmental investigations and remedial activities, including groundwater extraction, were conducted at the facility in the 1990s in association with contamination from the former USTs located at the facility (see Appendix I, Section I.4.7). Groundwater data collected in the late 1990s and early 2000s (Kennedy/Jenks 2002; GeoEngineers and Kennedy/Jenks 1990; Kennedy/Jenks 1996, 1999) were evaluated in the groundwater pathway assessment (Appendix G in Windward 2003a). Chemicals in groundwater that were identified as COCs were arsenic, barium, 1,1-dichloroethene, trichloroethene, tetrachloroethene, and vinyl chloride.[168]

The zone of potential groundwater discharge for the PACCAR/former Kenworth Truck Co. facility was estimated to be the sediment area adjacent to the site, extending from RM 3.9 to RM 4.0, based on the proximity of the facility to this area and groundwater flow information (Appendix G in Windward 2003a); however, the groundwater discharge zone for this facility has not been formally delineated. Arsenic was not detected in surface sediments at concentrations greater than the SQS in the zone of potential groundwater discharge (see Map 4-14e). Barium was detected in three sediment samples collected from the zone of potential groundwater discharge; there are no SMS criteria or DMMP guidelines for barium. None of the VOCs identified as groundwater COCs have been analyzed in surface sediment samples collected from the zone of potential groundwater discharge.

Five seeps were sampled as part of a data gaps investigation at the PACCAR facility in 2002 (Ecology and Environment 2008b). Total arsenic was detected in one of the seep

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[167] Any statements referring to the draft EE/CA should not be considered as the final opinion of EPA and Ecology.

[168] The groundwater COCs identified in the groundwater pathway assessment for the PACCAR/former Kenworth Truck Co. facility were those chemicals that were detected above MTCA Method B or C cleanup levels or detected at concentrations greater than the cleanup and remediation levels at the adjacent Boeing Thompson facility (as reported in Kennedy/Jenks 2002; Appendix G in Windward 2003a).

samples. Four seeps were sampled again in 2007; dissolved copper was detected (Ecology and Environment 2008b). The data gaps report (Ecology and Environment 2008b) did not specify whether barium or VOCs were analyzed in the seep samples collected in 2002 and 2007.

The VOCs identified as COCs in site groundwater are associated with past releases from leaking USTs (Appendix G in Windward 2003a). Tank removal and pump and treat remediation activities were conducted in this area. Groundwater monitoring data showed improvement in the groundwater quality during remediation (Appendix G in Windward 2003a). In addition, an air sparging/soil vapor extraction (AS/SVE) system has been used at the facility since 2004 to treat a VOC plume in groundwater on the northwest portion of the facility (Ecology and Environment 2008b). The AS/SVE system consists of over 30 air sparging wells and 6 soil vapor extraction lines.

Site-wide groundwater monitoring was conducted in 2004 as part of the Phase II data gaps investigation at the facility (Ecology and Environment 2008b). VOCs were detected in groundwater on the western portion of the facility, and arsenic was detected above natural background. Additional groundwater monitoring was conducted in 2006 as part of a wet- and dry-season groundwater study. Vinyl chloride was identified by Ecology as a potential COC based on groundwater sampling results in nearshore wells; however, arsenic was not identified as a groundwater COC at the facility (Ecology and Environment 2008b).

Groundwater monitoring was also conducted in 2007 to assess the effectiveness of the AS/SVE system at treating the VOC plume. Wells to the north, south, and downgradient of the AS/SVE system (adjacent to the LDW) were sampled. Sampling confirmed that VOCs were below MTCA Method B surface water cleanup levels (Ecology and Environment 2008b). Recent groundwater data are summarized in Appendix I (Section I.4.7).

Ecology is still assessing groundwater at this facility as part of two Agreed Orders signed with PACCAR and the property owner (Merrill Creek Holdings LLC) and as part of their source control program for the LDW.

Philip Services /Burlington Environmental

The Philip Services/Burlington Environmental facility is located approximately 4,300 ft to the east of the LDW at RM 1.4 (Map 9-17). The facility was entered into Ecology's CSCSL on March 1, 1988, and is listed as having confirmed groundwater, soil, and air contamination (Ecology 2007l). Confirmed contaminants in groundwater are halogenated organic compounds, EPA priority pollutants (metals and cyanide), PCBs, petroleum products, phenolic compounds, and PAHs. Suspected contaminants in groundwater include base/neutral/acid organics, non-halogenated solvents, and arsenic. Contaminants in groundwater listed as below MTCA cleanup levels after assessment include pesticides, reactive wastes, corrosive wastes, radioactive wastes, asbestos, and methyl tertiary butyl ether. Confirmed contaminants in soil are

identified as base/neutral/acid organics, halogenated organic compounds, EPA priority pollutants (metals and cyanide), PCBs, phenolic compounds, PAHs, and arsenic. An RFI was initiated in the late 1980s. Several investigations into groundwater conditions and potential sources of groundwater contamination were completed for this facility as part of the RFI and subsequent groundwater monitoring. Groundwater investigations conducted by Philip Services at offsite locations near the facility indicated there were likely additional sources of chlorinated solvents between the facility and the LDW.

Groundwater data evaluated as part of the groundwater pathway assessment (Appendix G in Windward 2003a) were collected from wells thought to represent the western boundary of the groundwater plume originating from the Philip Services/Burlington Environmental facility. Groundwater COCs that were selected for evaluation in the groundwater pathway assessment were benzoic acid, barium, cadmium, chromium, copper, lead, manganese, nickel, silver, 1,1,1-trichloroethane, 1,1-dichloroethane, chloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, tetrachloroethene, trichloroethene, vinyl chloride, and benzene, toluene, ethylbenzene, and xylene (BTEX).[169]

The zone of potential groundwater discharge for Philip Services/Burlington Environmental was estimated to be the area between RM 1.1 and RM 1.8 on the east side of the LDW, based on groundwater flow information (Appendix G in Windward 2003a); however, the groundwater discharge zone for this facility has not been formally delineated. None of the groundwater COCs that have SMS criteria were detected above the SQS in surface sediment samples collected from the zone of potential groundwater discharge (see Map 4-14b). None of the VOCs were detected in the three surface sediment samples analyzed from the zone of potential groundwater discharge.

Two seep samples have been collected from the zone of potential groundwater discharge (Windward 2004b; Weston 1999a) (Map 9-17). With the exception of barium and manganese, all of the groundwater COCs were analyzed in the seep samples. Cadmium, copper, and lead were detected in both seep samples, and nickel and silver were detected in one seep sample each.

One porewater sample was collected from within the zone of potential groundwater discharge; this sample was analyzed for metals and organometals. Of the metal groundwater COCs that were analyzed, only barium, lead, and manganese were detected in porewater.

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[169] Chemicals were selected as groundwater COCs for Philip Services/Burlington Environmental if they were retained after the first step in the aquatic ERA conducted by Philip Services (PSC 2001b) and they were detected in monitoring wells closest to the LDW.

In 2004, a subsurface barrier wall and a groundwater recovery system were installed. As of 2006, this system was still being monitored (Ecology and Environment 2008b).

Fate and transport analyses conducted as part of the FS for the Philip Services/ Burlington Environmental facility (Geomatrix 2006) indicated that COCs, including chlorinated ethenes, 1,4-dioxane, and possibly vinyl chloride, could reach the LDW at concentrations greater than the surface water protection criteria.[170] Ecology is still assessing groundwater at this facility as it progresses toward a new RCRA permit and Agreed Orders between Ecology and the Philip Services Corporation and as part of their source control program for the LDW.

Former Rhône-Poulenc Facility

The former Rhône-Poulenc facility is located on the east side of the LDW between RM 4.0 and RM 4.2 (Map 9-17). Multiple environmental investigations have been conducted at the site under RCRA since the 1990s (see Appendix I, Section I.4.7). Groundwater data evaluated in the groundwater pathway assessment were obtained from three separate reports: an RFI report (Rhône-Poulenc 1995), a sewer sediment technical document (Rhône-Poulenc 1996), and a groundwater monitoring report (GeoEngineers 2002). As of 2007, over 10 years of groundwater monitoring has been conducted at the site (Ecology and Environment 2008b). Groundwater COCs that were selected for evaluation in the groundwater pathway assessment were arsenic, chromium, copper, lead, mercury, vanadium, zinc, and BTEX.[171]

The zone of potential groundwater discharge for the former Rhône-Poulenc facility was estimated in the groundwater pathway assessment (Appendix G in Windward 2003a) to be the sediment area adjacent to the site (RM 4.0 to RM 4.2 on the east side of the LDW) based on the proximity of the facility to the zone and groundwater flow information; however, the groundwater discharge zone for this facility has not been formally delineated. Of the chemicals with SMS criteria that were identified as groundwater COCs for this facility, only mercury has been detected above the SQS (i.e., one CSL exceedance) in surface sediment samples collected from the zone of

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[170] The final RI cleanup levels selected for the water table, shallow, and intermediate groundwater were the minimum concentrations based on the following: calculated MTCA Method B groundwater cleanup levels based on an Asian and Pacific Islander exposure scenario for the consumption of fish for the groundwater-to-surface water exposure pathway; AWQC based on only the human health consumption of organisms (Section 304 of the federal CWA); ERA surface water screening levels protective of aquatic biota in surface water; AWQC freshwater and marine criteria maximum concentration, criteria continuous concentration, and organoleptic effects (Section 304 of the federal CWA); Washington State freshwater and marine acute and chronic effects criteria; and MTCA Method A cleanup levels (Geomatrix 2006).

[171] The groundwater COCs identified in the groundwater pathway assessment for the former Rhône-Poulenc facility were chemicals that were detected above action levels in groundwater (i.e., the lowest of the federal or state surface water quality standards for either fresh or marine water) in the monitoring wells closest to the LDW.

potential groundwater discharge (Map 4-14e). One surface sediment sample collected within this zone was analyzed for VOCs; BTEX was not detected in the sample (Appendix G in Windward 2003a).

Several seep samples were collected from the zone of potential groundwater discharge for Rhône-Poulenc as part of an RFI (Rhône-Poulenc 1996) (Map 9-17). All of the groundwater COCs identified in the groundwater pathway assessment were analyzed in the seep samples and were detected in at least one sample.

Porewater samples have also been collected from the zone of potential groundwater discharge as part of the LDW site inspection (Weston 1999a) and the Rhône-Poulenc sediment and porewater investigation (EPA 2005d) (Map 9-17). All of the metals identified as groundwater COCs were analyzed in the porewater sample collected as part of the LDW site inspection; arsenic and lead were the only COCs detected (Weston 1999a). All of the chemicals identified as groundwater COCs were analyzed in the porewater samples collected as part of the Rhône-Poulenc sediment and porewater investigation (EPA 2005d). Copper, mercury, and zinc were detected. Arsenic, chromium, lead, vanadium, and BTEX were not detected.

EPA's LDW site inspection (Weston 1999a) used sediment centrifugation to collect porewater samples. The Rhône-Poulenc investigation (EPA 2005d) used a mini-piezometer and seepage meter to collect porewater samples. Barium, iron, and manganese were the only metals that were detected in samples from both studies. The concentrations of barium and iron detected in the LDW site inspection porewater samples were within the range of the barium and iron concentrations detected in the Rhône-Poulenc investigation porewater samples. However, the concentration of manganese detected in the LDW site inspection sample was nearly three times higher than the maximum manganese concentration detected in the Rhône-Poulenc investigation porewater samples.

Recent groundwater monitoring and geoprobe sampling in an area along the west-central shoreline detected toluene, arsenic, and copper (Ecology and Environment 2008b). Recent groundwater data are summarized in Appendix I (Section I.4.7). Arsenic and copper concentrations in the sediment samples collected from the southwest shoreline area were less than the SQS. EPA is currently investigating the toluene groundwater contamination in the southwest corner of the East Parcel (Ecology and Environment 2008b), in accordance with the revised East Parcel corrective measures implementation work plan (Geomatrix 2007).

South Park Landfill

The South Park Landfill is located approximately 2,000 ft to the southwest of the LDW at RM 2.6 (Map 9-17). The facility has been a MTCA site since the late 1980s, and an independent remedial investigation and quarterly groundwater monitoring program were implemented at the facility in 1997 (Appendix G in Windward 2003a). Groundwater data collected in the late 1990s and early 2000s were evaluated in the

groundwater pathway assessment. Vinyl chloride was the only groundwater COC identified in downgradient wells at the facility when the groundwater pathway assessment was conducted; therefore, it was the only chemical selected for evaluation in the assessment.

The zone of potential groundwater discharge for the South Park Landfill was not estimated in the groundwater pathway assessment, but could be between approximately RM 2.6 and RM 3.0, based on the fact that groundwater flows to the northeast from this site (Appendix G in Windward 2003a); however, the groundwater discharge zone for this facility has not been formally delineated. One surface sediment sample collected between RM 2.6 and RM 3.0 on the west side of the LDW has been analyzed for vinyl chloride; vinyl chloride was not detected in the sample. One seep sample was collected from the west side of the LDW near RM 3.0 as part of the RI (Windward 2004a). Vinyl chloride was analyzed in this sample and was not detected. One porewater sample was collected within the navigation channel at approximately RM 2.65; the sample was not analyzed for vinyl chloride.

Long-term groundwater monitoring is ongoing at the South Park Landfill. During the past two semi-annual monitoring events, conducted in October 2008 and March 2009, vinyl chloride concentrations in groundwater at the downgradient monitoring wells were non-detect at the laboratory practical quantitation limit of 0.2 µg/L (Goldberg 2009). Ecology is still assessing groundwater at this facility as part of an Agreed Order signed with the City of Seattle and the current property owner (South Park Property Development, LLC) and as part of their source control program for the LDW (Ecology 2009). Preparations are underway for initiation of an RI/FS at the South Park Landfill (see Section 9.3.2.5 for additional information).

T-108 (former Chiyoda Property)

The T-108/former Chiyoda property is located on the east side of the LDW between RM 0.5 and RM 0.7 (Map 9-17). Numerous environmental investigations have been conducted at the facility (see Appendix I, Section I.4.1). Groundwater data evaluated in the groundwater pathway assessment were collected on the eastern portion of the facility in 1992 as part of a site assessment summary (AGI 1992). Chemicals that were considered to be groundwater COCs in the groundwater pathway assessment were arsenic, cadmium, chromium, copper, lead, nickel, zinc, total HPAHs, total LPAHs, and total PCBs.[172]

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[172] Chemicals selected as groundwater COCs for T-108 in the Phase I groundwater pathway assessment (Appendix G in Windward 2003a) were those detected above MTCA Method A or C levels in any of the onsite wells that were also detected in wells closest to the LDW in 1992 (the most recent groundwater data available at the time of the assessment). In addition, copper, nickel, and zinc were selected because they exceeded federal AWQC, and PCBs were included as a conservative measure (Appendix G in Windward 2003a).

The zone of potential groundwater discharge for T-108 was estimated to be the sediment area adjacent to the site, from RM 0.4 to RM 0.7, based on the proximity of the facility and groundwater flow information (Appendix G in Windward 2003a); however, the groundwater discharge zone for this facility has not been formally delineated. In general, groundwater at the site flows radially in all directions from a relative high near the center of the facility. This includes some relative flow to the north toward the Diagonal Avenue S CSO/SD system; the potential interaction of groundwater with this drainage network is unknown.

Of the groundwater COCs, cadmium has been detected above the SQS in one surface sediment sample collected within the zone of potential groundwater discharge, total HPAHs have been detected above the SQS in two samples, and total PCBs have been detected above the CSL in two samples and above the SQS in several samples (see Map 4-14a). No seep or porewater samples have been collected from the zone of potential groundwater discharge.

The shallow groundwater samples from the T-108 site were collected primarily within dredge-fill material, above the native tideflat surface. PCBs were detected at low concentrations in samples collected before 1991, but not in any consistent pattern. PCBs were not detected in samples collected in 1991 and 1992. The 1991/1992 data did not detect PAHs above MTCA Method C levels.

Arsenic, cadmium, chromium, lead, and zinc were detected in a few monitoring wells at concentrations above the MTCA Method C cleanup criteria. Given the fine-grained nature of the onsite soils, and the old high-flow groundwater sampling techniques used, it is suspected that some of the metals detected in the groundwater samples may be associated with fine soil particles suspended in the water samples and subsequently dissolved in the acid extraction conducted for laboratory analysis (Appendix G in Windward 2003a). Of these metals, none exceeded the SQS in the surface sediment in the zone of potential groundwater discharge.

Elevated concentrations of PCBs have been detected in sediments adjacent to the site; however, based on the groundwater data for the site and the known high attenuation of PCBs in groundwater, it is likely that a source other than groundwater migration was responsible for elevated PCBs in LDW sediment adjacent to this site (Appendix G in Windward 2003a).

An additional groundwater monitoring program was conducted by the Port in 2006 and 2007 to further evaluate the T-108 groundwater pathway to LDW sediment (Pacific Groundwater Group 2006, 2007). Groundwater data are summarized in Appendix I (Section I.4.1). Chemicals detected in groundwater in the four rounds of sampling conducted as part of this program were arsenic (total and dissolved), chromium (total and dissolved), copper (total and dissolved), lead (total only), zinc

(total and dissolved), and four individual PAHs.[173] Arsenic (total and dissolved) and lead (total only) were the only chemicals detected above MTCA Method A cleanup levels for groundwater. These exceedances were detected in samples collected during the first two rounds of sampling; arsenic and lead concentrations were below MTCA Method A cleanup levels in the third and fourth sampling rounds. The report concluded that the groundwater pathway for T-108 should be considered closed and that groundwater monitoring should be discontinued (Pacific Groundwater Group 2007). Upon review of the associated documentation, Ecology concurred with this recommendation and acknowledged that groundwater at T-108 was not a potential source of contamination to adjacent sediment in the LDW.

9.4.7 Bank erosion

Erosion of contaminated bank soils and sediments can be an ongoing source of contamination to the LDW, as discussed in Section 9.1.6. Unprotected shoreline banks are potentially susceptible to erosion by both wave action and surface water runoff. Most of the shoreline area along the LDW has been developed over the past 100 years for industrial, commercial, or manufacturing purposes, and currently, the majority of the LDW shoreline is armored with constructed steel, wood, concrete bulkheads, sheet pile walls, and riprap revetments. While the presence of shoreline armoring serves to reduce bank erosion in many areas, it does not eliminate the potential for contaminated bank material to reach LDW sediments. Tidal exchange, groundwater discharge, and soil and sediment erosion can occur even in areas that are armored, particularly when armoring is patchy or in disrepair. These processes have the potential to carry chemicals from bank areas to LDW sediments.

Characterization of erodible material is required at sites where bank construction or remediation is planned. Such characterization has been completed at facilities within several of the SCAs in the LDW. At the Slip 4 and T-117 SCAs, PCB contamination has been found in bank soils (see Appendix I). At both of these sites, the erosion of bank material was identified as a direct source of contamination in sediment (Ecology 2005a, 2006a). Remediation activities at these two EAAs, both planned and ongoing, will include removal or capping of contaminated bank soils to eliminate this pathway as a potential source of sediment recontamination.

In addition to bank characterization at the Slip 4 and T-117 SCAs, bank sampling has also been conducted at several other shoreline facilities along the LDW, including Boeing Plant 2, Jorgensen Forge, T-108, and the Industrial Container Services/Trotsky property. Bank soil data for these facilities are presented in Appendix I. Bank soils at the Rhône-Poulenc and Douglas Management Company facilities have also been sampled; however, the data were not available for inclusion in Appendix I (Thomas

[173] The results for one well in the second round of sampling were R-qualified (rejected). These results are not included in this summary or in Appendix I.

2009). Bank soil sampling has also been conducted at several of the restoration sites along the LDW, including Herrings House, Hamm Creek, and the Upper Turning Basin (Cargill 2009).

9.4.8 Routine waterway activities

Potential sources of contamination from routine activities on the LDW include dredging or in-water structure maintenance, which may resuspend contaminated material. In addition, chemicals may leach from structures such as piers or pilings, or originate from recreational and commercial boats or overwater cargo transfer. Vessel movement can potentially resuspend contaminated sediment by a process known as propeller wash. Further discussion of these activities is presented below.

9.4.8.1 Sediment resuspension activities

Dredging activities in the LDW have the potential to resuspend contaminated sediments. In-water construction projects, including the removal of old structures, also have the potential to resuspend sediments. To minimize sediment resuspension during dredging, demolition, or construction activities, appropriate BMPs are required. As part of the design phase of the project, BMPs, compliance protocols, and other requirements are identified and monitored. The most common types of BMPs are operational controls or the use of special equipment.

Operational controls are used to minimize the resuspension of sediment. These controls can include slowing down operations, making sure that barges are not overfilled, and containing or filtering leaks and/or spills from barges. Careful sequencing of the dredging operations by site, area, or lift can greatly minimize potential impacts to the waterway from dredging activities. The use of special equipment can also minimize the resuspension of sediment. Special equipment can include specially constructed dredging buckets designed to reduce increased turbidity of suspended solids (sometimes referred to as environmental or closed-bucket dredging), and silt curtains or Gunder booms designed to limit the distribution of suspended sediment. Water quality monitoring is also typically conducted during dredging and construction activities to ensure that potential water quality impacts are minimized.

Propwash, which generally occurs in or near berthing areas or in shallow areas LDW, may also resuspend sediment. The effect of propwash can vary depending on the sediment type, water depth, and vessel type (see Section 3). Higher bed scours may occur in the bench areas than in the navigation channel from the effects of ships maneuvering in the shallower near shore areas (Windward and QEA 2008).

9.4.8.2 Other activities

Normal day-to-day in-water operations and boat traffic in the LDW can also potentially introduce chemical contaminants to the LDW. These potential sources are generally localized. Some of these activities and potential sources are listed below.

- Direct discharge from boats such as gray, bilge, or ballast waters
- Fuel and other releases from spills and operation and maintenance of boats and vessels
- Spills and releases from loading/offloading and other practices associated with docks, wharves, and piers
- Wastes and other materials from marinas and small boatyards

Ballast is material placed on a vessel to control its stability and buoyancy. In general, ballast is comprised of water, sediment, or a combination of water and sediment. Regulations on ballast water from vessels 300 gross tons or greater in size are implemented by WDFW under RCW Chapter 77.120 (WDFW 2008). These regulations prohibit the discharge of ballast water to waters of the State of Washington, except in cases of open sea exchange, when the ballast water has been treated, or when it consists entirely of "common waters" ballast. Common waters ballast is that taken from designated areas off the coasts of Washington, Oregon, and British Columbia, which are specified by WDFW. The USCG has also implemented a national ballast water management program to enforce the regulations of 33 CFR 151, Subparts C and D. These regulations apply to all vessels with ballast tanks, regardless of size. The program implements mandatory ballast water management practices including regular cleaning and removal of sediments from ballast tanks, practices to limit ballast water discharge, and requirements for vessel-specific ballast water management plans (USCG 2008). Liquid wastes, such as bilge water (water that accumulates in the spaces between lower compartments of a boat and its hull), originate from marinas and boatyards and have the potential to contaminate the LDW. These wastes are regulated under Ecology's NPDES program. Bilge water can contain various chemicals, including oil and detergents (Port of Seattle 2007a).

Boatyards and marinas that conduct maintenance activities out-of-doors are required to maintain a general boatyard NPDES permit, or potentially an industrial NPDES permit. The boatyard general permit contains mandatory BMPs that must be followed for the management of bilge water. These regulations prohibit discharge of bilge waters to the waters of the state if they contain solvents, detergents, or other chemicals, or if they cause any visible sheen when discharged. Gray water must be discharged to the sanitary sewer.

Spill response and tracking programs have been established by the USCG, the Ecology, and SPU. These programs have established response and cleanup methods for both in-water and upland spills. These programs help provide spill source control for the LDW by containing and cleaning up reported spills that occur directly to the

water or within drainage systems that discharge to the waterway. Tables G-14 and G-15 in Appendix G list spills reported in the LDW and the LDW drainage basin.

9.5 SUMMARY

The LDW is a dynamic system that has been altered by over 100 yrs of industrial, commercial, and residential development. Potential sources of contamination to LDW sediment are numerous and may include both historical and ongoing operations and various pathways. Data gaps associated with the characterization of potential chemical sources to the LDW still exist; source control investigations started in the late 1980s and are ongoing.

This section is a summary of source control efforts and investigations with information available up to the date of the draft final version of this document (July 17, 2009). The cutoff date for inclusion of numerical data in this section was a collection date of December 31, 2007, and a reporting date of July 11, 2008, based on discussions with EPA and Ecology. Work to fill source control data gaps is expected to continue for years to come. Ecology will make site-specific recommendations on the status of source control and the potential for recontamination as source control work continues.

Earlier sediment investigations led to the identification of seven candidate EAAs for further sediment characterization and/or remediation; removal actions have already been implemented at two of these seven locations and removal actions are currently being planned for three more EAAs.

Ecology is leading the source control evaluation and assessment of the 23 SCAs, which includes the seven EAAs. Ecology has or will prepare SCAPs and data gaps reports to help direct future investigation and remediation efforts within these areas while assessing potential sources for the chemicals identified.

Modern regulatory requirements have established inspection and compliance programs to monitor and control the handling and disposal of manufacturing wastes produced by industrial operations along the LDW. These regulations have helped reduce sources of contamination that were common practices in the past.

Air emissions are a potential ongoing source of many chemicals to the LDW. Two hundred businesses in the greater LDW basin are registered as active sources of air pollutants. Programs are in place to help reduce these emissions over the long term. However, motor vehicles and the burning of wood and fossil fuels will remain ongoing sources of chemicals to the atmosphere until technologies evolve and these sources can be controlled.

Permit programs are in place to help monitor and control direct discharges to the LDW from CSOs, EOFs, and SDs in the basin. Since 1970, the City of Seattle has reduced the annual CSO volume citywide by approximately 95%; and since 1988, King County has reduced its annual CSO volume by 63%. Direct discharges to the LDW contribute approximately 1% of the annual sediment load to the LDW compared with inputs from

the Duwamish/Green River system. Note that this 1% refers to sediment loading and not chemical loading; direct discharges to the LDW may have a local impact at the point of discharge. Although CSO control programs and stormwater and wastewater discharge permits play an important role in source control, they have not been developed specifically to protect sediment quality.

Source sampling in the LDW study area has been conducted by several parties, including the City of Seattle, King County, the Port of Seattle, Ecology, and private companies. Most of the sampling conducted to date has focused on tracking potential sources so that source controls can be put in place to reduce the amount of contaminants discharged to the LDW. Various sampling techniques have been used to identify and characterize contaminant sources, including source sediment sampling (e.g., catch basin, inline sediment grabs, and inline sediment traps), as well as stormwater and wastewater sampling. These samples have been collected as part of business inspection programs, environmental investigations at individual facilities, and source-tracing investigations (see Section 9.4.4.7 for more information). Results from January 2002 through December 2007 indicate that zinc, BEHP, and BBP frequently exceeded the CSL in solids samples collected as part of source-tracing investigations.

Ongoing monitoring of industrial and municipal stormwater discharges to the waterway will provide useful information to help determine which chemicals might be migrating to sediments in the LDW while simultaneously helping to evaluate the success of any source control measures taken upland of the monitored locations. Monitoring requirements will be established in the ROD.

Chemicals identified in upland groundwater or seeps along the LDW have generally not been shown to accumulate in adjacent sediments, except in a few small areas (e.g., the head of Slip 1). Most chemicals identified in upland groundwater samples are likely to be diluted or attenuated prior to discharge.

Although the majority of the river bank along the LDW is covered or armored with impervious materials, erosion of contaminated bank material into the LDW is still possible. This potential source of chemicals to the waterway is currently not well characterized.

10 Key Findings

This section highlights the important findings of the RI and synthesizes these findings into a unified CSM. The physical, chemical, and ecological processes that have been examined in the RI are interrelated and must be considered in combination when assembling and analyzing alternatives in the FS, and when making remedy and risk management decisions for the LDW.

10.1 GEOGRAPHIC LANDSCAPE OF THE LDW

Prior to the significant alterations that began in the early 1900s, the lower sections of the Duwamish River were characteristic of the many estuarine rivers in the Pacific Northwest. The river exhibited high sinuosity as it meandered through the valley floor and emptied into Elliott Bay as a broad delta. Given the nature of the rivers feeding the lower Duwamish and the flat topography of the valley floor, the terminal section of the river was highly depositional, giving rise to the broad expanse of mudflats depicted in early maps of the area.

As a result of its development, the Green River/Duwamish River system has undergone significant hydrological changes, which have reduced flow by an estimated 78% from historical levels. These changes have included the natural diversion of the White River following the flood of 1906, the loss of flow from the Black River when the water level in Lake Washington dropped in response to the opening of the Ship Canal and Hiram M. Chittenden locks, and the diversion of the Cedar River to Lake Washington. Even with the loss of these water sources, the Green River/Duwamish River system continued to flood low-lying areas. The Howard Hansen Dam, built in 1961 for flood control, effectively decreased peak flows in the river system. Currently, peak flows rarely exceed 12,000 cfs. Despite these changes, the Green River still delivers an estimated 221,000[174] metric tons of sediment load to the Duwamish River each year (QEA 2008).

A portion of the LDW is maintained as a federal navigation channel by USACE. Elevations within the navigation channel are maintained between -30 ft MLLW and -15 ft MLLW, with the shallower elevations maintained in the upper reaches of the LDW. King County Waterway Commercial Waterway District No. 1 constructed an Upper Turning Basin at the head of the navigation channel (RM 4.6) prior to 1920, which serves as a catchment for sediment from the Green/Duwamish River system. The need for this engineered catchment, along with the periodic dredging required to

[174] Estimated sediment load from the Green River to the LDW from 1960 to 1980 (QEA 2008). This value remains relevant because no significant changes have occurred to the morphology of the river that would be expected to change the sediment load.

maintain the navigation channel, is evidence that the LDW continues to be a depositional environment.

The lower 5 mi of the Duwamish River have been highly modified. In the early 1900s, issues with flooding in the area precipitated the installation of levees and dams and the subsequent channelization of the river. Most of the tidal marsh, mudflats and shallows, and tidal wetlands historically present in the lower Duwamish River have either been filled or dredged. Today, the majority of the LDW shoreline consists of riprap, pier aprons, or sheet pilings, especially in the downstream portion of the site.

Intermittent, shallow benches exist in the nearshore, intertidal, and shallow subtidal zones of the LDW outside the navigation channel. These benches are of various dimensions and elevations, with minimum elevations of less than 3 ft MLLW. Intertidal habitats are dispersed in relatively small patches (i.e., generally less than 1 ac in size) downstream of RM 3.0, with the exception of Kellogg Island, which represents the largest contiguous area of intertidal habitat remaining in the LDW. Low intertidal mudflats are present below upper bank riprap and miscellaneous armoring in the reaches upstream of RM 3.0.

The LDW provides a navigational corridor for the movement of raw materials and products used by local facilities, and serves as a major base for marine transport to Alaska. Current land use, zoning requirements, and land ownership within most of the LDW corridor are consistent with the characteristics of an active industrial waterway. Non-industrial uses also occur on and along the waterway. Two mixed residential/commercial/industrial neighborhoods, South Park and Georgetown, are located west and east, respectively, of the LDW. The presence of these neighborhoods and various public access points along the LDW is associated with recreational use of the waterway. Recreational users can collect seafood from the various public access areas (although there is a health advisory in effect advising against consumption of resident fish and shellfish), can walk or play on the beaches, or can access the river by boat (most of the LDW is publicly owned and accessible by boat). In addition, the LDW is also one of the locations of the Muckleshoot Tribe's commercial, ceremonial, and subsistence fishery for salmon. The Suquamish Tribe actively manages aquatic resources north of the Spokane Street Bridge, located just north of the LDW. The Duwamish Tribe uses Herring's House Park and other parks along the Duwamish for cultural gatherings.

Despite the highly modified river habitat, the LDW is home to a diverse assemblage of aquatic and wildlife species and a robust food web that includes top predators. More than 53 resident and anadromous fish species are found in the LDW (Windward 2004d, 2005b, 2006c). A total of 61 invertebrate taxa were identified in a survey of the intertidal and subtidal benthic invertebrate community, including crabs, clams, mussels, crustaceans, marine worms, and gastropod species (Windward 2005e). In addition, surveys have indicated that up to 87 species of birds and 6 species of mammals use the LDW during part of the year to feed, rest, or reproduce. Avian

species include passerines, raptors, shorebirds, waterfowl, and seabirds (1979); mammals include river otters, which may be permanent residents, and harbor seals and sea lions, which may visit the area. Fifteen species identified in the LDW study area are listed under the ESA or by WDFW as candidate species, threatened species, or species of concern.

While the LDW will continue to be used as an industrial corridor, there is a high interest by the resource trustees and the public to create higher quality habitat where opportunities exist. The focus of these efforts thus far has been in small areas of marsh and unvegetated intertidal marsh habitat, including T-105 (RM 0.1); T-107 and Herring's House Park near Kellogg Island (RM 0.3 to RM 0.5); T-108 (RM 0.6); GSA marsh restoration (RM 0.8); Hamm Creek (RM 4.3); Muckleshoot Kenco Marine, Coastal America, and Port of Seattle mitigation sites near the Upper Turning Basin (RM 4.7); and Cecil B. Moses Park (North Winds Weir, RM 5.7).

10.2 CONCEPTUAL SITE MODEL

A CSM for the LDW that describes key features and processes of the waterway was developed as part of the RI/FS process. The CSM will aid in the assembly and evaluation of remedial action alternatives in the FS and in future decision-making for the site. The CSM is considered a working model throughout the RI/FS process, and may continue to be refined as new information and analyses are developed.

The LDW CSM provides a synthesis of the major processes governing the movement and distribution of chemicals at the site as well as potential exposure pathways for the people and animals that use the site (Figure 10-1). Three key components of the LDW CSM are worthy of discussion because of their importance:

- **Physical CSM –** The influence of hydrodynamic and sediment transport processes on the physical distribution of sediment within the LDW
- **Chemical CSM –** Patterns in the distribution of chemicals in the LDW
- **Exposure CSM –** Exposure of human and ecological receptors to chemicals within the LDW

Elliott Bay
- Source of salt water
- Tidal influence

salt water predominates

LDW inputs

bank erosion

discharges and runoff

seeps

groundwater

deposition

episodic erosion

ship-induced mixing

bioaccumulation

Exposure media

Receptors

Exposure media		Receptors
Seafood	consumption	**Humans and wildlife**
Intertidal sediment	clamming, beach play, netfishing	**Humans**
	incidental ingestion	**Wildlife, fish, and benthic community**
Subtidal sediment	netfishing	**Humans**
	incidental ingestion	**Wildlife, fish, and benthic community**

Key to strata
- Fresh water
- Salt water
- Biologically active zone
- Recent sediment
- Upper alluvium
- Lower alluvium

fresh water predominates

Green River
- Source of suspended sediments
- Source of fresh water

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Figure 10-1. Conceptual site model for the Lower Duwamish Waterway

10.2.1 Physical CSM

The LDW can be characterized as a well-stratified salt wedge estuary. The LDW receives inflows of marine (or salt) water from Elliott Bay and fresh water from the Green/Duwamish River system. Fresh water from the Green/Duwamish River system moving downstream overlies the tidally influenced salt water entering from Elliott Bay. Typical of tidally influenced estuaries, the LDW has a relatively sharp interface between the fresher water outflow at the surface and saltwater inflow at depth.

During average-flow conditions in the Green River, the saltwater wedge extends, on average, up to approximately RM 4.5 to RM 4.8, depending on the tidal cycle and river flows (Figure 10-1). During high-flow conditions, the salt wedge may not extend upstream of Slip 4 (RM 2.9). Under extreme conditions, such as very high tide stages during periods of low freshwater inflow, the saltwater wedge can extend as far upstream as RM 8.7. Thus, much of the LDW is dominated by two-layer estuarine circulation, in which the denser salt water is transported upstream in the lower layer of the water column and the fresh water is transported downstream in the upper layer. Above RM 4.8, the LDW is a tidally influenced river in which the entire water column is generally composed of fresh water.

The two-layer estuarine circulation plays a key role in patterns of sediment deposition and scour potential. Reaches of the LDW that are occupied by the saltwater wedge experience minimal bed scour from fresh water coming from upstream because much of the sediment bed is covered by tidally driven salt water. The tidal velocities within the saltwater wedge are much lower than the current (river) velocities. Reaches of the LDW that are entirely fresh water during high-flow events are more susceptible to bed scour because the near-bed velocities are driven by river flow and not tidal velocities.

The physical CSM, which is based on both empirical data collected from the LDW and an STM, identified three reaches of the LDW that have distinct sediment transport characteristics: RM 0.0 to RM 2.2 (Reach 1), RM 2.2 to RM 4.0 (Reach 2), and RM 4.0 to RM 4.8 (Reach 3). Differences among these reaches are defined by the hydrodynamic characteristics of each reach, particularly during high-flow events. The descriptions of reaches represent general conditions within each reach; conditions at specific locations within each reach may vary because of site-specific influences (e.g., berthing, outfalls, dredging activities). The sediment dynamics for Reaches 1, 2, and 3 are illustrated in Figures 10-2, 10-3, and 10-4, respectively, and summarized below.

- **Reach 1: RM 0.0 to RM 2.2 —** The permanent presence of the saltwater wedge in this reach serves as a protective barrier for the river bed. Consequently, the potential for bed scour, even during high-flow events, is relatively low, as is the potential for buried sediments to be re-exposed. This reach is net depositional on an annual time scale. Approximately 60% of the area within and outside the navigation channel has net sedimentation rates between 1 and 2 cm/yr; an additional 30% of the area has net sedimentation rates greater than 2 cm/yr.

- **Reach 2: RM 2.2 to RM 4.0 —** Reach 2 is occupied by the saltwater wedge during most flow conditions, but during high-flow events the toe of the saltwater wedge may only reach the downstream portion of this reach. As a result, Reach 2 could experience net erosion during high-flow events with 2-year or greater return intervals. Even during 100-year high-flow events, net erosion is generally limited to the upper 10 cm (i.e., within the biologically active zone; Section 2.8.2.2) (Ecology 2007n) of the sediment bed. Reach 2 is also net depositional on an annual time scale. Net sedimentation rates are estimated to be spatially variable. Between RM 2.2 and RM 2.6, approximately 94% of the area outside the navigation channel and all of the area within the navigation channel has net sedimentation rates greater than 2 cm/yr. Between RM 2.6 and RM 4.0, approximately 50% of the area both within and outside of the navigation channel has net sedimentation rates greater than 2 cm/yr.
- **Reach 3: RM 4.0 to RM 4.8 —** During most flow conditions, the saltwater wedge extends into this reach, with the location of the toe of the wedge dependent on a combination of river-flow and tidal influences. During high-flow events, the saltwater wedge is not present in this reach, and freshwater flows dominate. This reach is wider than the downstream reaches, which creates lower current velocities that are less likely to erode the sediment bed. The upstream portion of the reach serves as a catchment for sediments transported into the LDW from upstream; by dredging this area every several years, the USACE is able to keep a large portion of the sediments (especially bedload) entering the LDW from upstream from moving into the lower reaches of the LDW.

Over the entire LDW, approximately 50% of the area both inside and outside of the navigation channel has long-term (i.e., 30 years) net sedimentation rates greater than 2 cm/yr. Over shorter time scales (i.e., days to weeks) associated with high-flow events, approximately 80% of the LDW area is expected to be net depositional. Slightly more erosion is estimated for the 100-year high-flow event (12,000 cfs) compared with the 10-year (10,800 cfs) and 2-year (8,400 cfs) high-flow events, but the areas experiencing erosion as well as the net erosion depths within those areas are similar for all high-flow events (Maps 3-4, 3-5, and 3-6). Approximately 6% of the LDW is estimated to experience greater than 10 cm net erosion during a 100-year high-flow event, with a maximum estimated net erosion depth of approximately 21 cm. Based on these model results, high-flow events are not expected to expose subsurface sediment at greater depths.

Kellogg Island

Intertidal Areas
(<-4 ft MLLW)

Intertidal Areas
(<-4 ft MLLW)

Navigation Channel
(-30 ft MLLW)

West Bench Area
Subtidal Bench
(-4 ft MLLW to
Navigation Channel)

East Bench Area
Subtidal Bench
(-4 ft MLLW to
Navigation Channel)

Saltwater Wedge

SAME AS WEST BENCH AREA

Soft Sediment

Consolidated Sediment

Lower Net Depositional
Deposition
Episodic Erosion
Ship-induced Mixing
Net Deposition
(<0.5 cm/yr)

Intermediate Net Depositional
Deposition
Episodic Erosion
Ship-induced Mixing
Net Deposition
(0.5 - 2 cm/yr)

Higher Net Depositional
Deposition
Episodic Erosion
Ship-induced Mixing
Net Deposition
(>2 cm/yr)

Higher Net Depositional
Deposition
Episodic Erosion
Ship-induced Mixing
Net Deposition
(>2 cm/yr)

Notes: 1. Approximate net depositional rates from Sediment Transport Analysis Report, Windward and QEA 2006.
2. Inserts are qualitative illustrations and are not to scale.

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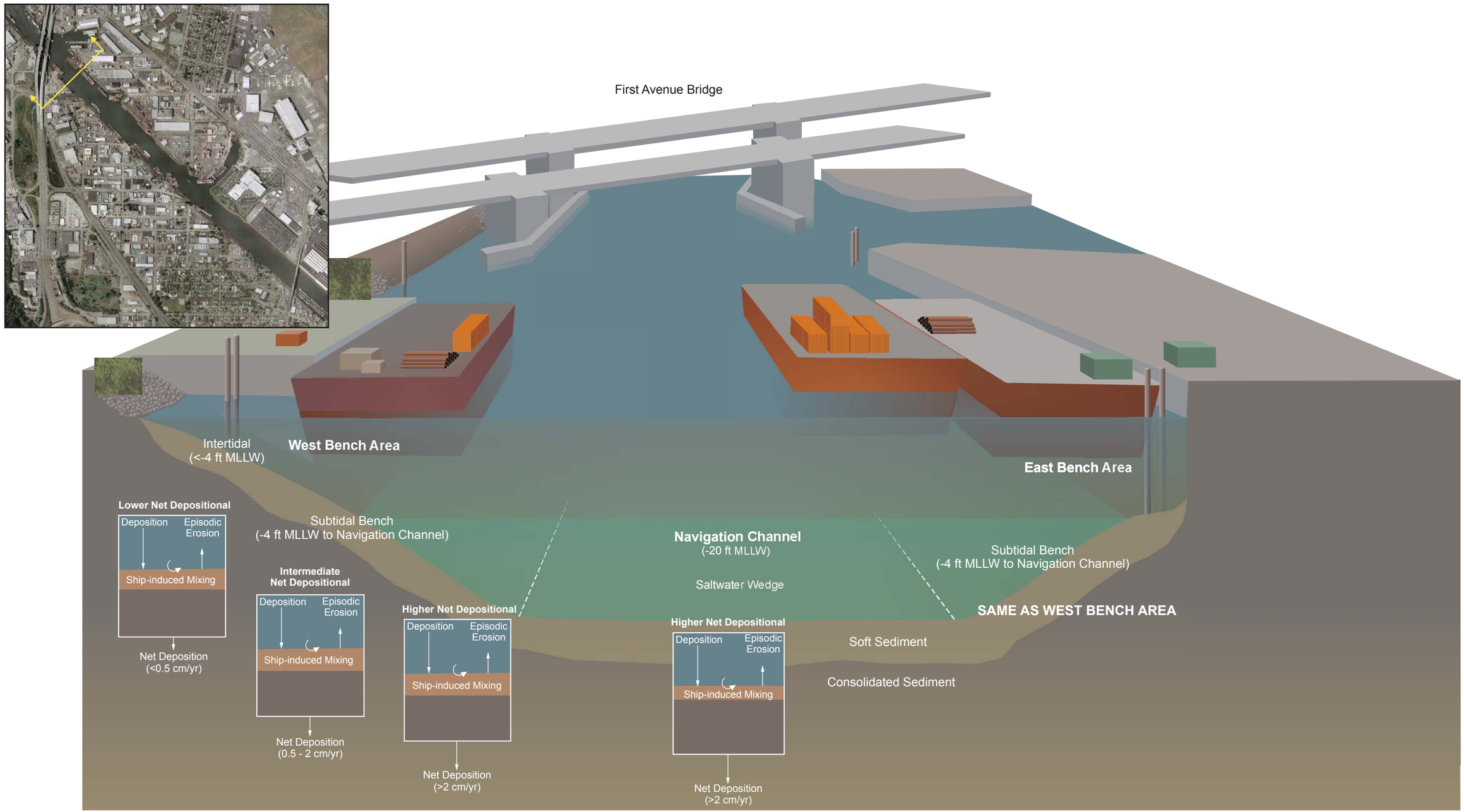
NOTE: Figure prepared January 11, 2006, by Brick Tudor Studios for RETEC, Inc. (RETEC | ENSR).
Updated July 25, 2008 by ZAC, Windward Environmental LLC

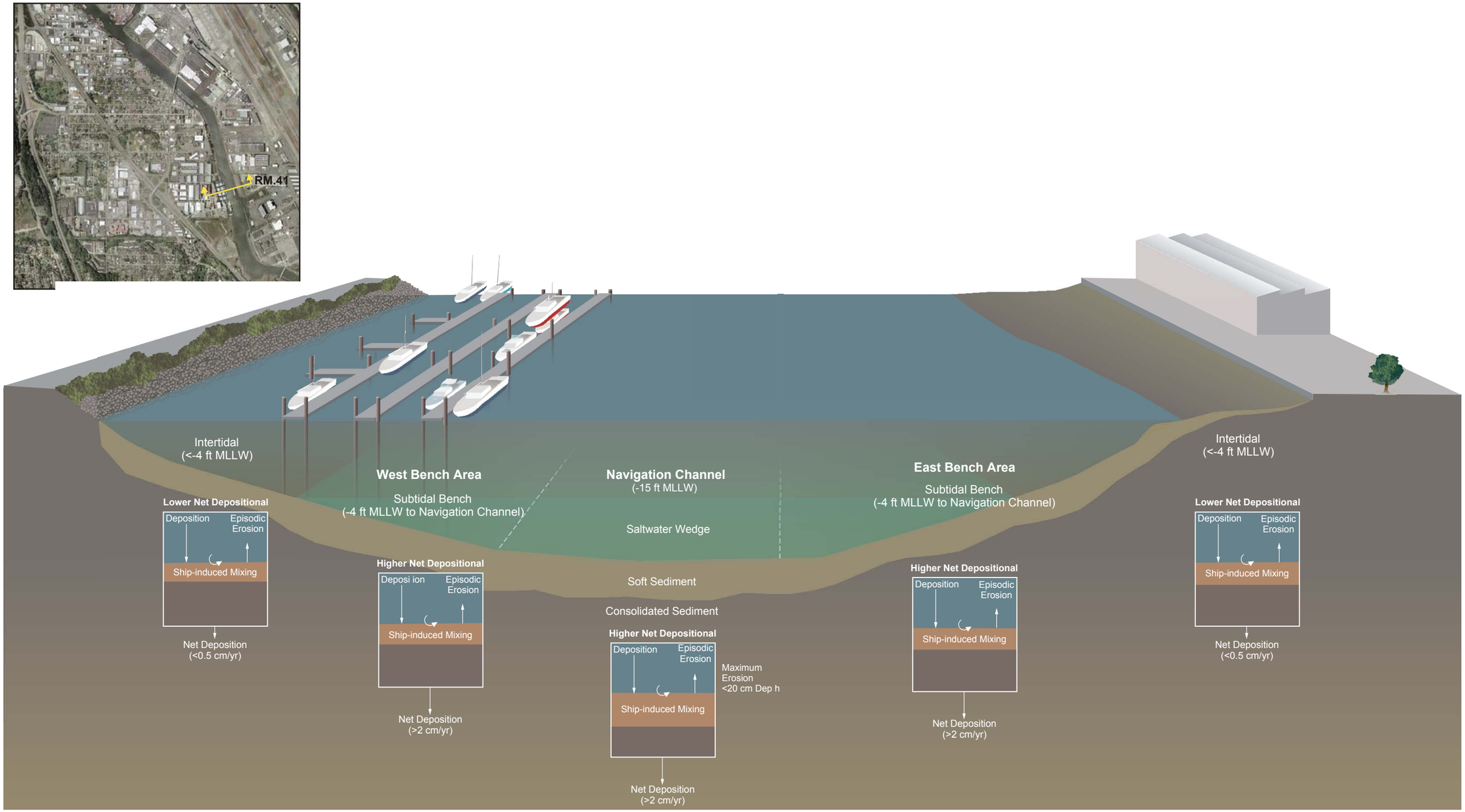
Figure 10-2. LDW sediment transport CSM for Reach 1 (RM 0.0 to RM 2.2)



Notes: 1. Approximate net depositional rates from Sediment Transport Analysis Report, Windward and QEA 2006.
2. Inserts are qualitative illustrations and are not to scale.

NOTE: Figure prepared January 11, 2006, by Brick Tudor Studios for RETEC, Inc. (RETEC | ENSR).
Updated July 25, 2008 by ZAC, Windward Environmental LLC

Figure 10-3. LDW sediment transport CSM for Reach 2 (RM 2.2 to RM 4.0)



Notes: 1. Approximate net depositional rates from Sediment Transport Analysis Report, Windward and QEA 2008.
2. Graphics and inserts are qualitative illustrations and are not to scale.

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NOTE: Figure revised August 2008 by Brick Tudor Studios for ENSR.

Figure 10-4. LDW sediment transport CSM for Reach 3 (RM 4.0 to RM 4.8)

On a smaller scale, there are a number of processes that can affect localized sediment deposition and erosion. Net sedimentation rates may be higher than estimated by the STM in the vicinity of specific outfalls if the actual particulate load from those outfalls is greater than assumed or not specifically included in the model. Net sedimentation rates in specific areas may also be higher than estimated by the model if there have been significant inputs of anthropogenic materials (e.g., sandblast grit in the vicinity of shipyards or bulk material spilled during offloading) that are not addressed by the STM. Prop wash associated with ship and tugboat operations in the LDW can also have localized effects and has the potential to erode deeper holes in small areas than the net erosion depths estimated by the STM. Ship-induced bed scour from passing vessels is estimated to result in a continual reworking of the uppermost 1 to 2 cm of the sediment bed within the navigation channel. In a typical event, sediment is suspended for a brief period of time, but is then re-deposited shortly thereafter once the propeller-driven forces are no longer present.

Based on a mass balance of sediment loads entering and leaving the LDW system, it is estimated that less than 1% of the sediment load enters the LDW from lateral inputs such as storm drains, CSOs, and surface water runoff. Over 99% of the sediment entering the system is from upstream. Approximately 50% of the incoming sediment exits the system as suspended sediment; the remaining material settles and becomes incorporated into the sediment bed. The sediment transported from upstream of the LDW is deposited onto the sediment bed and is mixed with the surface sediment layer (i.e., top 10 to 15 cm) by both biological and physical processes. Over time, the bed-source content of the surface layer decreases at an approximately exponential rate, primarily because of the deposition of upstream source sediment (Map 3-10). The STM report provides estimates of the rate at which sediment from upstream sources is added to bedded LDW sediment (QEA 2008). The sediment transport model developed for the LDW to estimate scour and deposition patterns was collaboratively developed and calibrated by a working group that included representatives from EPA, Ecology, USACE, and LDWG. Uncertainties in the STM are discussed in detail in the STM report (QEA 2008) and summarized in Section 3. The sediment transport working group (with representatives from EPA, USACE, and LDWG) considers the model to be functioning well for site-wide applications. At smaller spatial scales on the order of several grid cells (94% of the grid cells are 1 ac or less), the model results provide one line of evidence to guide decision-making.

10.2.2 Chemical CSM for sediment

The extensive RI dataset for both surface sediment (e.g., 0 to 15 cm in depth) and subsurface sediment provides a characterization of sediment contamination patterns within the LDW. The observed patterns in the spatial and vertical distributions of chemicals in surface and subsurface sediment, respectively, are the result of interactions among several factors, including the proximity and status of chemical sources (present-day and historical), mixing of the surface layer, transport and

deposition of sediment within the LDW over time, and localized conditions that affect sediment mixing (e.g., scour from outfalls and tugboats, dredging).

Numerous chemicals are present in surface sediment in the LDW. Risk driver chemicals (referred to as indicator hazardous substances in the MTCA program [WAC 173-340-703]) were selected as part of the baseline risk assessments, in consultation with EPA and Ecology, to focus the remedial analyses in the FS.[175] The nature and extent of contamination are discussed in Section 4.

Four risk drivers were identified in the HHRA based on risks associated with seafood consumption and direct sediment contact: total PCBs, arsenic, cPAHs, and dioxins and furans. Total PCBs were also identified in the ERA as a risk driver for river otter. In addition, 41 chemicals (including total PCBs, arsenic, several phthalates, and various PAHs) were identified as risk drivers for benthic invertebrates because detected concentrations of these 41 chemicals exceeded the SQS of the Washington State SMS at one or more locations (Table 4-16). Total PCB concentrations in surface sediment exceeded the SQS at more locations than any other chemical. The chemical with the next highest number of locations with detected concentrations in surface sediment greater than the SQS was BEHP. The distributions of these risk driver chemicals in sediment are discussed below.

10.2.2.1 Surface sediment patterns

In general, high concentrations of chemicals were detected in localized areas separated by larger areas of the LDW with relatively low concentrations (Maps 4-70a through 4-70c). PCBs are widely distributed throughout the LDW and concentrations are highly variable. Total PCBs were detected in 94% of the 1,365 surface sediment samples in which they were analyzed, at concentrations ranging from 1.6 to 220,000 µg/kg dw, with a median concentration of 115 µg/kg dw (Maps 4-18 and 4-19). Arsenic was detected in surface sediments throughout the LDW, with concentrations ranging from 1.2 to 1,100 mg/kg dw, with a median concentration of 11 mg/kg dw (Maps 4-29 and 4-30). The highest arsenic concentrations were also highly localized.

Despite the widespread distribution of both of these chemicals in the LDW, the locations of the highest total PCB and arsenic concentrations were generally not in the same areas, indicating that sources likely differ for these two chemicals. The majority of the high total PCB concentrations were located within fairly well defined areas (Map 4-19), suggesting the nearby presence of one or more ongoing or historical sources. Areas with the highest total PCB concentrations in the baseline surface sediment dataset included the Duwamish/Diagonal EAA, EAA 2 (RM 2.2 on the west

[175] Other chemicals that exceeded risk thresholds but were not selected as risk drivers for a particular exposure pathway will be addressed through a focused evaluation in the FS; these chemicals may also be re-assessed as part of the 5-year review or included in the post-remedial monitoring program, as appropriate.

shore), the Slip 4 EAA, the T-117 EAA, the Boeing Plant 2/Jorgensen Forge EAA, and the Norfolk EAA (Map 4-19).[176] Removal actions within some of the EAAs have already reduced surface sediment PCB concentrations in those areas. Likely sources of PCBs have been identified in most of these EAAs and source identification efforts are ongoing. However, specific sources have not been identified for all areas with higher total PCB concentrations (e.g., RM 1.0 in the navigation channel).

The majority of the higher arsenic concentrations were also located within fairly well-defined areas (Map 4-30), suggesting the presence of one or more nearby ongoing or historical sources. Areas with the highest arsenic concentrations in the baseline surface sediment dataset included the Duwamish/Diagonal EAA, Slip 1, RM 1.1 to RM 1.5, RM 2.0, RM 2.8, and RM 3.7 to RM 3.9 (Map 4-30).

Areas with the highest cPAH concentrations in the baseline surface sediment dataset were located in many of the same areas identified for arsenic and total PCBs, including the Duwamish/Diagonal EAA, RM 1.3 to RM 1.4, Slip 4, and RM 3.7 to RM 3.8 (Maps 4-37 and 4-38). Other areas with high cPAH concentrations were generally downstream of RM 1.1, at RM 2.1, RM 2.7, and in Slip 6. Sources of cPAHs for some of these areas have been identified. In general, high cPAH concentrations were more dispersed than PCBs and arsenic, suggesting more ubiquitous sources.

Except for a few areas with substantially higher dioxin and furan TEQs, dioxin and furan TEQs were generally uniformly distributed in the LDW (Section 7.3). Dioxin and furan TEQs were highest in the embayment on the west side of the LDW between RM 1.4 and RM 1.5 (Map 4-49). Other high concentrations were generally located in EAAs, such as the Duwamish/Diagonal EAA, EAA 2 at RM 2.2, and the Boeing Plant 2/Jorgensen Forge EAA. A few other locations also exist, such as the navigation channel at RM 1.0, where both the dioxin and furan TEQ and the total PCB concentrations were high.

Higher concentrations of numerous chemicals, including total PCBs, PAHs, and arsenic, are represented on Maps 4-14a through 4-14f as exceedances of SMS criteria. Most samples with high metals concentrations were located either downstream of RM 2.2 or generally in the same areas identified above for the other risk drivers, such as Slip 1, Slip 4, RM 1.3 to RM 1.5 on the west side, RM 2.2 on the west side, and the Boeing Plant 2/Jorgensen Forge EAA. The majority of locations with high BEHP concentrations in surface sediment were in many of these same locations (most notably in and near the Duwamish/Diagonal EAA, near RM 2.2 on the west side of

[176] The Duwamish/Diagonal EAA was dredged and capped by King County in 2003/2004 and a thin layer of sand was placed in an area to the south and west of the EAA in 2005. In the vicinity of the Norfolk EAA, two cleanup actions have occurred. In 1999, sediments near the Norfolk CSO/SD were dredged and capped by King County. In 2003, sediment was removed from a small area adjacent to the shoreline and the area was capped by Boeing.

the LDW, Slip 4, and in the Boeing Plant 2/Jorgensen Forge EAA). Thus, to a large extent, many of the highest chemical concentrations were co-located.

10.2.2.2 Subsurface sediment patterns

Data from subsurface sediments collected from cores also provide important information and offer insight into processes that contributed to present-day distributions. Physical events, such as dredging, river channelization, and debris disposal are recorded in the geological structure of subsurface sediments. Physical and chemical markers within sediment cores can be used to reconstruct historical records of contamination and estimate the age of subsurface sediments.

Subsurface sediment chemistry data, radioisotope data, and physical characteristics of the material retained in the cores, when combined with the history of industrial development in the waterway, including chemical spills, channel diversions, and construction of the Howard Hansen Dam, allow for interpretation of the history of sedimentation in the LDW. Based on subsurface sediment stratigraphy in sediment cores, LDW sediments can be divided into the following three relatively distinct zones:

- **Recent sediment –** This upper zone represents the sediments deposited in the LDW over approximately the last 50 years and generally provides a record of the more recent activities that have occurred within the LDW since construction of the Howard Hansen Dam.
- **Upper alluvium –** The second zone, located beneath the recent sediment, represents sediments deposited in the LDW following the construction of the waterway in the early 20th century but before construction of the Howard Hansen Dam. This layer contains the record of activities that occurred within the LDW through much of the early commercial and industrial development along the LDW.
- **Lower alluvium –** The deepest zone, located beneath the upper alluvium, represents historical sediment deposits that predate construction of the LDW.

The recent sediment zone and the upper alluvium consist of material that has been deposited in the LDW since the onset of urbanization and industrial activity in the uplands surrounding the LDW.

The distribution of chemicals within cores, coupled with the physical lithology of the cores, can be used to empirically evaluate the sedimentation history for a given location. The trend of total PCB concentrations in LDW sediment cores generally reflects the introduction of PCBs (circa 1935) and the ban on the use of PCBs (1978). Peak PCB use has been recorded in Puget Sound sediment cores between 1960 and 1970 (Lefkovitz et al. 1997; Van Metre and Mahler 2004); peak total PCB concentrations are often preserved in subsurface intervals of LDW cores as well. An initial analysis was conducted to compare the depths of peak total PCB concentrations in subsurface sediment to expected depths based on the net sedimentation rates estimated using the STM and assumptions regarding the period of peak PCB usage in the LDW and

minimal sediment disturbance. Most (70%) of the cores had peak concentrations as deep or deeper than expected,[177] based on the net sedimentation rates estimated by the STM and the time period of peak PCB releases. Some cores had peak total PCB concentrations that were shallower than expected; most, if not all, of these cores were either at locations with low net sedimentation rates or in areas with potential localized ongoing sources or localized disturbances, such as dredging (Maps 4-69a through 4-69d). The FS will present a more detailed analysis of MNR as a remedial option, including all lines of evidence regarding sedimentation rates.

Detected total PCB concentrations ranged from 0.52 to 890,000 µg/kg dw in subsurface sediments, with the highest concentrations generally detected below the co-located surface sediment sample or uppermost core interval, except in a few areas, including some of the EAAs, with low net sedimentation or potential ongoing sources, as discussed above (Maps 4-26a through 4-26h). Arsenic concentrations in subsurface sediment, which ranged from 3.9 to 2,000 mg/kg dw, also followed this pattern (although fewer data were available), with the highest concentrations generally detected below the co-located surface sediment sample or uppermost core interval, with a few exceptions (Maps 4-33a through 4-33e).

Profiles of cPAH concentrations in subsurface cores were less consistent. The onset of PAH contamination, typically associated with industrialization, and the decrease of PAH contamination, associated with the advent of environmental regulation from about 1972 onward, were more gradual. Moderately elevated concentrations of cPAHs were often found in uppermost core intervals, suggesting continued low-level contributions of PAHs to the LDW.

In the areas with the highest BEHP concentrations in surface sediment, such as the Duwamish/Diagonal EAA, peak BEHP concentrations were common in surface sediment or the uppermost core interval, but were otherwise variable in depth.

Dioxins and furans were generally analyzed in subsurface cores in areas with higher concentrations in surface sediment as part of the RI. In the core near RM 1.0 in the navigation channel, the highest TEQ occurred in the 4-to-6-ft interval. This TEQ was higher than the TEQ in the surface sediment sample from that area. In contrast, within the embayment between RM 1.4 and RM 1.5, which had the highest dioxin and furan TEQs in the LDW, the highest TEQ was detected in surface sediment and the uppermost core interval. In a subsurface core collected just outside the inlet, the highest TEQ in that core was detected in the 6-to-8-ft interval, but TEQs were lower. The estimated net sedimentation rate in this embayment was 2 to 3 cm/yr, although some of the embayment was not included in the model and is isolated by a pier across its mouth. The higher TEQs in surface sediment in this area indicate that burial by

[177] When 24 cores were excluded from the analysis because they had intervals ≥ 3 ft in the portion of the core where the peak PCB concentrations were estimated or detected, 65% of the remaining cores had peak concentrations as deep or deeper than expected.

cleaner material is not occurring, potentially because of lower-than-estimated sedimentation rates in this embayment or continuing sources in this area.

Overall, 77% of the cores collected from the LDW during RI sampling events had chemical concentrations that were less than the SQS in the lowest interval of the core that was analyzed. This depth was typically reached at about 4 to 6 ft. In the cores where the lower alluvium was analyzed (50% of the cores), only one SQS exceedance was detected in that zone.

In summary, the analysis of vertical patterns of chemicals in subsurface sediment showed that peak concentrations were mostly detected in deeper core intervals in sampled areas. This observation, along with the physical sediment transport analysis, supports a general conceptual site model of net sedimentation over time at an LDW-wide scale. However, the data indicate that at a more localized scale, some areas may be affected by ongoing sources, sediment disturbances, or lower net sedimentation rates resulting in peak concentrations at the surface.

10.2.3 Exposure CSM

One of the key components of the RI is the assessment of risks for people and ecological receptors that may be exposed to site-related contaminants. This section discusses the pathways of exposure that may lead to unacceptable risks. The risk assessments are summarized in Section 10.3.

The physical and chemical CSMs discussed above provide an overview of the distribution and movement of chemicals in the LDW, which influence the exposure of receptors to these chemicals. The exposure CSM includes chemical sources, transport mechanisms, exposure pathways, exposure routes, and potentially exposed receptors. Exposure pathways were presented for ecological receptors in Figures 5-1 and 5-2 and for people in Figure 6-1. Source information and transport mechanisms were discussed in Section 9.

The importance of various exposure pathways is dependent on the chemical and the receptor of interest (e.g., people, fish), but the principal pathways for exposure to contaminated sediment in the LDW are: 1) diet, primarily through ingestion of contaminated seafood; and 2) direct contact. Other pathways of exposure were also included in the risk assessments, but were generally less important or had low risks associated with them.

10.2.3.1 Dietary Exposure

People and wildlife can be exposed to chemicals associated with sediment contamination in the LDW through ingestion of contaminated seafood, such as fish, crabs, and clams. Most resident fish, which integrate their exposure throughout their foraging ranges in the LDW, are primarily exposed through the ingestion of benthic invertebrates, which have very localized exposures, or the ingestion of other fish that have a broader exposure.

Aquatic species that serve as food for other receptors are exposed to sediment-associated chemicals through various pathways (Figures 5-1 and 5-2). Concentrations of total PCBs and arsenic in the tissues of some species (e.g., benthic invertebrates) were correlated with the concentrations of those chemicals in sediment. Weak tissue/sediment relationships were observed for arsenic and cPAHs in clams, suggesting that factors affecting arsenic and cPAH concentrations in clam tissues are complex and involve important variables that are not well understood (Sections 8.3.2 and 8.3.3).

For fish and crabs, the relationship between total PCB concentrations in sediment and tissues was modeled using a steady-state bioaccumulation model (Appendix D). This model showed that total PCB concentrations in tissues could be related to concentrations in surface sediment within acceptable uncertainty bounds. The model also suggested that as the total PCB concentrations in sediment decrease in the future, concentrations in water will exert a relatively greater effect on total PCB concentrations in tissues.

Dietary exposures in the risk assessments were estimated based primarily on consumption rates and chemical concentrations in tissues, although other factors were also included. Consumption rates for people were estimated for various scenarios. EPA and Ecology required the application of seafood consumption rates that have been developed for adult and child consumers based on seafood harvest from King County or Puget Sound. There is considerable uncertainty about the applicability of some of the seafood consumption rates to this HHRA, particularly for clams, given the quality and quantity of shellfish habitat in the LDW.

WSDOH has issued health advisories for resident fish and shellfish in the LDW, warning the public that any seafood consumption from the LDW is unsafe because of elevated total PCB concentrations in these species (WSDOH 2005). WSDOH (Office of Food Safety and Shellfish) and Public Health—Seattle and King County also advise against consumption of bivalves (i.e., clams, mussels, and oysters) from all of King County, including the LDW, because of pollution concerns (WSDOH 2005). A creel survey conducted by King County as part of their water quality assessment indicated that very few people were fishing or crabbing in the LDW (Simmonds et al. 1998). This intensive survey was conducted for 2 months in the summer of 1997, the period of highest use, and showed that use in the LDW was significantly lower than in Elliott Bay or near the Spokane Street S Bridge. However, there is a substantial Muckleshoot Tribe fishery for salmon in the LDW, and individuals have been observed trapping crabs at T-105. In addition, a relatively high number of individuals were observed fishing or crabbing from the Spokane Street S Bridge, which is located 755 ft north of the northern LDW study area boundary. The seafood consumption advisory that was in place at the time that the survey was conducted included both the LDW and the

area of the Spokane Street S Bridge.[178] The home ranges of resident fish and crabs are large enough that individuals consuming fish or crabs caught at the Spokane Street S Bridge may be exposed to LDW-related contamination. Community outreach efforts conducted early in the LDW RI process indicated that the communities surrounding the LDW site were mostly unaware of this advisory (Environmental Health 2001). Since that survey was conducted, the LDW was added to the NPL (also known as the Superfund site list), and WSDOH updated their health advisories based on new data collected for the LDW RI. In addition, increased coverage by news media of the LDW has likely increased the public awareness of health risks associated with consuming resident seafood from the LDW. Future harvest rates are uncertain and are anticipated to be higher following remediation, although the availability of seafood for consumption will still be dictated largely by the availability of suitable habitat within the LDW.

To estimate exposure, chemical concentrations in tissues have been analyzed in various fish and invertebrate species that have been collected from throughout the LDW. Most of the tissue data are for English sole, shiner surfperch, Pacific staghorn sculpin, juvenile chinook salmon, Dungeness and slender crabs, soft-shell clams, and small invertebrates that live in the sediment, such as amphipods and marine worms. These species were selected because they were assumed to be representative of species within the LDW that could be consumed by people, fish, or wildlife. Their tissues were analyzed for a wide variety of chemicals.

Mean total PCB concentrations in the four sampling areas were highest for English sole, shiner surfperch, and crab hepatopancreas tissue (concentrations in edible crab meat were lower). Mean total PCB concentrations were lowest in mussels. Mean inorganic arsenic concentrations were highest in soft-shell clams. The highest cPAH concentrations in tissue were detected in clams, mussels, and benthic invertebrates. With the exception of one staghorn sculpin sample, concentrations were not as high in fish because fish metabolize PAHs. The concentration in one staghorn sculpin sample was similar to concentrations in some of the invertebrate samples. Other SVOCs were infrequently detected in tissue. DDT and other chlorinated pesticides were detected in tissue samples, but there is high uncertainty in these data because of analytical interference from PCBs. The highest mean concentrations of metals (including TBT) were detected in invertebrates.

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[178] Prior to the 2005 seafood consumption advisory update published by Washington Department of Health (WSDOH 2005), Public Health – Seattle & King County had an existing seafood consumption advisory for urban areas along the King County shoreline, including Elliott Bay and the LDW. The advisory warned of contaminants in shellfish, crabs, and bottom fish, but did not provide consumption limits, nor did it give specific advice against eating any of these species.

10.2.3.2 Direct contact

People are also exposed to chemicals in contaminated sediment through direct contact. The HHRA evaluated several scenarios for this pathway, including beach play, clamming, and netfishing, where people would come into direct contact with sediment. While many ecological species can be exposed through direct contact, the benthic invertebrate community is most closely related to direct sediment exposure pathways because they are constantly in direct contact with sediment.

10.3 RISK ASSESSMENT RESULTS

Baseline risk assessments were conducted to evaluate the potential for adverse effects for people and ecological species that may be exposed directly or indirectly to contaminated sediment in the LDW, as discussed above. Key findings from these assessments are presented in this section. The risk assessments are presented in full in Appendices A and B and summarized in Sections 5 and 6.

10.3.1 Ecological Health

The ERA assessed risks to a number of receptor groups that were selected to be both representative and protective of the range of species found in the LDW, either as resident species or transient/migratory species. Receptor groups included the benthic invertebrate community (including gastropods), fish, crabs, birds, and mammals. A summary of COCs based on the ERA is presented in Table 10-1.

Table 10-1. Summary of COCs based on the baseline ERA

COC	BENTHIC INVERTEBRATE COMMUNITY[a]	FISH	SPOTTED SANDPIPER	GREAT BLUE HERON	OSPREY	RIVER OTTER	HARBOR SEAL
PCBs	X	X	X			X	
Cadmium	X	X					
Chromium	X		X				
Copper	X		X				
Lead	X		X				
Mercury	X		X				
Vanadium		X	X				
BEHP	X						
Zinc	X						
Silver	X						
BBP	X						
Fluoranthene	X						
Indeno(1,2,3-cd)pyrene	X						
Arsenic	X						

[a] Forty-one chemicals were considered to be COCs and risk drivers for the benthic invertebrate community, based on exceedances of the chemical criteria of the SMS in one or more surface sediment samples within the LDW. Three additional COCs were identified with concentrations higher than TRVs or toxicologically based DMMP guidelines. The full list is presented in Table 5-6. COCs with eight or more CSL exceedances in surface sediments are included in this table.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
DMMP – Dredged Material Management Program
COC – chemical of concern
ERA – ecological risk assessment
PCB – polychlorinated biphenyl
TRV – toxicity reference value

Underlined Xs signify risk drivers.

Overall, seven chemicals were identified as COCs (total PCBs, cadmium, chromium, copper, lead, mercury, and vanadium) for at least one fish or wildlife species (Table 10-1). COCs were defined as chemicals with exposure levels that exceeded the lowest adverse effects thresholds. For most ecological species, risks were estimated to be low. Somewhat higher risks were estimated for river otter based on PCB exposures and for spotted sandpiper based on exposure to lead in one EAA (Table 5-16). No quantitative ecological risk estimates were calculated for dioxins and furans and fish or wildlife species because tissue data were not available when the ERA was completed.

For the benthic invertebrate community, 41 COCs were identified based on at least one surface sediment sample exceeding its SQS; three additional COCs were also identified with concentrations higher than TRVs or toxicologically based DMMP guidelines. Single locations with COC concentrations above the SQS for one or more chemicals were found throughout the LDW. Sediment toxicity tests were conducted primarily at locations where chemical concentrations suggested adverse impacts to benthic invertebrates could occur. Of the 48 sediment samples tested for toxicity during the RI, 11 exceeded the SQS biological effects criteria, 19 exceeded the CSL biological effects criteria, and 18 did not exceed either the SQS or CSL biological effects criteria. Based on sediment chemistry and toxicity data, no adverse effects on the benthic invertebrate community are expected for approximately 75% (345 ac) of the overall LDW area (i.e., the area in which chemical concentrations were less than or equal to chemical SQS criteria and where sediments were non-toxic[179] according to SQS biological criteria; Map 4-16).

There is a higher likelihood for adverse effects in approximately 7% of the LDW area (34 ac), which was found to have chemical concentrations or biological effects in excess of the CSL. The remaining 18% of the LDW area (82 ac) had chemical concentrations or biological effects between the SQS and CSL, indicating that risks to the benthic invertebrate community are less certain than in areas with concentrations greater than

[179] Sediment samples from 46 locations with chemical SQS exceedances were tested for toxicity. Sixteen of the samples were not toxic relative to SQS biological effects criteria. Toxicity tests were generally not conducted in areas with the highest contamination (e.g., EAAs), which were assumed to be toxic.

one or more CSL. Some areas had multiple locations with chemical concentrations greater than the CSL. Most of these areas are located within or near the EAAs.

Total PCBs and BEHP were the chemicals that most frequently exceeded the SQS and the CSL in surface sediment samples. Over 60% of the SQS exceedances for both total PCBs and BEHP and 71 and 90% of BEHP and total PCB CSL exceedances, respectively, were in EAAs. Mercury was the only other chemical with more than 20 locations with CSL exceedances. Other chemicals with more than 20 locations with SQS exceedances were butyl benzyl phthalate, lead, mercury, zinc, and a few individual PAHs. Risks to the benthic invertebrate community from TBT were low.

10.3.2 Human health

For the HHRA, risks were evaluated for several different seafood consumption scenarios and also for direct sediment exposure scenarios associated with beach play, clamming, or netfishing. There are limited data available on the amount of resident seafood organisms currently being harvested and consumed from the LDW. In the absence of site-specific human seafood consumption rates, EPA and Ecology required the application of seafood consumption rates that have been developed for tribal consumers based on seafood harvest from other areas of Puget Sound. The tribal seafood consumption rates represent relatively high rates that might occur for harvest from the LDW at some time in the future, although they likely overestimate the current consumption of resident seafood organisms from the LDW. In addition, API consumption rates were based on rates derived from self-harvested seafood from throughout King County (not limited to the LDW). It is not known if the seafood resources within the LDW at some future time would be sufficient to support these consumption rates, but these rates were assumed to represent hypothetical consumption rates for the estimation of risks.

Similarly, there are no LDW-specific data to estimate the degree to which humans may currently be directly exposed to sediments via beach play or clamming activities. The exposure scenarios assumed for these activities were intended to represent exposures for a health-protective estimation of risks. The tribal netfishing scenario, on the other hand, reflects exposure conditions that could occur under current tribal fishing activities within the LDW.

Using health-protective exposure assumptions, most of the risks are associated with a few chemicals (i.e., PCBs, arsenic, cPAHs, and dioxins and furans), which were designated as risk drivers (Table 10-2). Estimated excess cancer risks in the LDW were found to be highest for the seafood consumption scenarios. There were distinct differences in the contributions from each seafood type to the risk estimate for each chemical. For total PCBs, the excess cancer risks for the tribal adult RME scenario were attributed to several seafood types, including clams (35%), crabs (29%), and pelagic fish (24%). For arsenic and cPAHs, approximately 95% of the risk was attributed to consumption of clams.

Table 10-2. Summary of COCs based on the baseline HHRA

COC[a]	SEAFOOD CONSUMPTION	CLAMMING	BEACH PLAY	NETFISHING
Arsenic (inorganic)	X	X	X	X
cPAHs	X	X	X	X
Total PCBs	X	X	X	X
Dioxins and furans	X[b]	X	X	X
Aldrin	X			
BEHP	X			
alpha-BHC	X			
beta-BHC	X			
Carbazole	X			
Total chlordane	X			
Total DDTs	X			
Dieldrin	X			
gamma-BHC	X			
Heptachlor	X			
Heptachlor epoxide	X			
Hexachlorobenzene	X			
Pentachlorophenol	X			
Toxaphene		X		X
TBT	X			
Vanadium	X			

[a] COCs were defined in the HHRA based on risk estimates only from RME scenarios.

[b] Dioxins and furans were assumed to be a risk driver in the absence of any tissue chemistry data based on an expectation that if such data had been collected, the risks would have been unacceptable.

BEHP – bis(2-ethylhexyl) phthalate
BHC – benzene hexachloride
COC – chemical of concern
cPAH – carcinogenic polycyclic aromatic hydrocarbon
HHRA – human health risk assessment
PCB – polychlorinated biphenyl
RME – reasonable maximum exposure
TBT – tributyltin

Underlined Xs signify risk drivers.

Excess cancer risks for direct sediment contact RME scenarios for netfishing, clamming, and beach play were much lower than risk estimates for the seafood consumption scenarios. Most risks for beach play and clamming were associated with arsenic and cPAHs; for netfishing, the highest risks were associated with dioxins and furans. None of the direct sediment contact RME scenarios were estimated to result in non-cancer health risks.

10.4 RISK MANAGEMENT CONSIDERATIONS

This section summarizes key findings of the RI that are related to ongoing risk management decisions that will be made for the site. Key findings are presented for risk-based threshold concentrations and preliminary background concentrations of the risk drivers, and the relationship between the spatial distribution of risk driver chemicals in sediment and LDW sediment dynamics.

10.4.1 RBTCs and chemical concentrations in areas outside of the LDW

Risk estimates presented in the baseline risk assessments have been translated into sediment RBTCs that will be considered in the FS in combination with background concentrations and other factors. Sediment RBTCs were derived for direct sediment contact scenarios and also for seafood ingestion scenarios for humans and river otters, as appropriate, for four risk driver chemicals (total PCBs, arsenic, cPAHs, and dioxins and furans) (Table 10-3). Sediment RBTCs for benthic invertebrates were set equal to SMS criteria.

Information was compiled on concentrations of four risk driver chemicals (total PCBs, arsenic, cPAHs, and dioxins and furans) in areas outside of the LDW (Section 7). Background concentrations provide important context for RBTCs because EPA generally does not require cleanup below anthropogenic background concentrations in consideration of the potential for recontamination from sources unrelated to the site, cost effectiveness, and technical practicability (EPA 2002d). Under MTCA, natural background concentrations[180] are used in the evaluation of sediment cleanup levels as a lower limit below which cleanup levels cannot be achieved (WAC 173-340-705(6)).

Background concentrations will be considered in the FS and their role in determining cleanup levels will be determined by EPA and Ecology in the ROD. Concentrations of risk driver chemicals in Puget Sound reference areas are presented in Section 7.1 and summarized in Table 10-3. Relevant data for upstream environments are presented in Section 7.2 and Table 10-3. In addition to the upstream inputs, other anthropogenic inputs from the surrounding urban area could enter the LDW through atmospheric deposition and stormwater runoff, but these inputs were not quantified as part of the RI studies.

[180] According to MTCA (WAC 173-340-200), natural background concentrations are concentrations of hazardous substances that are consistently present in an environment that has not been influenced by localized human activities.

Table 10-3. Comparison of sediment RBTCs and concentrations for selected risk driver chemicals in samples collected from Puget Sound reference areas, upstream of the LDW and the Upper Turning Basin

Risk Driver Chemical	Unit	Risk Level	Sediment RBTCs for RME Direct-Contact Scenarios (Tribal Clamming, Beach Play, Netfishing)	Sediment RBTCs for RME Seafood Consumption Scenarios	Surface Sediment Data		Subsurface Sediment Data	Water Data
					Puget Sound Reference Areas[a]	Upstream[b]	Upper Turning Basin[c]	Upstream Suspended Solids[d]
Arsenic	mg/kg dw	1×10^{-6}	1.3, 2.8, 3.7[e]	nc[f]	2.3 – 15.9	11	13	73
		1×10^{-5}	13, 28, 37[e]	nc[f]				
		1×10^{-4}	130, 280, 370[e]	nc[f]				
		HQ = 1	na	na				
		SQS	57	na				
		CSL	93	na				
cPAHs[g]	µg/kg dw	1×10^{-6}	150, 90, 380[e]	nc[h]	14.7 – 244.7	135	201	354
		1×10^{-5}	1,500, 900, 3,800[e]	nc[h]				
		1×10^{-4}	15,000, 9,000, 38,000[e]	nc[h]				
		HQ = 1	na	na				
Dioxin and furan TEQ	ng/kg dw	1×10^{-6}	13, 28, 37[e]	nc[i]	0.141 – 2.3	2.0[j]	no data	no data
		1×10^{-5}	130, 280, 370[e]	nc[j]				
		1×10^{-4}	1,300, 2,800, 3,700[e]	nc[j]				
		HQ = 1	na	na				

Table 10-3, cont. Comparison of sediment RBTCs and concentrations for selected risk driver chemicals in samples collected from Puget Sound reference areas, upstream of the LDW and the Upper Turning Basin

Risk Driver Chemical	Unit	Risk Level	Sediment RBTCs for RME Direct-Contact Scenarios (Tribal Clamming, Beach Play, Netfishing)	Sediment RBTCs for RME Seafood Consumption Scenarios	Surface Sediment Data		Subsurface Sediment Data	Water Data
					Puget Sound Reference Areas[a]	Upstream[b]	Upper Turning Basin[c]	Upstream Suspended Solids[d]
Total PCBs	µg/kg dw	1×10^{-6}	500, 1,700, 1,300[e]	< 1[k]	0.2 – 19.9	40	86	107
		1×10^{-5}	5,000, 17,000, 13,000[e]	< 1[k]				
		1×10^{-4}	50,000, 170,000, 130,000[e]	7.3 – 185[l]				
		HQ = 1	nc[m]	128 – 159[n]				
		SQS	130[o]	na				
		CSL	1,000[p]	na				

[a] Information relevant to calculating preliminary natural background concentrations in sediment is presented in Section 7.1. The concentration ranges presented in this table (for informational purposes only) represent the ranges of 90th percentile concentrations calculated for multiple Puget Sound reference areas.

[b] Information relevant to upstream concentrations in sediment is presented in Section 7.2. The concentrations presented in this table (for informational purposes only) represent the 90th percentile concentrations in the upstream and Upper Turning Basin datasets. Other anthropogenic inputs from the surrounding urban area are likely due to atmospheric deposition and stormwater runoff but were not quantified as part of the RI studies. Concentrations in urban bays and lakes are discussed in Section 7.3.

[c] Information relevant to concentrations in subsurface sediment from the Upper Turning Basin is presented in Section 7.2.3. The concentrations presented in this table (for informational purposes only) represent the 90th percentile concentrations in sediment cores collected between RM 4.0 and RM 4.75.

[d] Information relevant to concentrations in suspended solids is presented in Section 7.2.4. For PCBs and cPAHs, suspended solids concentrations were estimated by normalizing whole-water concentrations in upstream samples to the sample-specific total TSS concentrations. For arsenic, sample-specific total and dissolved concentrations and TSS in upstream water samples were used to estimate suspended solids concentrations. The concentrations presented in this table (for informational purposes only) represent the 90th percentile concentrations.

[e] Sediment RBTCs developed from the human health direct contact RME scenarios (i.e., tribal clamming, beach play, netfishing).

Although identified as a COC for seafood consumption, sediment RBTCs were not calculated for arsenic for seafood consumption scenarios because a clear relationship has not been established between arsenic concentrations in surface sediment and clam tissues, but would be needed to develop an RBTC.

[g] cPAH concentrations are expressed in terms of benzo(a)pyrene equivalents.

[h] Although identified as a COC for seafood consumption, sediment RBTCs were not calculated for cPAHs for seafood consumption scenarios because a clear relationship has not been established between cPAH concentrations in surface sediment and clam tissues, but would be needed to develop an RBTC.

[i] Although identified as a COC for seafood consumption, sediment RBTCs were not calculated for dioxins and furans for seafood consumption scenarios because no tissue data were available from the LDW at the time of the risk assessments.

[j] Because of the small dataset, 90th percentiles were not calculated for dioxin and furan TEQs. The dioxin and furan TEQ represents the mean TEQ in upstream surface sediment samples. [f]

[k] A sediment RBTC could not be calculated; even if the total PCB concentration in sediment was set equal to 0 µg/kg dw, FWM-estimated total PCB concentrations in tissue would be greater than the tissue RBTC for the applicable risk level because of the contribution of PCBs from water alone.

Table 10-3, cont. Comparison of sediment RBTCs and concentrations for selected risk driver chemicals in samples collected from Puget Sound reference areas, upstream of the LDW and the Upper Turning Basin

[l] Sediment RBTCs developed from the human health seafood consumption RME scenarios.

[m] Sediment RBTCs were not estimated for non-cancer hazards for direct-contact scenarios because none of the RME scenarios had HQs for an individual chemical greater than 1 or generated endpoint-specific HIs in excess of 1 (Appendix B, Section B.5.6).

[n] RBTCs developed from the otter prey ingestion scenario, estimated through the FWM.

[o] Reported value is lowest AET, which is functionally equivalent to the SQS, but in dry weight units.

[p] Reported value is second lowest AET, which is functionally equivalent to the CSL but in dry weight units.

AET – apparent effects threshold
COC- chemical of concern
cPAH – carcinogenic polycyclic aromatic hydrocarbon
CSL – cleanup screening level
dw – dry weight
FWM – food web model
HI – non-cancer hazard index
HQ – non-cancer hazard quotient
LDW – Lower Duwamish Waterway
na – not available or applicable
nc – not calculated
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration
RI – remedial investigation
RM – river mile
RME – reasonable maximum exposure
SQS – sediment quality standards
TEQ – toxicity equivalent quotient
TSS – total suspended solids

Sediment RBTCs at the 1×10^{-6} level for direct sediment contact are higher than the range of Puget Sound reference area concentrations for total PCBs and dioxins and furans (Table 10-3). The cPAH sediment RBTC for netfishing at the 1×10^{-6} risk level is also greater than the range of Puget Sound reference area concentrations. The sediment RBTCs for cPAHs at the 1×10^{-6} threshold for beach play and clamming scenarios are within the range of Puget Sound reference area concentrations. For arsenic, the direct sediment contact RBTCs at the 1×10^{-6} risk level are toward the lower end or below the range of the Puget Sound reference area concentrations.[181]

RBTCs derived for the direct sediment contact scenarios should be applied to sediment concentrations averaged over the exposure areas for the specified uses, not on a point-by-point basis. The exposure area for the netfishing RME scenario included all of the intertidal and subtidal areas of the LDW. For the beach play RME scenario, eight separate intertidal areas were selected in the HHRA as exposure areas where children would be most likely to contact sediment (Map 6-1). These areas could change in the future if, for example, a new park was constructed. The exposure area for the RME clamming scenario included all intertidal areas where clamming could occur because such areas are potentially accessible either from a boat or from shore (Map 6-2).

Sediment RBTCs for total PCBs were estimated using a FWM calibrated to LDW environmental conditions and species for the RME human seafood consumption scenarios and for river otters, which had risk estimates greater than 1×10^{-6} or LOAEL-based HQs > 1, respectively. Sediment RBTCs estimated for human seafood consumption scenarios and for river otter prey ingestion are also intended to be average concentrations over the relevant exposure area, and not applied on a point-by-point basis. Sediment RBTCs for cPAHs and arsenic associated with the human consumption of clams could not be derived because a clear relationship has not been established between concentrations of these chemicals in clams and in sediment (Sections 8.3.2 and 8.3.3). Sediment RBTCs for dioxins and furans were not derived for seafood consumption pathways because tissue data were not available from the LDW at the time of the risk assessments (Section 8.3).

A wide range of sediment RBTCs for total PCBs was derived for the seafood consumption scenarios (Tables 8-10 and 8-11). Very few sediment RBTCs (and none of the sediment RBTCs for the RME scenarios) could be derived for the 1×10^{-6} risk level because the contribution from water alone resulted in estimated total PCB concentrations in tissue greater than this risk level, even in the absence of any

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[181] Of the 10 Puget Sound reference areas, one area (Rich Passage) had a 90th percentile arsenic concentration of 2.3 mg/kg dw; the remaining nine areas had 90th percentile arsenic concentrations ranging from 6.3 to 15.9 mg/kg dw. At higher risk levels, direct-contact sediment RBTCs are above the concentration ranges of samples collected from Puget Sound reference areas, upstream, and the Upper Turning Basin, except for arsenic. The direct-contact sediment RBTC for tribal clamming for arsenic at the 1×10^{-5} risk level is within the range of these concentrations.

contribution from sediment. The sediment RBTCs for non-RME scenarios that could be derived for the 1×10^{-6} risk level were lower than the range of the Puget Sound reference area concentrations for total PCBs for all non-RME scenarios, except the sediment RBTCs for the API CT scenario (10 µg/kg dw) and for the one-meal-per-month consumption of clams scenario (2 µg/kg dw), which were in the range of Puget Sound reference area concentrations (0.2 to 19.9 µg/kg dw).

At the 1×10^{-5} risk level, sediment RBTCs were still < 1 µg/kg dw for all of the RME seafood consumption scenarios, the adult tribal (Suquamish data) scenario, and the one-meal-per-month consumption of pelagic fish scenario. However, 1×10^{-5} sediment RBTCs calculated for other non-RME scenarios were generally higher than the range of the Puget Sound reference area concentrations, except for the RBTC for the one-meal-per-month consumption of benthic fish (13 µg/kg dw), which was within the 0.2 to 19.9 µg/kg dw range found in Puget Sound reference areas.

At the 1×10^{-4} risk level, sediment RBTCs for total PCBs could be calculated for all of the seafood consumption scenarios, except the non-RME adult tribal (Suquamish data) scenario. All of the calculated sediment RBTCs were greater than the Puget Sound reference area concentrations and greater than or within the range of the upstream and Upper Turning Basin (subsurface sediment) concentrations, except for the sediment RBTCs for the adult tribal RME scenario (Tulalip data; 7.3 µg/kg dw) and the adult tribal non-RME scenario (Suquamish data; < 1 µg/kg dw) (Tables 8-10 and 8-11).

Tissue RBTCs for total PCBs were also calculated for a given risk level and seafood consumption rate. For example, the total PCB concentration in seafood that would be necessary to achieve an excess cancer risk of 1×10^{-5} would be 4.2 µg/kg ww for the adult tribal RME scenario (Table 10-4) and 14 µg/kg ww for the API RME scenario. Just as it is important to put sediment RBTCs in the context of sediment background levels, it is important to put tissue RBTCs in the context of the PCB concentrations in other common dietary food items. As described in Section 7.4.1 and in WSDOH (2006), PCBs are frequently detected in many different seafood species throughout non-urban areas of Puget Sound at concentrations similar to tissue RBTCs, with mean total PCB concentrations ranging from 4.5 to 32.3 µg/kg ww in rockfish, 2.8 to 11.6 µg/kg ww in English sole fillet, 0.62 to 25 µg/kg ww in crab edible meat and hepatopancreas, and 0.12 to 2.8 µg/kg ww in clams (Table 10-4). Consumption of English sole, crabs, or clams from non-urban areas of Puget Sound at a rate equivalent to the adult tribal RME scenario would yield excess cancer risk estimates of 1×10^{-6} or higher, based on the total PCB concentrations in these tissues (Figures 10-5, 10-6, and 10-7). In addition, these tissue RBTCs are lower than the PCB concentrations that have been detected in some common food items from a typical diet (WSDOH 2006). Consumption of many of these common food items at the rates assumed under these RME scenarios would subject the consumer to risks that would be deemed unacceptable in the MTCA and CERLCA context. Tissue RBTCs for lower consumption rates are much higher than tissue RBTCs for the RME scenarios, with the exception of the 1×10^{-6} tissue RBTC for

the one-meal-per-month scenario (11 µg/kg ww), because of the large differences among the consumption rates.

Table 10-4. Total PCB concentrations in LDW and greater Puget Sound tissue compared with tissue RBTCs

EPC OR RBTC	TOTAL PCB CONCENTRATION (µg/kg ww)		
	ENGLISH SOLE	CLAM	DUNGENESS AND SLENDER CRAB
LDW-wide UCL	1,200	600	200
LDW-wide mean	700	140	170
Greater Puget Sound (range of mean values)[a]	2.8 – 11.6[b]	0.12 –- 2.8[c]	0.62 – 8.44[d]
1×10^{-4} RBTC (Tulalip RME)	42	42	42
1×10^{-5} RBTC (Tulalip RME)	4.2	4.2	4.2
1×10^{-6} RBTC (Tulalip RME)	0.42	0.42	0.42

[a] Range of mean total PCB concentrations from various studies and non-urban sampling areas in the greater Puget Sound, as presented in Table 7-15.

[b] Total PCB concentrations in English sole fillet tissue.

[c] Total PCB concentrations in clam soft tissue.

[d] Total PCB concentrations in crab edible meat or calculated whole-body tissue.

EPC – exposure point concentration
LDW – Lower Duwamish Waterway
PCB – polychlorinated biphenyl
RME – reasonable maximum exposure
RBTC – risk-based threshold concentration
UCL – upper confidence limit on the mean
ww – wet weight

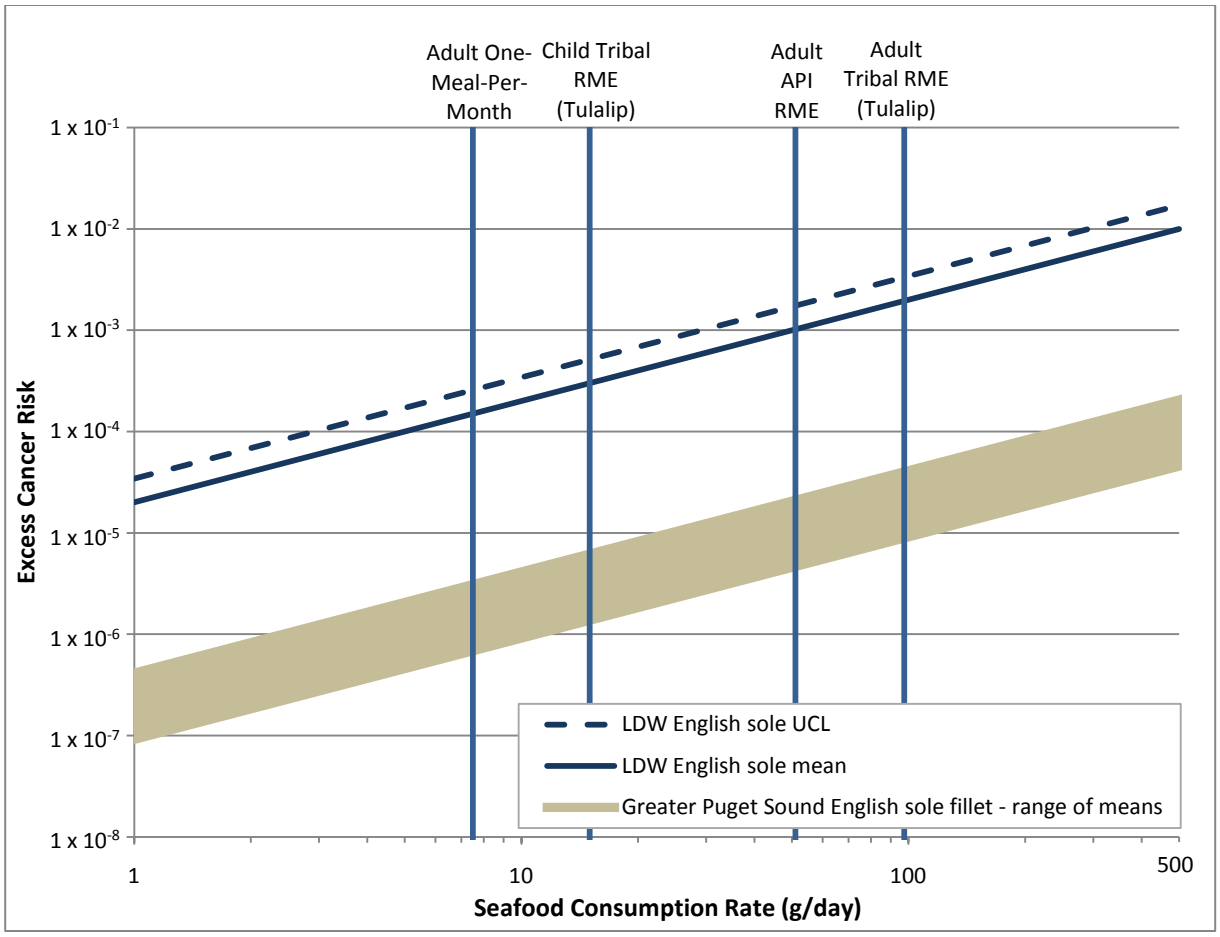
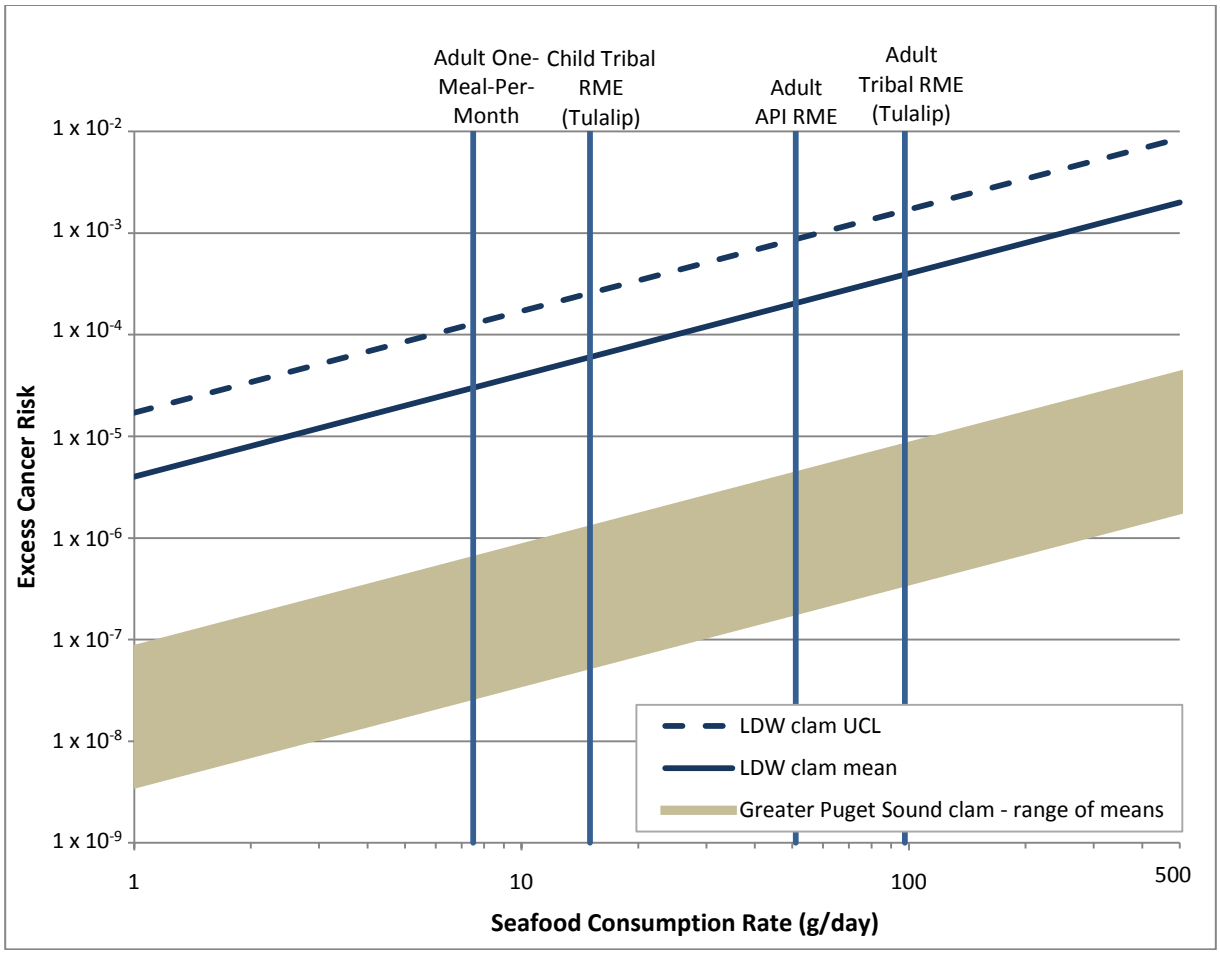


Figure 10-5. Excess cancer risks calculated using total PCB concentrations in English sole fillet composite samples collected from the LDW and from greater Puget Sound locations as a function of seafood consumption rate



Note: Clam samples from greater Puget Sound locations included geoduck from Freshwater Bay, horse clam tissue (excluding the visceral cavity) from Freshwater and Dungeness Bays, and littleneck clams from Padilla and Fidalgo Bays. None of these species are directly comparable to *Mya arenaria*, the soft-shelled clams sampled in the LDW.

Figure 10-6. Excess cancer risks calculated using total PCB concentrations in clam tissue composite samples collected from the LDW and from greater Puget Sound locations as a function of seafood consumption rate

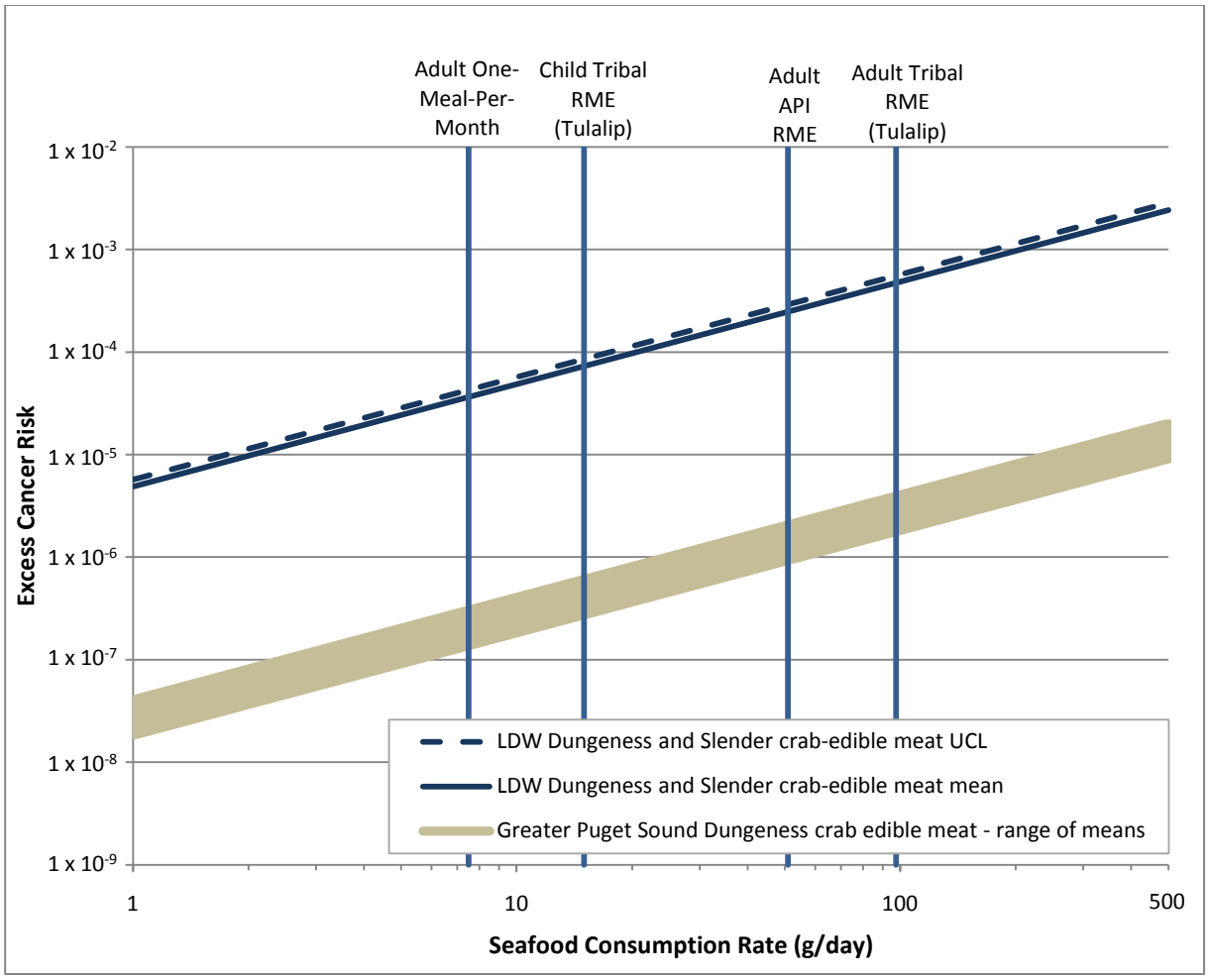


Figure 10-7. Excess cancer risks calculated using total PCB concentrations in crab edible meat composite samples collected from the LDW and from greater Puget Sound locations as a function of seafood consumption rate

10.4.2 Implications of chemical patterns and trends

As presented in Section 4 and further discussed in Section 10.2.2, chemicals in LDW sediments exhibit distinct patterns and trends. Chemical patterns that are of interest include spatial distributions in surface sediments, where exposure to ecological receptors and humans is most likely, and vertical distributions, which provides a record of the past and an indication of the rate of net sedimentation that has resulted in the burial of historical surface sediments. The presence of peak total PCB concentrations below the sediment surface at many different locations throughout the entire site is consistent with the independent lines of evidence that indicate that the LDW is largely a net depositional environment and that contamination associated with historical releases is being buried in most locations, with a few notable exceptions. These results will be further evaluated in the FS.

Despite the prevalence of peak total PCB concentrations at depth, elevated concentrations were also detected in surface sediments in distinct areas. The locations of these elevated concentrations were predominantly in areas where elevated concentrations were also detected at depth and historical contamination remains at the surface because of low net sedimentation rates in these areas. In other areas, the presence of elevated concentrations in surface sediments may be evidence of ongoing localized sources or localized disturbances. Focused sampling and source control evaluations at some of the EAAs confirm that ongoing sources are the most likely explanation for the presence of elevated concentrations at some of the EAAs.
The STM and the physical CSM are useful for evaluating future exposure conditions, especially in areas outside the EAAs. Sediment particles will be continually transported into the LDW, predominantly from the Green River, which is the source of approximately 99% of the sediments depositing within the LDW. Consequently, surface sediment quality in the LDW will eventually resemble the quality of the particles originating from the Green River, assuming that local sources are sufficiently controlled and areas with elevated concentrations and low sediment deposition rates are remediated. Results from the STM model indicate that 90% of the LDW has an estimated net sedimentation rate of 1.0 cm/yr or greater (Map 3-9). Thus, within 10 years, all of this area would receive at least 10 cm of new sediment, almost all of which comes from material flowing into the LDW from the Green River. The significance of these results, and the scale at which the predictive model is valid for estimating recovery, will be evaluated in the FS.

The Slip 4 area is instructive when considering the roles both net deposition and local sources can have on the distribution of risk drivers. This area has been intensively sampled recently in preparation for a non-time critical removal action. Slip 4 is within an area that has estimated net sedimentation rates between 1 and 3 cm/yr. Map 4-23 presents a time series of total PCB concentrations in surface sediment within Slip 4. There has been a marked decrease in surface sediment concentrations between 1990 and 2004 for much of the slip. This decrease suggests that chemical concentrations in depositing sediment (which includes sediment from upstream as well as from point sources such as storm drains) have decreased sufficiently to improve surface sediment quality during this period. The area of Slip 4 where elevated concentrations of total PCBs persist, even though at relatively lower concentrations, is in the head of the slip where there are active storm drain outfalls. Source identification studies in the storm drain systems have indicated ongoing sources of PCBs, which (until addressed) have the potential for limiting further improvements in sediment quality or recontaminating the slip after the removal action. This example illustrates the integrated temporal and spatial patterns that can be expected in depositional areas of the larger LDW.

The overall implication is that both active source control and remedial actions are likely to be required to reduce overall risks in the LDW. Focused investigations in the EAAs have highlighted the need to implement control measures for ongoing sources

prior to remediation, while time trend data from Slip 4, for example, suggest that continuing inputs of sediment from the Green River will result in improvements in surface sediment quality over time, except where additional efforts at source control are required.

10.5 ONGOING SOURCE CONTROL EFFORTS

Controlling sources is critical to the long-term success of any remedial action (EPA 2002c). Consistent with this concept, Ecology (2007j) has developed a source control strategy for the LDW which is currently being implemented. This program is being conducted in parallel with the RI/FS and is expected to continue into the foreseeable future as remedial actions are undertaken, where needed, to reduce human health and environmental risks. Source identification and source control actions will need to precede remediation or these areas may become recontaminated.

Initial source control efforts have been focused on source identification at those EAAs that are being remediated as non-time critical removal actions. Ecology, along with the SCWG, is leading the source control evaluation. As part of their source control evaluation process, data gaps reports and SCAPs are being prepared by Ecology to help direct future investigation and remediation efforts while assessing potential sources for the chemicals identified. These efforts will continue to evaluate potential sources to the LDW and implement corrective actions to reduce or eliminate identified sources.

In addition, current regulatory requirements have established inspection and compliance programs to monitor and control handling and disposal of manufacturing wastes produced by industrial operations along the LDW. These regulations have helped reduce sources of contamination that, in past practices, might have resulted in releases to the LDW. Permit programs are in place to help monitor and manage direct discharges to the LDW from CSOs, EOFs, and SDs in the basin. For example, since 1970, the City of Seattle has reduced the annual CSO volume citywide by approximately 95%, and since 1988, King County has reduced their annual CSO volume by 63%.

Continued coordination of the CERCLA/MTCA cleanup actions and source control programs (both the SCWG and other regulatory programs) will ensure that future remedial actions will not be unduly impacted by local sources.

10.6 KEY OBSERVATIONS AND FINDINGS

Key observations and findings for the RI are summarized below.

- Over the past 100 years, the LDW has been highly modified from its natural configuration to support urban and industrial development. Changes have included reductions and control of water flow, significant shoreline modifications, loss of intertidal habitat, and installation of riprap, pier aprons

and sheet pile walls. Some limited areas of natural shoreline still exist within the LDW.

- Industrial and commercial facilities occupy most of the shoreline; one residential community is also located along the shoreline with another community nearby.
- The LDW is currently used as an industrial navigational corridor. It also supports recreational uses such as boating, kayaking, fishing, and beach play. The LDW is also one of the locations of the Muckleshoot Tribe's commercial, ceremonial, and subsistence fishery for salmon, and the Suquamish Tribe actively manages aquatic resources north of the Spokane Street Bridge, located just north of the LDW. The Duwamish Tribe uses Herring's House Park and other parks along the Duwamish for cultural gatherings.
- Despite significant alterations in habitat and areas with elevated chemical concentrations, the LDW contains a diverse assemblage of aquatic and wildlife species and a robust food web that includes top predators.
- The majority of the high arsenic and total PCB concentrations in surface sediment were located within fairly well-defined areas. The locations of the highest arsenic and total PCB concentrations were generally not in the same areas, indicating that sources likely differ for these two chemicals. Areas with the highest cPAH concentrations were located in many of the same areas identified for arsenic and total PCBs, but were also more dispersed. There are several areas with high dioxin and furan TEQs in surface sediments.
- Most of the human health risk is from PCBs, arsenic, cPAHs, and dioxins and furans.
- The highest risks to people are associated with consumption of fish, crabs, and clams, with lower risks associated with activities that involve direct contact with sediment, such as clamming, beach play, and netfishing.
- Ecological risks to fish and wildlife were relatively low, with the exception of risks to river otter from PCBs.
- Based on sediment chemistry and toxicity test results, sediment contamination in approximately 75% of the LDW (345 ac) is estimated to have no effect on the benthic invertebrate community; approximately 7% (34 ac) of the surface sediment has chemical concentrations exceeding the higher of the two state standards, and is therefore expected to have adverse effects on the benthic invertebrate community (see WAC 173-204-310[b]). The remaining 18% of the LDW (82 ac) has chemical concentrations exceeding the lower of the two state standards and these areas are considered to have minor adverse effects on the benthic invertebrate community. Most of the exceedances of SMS criteria were for PCBs and phthalates, although 41 different chemicals had at least one exceedance.

- Sediment is continually depositing within the LDW, with almost all new sediment (99%) originating from the Green River. The STM estimates that over 200,000 metric tons of sediment per year enter the LDW. Approximately 50% of this load deposits in the LDW. STM modeling runs indicate that approximately 90% of the total bed area in the LDW receives 10 cm of new sediment (from the combined Green River and lateral sources) within 10 years or less. This sediment is mixed with the existing bedded sediment through various processes, including bioturbation and propeller wash.
- A few areas in the LDW will be scoured during high-flow events. Based on the STM, the maximum scour depth is relatively shallow and is generally limited to sediment in the top 20 cm; thus, deeper sediments would not be exposed as a result of high-flow events. Scour to these relatively shallow depths is expected to occur in relatively small areas of the LDW. The STM did not account for scour from localized activities, such as discharges from outfall, tugboat maneuvering, or anchor dragging, that could have caused localized erosional environments. Routine boat traffic is expected to mix the top few cm of sediment, which is part of the biologically active zone mixed by benthic invertebrates, whereas tugboat maneuvering is a potential source of localized erosion that could disturb sediment at greater depths in small areas. In addition, in some areas, ships may have caused localized erosion from physical forces (i.e., anchor dragging) unrelated to propeller-driven scour. Site-specific information, in addition to the results of the STM, will be evaluated in any future remedial designs.
- The physical conceptual site model of a net depositional environment is supported by both physical and chemical lines of evidence, including lithology and chemistry profiles in sediment, where these data were collected. Empirically derived net sedimentation rates from chemical and physical markers were within 1 cm/yr of the modeled sedimentation rates for 40 of 63 core locations. Most (70%)[182] of the 157 core locations evaluated had depths of peak PCB concentrations that were consistent with those predicted by the STM, with peak PCB concentrations as deep or deeper than those estimated by the STM. The remaining 30% of the cores had peak concentrations that were shallower than expected, assuming net sedimentation rates from the STM, peak PCB usage and release in the 1960s and 1970s, and minimal localized disturbances.
- Based on the STM, LDW surface sediment is generally expected to become more similar in character over time to the sediment being transported by the

[182] The percent of cores with peak concentrations as deep or deeper than expected is 65% when 24 cores were excluded from the analysis because they had samples composited over intervals ≥ 3 ft in the portion of the core where the peak PCB concentrations were estimated or detected.

Green River on an LDW-wide scale; localized areas may continue to be influenced by inputs from sources in those areas.

- A comparison of background concentrations with risk-based goals in sediment (represented by sediment RBTCs) will be important in risk management decisions by EPA and Ecology. Puget Sound sediment data will be considered in the derivation of natural background concentrations and data from other lines of evidence will be considered in the derivation of anthropogenic background concentrations.
- For total PCBs, all sediment RBTCs for direct-contact scenarios are above the concentration range of samples collected from Puget Sound reference areas, upstream of the LDW, and the Upper Turning Basin (subsurface sediment). All sediment RBTCs for RME human seafood consumption scenarios are below the range of Puget Sound reference area concentrations across the risk range of 1×10^{-6} to 1×10^{-4}, except for three sediment RBTCs. Sediment RBTCs for the child Tribal RME and the API RME scenarios (at 1×10^{-4} risk level) and for the protection of river otters are within the range or higher than the concentration range of samples collected from upstream of the LDW and from the Upper Turning Basin (subsurface sediment).
- No sediment RBTCs were derived for human seafood consumption scenarios for arsenic, cPAHs, and dioxins and furans. Sediment RBTCs for arsenic and cPAHs for human seafood consumption could not be estimated because the relationships between concentrations in clam tissue and sediment are not well understood and are highly uncertain. Sediment RBTCs for dioxins and furans for human seafood consumption could not be estimated because there were no dioxin/furan tissue data from the LDW when the risk assessment was conducted.
- For arsenic, sediment RBTCs for direct-contact scenarios at the 1×10^{-6} risk level are below the concentration range of samples collected from upstream of the LDW and from the Upper Turning Basin (subsurface sediment) and are just below or within the wider range of concentrations in Puget Sound reference area samples. The tribal clamming direct-contact sediment RBTC at the 1×10^{-5} risk level is above the upstream concentration and the same as from the Upper Turning Basin (subsurface sediment) concentration but within the range of concentrations in Puget Sound reference area samples. The beach play and netfishing direct-contact sediment RBTCs at the 1×10^{-5} risk level are above concentrations found in Puget Sound reference areas, upstream of the LDW, and the Upper Turning Basin. Direct-contact sediment RBTCs at the 1×10^{-4} risk level are above all of these concentrations.
- Sediment RBTCs for cPAHs for the tribal clamming and beach play direct-contact scenarios at the 1×10^{-6} risk level are within the range of concentrations in samples collected from Puget Sound reference areas,

upstream of the LDW, and the Upper Turning Basin (subsurface sediment). The netfishing sediment RBTC for cPAHs at the 1×10^{-6} risk level is above all of the aforementioned concentration ranges as are all direct-contact sediment RBTCs at the 1×10^{-5} and 1×10^{-4} risk levels.

- Sediment RBTCs for dioxins and furans for direct-contact scenarios across the excess cancer risk range of 1×10^{-6} to 1×10^{-4} are above the concentration ranges of samples collected from Puget Sound reference areas and upstream of the LDW.

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List of Maps

These maps are included in the Appendix Maps folio.

Map C.1-1. Exceedances of SMS criteria (SQS or CSL) by at least one chemical in surface sediment at Round 3 and other RI locations

Map C.3-1. Round 3 and other RI surface sediment locations within modeling areas

Map C.3-2. Round 3 and other RI surface sediment locations within spotted sandpiper exposure areas

Map C.3-3. Round 3 and other RI surface sediment locations within beach play areas

Map C.3-4. Round 3 and other RI surface sediment locations within clamming areas

C.1 Introduction

As part of the remedial investigation (RI), three rounds of surface sediment sampling were conducted in the Lower Duwamish Waterway (LDW) (Windward 2007).[1] Results from the first two rounds (conducted in 2005) were included in the baseline surface sediment dataset used in the ecological risk assessment (ERA) (Appendix A) and human health risk assessment (HHRA) (Appendix B). Prior to Round 3, the baseline dataset included a total of 1,446 surface sediment samples collected from 1,329 discrete locations throughout the LDW (Map C.1-1). Round 3 included the collection of 47 additional surface sediment samples from 44 discrete locations (Map C.1-1). Round 3 was conducted in October 2006 and results were not available for inclusion in the risk assessments because the sampling event was conducted after the draft HHRA and ERA had been submitted to the US Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology) in August 2006 and September 2006, respectively. As stated in the quality assurance project plan (QAPP) for the Round 3 sampling (Windward 2006), the HHRA and ERA would not include Round 3 data, but instead, ramifications of the new data with respect to risk conclusions would be discussed in an appendix to the RI. The purpose of this appendix is to evaluate whether the conclusions of the risk assessments would have been different if Round 3 surface sediment data had been included in the baseline datasets.

In this appendix the various surface sediment datasets are defined as follows:

- The surface sediment data used in the HHRA and ERA represent baseline conditions in the LDW prior to remedial activities at the Duwamish/Diagonal early action area and the Boeing Developmental Center south storm drain associated with the Norfolk early action area (Appendix E defines criteria for inclusion of data in baseline dataset)
- The Round 3 dataset contains surface sediment data collected during Round 3
- The combined baseline/Round 3 dataset includes surface sediment data used in the risk assessments as well as Round 3 data.[2] The combined baseline/Round 3 dataset is equivalent to the RI baseline dataset, which is the dataset used to describe the nature and extent of contamination in Section 4 of the RI.

[1] RI Appendix E provides criteria for including surface sediment data in the RI baseline dataset including details regarding incorporation of Round 3 data.

[2] In addition to adding the Round 3 surface sediment data to the risk assessment datasets, a few other minor revisions were made. For example, Round 3 surface sediment data replaced data from older sampling events if the samples were collected within 10 ft.

C.2 Use of Sediment Chemistry in Risk Assessments

In the ERA, surface sediment data were used as a component of the exposure assessment for each receptor of concern (ROC), except crabs.[3] Sediment data were used in various ways for each ROC, as presented in Table C.2-1. For the benthic invertebrate community, sediment chemical concentrations at each location were compared to one of the following: 1) available chemical criteria of the Washington State Sediment Management Standards (SMS) (Washington Administrative Code [WAC] 173-204), 2) toxicologically based Dredged Material Management Program (DMMP) guidelines, or 3) toxicity reference values (TRVs) from the scientific literature. In addition, surface sediment data were used to estimate the tributyltin (TBT) concentrations in benthic invertebrate tissue using a significant regression relationship between TBT concentrations in sediment and co-located tissue; this estimated tissue concentration was compared to a TRV in the ERA.

Table C.2-1. Use of surface sediment data in the risk assessments for each receptor

RECEPTOR	EXPOSURE PATHWAY	DATA USED	STATISTIC USED
Benthic invertebrate community	direct contact	LDW-wide	sediment concentrations at each location were compared to sediment criteria, guidelines, or TRVs
	direct contact	LDW-wide	UCL[a] tissue TBT concentration based on regression relationship between sediment and co-located tissue
Juvenile chinook salmon	ingestion of benthic invertebrate tissue	intertidal	UCL[a] tissue arsenic concentration based on regression relationship between sediment and co-located tissue
English sole	incidental ingestion (1% of diet)	LDW-wide	UCL[b] sediment concentration for the LDW-wide dataset
	ingestion of benthic invertebrate tissue	LDW-wide	UCL[a] tissue arsenic concentration based on regression relationship between sediment and co-located tissue arsenic concentrations
Pacific staghorn sculpin	incidental ingestion (1% of diet)	LDW-wide; four modeling areas	UCL[b] sediment concentration for the LDW-wide dataset and for each modeling area
	ingestion of benthic invertebrate tissue	LDW-wide; four modeling areas	UCL[a] tissue arsenic concentration based on regression relationship between sediment and co-located tissue arsenic concentrations
Spotted sandpiper	incidental ingestion (18% of diet)	six sandpiper exposure scenarios[c]	UCL[b] sediment concentration for each exposure scenario
	ingestion of benthic invertebrate tissue	six sandpiper exposure scenarios[c]	UCL[a] tissue PCB and arsenic concentrations based on regression relationships between sediment and co-

[3] Risk estimates for crabs did not include a sediment pathway because a critical tissue-residue approach was used instead.

RECEPTOR	EXPOSURE PATHWAY	DATA USED	STATISTIC USED
			located tissue concentrations of either PCBs or arsenic
Great blue heron	incidental ingestion (2% of diet)	intertidal	UCL[b] sediment concentration for the intertidal dataset
Osprey	incidental ingestion (2% of diet)	intertidal	UCL[b] sediment concentration for the intertidal dataset
River otter	incidental ingestion (1% of diet)	LDW-wide	UCL[b] sediment concentration for the LDW-wide dataset
Harbor seal	incidental ingestion (1% of diet)	LDW-wide	UCL[b] sediment concentration for the LDW-wide dataset
Humans	incidental ingestion and dermal absorption	LDW-wide (netfishing scenario); eight beach play areas; three clamming scenarios	UCL[b] sediment concentration for each scenario

[a] Co-located benthic invertebrate tissue and sediment data were used to determine UCLs, as discussed n the ERA (Appendix A, Attachment 11).

[b] ProUCL (EPA 2004, 2007) was used to determine specific methods for deriving UCLs, as discussed in the ERA (Appendix A, Attachment 11) and the HHRA (Appendix B, Section B.3).

[c] Within each of the three exposure areas, two foraging scenarios were evaluated: one in which spotted sandpipers forage in only high-quality habitat, and another in which they forage in both high- and poor-quality habitats.

LDW – Lower Duwamish Waterway

TRV – toxicity reference value

UCL – 95% upper confidence limit on the mean

For English sole, Pacific staghorn sculpin, and all wildlife ROCs, the exposure assessment included incidental sediment ingestion as a component of the diet. In addition, sediment data were used to estimate polychlorinated biphenyl (PCB) and arsenic concentrations in benthic invertebrate tissue based on significant regression relationships between concentrations in sediment and tissue. Dietary exposures based on benthic invertebrate tissue concentrations derived from regression models were used to evaluate risk to juvenile chinook salmon, English sole, and Pacific staghorn sculpin from arsenic and to spotted sandpiper from PCBs and arsenic.

For humans, risk estimates were based on exposure to sediment through incidental ingestion and dermal absorption.

C.3 Risk Implications

This section describes the implications of Round 3 surface sediment data on risk conclusions for the benthic invertebrate community, fish, wildlife, and humans. The following evaluations were conducted:

- For the benthic invertebrate community, the Round 3 surface sediment data were compared to SMS criteria, DMMP guidelines, or TRVs from the scientific literature.
- For fish, wildlife, and humans, mean COPC concentrations using Round 3 surface sediment data for ERA or HHRA exposure scenarios were compared to mean COPC concentrations used in the ERA and HHRA.

These comparisons were made to determine if the inclusion of the Round 3 samples would have resulted in a change of the HQ from > 1.0 to < 1.0 or vice versa. If the HQ could have changed for a particular dataset, then 95% upper confidence limits on the mean (UCLs) were recalculated using the RI baseline dataset.

C.3.1 BENTHIC INVERTEBRATE COMMUNITY

Risks to the benthic invertebrate community were evaluated in the ERA by comparing surface sediment chemical concentrations at each location to the sediment quality standards (SQS) and cleanup screening levels (CSL) of the SMS. Three chemicals of potential concern (COPCs) identified in the ERA did not have an SQS or CSL: nickel, total DDTs (dichlorodiphenyltrichloroethane), and total chlordane. Nickel concentrations were compared to the toxicologically based DMMP guidelines for nickel. Because the DMMP guidelines for total DDTs and total chlordane were not toxicologically based, concentrations of these chemicals in sediment were compared to TRVs selected from the scientific literature.

Concentrations of all COPCs in surface sediment samples at each Round 3 location were compared to the SMS criteria (SQS and CSL) or, in the case of nickel, to DMMP guidelines; no comparisons were made to TRVs for total DDTs or total chlordane because none of the samples collected during Round 3 were analyzed for pesticides. The sampling locations targeted for Round 3 surface sediment sampling were selected in part to improve the spatial coverage in areas of the LDW with SMS exceedances. Consequently, in Round 3, surface sediments at 20 of the 44 locations had detected COPC concentrations that exceeded the SQS, and eight of those also exceeded the CSL; none of the locations had concentrations of nickel that exceeded DMMP guidelines (Table C.3-1; Map C.1-1). Concentrations of PCBs exceeded the SQS or CSL at 17 of the 20 locations with SMS exceedances. Other chemicals with exceedances of the SQS or CSL were: 1) arsenic at one location, 2) mercury at six locations, 3) individual polycyclic aromatic hydrocarbon (PAH) compounds at five locations, 4) both bis(2-ethylhexyl)

phthalate (BEHP) and butyl benzyl phthalate at two locations, and 5) both benzoic acid and benzyl alcohol at one location.[4]

Table C.3-1. COPCs with detected concentrations in Round 3 surface sediment samples exceeding SMS criteria

COPC	No. of Locations with Detected Concentrations	
	> SQS and ≤ CSL	> CSL
Metals		
Arsenic		1
Mercury	2	4
PAHs		
Benzo(a)anthracene		1
Benzo(a)pyrene		1
Benzo(g,h,i)perylene	1	1
Total benzofluoranthenes		1
Chrysene	2	1
Dibenzo(a,h)anthracene	1	
Fluoranthene	2	2
Indeno(1,2,3-cd)pyrene	1	1
Phenanthrene	1	
Pyrene	1	1
Total HPAH	2	1
Phthalates		
Bis(2-ethylhexyl) phthalate	1	1
Butyl benzyl phthalate	2	
Other SVOCs		
Benzoic acid		1
Benzyl alcohol		1
PCBs		
Total PCBs	16	1

COPC – chemical of potential concern
CSL – cleanup screening level
HPAH – high-molecular-weight polycyclic aromatic hydrocarbons
ML – maximum level
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SL – screening level
SMS – Washington State Sediment Management Standards
SQS – sediment quality standard
SVOC – semivolatile organic compound

[4] Arsenic and PCB exceedances of SQS or CSL are presented in Figures 4-3 and 4-5 of the Round 3 surface sediment data report, respectively (Windward 2007).

In the ERA, point locations of sediment samples with chemical exceedances of SMS were spatially interpolated using Thiessen polygons to estimate the degree and areal extent of potential adverse effects on benthic invertebrate communities. On the basis of this analysis, the ERA concluded that no adverse effects to benthic invertebrate communities in intertidal and subtidal sediments were expected in approximately 74% of the LDW area (i.e., the area in which detected chemical concentrations were less than or equal to the SQS, or were not detected). There was a higher likelihood for adverse effects in approximately 7% of the LDW area, which was designated as having chemical concentrations in excess of the CSL. The remaining 19% of the LDW area had chemical concentrations or biological effects between the SQS and the CSL, indicating that risks to benthic invertebrate communities were considered less certain in these areas than in the areas with concentrations greater than one or more CSL values. This spatial analysis was repeated using the Round 3 data, and results were compared. Incorporation of the Round 3 data did not result in sizeable differences among areas in any of these three SMS categories for all chemicals (Table C.3-2). Eight additional point locations were identified as representing a higher likelihood of adverse effects on the benthic invertebrate community (i.e., exceeding the CSL); however, no additional COCs were identified for the benthic invertebrate community, and area estimates remained approximately the same.

Table C.3-2. Areas of the LDW with SQS or CSL exceedances as calculated using Thiessen polygons

SMS Category	Percent Area within Each SMS Category	
	ERA Dataset	RI Baseline Dataset[a]
> CSL, detected	6.7	7.1
> SQS and ≤ CSL, detected	19.4	20.0
Either all detected and non-detected concentrations < SQS or only non-detected concentrations > SQS or CSL	73.9	72.9

[a] The RI baseline dataset includes ERA data plus Round 3 data.

CSL – cleanup screening level
ERA – ecological risk assessment
LDW – Lower Duwamish Waterway
RI – remedial investigation
SMS – Washington State Sediment Management Standards
SQS – sediment quality standard

The ERA also used TBT concentrations in sediment to estimate TBT concentrations in benthic invertebrate tissue based on a significant regression relationship between sediment and co-located tissue concentrations. When the maximum sediment TBT concentration of 3.0 mg/kg dw was used to estimate the tissue TBT concentration, the LOAEL-based HQ was 0.26, indicating low risk to benthic invertebrates. The three sediment samples analyzed for TBT during Round 3 had concentrations of 0.016, 0.055, and 0.073 mg/kg dw, all much lower than the maximum concentration used in the ERA. Thus, Round 3 data would not have changed risk conclusions for the exposure of the benthic invertebrate community to TBT.

C.3.2 FISH

Surface sediment data were used to estimate exposures of English sole and Pacific staghorn sculpin to arsenic, cadmium, copper, and vanadium through the incidental ingestion of sediment as 1% of the diet (Table C.3-3). In addition, arsenic concentrations in benthic invertebrate tissue were estimated using regression relationships between sediment and tissue concentrations. These estimated benthic invertebrate tissue concentrations were used to estimate dietary exposures of juvenile chinook salmon, English sole, and Pacific staghorn sculpin through the diet. Round 3 sediment samples were collected for the four COPCs in all of the fish exposure areas used in the ERA (Table C.3-3; Map C.3-1).

Table C.3-3. Surface sediment data used to assess exposure of fish in the ERA

RECEPTOR	AREA	COPCS
English sole	LDW-wide	arsenic, cadmium, copper, vanadium
Pacific staghorn sculpin	LDW-wide; four modeling areas	arsenic, cadmium, copper, vanadium
Juvenile chinook salmon	intertidal	arsenic

ERA – ecological risk assessment
COPC – chemical of potential concern
LDW – Lower Duwamish Waterway

Summary statistics (i.e., number of samples, detection frequency, minimum, maximum, and mean) were calculated for arsenic, cadmium, copper, and vanadium in sediment separately for the ERA datasets and for the Round 3 datasets for each exposure scenario for fish (i.e., LDW-wide for all three fish ROCs in addition to four modeling areas for Pacific staghorn sculpin) (Table 1 in Attachment 1). The exposure point concentrations (EPCs) used in the ERA were the UCLs rather than the mean concentrations. However, rather than recalculate the UCLs for each dataset, this appendix compares the mean concentrations for the Round 3 datasets to the mean concentrations in the ERA dataset as a preliminary step to determine if risk conclusions could have changed based on the new data (Table 1 in Attachment 1).

For arsenic, the mean Round 3 surface sediment concentrations in each of the specific exposure scenarios were lower than the corresponding mean concentrations used in the ERA for those same exposure scenarios. Because the LOAEL-based HQs for arsenic were < 1.0 (indicating low risk to fish), HQs would not have been > 1.0 if Round 3 data had been available to estimate dietary exposure through incidental ingestion of sediment in the ERA. In addition, for arsenic, a regression relationship between co-located sediment and benthic invertebrate tissue concentrations was used to estimate UCL tissue concentrations for use as EPCs in the ERA. The same regression relationship would be used with Round 3 data because there were no new co-located data. Using the lower mean arsenic sediment concentrations from the Round 3 dataset in the regression equation would result in a lower estimated UCL arsenic concentration in benthic invertebrate tissue than using the mean concentrations in sediment from the dataset.

Therefore, because LOAEL HQs were all < 1.0 based on the ERA dataset, and Round 3 concentrations for arsenic were generally lower than in the ERA dataset, risk conclusions would not have changed based on inclusion of Round 3 data.

For cadmium, copper, and vanadium, there were a total of 18 fish exposure scenarios (i.e., six scenarios for each COPC). For the 11 fish exposure scenarios with LOAEL-based HQs < 1.0 (indicating low risk to fish) in the ERA, the mean concentrations for scenarios using Round 3 data were lower than the mean concentrations for the ERA scenarios, indicating that risk conclusions would not have changed (i.e., LOAEL-based HQs would not have increased to > 1.0). There were five scenarios in the ERA with LOAEL-based HQs ≥ 1.0 (suggesting some risk to fish): two scenarios for cadmium and three scenarios for vanadium (Table C.3-4). With one exception, HQs would not have decreased to < 1.0 even if the lowest COPC concentration in the exposure area from either the ERA dataset or the Round 3 dataset had been used. The HQs did not change substantially because they are driven by concentrations in prey, which constitute 99% of the fish diet. Thus risk conclusions would not have changed for these scenarios based on inclusion of Round 3 data. In the one scenario that would have changed, the cadmium LOAEL-based HQ for Pacific staghorn sculpin in Area M3 would have decreased to 0.9 if the lowest COPC concentration had been used. Therefore, the UCL was calculated for cadmium in Area M3 using the RI baseline dataset. The use of this UCL in risk calculations for Pacific staghorn sculpin did not change the LOAEL-based HQ (i.e., the HQ would still have been > 1.0). These results indicate that risk conclusions for fish would not have changed if Round 3 data had been incorporated into the ERA dataset.

Table C.3-4. Comparison of ERA and Round 3 surface sediment datasets for fish

Scenario				ERA Dataset		Round 3 Dataset	
ROC	COPC	Area	LOAEL HQ	Detection Frequency	Calculated Mean (mg/kg dw)	Detection Frequency	Calculated Mean (mg/kg dw)
English sole	cadmium	LDW-wide	**1.2**	565/797	1.0	22/44	0.35
	vanadium	LDW-wide	**1.2**	556/556	59	44/44	51
Pacific staghorn sculpin	cadmium	M3	**1.0**	180/239	2.3	1/4	0.29
	vanadium	M2	**1.2**	132/132	59	10/10	51
		M3	**1.2**	182/182	58	4/4	58

COPC – chemical of potential concern
dw – dry weight
ERA – ecological risk assessment
HQ – hazard quotient
LDW – Lower Duwamish Waterway
LOAEL – lowest-observed-adverse-effect level
ROC – receptor of concern
Bold identifies LOAEL-based HQs ≥1.0.

C.3.3 WILDLIFE

The exposure assessment for wildlife in the ERA evaluated exposure of the five wildlife ROCs to various COPCs through the incidental ingestion of sediment (Table C.3-5) as a component of the diet. During the Round 3 sampling event, surface sediment samples were collected from all areas included in wildlife exposure scenarios (i.e., LDW-wide, intertidal, and six sandpiper exposure areas) (Maps C.1-1 and C.3-2). Therefore, risk estimates for these areas were evaluated for potential changes in risk conclusions. Risk estimates for total DDTs and PCB TEQs would not have been affected by Round 3 data because samples were not analyzed for organochlorine pesticides or PCB congeners during Round 3.

Table C.3-5. Surface sediment wildlife exposure scenarios used in the ERA

ROC	AREA	COPCS
Spotted sandpiper	six exposure areas	arsenic, cadmium, chromium, cobalt, copper, total DDTs,[a] lead, mercury, nickel, total PCBs, PCB TEQ,[a] selenium, vanadium, zinc
Great blue heron	Intertidal	chromium, lead, mercury, total PCBs, PCB TEQ[a]
Osprey	Intertidal	chromium, lead, mercury, total PCBs, PCB TEQ[a]
River otter	LDW-wide	arsenic, cobalt, mercury, selenium, total PCBs
Harbor seal	LDW-wide	mercury, total PCBs

[a] No new data from Round 3 were available for these COPCs.

COPC – chemical of potential concern
DDT – dichlorodiphenyltrichloroethane
ERA – ecological risk assessment
LDW – Lower Duwamish Waterway
PCB – polychlorinated biphenyl
TEQ – toxic equivalency factor

Summary statistics (i.e., number of samples, detection frequency, minimum, maximum, and mean) were calculated for each of the COPCs in the LDW-wide, intertidal, and six sandpiper exposure areas using the Round 3 data (Table 1 in Attachment 1). The EPCs used in the ERA were UCLs rather than the mean concentrations. However, rather than recalculate the UCLs for each dataset, this appendix compares the mean concentrations from the ERA datasets to the mean concentrations from the Round 3 datasets as a preliminary step to determine if risk conclusions could have changed based on these new data (Table 1 in Attachment 1).

For all but 19 of the 88 wildlife exposure scenarios (i.e., ROC/area/COPC combinations), the LOAEL-based HQ was < 1.0 (indicating low risk), and the mean Round 3 dataset concentration was lower than or equal to the mean ERA dataset concentration, indicating that risk conclusions would not have changed (i.e., HQs would not have increased to > 1.0). Among the remaining 19 scenarios (see Table C.3-6), there was a potential for risk conclusions to change based on this preliminary analysis because: 1) LOAEL-based HQs were ≥1.0, and the mean concentrations in the Round 3 dataset were lower than in the ERA dataset (i.e., HQs could have decreased to < 1.0), or

2) HQs were < 1.0, and the mean concentrations in the Round 3 dataset were higher than in the ERA dataset (i.e., HQs could have increased to ≥ 1.0).

For these 19 scenarios, EPCs and LOAEL-based HQs were recalculated using data from the RI baseline dataset (Table C.3-6). EPCs were calculated as in the ERA (i.e., as the UCL) for each RI baseline dataset, with the exception of the total PCB dataset.

The total PCB EPCs[5] in Table C.3-6 were not recalculated because it was estimated that risk conclusions would not have changed based on the following two analyses: 1) if the maximum surface sediment concentration in Area 1 high-quality foraging habitat (H) and Area 1 high- and poor-quality foraging habitat (H/P) from the RI baseline dataset (1.01 mg/kg dw) had been used as the EPC, the LOAEL-based HQ for spotted sandpiper in each of these areas would have increased only slightly (from 0.18 to 0.19, still indicating low risk), and 2) if the minimum detected LDW-wide surface sediment concentration from the RI baseline dataset (0.0016 mg/kg dw) had been used as the EPC, the LOAEL-based HQ for river otter (2.9, indicating some risk) would not have changed, because sediment is a very small component of the dietary exposure for river otter. The maximum concentration was used in the first analysis to determine if HQs could have increased to > 1.0, and the minimum concentration was used in the second analysis to determine whether HQs could have decreased to < 1.0.

For the remaining 16 scenarios in Table C.3-6, three LOAEL-based HQs would have changed slightly based on the revised EPCs: 1) the lead HQ for spotted sandpiper in Area 2 H/P would have decreased from 5.5 to 5.3, 2) the mercury HQ for spotted sandpiper in Area 1 H would have increased from 0.22 to 0.23, and 3) the vanadium HQ for spotted sandpiper in Area 2 H would have decreased from 1.4 to 1.3. None of these changes would have affected the risk conclusions for spotted sandpiper. The LOAEL-based HQs for all of the other sandpiper scenarios in Table C.3-6 were unchanged.

The LOAEL-based HQs for mercury in river otter and harbor seal were the same when calculated with either the ERA dataset or the RI baseline dataset.

[5] The PCB EPCs were calculated in the ERA as the UCL of the spatially weighted average concentration (SWAC) for each exposure area under consideration (see the ERA [Appendix A], Attachment 11).

Table C.3-6. Comparison of the ERA and RI baseline surface sediment datasets for wildlife

Scenario			ERA Dataset				RI Baseline Dataset			
ROC	COPC	Area	Detection Frequency	Calculated Mean (mg/kg dw)	EPC (mg/kg dw)	LOAEL HQ	Detection Frequency[a]	Calculated Mean (mg/kg dw)	EPC (mg/kg dw)	LOAEL HQ
Spotted sandpiper	chromium	Area 2 H/P	49/49	28	32	**1.8**	52/52	27	32	**1.8**
	copper	Area 3 H/P	150/150	200	730	**1.1**	152/152	200	720	**1.1**
	lead	Area 2 H/P	49/49	70	96	**5.5**	52/52	71	92	**5.3**
		Area 3 H/P	150/150	300	1,000	**1.5**	152/152	340	1,000	**1.5**
	mercury	Area 1 H	34/39	0.13	0.17	0.22	37/45	0.14	0.18	0.23
		Area 1 H/P	40/47	0.13	0.16	0.22	43/53	0.14	0.17	0.22
		Area 3 H	71/87	0.20	0.45	**1.0**	73/89	0.20	0.44	**1.0**
	nickel	Area 2 H/P	41/42	17	20	< 0.1	45/45	18	20	< 0.1
	vanadium	Area 1 H	25/25	50	53	**1.1**	31/31	50	53	**1.1**
		Area 1 H/P	28/28	49	52	**1.0**	34/34	49	52	**1.0**
		Area 2 H	22/22	53	58	**1.4**	24/24	52	57	**1.3**
		Area 2 H/P	38/38	52	55	**1.3**	41/41	52	55	**1.3**
		Area 3 H	70/70	55	57	**1.3**	72/72	55	57	**1.3**
		Area 3 H/P	106/106	57	59	**1.3**	108/108	57	59	**1.3**
	total PCBs	Area 1 H	52/56	0.15	0.34	0.18	56/62	0.16	nc[b]	nc[b]
		Area 1 H/P	74/81	0.14	0.33	0.18	78/87	0.15	nc[b]	nc[b]
River otter	mercury	LDW-wide	715/831	0.21	0.30	0.57	747/869	0.19	0.23	0.57
	total PCBs	LDW-wide	1,203/1,288	1.0	0.98	**2.9**	1,243/1,327	1.2	nc[b]	nc[b]
Harbor seal	mercury	LDW-wide	715/831	0.21	0.30	< 0.1	747/869	0.19	0.23	< 0.1

[a] The total number of samples within either the entire LDW or specific subareas did not always increase by the number of Round 3 samples within those areas because some Round 3 sampling locations were within 10 ft of earlier stations, and therefore the Round 3 data replaced earlier data for those locations. In addition, some other minor changes were made in the RI baseline dataset.

[b] The EPCs for PCBs were calculated as the UCL of the SWAC in the ERA. These EPCs were not recalculated for the RI baseline dataset; however, risk conclusions would not have changed using conservative assumptions, as described in the text.

COPC – chemical of potential concern

EPC – exposure point concentration

H – high-quality sandpiper foraging habitat

HQ – hazard quotient

H/P – high- and poor-quality sandpiper foraging habitat

LDW – Lower Duwamish Waterway

LOAEL – lowest-observed-adverse-effect level

nc – not calculated

ROC – receptor of concern

PCB – polychlorinated biphenyl

SWAC – spatially-weighted average concentration

Bold identifies LOAEL-based HQs ≥1.0.

C.3.4 HUMAN HEALTH

The HHRA evaluated the exposure of people to various COPCs through incidental ingestion and dermal absorption of chemicals from sediment (Table C.3-7). Surface sediment samples were collected from netfishing (LDW-wide), beach play, and clamming areas during the Round 3 sampling event (Maps C.1-1, C.3-3, and C.3-4). Four of the beach play areas were not sampled during Round 3 (beach play areas 2, 3, 6, and 7), so risk conclusions would not have changed for those areas. In addition, risk estimates for aluminum, barium, benzidine, total DDTs, dieldrin, iron, manganese, and toxaphene would not have changed based on Round 3 data because sediments were not analyzed for these chemicals during Round 3. Risk estimates for PCB TEQ would not have changed because samples were not analyzed for PCB congeners in Round 3.

Table C.3-7. Surface sediment exposure scenarios used in the HHRA

SCENARIO	AREA	COPCS
Netfishing CT and RME	LDW-wide	aluminum,[a] antimony, arsenic, barium,[a] benzidine,[a] cadmium, carcinogenic PAHs, chromium, copper, total DDTs,[a] dieldrin,[a] dioxin/furan TEQ, iron,[a] lead, manganese,[a] n-nitrosodimethylamine,[b] total PCBs, PCB TEQ,[a] thallium, toxaphene,[a] vanadium
Beach play RME	eight beach play areas[c]	4,6-dinitro-o-cresol, aluminum,[a] antimony, arsenic, barium,[a] benzidine,[a] bis(2-chloroethyl)ether,[b] cadmium, carcinogenic PAHs, chromium, copper, total DDTs,[a] dieldrin,[a] dioxin/furan TEQ,[d] iron,[a] lead, manganese,[a] mercury, molybdenum, n-nitrosodimethylamine,[b] n-nitroso-di-n-propylamine,[b] total PCBs, PCB TEQ,[a] silver, thallium, toxaphene,[a] vanadium, zinc
Clamming	shoreline access only (7 days/year) boat and shoreline access (tribal clamming RME and tribal clamming of 120 and 183 days/year, respectively)	

[a] Round 3 sediment samples were not analyzed for these COPCs.

[b] These chemicals were not evaluated in this appendix (and are not included in Attachment 1) because they were not detected in any Round 3 samples or in any samples in the HHRA dataset.

[c] Round 3 sediment samples were not collected in beach play areas 2, 3, 6, or 7.

[d] Dioxin/furan sediment data were not collected in any beach play or clamming areas in Round 3.

COPC – chemical of potential concern
DDT – dichlorodiphenyltrichloroethane
LDW – Lower Duwamish Waterway
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
TEQ – toxic equivalency factor

Summary statistics (i.e., number of samples, detection frequency, minimum, maximum, and mean) were calculated for each of the COPCs in each area using the Round 3 data (Table 1 in Attachment 1). The EPCs used in the HHRA were UCLs rather than the mean concentrations. However, rather than recalculate the UCLs for each dataset, the mean concentrations from the HHRA dataset were compared to the mean concentrations from the Round 3 dataset as a preliminary step to determine if risk conclusions could have changed based on the new data (Table 1 in Attachment 1).

Non-cancer HQs presented in the HHRA were ≤ 0.1 for all scenarios that could have been affected by Round 3 data (Table 1 in Attachment 1). The Round 3 data likely would not have increased any of these HQs to > 1.0 because: 1) the HQs were much lower than 1.0 and the number of Round 3 samples was small compared to the number of samples in the HHRA datasets, and 2) mean concentrations were lower for 64 of the 88 chemicals analyzed in Round 3 compared to the mean concentrations in the HHRA datasets. In the RI baseline dataset, Round 3 samples comprised less than 10% of the total number of surface sediment samples in any scenario, with the exception of beach play Area 1, which included one new sample from Round 3 compared to five samples in the HHRA dataset. All HQs in beach play Area 1 were ≤ 0.02 for COPCs with higher mean concentrations in Round 3; therefore it is unlikely that any of the concentrations of chemicals in the one Round 3 sample in this area would have been sufficiently high to have increased the HQ to 1 or greater. For the 24 chemicals in the Round 3 dataset with higher mean concentrations than those in the HHRA dataset, most concentrations were only slightly higher; thus, inclusion of Round 3 data would not have resulted in substantially different EPCs if the datasets had been combined. For example, zinc in beach play Area 5 had one of the largest differences in mean concentrations, with 92 mg/kg dw in the HHRA dataset compared to 250 mg/kg in the Round 3 dataset. The zinc UCL in the HHRA dataset was 110 mg/kg dw compared to 120 mg/kg dw in the RI baseline dataset, both resulting in HQs < 1.0.

Risk estimates for lead were calculated in the HHRA using the Integrated Exposure Uptake Biokinetic (IEUBK) model for children (EPA 1994) and the Adult Lead Model (ALM) for adults (EPA 2003).[9] Based on the HHRA dataset, estimated risks from exposure to lead using these models were less than unacceptable risk levels for both children and adults for all scenarios**.** Risk estimates would not have increased for children or adults from lead exposure in beach play areas by incorporating Round 3 data. The highest calculated mean lead concentration in the Round 3 dataset for any HHRA scenario (70 mg/kg dw lead in beach play Area 5) was lower than the calculated mean of 150 mg/kg dw in the area with the highest EPC value used to calculate lead blood levels in the HHRA (beach play area 2). For the clamming and netfishing scenarios, the mean lead concentrations in the Round 3 dataset were lower than the mean sediment lead concentrations used in the HHRA.

Excess cancer risks were calculated for arsenic, carcinogenic PAHs (cPAHs), dioxins/furans, and total PCBs in the HHRA. For these chemicals, there was a potential for the risk conclusions to change for the following reasons: 1) excess cancer risks were greater than the 1×10^{-6} threshold in the HHRA, and the mean concentrations in the Round 3 dataset were lower than those in the HHRA dataset (i.e., excess cancer risk could have decreased to $< 1 \times 10^{-6}$ if Round 3 data were included), or 2) excess cancer

[9] Risk estimates for lead were expressed as the probability of exceeding a threshold blood lead concentration (10 µg/dL in children for exposure of children or 10 µg/dL in the fetus for exposure of a pregnant mother) rather than as an excess cancer risk estimate or hazard quotient, as used for other COPCs.

risks were < 1×10^{-6} in the HHRA, and the mean concentrations in the Round 3 dataset were higher than those in the HHRA dataset (i.e., excess cancer risk could have increased to greater than the threshold if Round 3 data were included). Therefore, EPCs and excess cancer risks for these COPCs were recalculated for the human health scenarios using the RI baseline dataset (Table C.3-8).[10]

As shown in Table C.3-8, some of the excess cancer risk estimates changed slightly using the RI baseline dataset compared to the HHRA dataset, but none of the risk conclusions would have changed.

[10] In the HHRA, EPCs were calculated as the UCL on the mean for each of the sediment areas over which the exposure could potentially occur.

Table C.3-8. Comparison of the HHRA and RI baseline surface sediment datasets for human health scenarios

Scenario	HHRA Dataset				RI Baseline Dataset			
	Detection Frequency	Calc'd Mean (mg/kg dw)	EPC (mg/kg dw)	Excess Cancer Risk	Detection Frequency[a]	Calc'd Mean (mg/kg dw)	EPC (mg/kg dw)	Excess Cancer Risk
Arsenic								
Beach play RME – Area 1	4/4	6.5	15[b]	**5×10^{-6}**	5/5	6.2	15[b]	**5×10^{-6}**
Beach play RME – Area 4	10/10	8.2	11	**4×10^{-6}**	11/11	7.8	10	**3×10^{-6}**
Beach play RME – Area 5	22/22	8.1	8.9	**3×10^{-6}**	23/23	8.5	9.5	**3×10^{-6}**
Beach play RME – Area 8	11/11	8.7	10	**3×10^{-6}**	13/13	8.4	9.8	**3×10^{-6}**
Clamming – 7 days/year	100/103	8.8	9.5	3×10^{-7}	110/113	8.9	9.5	3×10^{-7}
Tribal clamming RME – 120 days/year	254/275	18	27	**2×10^{-5}**	264/285	18	27	**2×10^{-5}**
Tribal clamming – 183 days/year				**3×10^{-5}**				**3×10^{-5}**
Netfishing – RME	755/817	17	21	**6×10^{-6}**	794/852	17	21	**6×10^{-6}**
Netfishing – CT	755/817	17	21	1×10^{-6}	794/852	17	21	1×10^{-6}
Carcinogenic PAHs								
Beach play RME – Area 1	3/4	0.33	1.2[b]	**1×10^{-5}**	3/5	0.26	1.2[b]	**1×10^{-5}**
Beach play RME – Area 4	9/10	0.20	0.73	**8×10^{-6}**	10/11	0.20	0.67	**8×10^{-6}**
Beach play RME – Area 5	22/22	0.21	0.41	**5×10^{-6}**	23/23	0.28	0.55	**6×10^{-6}**
Beach play RME – Area 8	11/11	0.23	0.32	**4×10^{-6}**	12/13	0.20	0.40	**5×10^{-6}**
Clamming – 7 days/year	97/103	0.27	0.48	1×10^{-7}	105/113	0.32	0.57	1×10^{-7}
Tribal clamming RME – 120 days/year	255/264	0.48	0.77	**5×10^{-6}**	263/274	0.49	0.78	**5×10^{-6}**
Tribal clamming – 183 days/year				**8×10^{-6}**				**8×10^{-6}**
Netfishing – RME	749/793	0.45	0.57	**2×10^{-6}**	780/828	0.46	0.57	**2×10^{-6}**
Netfishing – CT	749/793	0.45	0.57	2×10^{-7}	780/828	0.46	0.57	2×10^{-7}

Scenario	HHRA Dataset				RI Baseline Dataset			
	Detection Frequency	Calc'd Mean (mg/kg dw)	EPC (mg/kg dw)	Excess Cancer Risk	Detection Frequency[a]	Calc'd Mean (mg/kg dw)	EPC (mg/kg dw)	Excess Cancer Risk
Dioxin/furan TEQ[c]								
Netfishing – RME	43/43	1.0×10^{-4}	6.10×10^{-4}	**2×10^{-5}**	47/47	9.3×10^{-5}	5.60×10^{-4}	**2×10^{-5}**
Netfishing – CT	43/43	1.0×10^{-4}	6.10×10^{-4}	**4×10^{-6}**	47/47	9.3×10^{-5}	5.60×10^{-4}	**4×10^{-6}**
Total PCBs								
Beach play RME – Area 1	3/5	0.029	0.12[b]	7×10^{-8}	4/6	0.026	0.062[b]	4×10^{-8}
Beach play RME – Area 4	12/12	2.8	11	**6×10^{-6}**	13/13	2.6	9.3	**5×10^{-6}**
Beach play RME – Area 5	31/32	0.10	0.19	1×10^{-7}	32/33	0.11	0.20	1×10^{-7}
Beach play RME – Area 8	12/18	0.056	0.23	1×10^{-7}	14/20	0.058	0.11	6×10^{-8}
Clamming – 7 days/year	142/161	0.43	1.5	9×10^{-8}	151/171	0.42	1.5	9×10^{-8}
Tribal clamming RME – 120 days/year	415/440	2.0	4.0	8×10^{-6}	424/450	2.0	3.9	**8×10^{-6}**
Tribal clamming – 183 days/year				**1×10^{-5}**				**1×10^{-5}**
Netfishing – RME	1,205/1,291	1.0	2.5	**2×10^{-6}**	1,243/1,327	1.2	2.4	**2×10^{-6}**
Netfishing – CT	1,205/1,291	1.0	2.5	3×10^{-7}	1,243/1,327	1.2	2.4	3×10^{-7}

[a] The total number of samples within either the entire LDW or specific subareas did not always increase by the number of Round 3 samples within those areas because some Round 3 sampling locations were within 10 ft of earlier stations, and therefore the Round 3 data replaced earlier data for those locations. In addition, some other minor changes were made in the RI baseline dataset.

[b] The EPC was equal to the maximum detected concentration if there were ≤ 5 samples with detected concentrations.

[c] No dioxin/furan data were collected in clamming areas or beach play areas during Round 3.

CT – central tendency
EPC – exposure point concentration
HHRA – human health risk assessment
HQ – hazard quotient
PAH – polycyclic aromatic hydrocarbon
RME – reasonable maximum exposure
TEQ – toxic equivalent

Bold text identifies excess cancer risks > 1×10^{-6}.

C.4 Summary

Incorporation of the Round 3 surface sediment data into the ERA and HHRA datasets would have had a minimal effect on risk conclusions for benthic invertebrates, and would not have affected risk conclusions for the remaining ROCs, as discussed below.

- **Benthic invertebrate community**. Twenty of the 44 Round 3 surface sediment locations had COPC concentrations exceeding the SQS and eight of those also exceeded the CSL. Based on the use of Thiessen polygons to estimate the areal extent of potential effects, the LDW areas with either an SQS or CSL exceedance would not have increased by more than 1%. TBT concentrations in Round 3 surface sediment samples were lower than the maximum concentration used in the ERA to estimate a benthic invertebrate tissue concentration, which resulted in a LOAEL-based HQ of 0.26. Thus, Round 3 surface sediment data would not have changed risk conclusions for the benthic invertebrate community as a result of exposure to TBT.
- **Fish.** The mean COPC concentrations in the Round 3 surface sediment datasets were lower than the mean concentrations in the ERA dataset, indicating that risk conclusions would not have changed (i.e., LOAEL-based HQs would not have increased to > 1.0) for all but five fish ROC/COPC/area scenarios. For those five scenarios, risk conclusions would not have changed based on conservative assumptions or recalculation of EPCs and HQs.
- **Wildlife.** For 69 of the 88 wildlife exposure scenarios, the mean COPC concentrations in the Round 3 surface sediment dataset were lower than or equal to the mean COPC concentrations in the ERA dataset, indicating that risk conclusions would not have changed (i.e., HQs would not have increased to > 1.0). In the remaining 19 scenarios, there were three LOAEL-based HQs that would have changed slightly if Round 3 surface sediment data had been combined with the ERA dataset: 1) the lead HQ for spotted sandpiper in Area 2 H/P would have decreased from 5.5 to 5.3, 2) the mercury HQ for spotted sandpiper in Area 1 H would have increased from 0.22 to 0.23, and 3) the vanadium HQ for spotted sandpiper in Area 2 H would have decreased from 1.4 to 1.3. None of these changes would have affected risk conclusions.
- **Humans—non-cancer hazards.** For non-cancer hazard scenarios, the mean COPC concentrations in the Round 3 surface sediment dataset were not compared to mean COPC concentrations in the HHRA dataset. HQs for these scenarios in the HHRA were all very low (i.e., ≤ 0.1). Instead, it was assumed that HQs would not have increased if Round 3 surface sediment data had been included because the number of Round 3 samples was small compared to those in the HHRA datasets. For lead risks, which were calculated using the IEUBK and ALM models, the mean lead concentrations in the relevant Round 3 surface

sediment dataset were lower than those in the HHRA dataset for the same scenarios, indicating that risk conclusions would not have changed.

- **Humans—excess cancer risks.** Some of the excess cancer risk estimates would have changed slightly if Round 3 surface sediment data had been combined with the HHRA dataset, but none of the risk conclusions would have changed.

C.5 References

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Attachment 1. Comparison of surface sediment data used in the risk assessments with Round 3 surface sediment data

For each HHRA or ERA exposure scenario (other than for the benthic invertebrate community) where there were new Round 3 surface sediment data, and therefore, the potential for a difference in risk conclusions, this attachment consists of a table comparing the surface sediment data used in the risk assessments with the Round 3 surface sediment data (Table 1). For each of those scenarios, Table 1 reports the detection frequencies and the minimum, maximum, and calculated mean concentrations for both the surface sediment datasets used in the risk assessments and the Round 3 surface sediment dataset. The risk estimates for each scenario reported in the risk assessments (expressed as HQs for ecological risks or as either HQs [non-cancer] or excess cancer risks for human health risks) are also presented. See the text of Appendix C for a discussion of the potential effects of the Round 3 data on those risk estimates. Chemicals that were never detected in surface sediments in either the dataset used in the risk assessments or in the Round 3 dataset are not included.

Table 1. Comparison of surface sediment data used in risk assessments with Round 3 surface sediment data by chemical

HHRA or ERA	Exposure Scenario	Surface Sediment Data Used in Risk Assessments					Round 3 Surface Sediment Data					HHRA or ERA Risk Estimate (Without Round 3 Data)	
		Detection Frequency		Concentration (mg/kg dw)			Detection Frequency		Concentration (mg/kg dw)				
		Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	HQ[b]	Excess Cancer Risk
Antimony													
HHRA	beach play RME – Area 1	2/4	50%	0.21 J	1.05 J	0.38	1/1	100%	0.4 J	0.4 J	0.4	0.007	na
HHRA	beach play RME – Area 4	5/10	50%	0.7 J	6.0 J	2.1	0/1	0%	nd	nd	0.15	0.04	na
HHRA	beach play RME – Area 5	3/22	14%	0.26 J	5.0 J	1.7	0/1	0%	nd	nd	0.25	0.03	na
HHRA	beach play RME – Area 8	2/11	18%	1.72 J	7.0 J	2.7	0/2	0%	nd	nd	0.18	0.05	na
HHRA	clamming – 7 days/yr	24/89	27%	0.09 J	7.0 J	2.1	1/10	10%	0.4 J	0.4 J	0.22	0.00009	na
HHRA	tribal clamming RME[c]	52/159	33%	0.09 J	110 J	4.6	1/10	10%	0.4 J	0.4 J	0.22	0.008	na
	tribal clamming – 183 days/yr											0.05	na
HHRA	netfishing – RME	139/553	25%	0.09 J	122 J	4.2	2/44	5%	0.4 J	1.1 J	0.20	0.002	na
	netfishing – CT											0.0009	na
Arsenic													
HHRA	beach play RME – Area 1	4/4	100%	3.5	14.9	6.5	1/1	100%	5.1	5.1	5.1	0.1	5×10^{-6}
HHRA	beach play RME – Area 4	10/10	100%	2.7	17.3	8.2	1/1	100%	4.2	4.2	4.2	0.1	4×10^{-6}
HHRA	beach play RME – Area 5	22/22	100%	3.94	11.8	8.1	1/1	100%	16.9	16.9	16.9	0.09	3×10^{-6}
HHRA	beach play RME – Area 8	11/11	100%	5.8	15.6	8.7	2/2	100%	6.2	6.6	6.4	0.1	3×10^{-6}
HHRA	clamming – 7 days/yr	100/103	97%	2.7	20.7	8.8	10/10	100%	4.2	19.2	9.6	0.001	3×10^{-7}
HHRA	tribal clamming RME[c]	254/275	92%	1.2	1,100	18	10/10	100%	4.2	19.2	9.6	0.05	2×10^{-5}
	tribal clamming – 183 days/yr											0.3	3×10^{-5}
HHRA	netfishing – RME	755/817	92%	1.2	1,100	17	44/44	100%	4.0	123	13	0.02	6×10^{-6}
	netfishing – CT											0.008	1×10^{-6}
ERA	English sole – LDW-wide	754/814	93%	1.2	1,100	20	44/44	100%	4.0	123	13	0.8	na

Table 1, cont. Comparison of surface sediment data used in risk assessments with Round 3 surface sediment data by chemical

HHRA or ERA	Exposure Scenario	Surface Sediment Data Used in Risk Assessments					Round 3 Surface Sediment Data					HHRA or ERA Risk Estimate (Without Round 3 Data)	
		Detection Frequency		Concentration (mg/kg dw)			Detection Frequency		Concentration (mg/kg dw)				
		Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	HQ[b]	Excess Cancer Risk
	sculpin – LDW-wide											0.50	na
	River otter – LDW-wide											< 0.1	na
ERA	juvenile chinook salmon – intertidal	307/357	86%	1.2	1,100	16	13/13	100%	4.2	19.2	8.8	0.73	na
ERA	sandpiper – 1 H	37/39	95%	3.13	161	17	5/5	100%	5.1	19.2	11	0.12	na
ERA	sandpiper – 1 H/P	52/55	95%	1.2	161	15	5/5	100%	5.1	19.2	11	0.10	na
ERA	sandpiper – 2 H	23/25	92%	4.0	161	22	2/2	100%	4.2	7.6	5.9	0.13	na
ERA	sandpiper – 2 H/P	47/49	96%	1.2	161	15	3/3	100%	4.2	16.9	9.6	0.10	na
ERA	sandpiper – 3 H	80/87	92%	4.5	79.4	10	2/2	100%	6.2	6.6	6.4	< 0.1	na
ERA	sandpiper – 3 H/P	140/150	93%	4.5	1,100	20	2/2	100%	6.2	6.6	6.4	0.15	na
ERA	sculpin – Area M1	217/222	98%	1.55	725	19	24/24	100%	5.1	123	17	0.50	na
ERA	sculpin – Area M2	149/152	98%	1.2	807	22	10/10	100%	4.0	23.1	10	0.53	na
ERA	sculpin – Area M3	194/239	81%	2.5	1,100	18	4/4	100%	8.7	16.9	12	0.50	na
ERA	sculpin – Area M4	177/186	95%	1.5	51	11	6/6	100%	5.4	10.8	6.9	0.40	na
Cadmium													
HHRA	beach play RME – Area 1	2/4	50%	0.050	0.066	0.10	0/1	0%	nd	nd	0.15	0.0004	na
HHRA	beach play RME – Area 4	6/10	60%	0.12	2.0 J	0.52	1/1	100%	0.4	0.4	0.4	0.002	na
HHRA	beach play RME – Area 5	11/22	50%	0.060	0.4	0.19	1/1	100%	0.6	0.6	0.6	0.0007	na
HHRA	beach play RME – Area 8	5/11	45%	0.10 J	0.18	0.15	0/2	0%	nd	nd	0.18	0.0005	na
HHRA	clamming – 7 days/yr	65/103	63%	0.05	2.2	0.35	4/10	40%	0.4	0.7	0.32	0.00002	na
HHRA	tribal clamming RME[c]	179/268	67%	0.030 J	120	2.0	4/10	40%	0.4	0.7	0.32	0.003	na
	tribal clamming – 183 days/yr											0.02	na

Table 1, cont. Comparison of surface sediment data used in risk assessments with Round 3 surface sediment data by chemical

HHRA or ERA	Exposure Scenario	Surface Sediment Data Used in Risk Assessments					Round 3 Surface Sediment Data					HHRA or ERA Risk Estimate (Without Round 3 Data)	
		Detection Frequency		Concentration (mg/kg dw)			Detection Frequency		Concentration (mg/kg dw)				
		Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	HQ[b]	Excess Cancer Risk
HHRA	netfishing – RME	565/800	71%	0.030 J	120	1.0	22/44	50%	0.4	1.1	0.35	0.0005	na
	netfishing – CT											0.0002	na
ERA	English sole – LDW-wide	565/797	71%	0.030 J	120	1.0	22/44	50%	0.4	1.1	0.35	1.2	na
	sculpin – LDW-wide											0.76	na
ERA	sandpiper – 1 H	30/39	77%	0.050	1.0	0.36	2/5	40%	0.4	0.7	0.33	< 0.1	na
ERA	sandpiper – 1 H/P	43/55	78%	0.03	2	0.51	2/5	40%	0.4	0.7	0.33	< 0.1	na
ERA	sandpiper – 2 H	24/25	96%	0.070	2.7	0.84	1/2	50%	0.4	0.4	0.30	< 0.1	na
ERA	sandpiper – 2 H/P	38/49	78%	0.030 J	2.7	0.52	2/3	67%	0.4	0.6	0.40	< 0.1	na
ERA	sandpiper – 3 H	49/80	61%	0.068	5.2	0.52	0/2	0%	nd	nd	0.18	< 0.1	na
ERA	sandpiper – 3 H/P	98/143	69%	0.068	92	2.5	0/2	0%	nd	nd	0.18	< 0.1	na
ERA	sculpin – Area M1	190/217	88%	0.050	11.7	0.78	16/24	67%	0.4	1.1	0.42	0.98	na
ERA	sculpin – Area M2	128/152	84%	0.030	3	0.44	5/10	50%	0.4	0.6	0.32	0.60	na
ERA	sculpin – Area M3	180/239	75%	0.060	120	2.3	1/4	25%	0.6	0.6	0.29	1.0	na
ERA	sculpin – Area M4	66/177	37%	0.030	1	0.26	0/6	0%	nd	nd	0.16	0.64	na
Carcinogenic PAHs													
HHRA	beach play RME – Area 1	3/4	75%	0.023 J	1.20	0.33	0/1	0%	nd	nd	0.022	na	1×10^{-5}
HHRA	beach play RME – Area 4	9/10	90%	0.019	0.75 J	0.20	1/1	100%	0.12 J	0.12 J	0.12	na	8×10^{-6}
HHRA	beach play RME – Area 5	22/22	100%	0.015 J	1.00 J	0.21	1/1	100%	1.7 J	1.7 J	1.7	na	5×10^{-6}
HHRA	beach play RME – Area 8	11/11	100%	0.049	0.62	0.23	1/2	50%	0.10 J	0.10 J	0.061	na	4×10^{-6}
HHRA	clamming – 7 days/yr	97/103	94%	0.0097 J	3.0	0.27	8/10	80%	0.10 J	4.2	0.82	na	1×10^{-7}
HHRA	tribal clamming RME[c]	255/264	97%	0.0097 J	11	0.48	8/10	80%	0.10 J	4.2	0.82	na	5×10^{-6}
	tribal clamming – 183 days/yr											na	8×10^{-6}

Table 1, cont. Comparison of surface sediment data used in risk assessments with Round 3 surface sediment data by chemical

HHRA or ERA	Exposure Scenario	Surface Sediment Data Used in Risk Assessments					Round 3 Surface Sediment Data					HHRA or ERA Risk Estimate (Without Round 3 Data)	
		Detection Frequency		Concentration (mg/kg dw)			Detection Frequency		Concentration (mg/kg dw)				
		Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	HQ[b]	Excess Cancer Risk
HHRA	netfishing – RME	749/793	94%	0.0091 J	11	0.45	40/44	91%	0.045 J	4.2	0.50	na	2×10^{-6}
	netfishing – CT											na	2×10^{-7}
Chromium													
HHRA	beach play RME – Area 1	4/4	100%	9.10	20.8	15	1/1	100%	19.8	19.8	20	0.02	na
HHRA	beach play RME – Area 4	10/10	100%	12	122 J	34	1/1	100%	13.2	13.2	13	0.07	na
HHRA	beach play RME – Area 5	22/22	100%	12	61 J	23	1/1	100%	40	40	40	0.02	na
HHRA	beach play RME – Area 8	11/11	100%	15	26	21	2/2	100%	15.9	18.5	17	0.02	na
HHRA	clamming – 7 days/yr	103/103	100%	9.0	122 J	26	10/10	100%	13.2	40	23	0.0002	na
HHRA	tribal clamming RME[c]	275/275	100%	4.8	1,100 J	52	10/10	100%	13.2	40	23	0.01	na
	tribal clamming – 183 days/yr											0.07	na
HHRA	netfishing – RME	814/814	100%	4.8	1,100 J	40	44/44	100%	11.0	40	25	0.003	na
	netfishing – CT											0.002	na
ERA	great blue heron	357/357	100%	4.8	1,100 J	50	13/13	100%	12.5	40	21	< 0.1	na
	osprey											< 0.1	na
ERA	sandpiper – 1 H	39/39	100%	9.84	60.5	28	5/5	100%	18	37	25	0.28	na
ERA	sandpiper – 1 H/P	55/55	100%	4.8	60.5	27	5/5	100%	18	37	25	0.26	na
ERA	sandpiper – 2 H	25/25	100%	9.0	122 J	35	2/2	100%	13.2	19.6	16	0.80	na
ERA	sandpiper – 2 H/P	49/49	100%	4.8	122 J	28	3/3	100%	13.2	40	24	1.8	na
ERA	sandpiper – 3 H	87/87	100%	9.19	76 J	29	2/2	100%	15.9	18.5	17	0.32	na
ERA	sandpiper – 3 H/P	150/150	100%	9.19	1,100	67	2/2	100%	15.9	18.5	17	0.82	na
Cobalt													
ERA	river otter – LDW-wide	556/556	100%	2.82	140	9.5	44/44	100%	3.6	12	7.6	< 0.1	na
ERA	sandpiper – 1 H	25/25	100%	2.82	18.7	7.4	5/5	100%	3.6	8.1	6.0	< 0.1	na

Table 1, cont. Comparison of surface sediment data used in risk assessments with Round 3 surface sediment data by chemical

HHRA or ERA	Exposure Scenario	Surface Sediment Data Used in Risk Assessments					Round 3 Surface Sediment Data					HHRA or ERA Risk Estimate (Without Round 3 Data)	
		Detection Frequency		Concentration (mg/kg dw)			Detection Frequency		Concentration (mg/kg dw)				
		Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	HQ[b]	Excess Cancer Risk
ERA	sandpiper – 1 H/P	28/28	100%	2.82	18.7	7.1	5/5	100%	3.6	8.1	6.0	< 0.1	na
ERA	sandpiper – 2 H	22/22	100%	3.0	18.7	8.2	2/2	100%	4.1	5.4	4.8	< 0.1	na
ERA	sandpiper – 2 H/P	38/38	100%	3.0	18.7	7.3	3/3	100%	4.1	10.2	6.6	< 0.1	na
ERA	sandpiper – 3 H	70/70	100%	3.48	12	7.7	2/2	100%	5.9	6.4	6.2	< 0.1	na
ERA	sandpiper – 3 H/P	106/106	100%	3.48	37	9.2	2/2	100%	5.9	6.4	6.2	< 0.1	na
Copper													
HHRA	beach play RME – Area 1	4/4	100%	17.6	50.2	33	1/1	100%	27.7	27.7	28	0.003	na
HHRA	beach play RME – Area 4	10/10	100%	13.3	117	47	1/1	100%	19.0	19.0	19	0.005	na
HHRA	beach play RME – Area 5	22/22	100%	17.1	180	43	1/1	100%	100	100	100	0.005	na
HHRA	beach play RME – Area 8	11/11	100%	22	46.7	29	2/2	100%	17.9	26.9	22	0.002	na
HHRA	clamming – 7 days/yr	103/103	100%	7.9	180	44	10/10	100%	17.9	100	47	0.00003	na
HHRA	tribal clamming RME[c]	275/275	100%	5	12,000 J	180	10/10	100%	17.9	100	47	0.005	na
	tribal clamming – 183 days/yr											0.03	na
HHRA	netfishing – RME	817/817	100%	5	12,000 J	100	44/44	100%	14.5	137	59	0.001	na
	netfishing – CT											0.0005	na
ERA	English sole – LDW-wide	814/814	100%	5	12,000 J	110	44/44	100%	14.5	137	59	0.93	na
	sculpin – LDW-wide											0.56	na
ERA	sandpiper – 1 H	39/39	100%	7.90	365	74	5/5	100%	27.7	92	55	0.72	na
ERA	sandpiper – 1 H/P	55/55	100%	7.9	365	65	5/5	100%	27.7	92	55	0.72	na
ERA	sandpiper – 2 H	25/25	100%	16	365	87	2/2	100%	19.0	35.5	27	0.86	na
ERA	sandpiper – 2 H/P	49/49	100%	11.5	365	64	3/3	100%	19.0	100	52	0.83	na
ERA	sandpiper – 3 H	87/87	100%	17.2	290	45	2/2	100%	17.9	26.9	22	0.45	na
ERA	sandpiper – 3 H/P	150/150	100%	17.2	12,000	200	2/2	100%	17.9	26.9	22	1.1	na
ERA	sculpin – Area M1	222/222	100%	7.9	495	84	24/24	100%	27.7	137	72	0.65	na

Table 1, cont. Comparison of surface sediment data used in risk assessments with Round 3 surface sediment data by chemical

HHRA or ERA	Exposure Scenario	Surface Sediment Data Used in Risk Assessments					Round 3 Surface Sediment Data					HHRA or ERA Risk Estimate (Without Round 3 Data)	
		Detection Frequency		Concentration (mg/kg dw)			Detection Frequency		Concentration (mg/kg dw)				
		Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	HQ[b]	Excess Cancer Risk
ERA	sculpin – Area M2	152/152	100%	10	1420	100	10/10	100%	14.5	100	53	0.77	na
ERA	sculpin – Area M3	239/239	100%	14	12000	200	4/4	100%	30.1	100	58	0.45	na
ERA	sculpin – Area M4	186/186	100%	5	89.9	38	6/6	100%	16.5	32.2	22	0.48	na
Dioxin/furan TEQ													
HHRA	netfishing – RME	43/43	100%	1.10×10^{-6} J	0.00210 J	1.1×10^{-4}	5/5	100%	1.02×10^{-5} J	1.69×10^{-5} J	1.4×10^{-5}	na	2×10^{-5}
HHRA	netfishing – CT											na	4×10^{-6}
Lead													
HHRA	beach play RME – Area 1	4/4	100%	4	71	32	1/1	100%	40	40	40	bt[d]	na
HHRA	beach play RME – Area 4	10/10	100%	9	615	130	1/1	100%	16	16	16	bt[d]	na
HHRA	beach play RME – Area 5	22/22	100%	17	70 J	32	1/1	100%	70	70	70	bt[d]	na
HHRA	beach play RME – Area 8	11/11	100%	9.3	95	24	2/2	100%	15	26	21	bt[d]	na
HHRA	clamming – 7 days/yr	103/103	100%	4	615	53	10/10	100%	15	138	48	bt[d]	na
HHRA	tribal clamming RME[c]	275/275	100%	2	23,000	230	10/10	100%	15	138	48	bt[d]	na
	tribal clamming – 183 days/yr											bt[d]	na
HHRA	netfishing – RME	817/817	100%	2	23,000	100	44/44	100%	7	292	50	bt[d]	na
	netfishing – CT											bt[d]	na
ERA	great blue heron	357/357	100%	2	23000	190	13/13	100%	7	138	39	< 0.1	na
	osprey											< 0.1	na
ERA	sandpiper – 1 H	39/39	100%	7.94 J	400	70	5/5	100%	19	138	66	0.37	na
ERA	sandpiper – 1 H/P	55/55	100%	7.94 J	400	70	5/5	100%	19	138	66	0.37	na
ERA	sandpiper – 2 H	25/25	100%	8.2	615	110	2/2	100%	16	34	25	0.34	na
ERA	sandpiper – 2 H/P	49/49	100%	8.2	615	70	3/3	100%	16	70	40	5.5	na
ERA	sandpiper – 3 H	87/87	100%	6.3	533	50	2/2	100%	15	26	21	0.17	na

Table 1, cont. Comparison of surface sediment data used in risk assessments with Round 3 surface sediment data by chemical

HHRA or ERA	Exposure Scenario	Surface Sediment Data Used in Risk Assessments					Round 3 Surface Sediment Data					HHRA or ERA Risk Estimate (Without Round 3 Data)	
		Detection Frequency		Concentration (mg/kg dw)			Detection Frequency		Concentration (mg/kg dw)				
		Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	HQ[b]	Excess Cancer Risk
ERA	sandpiper – 3 H/P	150/150	100%	6.3	23,000	300	2/2	100%	15	26	21	1.5	na
Mercury													
HHRA	beach play RME – Area 1	3/4	75%	0.053	0.17	0.082	0/1	0%	nd	nd	0.030	0.005	na
HHRA	beach play RME – Area 4	8/10	80%	0.038	2.46	0.53	0/1	0%	nd	nd	0.030	0.05	na
HHRA	beach play RME – Area 5	14/22	64%	0.06	0.23	0.081	1/1	100%	0.28	0.28	0.28	0.003	na
HHRA	beach play RME – Area 8	8/11	73%	0.05	0.21	0.088	2/2	100%	0.070	0.080	0.075	0.003	na
HHRA	clamming – 7 days/yr	78/103	76%	0.025	2.46	0.15	7/10	70%	0.070	0.6	0.16	0.00005	na
HHRA	tribal clamming RME[c]	218/272	80%	0.021	4.6 J	0.18	7/10	70%	0.070	0.6	0.16	0.0009	na
	tribal clamming – 183 days/yr											0.006	na
ERA	great blue heron	278/356	78%	0.021	5.6	0.17	7/13	54%	0.060	0.6	0.13	< 0.1	na
	osprey											< 0.1	na
ERA	harbor seal – LDW-wide	715/831	86%	0.021	4.6 J	0.21	37/44	84%	0.060	1.8	0.28	< 0.1	na
	river otter – LDW-wide											0.57	na
ERA	sandpiper – 1 H	34/39	87%	0.025	0.63	0.13	3/5	60%	0.11	0.6	0.22	0.22	na
ERA	sandpiper – 1 H/P	40/47	85%	0.021	0.63	0.13	3/5	60%	0.11	0.6	0.22	0.22	na
ERA	sandpiper – 2 H	29/32	91%	0.03	2.46	0.30	0/2	0%	nd	nd	0.035	0.24	na
ERA	sandpiper – 2 H/P	41/49	84%	0.021	2.46	0.22	1/3	33%	0.28	0.28	0.12	0.21	na
ERA	sandpiper – 3 H	71/87	82%	0.030	4.6 J	0.20	2/2	100%	0.070	0.080	0.075	1.0	na
ERA	sandpiper – 3 H/P	124/149	83%	0.030	4.6	0.20	2/2	100%	0.070	0.080	0.075	0.99	na
Molybdenum													
HHRA	beach play RME – Area 1	4/4	100%	0.494 J	1.8	0.90	1/1	100%	0.5	0.5	0.5	0.001	na
HHRA	beach play RME – Area 4	7/7	100%	0.543 J	5.1	1.6	1/1	100%	0.3	0.3	0.3	0.002	na
HHRA	beach play RME – Area 5	15/15	100%	0.486 J	4	1.5	1/1	100%	2.1	2.1	2.1	0.001	na

Table 1, cont. Comparison of surface sediment data used in risk assessments with Round 3 surface sediment data by chemical

HHRA or ERA	Exposure Scenario	Surface Sediment Data Used in Risk Assessments					Round 3 Surface Sediment Data					HHRA or ERA Risk Estimate (Without Round 3 Data)	
		Detection Frequency		Concentration (mg/kg dw)			Detection Frequency		Concentration (mg/kg dw)				
		Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	HQ[b]	Excess Cancer Risk
HHRA	beach play RME – Area 8	6/6	100%	0.9	2	1.5	2/2	100%	0.4	0.5	0.45	0.001	na
HHRA	clamming – 7 days/yr	56/60	93%	0.399	5.8	1.5	10/10	100%	0.3	8.8	2.1	0.00001	na
HHRA	tribal clamming RME[c]	93/97	96%	0.390 J	49	2.7	10/10	100%	0.3	8.8	2.1	0.0003	na
	tribal clamming – 183 days/yr											0.002	na
Nickel													
ERA	sandpiper – 1 H	39/39	100%	6.0	37	19	5/5	100%	10	22.4	17	< 0.1	na
ERA	sandpiper – 1 H/P	47/48	98%	6.0	37	20	5/5	100%	10	22.4	17	< 0.1	na
ERA	sandpiper – 2 H	25/25	100%	8.9	39	19	2/2	100%	10.5	13.2	12	< 0.1	na
ERA	sandpiper – 2 H/P	41/42	98%	8.9	39	17	3/3	100%	10.5	35	20	< 0.1	na
ERA	sandpiper – 3 H	85/85	100%	7.66	52	20	2/2	100%	11.4	14.5	13	< 0.1	na
ERA	sandpiper – 3 H/P	141/141	100%	7.66	910	50	2/2	100%	11.4	14.5	13	0.11	na
Total PCBs													
HHRA	beach play RME – Area 1	3/5	60%	0.0031 J	0.119	0.029	1/1	100%	0.0084 J	0.0084 J	0.0084	0.02	7×10^{-8}
HHRA	beach play RME – Area 4	12/12	100%	0.011 J	23	2.8	1/1	100%	0.038	0.038	0.038	1	6×10^{-6}
HHRA	beach play RME – Area 5	31/32	97%	0.024 J	0.66	0.10	1/1	100%	0.30	0.30	0.30	0.04	1×10^{-7}
HHRA	beach play RME – Area 8	12/18	67%	0.0061 J	0.52	0.056	2/2	100%	0.060	0.088 J	0.074	0.04	1×10^{-7}
HHRA	clamming – 7 days/yr	142/161	88%	0.0022 J	23	0.43	9/10	90%	0.0084 J	1.01	0.21	0.005	9×10^{-8}
HHRA	tribal clamming RME[c]	415/440	94%	0.0022 J	110	2.0	9/10	90%	0.0084 J	1.01	0.21	0.05	2×10^{-6}
	tribal clamming – 183 days/yr											0.3	3×10^{-6}
HHRA	netfishing – RME	1205/1291	93%	0.0016 J	220	1.0	43/44	98%	0.0084 J	1.01	0.22	0.01	3×10^{-7}
	netfishing – CT											0.003	5×10^{-8}
ERA	great blue heron	509/552	92%	0.0022 J	220	2.3	12/13	92%	0.0084 J	1.01	0.16	0.12	na
	osprey											0.23	na

Table 1, cont. Comparison of surface sediment data used in risk assessments with Round 3 surface sediment data by chemical

HHRA or ERA	Exposure Scenario	Surface Sediment Data Used in Risk Assessments					Round 3 Surface Sediment Data					HHRA or ERA Risk Estimate (Without Round 3 Data)	
		Detection Frequency		Concentration (mg/kg dw)			Detection Frequency		Concentration (mg/kg dw)				
		Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	HQ[b]	Excess Cancer Risk
ERA	Harbor seal – LDW-wide	1203/1288	93%	0.0016 J	220	1.0	43/44	98%	0.0084 J	1.01	0.22	0.22	na
	river otter – LDW-wide											2.9	na
ERA	sandpiper – 1 H	52/56	93%	0.0026	0.81	0.15	4/5	80%	0.0084 J	1.01	0.29	0.18	na
ERA	sandpiper – 1 H/P	74/81	91%	0.0022 J	0.81	0.14	4/5	80%	0.0084 J	1.01	0.29	0.18	na
ERA	sandpiper – 2 H	49/50	98%	0.061	25	2.8	2/2	100%	0.038	0.097 J	0.068	0.71	na
ERA	sandpiper – 2 H/P	84/88	95%	0.0047	25	1.6	3/3	100%	0.038	0.30	0.15	0.46	na
ERA	sandpiper – 3 H	117/129	91%	0.0061 J	15	1.3	2/2	100%	0.060	0.088 J	0.074	0.32	na
ERA	sandpiper – 3 H/P	216/228	95%	0.0061 J	110	3.3	2/2	100%	0.060	0.088 J	0.074	0.41	na
Selenium													
ERA	river otter – LDW-wide	277/629	44%	0.2 J	28	4.3	0/44	0%	nd	nd	0.43	0.40	na
ERA	sandpiper – 1 H	12/28	43%	0.2 J	1	2.5	0/5	0%	nd	nd	0.46	0.39	na
ERA	sandpiper – 1 H/P	13/36	36%	0.2 J	10	0.71	0/5	0%	nd	nd	0.46	0.38	na
ERA	sandpiper – 2 H	12/22	55%	0.3	9	3.2	0/2	0%	nd	nd	0.40	0.55	na
ERA	sandpiper – 2 H/P	16/38	42%	0.3	9	3.3	0/3	0%	nd	nd	0.43	0.45	na
ERA	sandpiper – 3 H	22/60	37%	0.6 J	13	5.5	0/2	0%	nd	nd	0.40	0.50	na
ERA	sandpiper – 3 H/P	32/96	33%	0.6 J	20	5.9	0/2	0%	nd	nd	0.40	0.49	na
Silver													
HHRA	beach play RME – Area 1	1/4	25%	0.04	0.04	0.12	0/1	0%	nd	nd	0.15	0.0001	na
HHRA	beach play RME – Area 4	7/10	70%	0.083	1.7	0.49	0/1	0%	nd	nd	0.15	0.0004	na
HHRA	beach play RME – Area 5	9/22	41%	0.084	0.18	0.21	0/1	0%	nd	nd	0.25	0.00008	na
HHRA	beach play RME – Area 8	6/11	55%	0.06	0.13 J	0.18	0/2	0%	nd	nd	0.18	0.00006	na
HHRA	clamming – 7 days/yr	55/103	53%	0.04	5.7	0.35	0/10	0%	nd	nd	0.20	0.000003	na
HHRA	tribal clamming RME[c]	143/265	54%	0.02	270	2.1	0/10	0%	nd	nd	0.20	0.0005	na

Table 1, cont. Comparison of surface sediment data used in risk assessments with Round 3 surface sediment data by chemical

HHRA or ERA	Exposure Scenario	Surface Sediment Data Used in Risk Assessments					Round 3 Surface Sediment Data					HHRA or ERA Risk Estimate (Without Round 3 Data)	
		Detection Frequency		Concentration (mg/kg dw)			Detection Frequency		Concentration (mg/kg dw)				
		Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	HQ[b]	Excess Cancer Risk
	tribal clamming – 183 days/yr											0.003	na
Thallium													
HHRA	beach play RME – Area 1	1/4	25%	0.036	0.036	0.076	0/1	0%	nd	nd	0.15	0.006	na
HHRA	beach play RME – Area 4	6/10	60%	0.03	0.11 J	0.096	0/1	0%	nd	nd	0.15	0.003	na
HHRA	beach play RME – Area 5	9/22	41%	0.03	0.07	0.12	0/1	0%	nd	nd	0.25	0.002	na
HHRA	beach play RME – Area 8	6/11	55%	0.04	0.07	0.11	0/2	0%	nd	nd	0.18	0.002	na
HHRA	clamming – 7 days/yr	42/89	47%	0.010 J	0.18	1.1	0/10	0%	nd	nd	0.20	0.00003	na
HHRA	tribal clamming RME[c]	83/190	44%	0.010 J	30	2.7	0/10	0%	nd	nd	0.20	0.02	na
	tribal clamming – 183 days/yr											0.1	na
HHRA	netfishing – RME	325/638	51%	0.010 J	32 J	3.3	0/44	0%	nd	nd	0.18	0.007	na
	netfishing – CT											0.004	na
Vanadium													
HHRA	beach play RME – Area 1	4/4	100%	44.2	47.2	46	1/1	100%	43.6	43.6	44	0.1	na
HHRA	beach play RME – Area 4	10/10	100%	37.3	71	51	1/1	100%	36.3	36.3	36	0.2	na
HHRA	beach play RME – Area 5	22/22	100%	41.2	68.7	53	1/1	100%	67.6	67.6	68	0.1	na
HHRA	beach play RME – Area 8	11/11	100%	41	65.4	53	2/2	100%	40.7	49.9	45	0.2	na
HHRA	clamming – 7 days/yr	81/81	100%	15	71	51	10/10	100%	34.6	70.7	49	0.001	na
HHRA	tribal clamming RME[c]	192/192	100%	15	87	55	10/10	100%	34.6	70.7	49	0.02	na
	tribal clamming – 183 days/yr											0.1	na
HHRA	netfishing – RME	557/557	100%	15	150	59	44/44	100%	34.6	74	51	0.01	na
	netfishing – CT											0.006	na
ERA	English sole – LDW-wide	556/556	100%	15	150	59	44/44	100%	34.6	74	51	1.2	na

Table 1, cont. Comparison of surface sediment data used in risk assessments with Round 3 surface sediment data by chemical

HHRA or ERA	Exposure Scenario	Surface Sediment Data Used in Risk Assessments					Round 3 Surface Sediment Data					HHRA or ERA Risk Estimate (Without Round 3 Data)	
		Detection Frequency		Concentration (mg/kg dw)			Detection Frequency		Concentration (mg/kg dw)				
		Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	HQ[b]	Excess Cancer Risk
	sculpin – LDW-wide											0.79	na
ERA	sandpiper – 1 H	25/25	100%	34.8	72.6	50	5/5	100%	34.6	70.7	49	1.1	na
ERA	sandpiper – 1 H/P	28/28	100%	34.8	72.6	49	5/5	100%	34.6	70.7	49	1.0	na
ERA	sandpiper – 2 H	22/22	100%	15	72.6	53	2/2	100%	36.3	45.7	41	1.4	na
ERA	sandpiper – 2 H/P	38/38	100%	15	72.6	52	3/3	100%	36.3	67.6	50	1.3	na
ERA	sandpiper – 3 H	70/70	100%	27.9	83	55	2/2	100%	40.7	49.9	45	1.3	na
ERA	sandpiper – 3 H/P	106/106	100%	27.9	87	57	2/2	100%	40.7	49.9	45	1.3	na
ERA	sculpin – Area M1	128/128	100%	27.7	100	61	24/24	100%	34.6	74	52	0.86	na
ERA	sculpin – Area M2	132/132	100%	15	86	59	10/10	100%	35.0	71.9	51	1.2	na
ERA	sculpin – Area M3	182/182	100%	30	150	58	4/4	100%	49.5	67.6	58	1.2	na
ERA	sculpin – Area M4	100/100	100%	27.9	89.6	58	6/6	100%	38.2	54.1	44	0.65	na
Zinc													
HHRA	beach play RME – Area 1	4/4	100%	30.8	142 J	73	1/1	100%	98	98	98	0.001	na
HHRA	beach play RME – Area 4	10/10	100%	35.3	417	140	1/1	100%	57	57	57	0.002	na
HHRA	beach play RME – Area 5	22/22	100%	52.1	246 J	92	1/1	100%	250	250	250	0.001	na
HHRA	beach play RME – Area 8	11/11	100%	56	211	83	2/2	100%	51	76	64	0.001	na
HHRA	clamming – 7 days/yr	103/103	100%	28	480 J	110	10/10	100%	51	250	100	0.00001	na
HHRA	tribal clamming RME[c]	275/275	100%	16	9,700	270	10/10	100%	51	250	100	0.0006	na
	tribal clamming – 183 days/yr											0.004	na
ERA	sandpiper – 1 H	39/39	100%	31	607	150	5/5	100%	57	160	100	0.28	na
ERA	sandpiper – 1 H/P	54/55	98%	19.2	607	140	5/5	100%	57	160	100	0.27	na
ERA	sandpiper – 2 H	25/25	100%	28	607	190	2/2	100%	57	91	74	0.43	na
ERA	sandpiper – 2 H/P	48/49	98%	19.2	607	140	3/3	100%	57	250	130	0.52	na
ERA	sandpiper – 3 H	87/87	100%	35.6	343	110	2/2	100%	51	76	64	0.37	na

Table 1, cont. Comparison of surface sediment data used in risk assessments with Round 3 surface sediment data by chemical

HHRA or ERA	Exposure Scenario	Surface Sediment Data Used in Risk Assessments					Round 3 Surface Sediment Data					HHRA or ERA Risk Estimate (Without Round 3 Data)	
		Detection Frequency		Concentration (mg/kg dw)			Detection Frequency		Concentration (mg/kg dw)				
		Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	Ratio	%	Minimum Detect	Maximum Detect	Calc'd Mean[a]	HQ[b]	Excess Cancer Risk
ERA	sandpiper – 3 H/P	150/150	100%	35.6	6,400	320	2/2	100%	51	76	64	0.50	na

[a] Calculated mean concentration is the average of detected concentrations and one-half the RL for non-detected results.

[b] ERA HQs are the LOAEL-based HQs. HQs with values less than 0.1 were reported as < 0.1 in the ERA. HHRA hazard quotients are for non-cancer risks.

[c] Tribal clamming RME risk estimates are calculated using an exposure frequency of 120 days per year.

[d] Human health risks from exposure to lead were determined using the IEUBK model for children and the ALM model for adults. The risk estimates for lead were expressed as the probability of exceeding a threshold blood lead concentration (10 µg/dL in children for exposure of children or 10 µg/dL in the fetus for exposure of a pregnant mother) rather than as an excess cancer risk estimate or hazard quotient, as used for other COPCs. Consequently, the risk estimates are shown as "below threshold (or bt)" rather than as a hazard quotient.

bt – below threshold

COPC – chemical of potential concern

ERA – ecological risk assessment

H – high-quality sandpiper foraging habitat

HHRA – human health risk assessment

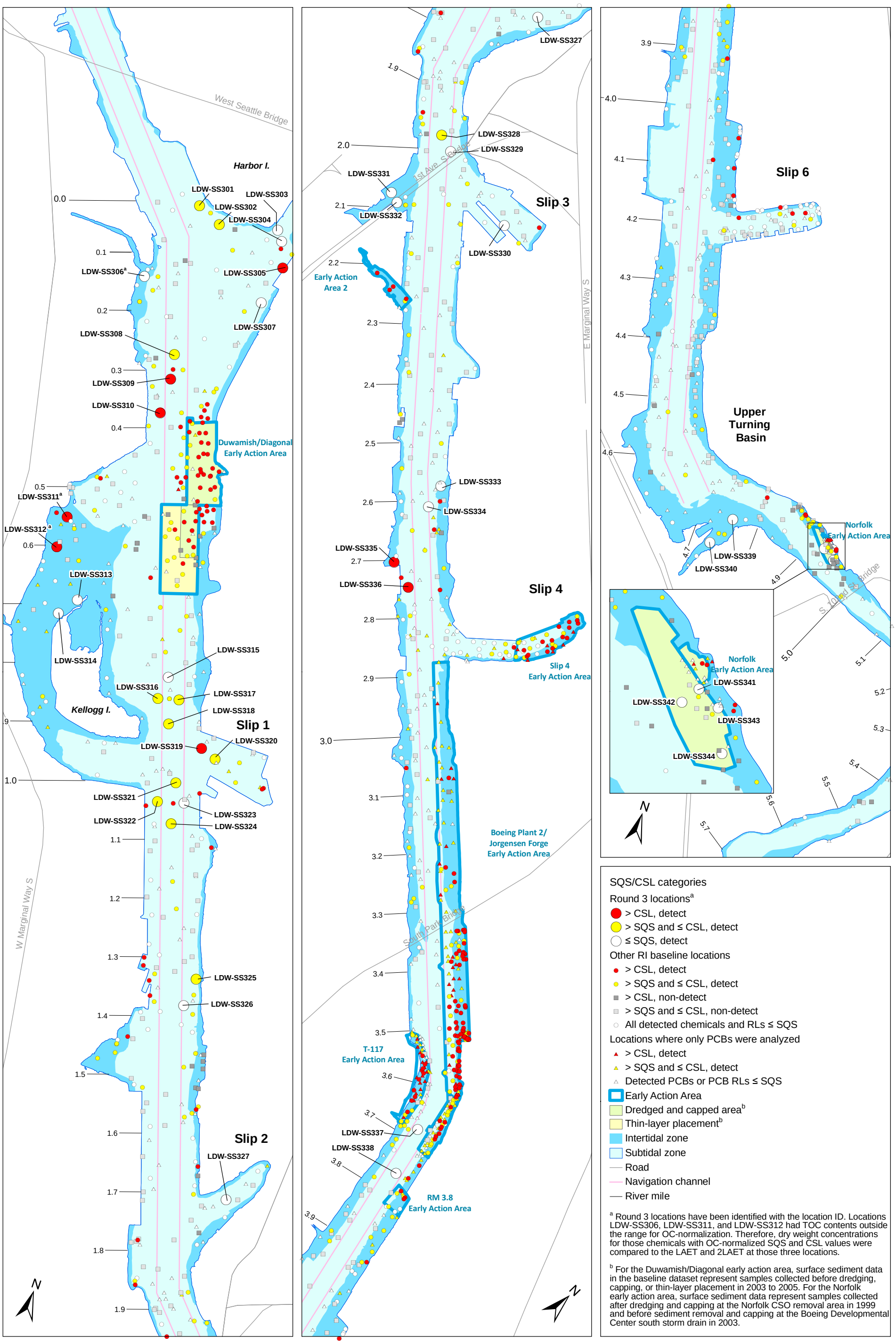
H/P – high- and poor-quality sandpiper foraging habitat

HQ – hazard quotient

J – estimated concentration

na – not applicable

nd – not detected



SQS/CSL categories

Round 3 locations[a]
- > CSL, detect
- > SQS and ≤ CSL, detect
- ≤ SQS, detect

Other RI baseline locations
- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- All detected chemicals and RLs ≤ SQS

Locations where only PCBs were analyzed
- > CSL, detect
- > SQS and ≤ CSL, detect
- Detected PCBs or PCB RLs ≤ SQS

Early Action Area
Dredged and capped area[b]
Thin-layer placement[b]
Intertidal zone
Subtidal zone
Road
Navigation channel
River mile

[a] Round 3 locations have been identified with the location ID. Locations LDW-SS306, LDW-SS311, and LDW-SS312 had TOC contents outside the range for OC-normalization. Therefore, dry weight concentrations for those chemicals with OC-normalized SQS and CSL values were compared to the LAET and 2LAET at those three locations.

[b] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

0 0.1 0.2 Miles

0 0.1 0.2 Kilometers

Scale is the same for each inset map

Map C.1-1. Exceedances of SMS criteria (SQS or CSL) by at least one chemical in surface sediment at Round 3 and other RI locations

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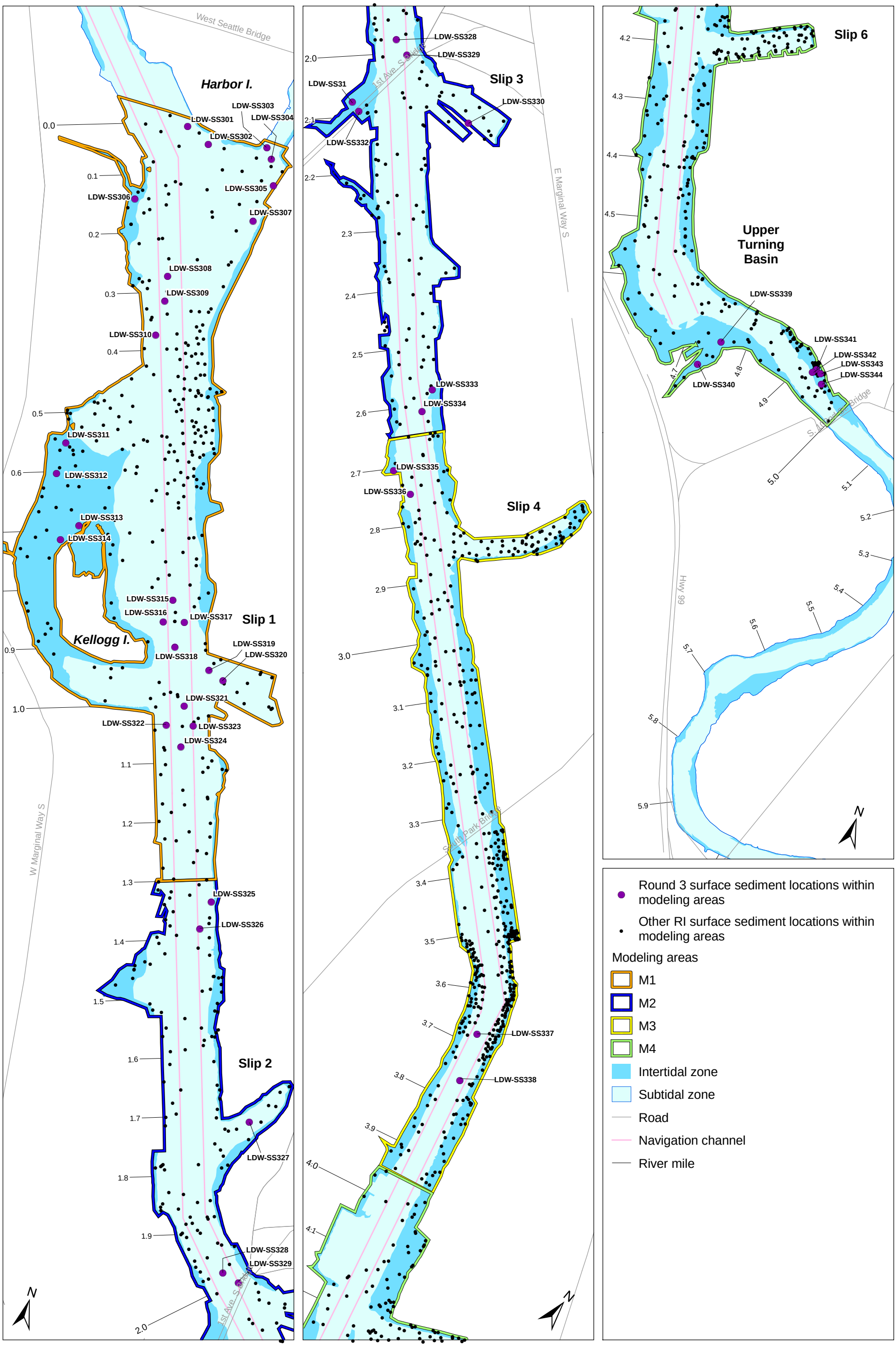

Map C.3-1. Round 3 and other RI surface sediment locations within modeling areas

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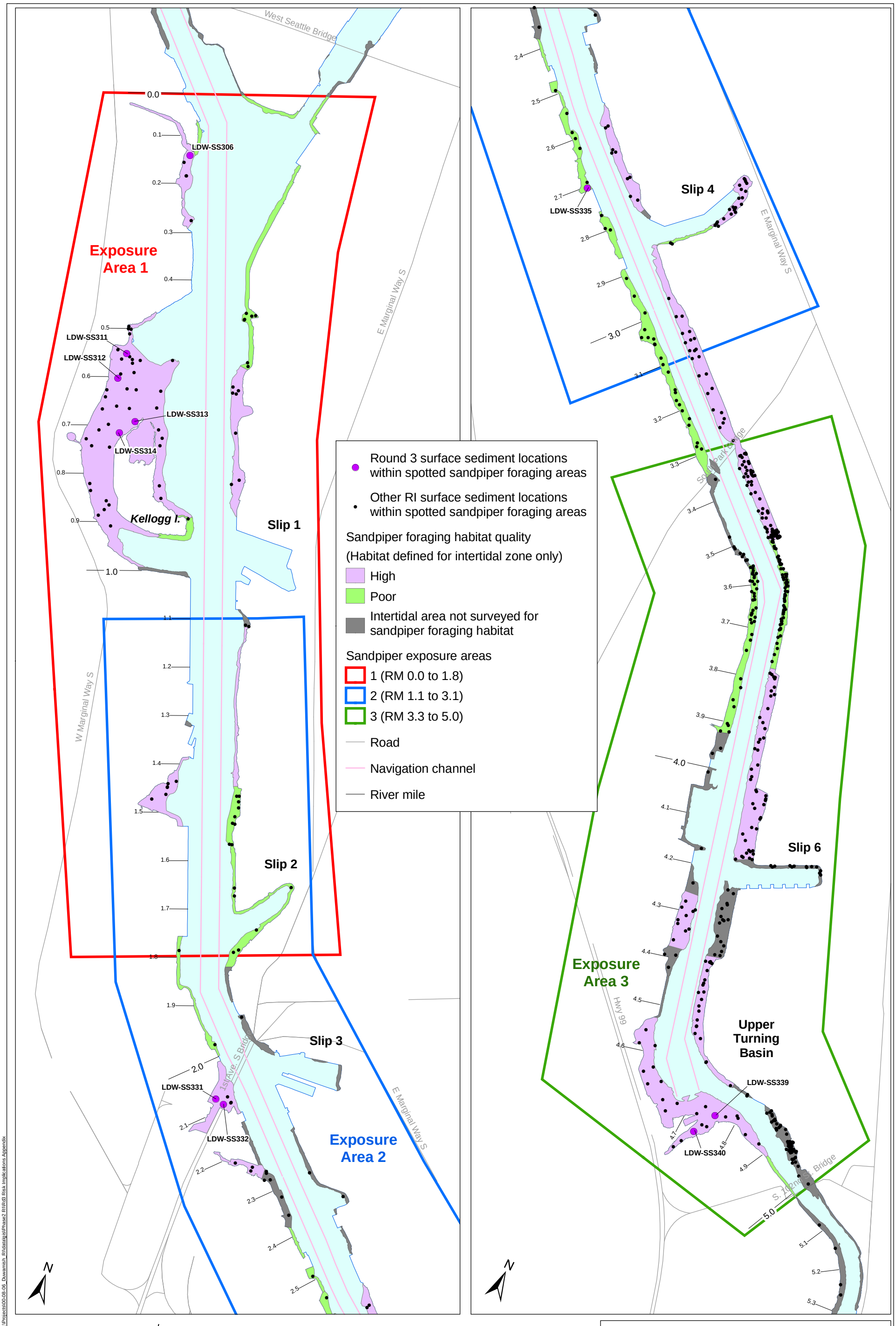

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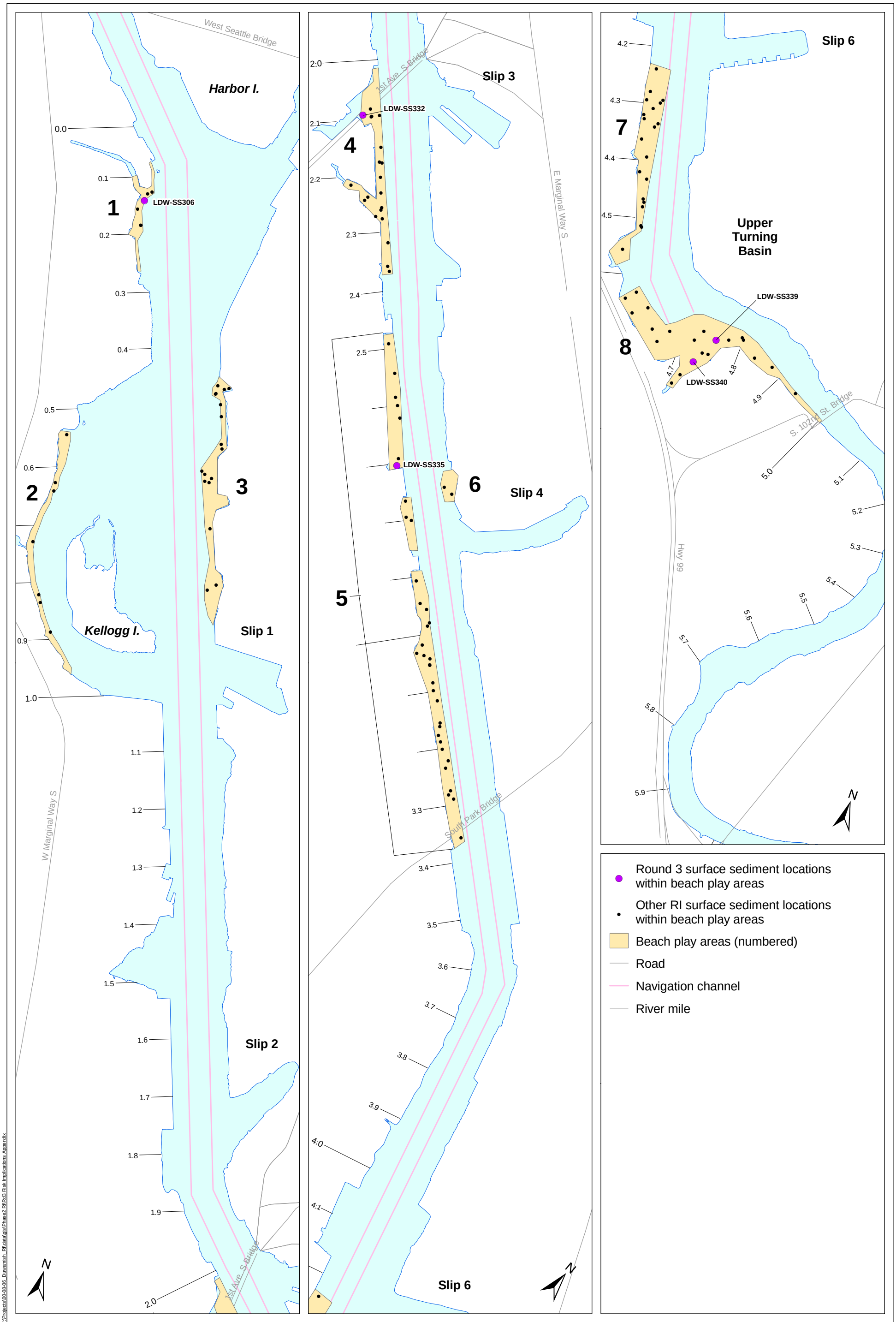
0 0.2 0.4 Miles

0 0.2 0.4 Kilometers

Scale is the same for each inset map

Map C.3-2. Round 3 and other RI surface sediment locations within spotted sandpiper exposure areas



Map C.3-3. Round 3 and other RI surface sediment locations within beach play areas

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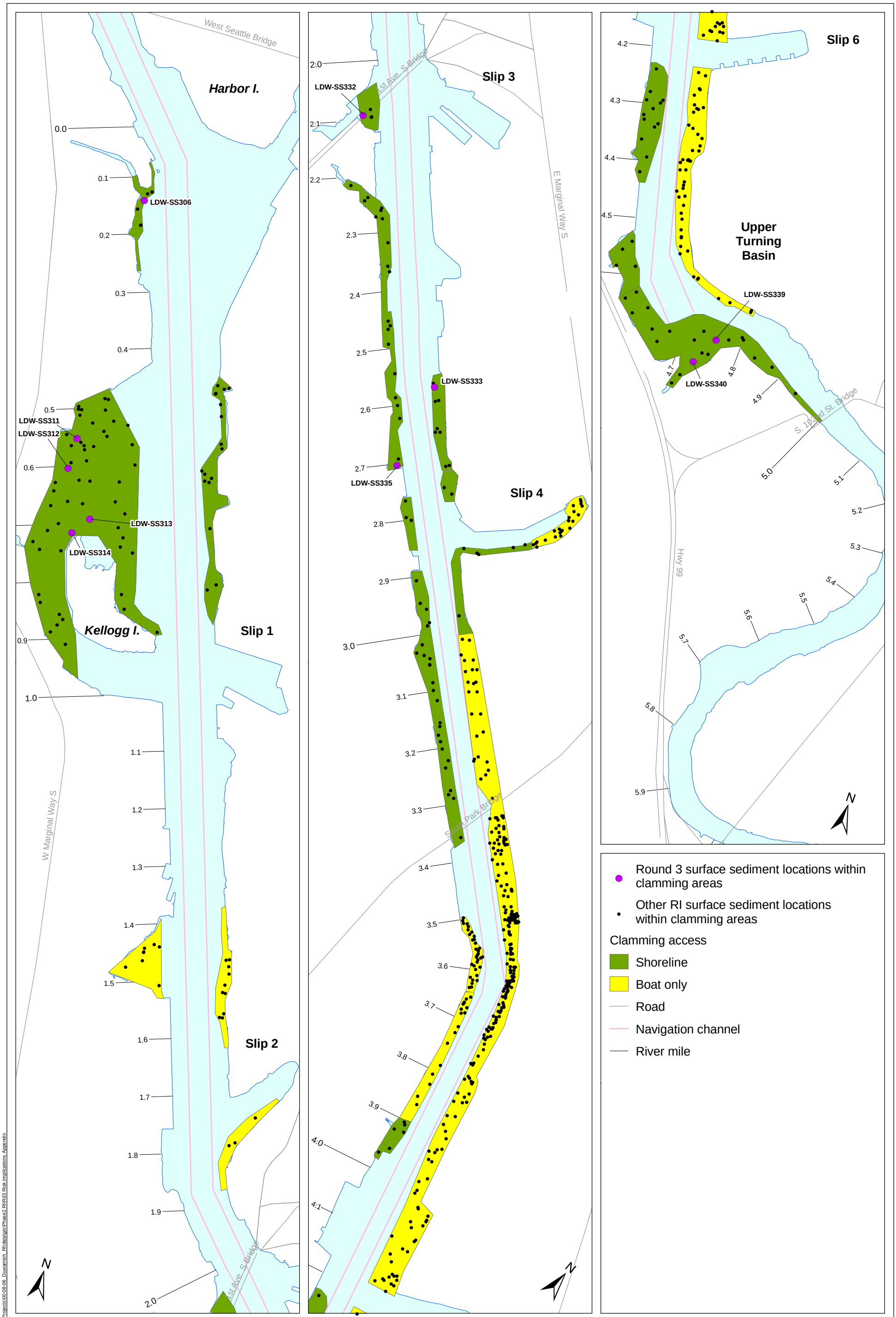

Map C.3-4. Round 3 and other RI surface sediment locations within clamming areas

Prepared by:CEH, 07/07/2010; MAP 2894; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Rd3 Risk Implications Appendix

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List of Maps

This map is included in the Appendix Maps folio.

Map D.3-1. LDW modeling areas and tissue and water sampling locations

Acronyms

Acronym	Definition
CSO	combined sewer overflow
CT	central tendency
DO	dissolved oxygen
DOC	dissolved organic carbon
dw	dry weight
Ecology	Washington State Department of Ecology
EFDC	Environmental Fluid Dynamics [Computer] Code
EPA	US Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
FS	feasibility study
FWM	food web model
GIS	geographic information system
HHRA	human health risk assessment
IDW	inverse distance weighting
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group

Acronym	Definition
NLOC	non-lipid organic carbon
NLOM	non-lipid organic matter
NOAA	National Oceanic and Atmospheric Administration
NRS	nominal range sensitivity
OC	organic carbon
PCB	polychlorinated biphenyl
POC	particulate organic carbon
RBTC	risk-based threshold concentration
RI	remedial investigation
RM	river mile
RME	reasonable maximum exposure
ROC	receptor of concern
SD	standard deviation
SE	standard error
SPAF	species predictive accuracy factor
SWAC	spatially weighted average concentration
TOC	total organic carbon
TSS	total suspended solids
ww	wet weight
Windward	Windward Environmental LLC

D.1 Introduction

This appendix describes the food web model (FWM) developed for the Lower Duwamish Waterway (LDW). A comprehensive dataset of chemical concentrations in sediment and tissue collected in the LDW has been compiled for the remedial investigation (RI) and to support the baseline risk assessments. These data were also used to support a FWM for total polychlorinated biphenyls (PCBs) in the LDW. Three draft memoranda describing the FWM have been submitted to the US Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology); these memoranda present the rationale for the specific model selected (Windward 2005f), describe the modeling approach (Windward 2005g), and present the results of preliminary modeling runs (Windward 2005h). The selection of initial parameter values and optimal methods for applying the FWM in the LDW were discussed in a series of meetings with EPA and the National Oceanic and Atmospheric Administration (NOAA). In addition, Jon Arnot, the co-author of the model (Arnot and Gobas 2004a), was consulted regarding technical details.

The FWM was developed to estimate the relationship between total PCB concentrations in tissue and sediment in order to estimate risk-based threshold concentrations (RBTCs) for total PCBs in sediment for the RI (see Section 8 in the main body of the RI and Section D.9). The FWM may also be used in the feasibility study (FS) to assess residual risks from PCBs that may remain following various sediment cleanup alternatives. Figure D.1-1 illustrates how the FWM will be used in the RI/FS process.

The FWM was calibrated using literature-derived and site-specific environmental data. The purpose of the calibration process was to identify sets of parameter values that best estimated empirical data. The calibration process does not necessarily identify the "true" value for each FWM parameter, because numerous combinations of parameters can produce the same results, or offer mechanistic insights regarding the bioaccumulation of PCBs in the LDW food web. Nonetheless, the results of the calibrated FWM were used in the development of sediment RBTCs for PCBs, and may serve as a tool to support risk management decision making at the site.

The selected FWM and its application to the LDW are discussed in greater detail in the subsections that follow. Section D.2 describes the Arnot and Gobas FWM (Arnot and Gobas 2004a). Section D.3 describes the approach for applying the FWM to the LDW. Section D.4 presents the model input parameters and describes how values were selected. Section D.5 presents methods and results of the calibration process, and Section D.6 presents methods and results of sensitivity and uncertainty analyses. Tests of the model's performance at the modeling area scale and for clams at clam intertidal locations are presented in Section D.7. Comparison of FWM-estimated tissue concentrations to 2007 tissue data is presented in Section D.8. Use of the FWM in the

calculation of sediment RBTCs is discussed in Section D.9. A summary is provided in Section D.10.

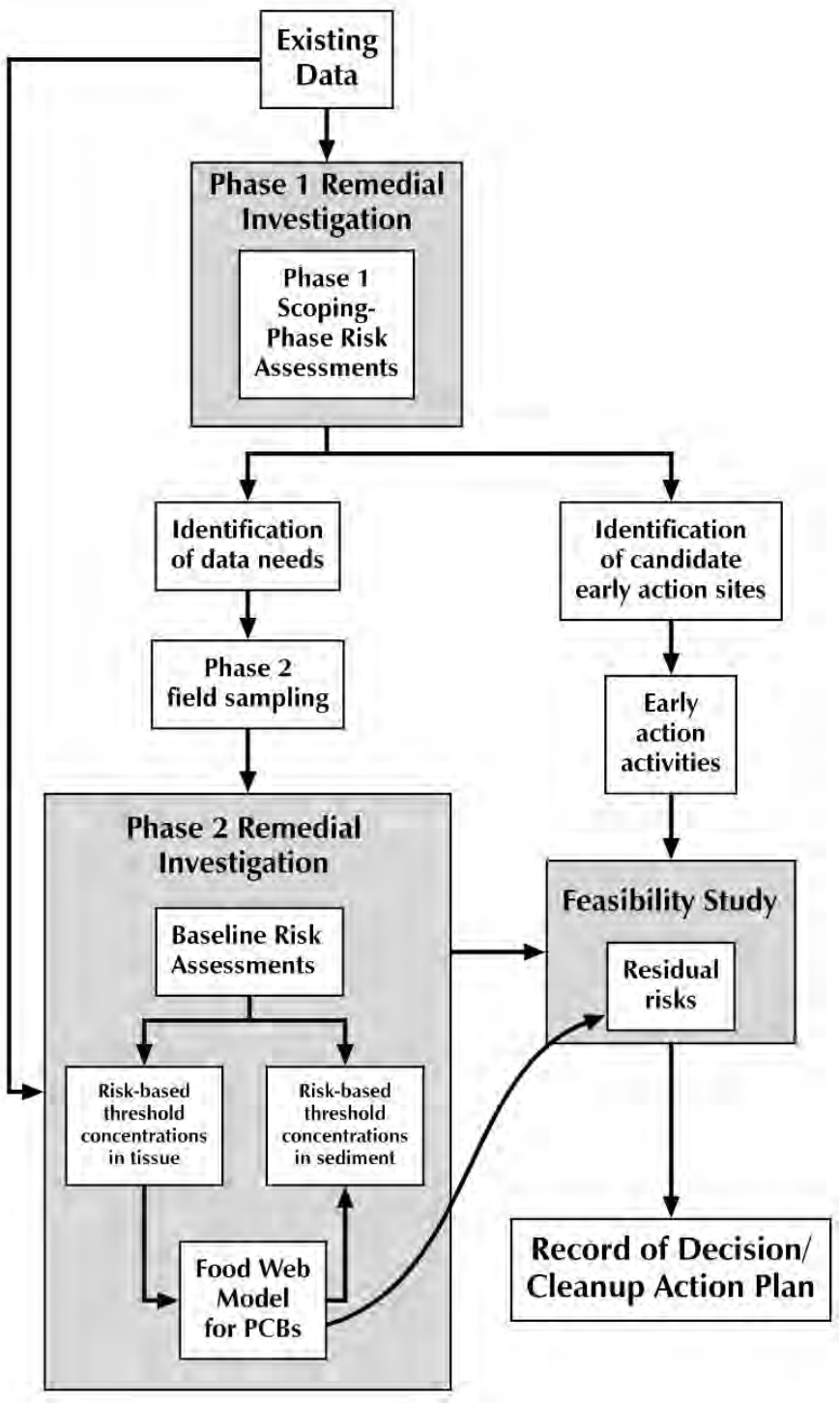

Figure D.1-1. Use of the FWM in the RI/FS process

D.2 Description of the Arnot and Gobas Food Web Model

To estimate the relationship between total PCB concentrations in tissue and sediment in the LDW, an update of the original Gobas model (Arnot and Gobas 2004a) was applied to the LDW. The original Gobas model (Gobas 1993) is a steady-state,[1] mass-balance bioaccumulation model that was originally developed to describe the bioaccumulation of PCBs in the Great Lakes food web. The Gobas model was later refined (Arnot and Gobas 2004a) to reflect a clearer understanding of bioaccumulation processes based on subsequent field and laboratory studies (Arnot and Gobas 2004b; Gobas and MacLean 2003; Gobas et al. 1999; Nichols et al. 2001; Roditi and Fisher 1999). New elements added by Arnot and Gobas (2004a) to refine the model included:

- A new model for partitioning chemicals into organisms that separates the organisms into three components: lipids, non-lipid organic matter (NLOM) or non-lipid organic carbon (NLOC) for phytoplankton and water
- Kinetic models for predicting chemical concentrations in algae, phytoplankton, and zooplankton
- New allometric relationships for predicting gill ventilation rates in a wide range of aquatic species
- A mechanistic model for predicting changes in the concentration of organic chemicals in the gut contents of a range of species as it passes through the gastrointestinal tract

The Arnot and Gobas FWM (Arnot and Gobas 2004a) has five compartments: phytoplankton/algae, zooplankton, filter-feeding benthic invertebrates, scavenger/predator/detritivore benthic invertebrates, and fish. The FWM estimates concentrations of hydrophobic organic chemicals for each compartment using equations that represent the biological processes involved in the uptake and loss of hydrophobic organic chemicals (Figure D.2-1). Thus, each compartment (e.g., fish) has its own unique set of equations. The model has three physical media: sediment, water column water, and porewater.

[1] A steady-state assumption means that concentrations of chemicals in tissues are assumed to not change over time or that concentrations of chemicals in tissues maintain a state of relative equilibrium even after undergoing fluctuations or transformations. The steady-state assumption is reasonable for applications to field situations in which organisms have been exposed to hydrophobic organic chemicals over a long period of time particularly at sites with contaminated sediment. Concentrations in tissues fluctuate slowly compared to exposures, so body burden – especially average body burden in a population of individuals – tends to reflect the average concentration to which the population is exposed over time.

The Arnot and Gobas model is based on several fundamental assumptions, including:

- Primary routes for the uptake of hydrophobic organic chemicals by zooplankton, benthic invertebrates, and fish are ventilation of porewater or water column water and ingestion of sediment or organisms.
- Primary routes for the loss of hydrophobic organic chemicals by zooplankton, benthic invertebrates, and fish are metabolism, growth dilution, ventilation of porewater or water column water, and fecal egestion.
- Chemicals are assumed to be homogeneously distributed within each tissue phase of the organism (i.e., lipids, water, and NLOM [e.g., proteins and carbohydrates] or NLOC[2]).
- Organisms are assumed to be single compartments that exchange chemicals with their surrounding environments.
- Chemical losses via egg deposition or sperm ejection are assumed to be negligible.

Justification is provided for these assumptions in Arnot and Gobas (2004a). Applicability of these assumptions to the LDW is a significant uncertainty that should be considered in interpreting model output. The fact that the Arnot and Gobas model includes species-specific compartments, multiple pathways, and mechanistic equations makes the model more complicated than other available methods, such as the use of a biota-sediment accumulation factors, which represent empirical relationships between few variables. The increased complexity of the Arnot and Gobas model does not necessarily increase the likelihood that the model estimates will be more accurate because the values used for certain parameters are derived from literature (rather than site-specific data). However, the model can be used as a tool to assess the relative importance of various pathways and mechanisms and can potentially be used to enable better estimates under varying conditions. It should also be noted that several different parameter sets can result in the same tissue estimates.

[2] NLOC was used as the third phase for chemical partitioning in phytoplankton instead of NLOM, as discussed in Section D.4.2.1. For sediment, PCBs were assumed to partition into organic carbon.

$$C_{WD} = \frac{C_{WT}}{[1+(\chi_{POC}\times D_{POC}\times \alpha_{POC}\times K_{OW} + \chi_{DOC}\times D_{DOC}\times \alpha_{DOC}\times K_{OW})] \times 1{,}000}$$

$$G_D = 0.022 \times W_B^{0.85} \times e^{(0.06\times T)}$$

$$v_{WD} = \sum P_i \times v_{WB,i}$$

$$v_{OCD} = P_P \times v_{OCP} + P_{SED} \times OC_{SED}$$

$$v_{LD} = \sum P_i \times v_{LB,i}$$

$$v_{ND} = \sum P_i \times v_{NB,i}$$

$$G_F = [(1-\varepsilon_L)\times v_{LD} + (1-\varepsilon_N) \times v_{OCD} + (1-\varepsilon_N) \times v_{ND} + (1-\varepsilon_W)\times v_{WD}]\times G_D$$

$$k_1 = E_W \times G_V / W_B$$

Surface Water

$k_1 \times m_O \times C_{WD}$

Metabolism

$k_{M=0}$

$$E_D = (3.0\times 10^{-7}\times K_{OW} + 2.0)^{-1}$$

$$k_D = E_D \times G_D / W_B$$

Diet

$k_D \times \sum P_i \times C_{D,i}$

$$G_D = 0.022 \times W_B^{0.85} \times e^{(0.06\times T)}$$

Water

$$k_2 = \frac{k_1}{K_{BW}}$$

Fish

$$C_B = \frac{[(k_1\times m_O\times C_{WD}) + (k_1\times m_P\times C_{WD,P}) + (k_D\times \sum P_i\times C_{D,i})]}{(k_2 + k_E + k_G + k_M)}$$

Egestion

$$k_E = \frac{G_F \times E_D \times K_{GB}}{W_B}$$

$$E_D = (3.0\times 10^{-7}\times K_{OW} + 2.0)^{-1}$$

$$K_{BW} = \frac{v_{LB}\times K_{OW}}{\delta_L} + v_{NB} \times \beta \times K_{OW} + \frac{v_{WB}}{\delta_W}$$

Growth

$k_G = 0.0005 \times W_B^{-0.2}$

Porewater

$k_1 \times m_P \times C_{WD,P}$

$$K_{GB} = \frac{\frac{v_{LG}\times K_{ow}}{\delta_L} + v_{OCG} \times \beta_{OC} \times K_{OW} + v_{NG} \times \beta \times K_{OW} + \frac{v_{WG}}{\delta_W}}{\frac{v_{LB}\times K_{ow}}{\delta_L} + v_{NB} \times \beta \times K_{OW} + \frac{v_{WB}}{\delta_W}}$$

$$E_W = \frac{1}{1.85+\left(\frac{155}{K_{OW}}\right)}$$

$$k_1 = E_W \times G_V / W_B$$

$$C_{WD,P} = C_{S,OC} / K_{OC}$$

$$G_V = \frac{1400\times W_B^{0.65}}{C_{OX}}$$

$$C_{S,OC} = C_S / OC_{SED}$$

$$v_{LG} = \frac{(1-\varepsilon_L) \times v_{LD}}{[(1-\varepsilon_L) \times v_{LD} + (1-\varepsilon_N) \times v_{OCD} + (1-\varepsilon_N) \times v_{ND} + (1-\varepsilon_W) \times v_{WD}]}$$

$$v_{OCG} = \frac{(1-\varepsilon_N) \times v_{OCD}}{[(1-\varepsilon_L) \times v_{LD} + (1-\varepsilon_N) \times v_{OCD} + (1-\varepsilon_N) \times v_{ND} + (1-\varepsilon_W) \times v_{WD}]}$$

$$v_{WG} = \frac{(1-\varepsilon_W) \times v_{WD}}{[(1-\varepsilon_L) \times v_{LD} + (1-\varepsilon_N) \times v_{OCD} + (1-\varepsilon_N) \times v_{ND} + (1-\varepsilon_W) \times v_{WD}]}$$

$$v_{NG} = \frac{(1-\varepsilon_N) \times v_{ND}}{[(1-\varepsilon_L) \times v_{LD} + (1-\varepsilon_N) \times v_{OCD} + (1-\varepsilon_N) \times v_{ND} + (1-\varepsilon_W) \times v_{WD}]}$$

Legend

- Uptake/loss from water
- Uptake/loss from diet
- Loss from growth
- Loss from metabolism

Note: Parameters defined by equations and parameters with defined values are presented in Tables D.2-1 and D.4-1 respectively.

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Figure D.2-1. Equations and parameters used to estimate total PCB concentrations for fish in the Arnot and Gobas model

Model equations are separated into biological equations that simulate the biological processes leading to uptake and loss of chemicals by organisms (Figure D.2-1), environmental equations that simulate the partitioning of the chemical in the environment, and a single chemical equation that derives a log K_{OC} value from log K_{OW} (Table D.2-1). Details on the model equations, including definitions for all model parameters, may be found in Arnot and Gobas (2004a). Each species in the model has a master equation that combines chemical uptake and loss for that species (C_B). The master equation has two potential chemical uptake mechanisms and four potential chemical loss mechanisms. Chemical concentrations in phytoplankton are calculated assuming aqueous uptake across the cell wall ($k_1 \times m_O \times C_{WD}$), loss across the cell wall (k_2), and loss via growth dilution (k_G). Chemical concentrations in zooplankton, invertebrates, and fish are calculated assuming uptake from water (i.e., water column water and porewater) via the respiratory surface ($k_1 \times (m_O \times C_{WD} + m_P \times C_{WD,P})$) and uptake from the diet ($k_D \times \sum P_i \times C_{D,i}$). Chemical loss mechanisms for zooplankton, invertebrates, and fish include metabolism (k_M), growth dilution (k_G), loss to water via the respiratory surface (k_2), and fecal egestion (k_E). Because the Arnot and Gobas model assumes steady state conditions, it does not recognize short-term changes in rates of uptake or loss from short-term changes in biological or environmental conditions. For each model run, one value was calculated for each uptake or loss mechanism.

Water column water, porewater, and sediment are the three environmental media included in the FWM. Total PCB concentrations in the water column (C_{WT}) are entered as whole water total PCB concentrations. The dissolved fraction (C_{WD}) is calculated in the model by estimating the relative partitioning of PCBs to particulate organic carbon (POC), dissolved organic carbon (DOC), and the freely dissolved phase (Table D.2-1). Total PCB concentrations in porewater are estimated assuming equilibrium partitioning with the sediment (Table D.2-1). The equilibrium partitioning equation does not account for partitioning to colloidal carbon within the sediment matrix. Total PCB concentrations in sediment are entered as total dry weight concentrations and converted to organic carbon (OC)-normalized concentrations for uptake and loss calculations. One sediment compartment represents both bottom sediments and suspended sediments; thus, sediment exposure is the same regardless of whether exposure occurs while sediments are settled at the bottom of the water column or are suspended in the water column as particulates. Exposure through direct sediment contact via the dermis or integument is not explicitly modeled in the FWM.

Exposure routes for chemicals in sediment include diffusion to porewater and the ingestion of sediment. The exposure route for chemicals in water column water and porewater is ventilation across the respiratory surface (e.g., gills) or cell wall.

Table D.2-1. Equations for the Arnot and Gobas Model

PARAMETER	SYMBOL	UNIT	EQUATION	NOTES	SOURCE
Biological					
Chemical concentration in the modeled species	C_B	µg/kg ww	$C_B = [k_1 \times (m_O \times C_{WD} + m_P \times C_{WD,P}) + k_D \times \sum P_i \times C_{D,i}]/(k_2 + k_E + k_G + k_M)$		Arnot and Gobas (2004a)
Chemical concentration in prey item i	$C_{D,i}$	µg/kg ww	$C_{D,I} = C_B$ or $C_{D,I} = C_S$ (depending on diet)	Concentration of prey items are represented by the equation for chemical concentration in the modeled species (C_B) for any organisms consumed or by the input value for concentration of total PCBs in sediment C_S for sediment consumed	Arnot and Gobas (2004a)
Fraction of water column water ventilated	m_O	fraction	$m_O = 1 - m_p$	fraction of total water ventilated from water column water (water not directly in association with the sediment)	Arnot and Gobas (2004a)
Rate constant for aqueous uptake by fish, invertebrates, and zooplankton	k_1	L/kg·day	$k_1 = E_W \times G_V/W_B$	chemical uptake via the respiratory area (e.g., gills or other respiratory surface)	Gobas (1993); Gobas and MacKay (1987), as cited in Arnot and Gobas (2004a)
Rate constant for aqueous uptake by phytoplankton /algae	k_1	L/kg·day	$k_1 = (A + (B/K_{OW}))^{-1}$	chemical uptake across the cell wall	Arnot and Gobas (2004a)
Rate constant for chemical elimination via the respiratory area	k_2	day^{-1}	$k_2 = k_1/K_{BW}$	chemical loss via the respiratory surface (e.g., gills or cell wall)	Gobas (1993), as cited in Arnot and Gobas (2004a)
Rate constant for chemical uptake via the diet	k_D	kg food/kg organism·day	$k_D = E_D \times G_D/W_B$	For phytoplankton/algae, k_D is zero.	Gobas (1993), as cited in Arnot and Gobas (2004a)
Rate constant for chemical elimination via excretion into egested feces	k_E	day^{-1}	$k_E = G_F \times E_D \times K_{GB}/W_B$	For phytoplankton/algae, k_E is zero.	Gobas et al. (1993), as cited in Arnot and Gobas (2004a)
Rate constant for growth of aquatic organisms	k_G	day^{-1}	$k_G = 0.000502 \times W_B^{-0.2}$	This regression relationship was established at temperatures around 10°C. (Mean water column temperatures in the LDW were 11°C.)	Thomann et al. (1992) as cited in Arnot and Gobas (2004a)
Dietary chemical transfer efficiency	E_D	%	$E_D = (3.0 \times 10^{-7} \times K_{OW} + 2.0)^{-1}$		Arnot and Gobas (2004a)
Respiratory surface chemical uptake efficiency	E_W	%	$E_W = (1.85 + (155/K_{OW}))^{-1}$		Gobas (1988), as cited in Arnot and Gobas (2004a)
Feeding rate – filter feeders	G_D	kg/d	$G_D = G_V \times Css \times \sigma$		Morrison et al. (1996), as cited in Arnot and Gobas (2004a)
Feeding rate – other species	G_D	kg/d	$G_D = 0.022 \times W_B^{0.85} \times e^{(0.06 \times T)}$	based on studies of feeding rates in cold-water fish (being used for zooplankton and aquatic invertebrate species as well).	Weiniger (1978), as cited in Arnot and Gobas (2004a)

Table D.2-1, cont. Equations for the Arnot and Gobas Model

PARAMETER	SYMBOL	UNIT	EQUATION	NOTES	SOURCE
Fecal egestion rate	G_F	kg/d	$G_F = [(1 - \varepsilon_L) \times v_{LD}) + (1 - \varepsilon_N) \times v_{OCD} + (1 - \varepsilon_N) \times v_{ND} + (1 - \varepsilon_W) \times v_{WD}] \times G_D$		Arnot and Gobas (2004a)
Gill ventilation rate	G_V	L/d	$G_V = 1{,}400 \times W_B^{0.65}/C_{OX}$		Arnot and Gobas (2004a)
Organism-water partition coefficient on a wet weight basis	K_{BW}	L water/kg biota	$K_{BW} = k_1/k_2 = v_{LB} \times K_{OW}/\delta_L + v_{NB} \times \beta \times K_{OW} + v_{WB}/\delta_W$		Arnot and Gobas (2004a)
NLOM content of organism	v_{NB}	%	$v_{NB} = 1 - (v_{LB} + v_{WB})$		Arnot and Gobas (2004a)
NLOC content of phytoplankton	v_{NP}	%	$v_{NP} = 1 - (v_{LP} + v_{WP})$		Arnot and Gobas (2004a)
Phytoplankton/algae-water partition coefficient on a wet weight basis	K_{PW}	L water/kg phytoplankton/ algae	$K_{PW} = v_{LP} \times K_{OW}/\delta_L + \beta_{OC} \times v_{NP} \times K_{OW} + v_{WP}/\delta_W$		Arnot and Gobas (2004a)
Chemical partition coefficient between the contents of the gastrointestinal tract and the organism	K_{GB}	kg biota/kg digesta	$K_{GB} = (v_{LG} \times K_{OW}/\delta_L + v_{OCG} \times \beta_{OC} \times K_{OW} + v_{NG} \times \beta \times K_{OW} + v_{WG}/\delta_W)/ (v_{LB} \times K_{OW}/\delta_L + v_{NB} \times \beta \times K_{OW} + v_{WB}/\delta_W)$		Arnot and Gobas (2004a)
Lipid fraction of gut contents	v_{LG}	kg lipid/kg digesta ww	$v_{LG} = (1 - \varepsilon_L) \times v_{LD}/ [(1 - \varepsilon_L) \times v_{LD} + (1 - \varepsilon_N) \times v_{OCD} + (1 - \varepsilon_N) \times v_{ND} + (1 - \varepsilon_W) \times v_{WD}]$		Arnot and Gobas (2004a)
NLOC fraction of gut contents	v_{OCG}	kg lipid/kg digesta ww	$v_{OCG} = [(1 - \varepsilon_N) \times v_{OCD}]/ [(1 - \varepsilon_L) \times v_{LD} + (1 - \varepsilon_N) \times v_{OCD} + (1 - \varepsilon_N) \times v_{ND} + (1 - \varepsilon_W) \times v_{WD}]$	NLOC was added to the model to account for higher affinity of PCBs for NLOC compared to NLOM	January 2006 update to Arnot and Gobas model (Arnot and Gobas 2004a). Updated model, AQUAWEB, can be found on Environmental Toxicology Research Group website (Gobas 2006)
NLOM fraction of gut contents	v_{NG}	kg NLOM/kg digesta ww	$v_{NG} = (1 - \varepsilon_N) \times v_{ND}/ [(1 - \varepsilon_L) \times v_{LD} + (1 - \varepsilon_N) \times v_{OCD} + (1 - \varepsilon_N) \times v_{ND} + (1 - \varepsilon_W) \times v_{WD}]$		Arnot and Gobas (2004a)
Water fraction of gut contents	v_{WG}	kg water/kg digesta ww	$v_{WG} = (1 - \varepsilon_W) \times v_{WD}/ [(1 - \varepsilon_L) \times v_{LD} + (1 - \varepsilon_N) \times v_{OCD} + (1 - \varepsilon_N) \times v_{ND} + (1 - \varepsilon_W) \times v_{WD}]$		Arnot and Gobas (2004a)
Overall lipid content of the diet	v_{LD}	kg lipid/kg food ww	$v_{LD} = \Sigma P_i \times v_{LB,i}$		Arnot and Gobas model spreadsheet (Gobas 2006)
Overall NLOC content of the diet	v_{OCD}	kg NLOC/kg food ww	$v_{OCD} = P_P \times v_{OCP} + P_{sed} \times OC_{sed}$	Phytoplankton/algae and sediment are the only dietary items with NLOC content.	January 2006 (Gobas 2006) update to Arnot and Gobas model (Arnot and Gobas 2004a)

Table D.2-1, cont. Equations for the Arnot and Gobas Model

PARAMETER	SYMBOL	UNIT	EQUATION	NOTES	SOURCE
Overall NLOM content of the diet	v_{ND}	kg NLOM/kg food ww	$v_{ND} = \Sigma P_i \times v_{NB,i}$		Arnot and Gobas model spreadsheet (Gobas 2006)
Overall water content of the diet	v_{WD}	kg water/kg food ww	$v_{WD} = \Sigma P_i \times v_{WB,i}$		Arnot and Gobas model spreadsheet (Gobas 2006)
Non-lipid organic carbon content of phytoplankton	v_{OCP}	kg NLOC/kg phytoplankton	$v_{OCP} = 1 - (v_{LP} + v_{WP})$		Arnot and Gobas (2004a)
Fraction of non-lipid organic matter in organism *i*	$v_{NB,i}$	kg NLOM/kg organism	$v_{NB,i} = 1 - (v_{LB,i} + v_{WB,i})$	B = biota	Arnot and Gobas (2004a)
Environmental					
Freely dissolved chemical concentration in the porewater	$C_{WD,P}$	µg/L	$C_{WD,P} = C_{S,OC}/K_{OC}$		Kraaij et al. (2002), as cited in Arnot and Gobas (2004a)
Chemical concentration in the sediment, organic carbon normalized	$C_{S,OC}$	µg/kg	$C_{S,OC} = C_S/OC_{sed}$		Calculated using Phase 1 and Phase 2 sediment data
Freely dissolved chemical concentration in the water	C_{WD}	µg/L	$C_{WD} = (C_{WT} \times \phi)/1{,}000$	Simulates sequestering of chemical by DOC and POC in the water.	Arnot and Gobas (2004a)
Bioavailable solute fraction	ϕ	unitless	$\phi = 1/(1 + \chi_{POC} \times D_{POC} \times \alpha_{POC} \times K_{OW} + \chi_{DOC} \times D_{DOC} \times \alpha_{DOC} \times K_{OW})$	Simulates sequestering of chemical by DOC and POC in the water.	Arnot and Gobas (2004a)
Chemical					
Organic carbon-water partition coefficient	K_{OC}	L/kg	$K_{OC} = 0.35 \times K_{OW}$	There are many different relationships established between K_{OW} and K_{OC}. This relationship was based on the analysis of a wide range of analytes (including PCB congeners) and soil/sediment matrices. The authors excluded data that may not have represented equilibrium conditions that can be very influential for high-molecular-weight PCBs. It is consistent with the commonly used approximation of $K_{OC} = 0.4\ K_{OW}$.	Seth et al. (1999)

C – centigrade
DOC – dissolved organic carbon
LDW – Lower Duwamish Waterway
NLOC – non-lipid organic carbon
NLOM – non-lipid organic matter
PCB – polychlorinated biphenyl
POC – particulate organic carbon
ww – wet weight

D.3 Approach for Applying the Food Web Model in the Lower Duwamish Waterway

Numerous simplifications and assumptions are required to apply a steady-state bioaccumulation model to the dynamic estuarine environment in the LDW. This section presents the species that were modeled and spatial aspects of applying the FWM in the LDW. Parameter-specific assumptions are discussed in Section D.4 and general model uncertainties are discussed in Section D.6.

D.3.1 SPECIES MODELED

In order to apply the Arnot and Gobas model to the LDW, each species or species assemblage to be modeled was assigned to a compartment (i.e., phytoplankton/algae, zooplankton, filter-feeding benthic invertebrates, scavenger/predator/detritivore benthic invertebrates, and fish). Even though all compartments share a master equation (see equation for C_B in Table D.2-1), they have different sub-models (e.g., equations for rate constants) and different parameters defining those sub-models. Thus, selection of a compartment determines the parameters that need to be defined for each species or species assemblage.

Three species of adult fish, two species of adult crabs, and soft-shell clam species were modeled in the LDW. These species are referred to as target species because they were either receptors of concern (ROCs) in the ecological risk assessment (ERA) or served as key prey species for other receptors in the ERA or in the human health risk assessment (HHRA). Target species modeled included:

- English sole as: 1) an ROC in the ERA representing benthic fish that primarily consume invertebrates, 2) prey for wildlife ROCs, and 3) seafood consumed by people
- Pacific staghorn sculpin as: 1) an ROC in the ERA representing fish that consume both invertebrates and small fish, and 2) prey for wildlife ROCs
- Shiner surfperch as: 1) prey for wildlife ROCs, and 2) seafood consumed by people
- Dungeness crabs as: 1) an ROC in the ERA representing larger and more mobile invertebrates, 2) prey for wildlife ROCs, and 3) seafood consumed by people
- Slender crabs as: 1) prey for wildlife ROCs, and 2) seafood consumed by people
- Clams as: 1) prey for wildlife ROCs, and 2) seafood consumed by people

Fish and crabs were each modeled using a fish compartment.[3] Large clams[4] (*Mya arenaria*) were modeled using for a filter-feeding benthic invertebrate compartment.

Other prey species modeled included phytoplankton, zooplankton, benthic invertebrates, and juvenile fish. Phytoplankton, zooplankton, and juvenile fish were modeled using phytoplankton/algae, zooplankton, and fish compartments respectively. Benthic invertebrates, which make up a large portion of fish diets (see Section D.4.2.2), were modeled as a single assemblage using a scavenger/predator/ detritivore benthic invertebrate compartment. These species were modeled to serve as prey, approximating the transfer of chemicals from environmental media through the food web.

D.3.2 SPATIAL CONSIDERATIONS

The FWM was calibrated at the LDW-wide spatial scale (River Mile [RM] 0.0 to RM 5.25) (Map D.3-1). This assumes that the factors affecting a species' average bioaccumulation LDW-wide, and the factors affecting that species' average bioaccumulation at other spatial scales where the model is to be used, are similar. EPA/Ecology expressed an interest in applying the FWM at both the LDW-wide scale and smaller scales. Four subsections of the LDW (modeling areas M1, M2, M3, and M4) were defined, based on the four fish and crab tissue sampling areas (Map D.3-1). The performance of the FWM was tested for each modeling area (Section D.7.1).

Statistical analyses were conducted at the tissue sampling areas scale (ANOVAs) to explore absolute differences in total PCB concentrations in tissue among areas and at the tissue sampling subareas scale (regressions) in order to explore relationships between total PCB concentrations in tissue vs. sediment. This information was used to draw conclusions about how well the FWM is expected to perform at the scale of the modeling areas.

D.3.2.1 Summary of the literature on spatial scale of exposure

Information on the foraging ranges, specific habitat utilization, and migratory patterns of the modeled species within the LDW is for the most part unavailable; therefore, the spatial extent of their PCB exposure is uncertain. This section provides an overview of available literature and local expert opinion regarding exposure information for each

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[3] Crabs are large mobile invertebrates that eat shrimp, juvenile crabs, and fish. Crabs were modeled using fish equations instead of scavenger/predator/ detritivore benthic invertebrate equations because the majority of the species used to develop the scavenger/predator/ detritivore benthic invertebrate equations and constants were filter feeders or detritivores. In addition, it was determined early in the modeling process that using fish equations resulted in estimates that were more similar to empirical data for crabs.

[4] The average length of *Mya arenaria* collected in the LDW for the 14 composite clam samples was 7.0 cm. *Macoma nasuta*, a smaller species, was collected at three locations in the LDW and included with *Mya arenaria* in three composite samples. Average length of the *Macoma nasuta* collected was 2.2 cm.

of the target species based on inferences from studies conducted in areas outside the LDW. Dietary preferences for each of the target species are discussed in Section D.4.2.2.

According to local fish experts, the FWM target species are likely to have foraging areas that are smaller than the entire LDW, with the possible exception of English sole and Dungeness crabs. However, uncertainty exists regarding the sizes of these areas. Thus, two different spatial scales were modeled (i.e., LDW-wide and modeling area scales). The information available regarding the seasonal movements and home ranges of the target species in the LDW is summarized below.

Adult English sole migrate seasonally out of the LDW system in order to spawn over the course of the winter, with spawning generally occurring in February and March. In Puget Sound, adult populations of English sole congregate in Elliott Bay and Port Gardner for winter spawning and then disperse. Angell et al. (1975) reported the off-season migration of central Puget Sound fish in winter and spring, from Meadow Point to Carkeek Park (northwest of downtown Seattle), at depths of 3 to 30 m. English sole are believed to maintain migration patterns throughout their lives (Day 1976). Home range estimates of approximately 3 km^2 (1.2 square miles) have been developed for English sole using acoustic tracking (O'Neill et al. 2005) and an empirical relationship between sediment PAH concentrations and lesion prevalence (Stern et al. 2003). Estimates of approximately 9 km^2 (3.5 square miles) were reported in the Puget Sound Dredged Disposal Analysis (PSDDA) report based on best professional judgment (PSDDA 1988). During September 2004, 2005, and 2007 trawl sampling throughout the LDW, the abundance of adult English sole (> 200 mm) in the lower waterway (i.e., from RM 0.0 to RM 2.5) was greater than in the upper waterway (RM 2.5 to RM 4.8) (Windward 2005c, 2006a, 2009).

Information available on shiner surfperch suggests that the LDW likely supports resident juveniles and first-year adults in addition to second- and third-year adults that migrate from Puget Sound during summer mating and parturition. February to October monthly beach seine sampling data from locations throughout the LDW and into Elliott Bay indicate that shiner surfperch are rare in the LDW from February through April and abundant from May through October (Shannon 2006). Shiner surfperch abundance in the LDW peaks in the summer, when they bear their young (Miller et al. 1975; Shannon 2006). September 2004, 2005, and 2007 trawl data indicated an increasing abundance of adult shiner surfperch (> 80 mm) from downstream to upstream in the LDW (Windward 2005c, 2006a). In San Francisco Bay, females migrate from nearshore coastal waters in the summer prior to giving birth in the bay. During their first year after birth, most females remain in San Francisco Bay and give birth before migrating to the ocean; males, on the other hand, migrate to the ocean soon after birth. Morrow (1980) also describes the inshore-offshore migration of shiner surfperch in Alaska. No data on shiner surfperch foraging ranges are available for the LDW.

Pacific staghorn sculpin were present in LDW beach seine samples in all months sampled (February through October) (Shannon 2006), although it is not known if they are year-round residents. During September 2004, 2005, and 2007 trawl sampling throughout the LDW, adult Pacific staghorn sculpin (> 150 mm) were collected in all areas sampled with similar abundance throughout. In San Francisco Bay, adult Pacific staghorn sculpin are reported to be present throughout the year in marine areas but seasonally absent from freshwater and slightly saline areas (Jones 1962). Adults are reported to be intolerant of brackish water (Jones 1962). In San Francisco Bay, young-of-the-year move into freshwater areas for rearing and move to more saline waters as they grow (Jones 1962). Tagged subyearlings (< 150 mm) in Tomales Bay, California, were reported to have home ranges less than 800 m (Tasto 1975). No studies reporting the migration of adults were identified; however, PSAMP reports that Pacific staghorn sculpin have restricted home ranges (WDFW 2002b).

Results from a quarterly survey of the LDW indicate that the abundance of Dungeness crabs may not vary substantially throughout the year (Windward 2004a), although it is not known if Dungeness crabs are year-round residents. In California, female Dungeness crabs are reported to have annual home ranges less than 2 km (1.25 miles) (Diamond and Hankin 1985, as cited in Pauley et al. 1986). A separate report states that most migrations in California waters were less than 10 miles, but some individuals moved up to 100 miles, with males moving farther than females (CDFG 2002). PSAMP reports that Dungeness crabs seasonally move between estuaries and offshore waters (WDFW 2002a). Samples collected during late August or early September of 2004, 2005, and 2007 suggest that abundance throughout the LDW is not highly variable, with the exception of RM 1.6 to RM 2.4, where Dungeness crabs were rare during sampling events (Windward 2005c, 2006a, 2009).

Results from a quarterly survey of the LDW suggest that the abundance of slender crabs does not vary greatly throughout the year (Windward 2004a). Slender crabs are able to withstand periods of low salinity but do not actively forage in brackish water areas (Curtis et al. 2007). Trawls conducted at the end of August or early September in 2004, 2005, and 2007 collected higher numbers of slender crab in the lower sections of the LDW (i.e., RM 0.0 to RM 2.5) relative to the upper section of the LDW (i.e., RM 2.5 to RM 6.0) (Windward 2005c, 2006a, 2009). Slender crab movements and home range in the LDW are unknown, and no information was identified on their migrations in other areas.

D.3.2.2 Summary of statistical findings on spatial scale of exposure in the LDW

Data from 190 composite tissue samples collected between 1997 and 2005 for seven species (English sole, shiner surfperch, Pacific staghorn sculpin, Dungeness crab, slender crab, clams, and benthic invertebrates) were used to develop FWM input parameter values (e.g., lipid content and water content) and to test model performance

(e.g., total PCB concentrations in tissue). Data from 1,264 surface sediment samples (baseline sediment database) collected since 1990 were used to calculate total PCB concentrations in sediment and percent sediment organic carbon. Statistical analyses were conducted on the co-located sediment and tissue data for PCBs. These analyses were helpful in assessing whether average total PCB concentrations in tissues varied by tissue sampling area, and if tissue concentrations in samples collected from specific subareas were correlated with subarea spatially weighted average concentrations (SWACs).

Statistical analyses were conducted to investigate the relationship between the concentrations of chemicals in tissue from fish and crabs caught in the LDW and concentrations in sediment samples collected in the LDW. These analyses provided modest support for the assumption that during the time that English sole and crab species reside in the LDW, they integrate exposure over areas larger than the modeling areas and that Pacific staghorn sculpin, and to a lesser extent shiner surfperch, may integrate exposures over areas smaller than the modeling areas. A summary of the analyses is provided below. ANOVAs were conducted to evaluate whether there were differences among the four sampling areas in either 2004 or in 2005. Crabs were not evaluated because of insufficient sample sizes in some tissue sampling areas. The highest average sediment total PCB concentrations were in Area T3 (880 µg/kg dw); whereas those in Areas T1 (300 µg/kg dw), T2 (270 µg/kg dw), and T4 (190 µg/kg dw) were below the SWAC for the LDW from RM 0.0 to RM 5.25 (380 µg/kg dw) (Figure D.3-1).

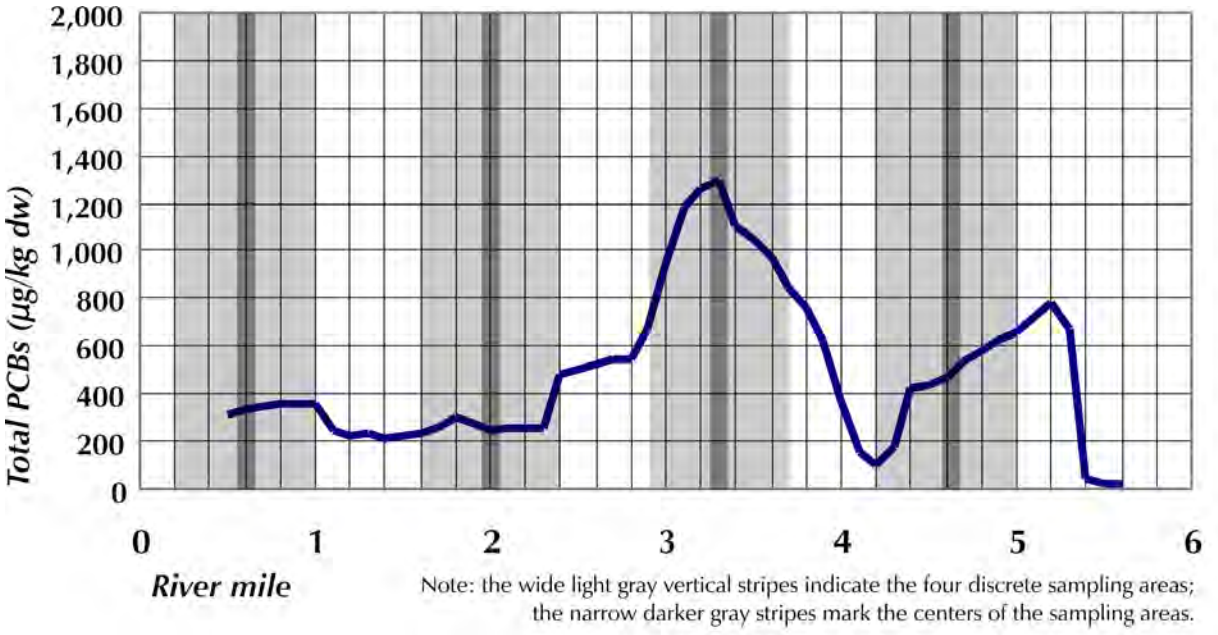

Figure D.3-1. One-mile rolling average total PCB concentration in LDW surface sediment

For both English sole and shiner surfperch, the relative magnitudes (rank ordering) of mean log_{10}-transformed total PCB concentrations in all four sampling areas were consistent in 2005 and 2004[5] (Figure D.3-2). Both species had their lowest mean tissue concentrations in Area T4 in both years. In 2004, the mean of log_{10}-transformed concentrations in Area T4 was significantly lower than mean of log_{10}-transformed concentrations from the two areas with the highest mean concentrations (Areas T1 and T2 for English sole; Areas T2 and T3 for shiner surfperch).[6] Also in that year, the mean of log_{10}-transformed concentrations in tissues from the two areas with the highest mean concentrations did not differ significantly[7] and the mean of log_{10}-transformed concentrations in tissue samples from the two areas with the lowest concentrations did not differ significantly[8] (Areas T3 and T4 for English sole; Areas T1 and T4 for shiner surfperch). Statistical differences between concentrations in areas with intermediate concentrations were marginally significant.[9]

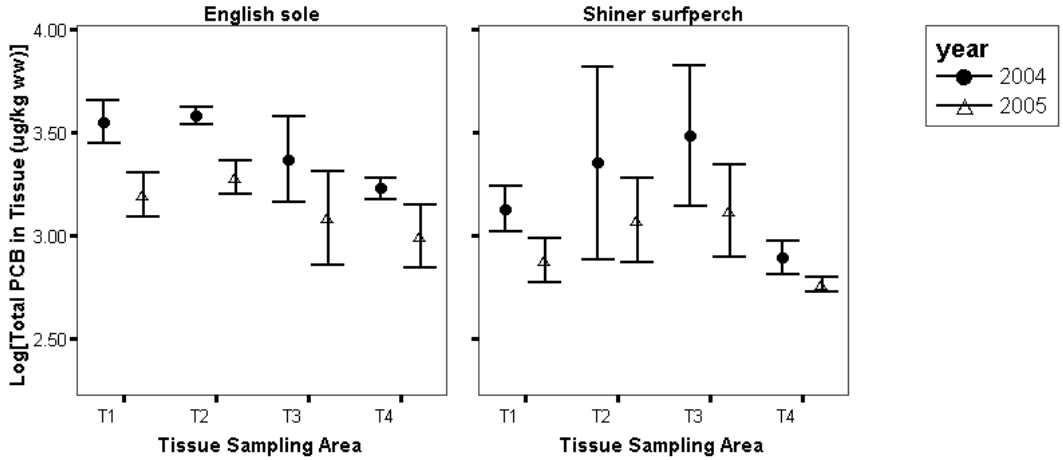

Figure D.3-2. Mean and 95% confidence intervals for total PCBs in English sole and shiner surfperch tissues by tissue sampling area

[5] Interaction effect in two-way ANOVA not significant. See methods and results of two-way ANOVA discussed in Section 4.2.1.4.1 of the RI.

[6] Based on post hoc multiple pairwise ANOVA comparisons run after finding a significant effect of area in a one-way ANOVA testing for effects of year ($p < 0.0005$ for both species; see methods and results of two-way ANOVA discussed in Section 4.2.1.4.1 of the RI. For log-transformed tissue concentrations in English sole, T4 < T1 ($p = 0.003$); and T4 < T2 ($p = 0.008$). For log-transformed tissue concentrations in shiner surfperch, T4 < T3 ($p = 0.001$); and T4 < T2 ($p = 0.009$).

[7] $p > 0.92$ for both species.

[8] $p > 0.43$ for both species.

[9] For English sole mean log-transformed tissue concentrations were lower in T3 than T2 ($p = 0.049$); and for shiner surfperch they were lower in T1 than T3 ($p = 0.075$).

In 2005, fewer statistically significant differences existed between the modeling areas. For English sole, concentrations in Area T4 were lower than concentrations in T2;[10] but for shiner surfperch, there were no significant differences among areas.[11]

Regression analyses of total PCB concentrations in shiner surfperch and Pacific staghorn sculpin composite samples relative to average total PCB concentrations in sediment were performed to determine if there was a relationship at the spatial scale of a subarea (defined as one-sixth of the associated modeling area, roughly 0.3 mi in length and half the width of the waterway). Tissue data were available from 22 of 24 subareas for shiner surfperch (n = 24 in 2004, n = 22 in 2005) and from 23 of 24 subareas[12] for Pacific staghorn sculpin (n = 24 in 2004, n = 4 in 2005). Other species were sampled on an area-wide basis (see Map 4-9 in the main body of the RI). Regression relationships were analyzed using raw data, square root-transformed data, and log-transformed data. Relationships between dry and OC-normalized sediment concentrations were also examined. Regression relationships with the highest R^2 values (each had $p < 0.05$) are presented in Figures D.3-3 through D.3-5. Significant positive linear relationships were identified using 2004 data for both Pacific staghorn sculpin (Figure D.3-3, $R^2 = 0.51$) and shiner surfperch (Figure D.3-4, $R^2 = 0.64$), in which sediment concentrations explained more than 50% of the variance in tissue concentrations. In 2005, the relationship for shiner surfperch was significant but not strong (Figure D.3-5, $R^2 = 0.29$). A regression analysis was not conducted using 2005 data for Pacific staghorn sculpin because fewer data were available for 2005. These results demonstrate that total PCB concentrations in sediment do not explain all the variability in total PCB concentrations in tissue at a subarea scale for these species.

[10] For English sole, mean log-transformed tissue concentrations were lower in T4 than T2 ($p = 0.025$) and in T3 than T2 ($p = 0.080$). The lowest p value for all other pairwise comparisons was 0.20.

[11] For shiner surfperch, the lowest pairwise comparison p value was 0.13.

[12] Two composite samples were collected from one subarea.

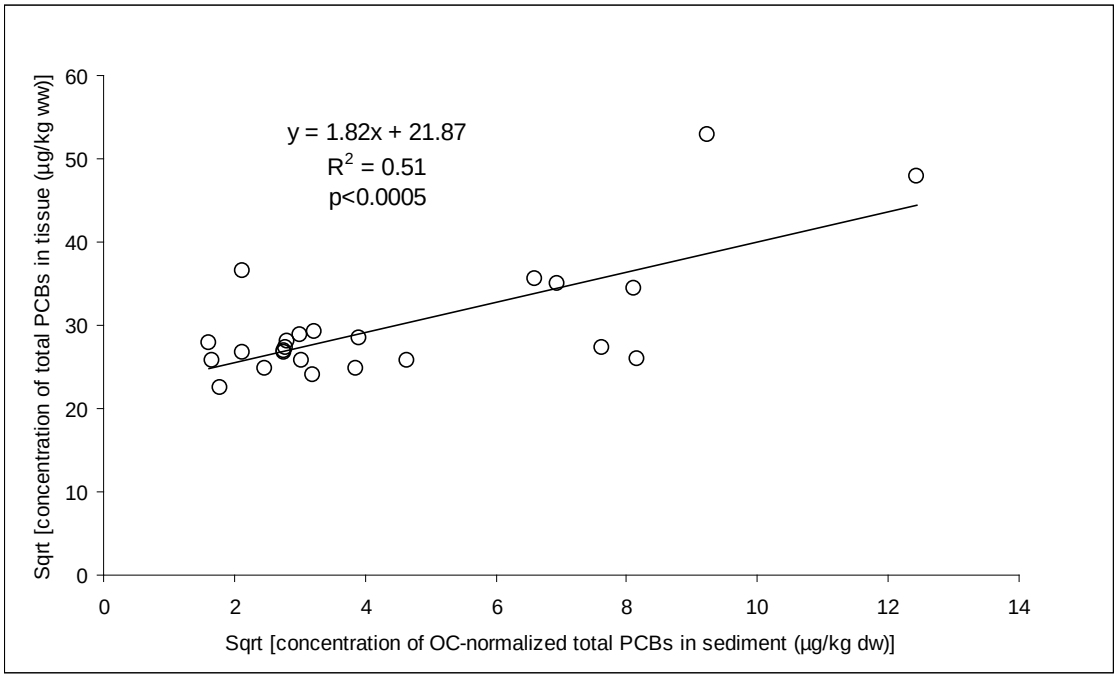

Figure D.3-3. Regression between total PCB concentrations in sediment and 2004 Pacific staghorn sculpin tissue on a subarea basis

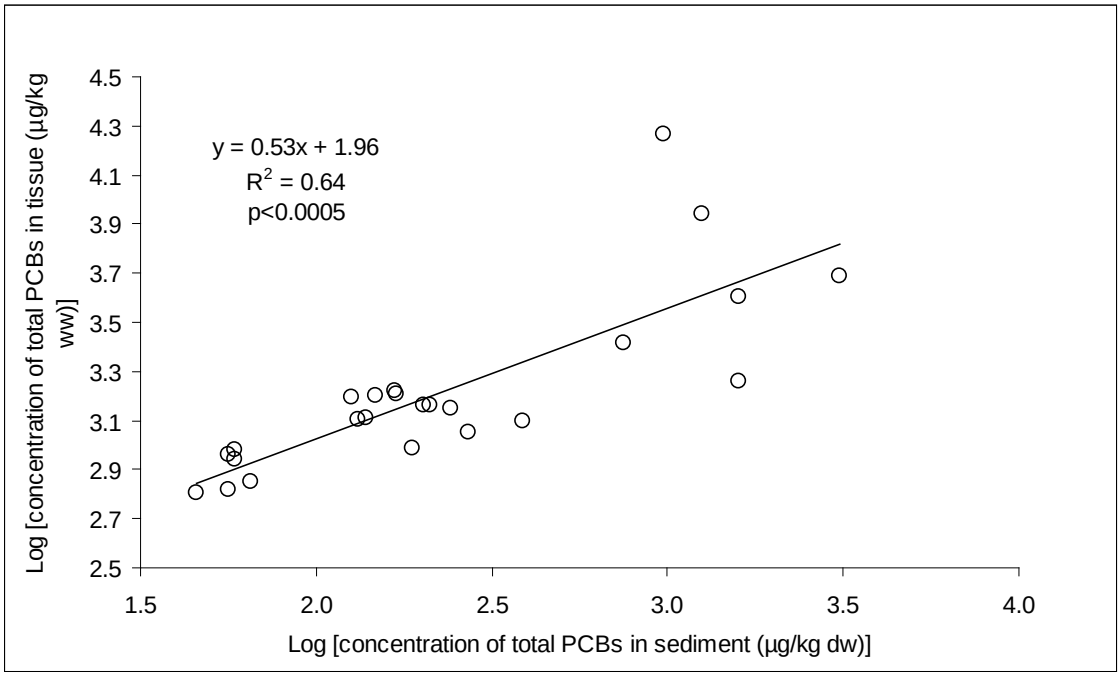

Figure D.3-4. Regression between total PCB concentrations in sediment and 2004 shiner surfperch tissue on a subarea basis

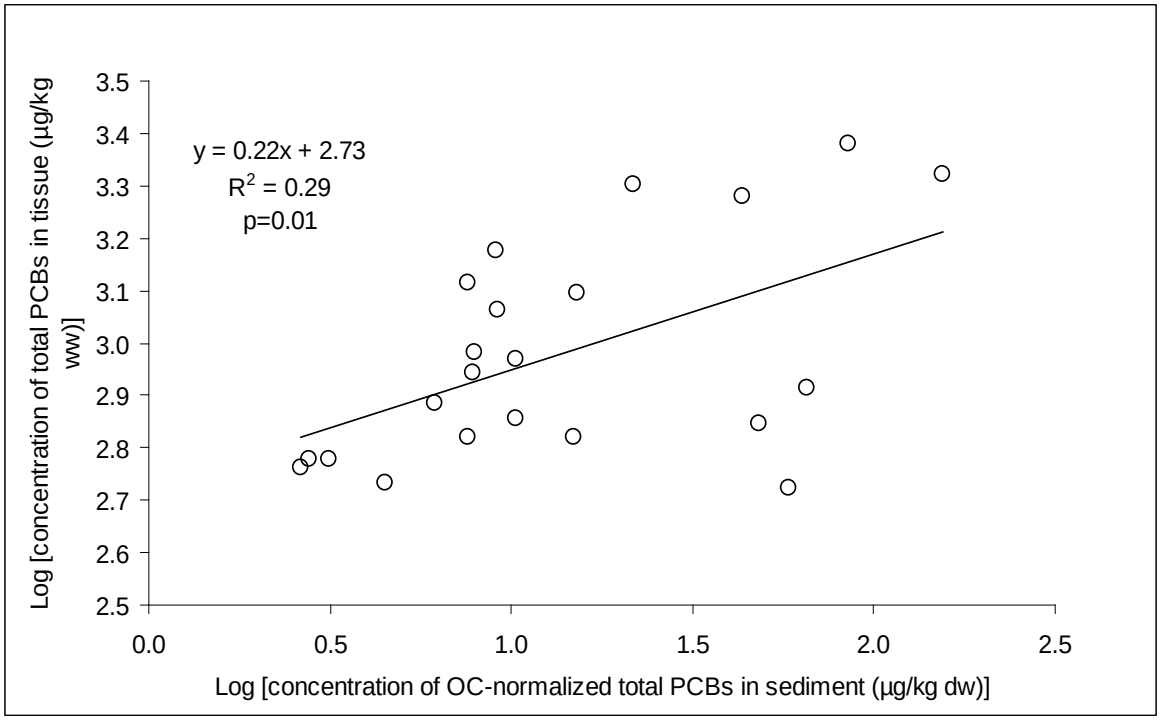

Figure D.3-5. Regression between total PCB concentrations in sediment and 2005 shiner surfperch tissue on a subarea basis

Results from the ANOVAs and regressions indicate that the application of the FWM at areas smaller than the LDW could be appropriate for shiner surfperch and Pacific staghorn sculpin because tissue concentrations varied among tissue sampling areas, patterns of tissue concentrations roughly corresponded to patterns of total PCB concentrations in sediment, and regressions of tissue sediment data were significant at the subarea scale. At the area scale for Pacific staghorn sculpin, a regression of log-transformed area mean tissue and sediment concentrations (weighted by area) was also significant with an R^2 of 99%. For shiner surfperch, regressions of area mean log-transformed tissue and sediment concentrations were not significant.

Tissue data were not available for English sole and crab at the subarea scale. Although the ANOVAs indicated differences in area mean tissue concentrations at the area scale for these two species, regressions of the log of area mean tissue concentrations vs. the log of area mean sediment concentrations were not significant for either species in either 2004 or 2005. English sole and the crab species appear to be wide-ranging species relative to the spatial scale of the modeling areas, thus the FWM should not be applied at that spatial scale for English sole and crabs.

One shiner surfperch composite sample collected from Subarea T2E in 2004 had a total PCB concentration (18,400 µg/kg ww) that was significantly higher than the rest of the

data.[13] The total PCB concentration based on the sum of PCB congeners for that sample was also very high (12,230 µg/kg ww) and provided laboratory confirmation of the initial Aroclor results. To better understand the variability of total PCB concentrations in shiner surfperch collected from Subarea T2E in 2004, 10 archived fish from this subarea were analyzed individually.[14] Total PCB concentrations in these individual fish ranged from 172 to 1,140 µg/kg ww, with a mean concentration of 640 µg/kg ww. Based on these data, it is likely that one or more of the 10 fish included in the composite sample with a total PCB concentration of 18,400 µg/kg ww had a very high concentration of total PCBs.

It is likely that species do not use all areas of the LDW equally, and some species may leave the LDW for part of the year. Therefore, the performance of the FWM at the modeling area was tested for all species. Methods and results of this test are presented in Section D.7.1. In addition, a second type of analysis was conducted to evaluate the performance of the model at spatial scales smaller than that of the modeling area. This analysis focused on the shallow bench areas of the river, on either side of the navigation channel, and was designed to investigate the impact of exposure on species that may have smaller home ranges, specifically Pacific staghorn sculpin and shiner surfperch. The results of this analysis are also presented in Section D.7.1.

D.4 Model Parameters

Application of the Arnot and Gobas (2004a) FWM to the LDW required the selection of values for 114 input parameters (including dietary fractions). Because the Arnot and Gobas model was applied in the LDW assuming steady-state conditions, it was most appropriate for parameter values to represent means of populations (as opposed to individuals) and means over several years (as opposed to shorter periods [e.g., 1 month]). Uncertainty regarding the estimates of mean values for parameters was represented quantitatively through the use of probability distributions. The model was run and calibrated probabilistically in order to systematically explore all plausible parameter sets and their corresponding estimated total PCB concentrations in tissue. Probability distributions were developed for 95 parameters, and point estimates were used to characterize 19 parameters with limited data, low variability, and/or low sensitivity.

[13] Using Rosner's test for outliers from a log-normal distribution, this value was considered a statistical outlier ($p < 0.005$).

[14] A total of 20 shiner surfperch (> 80 mm) were collected in subarea T2E in 2004. Ten of these fish were included in the initial composite tissue sample for this area, and the ten remaining fish were archived frozen as individual fish.

To characterize a parameter distribution, several statistical descriptors (e.g., mean, mode, standard deviation [SD]) were required. Estimates of the probable mean values for each input parameter were represented by either a normal or triangular distribution, which was assumed to represent the uncertainty around the mean estimate). Parameter names, symbols, units, selected values (probability distributions or point estimates), comments, and source information are presented in Table D.4-1.

According to the central limit theorem, with sufficient sample size, estimates of the mean approach a normal distribution. Parameters that had adequate site-specific empirical data or literature data with means and SDs were assigned a normal distribution. Triangular distributions were assumed for those parameters with more limited data. A triangular distribution requires a mode (a most likely value) and maximum and minimum values for the parameter (Warren-Hicks and Moore 1998). Both mode and mean values are presented for parameters with triangular distributions (Table D.4-1); means were only used for comparison with calibration results, which are presented as mean, maximum, and minimum statistics as discussed in Section D.4.2.2.3. The mean of the triangular distribution was calculated using the following equation:

$$\text{Mean} = \frac{(\text{mode} + \text{minimum} + \text{maximum})}{3} \qquad \textbf{Equation D.4-1}$$

Values and statistical descriptors for each of the FWM parameters were derived from site-specific LDW data, data from the literature (including data from other models), and default values used in previous applications of the Arnot and Gobas model to the Great Lakes (Arnot and Gobas 2004a) or San Francisco Bay (Gobas and Arnot 2005). Default values used in previous applications of the Arnot and Gobas model were also derived from the literature. Table D.4-1 presents the parameters, estimates of relevant statistical descriptors, and the form of the probability distribution selected to represent each parameter. The remainder of this section provides the rationale for selecting individual parameter values or distributions for the biological, environmental, and chemical parameters.

Table D.4-1. Input parameter probability distribution statistics and point estimate values

Parameter	Symbol	Unit	Values[a]	Distribution Type	Source/Notes
Environmental Parameters					
Concentration of total PCBs in water column water	C_{WT}	ng/L	mode = 1.43 mean = 1.59 min = 0.185 max = 3.14	triangular	Mode used for the distribution is equivalent to the mean of 12 monthly averages from bottom three layers in EFDC model (Nairn 2009). Mean presented here is based on Equation D.4-1. Maximum and minimum values are from King County empirical PCB water data from samples 1 m above bottom (Mickelson and Williston 2006).
Concentration of POC in water column water	χ_{DOC}	kg/L	mean = 2.6×10^{-7} SE = 4.4×10^{-8}	normal	Calculated from unpublished King County 2005 water data (Mickelson 2006) from samples 1 m above bottom. POC is calculated as follows, POC = TOC – DOC. Samples with zero or negative results for POC were replaced with an estimate of POC calculated as follows: POC = 0.0186 × TSS.
DOC in water column water	χ_{POC}	kg/L	mean = 2.2×10^{-6} SE = 2.5×10^{-7}	normal	Unpublished King County 2005 water data (Mickelson 2006) from samples 1 m above bottom.
Proportionality constant describing similarity in phase partitioning of DOC relative to that of octanol	α_{DOC}	unitless	0.08	point estimate	Value from Burkhard (1999), as cited in Arnot and Gobas (Arnot and Gobas 2004a). Used in the bioavailable solute fraction equation for simulating sequestering of chemical by DOC in the water.
Proportionality constant describing similarity in phase partitioning of POC relative to that of octanol	α_{POC}	unitless	0.35	point estimate	Value from Seth et al. (1999) as cited in Arnot and Gobas (Arnot and Gobas 2004a). Used in the bioavailable solute fraction equation for simulation of sequestering of chemical by POC in the water.
Disequilibrium factor for DOC partitioning	D_{DOC}	unitless	1	point estimate	Value from Arnot and Gobas (2004a). Used in the bioavailable solute fraction equation for simulation of sequestering of chemical by DOC in the water. Assumes chemicals in water column water are in equilibrium with DOC.
Disequilibrium factor for POC partitioning	D_{POC}	unitless	1	point estimate	Value from Arnot and Gobas (2004a).Used in the bioavailable solute fraction equation for simulation of sequestering of chemical by POC in the water. Assumes chemicals in water column water are in equilibrium with POC.

Table D.4-1, cont. Input parameter probability distribution statistics and point estimate values

Parameter	Symbol	Unit	Values[a]	Distribution Type	Source/Notes
Mean temperature of water column water	T	°C	mean = 11.2 SE = 0.397	normal	Unpublished King County 2005 water data (Mickelson 2006) from samples 1 m above bottom.
Dissolved oxygen concentration in water column water	C_{OX}	mg/L	mean = 7.93 SE = 0.203	normal	Unpublished King County 2005 water data (Mickelson 2006) from samples 1 m above bottom.
TSS concentration in water column water	C_{SS}	kg/L	mean = 5.8×10^{-6} SE = 8.8×10^{-7}	normal	Unpublished King County 2005 water data (Mickelson 2006) from samples 1 m above bottom. Used TSS samples filtered with a 45-µm filter to be consistent with POC definition (> 45 µm).
Density of seawater	δ_W	kg/L	1.03	point estimate	Value from Sverdrup et al. (1942). Point estimate assumed because of the narrow range of values in literature.
Concentration of total PCBs in sediment	C_S	µg/kg dw	mean = 380	point estimate	SWAC calculated using IDW on October 20, 2006, based on 1,264 samples between RM 0.0 and RM 5.25 from the LDW baseline surface sediment database.
Sediment organic carbon	OC_{sed}	%	mean = 1.91 SE = 0.025	normal	SWAC calculated using Thiessen polygons on October 20, 2006, based on 1,264 samples between RM 0.0 and RM 5.25 from the LDW baseline surface sediment database. Sediment OC calculated using Thiessen polygons to allow calculation of SE.
Chemical Parameters					
Log octanol-water partition coefficient for total PCBs	log K_{OW}	L/kg	mean = 6.6 SE = 0.05	normal	Weighted average of log K_{OW} based on PCB congeners analyzed in benthic invertebrate tissue. Log K_{OW}s for each congener from Hawker and Connell (1988).
Proportionality constant expressing the sorption capacity of NLOM for an organic chemical relative to that of octanol	β	unitless	mean = 0.035 SE = 0.005[b]	normal	Mean from Arnot and Gobas (2004a); SE was set equal to the SD reported by Arnot (2005).
Proportionality constant expressing the sorption capacity of NLOC for an organic chemical relative to that of octanol	β_{OC}	L/kg	0.35	point estimate	Value from Seth et al. (1999), as cited in Arnot and Gobas (2004a).
Rate constant for metabolic transformation of total PCBs	k_M	day^{-1}	0	point estimate	Value for k_M assumed to be zero for total PCBs (Arnot 2006b).

Table D.4-1, cont. Input parameter probability distribution statistics and point estimate values

PARAMETER	SYMBOL	UNIT	VALUES[a]	DISTRIBUTION TYPE	SOURCE/NOTES
Biological Parameters					
Density of lipids	δ_L	kg/L	mode = 0.9 mean = 0.9 min = 0.8 max = 1	triangular	Data from Arnot (2006a).
Fraction of prey item i in the diet of organism	P_i	fraction	na		See Section D.4.2.2.3 for values defining triangular distributions for each dietary item for all species. Prey items consist of organisms (phytoplankton, zooplankton, benthic invertebrates and juvenile fish) and sediment.
Phytoplankton/Algae					
Lipid content	v_{LP}	%	mean = 0.12 SE = 0.05[b]	normal	Data from Mackintosh et al. (2004). SE was set equal to the SD reported by Mackintosh et al.
Water content[c]	v_{WP}	%	mean = 95.6 SE = 0.55[b]	normal	Data from Mackintosh et al. (2004). SE was set equal to the SD reported by Mackintosh et al.
Rate constant for growth of phytoplankton/algae	k_G	day^{-1}	0.08	point estimate	Value from Swackhamer and Skoglund (1993) as cited in Arnot and Gobas (2004a). Only phytoplankton/algae has k_G as an input number instead of an equation. This is a mean annual value based on empirical data in which slow-growth conditions (winter) were 0.03 day^{-1} and active-growth conditions (summer) were 0.13 day^{-1}.
Resistance to chemical uptake through aqueous phase for phytoplankton/algae	A	day^{-1}	mean = 6×10^{-5} SE = 1×10^{-5} [b]	normal	Values from Gobas and Arnot (2005). SE was set equal to the SD reported by Gobas and Arnot (2005).
Resistance to chemical uptake through organic phase for phytoplankton/algae	B	unitless	mode = 5.5 mean = 5.5 min = 1.8 max = 9.2	triangular	Values from Gobas and Arnot (2005) and Arnot and Gobas (2004a).
Zooplankton					
Weight	W_B	kg	mean = 1.6×10^{-7} SE = 3.6×10^{-8} [b]	normal	Data from Giles and Cordell (1998). SE was set equal to the SD reported by Giles and Cordell (1998).

Table D.4-1, cont. Input parameter probability distribution statistics and point estimate values

PARAMETER	SYMBOL	UNIT	VALUES[a]	DISTRIBUTION TYPE	SOURCE/NOTES
Lipid content	v_{LB}	%	mean = 1.2 SE = 0.3[d]	normal	Data from Kuroshima et al. (1987). SE was set equal to the SD of data reported in Kuroshima et al. (1987), assuming the data represented a distribution of mean values.
Water content[e]	v_{WB}	%	mean = 90 SE = 1.5[d]	normal	Data from Kuroshima et al. (1987). SE was set equal to the SD of data reported in Kuroshima et al. (1987), assuming the data represented a distribution of mean values.
Dietary absorption efficiency of lipids	ε_L	%	mode = 72 mean = 71 min = 55 max = 85	triangular	Data from Conover (1966) as cited in Arnot and Gobas (2004a). Study involved *Calanus hyperboreus* eating diatoms and flagellates from Gulf of Maine.
Dietary absorption efficiency of NLOM	ε_N	%	mode = 72 mean = 71 min = 55 max = 85	triangular	Data from Conover (1966) as cited in Arnot and Gobas (2004a). Study involved *Calanus hyperboreus* eating diatoms and flagellates from Gulf of Maine.
Dietary absorption efficiency of water	ε_W	%	55	point estimate	Value from Gobas and Arnot (2005).
Benthic Invertebrates					
Weight	W_B	kg	mean = 5.1×10^{-5} SE = 2.0×10^{-5}	normal	Values derived from LDWG Phase 2 data. See description of methods for deriving weights in Section D.4.1.3.2.
Lipid content	v_{LB}	%	mean = 0.89 SE = 0.06	normal	LDWG Phase 2 data (n = 20).
Water content[e]	v_{WB}	%	mode = 80 mean = 79 min = 71 max = 87	triangular	Water content range data for bivalves, isopods, amphipods, and cladocerans reported in an Oak Ridge National Laboratory publication were used to derive the mode, maximum, and minimum statistics of a triangular distribution for benthic invertebrate water content (Sample et al. 1997).
Relative fraction of porewater ventilated[f]	m_P	unitless	mode = 0.20 mean = 0.17 min = 0.05 max = 0.25	triangular	Used Winsor et al. (1990), Gobas and Wilcockson (2003), Gobas and Arnot (2005), and knowledge of organism behavior to develop values.
Dietary absorption efficiency of lipids	ε_L	%	mode = 75 mean = 62 min = 15 max = 96	triangular	Data from Roditi and Fisher (1999), Berge and Brevik (1996), Gordon (1966), Parkerton (1993) as cited in Arnot and Gobas (2004a). These studies involved zebra mussels from tidal freshwater section of the Hudson River and polychaetes from Cape Cod intertidal flats.

Table D.4-1, cont. Input parameter probability distribution statistics and point estimate values

PARAMETER	SYMBOL	UNIT	VALUES[a]	DISTRIBUTION TYPE	SOURCE/NOTES
Dietary absorption efficiency of NLOM	ε_N	%	mode = 75 mean = 62 min = 15 max = 96	triangular	Data from Roditi and Fisher (1999), Berge and Brevik (1996), Gordon (1966), Parkerton (1993) as cited in Arnot and Gobas (2004a). These studies involved zebra mussels from the tidal freshwater section of the Hudson River and polychaetes from Cape Cod intertidal flats.
Dietary absorption efficiency of water	ε_W	%	55	point estimate	Value from Gobas and Arnot (2005).
Clam					
Weight	W_B	kg	mean = 0.037 SE = 0.0027	normal	Weight calculated using 2004 length data and a weight vs. length regression based on *Mya arenaria* data from the August 8 to 12, 2003, intertidal clam survey in the LDW and the August 13, 2003, catch per unit effort survey.
Lipid content	v_{LB}	**%**	mean = 0.71 SE = 0.026	normal	LDWG Phase 2 data (n = 14).
Water content[e]	v_{WB}	**%**	mean = 85.2 SE = 0.345	normal	LDWG Phase 2 data (n = 14).
Relative fraction of porewater ventilated[f]	m_P	unitless	mode = 0.20 mean = 0.17 min = 0.05 max = 0.25	triangular	Used Winsor et al. (1990), Gobas and Wilcockson (2003), Gobas and Arnot (2005), and knowledge of organism behavior to develop values.
Dietary absorption efficiency of lipids	ε_L	%	mode = 75 mean = 62 min = 15 max = 96	triangular	Data from Roditi and Fisher (1999), Berge and Brevik (1996), Gordon (1966), Parkerton (1993) as cited in Arnot and Gobas (2004a). These studies involved zebra mussels from tidal freshwater section of the Hudson River and polychaetes from Cape Cod intertidal flats.
Dietary absorption efficiency of NLOM	ε_N	%	mode = 75 mean = 62 min = 15 max = 96	triangular	Data from Roditi and Fisher (1999), Berge and Brevik (1996), Gordon (1966), Parkerton (1993) as cited in Arnot and Gobas (2004a). These studies involved zebra mussels from the tidal freshwater section of the Hudson River and polychaetes from Cape Cod intertidal flats.
Dietary absorption efficiency of water	ε_W	%	55	point estimate	Value from Gobas and Arnot (2005).
Filter feeder particle scavenging efficiency	σ	fraction	1	point estimate	Value from Arnot and Gobas (2004a). Used to calculate feeding rate for filter feeders.

Table D.4-1, cont. Input parameter probability distribution statistics and point estimate values

PARAMETER	SYMBOL	UNIT	VALUES[a]	DISTRIBUTION TYPE	SOURCE/NOTES
Juvenile Fish					
Weight	W_B	kg	mean = 6×10^{-3} SE = 7×10^{-4}	normal	Based on ≤ 80 mm shiner surfperch from the LDW and background locations from sampled in 2004 and 2005 (n = 16).
Lipid content	v_{LB}	%	mean = 2.5 SE = 0.6	normal	Mean value based on mean lipid content of adult shiner surfperch and English sole collected from the LDW with a correction factor of 0.5 applied based on ratios of juvenile and adult fish lipids described in the literature (Gobas and Arnot 2005; Robards et al. 1999). Standard deviation estimated as 2 × SE of 19 lipid values (Section D.4.2.1).
Water content[e]	v_{WB}	%	mean = 73.9 SE = 2.0	normal	Based on LDWG Phase 2 data for adult shiner surfperch. Mean of all composite samples (n = 46).
Relative fraction of porewater ventilated[f]	m_P	unitless	mode = 0.01 mean = 0.01 min = 0.005 max = 0.02	triangular	Used Winsor et al. (1990), Gobas and Wilcockson (2003), Gobas and Arnot (2005), and knowledge of organism behavior to develop values.
Dietary absorption efficiency of lipids	ε_L	%	mode = 92 mean = 92 min = 90 max = 95	triangular	Data from Gobas et al. (1999) as cited in Arnot and Gobas (2004a). Based on 73-day laboratory test with adult rainbow trout (*Oncorhynchus mykiss*) and a field study of rock bass (*Ambloplites rupestris*).
Dietary absorption efficiency of NLOM	ε_N	%	mode = 60 mean = 58 min = 50 max = 65	triangular	Data from Nichols et al. (2001) as cited in Arnot and Gobas (2004a). Based on study with tetrachlorobiphenyl and rainbow trout.
Dietary absorption efficiency of water	ε_W	%	55	point estimate	Value from Gobas and Arnot (2005).
Slender Crab					
Weight	W_B	kg	mean = 0.167 SE = 0.0038	normal	LDWG Phase 2 data (n = 13). Values derived using a weight-weighted approach[g] for each crab in a composite sample (see Section D.4.1.3.2 for methods).
Lipid content	v_{LB}	%	mean = 1.1 SE = 0.047	normal	LDWG Phase 2 data (n = 13).

Table D.4-1, cont. Input parameter probability distribution statistics and point estimate values

PARAMETER	SYMBOL	UNIT	VALUES[a]	DISTRIBUTION TYPE	SOURCE/NOTES
Water content[e]	v_{WB}	%	mean = 83.8 SE = 0.371	normal	LDWG Phase 2 data (n = 13).
Relative fraction of porewater ventilated[f]	m_P	unitless	mode = 0.02 mean = 0.02 min = 0.01 max = 0.03	triangular	Used Winsor et al. (1990), Gobas and Wilcockson (2003), Gobas and Arnot (2005), and knowledge of organism behavior to develop values.
Dietary absorption efficiency of lipids	ε_L	%	mode = 75 mean = 62 min = 15 max = 96	triangular	Data from Roditi and Fisher (1999), Berge and Brevik (1996), Gordon (1966), Parkerton (1993) as cited in Arnot and Gobas (2004a). These studies involved zebra mussels from tidal freshwater section of the Hudson River and polychaetes from Cape Cod intertidal flats.
Dietary absorption efficiency of NLOM	ε_N	%	mode = 75 mean = 62 min = 15 max = 96	triangular	Data from Roditi and Fisher (1999), Berge and Brevik (1996), Gordon (1966), Parkerton (1993) as cited in Arnot and Gobas (2004a). These studies involved zebra mussels from the tidal freshwater section of the Hudson River and polychaetes from Cape Cod intertidal flats.
Dietary absorption efficiency of water	ε_W	%	55	point estimate	Value from Gobas and Arnot (2005).
Dungeness Crab					
Weight	W_B	kg	mean = 0.528 SE = 0.058	normal	LDWG Phase 2 data (n = 10). Values derived using a weight-weighted[g] approach for each crab in a composite sample (see Section D.4.1.3.2 for methods).
Lipid content	v_{LB}	%	mean = 2.6 SE = 0.40	normal	LDWG Phase 1 and 2 data (n = 12).
Water content[e]	v_{WB}	%	mean = 82 SE = 0.74	normal	LDWG Phase 1 and 2 data (n = 12).
Relative fraction of porewater ventilated[f]	m_P	unitless	mode = 0.02 mean = 0.02 min = 0.01 max = 0.03	triangular	Used Winsor et al. (1990), Gobas and Wilcockson (2003), Gobas and Arnot (2005), and knowledge of organism behavior to develop values.
Dietary absorption efficiency of lipids	ε_L	%	mode = 75 mean = 62 min = 15 max = 96	triangular	Data from Roditi and Fisher (1999), Berge and Brevik (1996), Gordon (1966), Parkerton (1993) as cited in Arnot and Gobas (2004a). These studies involved zebra mussels from tidal freshwater section of the Hudson River and polychaetes from Cape Cod intertidal flats.

Table D.4-1, cont. Input parameter probability distribution statistics and point estimate values

PARAMETER	SYMBOL	UNIT	VALUES[a]	DISTRIBUTION TYPE	SOURCE/NOTES
Dietary absorption efficiency of NLOM	ε_N	%	mode = 75 mean = 62 min = 15 max = 96	triangular	Data from Roditi and Fisher (1999), Berge and Brevik (1996), Gordon (1966), Parkerton (1993) as cited in Arnot and Gobas (2004a). These studies involved zebra mussels from the tidal freshwater section of the Hudson River and polychaetes from Cape Cod intertidal flats.
Dietary absorption efficiency of water	ε_W	%	55	point estimate	Value from Gobas and Arnot (2005).
Pacific Staghorn Sculpin					
Weight	W_B	kg	mean = 0.077 SE = 0.0037	normal	LDWG Phase 2 data (n = 28). Values derived using a weight-weighted[g] approach for each fish in a composite sample (see Section D.4.1.3.2 for methods).
Lipid content	v_{LB}	%	mean = 2.1 SE = 0.07	normal	LDWG Phase 2 data (n = 28).
Water content[e]	v_{WB}	%	mean = 79.0 SE = 0.1	normal	LDWG Phase 2 data (n = 28).
Relative fraction of porewater ventilated[f]	m_P	unitless	mode = 0.05 mean = 0.06 min = 0.02 max = 0.1	triangular	Used Winsor et al. (1990), Gobas and Wilcockson (2003), Gobas and Arnot (2005), and knowledge of organism behavior to develop values.
Dietary absorption efficiency of lipids	ε_L	%	mode = 92 mean = 92 min = 90 max = 95	triangular	Data from Gobas et al. (1999) as cited in Arnot and Gobas (2004a). Based on 73-day laboratory test with adult rainbow trout (*Oncorhynchus mykiss*) and a field study of rock bass (*Ambloplites rupestris*).
Dietary absorption efficiency of NLOM	ε_N	%	mode = 60 mean = 58 min = 50 max = 65	triangular	Data from Nichols et al. (2001) as cited in Arnot and Gobas (2004a). Based on study with tetrachlorobiphenyl and rainbow trout.
Dietary absorption efficiency of water	ε_W	%	55	point estimate	Value from Gobas and Arnot (2005).
Shiner Surfperch					
Weight	W_B	kg	mean = 0.019 SE = 0.00043	normal	LDWG Phase 2 data (n = 46). Values derived using a weight-weighted[g] approach for each fish in a composite sample (see Section D.4.1.3.2 for methods).

Table D.4-1, cont. Input parameter probability distribution statistics and point estimate values

PARAMETER	SYMBOL	UNIT	VALUES[a]	DISTRIBUTION TYPE	SOURCE/NOTES
Lipid content	v_{LB}	%	mean = 4.6 SE = 0.19	normal	LDWG Phase 1 and 2 data (n = 49).
Water content[e]	v_{WB}	%	mean = 73.9 SE = 0.3	normal	LDWG Phase 2 data (n = 46).
Relative fraction of porewater ventilated[f]	m_P	unitless	mode = 0.01 mean = 0.01 min = 0.005 max = 0.02	triangular	Used Winsor et al. (1990), Gobas and Wilcockson (2003), Gobas and Arnot (2005), and knowledge of organism behavior to develop values.
Dietary absorption efficiency of lipids	ε_L	%	mode = 92 mean = 92 min = 90 max = 95	triangular	Data from Gobas et al. (1999) as cited in Arnot and Gobas (2004a). Based on 73-day laboratory test with adult rainbow trout (*Oncorhynchus mykiss*) and a field study of rock bass (*Ambloplites rupestris*).
Dietary absorption efficiency of NLOM	ε_N	%	mode = 60 mean = 58 min = 50 max = 65	triangular	Data from Nichols et al. (2001) as cited in Arnot and Gobas (2004a). Based on study with tetrachlorobiphenyl and rainbow trout.
Dietary absorption efficiency of water	ε_W	%	55	point estimate	Value from Gobas and Arnot (2005).
English Sole					
Weight	W_B	kg	mean = 0.247 SE = 0.010	normal	LDWG Phase 2 data (n = 42). Values derived using a weight-weighted[g] approach for each fish in a composite sample (see Section D.4.1.3.2 for methods).
Lipid content	v_{LB}	%	mean = 5.5 SE = 0.20	normal	LDWG Phase 2 data (n = 42).
Water content[e]	v_{WB}	%	mean = 75.0 SE = 0.3	normal	LDWG Phase 2 data (n = 42).
Relative fraction of porewater ventilated[f]	m_P	unitless	mode = 0.01 mean = 0.01 min = 0.005 max = 0.02	triangular	Used Winsor et al. (1990), Gobas and Wilcockson (2003), Gobas and Arnot (2005), and knowledge of organism behavior to develop values.

Table D.4-1, cont. Input parameter probability distribution statistics and point estimate values

PARAMETER	SYMBOL	UNIT	VALUES[a]	DISTRIBUTION TYPE	SOURCE/NOTES
Dietary absorption efficiency of lipids	ε_L	%	mode = 92 mean = 92 min = 90 max = 95	triangular	Data from Gobas et al. (1999) as cited in Arnot and Gobas (2004a). Based on 73-day laboratory test with adult rainbow trout (*Oncorhynchus mykiss*) and a field study of rock bass (*Ambloplites rupestris*).
Dietary absorption efficiency of NLOM	ε_N	%	mode = 60 mean = 58 min = 50 max = 65	triangular	Data from Nichols et al. (2001) as cited in Arnot and Gobas (2004a). Based on study with tetrachlorobiphenyl and rainbow trout.
Dietary absorption efficiency of water	ε_W	%	55	point estimate	Value from Gobas and Arnot (2005).

[a] The mean value is shown for triangular distributions to facilitate comparison with calibration results only; it was not used in the model. Standard error was used to represent the SD in Crystal Ball™, assuming that values in the distribution were estimates of the mean.

[b] SE was represented by an SD reported in the literature.

[c] NLOC content of phytoplankton (v_{NP}, in units of %) was calculated using the following equation: $v_{NP} = 1 – (v_{LP} + v_{WP})$.

[d] SE was represented by an SD calculated from data assumed to represent a distribution of mean values.

[e] NLOM content of organism (v_{NB}, in units of %) was calculated using the following equation: $v_{NB} = 1 – (v_{LB} + v_{WB})$.

[f] Fraction of overlying water ventilated (m_O, fraction) was calculated using the following equation: $m_O = 1 - m_p$.

[g] The body weight-weighted average for a given composite sample was calculated by multiplying the weight of each individual fish or crab in a composite sample by the fraction of the total composite sample weight each represents and then summing these products. The weight-weighted average for a given composite sample was calculated using the following equation:

$$W_C = \sum_{i=1}^{n}\left(W_i \times \left(\frac{W_i}{\sum W_{i...n}}\right)\right)$$

Where: W_C = weight-weighted average for a given composite sample (kg)
W_i = individual fish or crab weight from a given composite sample (kg)
n = number of individual fish or crabs included in a given composite sample

DOC – dissolved organic carbon
dw – dry weight
EFDC – Environmental Fluid Dynamics [Computer] Code
IDW – inverse distance weighting
LDWG – Lower Duwamish Waterway Group
max – maximum
min – minimum
NLOC – non-lipid organic carbon
NLOM – non-lipid organic matter
OC – organic carbon
PCB – polychlorinated biphenyl
POC – particulate organic carbon
SD – standard deviation
RBTC – risk-based threshold concentration
SE – standard error
SWAC – spatially weighted average concentration
TSS – total suspended solids

D.4.1 PARAMETER VALUES FROM SITE-SPECIFIC DATA

Site-specific data from the LDW were used to derive values for eight environmental parameters: total PCB concentrations in sediment, percentage of sediment total organic carbon (TOC), total PCB concentrations in water, and five water quality parameters (total suspended solids [TSS], dissolved oxygen [DO], DOC, POC, temperature). These site-specific data were generated from various field sampling events conducted in the LDW.

D.4.1.1 Sediment concentration of total PCBs and organic carbon content

The main reason for developing the FWM was to estimate RBTCs for total PCBs in sediment[15] (as a SWAC) based on RBTCs in tissue. Tissue RBTCs were derived based on the results of the baseline risk assessments (see Section D.9 and Section 8 in the main body of the RI).

The SWAC is considered to be a decision variable[16] in the FWM because the total PCB sediment RBTC (as a SWAC) will be considered in developing PRGs in the feasibility study. Therefore, the total PCB concentration in sediment (as a SWAC) was represented by a single value (point estimate). This is consistent with the approach recommended by Morgan and Henrion (1990) for the treatment of decision variables. Representing the SWAC as a point estimate does not account for the uncertainties in the interpolation methodology or in the true exposure areas for modeled species. Effects of SWAC uncertainties on model estimates are discussed in Section D.6.2.4.

Total PCB concentrations (Aroclor sum) in sediment and OC content were derived using the baseline surface sediment database (Figure D.4-1). The total PCB SWAC was calculated using inverse distance weighting (IDW) interpolations derived from 1,264 surface sediment samples (Windward 2006b). The SWAC provides a less-biased estimate of average concentrations in areas where spatially biased sampling has occurred. The use of a SWAC does not address differential habitat use within the LDW by various species; instead, application of the SWAC assumes that all areas of the LDW are used equally by all species. This assumption is likely an over-simplification of habitat use, as discussed in Section D.7.

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[15] RBTCs for sediment are presented in Section 8 of the RI. RBTCs were calculated based on a best-fit estimate and a range based on acceptable output from the model defined by the model performance criterion (see Sections D.5 and D.8 for more details).

[16] Identification of a parameter as a decision variable affects how a parameter is addressed in the calibration of the model; decision variables are best presented as single values to be representative of their likely use in decision-making.

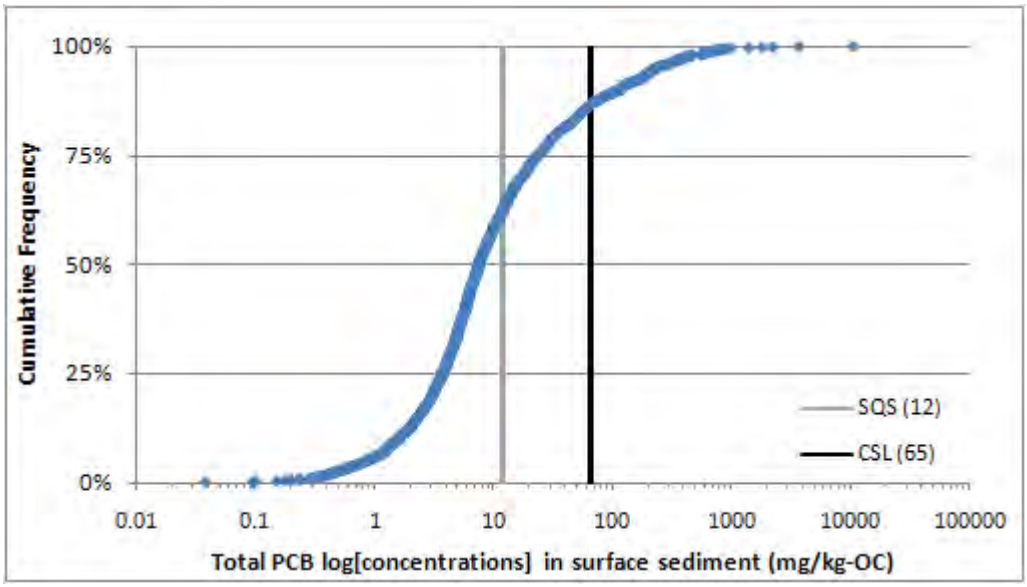

Figure D.4-1. Cumulative frequency of OC-normalized total PCB concentrations in surface sediment (log-scale)

The IDW approach used to develop the SWAC for the FWM was described in a technical memorandum on the geographic information system (GIS) interpolation of total PCBs in LDW surface sediment (Windward 2006b). Interpolation was required because most of the sampling in the LDW has been focused on areas that were known to have elevated concentrations of chemicals of concern. The comparatively large number of samples collected from contaminated areas biases the overall average concentration high and also imparts a spatial bias (i.e., regions that were more densely sampled are emphasized).

Interpolation methods were used to estimate the total PCB SWAC in the LDW surface sediment dataset to reduce the potential for bias. The process for creating SWAC estimates was developed in consultation with EPA and Ecology. The IDW parameters (e.g., search radius, weighting factor) were selected to optimize the ability of the IDW interpolation to estimate total PCB concentrations in sediment. The IDW method for interpolation was selected for both technical and practical reasons, including the accuracy of the estimates. IDW is a deterministic method in which interpolated estimates are made based on concentrations at nearby locations. The IDW method creates a continuous surface of grid cells (10 x 10 ft), in which each cell is represented by a single estimated concentration. These individual grid cell concentrations are estimated as a function of the empirically determined concentrations at nearby locations; empirical data points are weighted by the inverse of their distance to the estimated cell, with the effect that nearby data points are given more weight than

those farther away. The optimized interpolation resulted in a total PCB SWAC of 380 µg/kg dry weight (dw) for the LDW from RM 0.0 to RM 5.25[17] (Table D.4-1).

In order to develop a probability distribution for sediment organic carbon, mean and standard error (SE) statistics needed to be calculated. Thiessen polygons were used for calculating sediment organic carbon because calculation of SE statistics for Thiessen polygons uses only sample concentrations, and therefore, does not incorporate the uncertainty of the estimated concentrations of IDW cells. The sediment OC content was calculated using Thiessen polygons derived from 1,264 surface sediment samples. The spatially weighted average sediment OC content was 1.91% (Table D.4-1).

D.4.1.2 Water data

Water samples for the analysis of conventional parameters were collected in 2005 by King County as part of the Marine Ambient and Outfall Water Column Monitoring Program (Mickelson 2006). Water parameters were estimated for the FWM using these site-specific data, which included DO, temperature, TSS, DOC, and POC. POC was estimated from site-specific values for DOC and TOC in water column water. Water samples for the analysis of PCB congeners were collected in 2005 to assist in the re-calibration of the Environmental Fluid Dynamics [Computer] Code (EFDC) model (King County 2005).

Total PCB concentrations in the water column were derived from these site-specific data (Mickelson and Williston 2006) and output as monthly averages from the EFDC model (Nairn 2006, 2009).[18] The distribution of total PCB concentrations in water was assumed to be triangular because few site-specific data were available. More data were available for distributions for all other water chemistry parameters, which were assumed to have a normal distribution.

In 2005, water samples were collected from two depths (1 m below the water surface [surface samples] and 1 m above the sediment surface [bottom samples]) at each of two stations in the LDW (King County 2005). The two stations were located near RM 0.0 west of Harbor Island (LTKE03) and at the 16th Avenue Bridge (LTUM03) (Figure D.3-1). Samples were collected for analysis of conventional parameters (DO, temperature, TSS, DOC, and TOC) monthly from January through December, for a total of 48 samples (i.e., 24 surface samples and 24 bottom samples). Because most of

[17] To the extent possible, the same estimation methods (e.g., spatial interpolation, treatment of non-detect data, boundary definitions) used to calculate the SWAC for calibration of the FWM should be used when the model results are applied to support risk management decisions. A new SWAC (350 µg/kg dw) was generated after the calibration of the FWM using a new IDW parameterization (see Section 4.2.2 of the RI) and the inclusion of additional surface sediment data collected as part of the RI. The effects of this new SWAC on model performance are discussed in Section D.6.2.3.

[18] The Environmental Fluid Dynamics [Computer] Code model, a hydrodynamic model, was created as part of the water quality assessment for the Duwamish River and Elliott Bay (King County 1999 [Appendix B1]).

the fish and crab species being modeled spend the majority of their time in more saline, deeper waters in the estuary, means and SEs for each parameter were calculated from the 24 bottom samples (Table D.4-1).

Water samples collected by King County in August, September, November, and December in 2005 were also analyzed for PCB congeners. These months were selected with the intention of capturing two low-flow events (August and September) and two high-flow events (November and December) in the LDW. The samples were analyzed for all 209 individual PCB congeners, and total PCBs were calculated as the sum of detected PCB congeners. Seven bottom samples were analyzed for PCBs.[19] The maximum and minimum values for the triangular distribution for the total PCB concentrations in water were based on the results of these seven bottom samples, as reported in Table 1 of the *Technical Memorandum: Duwamish River/Elliott Bay/Green River Water Column PCB Congener Survey, Transmittal of Data and Quality Assurance Documentation* (Mickelson and Williston 2006). These empirical data are summarized in Table D-4.2.

Table D.4-2. Total PCB concentrations in water based on empirical data and estimates from the EFDC model

Source of Water Data	Concentration (ng/L)		
	Mean	Minimum	Maximum
Empirical data for bottom water samples (Mickelson and Williston 2006)	1.31[a]	0.185	3.14
EFDC model data for bottom three cells (Nairn 2009)	1.43[b]		
EFDC model data for cells that correspond to water samples (Nairn 2009)	1.43[b]	0.1[c]	5.4[d]

[a] Mean of empirical data collected at two locations (two depths each) in August, September, November, and December 2005.

[b] Yearly mean based on monthly mean estimates from the bottom three cells throughout the LDW estimated from the EFDC LDW-wide model.

[c] Minimum EFDC model estimate (based on 3-hour-interval model prediction) for the location where the sample with the minimum total PCB concentration was detected (LTUM03, bottom).

[d] Maximum EFDC model estimate (based on 3-hour-interval model prediction) for the location where the sample with the maximum total PCB concentration was detected (LTUM03, bottom).

EFDC – Environmental Fluid Dynamics [Computer] Code

LDW – Lower Duwamish Waterway

PCB – polychlorinated biphenyl

[19] The laboratory had instrument problems while analyzing the September bottom sample from the Harbor Island station (LTKE03).

The mode of the water distribution was estimated using the output of the EFDC model, a hydrodynamic model created as part of a water quality assessment for the Duwamish River and Elliott Bay (King County 1999 [Appendix B1]). Since its application to the water quality assessment for the Duwamish River and Elliott Bay in 1999, the EFDC model has been recalibrated (Nairn 2009).[20] The recalibrated version of EFDC was used to generate output to provide total PCB concentrations for the LDW FWM on an LDW-wide basis and for the four modeling areas. The EFDC model generated estimates of total PCB concentrations every 3 hours in each prediction cell for 1 year.[21] The 3-hour-interval estimated concentrations were then averaged within each month to derive 12 monthly average water concentrations for each prediction cell (Nairn 2009). Average monthly concentrations from all prediction cells in the bottom three water layers of the EFDC model were then averaged to represent an annual average total PCB concentration in the water column for the entire LDW; this concentration was used as the mode for the FWM (Table D.4-1). The EFDC model was also used to generate maximum and minimum concentrations for the locations where the maximum and minimum empirical water concentration data were collected (Table D.4-2). The model estimates for those locations bounded the range of empirical data; however, as described in Table D.4-1, the maximum and minimum of the empirical data were used to bound the triangular distribution used for the FWM. The EFDC modeling effort for predicting PCB water concentrations is further described in Attachment 3.

Average exposure concentrations were used to represent long-term exposure conditions averaged over the LDW because the modeled species spend long periods of time in the LDW (months to years) and integrate their exposure over their foraging range. In reality, total PCB concentration in water can vary on smaller scales and can

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[20] Updates to the EFDC model included adding LDW slips, changing K_{OW} values for PCB partitioning, and adding and replacing sediment PCB data to reflect conditions after the Duwamish/Diagonal dredging event.

[21] A prediction cell is a three-dimensional space that represents a portion of the LDW in the EFDC model. Prediction cells were defined by dividing the depth, width, and length of the LDW into sections. The depth of the LDW was divided into 10 sections, the width was divided into 3 sections (with the exception of the area around Kellogg Island, which was divided into 7 sections), and the length (i.e., RM 0.0 to RM 5.3) was divided into 30 sections. A typical prediction cell was 820 ft long, 165 ft wide, and one-tenth of the depth of the LDW (which varies by tidal cycle and location). Because depth varies from 3 to 36 ft in the LDW, the depth of water represented by the bottom three cells of the EFDC model varied from approximately 0.5 to 12 ft. Note that the EFDC model referred to in Section 3 of the main body of the RI, where the sediment transport model is discussed, had 7 model cells across the LDW versus the 3 model cells discussed above. The longitudinal grid resolution was also greater in the along-channel direction, using 80 cells of variable length to replace 30 cells in the configuration used to support the FWM. The coarser grid configuration was used in the EFDC model supporting the FWM in order to take advantage of the previous configuration and calibration for PCB and other chemical simulations and to avoid the lengthy simulation times that would be required with the more refined grid configuration.

also fluctuate daily and seasonally, as demonstrated by the EFDC model. For example, on a prediction cell basis, the maximum annual average concentration was predicted to be 16 ng/L, compared with an LDW-wide average of 1.3 ng/L. The total PCB concentration in individual prediction cells can vary by a factor of 6 or more during a day, as tidal conditions change (Nairn 2009). Therefore, while the FWM evaluates exposures over the long-term, some species such as English sole could have short-term exposures to water PCB concentrations much higher than the long-term spatial average concentrations. Seasonal variability has also been demonstrated in the LDW and elsewhere. Studies of the Kalamazoo, Hudson, and Grasse Rivers have demonstrated that during late spring and summer (i.e., during periods of low flow), PCBs can be transferred from the sediment to the water column (dissolved phase) at rates that are higher than those estimated by standard chemical fate and transport models (Thibodeaux and Bierman 2003). The model predicted just such seasonal changes during low-flow periods. Higher concentrations in water just above the sediment surface were estimated on the benches in a few specific areas with higher sediment concentrations. These higher concentrations were included in the EFDC model output used to generate the average concentrations used in the FWM. Dilution and mixing tend to diminish the importance of this contribution over time.

The EFDC model does not simulate the effect of temperature on the physical properties of PCB compounds, nor does it include any simulation of biological activity. The temperature in the LDW surface water varied between 4°C and 17°C, and the near-bottom water ranged between 7°C and 14°C based on historical King County data. No information is available on the relative amount of biological activity or the influence of that activity on stabilizing or destabilizing sediments. The EFDC model was calibrated to water column PCB concentrations obtained between August and December. This period of calibration should encompass variations resulting from changes in temperature and biological activity. Even without simulating temperature or biological effects, predicted concentrations tend to increase in late summer and decline afterwards, following the same trend as the empirical observations (Nairn 2009). While consideration of these processes could lead to potential improvements in model calibration, the existing level of calibration suggests that the impact is likely to be small.

Because the LDW water samples (Table D.4-2) were collected in the middle of the navigation channel rather than directly above the benches, where PCB concentrations are known to be the highest, it is possible that the extreme high end of the water PCB range was not captured in the empirical data. However, because the PCB water concentration used in the FWM represents a yearly average of the exposure throughout the entire LDW, the uncertainty associated with the variability in LDW water concentrations is minimized.

The bottom three cells from the EFDC model, which represent 1 to 12 ft of water depth, were selected to represent the exposure of all species to PCBs in the water column (i.e.,

was set equal to the mode of water concentration triangular distribution). Although different species occupy different water depths in the LDW, and thus could be exposed to somewhat different concentrations of waterborne PCBs, most of the species modeled (e.g., English sole, crabs, clams, benthic invertebrates) spend the majority of their lives at or near the sediment/water interface. The FWM is not amenable to assigning different PCB concentrations in water to different species. Instead, the potentially higher exposure of organisms dwelling on the river bottom to chemicals present in sediment is accounted for by the species-specific porewater ventilation rate. The degree of porewater exposure was set proportional to the porewater ventilation rate assumed for each modeled species. Species with high porewater exposure (e.g., benthic invertebrates) had high porewater ventilation rates; species with low porewater exposure (e.g., shiner surfperch) had low porewater ventilation rates. The total PCB concentrations in porewater were estimated in the FWM based on equilibrium partitioning with sediment.

D.4.1.3 Tissue data

Site-specific tissue data for target species and benthic invertebrates, including percent lipids, percent moisture, body weights, and total PCB concentrations, were generated in a series of sampling events, including the larger datasets derived as part of the RI. Data from different sampling events identified as acceptable for use in the RI (Windward 2005j) were combined and used for the FWM (Table D.4-3). Phase 1 data for Dungeness crabs and shiner surfperch were used; Phase 1 data for other species were not used because Phase 1 composite samples were not whole-body samples (i.e., only fillet [fish] and edible meat [crabs] were available). Body weights, water content, and lipid content data were used as input values for the FWM (Table D.4-3). Total PCB concentrations were used in model calibration, as discussed in Section D.5.

Table D.4-3. Tissue datasets used in the FWM

Year	Species	Tissue Type	No. of Individuals per Composite Tissue Sample	No. of Composite Tissue Samples Analyzed	Parameter	Source
LDW RI						
2005	Dungeness crab	edible meat	5	3	weight, lipid content, water content (from % solids), PCB Aroclors	Windward (2006a)
		hepatopancreas	5	3		
	slender crab	edible meat	5	1		
		hepatopancreas	10	1		
	English sole	whole body	5	11		
		paired skin-on fillet and remainder[a]	5	10		
	shiner surfperch	whole body	10	22		
	Pacific staghorn sculpin	whole body	10	4		
2004	benthic invertebrates	whole body	> 100	20	weight, lipid content, PCB Aroclors, PCB congeners[b]	Windward (2005a, b)
	clams	whole body	19 – 52	14	weight (from length data), lipid content, water content (from % solids), PCB Aroclors	
	Dungeness crab	edible meat	5	7	weight, lipid content, water content (from % solids), PCB Aroclors	Windward (2005c, e)
		hepatopancreas	6 – 15	3		
	slender crab	edible meat	5	12		
		hepatopancreas	15 – 18	4		
	English sole	whole body	5	21		
	Pacific staghorn sculpin	whole body	7 – 10	24		
	shiner surfperch	whole body	9 – 10	24		

Year	Species	Tissue Type	No. of Individuals per Composite Tissue Sample	No. of Composite Tissue Samples Analyzed	Parameter	Source
King County CSO water quality assessment for the Duwamish River and Elliott Bay						
1997	Dungeness crab	edible meat	3	2	lipid content, water content (from % solids), PCB Aroclors	King County (1999)
		hepatopancreas	3	1		
	shiner surfperch	whole body	10	3	lipid content, PCB Aroclors	

[a] The remainder is the portion of fish that remains after the removal of the skin-on fillet. These remainder and fillet data were used to estimate whole-body English sole concentrations as specified in the quality assurance project plan (Windward 2005i) and the data report (Windward 2006a).

[b] PCB congener data were used in the derivation of log K_{OW} values.

CSO – combined sewer overflow

FWM – food web model

PCB – polychlorinated biphenyl

D.4.1.3.1 Lipid and water content

Tissue composite samples collected from the LDW were used to determine mean and SE estimates for lipid content (v_{LB}) and water content (v_{WB}) for fish, crabs, clams, and benthic invertebrates. Water content for benthic invertebrates and lipid content for juvenile fish were derived from the literature (Table D.4-1). Water content (V_{WB}) was calculated from total solids using the following equation:

$$V_{WB} = (100 - \text{total solids}) \qquad \textbf{Equation D.4-2}$$

Ten of the twenty-one English sole samples in the 2005 tissue dataset were paired English sole fillet and remainder samples. Whole-body lipid content for each of these English sole whole-body composite samples was calculated using the following equation:

$$V_{LWB} = \left(\left(\frac{W_F}{W_F + W_R}\right) \times V_{LF}\right) + \left(\left(\frac{W_R}{W_F + W_R}\right) \times V_{LR}\right) \qquad \textbf{Equation D.4-3}$$

Where:

V_{LWB} = lipid content of calculated whole-body composite sample (%)
V_{LF} = lipid content of fillet composite sample (%)
V_{LR} = lipid content of remainder composite sample (%)
W_F = weight of fillet composite sample (kg)
W_R = weight of remainder composite sample (kg)

Lipid content is a particularly important parameter in the bioaccumulation of hydrophobic chemicals. The lipid content of fish and crab collected from the LDW varied within each sampling event and from year to year. Seasonal differences may have also contributed to differences in lipid content in the samples collected in the 1990s relative to those collected for the RI. The variability in lipid contents could be the result of variability in food abundance, food type, changing dietary preferences, or a myriad of other factors that could affect the condition of fish and crabs. Figure D.4-2 shows the available lipid content data for whole-body English sole and shiner surfperch and in Dungeness and slender crab edible tissue samples. Graphs presenting variability in lipid and PCB concentrations over time are presented in Appendix E.5.

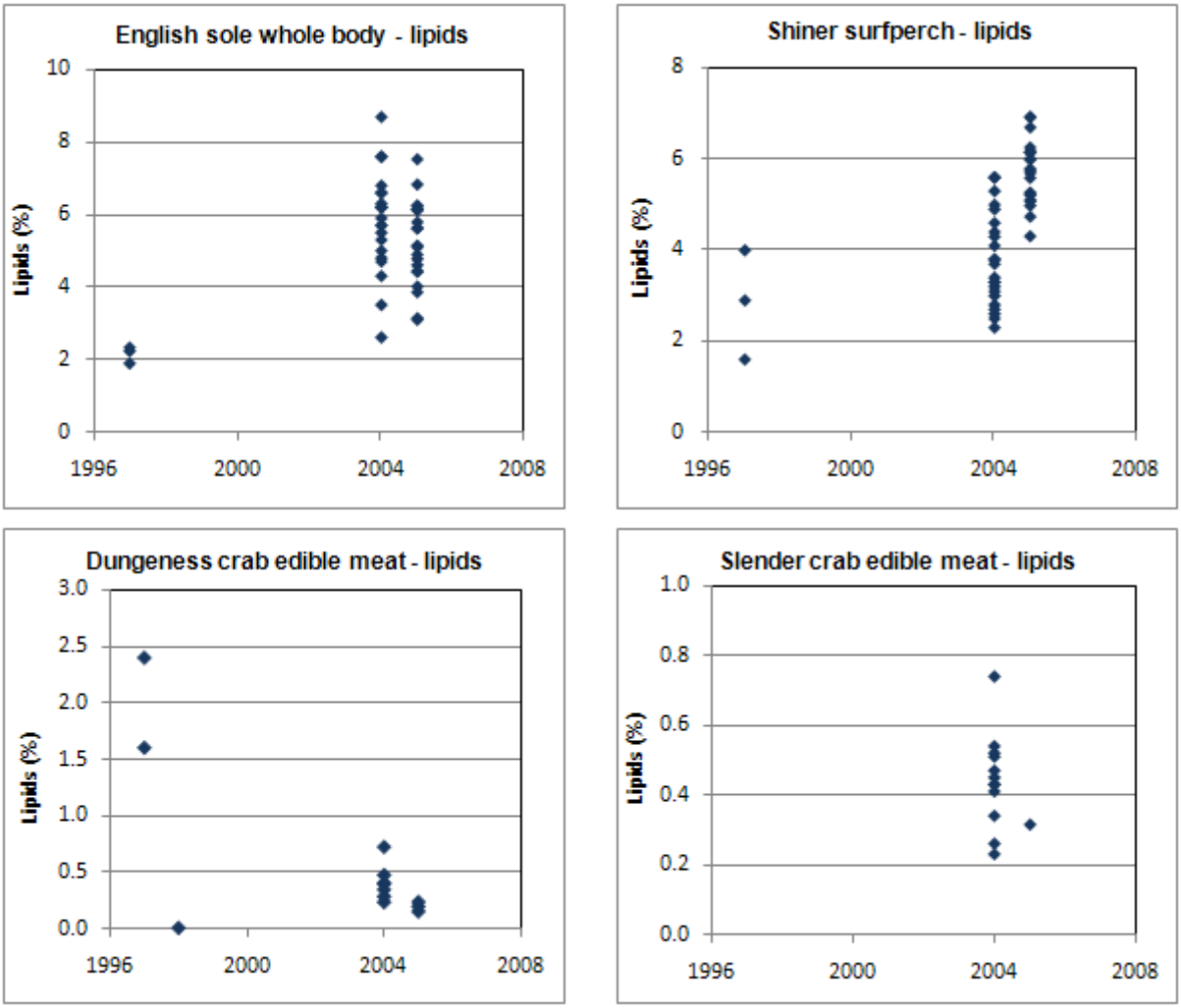

Figure D.4-2. Variability in fish and crab lipid content

The percent total solids content used to calculate water content for each of these English sole whole-body composite samples was calculated using the following equation:

$$V_{TSWB} = \left(\left(\frac{W_F}{W_F + W_R}\right) \times V_{TSF}\right) + \left(\left(\frac{W_R}{W_F + W_R}\right) \times V_{TSR}\right) \qquad \textbf{Equation D.4-4}$$

Where:

V_{TSWB} = total solids content of calculated whole-body composite sample (%)
V_{TSF} = total solids content of fillet composite sample (%)
V_{TSR} = total solids content of remainder composite sample (%)
W_F = weight of fillet composite sample (kg)
W_R = weight of remainder composite sample (kg)

Mean and SE estimates of whole-body lipid and water contents were calculated for Dungeness and slender crabs based on a combination of edible meat composite samples with corresponding hepatopancreas composite samples from the same crabs. Whole-body percentages of lipid or moisture content for Dungeness and slender crabs were estimated using the following equation:

$$V_{wb} = (V_h \times F_h) + (V_{em} \times F_{em}) \qquad \textbf{Equation D.4-5}$$

Where:

V_{wb} = lipid or moisture content in whole-body crabs (%)
V_h = lipid or moisture content in hepatopancreas of crabs (%)
V_{em} = lipid or moisture content in edible meat of crabs (%)
F_h = fraction of whole-body weight consisting of hepatopancreas weight
F_{em} = fraction of whole-body weight consisting of edible meat weight

The hepatopancreas and edible meat fractions were estimated to be 0.31 and 0.69, respectively, based on the ratio of wet masses of these tissues in a 16.6-cm Dungeness crab[22] dissected at Windward Environmental LLC.[23] Similar relative masses for edible meat and hepatopancreas were presented in Atar and Secer (2003).

Juvenile fish in the FWM represent small fish that would serve as prey for fish and crab species, such as Pacific staghorn sculpin and crabs. Juvenile shiner surfperch and juvenile starry flounder were the most abundant small fish (< 100 mm) captured in trawls during Phase 2 sampling events conducted in late summer (Windward 2005c, 2006a). Juvenile shiner surfperch and juvenile starry flounder represented 54 and 30%, respectively, of the non-target fish catch in 2004,[24] and 40 and 42%, respectively, in the 2005 sampling event. Thus, these species are likely prey for Pacific staghorn sculpin and crabs in the LDW.

Because they were not target fish during 2004 and 2005 sampling events, tissue data for juvenile starry flounder and juvenile shiner surfperch were not available (with the exception of limited weight data). Therefore, estimates for juvenile fish mean lipid content were calculated using Phase 2 adult shiner surfperch and adult English sole data (Table D.4-1). Because juvenile fish lipids are approximately 50% of adult lipid values (Gobas and Arnot 2005; Robards et al. 1999), mean lipid content for juvenile fish (2.5%) was estimated as 50% of the combined mean lipid content of adult shiner surfperch and adult English sole. The selection of this value was supported by the fact

[22] Maximum width of the shell from tip of spine to tip of spine.

[23] A live Dungeness crab was purchased and dissected at Windward to determine the relative weights of edible meat and hepatopancreas. The weights of the crab's edible meat and hepatopancreas were 158 g and 49 g, respectively.

[24] Non-target fish were individual fish not retained for tissue analysis either because they were too small or the wrong species. Each non-target fish captured was identified to species, measured (length), counted, and then returned to the LDW.

that 2.5% was both the median and the mode of mean lipid content values reported for 19 juvenile and small fish species eaten by salmon in the Bering Sea (Nomura and Davis 2005). Juvenile fish water content was based on Phase 2 adult shiner surfperch data.[25]

D.4.1.3.2 Body weights

Mean and SE estimates for fish and crab weights (W_B) were calculated based on the average whole-body weight of fish and crabs included in composite samples (W_C) collected in 2004 and 2005. The average whole-body weight for each fish or crab composite sample was calculated as a body weight-weighted average to account for the fact that composite samples included fish (or crabs) with different weights (kg), and thus some fish (or crabs) contributed more tissue mass (kg) to the composite sample than others. The body weight-weighted average for a given composite sample was calculated using Equation D.4-6.

$$W_C = \sum_{i=1}^{n}\left(W_i \times \left(\frac{W_i}{\sum W_{i...n}} \right) \right) \qquad \textbf{Equation D.4-6}$$

Where:

W_C = body weight-weighted average for a given composite sample (kg)
W_i = individual fish or crab weight from a given composite sample (kg)
n = number of individual fish or crabs included in a given composite sample

Mean weights of all composite samples were then calculated using the following equation:

$$W_B = \frac{\sum W_{C(i...n)}}{n} \qquad \textbf{Equation D.4-7}$$

Where:

W_B = mean weight for a given species of fish or crab (weight of biota) (kg)
W_C = body weight-weighted average for a given composite sample (kg)
n = number of fish or crab composite samples

Because the benthic invertebrate compartment was defined as a species assemblage, an estimate of the mean body weight across species (or other taxonomic groups) was needed to define mean and SE values for benthic invertebrates. Estimates of benthic invertebrate body weights in samples analyzed for PCBs were based on abundances of major taxonomic groups (i.e., annelids, crustaceans, mollusks, and miscellaneous taxa) of benthic invertebrates in taxonomy samples collected in 2004 (Windward 2005d)

[25]Lipid content values for juvenile fish were based on the literature (Table D.4-1).

combined with weight data of major taxonomic groups from samples analyzed for PCBs (Windward 2005b).

To estimate individual clam weights in the LDW, a regression relationship was developed between length and weight data for 609 individual *Mya arenaria* clams from the 2003 LDW intertidal and catch-per-unit effort surveys[26] (Windward 2004b). This regression was needed because lengths, but not weights, were determined in the 2004 sampling event for clams; clams collected in 2004 were analyzed for PCBs. Average clam weight estimates for the 14 clam composite samples collected in 2004 were calculated using 2004 mean length data from those samples (Windward 2005b) and the following regression equation developed from the 2003 data:

$$W_{Clam} = 0.106 \times (L_{Clam})^{2.9974} \qquad \textbf{Equation D.4-8}$$

Where:

W_{Clam} = weight of clam (g)
L_{Clam} = length of clam (cm)

Average and SE estimates of clam weights were calculated from the 14 mean composite sample weights calculated using Equation D.4-7.

D.4.1.4 Estimation of log K_{OW} for PCBs

The concentration-weighted average log K_{OW} value for total PCBs was estimated using site-specific concentrations of individual PCB congeners in benthic invertebrate tissue and the log K_{OW} values for individual PCB congeners from the literature (Equation D.4-9). A concentration-weighted average log K_{OW} was calculated using Equation D.4-9 for the eight benthic invertebrate tissue samples for which all 209 individual PCB congeners were analyzed (Windward 2005a) (Table D.4-4). PCB congener-specific log K_{OW}s were taken from Hawker and Connell (1988).

$$\text{Average log } K_{OW} = \frac{\sum_{i=1}^{n} C_i \times \log K_{OWi}}{\sum C_i} \qquad \textbf{Equation D.4-9}$$

Where:

C_i = Detected concentration of PCB congener i (µg/kg ww)
Log K_{OWi} = log K_{OW} of PCB congener i (L/kg)
n = number of detected PCB congeners

[26] The regression was developed using *Mya arenaria* data. Clam tissue samples collected from the LDW consisted mostly of *Mya arenaria*. A few composite samples had 2 to 3 *Macoma nasuta* individuals compared to 17 to 19 *Mya arenaria*. All other composite samples were composed only of *Mya arenaria*.

Table D.4-4. Weighted log K_{OW}s for benthic invertebrate composite samples

Sample ID	Weighted Log K_{OW} (L/kg)
LDW-B1b-T	6.6
LDW-B2a-T	6.5
LDW-B3b-T	6.5
LDW-B4b-T	6.5
LDW-B5a-T	6.4
LDW-B8a-T	6.9
LDW-B9b-T	6.5
LDW-B10a-T	6.5
Mean	**6.6**
Standard error	**0.05**

ID – identification
K_{ow} – octanol water partition coefficient

The decision to use a log K_{OW} based on benthic invertebrate tissue data was made in collaboration with EPA and NOAA. The mean and SE of the eight weighted log K_{OW} values for benthic invertebrates were used to define the normal distribution for log K_{OW}. The average log K_{OW} derived based on the pattern of PCB congeners in all available tissue types (i.e., fish, crabs, shellfish, and invertebrates) was the same as the average derived using only benthic invertebrate samples (Table D.4-5).

Table D.4-5. Average weighted log K_{OW}s for LDW species

Species	Number of Samples	Weighted Log K_{OW} (L/kg)	
		Range	Average
English sole	7	6.5 – 6.6	6.6
Pacific staghorn sculpin	8	6.6 – 6.8	6.7
Starry flounder	1	6.6	6.6
Shiner surfperch	9	6.4 – 7.0	6.7
Dungeness crab	5	6.5 – 6.7	6.6
Slender crab	7	6.6	6.6
Benthic invertebrates	8	6.4 – 6.9	6.6
Clams	8	6.2 – 6.8	6.4
Overall	**53**	**6.2 – 7.0**	**6.6**[a]

[a] The overall average was calculated using data from the 53 individual samples; it was not determined from the species averages.

K_{ow} – octanol water partition coefficient
LDW – Lower Duwamish Waterway

D.4.2 PARAMETER VALUES FROM LITERATURE DATA

Literature sources were used to derive water and lipid content for phytoplankton, weight and water and lipid content for zooplankton, water content for benthic invertebrates, and lipid content for juvenile fish. In addition, literature sources were used to derive values for fraction of porewater ventilated for all species, diets for all species, and densities for lipids and water (see Table D.4-1 for a description of methods and sources). Methods for determining values for these parameters are discussed below.

D.4.2.1 Values for organism lipid, water, and NLOC content and weight

Phytoplankton water and lipid content were derived from one study that reported lipid and NLOC content data for phytoplankton and macroalgae in False Creek, Burrard Inlet, Vancouver, British Columbia (Mackintosh et al. 2004). Data for green algae, brown algae, and phytoplankton were used because the phytoplankton/algae compartment in the model represents both phytoplankton and macroalgae. In Mackintosh et al. (2004), green and brown macroalgae samples were collected by hand, and plankton samples were collected using a 236-µm plankton tow net. The plankton tow net collected both phytoplankton and microzooplankton. Because microzooplankton are the same size as phytoplankton (20 to 200 µm), they are normally included in bulk analyses of phytoplankton as part of a constituent analysis (Olson 2006). Therefore, most marine FWMs include microzooplankton as part of their phytoplankton compartment (Olson 2006).

Mackintosh et al. (2004) reported lipid and NLOC content data for these species assemblages. Because phytoplankton and algae have low lipid concentrations, NLOC is an important organic chemical storage phase in these organisms. NLOC, which makes up a fraction of NLOM, is used rather than NLOM for phytoplankton/algae because it is a better predictor of organic chemical content in phytoplankton (Skoglund and Swackhamer 1999). Water content for phytoplankton was calculated from NLOC using the following equation:

$$\text{water content} = (100 - \text{NLOC}) \qquad \textbf{Equation D.4-10}$$

Where:

NLOC = non-lipid organic carbon content (%)

Mean and SE values of water and lipid content percentages were calculated across green algae, brown algae, and plankton (Table D.4-1).

Zooplankton lipid and water content were derived from a study in Maizura Bay, Japan (Kuroshima et al. 1987). In this study, five 1-month average values for lipid and water content were reported. Water content for each monthly average was used to convert lipid content from dry to wet weight.

Zooplankton body weights were derived from a study in Budd Inlet, Puget Sound, Washington (Giles and Cordell 1998). Twenty-one zooplankton samples were collected from six stations over 12 months. Zooplankton samples contained crustaceans, cnidarians, larvaceans, and polychaetes. Dry weights were converted to wet weights assuming 90% water content.

Benthic invertebrate water content was derived from the literature. Mean and range data for the water content of bivalves, isopods, amphipods, and cladocerans reported in an Oak Ridge National Laboratory publication (Sample et al. 1997) were used to derive mode, maximum, and minimum statistics of a triangular distribution for benthic invertebrate water content.

The SD value for juvenile fish lipids[27] (0.6%) was derived from a study of salmon prey fish in the Bering Sea (Nomura and Davis 2005) as the SE of lipid content for 19 juvenile and small fish species (0.3%) multiplied by a factor of 2. The SE was multiplied by 2 to account for variation in lipid values within species. In the Bering Sea study, samples were collected during the summer and fall of a single year and thus did not capture potential variation throughout the entire year or from year to year.

D.4.2.2 Diets

Simplifying assumptions must be made when estimating diets of aquatic species because ecosystems are complex, dynamic environments that cannot be fully characterized in a quantitative manner without a high level of uncertainty. Ecology, behavior, feeding observation studies, and stomach content analyses were considered in the creation of the simplified uptake routes and plausible dietary scenarios were developed to reflect average diets. Stomach content analyses were the dominant sources used in the creation of dietary scenarios.

Different dietary scenarios were created to represent the variability and uncertainty in the average feeding preference of the LDW resident species being modeled (Windward 2005h). To support the probabilistic approach used to calibrate the FWM, it was necessary to develop probability distributions for each dietary item for each species. Triangular distributions were assumed for each dietary item with mode, maximum, and minimum values derived from the dietary scenarios.[28]

Dietary scenarios were established for all species except phytoplankton and zooplankton. Although some phytoplankton species consume other plankton or detritus (e.g., mixotrophic dinoflagellates), the phytoplankton/algae compartment

[27] Mean lipid content for juvenile fish (2.5%) was estimated as 50% of the combined mean lipid content of adult shiner surfperch and English sole (Section D.4.1.3.1).

[28] Dietary triangular distributions for clams were derived from the literature and best professional judgment (see Table D.4-7).

was assumed to represent only photosynthesizing organisms. The diets of zooplankton were assumed to consist entirely of phytoplankton.

D.4.2.2.1 Fish and crab dietary scenarios

Three dietary scenarios were created for each target fish and crab species, with the exception of Dungeness crab, for which four dietary scenarios were created. Diets of fish and crabs are difficult to characterize because they likely vary by location, season, age, and size class. Fish and crab diets are also difficult to quantify in terms of mass or volume fractions because stomach content analyses favor items that are digested more slowly. In addition, certain feeding habits, such as scavenging or extensive mastication of food items, make food-item species identification difficult.

Although the FWM has five compartments, four compartments serve to categorize dietary prey species for fish or crabs: phytoplankton/algae, zooplankton, benthic invertebrates, and juvenile fish. The two benthic invertebrate compartments were combined into a single prey compartment to represent scavenger/predator/detritivore benthic invertebrates as well as small filter-feeding benthic invertebrates.[29] These species were combined into a single compartment because the empirical benthic invertebrate data from the LDW were available as composite samples with multiple species and because prey preference information is limited at the level of specific benthic invertebrate species. Zooplankton represent herbivorous invertebrates exposed to chemicals in the water column.[30]

Sediment is also a dietary item for fish or crabs. In order to create dietary scenarios for each fish and crab species, it was necessary to assign each species or organism type identified in stomach content studies to one of the four compartments above or to sediment. Fish and crabs consume a diversity of prey items, some of which were not represented in the above compartments (e.g., juvenile crabs and shrimp). As discussed below, shrimp and juvenile crabs were represented by benthic invertebrates or zooplankton in the dietary scenarios.

Three dietary scenarios were created for fish species and slender crab, which are all opportunistic feeders. Four dietary scenarios were created for Dungeness crabs (Table D.4-6). In general, Dietary Scenarios 1 and 2 were statistical estimates of the organisms' diets based on stomach content analyses presented in the literature. Dietary Scenario 2 was similar to Dietary Scenario 1, except that juvenile crab or shrimp prey items in the dietary studies were represented by zooplankton instead of benthic invertebrates. Zooplankton are a reasonable surrogate for juvenile crabs and shrimp because zooplankton, juvenile crabs, and shrimp are primarily exposed to

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[29] Large clams, *Mya arenaria*, were modeled separately (see Section D.7.3).

[30] Weight, lipid and water content, and dietary absorption efficiencies for the zooplankton compartment were derived solely from literature data for macrozooplankton (copepods, crustaceans, cnidarians, larvaceans, and polychaetes).

PCBs in water, unlike benthic invertebrates, which are in closer association with the sediment. Dietary Scenario 3 was created from studies that considered organism ecology and behavior in addition to stomach content analyses. Dietary Scenario 3 was the only scenario that included sediment as a fraction of the diet; sediment was assumed to be 10% of the diet of all fish and crab species for this scenario. Dungeness crab was the only species with a fourth dietary scenario. This scenario was based on an additional literature source that quantified stomach contents using a different metric (Gotshall 1977). These dietary scenarios were used to develop probability distributions applied in the FWM, as discussed in Section D.4.2.2.3.

Table D.4-6. Fraction of prey items consumed by fish and crab species in the four dietary scenarios

Species	Dietary Surrogate	Fraction of Diet[a]				Sources
		Scenario 1[b]	Scenario 2[c]	Scenario 3[d]	Scenario 4[b]	
Juvenile fish	zooplankton	0.07	0.17	0.05	na	Fresh et al. (1979); Miller et al. (1977); Wingert et al. (1979)
	benthic invertebrates	0.93	0.83	0.85	na	
	sediment	0	0	0.10	na	
Slender crab	zooplankton	0	0.12	0	na	Bernard (1979)
	benthic invertebrates	0.99	0.87	0.90	na	
	juvenile fish	0.01	0.01	0	na	
	sediment	0	0	0.10	na	
Dungeness crab	zooplankton	0	0.48	0	0	Stevens et al. (1982) for Scenarios 1 and 2; Gotshall (1977) for Scenario 4
	benthic invertebrates	0.63	0.16	0.75	0.75	
	juvenile fish	0.37	0.36	0.15	0.25	
	sediment	0	0	0.10	0	
Pacific staghorn sculpin	zooplankton	0	0.37	0.25	na	Fresh et al. (1979); Miller et al. (1977); Wingert et al. (1979)
	benthic invertebrates	0.56	0.19	0.50	na	
	fish	0.44	0.44	0.15	na	
	sediment	0	0	0.10	na	
Shiner surfperch	zooplankton	0.14	0.21	0.10	na	Fresh et al. (1979); Miller et al. (1977); Wingert et al. (1979)
	benthic invertebrates	0.86	0.79	0.80	na	
	sediment	0	0	0.10	na	
English sole	phytoplankton/ algae	0.08	0.07	0	na	Fresh et al. (1979); Wingert et al. (1979)
	zooplankton	0	0.05	0	na	
	benthic invertebrates	0.92	0.88	0.90	na	
	sediment	0	0	0.10	na	

[a] Unidentifiable prey items were not included in calculations (fractions were normalized without unidentified items).

[b] Crab and shrimp prey were assigned to the benthic invertebrate compartment.

[c] Crab and shrimp prey were assigned to the zooplankton compartment.

[d] Ten percent incidental sediment consumption was assumed for all fish and crab species. For Pacific staghorn sculpin, crab and shrimp prey were assigned to the zooplankton compartment.

na – not available; no scenario investigated

D.4.2.2.2 Benthic invertebrate dietary scenarios

Benthic invertebrate communities in the LDW are composed of many species from numerous phyla within multiple feeding guilds. The 20 benthic invertebrate composite tissue samples collected from the LDW in 2004 consisted primarily of annelids (polychaetes), crustaceans (e.g., amphipods, isopods, cumaceans, copepods, decapods), and small mollusks (e.g., bivalves [*Macoma* sp.] and gastropods). Miscellaneous invertebrates included flatworms (Platyhelminthes), cnidarians, nematodes, and nemertines. Two dietary scenarios were created for benthic invertebrates to encompass the diversity of feeding modes in this multi-species compartment (Table D.4-7).

Table D.4-7. Fraction of prey items consumed by benthic invertebrates under the two dietary scenarios

Benthic Invertebrate Dietary Item	Dietary Fraction			
	Dietary Scenario 1		Dietary Scenario 2	
	Mean	Range	Mean	Range
Phytoplankton/algae	0.11	0.01 – 0.16	0.11	0.01 – 0.16
Zooplankton	0.05	0.01 – 0.07	0.12	0.02 – 0.17
Sediment	0.84	0.77 – 0.99	0.77	0.67 – 0.97

Benthic invertebrate dietary scenarios were established by estimating percent feeding guilds in benthic invertebrate samples and then assigning percentages of each dietary item to feeding guilds. Average percent feeding guilds (deposit feeders or detritivores, suspension feeders, and carnivores) were estimated for all LDW subtidal[31] benthic samples based on the literature[32] and information on major taxonomic groups in each sample (Windward 2005b). Each feeding guild was assigned percentages of benthic invertebrate dietary items, including phytoplankton, zooplankton, and sediment. Two

[31] Subtidal samples were used because is was necessary to compare species composition in samples collected for chemical analysis of tissue and samples collected for taxonomy, and sampling procedures were consistent for tissue and taxonomy samples in the subtidal.

[32] Various sources were used to determine feeding types of invertebrates identified in the LDW benthic invertebrate samples (Barnes and Mann 1980; California Academy of Sciences 2002; Cruz-Rivera and Hay 2001; Fauchald and Jumars 1979; Harbo 2001; Jensen 1995; Kozloff 1983; MarLIN 2002, 2004, 2005; Museum Victoria 1996; Palaeos 2004; Ricketts et al. 1985; Shimek 2003, 2004; Word 1990).

dietary scenarios were developed by having two different sets of assumptions about what dietary items were consumed by carnivores.

Dietary Scenario 1 was constructed assuming that carnivores consumed 100% sediment. Dietary Scenario 2 was constructed assuming that carnivores consumed 50% zooplankton and 50% sediment. Because the FWM does not allow for a fraction of a modeled species diet coming from their own model compartment and because some of the species in the benthic invertebrate samples are carnivores that eat other species also in the benthic invertebrate samples, it was necessary to assign a surrogate prey item to represent "cannibalism" within benthic invertebrates. Because total PCB concentrations in sediment were more similar to those in benthic invertebrates than in plankton or juvenile fish and because benthic invertebrates are in close association with sediment, sediment was used as a surrogate for benthic invertebrate prey consumed by benthic invertebrate carnivores. Zooplankton were used as a dietary item for carnivores to represent prey items exposed primarily to the water column. Both dietary scenarios assumed that suspension feeders consumed 30% zooplankton and 70% phytoplankton/algae and that deposit feeders consumed 100% sediment. Even though suspension feeders and deposit feeders consume a significant amount of detritus, a "detritus" compartment was not modeled because there were insufficient data to generate values for such a compartment. Surrogate prey items for detritus included both sediment (benthic detritus) and phytoplankton (water column detritus).

D.4.2.2.3 Probability distributions for diets

To calibrate the FWM using a probabilistic approach, probability distributions were developed for diets. Triangular distributions were assumed for diets because there were limited data (Table D.4-8). Because the dietary scenarios for each species were created using different assumptions, they represented a range of variability and uncertainty in the average diets (e.g., variability and uncertainty in mean population-level feeding preferences). Therefore, dietary scenarios served as the source of information from which dietary probability distributions were developed. Input on the relative fractions of phytoplankton and/or zooplankton consumed by benthic invertebrates, clams, juvenile fish, and shiner surfperch from NOAA and EPA also contributed to the development of dietary distributions (Field 2006). Mean values are presented in addition to modes (Table D.4-8) to facilitate comparison with post calibrated values, which are presented as mean, maximum, and minimum values (Attachment 2).

Table D.4-8. Summary of triangular dietary distributions for LDW food web model

Species	Dietary Item																			
	Sediment				Phytoplankton				Zooplankton				Benthic Invertebrates				Juvenile Fish			
	Min	Max	Mode	Mean	Min	Max	Mode	Mean	Min	Max	Mode	Mean	Min	Max	Mode	Mean	Min	Max	Mode	Mean
Benthic invertebrates	0.62	0.93	0.79	0.78	0.06	0.21	0.16	0.14	0.01	0.17	0.05	0.08	0	0	0	0	0	0	0	0
Clam	0.30	0.60	0.45	0.45	0.40	0.60	0.50	0.50	0	0.10	0.05	0.05	0	0	0	0	0	0	0	0
Juvenile fish	0	0.01	0	0	0	0	0	0	0.3	0.87	0.50	0.56	0.13	0.70	0.50	0.44	0	0	0	0
Slender crab	0	0.05	0	0.02	0	0	0	0	0	0.12	0.12	0.08	0.86	0.99	0.87	0.91	0.01	0.01	0.01	0.01
Dungeness crab	0	0.05	0	0.02	0	0	0	0	0	0.68	0.48	0.39	0.16	0.84	0.16	0.39	0.16	0.58	0.36	0.37
Pacific staghorn sculpin	0	0.05	0	0.02	0	0	0	0	0	0.50	0.25	0.25	0.04	0.83	0.50	0.46	0.17	0.68	0.25	0.37
Shiner surfperch	0	0.01	0.01	0.01	0	0	0	0	0.15	0.72	0.35	0.41	0.28	0.85	0.64	0.59	0	0	0	0
English sole	0	0.10	0.01	0.04	0.05	0.10	0.06	0.07	0	0.09	0.05	0.05	0.86	0.90	0.88	0.88	0	0	0	0

LDW – Lower Duwamish Waterway

D.4.2.3 Default values

For several parameters, literature-derived values from previous applications of the Arnot and Gobas model (Arnot and Gobas 2004a; Gobas and Arnot 2005) were used to estimate values and statistical descriptors. There were insufficient site-specific data and limited new literature data to derive new values or probability distributions for these parameters.

Point estimate values for eight parameters were taken directly from applications of the model for the Great Lakes (Arnot and Gobas 2004a) and San Francisco Bay (Gobas and Arnot 2005). The eight parameters were the filter feeder particle scavenging efficiency (σ), the disequilibrium factors for DOC and POC partitioning (D_{DOC}, D_{POC}), the proportionality constants that quantify the similarity in phase partitioning of DOC and POC relative to that of octanol (α_{DOC}, α_{POC}), the proportionality constant that expresses the sorption capacity of NLOC relative to octanol (β_{OC}), the dietary absorption efficiency of water (ε_W), and the rate constant for the growth of phytoplankton/algae (k_G).

Values for statistical descriptors (e.g., mean and SD) of probability distributions for the proportionality constant expressing the sorption capacity of NLOM relative to that of octanol, fractions of porewater and overlying water ventilated by all species (except plankton), dietary absorption efficiencies of lipids and NLOM, as well as values for resistance to chemical uptake through aqueous and organic phases for phytoplankton/algae were also derived from these previous applications of the Arnot and Gobas FWM.

D.5 Calibration

Calibration is a process of deriving a set of FWM parameter values that optimizes the ability of the FWM to estimate total PCB concentrations in tissues that match empirical data as closely as possible. This process is important because proper calibration should improve the FWM's performance in estimating RBTCs in sediment (Section D.9). However, improving the ability of the model to match empirical data does not necessarily mean that the "true" values for each parameter have been identified. Numerous combinations of parameters can result in similar estimates. The fact that a model has the ability to accurately estimate concentrations using the calibration dataset does not necessarily indicate that the model will accurately predict actual concentrations under all conditions.

The FWM is a steady-state model (i.e., it assumes that concentrations do not change as a function of time). Thus, it was not designed to estimate changes in tissue concentrations resulting from short-term physical perturbations in the system (e.g., seasonal influences, such as changing prey availability, or short-term physical disturbances, such as dredging). The FWM estimates average conditions that are

assumed to be stable as a function of time. Therefore, the empirical dataset selected for the calibration process is important; to be effective, the calibration data set should represent "average" conditions expected in the LDW.

The empirical data (i.e., total PCB concentrations in tissues collected from the LDW) used for calibrating the FWM were collected in the late 1990s, 2004, and 2005. The largest datasets were collected in 2004 and 2005. Based on empirical data, total PCB concentrations in tissue (as a sum of Aroclors) were higher in several species in 2004 than in other years (see Section 4.2.2.4 and Appendix E.5). Although additional tissue data were collected in 2006 and 2007, these data were not used for FWM calibration because they were not available at that time.

D.5.1 METHODS

The FWM was calibrated probabilistically in order to systematically explore the plausible combinations of parameter values and their ability to estimate empirical data. The calibration process involved three steps:

- Step 1. Monte Carlo simulation
- Step 2. Model performance filtering
- Step 3. Identification of the best-fit parameter set

Each step is discussed in detail in the following subsections.

D.5.1.1 Monte Carlo simulation

The FWM was run probabilistically in Excel® with Crystal Ball® software. For each of the thousands of Monte Carlo simulations, parameter values were randomly selected from the parameter probability distributions described in Section D.4. The resulting set of parameter values selected in each model run is termed a "parameter set."[33] Each parameter set yielded an estimate of total PCB concentrations in tissues of the modeled species.

During the Monte Carlo simulation, the probability distributions of dietary items for each species were treated as independent random variables, which meant that the sum of the dietary fractions had to be normalized (because dietary fractions must sum to 1). Dietary fractions for each species in the FWM were normalized by dividing each dietary fraction by the sum of all dietary fractions for a given species. Treating the dietary fractions as independent random variables greatly simplified the Monte Carlo simulation. However, as a consequence, the normalized dietary fractions for some parameter sets fell outside of their specified probability distributions. The easiest way to address this issue was to apply a diet filter. Therefore, the last action taken in the

[33] Point estimates were assigned for some parameters so that the same value was selected for that parameter for each Monte Carlo simulation.

Monte Carlo simulation step was to discard parameter sets if any of the normalized dietary fractions fell outside of their assigned ranges as defined in Table D.4-8. This step was a bookkeeping step, the only effect of which was to correct for an artifact of the way dietary fractions were defined.

D.5.1.2 Model performance filtering

The model performance filter step consisted of comparing estimated total PCB concentrations in tissues with available empirical data (i.e., total PCB concentrations detected in species collected in the LDW). The parameter sets that resulted in estimated concentrations that were outside specified bounds for empirical data (i.e., a difference greater than a factor of 2) were rejected. The remaining parameter sets were retained for use in the next step (i.e., identification of the best-fit parameter set) and also in the sensitivity and uncertainty analyses. Mean and range information for the empirical dataset used in model calibration is presented in Table D.5-1.

Model estimates were compared to mean concentrations of total PCBs in composite samples of fish and crabs collected from the LDW. Mean total PCB tissue concentrations were used rather than single composite sample values because the biological compartments in the FWM were assumed to represent populations, not individual organisms.

Benthic invertebrate tissue data were not used directly in the calibration because these data were not collected to provide a representative sampling of total PCB concentrations in benthic invertebrate tissue throughout the LDW. Instead, benthic invertebrate sampling was designed to sample a range of total PCB concentrations in sediment from various locations throughout the LDW. The data were collected in this manner to explore the relationship between total PCB concentrations in tissue and sediment through the use of a regression, so that total PCB concentrations in benthic invertebrate tissues could be estimated from an average total PCB concentration in sediment. A tissue-sediment regression (Equation D.5-1) was used to estimate a single total PCB concentration in benthic invertebrate tissues based on a SWAC of 380 µg/kg dw (the LDW-wide spatially weighted average total PCBs concentration in sediment).

$$C_{BI} = (0.34 \times C_S) + 75 \qquad \textbf{Equation D.5-1}$$

Where:

C_{BI} = total PCB concentration in benthic invertebrate tissue (µg/kg ww)
C_S = total PCB concentration in sediment (µg/kg dw)

Estimated total PCB concentrations in benthic invertebrates were compared to the single concentration of total PCBs in benthic invertebrates generated by the tissue-sediment regression.

Table D.5-1. Empirical dataset for calibration: total PCB concentrations detected in fish, crab, and benthic invertebrate tissues collected in Phase 1 (late 1990s) and Phase 2 (2004 and 2005)

Species	Total PCB Concentration in Tissues (µg/kg ww)		No. of Composite Samples	Notes	Dataset Summary
	Mean	Range			
Benthic invertebrates	200	na	20	Mean was estimated using surface sediment total PCB SWAC of 380 µg/kg dw for the entire LDW and the following tissue-sediment regression equation (described further in Attachment 1): $C_{BI} = (0.34 \times C_S) + 75$.	Phase 2 (2004) benthic invertebrate tissue data and co-located sediment data used for the tissue-sediment regression (n = 20), and Phase 1 and Phase 2 sediment data used for the total PCB SWAC
Slender crab	670	250 – 838	13	combined edible meat and hepatopancreas tissue samples[a]	Phase 2 (2004, n = 12) and Phase 2 (2005, n = 1)
Dungeness crab	1,100	420 – 1,900	12	combined edible meat and hepatopancreas tissue samples[a]	Phase 1 (n = 2), Phase 2 (2004, n = 7), and Phase 2 (2005, n = 3)
Pacific staghorn sculpin	900	430 – 2,800	28	whole-body tissue samples	Phase 2 (2004, n = 24) and Phase 2 (2005, n = 4)
Shiner surfperch	1,800[b]	350 – 18,400	49	whole-body tissue samples	Phase 1 (n = 3), Phase 2 (2004, n = 24), and Phase 2 (2005, n = 22)
English sole	2,300	610 – 4,700	42	whole-body tissue samples[c]	Phase 2 (2004, n = 21) and Phase 2 (2005, n = 21)

[a] Concentrations in whole-body crab tissue (i.e., edible meat plus hepatopancreas) were calculated for each edible meat sample assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004.

[b] Mean would be 1,400 µg/kg ww if the 18,400-µg/kg ww sample in Area M2 were excluded.

[c] Ten English sole samples (three each from Areas M1, M2, and M3 and one from Area M4) from 2005 were "calculated whole-body" from paired fillet and remainder samples.

dw – dry weight
LDW – Lower Duwamish Waterway
n – number of composite samples
na – not applicable
PCB – polychlorinated biphenyl
ww – wet weight

Clams were included as target species in the FWM to support calculations of sediment RBTCs for human health consumption scenarios (see Section D.9). The FWM was not calibrated for clams because clams are present only in intertidal areas in the LDW with suitable habitat.[34] No empirical data existed for phytoplankton, zooplankton, or juvenile fish, so the model was not calibrated for those species.

A species predictive accuracy factor (SPAF) was selected as the metric for model performance evaluation (i.e., to quantitatively compare model estimates and empirical data). The SPAF is the ratio of estimated to empirical total PCB concentrations in tissue for a given species, or the inverse of that ratio, whichever is greater (i.e., the SPAF will always be a number greater than 1). Accordingly, if the estimated concentration was greater than the empirical concentration, Equation D.5-2 was used to calculate the SPAF:

$$SPAF = \frac{C_M}{C_E} \qquad \textbf{Equation D.5-2}$$

Where:

C_M = model-estimated total PCB concentration in tissue (µg/kg ww)
C_E = mean empirical total PCB concentration in tissue (µg/kg ww)

If the estimated concentration was less than empirical concentration, the reciprocal ratio (Equation D.5-3) was used:

$$SPAF = \frac{C_E}{C_M} \qquad \textbf{Equation D.5-3}$$

A perfect correlation between model-estimated and mean empirical concentrations would result in a SPAF of 1. Any difference between the model-estimated and mean empirical tissue concentrations would result in a SPAF > 1.

To meet the selected model performance criterion, SPAFs for all species had to be $\leq$ 2. If the SPAF of any species was > 2, the corresponding parameter set was rejected. This model performance criterion was selected at a meeting on October 6, 2006, by participating parties, including Lower Duwamish Waterway Group (LDWG), EPA, and NOAA.

In order to understand a model performance assessment, it is important to understand the metric used. If a model run has a SPAF of X, the model's estimate differs from the

[34] The FWM was not calibrated using empirical clam tissue data because the empirical data were not considered representative of the entire area being modeled because large clams for which empirical data are available (i.e., *Mya arenaria*) were only collected in intertidal areas where clamming might occur. Model estimates of PCB concentrations in clam tissues were compared to empirical data from the various LDW areas to assess model performance. This assessment was needed to ensure that the estimates were sufficiently similar to empirical data to be used in the derivation of RBTCs (see Section D.7.3).

empirical data to which it is being compared by a factor of X. Thus, model estimates with equal distance but opposite direction from an empirical data point (e.g., ±100 µg/kg ww from a mean concentration) will have different SPAFs, with the over-estimate always having a higher SPAF. For example, if the mean empirical total PCB concentration in Pacific staghorn sculpin tissue is 900 µg/kg ww, and for one parameter set the model estimate is 1,000 µg/kg ww (i.e., 100 µg/kg ww greater than the mean empirical concentration) and for another parameter set the model estimate is 800 µg/kg ww (i.e., 100 µg/kg ww less than the mean empirical concentration), the percent difference of both model estimates from the mean empirical tissue chemical concentration is 11.1%, but the SPAFs are 1.11 and 1.13, respectively. SPAF and percent difference metrics are both useful tools for assessing model performance. The SPAF metric was used to assess model performance.

Parameter sets that met the model performance criterion (SPAF ≤ 2 for all species) were checked to ensure that unrealistic relationships among parameters did not occur (e.g., if temperature and DO, which should be negatively correlated, were found to be positively correlated with an r-value greater than 0.3). These combinations could occur by chance during Monte Carlo sampling. None of the parameter sets that met the model performance criterion were excluded based on this review.

D.5.1.3 Identification of the best-fit parameter set

The final step in the FWM calibration was to identify the parameter set that produced estimates most similar to the empirical data (i.e., mean total PCB concentrations in tissues). This parameter set was defined as the parameter set with the lowest mean SPAF across all species with empirical data. To identify this parameter set, the average SPAF across species was calculated for each parameter set that passed the model performance filter. Parameter sets were then sorted by average SPAF across species, and the set with the lowest average SPAF was identified.

D.5.2 RESULTS

The calibration process identified FWM parameter sets that estimated total PCB concentrations for all species within a factor of 2 of empirical data (i.e., SPAF ≤ 2).

The mean SPAF across species for parameter sets passing the model performance criterion was 1.4 (Table D.5-2). The SPAF for the best-fit parameter set was 1.2. Empirical data were not available for total PCB concentrations in phytoplankton, zooplankton, and juvenile fish tissues and, hence, were not included in the tabulated summary of model performance (Table D.5-2).

Table D.5-2. Summary of model performance

Species	SPAFs from Parameter Sets that Passed the Model Performance Filter			
	Closest to Empirical (by species)	Greatest Under-Prediction (by species)	Greatest Over-Prediction (by species)	Best Fit (for all species)
Benthic invertebrate	1.2	na[a]	2.0	1.5
Slender crab	1.0	**2.0**	2.0	1.0
Dungeness crab	1.0	**2.0**	2.0	1.1
Pacific staghorn sculpin	1.0	**1.2**	2.0	1.2
Shiner surfperch	1.0	**2.0**	1.2	**1.2**
English sole	1.0	**1.3**	1.7	1.1
Average SPAF	1.0	**1.6**	1.8	1.2

[a] There were no under-predictions for benthic invertebrates.

na – not applicable

SPAF – species predictive accuracy factor

Bold indicates an under-prediction.

Estimated total PCB concentrations in fish and crab tissues associated with the best-fit parameter sets were generally similar to mean empirical data for each species (Figure D.5-1). The estimates associated with the best-fit parameter sets were generally higher than the mean empirical data, with the exception of shiner surfperch. Possible reasons for overestimation are discussed in Section D.6.2.4. The benthic invertebrate tissue concentration, estimated using the tissue-sediment regression and an LDW-wide SWAC of 380 µg/kg dw, was lower than the benthic invertebrate tissue concentration estimated by the FWM using the best-fit parameter set (Figure D.5-2).

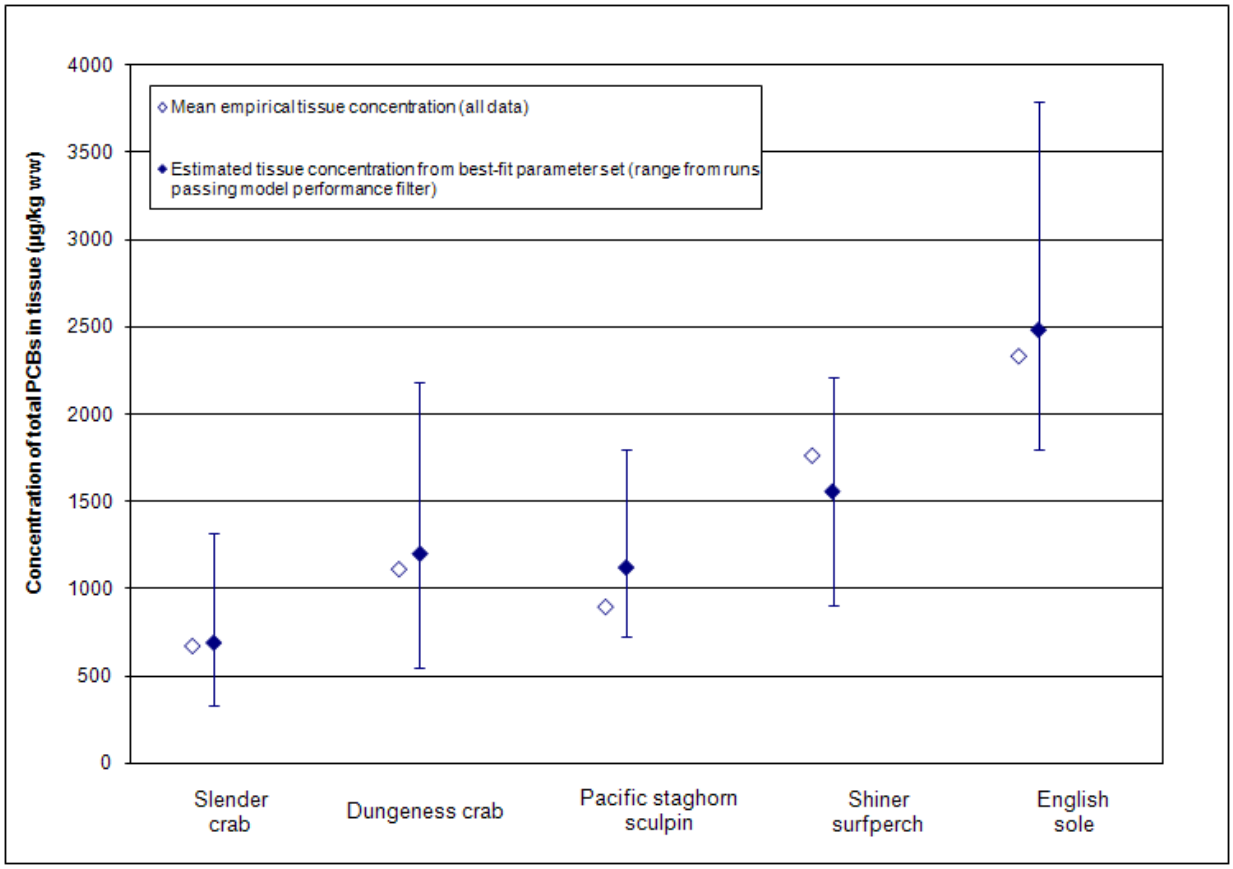

Figure D.5-1. Estimated total PCB concentrations in tissues of adult fish and crab species for parameter sets that passed the model performance filter in the best-fit model parameter set relative to empirical data

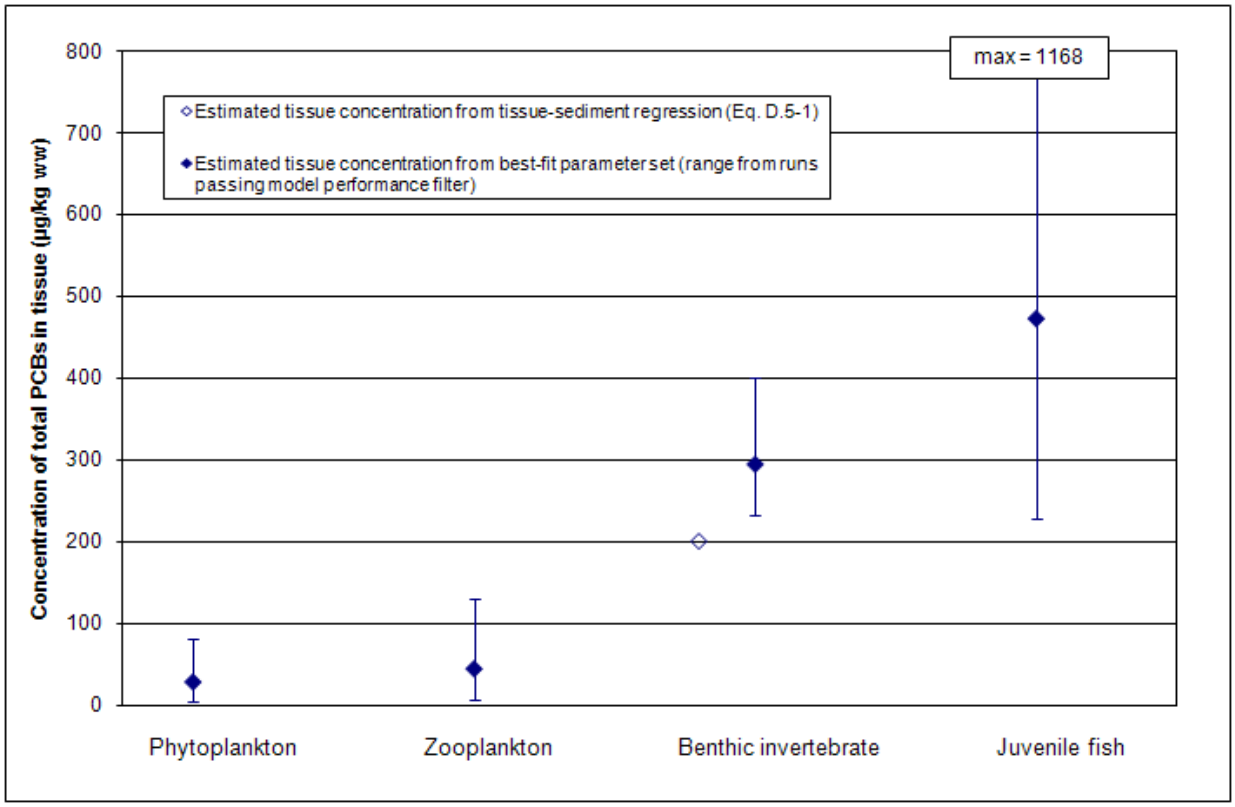

Figure D.5-2. Estimated total PCB concentrations in tissues of prey species for parameter sets that passed the model performance filter in the best-fit model parameter set relative to empirical data

The calibration process rejected parameter sets that resulted in estimated tissue concentrations greater than a factor of 2 from empirical values for any species. Therefore, as part of the calibration process, parameter values were adjusted to optimize the fit of the model estimates to empirical total PCB data. Relative to the original model input values (Table D.4-1), the best-fit parameter set (Table D.5-3) generally had:

- Lower total PCB concentrations in the water column compared to the average predicted by the EFDC model (1.43 ng/L)
- Lower uptake of total PCBs by benthic invertebrates (e.g., lower lipid content, lower dietary absorption efficiencies, greater fraction of zooplankton [surrogate for detritus] instead of sediment in diet)
- Higher dietary fraction of plankton (which was also intended to partially represent detritus) and a lower dietary fraction benthic invertebrates and sediment for some species

Table D.5-3. Best-fit parameter set for the calibrated model

Parameter Description	Unit	Best-Fit Parameter Set
Environmental Parameters		
Concentration of total PCBs in the water column	ng/L	1.22
Concentration of POC in the water column	kg/L	2.3×10^{-7}
Concentration of DOC in the water column	kg/L	2.2×10^{-6}
Mean water temperature	°C	11.0
Concentration of dissolved oxygen in the water column	mg/L	8.15
Concentration of total suspended solids in the water column	kg/L	5.4×10^{-6}
Concentration of total PCBs in sediment	µg/kg dw	380
Sediment total organic carbon	%	1.91
Chemical Parameters		
Octanol-water partition coefficient for total PCBs (log K_{ow})	unitless	6.5
Biological Parameters		
Proportionality constant expressing the sorption capacity of NLOM relative to that of octanol (β)	unitless	0.031
Resistance to chemical uptake through aqueous phase for phytoplankton/ algae (A)	day-1	6×10^{-5}
Resistance to chemical uptake through organic phase for phytoplankton/ algae (B)	unitless	6.2
Density of lipids	kg/L	0.9
Phytoplankton		
Lipid content of organism	%	0.14
Water content of organism	%	95.7
Zooplankton		
Organism weight	kg	2.2×10^{-7}
Lipid content	%	1.4
Water content of organism	%	92
Dietary absorption efficiency of lipids (ε_L)	%	66
Dietary absorption efficiency of NLOM (ε_N)	%	72
Benthic Invertebrates		
Organism weight	kg	4.1×10^{-5}
Lipid content	%	0.83
Water content of organism	%	82
Relative fraction of porewater ventilated	unitless	0.13
Dietary absorption efficiency of lipids (ε_L)	%	30

Table D.5-3. cont. Best-fit parameter set for the calibrated model

PARAMETER DESCRIPTION	UNIT	BEST-FIT PARAMETER SET
Dietary absorption efficiency of NLOM (ε_N)	%	56
Juvenile Fish		
Organism weight	kg	6×10^{-3}
Lipid content	%	1.5
Water content of organism	%	74.3
Relative fraction of porewater ventilated	unitless	0.01
Dietary absorption efficiency of lipids (ε_L)	%	92
Dietary absorption efficiency of NLOM (ε_N)	%	54
Slender Crab		
Organism weight	kg	0.165
Lipid content	%	1.1
Water content of organism	%	83.7
Relative fraction of porewater ventilated	unitless	0.03
Dietary absorption efficiency of lipids (ε_L)	%	75
Dietary absorption efficiency of NLOM (ε_N)	%	76
Dungeness Crab		
Organism weight	kg	0.653
Lipid content	%	3.4
Water content of organism	%	81
Relative fraction of porewater ventilated	unitless	0.02
Dietary absorption efficiency of lipids (ε_L)	%	71
Dietary absorption efficiency of NLOM (ε_N)	%	59
Pacific Staghorn Sculpin		
Organism weight	kg	0.075
Lipid content	%	2.1
Water content of organism	%	79
Relative fraction of porewater ventilated	unitless	0.03
Dietary absorption efficiency of lipids (ε_L)	%	93
Dietary absorption efficiency of NLOM (ε_N)	%	50
Shiner Surfperch		
Organism weight	kg	0.019
Lipid content	%	4.6
Water content of organism	%	74.0
Relative fraction of porewater ventilated	unitless	0.02
Dietary absorption efficiency of lipids (ε_L)	%	94
Dietary absorption efficiency of NLOM (ε_N)	%	56

Table D.5-3. cont. Best-fit parameter set for the calibrated model

Parameter Description	Unit	Best-Fit Parameter Set
English Sole		
Organism weight	kg	0.246
Lipid content	%	5.5
Water content of organism	%	75.0
Relative fraction of porewater ventilated	unitless	0.1
Dietary absorption efficiency of lipids (ε_L)	%	92
Dietary absorption efficiency of NLOM (ε_N)	%	59
Dietary Fraction		
Benthic Invertebrates		
Sediment	fraction	0.70
Phytoplankton	fraction	0.18
Zooplankton	fraction	0.12
Juvenile Fish		
Sediment	fraction	0.00
Zooplankton	fraction	0.53
Benthic invertebrates	fraction	0.47
Slender Crab		
Sediment	fraction	0.02
Zooplankton	fraction	0.09
Benthic invertebrates	fraction	0.88
Juvenile fish	fraction	0.01
Dungeness Crab		
Sediment	fraction	0.00
Zooplankton	fraction	0.37
Benthic invertebrates	fraction	0.24
Juvenile fish	fraction	0.39
Pacific Staghorn Sculpin		
Sediment	fraction	0.00
Zooplankton	fraction	0.22
Benthic invertebrates	fraction	0.54
Juvenile fish	fraction	0.24
Shiner Surfperch		
Sediment	fraction	0.00
Zooplankton	fraction	0.23
Benthic invertebrates	fraction	0.76

Table D.5-3. cont. Best-fit parameter set for the calibrated model

PARAMETER DESCRIPTION	UNIT	BEST-FIT PARAMETER SET
English Sole		
Sediment	fraction	0.04
Phytoplankton	fraction	0.05
Zooplankton	fraction	0.05
Benthic invertebrates	fraction	0.86

DOC – dissolved organic carbon
dw – dry weight
NLOM – non-lipid organic matter
PCB – polychlorinated biphenyl
POC – particulate organic carbon

The minimum, maximum, mean, and range for parameter values for the 10 best performing model runs (based on lowest average SPAF across species) are presented in Attachment 2.

D.6 Sensitivity and Uncertainty Analyses

Sensitivity and uncertainty analyses were performed to assess the sensitivity of the FWM to individual input parameters in combination with the uncertainty in the estimates of those parameters. These analyses provide insight into uncertainties in the application of FWM results.

An uncertainty analysis is an evaluation of how uncertainties in model parameters affect the reliability of the model's output both qualitatively and quantitatively. Uncertainties can be reducible (i.e., they can be eliminated by gathering more information and/or considering available information differently) or irreducible (i.e., they cannot be eliminated because there is an element of either chance or variability in the parameter's distribution, such as variability across individuals in a population or within an individual over time).

A sensitivity analysis is an evaluation of how model estimates respond to changes in input values. The greater the response to a particular change (or set of changes), the higher the sensitivity to that parameter or parameters. A sensitivity analysis can thus provide information regarding the relative importance of uncertainties by examining their potential influence on model output.

All models are simplifications of the processes and parameters that they describe. The calibrated FWM is designed to represent, to the extent possible, the complicated relationship between sediment and tissue, including aquatic organism life histories and foraging strategies across the food web. It is important to assess the potential uncertainties in the FWM so that these uncertainties can be acknowledged in the

model's application. The following two sensitivity and uncertainty analyses were conducted using the best-fit parameter set and are described in this section:

- Correlation coefficient analysis
- Nominal range sensitivity (NRS) analysis

Because the SWAC was not varied in the calibration (i.e., it was treated deterministically as described in Section D.4.1.1), the influence of sediment concentration on model predictions was not examined as part of the correlation coefficient and NRS analyses described in this section.

Because the SWAC is an influential input parameter and was treated deterministically, any error in the point estimate of the SWAC used in calibration was countered by offsetting adjustments in other FWM parameters. Thus, the parameter sets identified through the calibration process were highly influenced by the SWAC. For these reasons, which underlie the importance of this parameter to FWM calibration and predictions, the sensitivity of the FWM to total PCB concentrations in sediment was investigated (see Section D.6.3).

D.6.1 CORRELATION COEFFICIENT ANALYSIS

Pearson product-moment correlation coefficients (r-values) were calculated to characterize the strength of correlations between each FWM parameter and estimated total PCB concentrations in tissues. For each parameter, the absolute values of the correlation coefficients were averaged across all species in the FWM to get a general sense of the degree of covariance between a given parameter and predicted total PCB concentrations in tissues of all species combined. The 20 parameters that correlated most strongly with tissue concentration estimates (i.e., had the highest average absolute r-values) were carried forward into the NRS analysis. Parameters for which correlations were lower were not evaluated further because they had relatively low influence on model estimates.

Because the correlation coefficient analysis used output from the Monte Carlo runs, it accounted for parameter interactions as opposed to univariate analyses, which hold all other parameter values constant while changing the value for one parameter at a time. The NRS (Section D.6.2) is a univariate analysis. Because the correlation analysis incorporated parameter interactions, it was the most suitable analysis for identifying the 20 most important parameters.

The 20 parameters with the highest average absolute value correlation coefficients across species are presented in Table D.6-1. A positive correlation indicates that an increase in a parameter value led to an increase in estimated total PCB concentrations in tissue for a given species. A negative correlation indicates that an increase in a parameter value led to a decrease in the estimated concentrations for a given species. In general, parameter values that most strongly correlated with estimates for at least one tissue type included those that:

- Affected PCB exposure in the water column, particularly the concentration of total PCBs (for phytoplankton and zooplankton)
- Contributed to the uptake of total PCBs, including dietary absorption efficiencies (for crabs) and lipid content (for various species)
- Characterized dietary preferences (e.g., pelagic vs. benthic components of the food web) (for shiner surfperch, juvenile fish, Pacific staghorn sculpin)
- Affected the uptake of total PCBs by benthic invertebrates (e.g., porewater ventilation) (for English sole)

Table D.6-1. Parameters most strongly correlated with estimated total PCB concentrations in tissues

Parameter	Correlation Coefficient										
	Maximum Correlation	Average Correlation (Absolute Value)	Phyto-plankton	Zooplankton	Benthic Inverte-brates	Juvenile Fish	Slender Crab	Dungeness Crab	Pacific Staghorn Sculpin	Shiner Surfperch	English Sole
Concentration of total PCBs in the water column	**0.96**	0.37	**0.96**	0.86	0.09	0.31	0.06	0.17	0.33	0.32	0.19
Dietary absorption efficiency of lipids for slender crab	**0.75**	0.10	-0.02	-0.01	-0.03	-0.03	**0.75**	-0.01	-0.01	-0.01	-0.02
Fraction of benthic invertebrates in diet of shiner surfperch	**0.68**	0.10	-0.04	-0.03	-0.04	-0.01	-0.03	-0.05	-0.001	**0.68**	-0.05
Fraction of zooplankton in diet of shiner surfperch	**-0.68**	0.10	0.04	0.03	0.04	0.01	0.03	0.05	0.002	**-0.68**	0.05
Dietary absorption efficiency of lipids for Dungeness crab	**0.67**	0.11	-0.04	-0.04	-0.04	-0.03	-0.03	**0.67**	-0.03	-0.06	-0.02
Lipid content of juvenile fish	**0.61**	0.16	-0.07	-0.08	-0.07	**0.61**	-0.05	0.06	0.27	-0.09	-0.12
Fraction of benthic invertebrates in diet of juvenile fish	**0.46**	0.15	-0.04	-0.06	-0.11	**0.46**	-0.05	0.17	0.25	-0.10	-0.14
Fraction of zooplankton in diet of juvenile fish	**-0.46**	0.15	0.04	0.06	0.11	**-0.46**	0.05	-0.17	-0.26	0.10	0.14
Dietary absorption efficiency of NLOM for slender crab	**0.46**	0.07	-0.01	0.01	0.02	0.01	**0.46**	-0.03	0.01	-0.02	0.01
Lipid content of zooplankton	**0.41**	0.07	-0.01	**0.41**	-0.03	0.04	-0.02	-0.07	0.02	0.01	-0.04
Relative fraction of porewater ventilated by benthic invertebrates	**0.36**	0.14	-0.07	-0.10	0.28	0.03	0.13	0.05	0.11	0.13	**0.36**
Lipid content of Dungeness crab	**0.30**	0.06	-0.03	-0.02	-0.03	-0.001	-0.04	**0.30**	-0.03	-0.02	-0.06
Fraction of zooplankton in diet of Pacific staghorn sculpin	**-0.30**	0.09	0.07	0.07	0.04	0.13	0.05	0.04	**-0.30**	0.03	0.09
Density of lipids	**-0.29**	0.09	0.10	0.04	-0.02	0.02	-0.03	-0.04	-0.12	-0.16	**-0.29**
Water content of benthic invertebrates	**-0.28**	0.09	0.03	0.03	**-0.28**	-0.02	0.11	0.03	0.06	0.05	0.19
Fraction of juvenile fish in diet of Pacific staghorn sculpin	**-0.25**	0.12	-0.11	-0.10	-0.11	**-0.25**	-0.05	-0.11	0.14	-0.10	-0.12
Dietary absorption efficiency of NLOM for benthic invertebrates	**0.25**	0.10	-0.10	-0.11	0.20	0.01	0.11	0.04	0.02	0.07	**0.25**
Lipid content of benthic invertebrates	**0.24**	0.06	-0.05	-0.05	**0.24**	0.01	-0.08	-0.05	-0.02	-0.004	-0.06
Log octanol-water partition coefficient (log K_{OW}) for total PCBs	**0.20**	0.10	-0.003	0.05	0.05	0.08	0.15	0.06	**0.20**	0.16	0.12
Weight of benthic invertebrates	**0.20**	0.08	-0.03	-0.04	0.17	0.02	0.04	0.02	0.06	0.11	**0.20**

NLOM – non-lipid organic matter PCB – polychlorinated biphenyl

Bold identifies the maximum correlation for each parameter.

D.6.2 NOMINAL RANGE SENSITIVITY ANALYSIS

In the NRS analysis, the input values for each of the top 20 parameters were varied, one at a time, from their minimum to their maximum values while all other FWM parameters were held at their best-fit parameter set values.[35] Minimum and maximum parameter values were identified in the sets passing the model performance filter for each of the top 20 parameters (Table D.6-2).

Table D.6-2. Minimum and maximum values for each parameter evaluated in the NRS

PARAMETER DESCRIPTION	UNIT	VALUES FROM PARAMETER SETS THAT PASSED MODEL PERFORMANCE FILTER FROM CALIBRATION 1	
		MINIMUM	MAXIMUM
Concentration of total PCBs in the water column	ng/L	0.218	2.940
Log octanol-water partition coefficient for PCBs (log K_{ow})	unitless	6.4	6.8
Density of lipids	kg/L	0.8	1.0
Zooplankton lipid content	%	0.2%	2.3%
Weight of benthic invertebrates	kg	7.1×10^{-8}	1.2×10^{-4}
Lipid content of benthic invertebrates	%	0.69%	1.05%
Water content of benthic invertebrates	%	71%	87%
Relative fraction of porewater ventilated by benthic invertebrates	unitless	0.050	0.247
Dietary absorption efficiency of NLOM (ε_N) for benthic invertebrates	%	17%	93%
Lipid content juvenile fish	%	0.6%	4.6%
Dietary absorption efficiency of lipids (ε_L) for slender crab	%	16%	95%
Dietary absorption efficiency of NLOM (ε_N) for slender crab	%	16%	95%
Lipid content of Dungeness crab	%	1.1%	4.2%
Dietary absorption efficiency of lipids (ε_L) for Dungeness crab	%	16%	96%
Relative fraction of zooplankton in juvenile fish diet	fraction	0.35	0.81
Relative fraction of benthic invertebrates in juvenile fish diet	fraction	0.18	0.65
Relative fraction of zooplankton in Pacific staghorn sculpin diet	fraction	0.01	0.50
Relative fraction of juvenile fish in Pacific staghorn sculpin diet	fraction	0.172	0.661
Relative fraction of zooplankton in shiner surfperch diet	fraction	0.188	0.689
Relative fraction of benthic invertebrate in shiner surfperch diet	fraction	0.304	0.803

NLOM – non-lipid organic matter
PCB – polychlorinated biphenyl

[35] Nominal range sensitivity analysis is conventional terminology, but this analysis can also be referred to as an uncertainty analysis because it provides information about how uncertainties in model parameters affect the reliability of the model's output. The term "sensitivity" was adopted for this section to emphasize the comparative nature of the analysis.

Each of the minimum and maximum values was substituted, in turn, into the best-fit parameter set, yielding 40 new estimates of total PCB concentrations in each species' tissue. For each of the 20 parameters, NRS was calculated for each species as:

$$NRS = \left|\left(C_{Max} - C_{Min}\right)\right| \qquad \textbf{Equation D.6-1}$$

Where:

C_{Max} = estimated total PCB concentration in tissue when the maximum value for the parameter being tested was substituted into the best-fit parameter set

C_{Min} = estimated total PCB concentration in tissue when the minimum value for the parameter being tested was substituted into the best-fit parameter set

A parameter's NRS value is a measure of the relative influence that parameter has on the uncertainty of FWM tissue estimates for each species.

NRS values for each parameter for each species are presented in Table D.6-3. NRS values ranked by maximum NRS value across species indicate the relative potential effect of a given parameter on the uncertainty of FWM estimates. In order to understand the importance of a parameter, it is necessary to compare the NRS value to the estimated total PCB concentration for each modeled species (Table D.6-3). This comparison provides a sense of the magnitude of the uncertainty associated with a specific parameter relative to the estimate.

Table D.6-3. NRS values for the top 20 parameters

Parameter	NRS (µg/kg ww)								
	Phyto-plankton	Zoo-plankton	Benthic Inverte-brates	Juvenile Fish	Slender Crab	Dungeness Crab	Pacific Staghorn Sculpin	Shiner Surfperch	English Sole
Dietary absorption efficiency of lipids (ε_L) for Dungeness crab	0	0	0	0	0	**1,200**	0	0	0
Weight of benthic invertebrates	0	0	130	160	280	400	410	610	**920**
Lipid content of Dungeness crab	0	0	0	0	0	**840**	0	0	0
Relative fraction of benthic invertebrates in the shiner surfperch diet	0	0	0	0	0	0	0	**830**	0
Relative fraction of porewater ventilated by benthic invertebrates	0	0	110	140	240	350	360	530	**800**
Relative fraction of zooplankton in the shiner surfperch diet	0	0	0	0	0	0	0	**790**	0
Concentration of total PCBs in the water column	63	100	61	280	190	**740**	520	560	600
Lipid content of juvenile fish	0	0	0	**680**	5.3	450	510	0	0
Dietary absorption efficiency of NLOM (ε_N) for benthic invertebrates	0	0	86	110	180	270	270	410	**620**
Dietary absorption efficiency of lipids (ε_L) for slender crab	0	0	0	0	**570**	0	0	0	0
Log octanol-water partition coefficient (Log K_{OW}) for total PCBs	6.6	20	69	240	270	**560**	550	560	540
Relative fraction of zooplankton in the juvenile fish diet	0	0	0	340	7.5	**560**	300	0	0
Relative fraction of benthic invertebrates in the juvenile fish diet	0	0	0	340	7.5	**560**	300	0	0
Density of lipids	0.5	8.4	36	110	130	310	320	380	**550**
Lipid content of benthic invertebrates	0	0	75	86	77	190	210	330	**460**
Relative fraction of zooplankton in Pacific staghorn sculpin diet	0	0	0	0	0	0	**460**	0	0
Relative fraction of juvenile fish in Pacific staghorn sculpin diet	0	0	0	0	0	0	**380**	0	0
Dietary absorption efficiency of NLOM (ε_N) for slender crab	0	0	0	0	**310**	0	0	0	0
Lipid content of zooplankton	0	57	24	6.4	91	**230**	40	75	170
Water content of benthic invertebrates	0	0	92	59	93	130	56	**160**	140
FWM-estimated total PCB concentrations in tissue (for reference)	28	45	300	470	690	1,200	1,100	1,600	2,500

NLOM – non-lipid organic matter
NRS – nominal range sensitivity
PCB – polychlorinated biphenyl
ww – wet weight

Bold indicates maximum NRS for that parameter.

Parameters that influenced estimates for all species are concentration of total PCBs in the water column, log K_{OW}, and density of lipids (Table D.6-3). All five benthic invertebrate parameters had an effect on all species except phytoplankton and zooplankton. Parameters specific to an adult fish or crab species (e.g., dietary absorption efficiency of lipids (ε_L) for Dungeness crab) influenced tissue estimates for that species only.

The results of the correlation coefficient analysis (Table D.6-1) and the NRS analysis (Table D.6-3) are different. These differences can be partly explained by the fact that correlation coefficients take parameter interaction into account, whereas NRS values are based on the effect of changing one parameter value at a time while all other values are held constant.

NRS values for benthic invertebrates, juvenile fish, and fish and crab species are presented graphically in Figures D.6-1 to D.6-7. Estimated correlation coefficients from the correlation analysis discussed in Section D.6.1 are also included for reference. Parameters with NRS values of zero are not shown on figures for individual species.

The total PCB concentrations in tissue shown in bold on the figures are the estimated concentrations resulting from the best-fit parameter set for Calibration 1. The bars range from C_{Max} (the estimated concentration in tissue that results when the maximum value for a given parameter is used) to C_{Min} (the estimated concentration in tissue that results when the minimum value for a given parameter is used) (see Table D.6-2). NRS is the absolute value of the difference between C_{Max} and C_{Min} (Equation D.6-1).

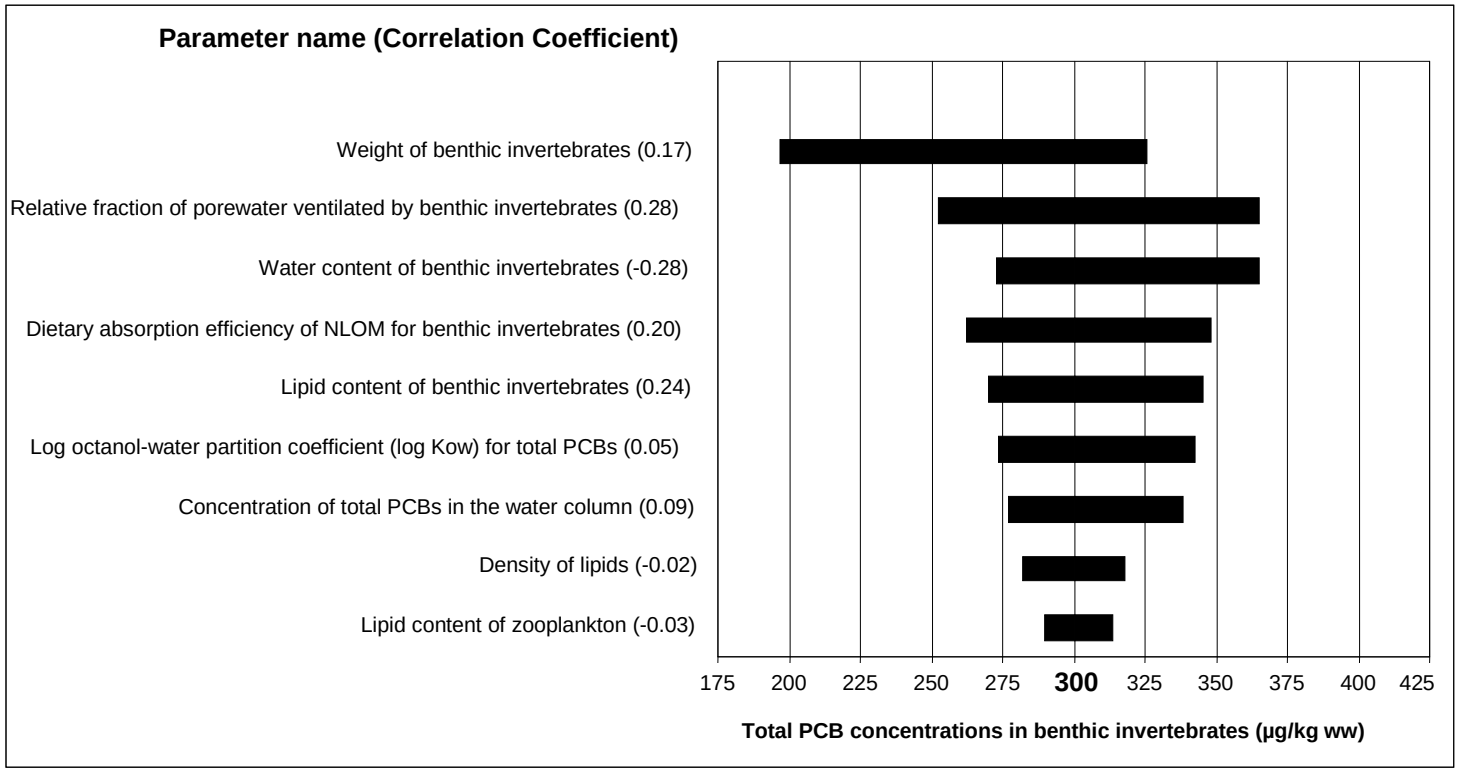

Figure D.6-1. Results of the NRS analysis for benthic invertebrates

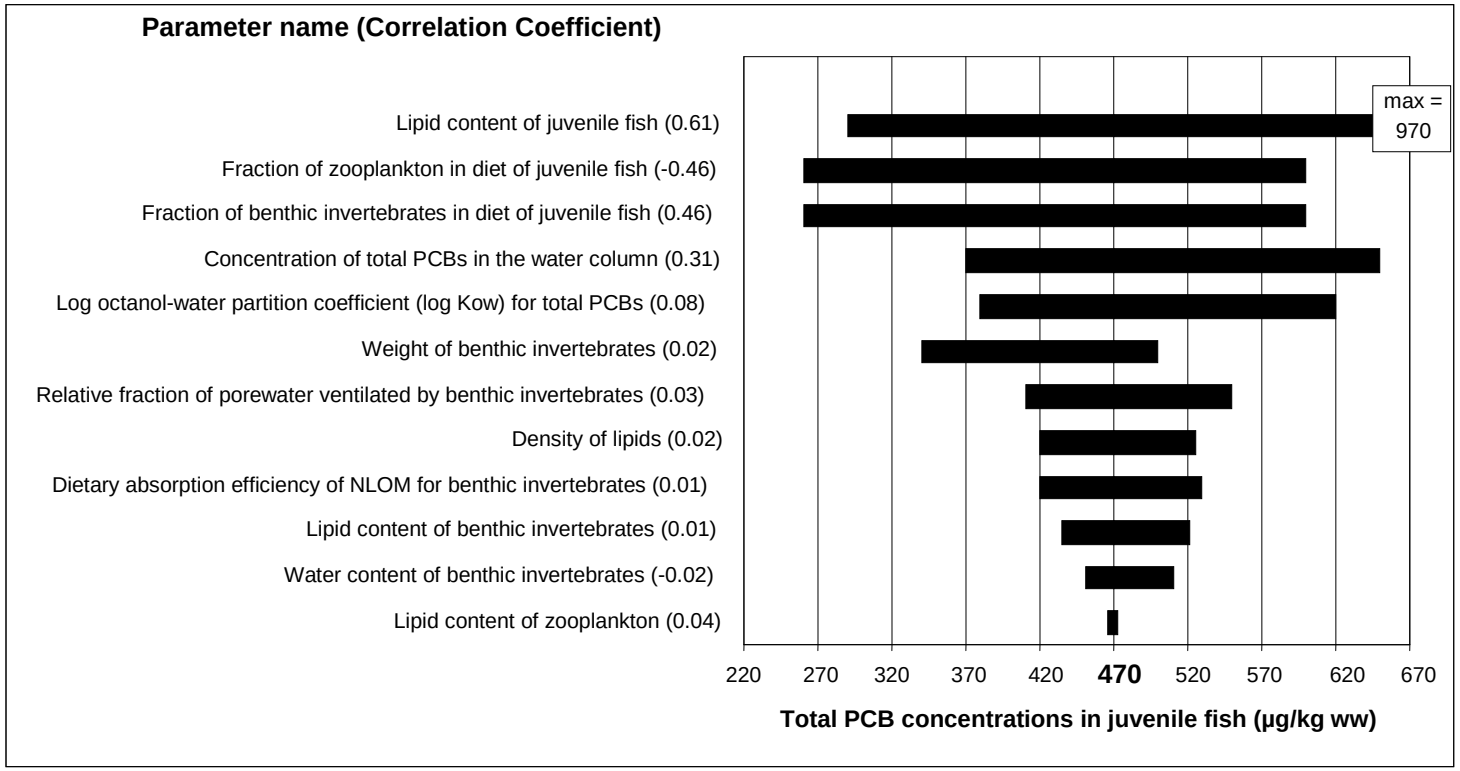

Figure D.6-2. Results of the NRS analysis for juvenile fish

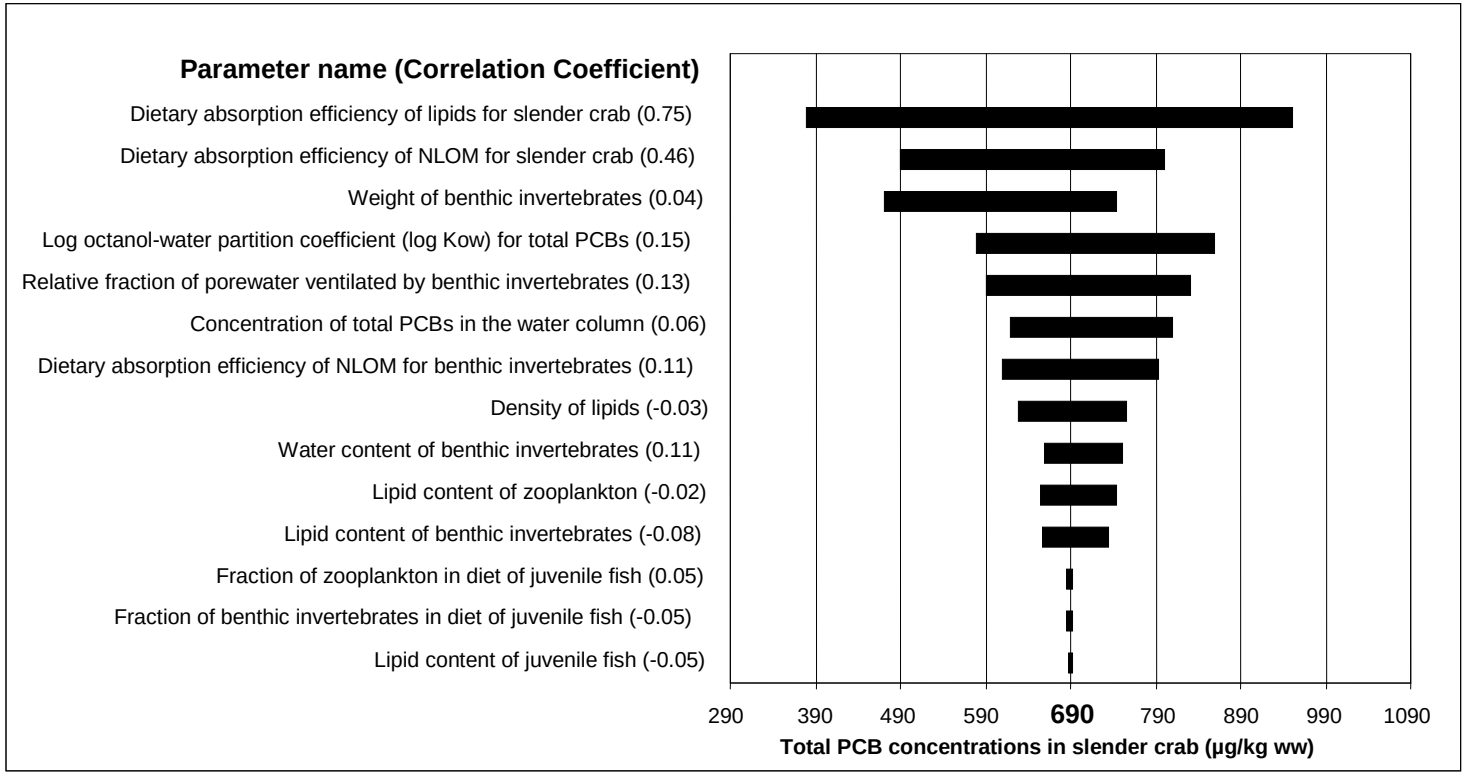

Figure D.6-3. Results of the NRS analysis for slender crabs

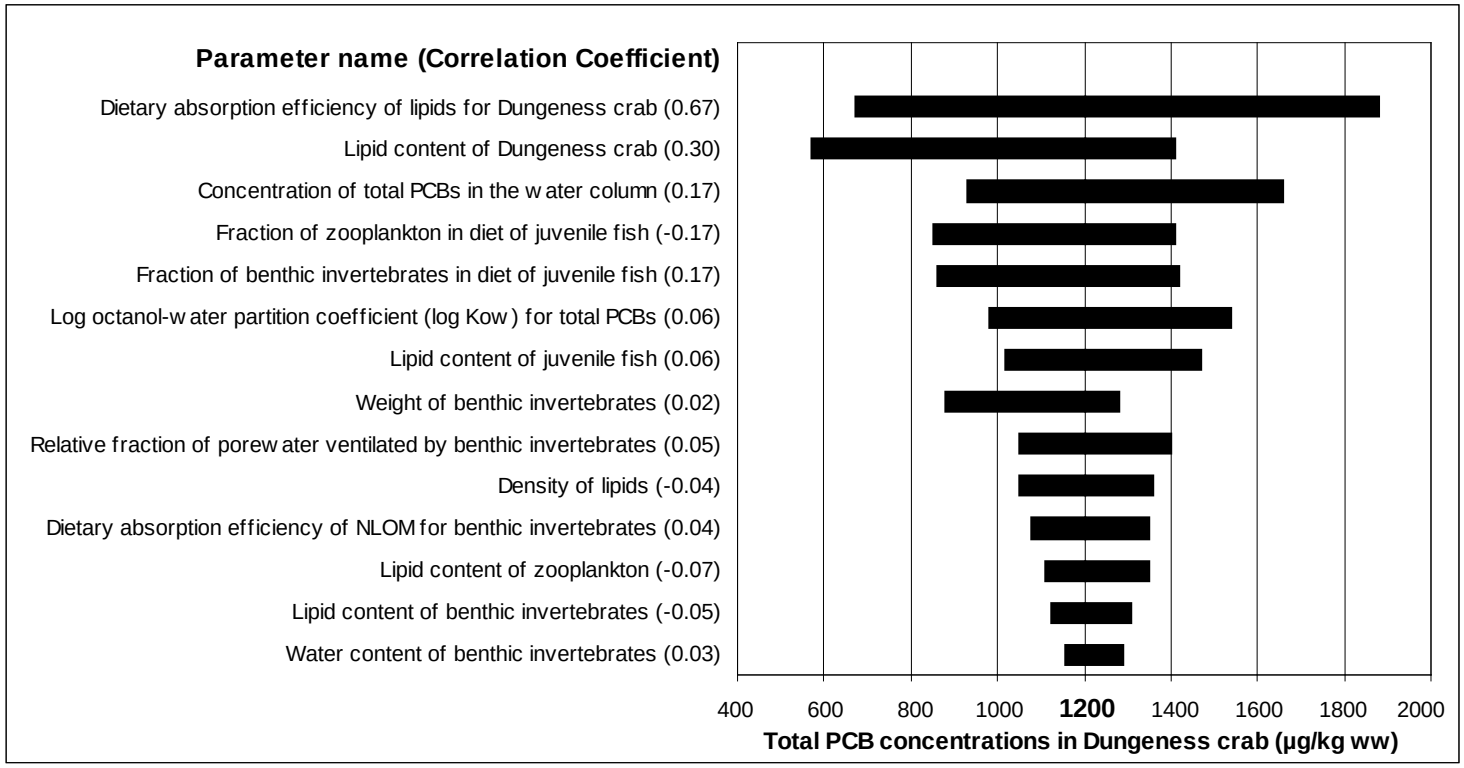

Figure D.6-4. Results of the NRS analysis for Dungeness crabs

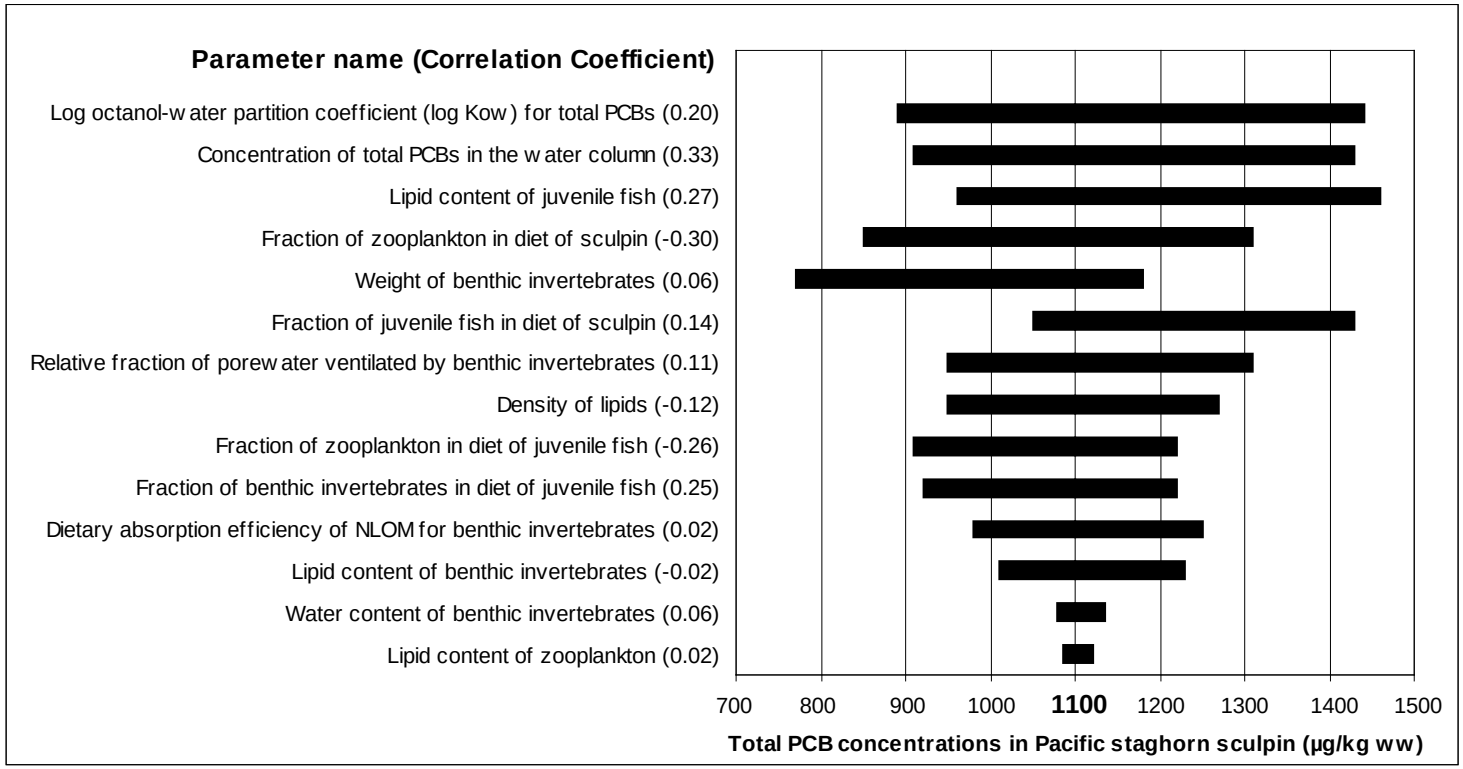

Figure D.6-5. Results of the NRS analysis for Pacific staghorn sculpin

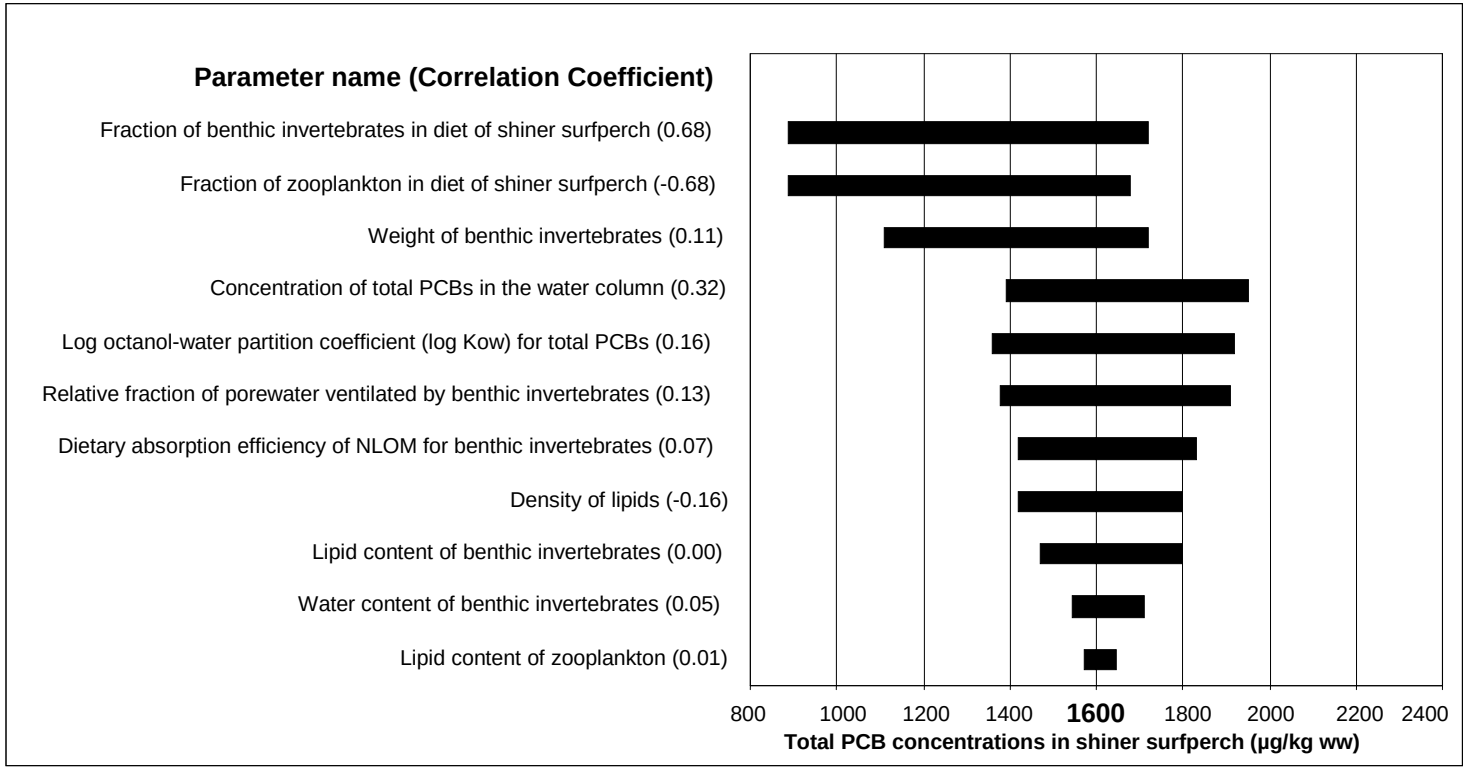

Figure D.6-6. Results of the NRS analysis for shiner surfperch

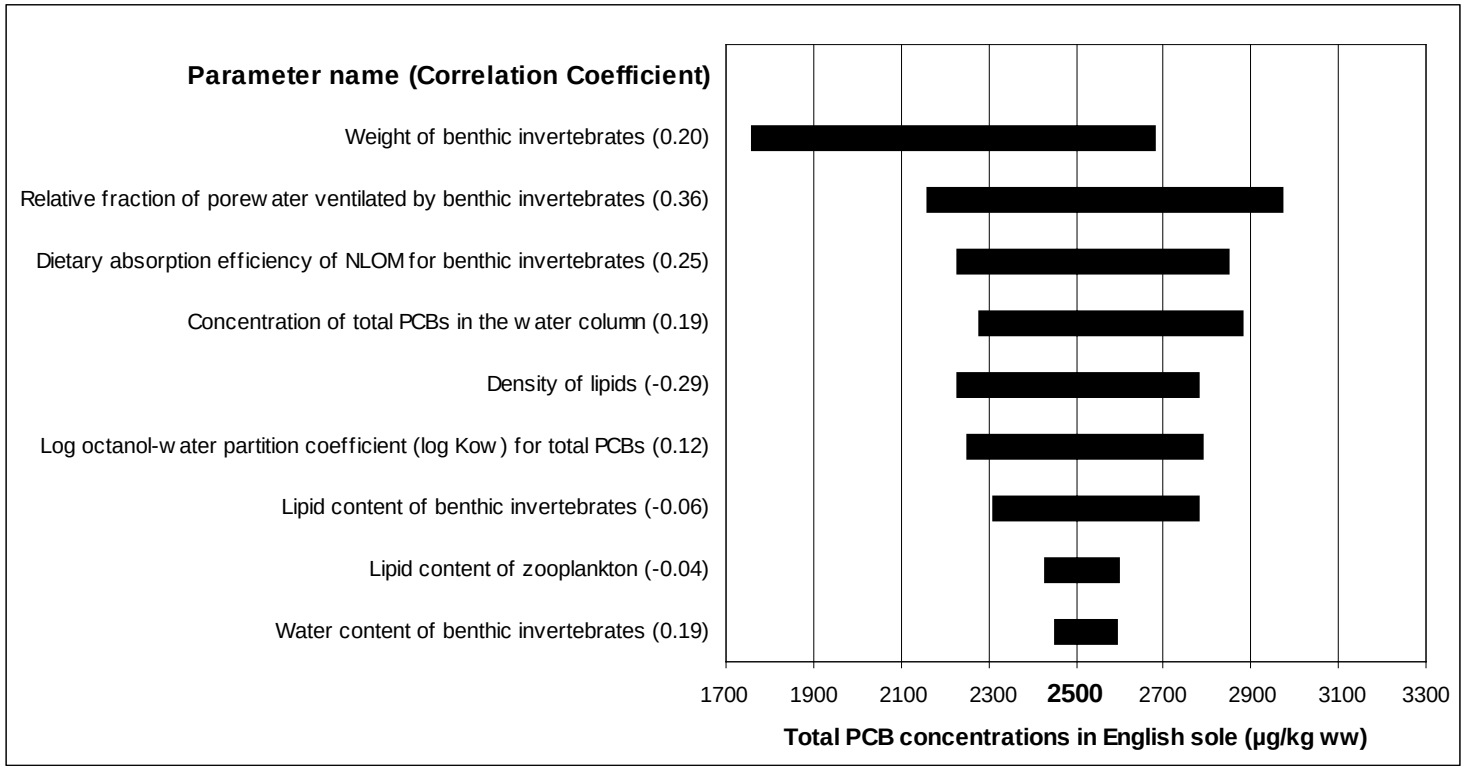

Figure D.6-7. Results of the NRS analysis for English sole

Log K_{OW} had a significant influence on estimates of total PCBs in tissue for all species (i.e., its NRS ranked in the top six parameters for all species). Log K_{OW} is a key parameter for total PCB uptake and loss in the FWM. The range of possible input values for this parameter is high (i.e., the maximum log K_{OW} value is 60% greater than the mean, and the minimum log K_{OW} value is 40% less than the mean), which may contribute to the high NRS values.

The benthic invertebrate-specific parameters of body weight, relative fraction of porewater ventilated, and dietary absorption efficiency of NLOM had a relatively significant influence on model estimates for many species. All target fish and crab species modeled were assumed to consume benthic invertebrates as a significant component of their diet. The broad range of input values assumed for benthic invertebrate weight (i.e., 7.1×10^{-8} kg to 1.2×10^{-4} kg), contributed to the high NRS. Compared to other species consumed by fish and crab species, benthic invertebrates had the greatest range of fraction of porewater ventilated, and consequently NRS values for this parameter also ranked high. Benthic invertebrates and the species that consume them were sensitive to the benthic invertebrate dietary absorption efficiency of NLOM because the diet of benthic invertebrates is composed of items with very low lipid content (i.e., sediment, phytoplankton, and zooplankton). Benthic invertebrate lipid and water content had less of an influence on the FWM estimates because of the relatively narrow range of values around the mean defined for these parameters.

Total PCB concentrations in the water column had a significant influence on estimated total PCB concentrations in phytoplankton and zooplankton. Other species affected by the total PCB concentration in water were organisms that consume at least 25% zooplankton in their diets (i.e., juvenile fish, Dungeness crab, Pacific staghorn sculpin, and shiner surfperch). In addition, because juvenile fish were assumed to consume 57% zooplankton, estimated tissue total PCB concentrations in species that consume juvenile fish (e.g., Dungeness crabs and Pacific staghorn sculpin) had additional sensitivity to this parameter.

Estimated total PCB concentrations in crabs were highly influenced by dietary absorption efficiencies (Figures D.6-3 and D.6-4). Model estimates for slender crabs were sensitive to lipid and NLOM dietary absorption efficiencies; model estimates for Dungeness crabs were sensitive to dietary absorption efficiency of lipids. Dietary absorption efficiencies for crabs had a broad range of defined mean values (i.e., both NLOM and lipid dietary absorption efficiencies ranged from 16 to 96 percent),[36] which may explain the significant influence of these parameters.

Estimated total PCB concentrations in Pacific staghorn sculpin were influenced by dietary assumptions and juvenile fish lipid content (Figure D.6-5). Pacific staghorn sculpin were assumed to consume an average of 24% zooplankton and 33% juvenile

[36] For comparison, the dietary absorption efficiency ranges for fish were 50 to 65% for NLOM and 90 to 95% for lipids.

fish, but the ranges for these dietary fractions were allowed to increase up to 50% zooplankton or 66% juvenile fish. Because juvenile fish were assumed to have higher lipid contents and are higher in the food chain than zooplankton, the relative consumption of juvenile fish and zooplankton had a significant effect on estimated total PCB concentrations in Pacific staghorn sculpin.

Estimated total PCB concentrations in shiner surfperch were influenced by the relative dietary fractions of zooplankton vs. benthic invertebrates (Figure D.6-6), which is highly uncertain. Greater amounts of zooplankton in the diet of shiner surfperch would decrease estimated total PCB concentrations in their tissue (because zooplankton have lower estimated tissue total PCB concentrations than do benthic invertebrates).

Benthic invertebrates make up 86 to 90% of the diet of English sole. Consequently, estimated total PCB concentrations in English sole were heavily influenced by benthic invertebrate-specific parameters (Table D.6-3 and Figure D.6-7).

The NRS analysis provided a sense of which parameters had the greatest potential to influence FWM estimates. It is not surprising that the parameters identified as the "most sensitive" through the NRS analysis were generally the same parameters that were adjusted through calibration (Section D.5.2). In general, the parameters that had the largest influence on model uncertainty were those with values that were derived from the literature and had broad ranges.

D.6.3 SWAC SENSITIVITY AND UNCERTAINTY ANALYSIS

The SWAC was not evaluated in the correlation coefficient or NRS analyses (Sections D.6.1 and D.6.2) because the SWAC is a decision variable and thus had only one value for calibration. The results of an analysis of the sensitivity of the FWM to the SWAC and the potential influence of the SWAC on the uncertainty of FWM estimates are presented in this section.

As discussed in Section D.5.2, the FWM tended to overestimate total PCB concentrations in tissues (Figures D.5-1 and D.5-2). The following assumptions made in defining the SWAC for the FWM could have contributed to the model's tendency to overestimate tissue concentrations for target species in the LDW.

- The interpolation method used to generate the SWAC (i.e., IDW) has uncertainties.
- The SWAC used in the FWM assumed that fish and crab species in the LDW use all areas of the LDW equally. In reality, some or all of the fish and crab species may preferentially use some areas of the LDW with more suitable habitat (e.g., better food sources or refuge from predators).
- The SWAC used in the FWM assumed that all modeled species use the LDW 100% of the time. No site use factors were applied for species that may move out of the LDW for part of the year.

To explore the effects of SWAC uncertainty on FWM estimates and on the tendency of the FWM to overestimate concentrations of total PCBs in tissue (Section D.6), the best-fit parameter set was run an additional eight times, each time with a lower SWAC, starting at the initial estimate of 380 µg/kg dw. Model estimates were compared to empirical data to determine which SWAC resulted in the best fit for the FWM. The water PCB concentration was held constant in order to illustrate the impact of the sediment PCB concentration on model estimates.

The initial run used a SWAC of 380 µg/kg dw, which was the SWAC for the calibrated model; each additional run used a lower SWAC (Table D.6-4) starting at the initial estimate of 380 µg/kg dw (Table D.6-5). Lower SWACs were investigated because the FWM over-estimated tissue concentrations for most species at 380 µg/kg dw and because SWACs generated from the baseline sediment database using Thiessen polygons and a new IDW parameterization (see Section 4.2.3.1 in the main body of the RI) resulted in lower values.

Table D.6-4. Sensitivity of FWM estimates to the SWAC

Species	Mean Empirical Total PCB Concentration in Tissue (µg/kg ww)	Estimated Total PCB Concentrations in Tissue for Selected SWACs (µg/kg ww)[a]								
		380	350	340	300	250	200	150	100	50
Slender crab	670	**690**	642	626	563	483	404	324	245	165
Dungeness crab	1,100	1,201	1,132	**1,109**	1,018	903	789	674	560	445
Pacific staghorn sculpin	900	1,122	1,052	1,028	**935**	818	701	585	468	351
Shiner surfperch	1,800	**1,558**	1,455	1,420	1,283	1,111	939	767	595	423
English sole	2,300	2,485	**2,310**	2,252	2,019	1,727	1,435	1,144	852	561

[a] Best-fit parameter set was used for model runs. SWACs are in µg/kg dw.

dw – dry weight

FWM – food web model

PCB – polychlorinated biphenyl

SWAC – spatially weighted average concentration

ww – wet weight

Bold values are estimates closest to mean empirical tissue data for that species.

Table D.6-5. Effects of SWAC on FWM performance

Species	SPAFs Based on FWM Runs that Used Selected SWACs[a]								
	380	350	340	300	250	200	150	100	50
Slender crab	**1.0**	1.0	1.1	1.2	1.4	1.7	2.1	2.7	4.1
Dungeness crab	1.1	1.0	**1.0**	1.1	1.2	1.4	1.6	2.0	2.5
Pacific staghorn sculpin	1.2	1.2	1.1	**1.0**	1.1	1.3	1.5	1.9	2.6
Shiner surfperch	**1.2**	1.2	1.3	1.4	1.6	1.9	2.3	3.0	4.3
English sole	1.1	**1.0**	1.0	1.1	1.3	1.6	2.0	2.7	4.1

Species	SPAFs Based on FWM Runs that Used Selected SWACs[a]								
	380	350	340	300	250	200	150	100	50
Slender crab	**1.0**	1.0	1.1	1.2	1.4	1.7	2.1	2.7	4.1
Average SPAF	**1.1**	**1.1**	**1.1**	**1.2**	**1.3**	**1.6**	**1.9**	**2.5**	**3.5**

[a] Best-fit parameter set was used for model runs. SWACs are in µg/kg dw.

dw – dry weight
FWM – food web model
IDW – inverse distance weighted
SPAF – species predictive accuracy factor
SWAC – spatially weighted average concentration
ww – wet weight

Bold values are the best-fit estimate for a species compared to empirical tissue data.
Underlined values are SPAFs calculated from underestimated tissue concentrations.

The SWAC that produced the lowest average SPAF across species for the best-fit parameter set was 350 µg/kg dw (Table D.6-5), although average SPAFs were similar for 380 and 340 µg/kg dw, and SPAFs for each individual species were less than 2 for all SWACs ≥ 200 µg/kg dw. Interestingly, the SWAC presented in Section 4.2.2.1 in the main body of the RI, based on an updated IDW interpolation, is 350 µg/kg dw.

When total PCB concentrations in sediment were reduced from 380 to 150 µg/kg dw, a change of 61%, the average change in tissue concentrations, across all species, was 63%. This indicates that the average of FWM estimates across species responds in a proportional manner to changes in total PCB concentrations in sediment when the concentration of total PCBs in water is held constant. However, because the FWM was overestimating for all species (except shiner surfperch) when the SWAC was 380 µg/kg dw and underestimating for all species when the SWAC was 200 µg/kg dw, the average SPAF across species was not highly influenced.

D.6.4 Uncertainty in Other Input Parameters

A number of uncertainties were not evaluated in the sensitivity and uncertainty analyses presented above. These uncertainties include:

- True uptake and depuration processes described by the FWM equations
- Applicability of basic assumptions of the Arnot and Gobas FWM to LDW organisms and conditions (i.e., primary routes of chemical uptake, homogeneous distribution of chemicals within organisms, assumptions about equilibrium between organisms and the environment) (Arnot and Gobas 2004b)
- Mean of the empirical data as an estimate of true mean tissue total PCB concentrations in the LDW
- Impact of temporal differences among datasets for different media
- Distributions assigned to FWM parameters

The model's quantitative description of uptake and depuration processes is an important uncertainty of the model. Biological processes are highly complex and were necessarily simplified for the creation of the model. The degree to which this simplification appropriately captures the critical elements of these processes for

predicting current and particularly future conditions is unknown. With regard to current conditions, the model reasonably estimates current PCB tissue concentrations, providing some confidence in its design.

The degree to which the model is appropriate for the LDW organisms and conditions is another source of uncertainty. The Gobas model was originally developed for a freshwater lake very different from the LDW (Gobas 1993). The model has since been applied in a various freshwater and marine environments (deBruyn et al. 2004; Gobas and Arnot 2005). However, each system is unique and the model assumptions related to primary routes of chemical uptake, homogeneous distribution of chemicals within organisms, and assumptions about equilibrium between organisms and the environment (Arnot and Gobas 2004b) are violated to some degree in any system.

Empirical data for each species tended to be highly variable; minimum and maximum total PCB concentrations in the tissues of different species ranged from 2 to 10 times the species' mean tissue concentrations. Factors that contribute to the variance in tissue concentrations include laboratory protocols, time, and spatial heterogeneity. The variability in the empirical dataset reflects uncertainties that carry over into the calibration process. Although empirical data represent the best approximation of tissue concentrations in the LDW, the variability in the data suggest the potential for uncertainty in estimates of the mean.

Another source of uncertainty is the temporal relationship among the datasets. Ideally, all empirical data would have been collected concurrently. Most of the tissue total PCB concentrations used in the calibration were collected in 2004 and 2005, and most of the sediment total PCB concentrations were collected in the late 1990s, 2004, and 2005. These sediment data along with water data collected in 2005 were used in the EFDC model, which generated the water concentration estimates used in the FWM. Inclusion of data from multiple years increases the level of uncertainty. However, the larger dataset, particularly for sediment, was believed to provide a better estimate of average conditions throughout the LDW than a smaller, concurrent dataset.

One of the temporal factors that complicated the selection of empirical calibration and input data for the FWM involved the dredging that occurred in 2003/2004 in the Duwamish/Diagonal area within Area T1. The surface sediment layer used to derive the SWAC used in the FWM was based on baseline (pre-dredging) conditions (Section D.4.1.1), consistent with the dataset used in the risk assessments. The surface sediment layer used in the EFDC model for estimation of water column concentrations was somewhat different; 2005 post-dredging surface sediment data were used in the area around the Duwamish/Diagonal dredging project instead of the pre-dredging data in the baseline dataset. These post-dredging data were used to better coincide with the PCB surface water data collected by King County in 2005 (Nairn 2009).

The fact that the surface sediment data used in the Duwamish/Diagonal area were different in the FWM and the EFDC modeling efforts generates some uncertainty. However, the water column total PCB concentrations predicted by the EFDC model,

and thus used in the FWM, would be similar with either set of sediment data because the EFDC model was calibrated to empirical water column total PCB concentrations (Section D.4.1.2). Calibration to the different sediment data would still estimate water concentrations very similar to those estimated from the current EFDC model. Similarly, the FWM was calibrated to empirical tissue total PCB concentrations, and thus the difference in sediment total PCB concentrations would likely not have had a large effect on the estimated total PCB concentrations in tissues.

As an additional assessment, SWACs were generated using IDW interpolation to assess the effect of using pre-dredging vs. post-dredging data in the Duwamish/Diagonal area. The FWM used an LDW-wide SWAC for total PCBs. LDW-wide (i.e., RM 0.0 to RM 5.25) total PCB SWACs were 380 and 340 µg/kg dw using the pre-dredging and post-dredging Duwamish/Diagonal data, respectively. Based on the analysis presented in Table D.6-5, a change in sediment SWAC from 380 to 340 µg/kg dw did not result in a change in the average SPAF (1.1), and none of the SPAFs changed by more than 0.1 for individual species.

The effect of using the post-dredging data was also evaluated on a sampling-area basis to assess the potential influence of using these data on smaller scales (Section D.7). The Area T1 total PCB SWAC would have decreased from 300 to 230 µg/kg dw if the post-dredging data had been used in the Duwamish/Diagonal area rather than the pre-dredging data in the Duwamish/Diagonal area. The sensitivity of the FWM to the SWAC was not evaluated at this scale. However, if the influence of the SWAC on SPAFs was similar to that calculated for the LDW-wide scale, the decrease in SWAC would have increased the average SPAF from 1.2 to approximately 1.4, with changes on the order of 0.2 to 0.3 for individual species. All estimated tissue concentrations could still be within a factor of 2 of the empirical tissue dataset.

Distributions were assigned to many of the input parameters to describe uncertainty in their values. The type of distribution selected (e.g. normal, triangular, uniform, etc.) indicates something about the how well the parameter was characterized and/or what type of information was available. The distribution assigned for concentration of PCBs in water is illustrative of this issue. As discussed in Section D.4.1.2, the distribution assigned to water was based on both empirical and EFDC model estimates. Empirical data from the two mid-channel locations were used to define the upper and lower bounds of PCB concentrations in water for the FWM. The mode used in the data distribution was generated by the EFDC model, which was calibrated with several large empirical datasets for many parameters. Because the LDW water samples were collected mid-channel rather than directly above the benches (Map 4-11a), where PCB concentrations would be expected to be the highest, it is possible that the extreme high end of the water PCB range was not captured in the empirical data. The model estimated higher concentrations in prediction cells just above the sediment surface on the benches in a few specific areas of higher sediment concentrations. These higher concentrations were included in the EFDC model output used to generate the average concentrations. The mode of the total PCB concentration in water used in the FWM

represents a yearly average of the exposure throughout the entire LDW estimated by the EFDC model. As discussed in Section D.3.2.2, because the modeled species integrate their exposure over space and time, identifying upper and lower limits is less important than identifying a reasonable average exposure concentration. Therefore, modeled monthly averages should be a better estimate of actual exposure than empirical data because of the inherent variability in water concentrations over small spatial and temporal scales. Although the baseline water PCB concentration represents a source of uncertainty in the FWM, it is not expected to be the most significant input parameter for any of the target species.

D.7 Testing the FWM at Different Spatial Scales

To test the performance of the calibrated model for areas smaller than the LDW, the best-fit parameter set was applied to the four modeling areas (M1, M2, M3, and M4), and model estimates for each area were compared to area-specific empirical tissue data. These tests were conducted because EPA expressed an interest in potentially running the FWM at a scale smaller than the entire LDW, and there were sufficient empirical data to test model performance at the scale of modeling areas. Modeling area tests were also used to investigate the potential impact of the uncertainty associated with home ranges of species used in the FWM.

The best-fit parameter set was also used to test the performance of the FWM at specific intertidal locations to assess the ability of the model to estimate total PCB concentrations in clam tissue. Clams were modeled to support calculations of RBTCs in sediment for human health consumption scenarios. The model was not calibrated for clams because clams that are harvested for human use are present only in select intertidal areas, where the habitat is suitable, and the model was calibrated for the entire LDW.

D.7.1 MODELING AREAS

The FWM was applied to the four modeling areas (M1, M2, M3, and M4) (Figure D.3-1) to assess model performance for fish and crab species at a spatial scale smaller than the LDW.[37] Site-specific input parameters that were changed for modeling area runs were the total PCB concentration in the water column, the total PCB concentration in sediment, and the sediment OC content (Table D.7-1).

[37] The performance of the FWM was not tested at a subarea scale because fewer composite tissue samples were available at that scale.

Table D.7-1. Modeling area-specific input parameter values

Modeling Area	Total PCB Concentration in the Water Column (ng/L)[a]	Total PCB Concentration in Sediment (SWAC) (µg/kg dw)[b]	TOC (%)[c]
M1	1.06	300	2.00
M2	1.29	270	2.05
M3	2.72	880	1.76
M4	2.16	190	1.72

[a] Total PCB concentrations in the water column were derived for each modeling area from EFDC model output (as the average of 12 monthly averages in cells from the bottom three layers of the model for each modeling area) (Nairn 2009).

[b] SWACs of total PCBs in sediment were calculated using the 2006 IDW interpolation method and pre-Round 3 sediment data for modeling areas using the same interpolation grids generated for the entire LDW but clipped to modeling areas.

[c] Spatially weighted average percentages of sediment TOC were calculated using the 2006 IDW interpolation method and pre-Round 3 sediment data for modeling areas using Thiessen polygons generated for the entire LDW but clipped to modeling areas.

dw – dry weight
IDW – inverse distance weighting
LDW – Lower Duwamish Waterway
PCB – polychlorinated biphenyl
SWAC – spatially weighted average concentration
TOC – total organic carbon

At a modeling area scale, estimates were within a factor of 2 of empirical data for Areas M1, M2, and M4 (Table D.7-2) with a few exceptions. In Area M2, the estimate for shiner surfperch was 2.4 times lower than the empirical average. However, as discussed in Section D.3.2.2 and Section 4.2.2.4 (in the main body of the RI), there was one shiner surfperch composite sample with very a high concentration of PCBs (18,400 µg/kg ww). If that sample had been removed from the dataset for Area M2, the model would have predicted within a factor of 2. In Area M3, estimates for benthic invertebrates, Dungeness crab, slender crab, and English sole ranged from 2.2 to 3.0 times higher than empirical data (Table D.7-2). The model performed reasonably well for shiner surfperch and Pacific staghorn sculpin in Area M3 (estimates were 1.4 and 1.9 times higher than empirical data, respectively).

Literature and statistical analyses of empirical total PCB tissue data (Section D.3.2) suggested that the FWM may perform better at the modeling area scale for Pacific staghorn sculpin and possibly better for shiner surfperch than for English sole and Dungeness and slender crab. English sole and crabs appear to be wider-ranging species relative to the spatial scale of the modeling areas (Section 4.2.2.4 in the main body of the RI).

Table D.7-2. Application of the FWM to individual modeling areas

Modeling Area	Species	Mean Empirical Total PCB Concentration (µg/kg ww)	n	Best-Fit Parameter Set		
				Estimated Total PCB Concentration (µg/kg ww)	SPAF	Over (+) or Under (-) Estimate
M1	benthic invertebrates	180[a]	6	231	1.3	+
	slender crab	650	3	542	1.2	-
	Dungeness crab	990	6	960	1.0	-
	Pacific staghorn sculpin	720	7	889	1.2	+
	shiner surfperch	970	15	1,229	1.3	+
	English sole	2,600	12	1,946	1.3	-
M2	benthic invertebrates	170[b]	6	214	1.3	+
	slender crab	700	7	507	1.4	-
	Dungeness crab	na	0	948	na	na
	Pacific staghorn sculpin	750	7	858	1.1	+
	shiner surfperch	2,800	12	1,165	2.4	-
	English sole	2,900	12	1,808	1.6	-
M3	benthic invertebrates	370[c]	4	702	1.9	+
	slender crab	631	3	1,636	2.6	+
	Dungeness crab	1,300	4	2,820	2.2	+
	Pacific staghorn sculpin	1,400	7	2,648	1.9	+
	shiner surfperch	2,600	12	3,689	1.4	+
	English sole	2,000	12	5,918	3.0	+
M4	benthic invertebrates	140[d]	4	188	1.3	+
	slender crab	na	0	467	na	na
	Dungeness crab	1,200	2	1,040	1.2	-
	Pacific staghorn sculpin	730	7	879	1.2	+
	shiner surfperch	710	10	1,127	1.6	+
	English sole	1,400	6	1,639	1.2	+

[a] The mean "empirical" total PCB concentration for benthic invertebrates in Area M1 was estimated using a total PCB SWAC of 300 µg/kg dw and the benthic invertebrate tissue-sediment regression: concentration of total PCBs in benthic invertebrate tissue = 0.34 x (sediment PCB concentration) + 75 (see Attachment 1).

[b] The mean "empirical" total PCB concentration for benthic invertebrates in Area M2 was estimated using a total PCB SWAC of 270 µg/kg dw and the benthic invertebrate tissue-sediment regression described in Footnote a.

[c] The mean "empirical" total PCB concentration for benthic invertebrates in Area M3 was estimated using a total PCB SWAC of 880 µg/kg dw and the benthic invertebrate tissue-sediment regression described in Footnote a.

[d] The mean "empirical" total PCB concentration for benthic invertebrates in Area M4 was estimated using a total PCB SWAC of 190 µg/kg dw and the benthic invertebrate tissue-sediment regression described in Footnote a.

FWM – food web model
LDW – Lower Duwamish Waterway
n – number of composite samples
na – not available
PCB – polychlorinated biphenyl
SPAF – species predictive accuracy factor
SWAC – spatially weighted average concentration
ww – wet weight

Differences in home range size could possibly explain the poorer performance of the FWM for Dungeness and slender crabs and English sole relative to the performance for shiner surfperch and Pacific staghorn sculpin in Area M3. SWACs for Areas M1, M2, and M4 varied from 190 to 300 µg/kg dw, a difference of 80 to 190 µg/kg dw from the LDW-wide SWAC of 380 µg/kg dw. The SWAC for Area M3 was 880 µg/kg dw, a difference of 500 µg/kg dw from the LDW-wide SWAC of 380 µg/kg dw. If the exposure areas for Dungeness and slender crabs and English sole include the entire LDW, then the SWACs for these species would have been reasonably approximated by the LDW-wide SWAC of 380 µg/kg dw. Therefore, the good performance of the FWM for these species in Areas M1, M2, and M4 does not necessarily indicate that the modeling area SWACs represented the full exposure area (i.e., home ranges), but instead could be explained by the similarity of the SWACs in these modeling areas to the LDW-wide SWAC. If the home range of shiner surfperch is smaller than the LDW and corresponds roughly with the modeling areas, then sediment exposure should have been better approximated by modeling area SWACs. In addition, the home-range hypothesis for the good performance of Pacific staghorn sculpin and shiner surfperch in Area M3 is supported by the ANOVAs and regressions performed with the empirical tissue data among the four modeling areas for these species (Section D.3.2.2). These analyses indicated that Pacific staghorn sculpin, and to a lesser extent shiner surfperch, may integrate their exposure over areas smaller than the LDW.

In summary, for Pacific staghorn sculpin and shiner surfperch, the FWM performed within the SPAF criterion (SPAF ≤ 2) for all modeling areas when the 18,400-µg/kg ww sample result was removed from the shiner surfperch Area M2 dataset. These results indicate that applying the FWM at the modeling area scale for these species may be appropriate, although uncertainty is higher at the modeling area scale, as discussed in Section D.3.2. For Dungeness and slender crabs and English sole, the FWM performed within the SPAF criterion (SPAF ≤ 2) for all modeling areas except Area M3. The fact that the SPAF criterion was met in Areas M1, M2, and M4 but not in M3 (the modeling area with the highest sediment SWAC) indicates that these species may have home ranges that are larger than the modeling areas.

Regardless of the species, some loss of performance is to be expected if the model is applied on a smaller spatial scale because of the following:

- Greater SE because of smaller tissue sample sizes when the data are split by tissue sampling area
- Potential differences in diet at the modeling area scale versus the LDW-wide scale because of potential differences in the relative abundance of different types of prey
- Potential differences in the spatial distributions of habitat and sediment contamination (both for the modeled species and their prey)
- Potential differences in factors that affect the bioavailability of PCBs (e.g., differences in PCB congener patterns or in sediment organic carbon content)

- Potential differences in water exposure at the modeling area spatial scale relative to LDW-wide
- Movement of individuals (of the sampled population or their prey) across modeling area boundaries

In summary, because of their larger home range and the likelihood that exposure occurs on a scale larger than that of the modeling areas, the application of the FWM at the modeling area scale may not be appropriate for Dungeness and slender crabs and English sole, particularly if the SWACs within the smaller areas are dramatically different than the LDW-wide SWAC. This issue would need to be considered if the LDW FWM is applied on a smaller scale in the future.

D.7.2 BENCH AREA SCALE

In addition to evaluating FWM performance at the modeling area scale, the model was evaluated on a bench area scale, per EPA request, to assess the potential for preferential use of nearshore areas. Modeling Area 3 was selected for this analysis because of the variation in sediment concentrations for the nearshore bench areas. The benches were defined as the area outside of the navigation channel. Model inputs for sediment PCB concentration and TOC were estimated as SWAC values, and water concentrations were estimated from EFDC prediction cells in those areas. Table D.7-3 presents the input values and results of the bench analysis. It should be noted that the fish tissue data available for comparison to model predictions were not collected exclusively from the benches but were instead collected as available within the entire sampling subareas, which generally bisected the LDW.

Table D.7-3. Input parameters and results of bench area FWM analysis

		FWM INPUT PARAMETERS				FWM OUTPUT	
SPECIES NAME	EXPOSURE AREA	TOTAL PCB CONCENTRATION IN WATER (ng/L)[a]	TOTAL PCB SWAC IN SURFACE SEDIMENT (µg/kg dw)[b]	TOC (%)[c]	EMPIRICAL TOTAL PCB CONCENTRATION IN TISSUE (µg/kg ww)[d]	ESTIMATED TOTAL PCB CONCENTRATION IN TISSUE (µg/kg ww)	SPAF
Pacific staghorn sculpin	LDW-wide	1.2	380	1.9	900	1,122	1.2
	M3	2.7	880	1.76	1,400	2,648	1.9
	M3, navigation channel excluded	3.5	1,065	1.79	1,400	3,228	2.3
	M3, west bench	3.5	428	1.62	940	1,748	1.9
	M3, east bench	3.5	1,586	1.92	1,700	4,365	2.6

Species Name	Exposure Area	FWM Input Parameters			Empirical Total PCB Concentration in Tissue (µg/kg ww)[d]	FWM Output	
		Total PCB Concentration in Water (ng/L)[a]	Total PCB SWAC in Surface Sediment (µg/kg dw)[b]	TOC (%)[c]		Estimated Total PCB Concentration in Tissue (µg/kg ww)	SPAF
Shiner surfperch	LDW-wide	1.2	380	1.9	1,800	1,558	1.2
	M3	2.7	880	1.76	2,600	3,689	1.4
	M3, navigation channel excluded	3.5	1,065	1.79	2,600	4,482	1.7
	M3, west bench	3.5	428	1.62	2,500	2,302	1.1
	M3, east bench	3.5	1,586	1.92	2,800	6,159	2.2

[a] LDW-wide water concentration based on water concentration in the best-fit parameter set (Table D.5-3). Other water concentrations were estimated from EFDC model output for the specified exposure area (Nairn 2009).

[b] SWACs of total PCBs in sediment were calculated using the 2006 IDW interpolation method and pre-Round 3 sediment data using the same interpolation grids generated for the entire LDW but clipped to specific areas.

[c] Spatially weighted average percentages of sediment TOC were calculated using the 2006 IDW interpolation method and pre-Round 3 sediment data using Thiessen polygons generated for the entire LDW but clipped to specific areas.

[d] Mean total PCB concentrations in fish collected from specified exposure areas. The west bench included fish from Subareas 3B, 3D, and 3F. The east bench included fish from subareas 3A, 3C, and 3E.

dw – dry weight

EFDC – Environmental Fluid Dynamics [Computer] Code

FWM – food web model

LDW – Lower Duwamish Waterway

PCB – polychlorinated biphenyl

SPAF – species predictive accuracy factor

TOC – total organic carbon

SPAFs ranged from 1.2 (LDW-wide) to 2.6 (east bench) for Pacific staghorn sculpin and from 1.1 (west bench) to 2.2 (east bench) for shiner surfperch. The FWM tended to overestimate PCB concentrations in tissue when the sediment SWAC was assumed to be higher (i.e., the concentration for the benches). However, because the fish tissue data were not collected exclusively from the benches, results of this assessment cannot be considered conclusive for characterizing the exposure of Pacific staghorn sculpin or shiner surfperch to contamination on the benches relative to that in the entire subarea.

D.7.3 Clam Intertidal Areas

To test how well the model estimated total PCB concentrations in clam tissue, the model was run for the 10 clam intertidal areas, and estimated total PCB tissue concentrations in clams were compared to empirical clam tissue data. Four of the 10 intertidal areas (i.e., C2, C3, C7, and C10) had two sampling locations each, for a total of 14 locations (Figure D.3-1). Co-located tissue and sediment samples were collected at each of the 14 clam sampling locations.

The best-fit parameter set was used for all 14 clam sampling locations, except for three parameters that were location-specific. Location-specific input parameters that were

changed for clam runs were the total PCB concentration in the water column, the total PCB concentration in sediment, and the sediment OC content (Table D.7-4).

Table D.7-4. Location-specific input parameter values for 14 clam intertidal locations in the LDW

Location ID	Modeling Area	Total PCB Concentration in the Water Column (ng/L)[a]	Total PCB Concentration in Sediment (□g/kgdw)[b]	Organic Carbon in Sediment (%)[b]
C1	M1	1.1	3.1	0.47
C2-1	M1	1.1	56	1.82
C2-2	M1	1.1	99	1.06
C3-1	M1	1.1	52	0.93
C3-2	M1	1.1	20 U	1.31
C4	M2	1.3	69	1.4
C5	M2	1.3	53	0.32
C6	M2	1.3	61	1.24
C7-1	M3	2.7	1,000	1.55
C7-2	M3	2.7	380	0.78
C8	M3	2.7	3,300	2.11
C9	M3	2.7	35	0.56
C10-1	M3	2.7	6,600	1.63
C10-2	M3	2.7	15,000	2.27

[a] The total PCB concentration in the water column for each clam intertidal area was assumed to be the same as the corresponding modeling area based on output from the bottom three layers of the EFDC model.

[b] Total PCB concentrations in sediment and organic carbon content at specific intertidal locations were based on composite sediment samples collected at the same locations as the clam tissue samples. These sediment samples represented total PCB concentrations and organic carbon content over the area from which clams were collected at a given intertidal location.

dw – dry weight
ID – identification
LDW – Lower Duwamish Waterway
PCB – polychlorinated biphenyl
U – not detected at the reporting limit shown

Compared to the empirical data for clams, estimated total PCB concentrations in clams for 12 of the 14 clam intertidal locations had SPAFs < 2 (Table D.7-5). These results indicate that the model generally performed well for locations where total PCB concentrations in the sediment are 3,300 µg/kg dw or lower (Table D.7-5).

Table D.7-5. Application of the calibrated FWM for clams

Location ID	Empirical Total PCB Concentration in Clam Tissue (µg/kg ww)	FWM-Estimated Total PCB Concentration in Clam Tissue (µg/kg ww)	SPAF	Over (+) or Under (-) Estimate
C1	24	22	1.1	-
C2-1	24	34	1.4	+
C2-2	29	61	2.1	+
C3-1	33	43	1.3	+
C3-2	32	26	1.2	-
C4	31	46	1.5	+
C5	43	91	2.1	+
C6	34	45	1.3	+
C7-1	220	352	1.6	+
C7-2	250	259	1.0	+
C8	580	828	1.4	+
C9	50	75	1.5	+
C10-1	320	1,973	6.2	+
C10-2	330	3,395	10.3	+

FWM – food web model
ID – identification
PCB – polychlorinated biphenyl
SPAF – species predictive accuracy factor
ww – wet weight

Total PCB concentrations were overestimated at locations C10-1 and C10-2 (SPAFs of 6.2 and 10.3, respectively); these locations had the highest total PCB concentrations in sediment (6,600 and 15,000 µg/kg dw, respectively). Empirical clam tissue total PCB concentrations at locations C10-1 and C10-2 (320 and 330 µg/kg ww, respectively) were in the same range as clam tissue concentrations (220 to 580 µg/kg ww) from locations with sediment total PCB concentrations that ranged from 380 to 3,300 µg/kg dw (Table D.7-4). These results may indicate that clam tissue concentrations are not greatly influenced by local sediment total PCB concentrations and may be more a function of some other parameter. The other two locations with SPAFs > 2 (C2-2 and C5, each with a SPAF of 2.1) had total PCBs concentrations in sediment similar to those for the other areas.

An NRS analysis for clams was conducted using the same methods described in Section D.6.2. In the NRS analysis, input values for a given set of parameters were varied, one at a time, from their minimum to their maximum values in the parameter sets that passed the model performance filter. All other FWM parameters were held at their best-fit parameter set values. The higher the NRS value, the greater the sensitivity of the model to that parameter.

The NRS analysis was conducted for three intertidal locations, representing a range of total PCB concentrations in sediment (52, 380, and 15,000 µg/kg dw). Testing the sensitivity and uncertainty of the FWM at three locations with differing total PCB concentrations in sediment provides insight into how the sensitivity of the FWM changes with environmental conditions. Six of the twenty parameters tested in the NRS analysis had an effect on estimated total PCB concentrations in clams (Table D.7-6).

Table D.7-6. Results of NRS analysis at three clam intertidal locations

Parameter	NRS Value for Clams (µg/kg ww)		
	Intertidal Location C3-1[a]	Intertidal Location C7-2[a]	Intertidal Location C10-2[a]
Estimated concentration of total PCBs in the water column	48	48	47
Relative fraction of porewater ventilated by clams[a]	29	280	3,800
Density of lipids	5.4	33	430
Log octanol-water partition coefficient (Log K_{OW}) for total PCBs	4.4	6.5	69
Dietary absorption efficiency of NLOM (ε_N) for clams[a]	2.8	16	270
Lipid content of zooplankton	0.045	1	25

[a] For the NRS analysis, the maximum and minimum fractions of porewater ventilation for clams were assumed to be the same as the values used for benthic invertebrates.

[b] The total PCB concentrations in co-located sediment at locations C3-1, C7-2, and C10-2 were 52, 380, and 15,000 µg/kg dw, respectively.

dw – dry weight
PCB – polychlorinated biphenyl
NLOM – non-lipid organic matter
NRS – nominal range sensitivity
ww – wet weight

The six parameters that had an effect on FWM clam tissue estimates were also identified as important parameters for the other modeled species (Figures D.6-1 through D.6-7). The influence of total PCB concentrations in the water column, relative to the influence of other parameters, increased with decreasing sediment concentrations (Table D.7-6). These results indicate that as total PCB concentrations in sediment decrease, FWM estimates of total PCB concentrations for clams become more sensitive to total PCB concentrations in water.

A regression model was also evaluated to assess its ability to estimate total PCB concentrations in clam tissue. When both sediment and tissue concentrations were log transformed to help meet the assumptions of a regression analysis (linearity of the relationship and homogeneous variance of the dependent variable around the regression line), the sediment variable explained 80% of the variance in tissue concentrations ($R^2 = 0.80$) and the regression was significant ($p < 0.0005$) (Figure D.7-1).

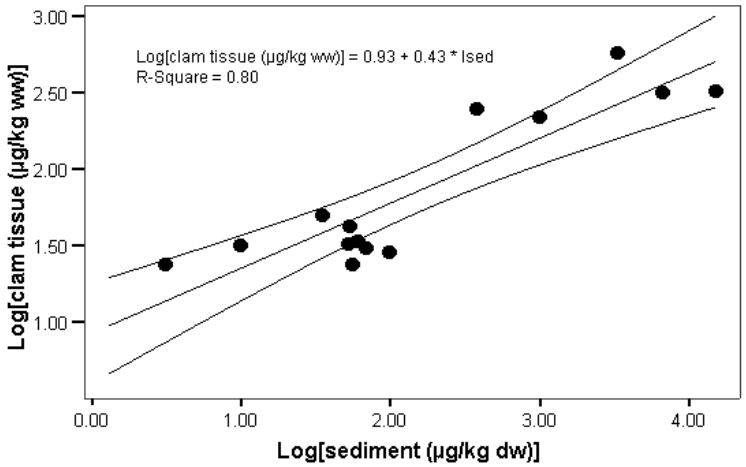

Figure D.7-1. PCB regression using log(10)-transformed concentrations of co-located clam tissue and sediment samples.

The regression model provided better estimates of total PCB concentrations in clam tissue at high sediment concentrations (i.e., PCB concentrations in sediment greater than 6,600 µg/kg dw) but provided estimates similar to the FWM (in terms of SPAFs) at the low end of the sediment scale, particularly in the range of sediment RBTCs (Table D.7-7). Because the regression model performed similarly to the FWM in the lower range of total PCB concentrations in sediment, the FWM was selected to estimate the clam tissue sediment relationship in the derivation of sediment RBTCs, which is discussed in Section D.9.

Table D.7-7. Comparison of empirical total PCB concentrations in clam tissue relative to estimates made using the FWM and a regression equation

Location ID	Sediment PCB Concentration (µg/kg dw)	Empirical Tissue PCB Concentration (µg/kg ww)	FWM Estimate		Regression Estimate	
			Tissue PCB Concentration (µg/kg ww)	SPAF	Tissue PCB Concentration (µg/kg ww)	SPAF
C1	3.1	24	22	1.1	14	1.7
C2-1	56	24	34	1.4	48	2.0
C2-2	99	29	61	2.1	61	2.1
C3-1	52	33	43	1.3	47	1.4
C3-2	10	32	26	1.2	23	1.4
C4	69	31	46	1.5	53	1.7
C5	53	43	91	2.1	47	1.1
C6	61	34	45	1.3	50	1.5
C7-1	1,000	220	352	1.6	166	1.3

Location ID	Sediment PCB Concentration (µg/kg dw)	Empirical Tissue PCB Concentration (µg/kg ww)	FWM Estimate		Regression Estimate	
			Tissue PCB Concentration (µg/kg ww)	SPAF	Tissue PCB Concentration (µg/kg ww)	SPAF
C7-2	380	250	259	1.0	109	2.3
C8	3,300	580	828	1.4	277	2.1
C9	35	50	75	1.5	39	1.3
C10-1	6,600	320	1,973	6.2	374	1.2
C10-2	15,000	330	3,395	10.3	532	1.6

dw – dry weight
FWM – food web model
ID – identification
PCB – polychlorinated biphenyl
SPAF – species predictive accuracy factor
ww – wet weight

D.8 Comparison of FWM Estimates to 2007 Tissue Data

Most of the tissue total PCB data used in the FWM calibration were collected in 2004 and 2005, with a smaller amount of data from the 1990s. Additional tissue data were collected in the LDW in 2006 and 2007. These additional data were collected after the FWM was calibrated so they were not included in the calibration dataset. In this section, FWM-estimated concentrations in tissue are compared to the 2007 data as an informational exercise.

As discussed in Section 4.2.2.4 in the main body of the RI, total PCB concentrations (Aroclor sum) in fish, crabs, and clams were generally lower in 2006 and 2007 than in 2004 and 2005. The reason for this decrease is not known. Possible hypotheses include higher total PCB concentrations in tissue samples collected in 2004 because of the dredging of PCB-contaminated sediments in 2004 that could have mobilized PCBs and made them more available to organisms, a gradual decline in total PCB concentrations in sediment and water over time because of natural recovery (which will be discussed in greater detail in the FS), reductions in surface sediment concentrations from the Duwamish/Diagonal dredging lowering site-wide exposures after 2004, analytical uncertainties associated with the use of different laboratories in 2004 versus 2005, 2006, and 2007 (see Section 4.2.2.4 in the main body of the RI), or a combination of these factors.

Interest has been expressed by agency reviewers in seeing how well the FWM would predict the 2007 tissue concentrations. Because there are no alternative input parameters (e.g., surface sediment total PCB concentrations, surface water total PCB concentrations) that could be used in the FWM to be reflective of the more recent conditions, this exercise does not constitute a validation of the FWM. For example, the baseline surface sediment dataset that served as the basis for the SWAC used in the

FWM represents samples collected from 1990 through 2005; there are too few samples from the latter years to estimate an LDW-wide SWAC that might more accurately reflect the exposure regime of the organisms collected in 2006 or 2007. Nevertheless, for the sake of demonstration, mean tissue PCB concentrations (sum of detected Aroclors) for species collected in 2007 were compared with the total PCB concentrations estimated for those species using the FWM and the best-fit parameter set identified in calibration of the FWM (Table D.8-1). Similar comparisons cannot be made for tissue samples collected in 2006 because tissue samples in that year were available for only two of the target species and only from Area T1. Clam data were also not included in this comparison because those data were not considered spatially representative of the entire LDW. SPAFs were then calculated by comparing the empirical 2007 tissue PCB data to the FWM-estimated total PCB concentrations.

Table D.8-1. FWM-estimated total PCB concentrations in tissue compared to empirical data from 2007, tissue data in the calibration dataset, and the combined tissue dataset

Species	Mean Total PCB Concentration in Tissue (µg/kg ww)				SPAF		
	FWM Estimate Using the Best-Fit Parameter Set[a]	2007 Tissue Data[b]	Tissue Data in the Calibration Dataset (1990s – 2005)	All Tissue Data (1990s – 2007)[b, c]	2007 Tissue Data	Tissue Data in the Calibration Dataset (1990s – 2005)	All Tissue Data (1990s – 2007)[c]
Benthic invertebrates	300	nd	200	nc	nd	1.5	nc
Slender crab	690	155	670	510	4.5	1.0	1.4
Dungeness crab	1,200	200	1,100	890	6.0	1.1	1.3
Pacific staghorn sculpin	1,100	nd	900	nc	nd	1.2	nc
Shiner surfperch	1,600	452	1,800	1,400	3.5	**1.2**	1.1
English sole	2,500	683	2,300	1,800	3.7	1.1	1.4
Average	nc	nc	nc	nc	**4.4**	**1.2**	**1.3**

[a] FWM estimates were determined without changing any of the input parameters to attempt to reflect any changes in the exposure regime of organisms sampled in 2007.

[b] Mean total PCB concentrations are based on the sum of detected Aroclors.

[c] Does not include 2006 data because these data were not considered spatially representative.

FWM – food web model
LDW – Lower Duwamish Waterway
nd – no data (not sampled in 2007)
nc – not calculated
PCB – polychlorinated biphenyl
SPAF – species predictive accuracy factor
ww – wet weight

Although the FWM estimates were within a factor of 2 of the tissue concentrations in the FWM calibration dataset (i.e., SPAFs ranged from 1.1 to 1.5, with an average SPAF of 1.2), the FWM slightly overpredicted tissue concentrations (i.e., estimated higher

concentrations) for five of the six modeled species. Given that tissue concentrations in 2007 were substantially lower than those in the calibration dataset, it is not surprising that SPAFs were higher still; SPAFs calculated using the 2007 empirical tissue data ranged from 3.5 to 6.0, with an average of 4.4 across species.

In addition to comparing FWM estimates to the 2007 data, the FWM estimates were also compared to a combined LDW dataset (including all tissue data from the 1990s through 2007, except data from 2006). This comparison resulted in SPAFs that were very similar to those generated from the FWM calibration dataset. The average SPAF was 1.3 compared to an average SPAF of 1.2 for the FWM calibration dataset. Thus, if it is assumed that conditions in the system did not change significantly between the period when the FWM calibration data set was collected and 2007, then the FWM estimates this larger dataset quite well.

The FWM's underestimation of 2007 tissue concentrations should not be taken as an indication that the FWM performed poorly; true validation of the FWM would only be possible if there was a sufficiently robust exposure dataset with significantly different PCB concentrations that could be used in the FWM to reflect the actual exposure of the organisms sampled in 2007. In the absence of a robust synoptic sediment, water, and tissue dataset, the 2007 tissue data cannot be used to "validate" the FWM. Comparison of model predictions to the larger dataset, including FWM calibration data and 2007 data, indicated that the model predicts this larger dataset quite well. Although the FWM may be used to estimate future tissue concentrations under alternative exposure scenarios, the best indication of possible linkage between sediment and tissue PCB concentrations will result from a thoughtfully designed monitoring program to be implemented after remediation has begun.

D.9 Application of the FWM to Calculate Sediment RBTCs

RBTCs represent the concentrations that correspond to specific thresholds of risk.[38] In Section 8 in the main body of the RI, RBTCs were estimated for various human exposure pathways for risk driver chemicals identified in the baseline risk assessments (Appendices A and B). The FWM was used to generate sediment RBTCs for total PCBs for exposure through the ingestion of aquatic species (seafood) by humans and river otter. This use of the FWM carries an implicit assumption that risks associated with tissue concentrations of PCBs are a predictable function of sediment PCB concentrations and that risks from PCBs can thus be predictably reduced by lowering sediment concentrations.

This section describes the four main steps of the process used to generate estimates of sediment RBTCs for total PCBs. Briefly, sediment and water input parameters were selected, and then the model was run iteratively to estimate the tissue concentrations

[38] For example, a 1×10^{-6} RBTC is the tissue concentration (or the associated sediment concentration) at which the excess cancer risk equals 1×10^{-6} for a specific human exposure scenario.

that correspond to each set of input parameters. The estimated tissue concentrations were then used in the human health risk equations, and the sediment concentrations associated with particular risk thresholds were identified. Details for each of these steps are discussed below.

Step 1. Estimate total PCB concentrations in surface sediment and in overlying water in the water column

To estimate sediment RBTCs, the FWM required paired inputs of total PCB concentrations in surface sediment and overlying water; both of these input parameters are important for the model. The surface sediment concentration was represented by the SWAC for the LDW from RM 0.0 to RM 5.25, which has been estimated to be 380 µg/kg dw.[39] The EFDC model[40] estimated an annual LDW-wide mean total PCB concentration in water of 1.43 ng/L using the three bottom cells of the EFDC model. These concentrations represent water in the lower portion of the water column, closer to the sediment surface, where most of the fish and crab species being modeled spend the majority of their time.

In the future, total PCB concentrations in sediment and water are likely to be lower following sediment remediation and source control actions within the LDW. Because these concentrations are not yet known, the FWM was run with total PCB concentrations in sediment ranging from 0 to 380 µg/kg dw. Total PCB concentrations in sediment will never be 0 µg/kg dw because of background sources of PCBs. The low end of the range (approaching zero PCBs in sediment) was modeled to estimate total PCB concentrations in tissues at very low concentrations in sediment.

The EFDC model was not used to estimate future total PCB concentrations in the water column for each concentration in sediment; these estimates would have been highly uncertain because of the numerous modeling assumptions that would have been required (e.g., assumed spatial distributions of PCBs in sediment, including values for East and West Waterway). In addition to these uncertainties, the simulation run time required to process each sediment scenario would have required significant computational time (Nairn 2009).

Because the EFDC model was not used, future total PCB concentrations in the water column were divided into three general ranges. To define these ranges, total PCB concentrations in the water column and in surface sediment were assumed to be related. For total PCB concentrations in surface sediment between 250 and 380 µg/kg dw, a water concentration of 1.2 ng/L was assumed based on the best-fit parameter set (Table D.5-3). This concentration is slightly below the LDW-wide mean concentration

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[39] The 2006 IDW parameterization used to estimate the SWAC for the FWM was discussed in the *Technical Memorandum: GIS Interpolation of Total PCBs in LDW Surface Sediment* (Windward 2006b). The baseline surface sediment dataset used in this application was the same dataset used in the risk assessments and thus did not include surface sediment data collected during Round 3 in 2006.

[40] Estimates from the EFDC model were received in October 2006. Additional information on the EFDC model is provided in a memo produced by King County (Nairn 2009).

of 1.43 ng/L (Table D.4-1) estimated by the EFDC model. For the lower sediment ranges, total PCB concentrations in water were assumed to be proportionately lower (Table D.9-1). As a point of reference, total PCB concentrations in water from the Green River, which is the upstream source of surface water to the LDW, ranged from 0.04 to 0.8 ng/L in 2005 and from 0.04 to 2.4 ng/L in 2007 (Mickelson and Williston 2006; Williston 2008). The total PCB concentration in water in Elliott Bay, the source of saline water to the LDW, ranged from 0.056 to 0.089 ng/L in 2005 (Mickelson and Williston 2006). The selection of a single water value was necessary for each sediment range because the FWM can only accommodate a single value for overlying water. The porewater concentration parameter (estimated by the model) provides a mechanism for the FWM to account for the potentially higher concentrations of chemicals within the sediment-water interface.

Table D.9-1. Assumed relationship between total PCB concentrations in sediment and overlying water for the calculation of RBTCs in sediment

Range of Total PCB Concentrations in Sediment (µg/kg dw)	Assumed Total PCB Concentrations in the Water Column (ng/L)
0 – 100	0.6
100 – 250	0.9
250 – 380	1.2

dw – dry weight
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration

Step 2. Run the model probabilistically using Monte Carlo simulation

The FWM was run probabilistically as a Monte Carlo simulation using Crystal Ball® software, allowing numerous model runs for small incremental changes in total PCB concentrations in sediment, with concentrations ranging from 0 to 380 µg/kg dw. The total PCB concentration in water for each of these runs also varied, per the relationship described in Table D.9-1.

Results of these model runs (i.e., estimates of total PCB concentrations in tissues) using the best-fit parameter set are displayed graphically in Figure D.9-1. The "steps" in estimated total PCB concentrations in tissue occurred at total PCB concentrations in sediment corresponding to the three sediment/water intervals defined in Step 1.

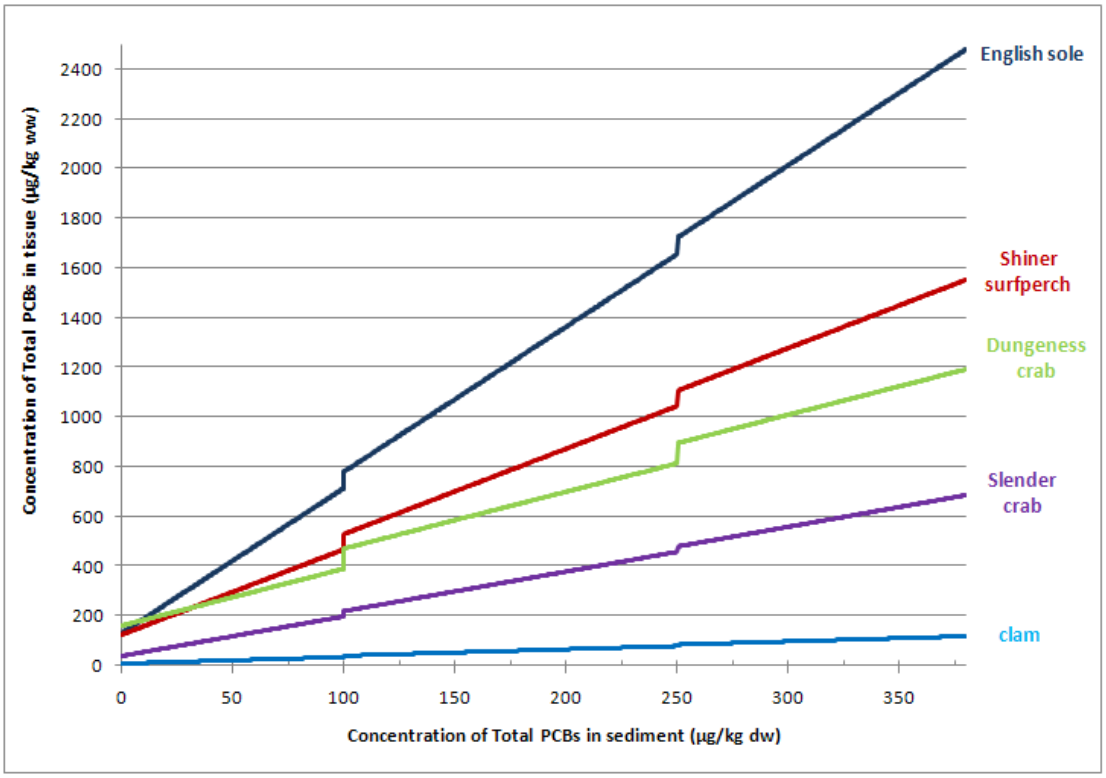

Figure D.9-1. Total PCB concentrations in whole-body tissues of seafood species as a function of total PCB concentrations in sediment

The FWM was also used to estimate a range of total PCB concentrations in each tissue type. Parameter sets that passed the model performance criterion (SPAF ≤ 2 for all species) were reviewed to determine which set produced the highest and lowest estimated total PCB concentrations for each species, regardless of the performance of other species.

Figures D.9-2 and D.9-3 present the results for Dungeness crabs and English sole, respectively, as examples. The red lines represent the FWM estimates using the best-fit parameter set. The yellow and orange lines are the lower- and upper-bound estimates, respectively.

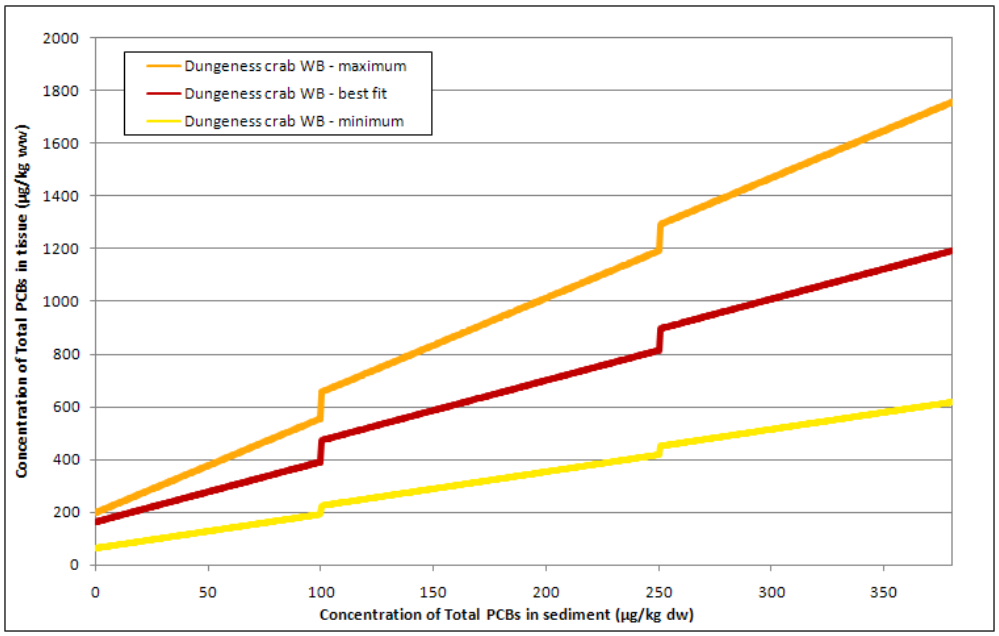

Figure D.9-2. Estimated total PCB concentrations in whole-body Dungeness crab using best-fit, maximum, or minimum parameter sets as a function of total PCB concentration in sediment

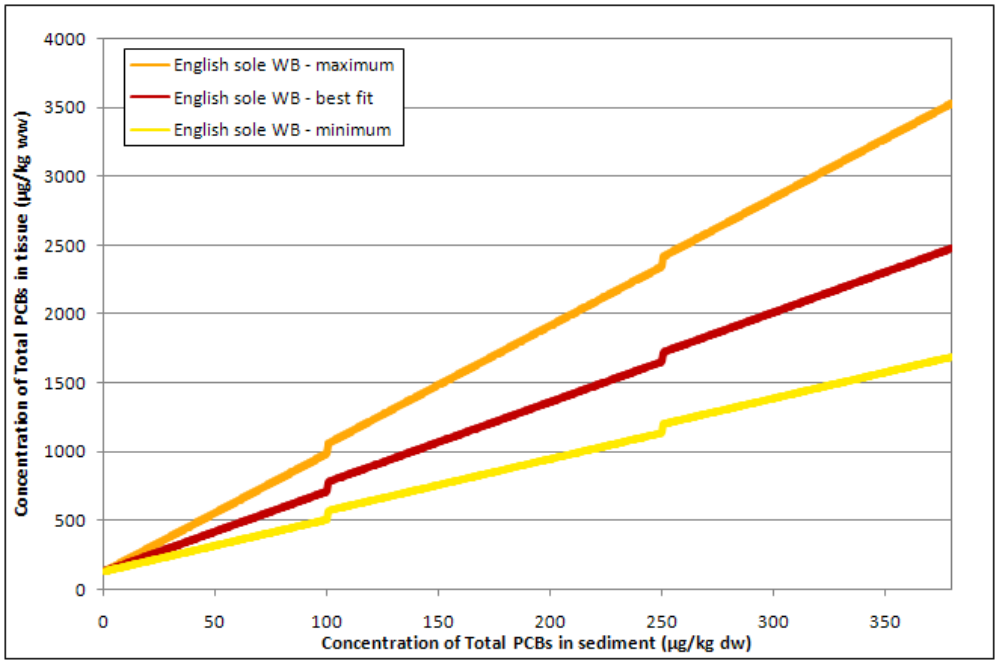

Figure D.9-3. Estimated total PCB concentrations in whole-body English sole using best-fit, maximum, or minimum parameter sets as a function of total PCB concentration in sediment

Because of the way the range of estimates was defined, the upper-bound estimate (orange line) could exceed the best-fit estimate (red line) by up to a factor of 2 at any

given sediment total PCB concentration, as was frequently the case. Similarly, the lower-bound estimate (yellow line) could be as low as 50% of the best-fit estimate (red line). However, the lower-bound estimates were more similar to the best-fit estimates because the greatest underestimate of the FWM was 36% (vs. the 50% allowed). Therefore, the specific model criterion selected (SPAF ≤ 2 for all species) did not result in the elimination of any of the parameter sets that underestimated the mean and thus did not influence the lower-bound estimate. The upper-bound estimate would have been higher if the criterion had been less stringent (i.e., a SPAF threshold > 2). The upper- and lower-bound estimates are not upper and lower confidence intervals and do not reflect a statistical measure of uncertainty. Instead, the upper and lower bounds reflect some of the variability in FWM estimates, which was constrained by the model performance SPAF of ≤ 2. The upper and lower bounds do not include consideration of sediment variance (or uncertainty in the SWAC) because the sediment concentration was considered a decision variable (see Section D.4.1.1). Analyses of model sensitivity and uncertainty associated with the SWAC were presented in Section D.6.3.

Step 3. Calculate risk estimates using the output generated by each FWM run

The estimated total PCB concentrations in tissue for the modeled species,[41] corresponding to each of the thousands of FWM runs associated with incremental steps in total PCB concentration in sediment, were entered into the human health and ecological receptor risk equations. These estimated tissue concentrations were used in the risk equations in the same way that exposure point concentrations (EPCs) were used in the risk assessments.

Excess cancer risks and non-cancer hazards were estimated using these estimates for each of the seafood ingestion scenarios evaluated in the HHRA (Appendix B) and in the ERA (Appendix A) for river otters. Risks were calculated using the best-fit, maximum, and minimum estimates over the full range of paired total PCB concentrations in sediment and water.

To determine the upper-bound EPCs for each risk scenario, the highest estimates for each species were combined to estimate the total PCB concentration in a given market basket selection. To determine the lower-bound EPCs for each risk scenario, the lowest estimates for each species were combined to estimate the lowest total PCB concentration

[41] The FWM estimated total PCB concentrations in whole-body organisms. In the HHRA, some of the seafood ingestion scenarios included the consumption of edible meat (crabs) or fillet (English sole). Therefore, conversion factors were developed. The conversion factors used to convert total PCB concentrations in whole-body organisms to lower concentrations in edible meat or fillet concentrations were 0.295 for slender crabs, 0.139 for Dungeness crabs, and 0.526 for English sole. These conversion factors were based on the ratio of whole-body to edible-meat concentrations detected in individual LDW fish tissue samples and detected in composite crab edible meat and hepatopancreas samples collected as part of the LDW RI.

in a particular market basket selection. For receptors that consume multiple species, this approach may lead to an over- or underestimate of possible exposures and associated risks; parameter sets were selected on a species-by-species basis rather than as a single set of parameters that resulted in the highest (or lowest) tissue concentrations across all species consumed by a particular receptor. Uncertainties associated with the risk assumptions are discussed in Appendices A and B, and FWM uncertainties are discussed in Section D.6.

Step 4. Identify the sediment RBTC associated with a given risk threshold

Because of the large number of tissue predictions and risks generated for each scenario, it was necessary to devise a method to organize the data so that RBTCs could be efficiently identified for any of the risk thresholds of interest (i.e., 1×10^{-4}, 1×10^{-5}, and 1×10^{-6}). Thus, the risk estimates described in Step 3 were compiled in a table to facilitate the identification of the total PCB concentration in sediment corresponding to a selected excess cancer risk threshold (1×10^{-4}, 1×10^{-5}, or 1×10^{-6}) or a non-cancer hazard (hazard quotient = 1) for each of the exposure scenarios.

Table D.9-2 demonstrates the manner in which sediment RBTCs were identified for two of the seafood consumption scenarios. The full table, which included all of the seafood consumption scenarios evaluated in the HHRA (Appendix B) and the river otter scenario evaluated in the ERA (Appendix A), was too large to reproduce in this format.

Table D.9-2 presents 16 of the many model runs that were conducted. The right-hand columns show excess cancer risk for adult Tulalip seafood consumption scenarios, and the bold cells identify specific excess cancer risk levels (1×10^{-4} for the adult Tulalip reasonable maximum exposure [RME] and 1×10^{-5} for adult Tulalip central tendency [CT]). The sediment value corresponding to those excess cancer risk values are shown in bold type. For the adult tribal RME scenario based on Tulalip data, a sediment RBTC of 5 µg/kg dw total PCBs was associated with the 1×10^{-4} excess risk level; for the adult tribal CT scenario based on Tulalip data, a sediment RBTC of 24 µg/kg dw total PCBs was associated with the 1×10^{-5} excess risk level. Sediment RBTCs for other risk scenarios and risk thresholds are presented in Section 8 in the main body of the RI.

In total, three sediment RBTCs were identified for each risk scenario/risk threshold: a best-fit sediment RBTC (based on the best-fit parameter set) and upper and lower bound RBTCs. These sediment RBTCs are presented in Figure 8-7 in Section 8 in the main body of the RI.

At extremely low sediment PCB concentrations, the PCB concentration in water alone is sufficient to result in estimates of tissue concentrations that correspond to excess cancer risk estimates greater than 1×10^{-5} for human seafood consumers (for all RME consumption scenarios). Thus, it was not possible to calculate a sediment RBTC at the lower risk threshold levels, such as 1×10^{-6} and 1×10^{-5}. This exercise indicates that the assumption implicit in RBTC calculations that tissue concentrations (and therefore risk estimates) are predictable functions of PCB sediment concentrations, may be tenuous, particularly at very low sediment concentrations.

Table D.9-2. Excess risk levels for two seafood consumption scenarios corresponding to total PCB concentrations in sediment

Total PCB Concentrations Used as Input Values		Estimated Total PCB Tissue Concentration (µg/kg ww)										Excess Cancer Risk Estimates Based on FWM Output	
Sediment (µg/kg dw)	Water (ng/L)	Clam	Juvenile Fish	Slender Crab WB	Slender Crab EM	Dungeness Crab WB	Dungeness Crab EM	Pacific Staghorn Sculpin	Shiner Surf-perch	English Sole WB	English Sole Fillet	Adult Tribal RME (Tulalip data)	Adult Tribal CT (Tulalip data)
1	0.6	11	63	43	13	164	23	117	126	137	72	9.0×10^{-5}	6.3×10^{-6}
5	0.6	12	67	51	15	174	24	127	141	163	86	**1.0×10^{-4}**	7.0×10^{-6}
10	0.6	13	72	58	17	185	26	139	158	191	101	1.1×10^{-4}	7.8×10^{-6}
20	0.6	16	81	74	22	208	29	161	192	248	130	1.3×10^{-4}	9.4×10^{-6}
24	0.6	17	84	80	23	216	30	170	204	270	142	1.4×10^{-4}	**1.0×10^{-5}**
30	0.6	18	90	89	26	231	32	185	226	306	161	1.6×10^{-4}	1.1×10^{-5}
40	0.6	21	99	106	31	254	35	208	261	365	192	1.8×10^{-4}	1.3×10^{-5}
50	0.6	23	108	121	36	277	38	232	295	423	223	2.0×10^{-4}	1.4×10^{-5}
70	0.6	28	126	153	45	322	45	278	363	539	284	2.5×10^{-4}	1.8×10^{-5}
90	0.6	34	144	185	55	368	51	325	432	656	345	3.0×10^{-4}	2.1×10^{-5}
100	0.6	36	153	201	59	391	54	348	467	715	376	3.2×10^{-4}	2.2×10^{-5}
150	0.9	54	230	301	89	587	82	523	700	1,072	564	4.8×10^{-4}	3.4×10^{-5}
200	0.9	67	276	380	112	700	97	638	870	1,361	716	5.9×10^{-4}	4.2×10^{-5}
250	0.9	80	321	460	136	815	113	756	1,044	1,655	871	7.1×10^{-4}	5.0×10^{-5}
300	1.2	98	398	561	165	1,011	141	930	1,277	2,012	1,059	8.7×10^{-4}	6.1×10^{-5}

Note: Values shown are excerpt of the full table used to estimate RBTCs. The excess cancer risk estimate on the right side of the table corresponds with the sediment concentration on the left side of the table for each row.

CT – central tendency
EM – edible meat
FWM – food web model
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration
RME – reasonable maximum exposure
WB – whole-body
ww – wet weight

Bold values are those called out in the example discussed in the text.

D.10 Summary

The FWM was developed to estimate the relationship between total PCB concentrations in tissue and sediment in order to estimate RBTCs in sediment for the RI. The FWM may also be used in the FS to assess residual risks that may remain following various sediment cleanup alternatives.

The FWM structure was based on the Arnot and Gobas model (Arnot and Gobas 2004a), a steady-state bioaccumulation model. The FWM provides estimates of total PCB concentrations in the tissues of nine species or species groups, based on bioaccumulation of total PCBs from the sediment and water column. Many of the species included in the FWM were ecological receptors, prey for ecological receptors, or consumed by humans, as described in the risk assessments (Appendices A and B).

Input parameter values and distributions for the model were based on literature-derived and site-specific environmental data. The model was then calibrated to identify sets of parameter values that best estimated empirical tissue total PCB concentration data. For many model input parameters, distributions of estimates of mean values were developed to reflect uncertainty in their values. Calibration was performed using a probabilistic approach in order to systematically explore all combinations of plausible parameter sets and their corresponding estimated total PCB concentrations in tissue.

Through the calibration process, a best-fit parameter set was identified that estimated total PCB concentrations for all modeled fish and crab species within a factor of 2 (1.2 on average) of empirical data.

To better understand the strengths and limitations of the model, model sensitivities and uncertainties were evaluated. The parameters that most influenced model uncertainty were dietary absorption for crabs, relative fractions of benthic versus pelagic food items in the diet of various modeled species, and parameters that characterized prey species (such as lipid content and porewater ventilation rate). In general, the parameters that most influenced model uncertainty had broad ranges of values derived from the literature.

The FWM was calibrated at a LDW-wide spatial scale. It was tested at smaller scales within the LDW to assess its performance, in part because home ranges of many of the modeled species were uncertain. Based on these analyses, application of the FWM appeared to be inappropriate at the modeling area scale for most species. The FWM was performed well for clams at locations with sediment total PCB concentrations of 3,300 µg/kg dw or lower.

The FWM was used to develop sediment RBTCs for total PCBs. Following a four-step process, sediment RBTCs associated with various risk thresholds for various seafood ingestion scenarios were identified. Best-fit sediment RBTCs were identified as well as upper- and lower-bound RBTCs. Upper and lower bounds were developed based on

the model performance criterion and do not reflect the total range of uncertainty in the sediment RBTCs. Sediment RBTCs are presented in Section 8 in the main body of the RI.

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Attachment 1 Benthic Invertebrate Tissue-Sediment Regression

Total PCB tissue concentrations for benthic invertebrates were derived from tissue-sediment regressions. Benthic invertebrate tissue and co-located surface sediment samples were collected from 20 locations in the LDW (10 intertidal locations and 10 subtidal locations). Linear least-squares regression was used to model the relationship between total PCB concentrations[42] in benthic invertebrate tissue and co-located sediment. Although the log-log relationship provided the closest fit to the data, a simple linear regression was selected because of the uncertainty associated with adjusting for variance when back-transforming predictions from a log-log regression model. The selected linear model has a reasonable fit with homogeneous residuals (Figure 1), except for two extreme points (locations B5a-1 and B8a). Location B5a-1 had a low-moderate sediment total PCB concentration and a high tissue concentration. The sediment had very low organic carbon content, so this point was not extreme when the data were organic carbon-normalized. Location B8a had a high total PCB sediment concentration. This point was exerting undue influence on the regression estimates and was far higher than the total PCB concentrations in sediment for which total PCB concentrations were to be estimated in tissue. The R^2 value for the regression when the two influential values were included was 0.72. Without these two influential values, the regression continued to provide a good fit to the data in the range for which total PCB concentrations will be estimated in tissue. Exclusion of the two influential high values is warranted if the use of the model is to provide the closest fit to the data for the range across which the model will be applied. Because the FWM will be used to calculate tissue concentrations less than or equal to the current SWAC of 380 µg/kg dw, removal of the two high values that influenced the regression slope was justified. The R^2 value with the two high values removed was 0.57. The regression parameters were estimated with one half the reporting limit for the two non-detect samples.[43] The equation for the line with outliers removed is presented as Equation 1.

$$C_{BI} = (0.34 \times C_S) + 75 \qquad \textbf{Equation 1}$$

Where:

C_{BI} = total PCB concentration in benthic invertebrate tissue (µg/kg ww)
C_S = total PCB concentration in sediment (µg/kg dw)

[42] The relationship between organic carbon-normalized total PCB concentrations in sediment and lipid-normalized total PCB concentrations in tissue was also tested, but the relationship without normalization provided a better fit to the data.

[43] There was one non-detect sediment sample (B1a; reporting limit = 20 µg/kg dw) and one non-detect tissue sample (B4a; reporting limit = 200 µg/kg ww).

Total PCB concentrations in benthic invertebrate tissues for the entire LDW and for each modeling area were estimated from total PCBs in sediment using the equation above. The sediment concentrations (C_S) used were the spatially weighted average concentrations (SWACs) from corresponding areas of the LDW.

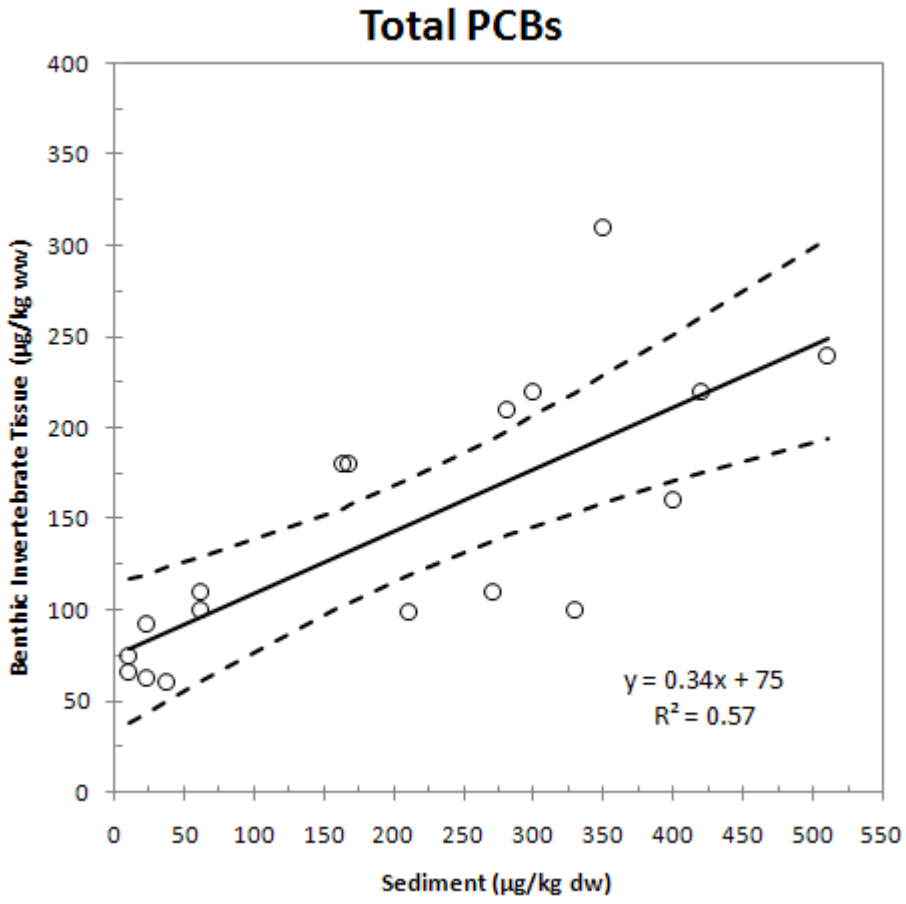

Figure 1. Linear regression fit to total PCB concentration in benthic invertebrate tissue as a function of total PCB concentration in sediment

Attachment 2 Statistics for the Calibrated Food Web Model

Parameter Description	Unit	Passed Model Performance Filter					Top 10 Runs (Ranked by average SPAF across species)			
		Min	Max	Mean	Range	Best Fit	Min	Max	Mean	Range
Environmental Parameters										
Concentration of total PCBs in the water column	ng/L	0.218	2.940	1.322	2.721	1.22	0.470	2.13	1.34	1.66
Concentration of particulate organic carbon (POC) in the water column	kg/L	$1.0E^{-7}$	4.0×10^{-7}	2.6×10^{-7}	3.0×10^{-7}	2.3×10^{-7}	1.8×10^{-7}	3.5×10^{-7}	2.5×10^{-7}	1.7×10^{-7}
Dissolved organic carbon (DOC) in the water column	kg/L	1.3×10^{-6}	3.0×10^{-6}	2.2×10^{-6}	1.7×10^{-6}	2.2×10^{-6}	1.7×10^{-6}	2.4×10^{-6}	2.2×10^{-6}	6.6×10^{-7}
Mean water column temperature	°C	9.9	12.5	11.2	2.5	11.0	10.8	11.9	11.2	1.1
Dissolved oxygen concentration in the water column	mg/L	7.12	8.56	7.91	1.44	8.15	7.75	8.19	7.96	0.44
Total suspended solids in the water column	kg/L	3.1×10^{-6}	8.6×10^{-6}	5.8×10^{-6}	5.5×10^{-6}	5.4×10^{-6}	4.2×10^{-6}	8.4×10^{-6}	6.1×10^{-6}	4.2×10^{-6}
Concentration of PCBs in sediment	µg/kg dw	380	380	380	0	380	380	380	380	0
Sediment total organic carbon	%	1.82%	1.98%	1.91%	0.17%	1.91%	1.89%	1.95%	1.92%	0.06%
Chemical Parameters										
Octanol-water partition coefficient for PCBs (log K_{ow})	unitless	6.4	6.8	6.6	0.4	6.5	6.5	6.7	6.6	0.2
Biological Parameters										
Proportionality constant expressing the sorption capacity of NLOM relative to that of octanol (β or MAF)	unitless	0.016	0.050	0.033	0.034	0.031	0.022	0.040	0.032	0.018
Resistance to chemical uptake through aqueous phase for phytoplankton/ algae (A)	day-1	2×10^{-5}	1×10^{-4}	6×10^{-5}	8×10^{-5}	6×10^{-5}	4×10^{-5}	8×10^{-5}	6×10^{-5}	4×10^{-5}

Attachment 2, cont. **Statistics for the calibrated food web model**

Parameter Description	Unit	Passed Model Performance Filter					Top 10 Runs (Ranked by average SPAF across species)			
		Min	Max	Mean	Range	Best Fit	Min	Max	Mean	Range
Resistance to chemical uptake through organic phase for phytoplankton/ algae (B)	unitless	2.0	9.2	5.5	7.2	6.2	3.1	8.0	5.8	4.8
Density of lipids	kg/L	0.8	1.0	0.9	0.2	0.9	0.8	1.0	0.9	0.1
Phytoplankton										
Lipid content of organism	%	0.00%	0.28%	0.12%	0.28%	0.14%	0.09%	0.21%	0.15%	0.13%
Water content of organism	%	93.7%	97.2%	95.6%	3.5%	95.7%	94.8%	96.7%	95.5%	2.0%
Zooplankton										
Organism weight	kg	2.2×10^{-8}	2.7×10^{-7}	1.6×10^{-7}	2.5×10^{-7}	2.2×10^{-7}	5.3×10^{-8}	2.4×10^{-7}	1.6×10^{-7}	1.9×10^{-7}
Lipid content	%	0.2%	2.3%	1.2%	2.1%	1.4%	0.7%	1.7%	1.3%	1.0%
Water content of organism	%	85%	96%	90%	10%	92%	88%	92%	91%	4%
Dietary absorption efficiency of lipids (ε_L)	%	55%	85%	71%	30%	66%	61%	81%	71%	20%
Dietary absorption efficiency of NLOM (ε_N)	%	55%	85%	71%	29%	72%	58%	83%	70%	25%
Benthic Invertebrates										
Organism weight	kg	7.1×10^{-8}	1.2×10^{-4}	4.5×10^{-5}	1.1×10^{-4}	4.1×10^{-5}	4.1×10^{-5}	8.5×10^{-5}	5.9×10^{-5}	4.4×10^{-5}
Lipid content	%	0.69%	1.05%	0.86%	0.35%	0.83%	0.69%	0.90%	0.80%	0.21%
Water content of organism	%	71%	87%	81%	15%	82%	76%	85%	83%	10%
Relative fraction of porewater ventilated	unitless	0.050	0.247	0.142	0.197	0.134	0.059	0.22	0.13	0.161
Dietary absorption efficiency of lipids (ε_L)	%	16%	95%	61%	80%	30%	30%	89%	59%	58%
Dietary absorption efficiency of NLOM (ε_N)	%	17%	93%	52%	77%	56%	18%	76%	43%	58%
Juvenile Fish										
Organism weight	kg	3×10^{-3}	8×10^{-3}	6×10^{-3}	5×10^{-3}	6×10^{-3}	5×10^{-3}	7×10^{-3}	6×10^{-3}	2×10^{-3}
Lipid content	%	0.6%	4.6%	2.4%	4.0%	1.5%	1.1%	3.1%	1.9%	2.0%

Attachment 2, cont. **Statistics for the calibrated food web model**

Parameter Description	Unit	Passed Model Performance Filter					Top 10 Runs (Ranked by average SPAF across species)			
		Min	Max	Mean	Range	Best Fit	Min	Max	Mean	Range
Water content of organism	%	65.9%	82.0%	74.0%	16.1%	74.3%	69.8%	76.3%	73.2%	6.5%
Relative fraction of porewater ventilated	unitless	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Dietary absorption efficiency of lipids (ε_L)	%	90%	95%	92%	5%	92%	91%	93%	92%	2%
Dietary absorption efficiency of NLOM (ε_N)	%	50%	65%	58%	15%	54%	54%	61%	58%	7%
Slender Crab										
Organism weight	kg	0.152	0.180	0.167	0.028	0.165	0.163	0.175	0.167	0.012
Lipid content	%	0.9%	1.2%	1.1%	0.3%	1.1%	1.0%	1.2%	1.1%	0.1%
Water content of organism	%	82.5%	85.1%	83.8%	2.7%	83.7%	83.4%	84.5%	83.9%	1.1%
Relative fraction of porewater ventilated	unitless	0.01	0.03	0.02	0.02	0.03	0.01	0.03	0.02	0.02
Dietary absorption efficiency of lipids (ε_L)	%	16%	95%	62%	79%	75%	39%	90%	68%	51%
Dietary absorption efficiency of NLOM (ε_N)	%	16%	95%	62%	79%	76%	39%	89%	68%	51%
Dungeness Crab										
Organism weight	kg	0.328	0.719	0.527	0.391	0.653	0.431	0.653	0.570	0.222
Lipid content	%	1.1%	4.2%	2.6%	3.1%	3.4%	2.3%	3.4%	2.8%	1.1%
Water content of organism	%	79%	84%	82%	5%	81%	81%	83%	82%	2%
Relative fraction of porewater ventilated	unitless	0.01	0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.01
Dietary absorption efficiency of lipids (ε_L)	%	16%	96%	61%	79%	71%	47%	82%	66%	35%
Dietary absorption efficiency of NLOM (ε_N)	%	18%	95%	62%	77%	59%	48%	82%	65%	34%
Pacific Staghorn Sculpin										
Organism weight	kg	0.062	0.089	0.077	0.026	0.075	0.065	0.078	0.074	0.013

Attachment 2, cont. **Statistics for the calibrated food web model**

Parameter Description	Unit	Passed Model Performance Filter					Top 10 Runs (Ranked by average SPAF across species)			
		Min	Max	Mean	Range	Best Fit	Min	Max	Mean	Range
Lipid content	%	1.9%	2.3%	2.1%	0.4%	2.1%	2.0%	2.2%	2.1%	0.2%
Water content of organism	%	79%	79%	79%	1%	79%	79%	79%	79%	0%
Relative fraction of porewater ventilated	unitless	0.02	0.10	0.06	0.08	0.03	0.03	0.09	0.06	0.06
Dietary absorption efficiency of lipids (ε_L)	%	90%	95%	92%	5%	93%	90%	94%	92%	3%
Dietary absorption efficiency of NLOM (ε_N)	%	50%	65%	58%	14%	50%	50%	62%	58%	12%
Shiner Surfperch										
Organism weight	kg	0.017	0.021	0.019	0.003	0.019	0.018	0.020	0.019	0.001
Lipid content	%	3.9%	5.3%	4.6%	1.3%	4.6%	4.2%	4.9%	4.6%	0.7%
Water content of organism	%	72.8%	75.2%	73.9%	2.4%	74.0%	73.3%	74.4%	73.9%	1.0%
Relative fraction of porewater ventilated	unitless	0.01	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.01
Dietary absorption efficiency of lipids (ε_L)	%	90%	95%	92%	5%	94%	91%	94%	92%	3%
Dietary absorption efficiency of NLOM (ε_N)	%	50%	65%	58%	15%	56%	52%	63%	58%	11%
English Sole										
Organism weight	kg	0.212	0.282	0.247	0.070	0.246	0.231	0.258	0.246	0.027
Lipid content	%	4.7%	6.2%	5.5%	1.4%	5.5%	5.2%	6.0%	5.5%	0.7%
Water content of organism	%	74.0%	76.0%	75.0%	2.0%	75.0%	74.4%	75.3%	75.0%	1.0%
Relative fraction of porewater ventilated	unitless	0.01	0.20	0.10	0.19	0.15	0.04	0.1	0.09	0.11
Dietary absorption efficiency of lipids (ε_L)	%	90%	95%	92%	5%	92%	91%	94%	93%	3%
Dietary absorption efficiency of NLOM (ε_N)	%	50%	65%	58%	15%	59%	54%	63%	59%	9%

Attachment 2, cont. **Statistics for the calibrated food web model**

Parameter Description	Unit	Passed Model Performance Filter					Top 10 Runs (Ranked by average SPAF across species)			
		Min	Max	Mean	Range	Best Fit	Min	Max	Mean	Range
Dietary Fraction Statistics										
Benthic Invertebrates										
Sediment	fraction	0.66	0.91	0.77	0.24	0.70	0.70	0.82	0.76	0.12
Phytoplankton	fraction	0.07	0.21	0.15	0.14	0.18	0.10	0.18	0.16	0.08
Zooplankton	fraction	0.01	0.17	0.08	0.16	0.12	0.04	0.12	0.08	0.08
Juvenile Fish										
Sediment	fraction	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.01
Zooplankton	fraction	0.35	0.81	0.57	0.47	0.53	0.51	0.78	0.60	0.27
Benthic invertebrate	fraction	0.18	0.65	0.42	0.46	0.47	0.22	0.49	0.39	0.27
Slender Crab										
Sediment	fraction	0.000	0.049	0.015	0.048	0.021	0.00	0.02	0.01	0.018
Zooplankton	fraction	0.004	0.118	0.076	0.114	0.094	0.016	0.115	0.075	0.099
Benthic invertebrate	fraction	0.860	0.976	0.899	0.115	0.876	0.863	0.968	0.903	0.105
Juvenile fish	fraction	0.009	0.011	0.010	0.002	0.009	0.009	0.010	0.010	0.001
Dungeness Crab										
Sediment	fraction	0.00	0.05	0.01	0.05	0.00	0.000	0.040	0.016	0.04
Zooplankton	fraction	0.01	0.59	0.33	0.57	0.37	0.07	0.39	0.31	0.32
Benthic invertebrate	fraction	0.16	0.73	0.33	0.57	0.24	0.18	0.53	0.31	0.34
Juvenile fish	fraction	0.16	0.58	0.32	0.41	0.39	0.28	0.42	0.37	0.14
Pacific Staghorn Sculpin										
Sediment	fraction	0.00	0.05	0.02	0.05	0.00	0.00	0.02	0.01	0.02
Zooplankton	fraction	0.01	0.50	0.24	0.49	0.22	0.22	0.40	0.32	0.18
Benthic invertebrate	fraction	0.073	0.744	0.415	0.671	0.543	0.27	0.54	0.39	0.277
Juvenile fish	fraction	0.172	0.661	0.325	0.489	0.236	0.176	0.335	0.280	0.159

Attachment 2, cont. **Statistics for the calibrated food web model**

Parameter Description	Unit	Passed Model Performance Filter					Top 10 Runs (Ranked by average SPAF across species)			
		Min	Max	Mean	Range	Best Fit	Min	Max	Mean	Range
Shiner Surfperch										
Sediment	fraction	0.00	0.01	0.01	0.01	0.00	0.004	0.009	0.007	0.01
Zooplankton	fraction	0.188	0.689	0.403	0.501	0.230	0.23	0.37	0.32	0.137
Benthic invertebrate	fraction	0.304	0.803	0.591	0.499	0.765	0.629	0.765	0.677	0.135
English Sole										
Sediment	fraction	0.00	0.08	0.02	0.08	0.04	0.003	0.037	0.022	0.03
Phytoplankton	fraction	0.05	0.10	0.07	0.05	0.05	0.05	0.08	0.07	0.03
Zooplankton	fraction	0.00	0.08	0.04	0.08	0.05	0.01	0.06	0.04	0.05
Benthic invertebrate	fraction	0.86	0.90	0.88	0.04	0.86	0.86	0.89	0.87	0.03
Estimated Total PCB Concentrations in Biota										
Estimated total PCB concentration in phytoplankton tissue	µg/kg ww	5	82	31	77	28	11	61	33	50
Estimated total PCB concentration in zooplankton tissue	µg/kg ww	7	130	45	120	45	15	76	49	61
Estimated total PCB concentration in benthic invertebrate tissue	µg/kg ww	230	400	360	170	300	270	350	310	77
Estimated total PCB concentration in juvenile fish tissue	µg/kg ww	230	1200	700	940	470	410	680	530	270
Estimated total PCB concentration in slender crab tissue	µg/kg ww	340	1,300	670	980	690	570	740	660	170
Estimated total PCB concentration in Dungeness crab tissue	µg/kg ww	550	2,200	1,100	1,600	1,200	910	1,200	1,100	320
Estimated total PCB concentration in Pacific staghorn sculpin tissue	µg/kg ww	720	1,800	1,500	1,100	1,100	1,100	1,300	1,100	180
Estimated total PCB concentration in shiner surfperch tissue	µg/kg ww	900	2,200	1,500	1,300	1,600	1,200	1,700	1,500	490
Estimated total PCB concentration in English sole tissue	µg/kg ww	1,800	3,800	2,726	2,000	2,500	2,100	2,800	2,500	700

Attachment 2, cont. Statistics for the calibrated food web model

Parameter Description	Unit	Passed Model Performance Filter					Top 10 Runs (Ranked by average SPAF across species)			
		Min	Max	Mean	Range	Best Fit	Min	Max	Mean	Range
Species Predictive Accuracy Factor (SPAF)										
Benthic invertebrate SPAF	unitless	1	2	2	1	1.5	1.4	1.7	1.5	0.4
Slender crab SPAF	unitless	1.0	2.0	1.2	1.0	1.0	1.0	1.2	1.1	0.2
Dungeness crab SPAF	unitless	1.0	2.0	1.3	1.0	1.1	1.0	1.2	1.1	0.2
Pacific staghorn sculpin SPAF	unitless	1.0	2.0	1.7	1.0	1.2	1.2	1.4	1.3	0.2
Shiner surfperch SPAF	unitless	1.0	2.0	1.2	1.0	1.2	1.1	1.5	1.2	0.4
English sole SPAF	unitless	1.0	1.7	1.2	0.7	1.1	1.0	1.2	1.1	0.2
Average SPAF	unitless	1.2	1.7	1.4	0.5	1.18	1.2	1.2	1.2	0.05

DOC – dissolved organic carbon
NLOM – non-lipid organic matter
PCB – polychlorinated biphenyl
POC – particulate organic carbon
SPAF – species predictive accuracy factor
ww – wet weight

Attachment 3 EFDC Calibration Process for Predicting PCB Water Concentrations in Lower Duwamish Waterway

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MEMO

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TO: Jeff Stern, Debra Williston

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RE: EFDC Calibration Process for predicting PCB water concentrations in Lower Duwamish Waterway

1.0 Introduction

A three-dimensional hydrodynamic model of the Duwamish River and Elliott Bay was developed for the King County *Water Quality Assessment of the Duwamish River and Elliott Bay* (WQA Study) (King County 1999a). This model was created using the Environmental Fluid Dynamics Code (EFDC) and included Elliott Bay, the East and West Waterways, and the Lower Duwamish Waterway (LDW) (Figure 1). The model was used to simulate hydrodynamic, sediment transport and chemical fate processes within the modeled waterbodies. Calibration and validation results indicate that the model (referred to as the King County model) simulates hydrodynamic processes in the Duwamish River and Elliott Bay with reasonable accuracy (King County 1999b). The model also preformed well for the sediment transport and chemical fate processes. However, at the time there were limited polychlorinated biphenyl (PCB) water data available for model calibration. Therefore, the purpose of this memorandum is to document the modifications made to the King County model to improve upon the water column predictions of PCBs for the Lower Duwamish Waterway. These water column predictions were used to help calibrate the PCB food web model used for the LDW Remedial Investigation (RI). The remainder of this memo discusses the model modifications and calibration process and the resulting outcomes to PCB water column predictions. Many of these modifications were made in consultation with the national and regional Environmental Protection Agency staff and regional NOAA staff.

2.0 EFDC Model Modifications and Calibration

The EFDC model was based on the model used in the WQA study with some modifications. The source code was updated with code revisions that had been released before April 19, 2004. EFDC was configured to simulate wetting and drying of the model cells and the model cell depths were updated with the 2004 bathymetric survey. The model grid was expanded to include slips along the Waterway. Sediment concentrations were updated with recent sampling data, and partitioning constants were recalculated based on recent PCB congener data. The sections below provide more detail regarding the model modifications and calibration updates.

2.1 Grid Cells

The King County model as used in the WQA Study generally had three horizontal grid cells typically being used to represent lateral variations in the LDW[1]. The basic structure of the original hydrodynamic model developed by King County was not

[1] The area east of Kellogg Island had four horizontal grid cells because of the greater width of the LDW in this area.

altered for this application. However, the numerical horizontal grid for the LDW was slightly refined (Figure 2). Horizontal model cells were added to provide a coarse representation of the slips along the LDW. The horizontal boundary of the cells throughout the LDW was adjusted to better align with the physical shoreline. Figure 2 shows a comparison of the revised grid and the previous grid structure for the LDW. Rectangular cells were used to replace the triangular cells to the west of Kellogg Island. The revised model contains a total of 521 horizontal cells (up from 512 in the WQA King County model), of which 115 cells represented the LDW. Three lateral grid cells represented the LDW at most locations.

Each horizontal cell contains 10 vertical cells, each vertical cell is 1/10 of the water column depth. No modifications were made to the number of vertical cells. The cell depths were updated to reflect bathymetric data collected in the LDW during 2003 (Windward and DEA 2004). The wetting-drying option in EFDC was activated for these simulations to account for the wetting and drying of shallow areas resulting from variable tidal and flow conditions.

The original EFDC grid did not include model cells for the slips because the width of the slips is smaller than the length of a model grid cell. However, for this application grid cells were added to provide a coarse representation of the slips. It was thought this would be beneficial to account for the generally higher PCB sediment concentrations that are found in some of the slips. For this purpose, one or two grid cells were added to the appropriate side of the 3-cell wide LDW model at the location closest to each slip. The cells were sized so that the surface area of the cell (or cells) was approximately equal to the surface area of the corresponding slip. If the slip was represented by multiple cells, it was separated into sections that corresponded to the surface area of the model cells. The sediment grain sizes and PCB concentrations of each slip were calculated for the area represented by each model cell and applied to the model. The cells representing the slips are handled identically to other cells in the LDW by the EFDC model. The model calculates the transport flux between the cells that represent the LDW channel and those that represent the slips. As the model is not constructed at a sufficiently fine horizontal scale to accurately represent the physical dimensions of the slips, the level of uncertainty associated with predictions within the slips should be considered to be much higher than the rest of the model.

2.2 Sediment Conditions

The model was configured with four sediment layers, each 2 cm thick. A high sediment diffusivity was used so these layers act as one 8cm thick layer. The previous WQA model used one layer of infinite thickness. The sediment/water column flux was represented by a flux velocity instead of a diffusion parameter.

Sediment characteristics within the model were updated to include historic and LDW RI Phase 2 surface sediment data [2](sand/silt/clay composition and total PCBs). Sediment conditions reflecting a post Diagonal/Duwamish Combined Sewer Overflow/storm drain (CSO/SD) site remediation in 2004 and 2005 (both cap and perimeter conditions prior to placement of thin sand layer cover in 2005) were also included (Figure 3). Pre- and post- remediation samples at perimeter stations showed a change in both sediment grain size and PCB concentrations. As a result, only post remediation samples were used in both the remediation area and in a buffer area surrounding the remediation area. Details of the sediment concentrations and sample locations are provided in Appendix A. Multiple data points within a model cell were averaged; values in cells lacking any data were determined by linear interpolation from neighboring cells. Any data points outside of the grid (due to shoreline irregularities, for instance) were included in the nearest grid cell average.

One sample about 430 ft to the northwest of the Norfolk CSO/SD outfall was removed from the dataset (Figure 4). This sample is located near the upper bank and has a total PCB value of 220,000 µg/kg dw. When this value was included, it elevated the PCB concentrations in that model cell in excess of what was thought to be reasonable when all other data for that cell were considered (mean 660 µg/kg dw, n = 56). This is because this value was much higher than all other data. This approach was discussed and agreed to with EPA and NOAA.

2.3 Boundary conditions

The hydrodynamic model requires three types of boundary conditions:

1) water surface (tidal) elevation, salinity, and PCB concentrations along the open boundary in Elliott Bay,
2) surface wind velocity and direction, and
3) freshwater inflow and PCB concentrations from the Lower Green River at the upstream boundary.

At the Elliott Bay boundary, the tidal forcing consists of six tidal harmonic constituents (i.e., M2, S2, N2, K1, O1, P1), as discussed in the WQA modeling appendix (King County 1999a). This is the same parameterization of the tidal height as in the WQA configuration. Salinity of the incoming water from Elliott Bay was updated from 1996-97 data to reflect the actual observations for 2004 and 2005. CTD measurements taken by King County at station LTED04[3] were used to represent this open boundary. PCB water concentrations were set based on 2005 low-level PCB congener sampling (King County, 2006). PCBs were measured in August, September, November and December 2005 from a depth of 20 m below the water surface at Station LTED04 in Elliott Bay

[2] At the time of the model update, only Round 1 and 2 surface sediment data from Phase 2 data collection efforts of the LDW RI were available (Windward 2005a, b).
[3] Data can be obtained from King County at http://dnr.metrokc.gov/wlr/waterres/marine/DownloadData.aspx.

(Figure 5). An average total PCB concentration of 65 pg/L was used to set the Elliott Bay boundary condition for PCBs as the data showed no seasonal trend.

Wind forcing was assumed to be spatially uniform and was based on observations recorded at Boeing Field, and was updated for 2004-2005.

Upstream boundary conditions for PCBs were also based on the 2005 low-level PCB congener sampling. Samples for PCBs were collected in the Green River by Fort Dent Park (Station TGS/1) during the same time as those for Elliott Bay (Figure 5). An average total PCB concentration of 100 pg/L was used to set the Green River boundary condition for PCBs. TSS was calculated at this boundary using the same regression equation as was used in the WQA configuration (Equations 3-1 and 3-2 in King County 1999).

For the fine sands/coarse silts sediment class:

$$SS\left[\frac{mg}{l}\right] = 0.964Q^{1.09} \text{ where Q is flow } (m^3/s)$$

and for both the silt and the clay sediment classes:

$$SS\left[\frac{mg}{l}\right] = 0.654Q^{1.09} \text{ where Q is flow } (m^3/s)$$

PCB concentrations in lateral inflows into the LDW were set at zero, following the approach used in the original King County model. This is largely due to a lack of water column data with detected results for PCBs for lateral inflows. During the WQA study, CSOs were sampled for PCBs but no PCBs were detected. At the time the model was configured, there had been no CSO or stormwater samples collected for PCBs. Based on this approach, the source of PCBs in the water column of the LDW is largely due to flux from the sediments as well as some inputs from the boundary conditions. Current sediment transport modeling of the LDW indicates that the greatest solids input to the LDW is from the Green River with lateral inflows only contributing approximately 0.6% of the sediment load (QEA 2007-STM Report). This may result in a slightly overestimated flux being predicted from the sediment.

2.4 Partition Coefficients for PCBs

Updated solids partitioning coefficients (Kd) for total PCBs in both the sediment and water column were estimated based on a PCB congener weighted octonal-water partition coefficients (Kow). The congener weighted Kow for sediments was calculated in the same method described in the Food Web Model Memorandum 3 (Windward, 2006). The congener weighted Kow was based on the PCB congener data for benthic invertebrates because a full congener analysis was not available for

sediments in the LDW. It was agreed with EPA and NOAA that using the benthic invertebrate congener data was the closest approximation to sediment congener results for the purposes of developing a weighted Kow for sediments. Therefore, within the sediment bed, log Kow of 6.6 was used as a representative value based on the benthic invertebrate PCB congener data (Windward, 2006).

A different partition coefficient for PCBs in the water column of the LDW was assigned to the model. This log Kow value was based on weighted PCB congener data for PCBs in whole water samples collected in 2005 in the LDW. Two locations with two depths each were collected for low-level PCB congener analysis (Figure 5). These data were collected during the same months the low-level PCB congener samples in the Green River and Elliott Bay were collected. The Kows for each congener were based on data provided in Hawker and Connell (1988). This is the same data as was used in the LDWG's Food Web Model Memorandum 3 (Windward, 2006). Based on these PCB sampling data, log Kow of 5.8 was selected as a representative value for PCB's in the water column.

The EFDC model was configured to use a solids partitioning coefficient, similar to the approach used in the WQA study. The partitioning coefficient (Kd) is the ratio of the solid to dissolved concentration, C_s(mg/kg)/C_d(mg/L). To estimate a solids partitioning coefficient (Kd), the approach in Schwarzenbach, Gschend, and Imboden (Environmental Organic Chemistry, 1993) was used. Binding sites on the solids is assumed to be dominated by organic carbon, so the solids partitioning coefficient is estimated as the product of the organic carbon partition coefficient (Koc) and the fraction of organic carbon in the sediment. Log Kd was estimated based on the following equation:

$$\log Kd = \log (2\ foc) + 0.88 \log Kow - 0.27$$

Where foc is the fraction of organic carbon to sediment mass, and Kow is based on the weighted PCB congener results as described above. Organic carbon of the sediments was assumed to be 2% based on the overall average total organic carbon data for the LDW. The organic carbon content of the suspended solids was set at 4% based on TOC and TSS data collected in 2005 by King County in the LDW. In this approach to partitioning, these organic carbon values do not vary temporally or spatially. The partitioning coefficients calculated in this manner are Kd = 1.4×10^{-2} L/mg for the sediment bed and Kd = 5.5×10^{-3} L/mg for the water column.

The use of a single partitioning coefficient means that the EFDC model does not simulate the effect of temperature on the physical properties of PCB compounds. The temperature in the LDW surface water varied between 4°C and 17°C, and the near-bottom water ranged between 7°C and 14°C based on historical King County data.

2.5 Calibration of Total PCB Water Column Predictions

The model was previously calibrated during King County's WQA study for tidal elevation, salinity, velocity, suspended solids, metal and organic chemicals, and bacterial parameters. While minor modifications were made to the model grid, the existing calibration was used without modification. The effect of the grid changes on the calibration were not quantified, although qualitative comparison indicated the model produced similar results.

The calibration objective for this modeling was to obtain total PCB predictions that would be within a factor of two when averaged LDW-wide on a monthly timescale. The diffusion flux across the sediment/water interface is the primary calibration parameter. This flux rate was adjusted so that the model predictions would align with the low level PCB congener water data collected in the LDW by King County in 2005 (King County, 2006) (Figure 5). Water samples were collected during both the dry warmer summer period and wet, cooler fall season. The flux rate was set at 1.0e-6 m/s for this simulation. This flux rate is constant in time, and the model does not include any simulation of biological activity or time varying estimates of the sediment flux rate. No information is available on the relative amount of biological activity or the influence of that activity on PCB flux rates.

The model predictions and empirical total PCB water column data are shown in Figure 6 for the Spokane Street Bridge (LTKE03) station and in Figure 7 for 16th Avenue Bridge (LTUM03) station. Samples at these locations were collected at depths of 1 meter below the surface and 1 meter above the bottom. Model predictions are shown for the vertical model layers 2 and 9, which correspond to the sample water depths. For example, at mean sea level (MSL) model layer 2 spans the distance from 0.73 to 1.47 meters above the bottom at 16th Avenue Bridge sample location (LTUM03), which corresponds with the 1 meter above the bottom water sampling location. Model layer 9 corresponds to 0.73 to 1.47 meters below the surface at 16th Avenue Bridge sample location (LTUM03), which corresponds with the 1 meter below the surface water sampling location. Finally, model layer 2 and 9 at Spokane Street Bridge sample location (LTKE03) spans the distance of 0.93 to 1.86 meters above the bottom and below the surface, respectively, which corresponds to each surface and bottom water sampling location. As the model layers are a fraction of the water depth, the depths will vary with the tidal elevation. The sampling locations remain within the indicated model layers for most tidal conditions. Therefore, the model was calibrated to corresponding sample water depths. As a conservative step, total PCB concentrations were not adjusted for potential laboratory blank contamination for specific congeners detected in laboratory blank samples.

The model predictions and observations are in qualitative agreement. At the Spokane Street Bridge station (LTKE03), the model predicts surface water concentrations to be higher at the surface than at depth, in agreement with the empirical observations (Figure 6). This is consistent with the overall circulation of the LDW. At the

downstream portion of the LDW (closer to Elliott Bay), relatively clean Elliott Bay water is expected to enter the LDW at depth, moving upriver until it is entrained into the outgoing surface water. This is reflected in the model predictions as well as the empirical observations where PCB concentrations tend to be lower at depth.

At the 16th Avenue Bridge station (LTUM03), the model predicts bottom water concentrations to be similar or slightly higher than near surface, corresponding with the trend in the empirical observations (Figure 7). Located towards the upstream portion of the LDW, the PCB concentration in bottom water has increased in concentration due to PCB flux from the sediments. Surface concentrations are lower due to the lower concentrations observed in the freshwater input from the Green River.

As previously noted, the EFDC model does not include effects of temperature or biological activity on the physical parameters of PCBs or on the exchange rate at the sediment-water interface. The calibration data was obtained between August and December, and this period of calibration should encompass variations resulting from changes in temperature and biological activity. The predicted concentrations tend to increase in late summer and decline afterwards, following the same trend as the observations (Figures 6, 7). While consideration of these processes could lead to potential improvements in model calibration, the existing level of calibration suggests that the impact is likely to be small.

3.0 Model Simulation and Results for Total PCBs

A 1 year "spin-up" period (2004) was simulated to remove the influence of the initial model conditions. This is typically done in model simulations when the exact conditions throughout the domain are unknown. It allows the model to evolve to a condition that is reflective of the boundary conditions, which are typically better known than conditions throughout the domain. The model was then run for an additional year (2005) to provide predictions of total PCB water column concentrations for the LDW. These predictions were used in the LDW food web model calibration process. For purposes of the food web model, the model output was processed to calculate monthly average concentrations, spatially averaged over the entire LDW, and separately, over each of the four modeling sub areas (Figure 8). This was averaged vertically over the entire water column, and separately, over the bottom three model layers (bottom 30% of the water column). These results are provided in Tables 1 and 2.

The modeling predicted PCB concentrations on a monthly basis ranging from 0.99 ng/L to 1.78 ng/L for the LDW as a whole when the entire water column was included (Table 1). The ranges for the bottom three model cells only were very similar to monthly averages for the entire water column (Table 2). PCB concentrations did show some differences on a modeling area scale with area 3 having the highest predicted concentrations. The modeling area results for the bottom three cells showed some

slight increases for areas 3 and 4 when compared to the entire water column but areas 1 and 2 were similar. These results are likely due to the influence of Elliott Bay flows in the bottom layer in areas 1 and 2 and the differences in sediment concentrations between modeling areas.

The model output was also post-processed to examine the distribution of PCB concentrations at the two sampling stations within the LDW (LTKE03, LTUM03) at both the bottom and surface sampling depths. This was to provide a bounds for the long-term averages used in the LDW Food Web Model. The values are shown graphically on Figures 6 and 7, with a minimum of 0.13 ng/L and a maximum of 5.3 ng/L.

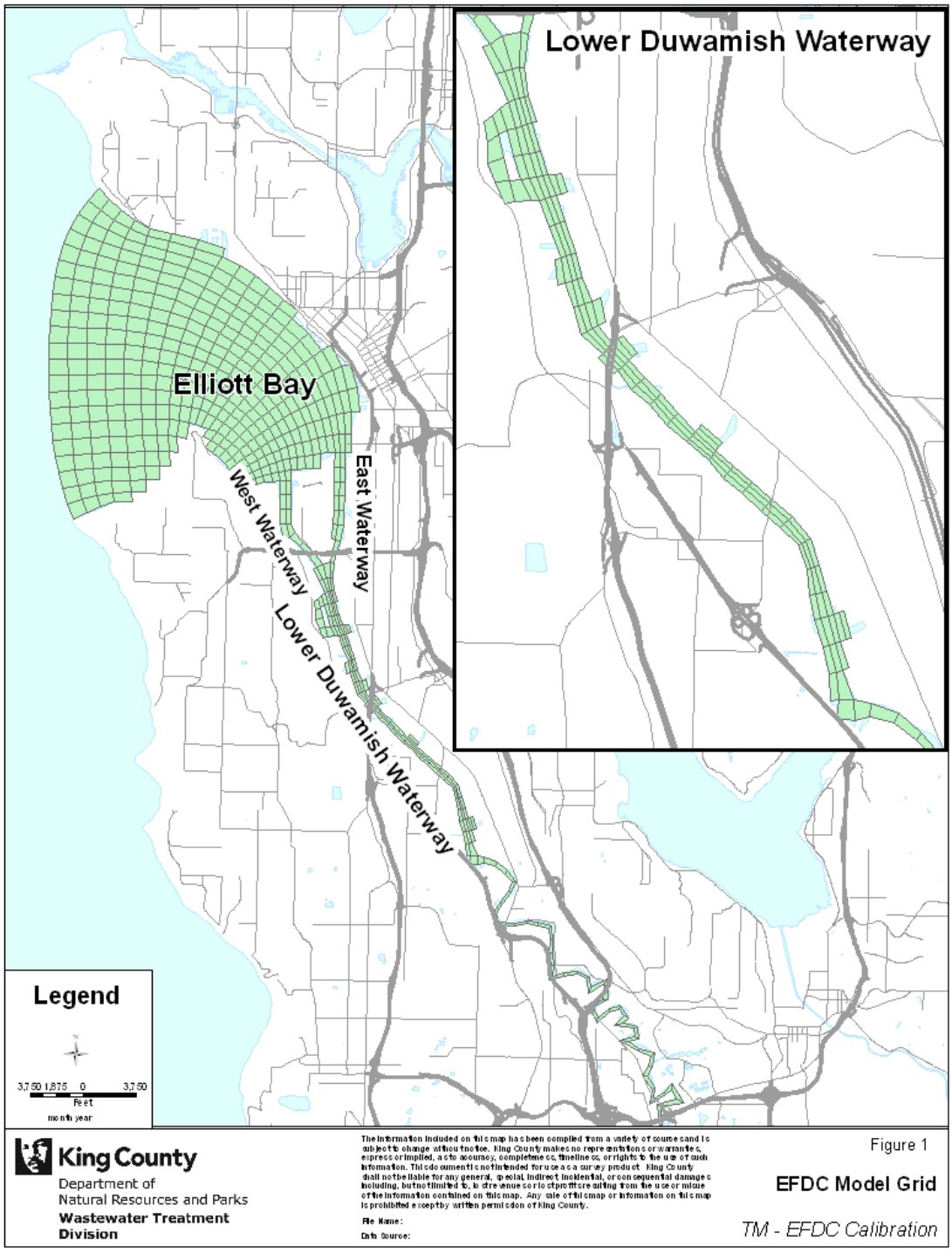

Figure 1. EFDC model grid.

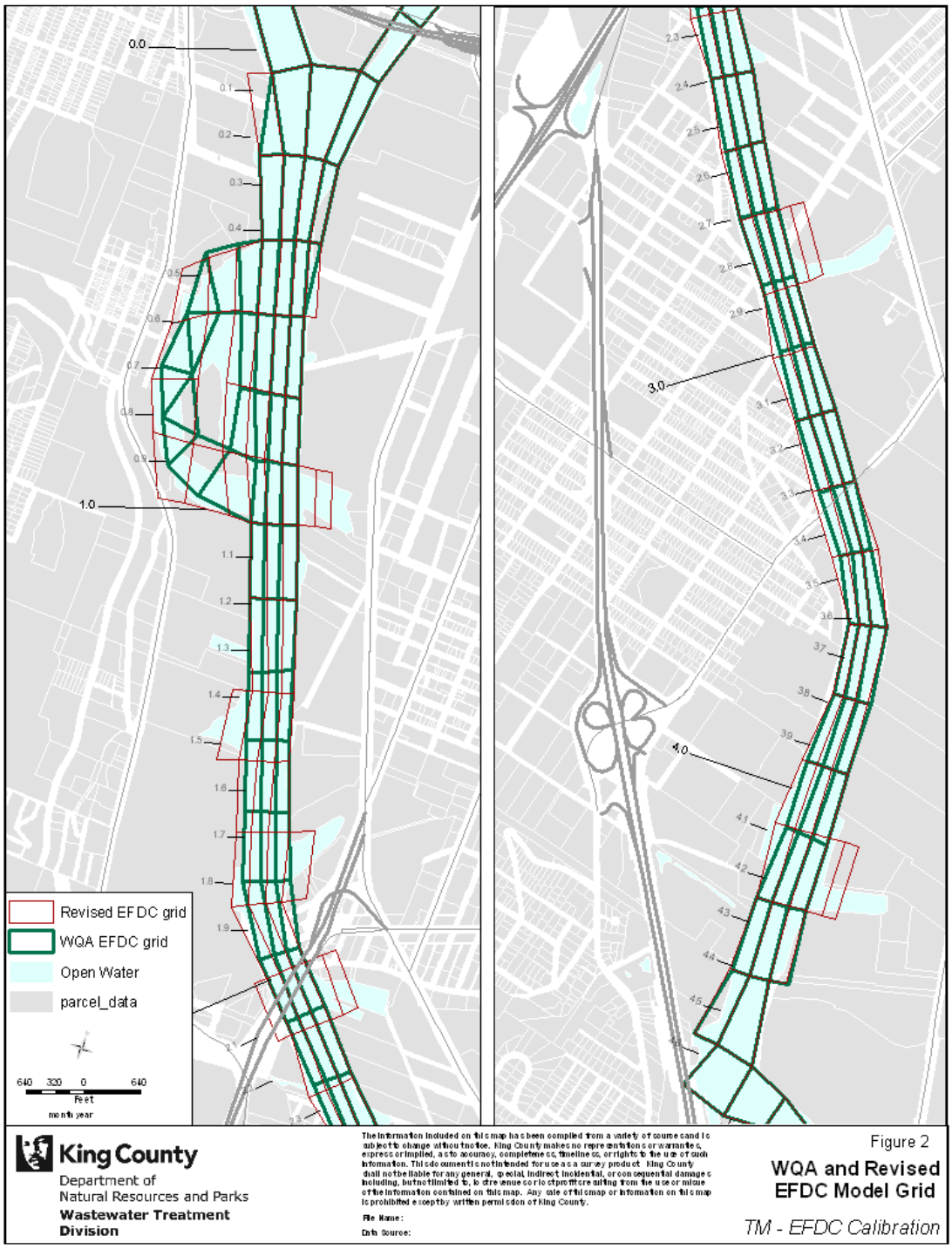

Figure 2. Comparison of original WQA model grid and revised model grid. Cells representing slips were sized to match surface area and depth of the slips.

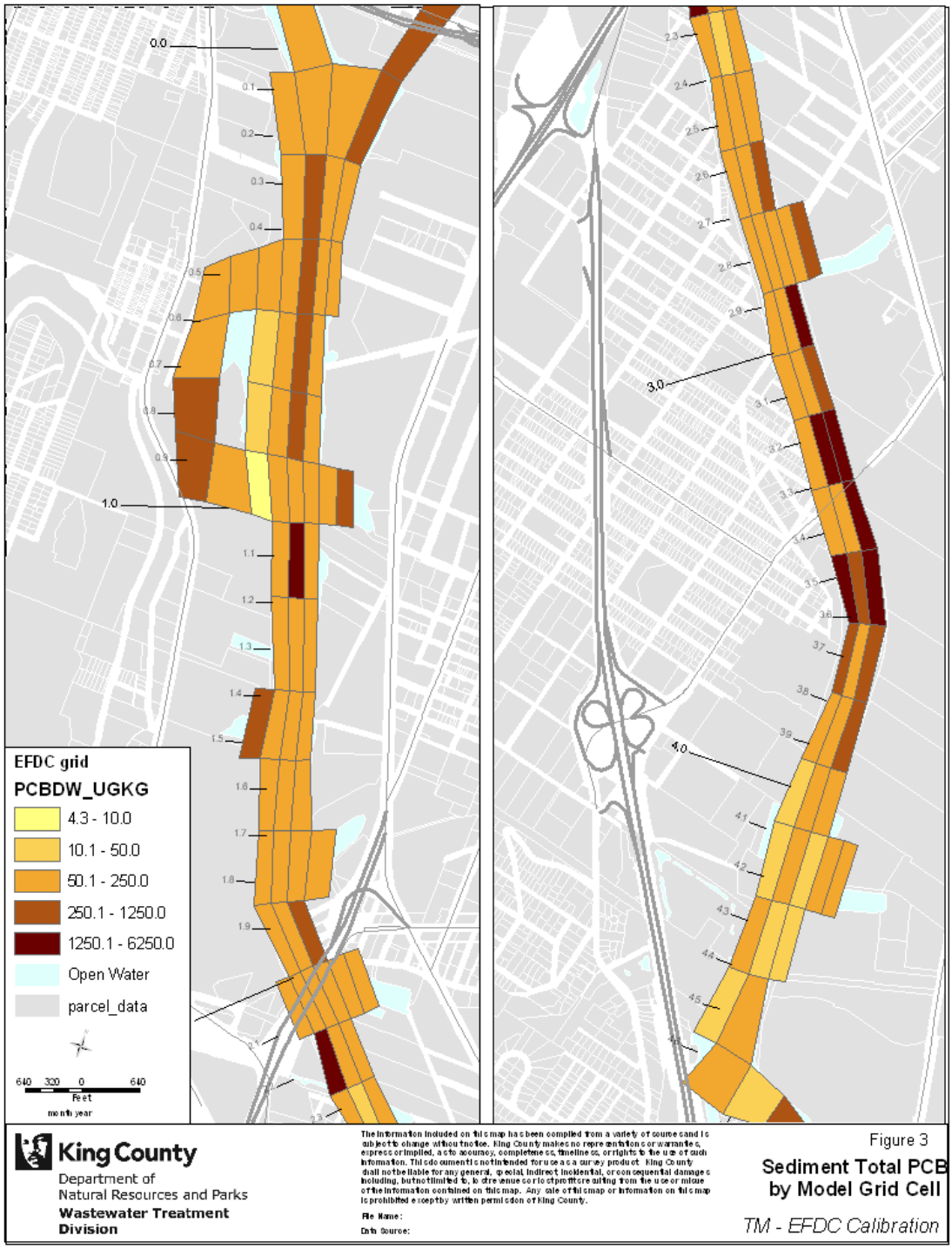

Figure 3. Sediment conditions reflecting a post Diagonal/Duwamish Combined Sewer Overflow/storm drain (CSO/SD) site remediation in 2005 (both cap and perimeter conditions prior to placement of thin-layer cap) were also included.

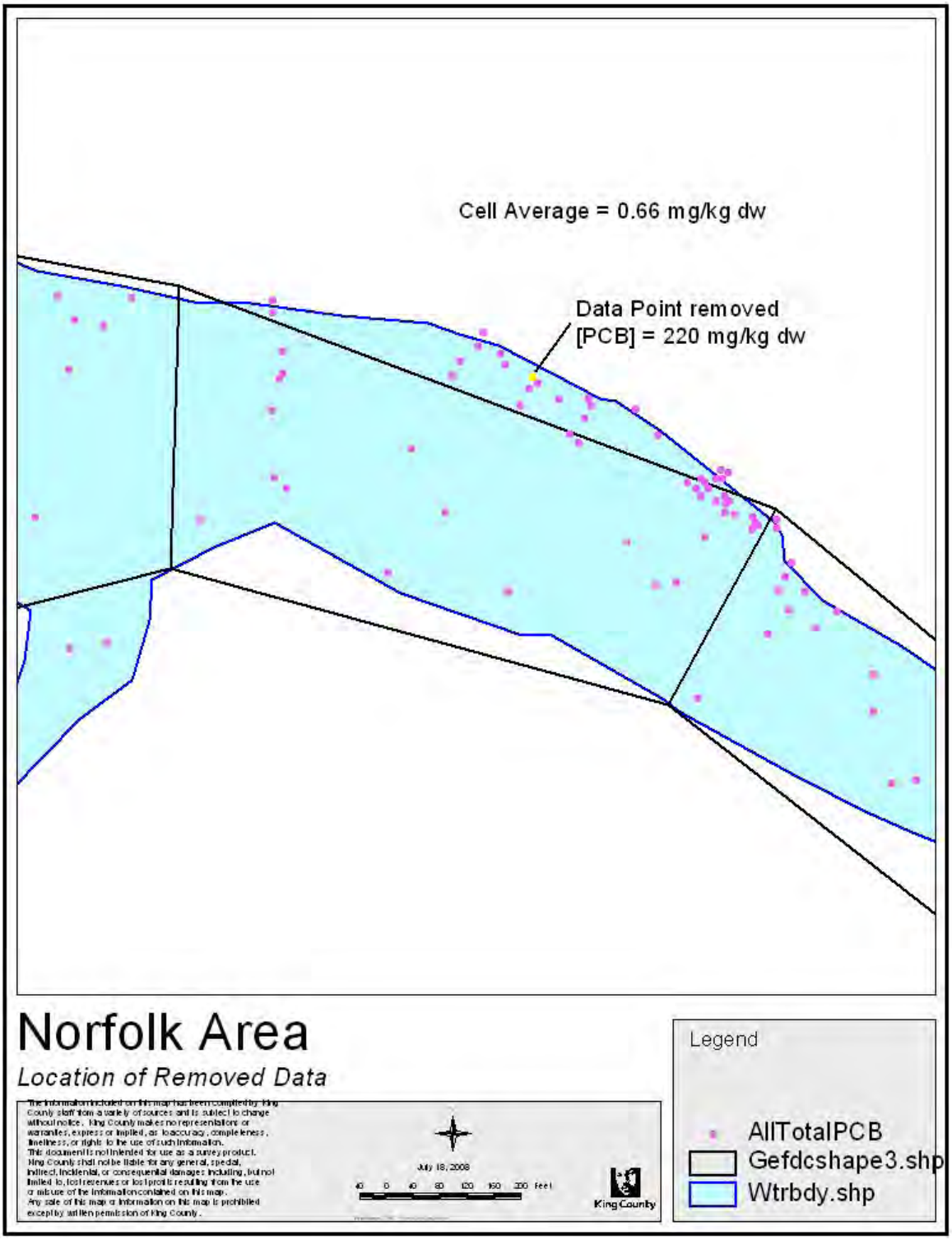

Figure 4. One sample about 430 ft to the northwest of the Norfolk CSO/SD outfall was removed from the dataset.

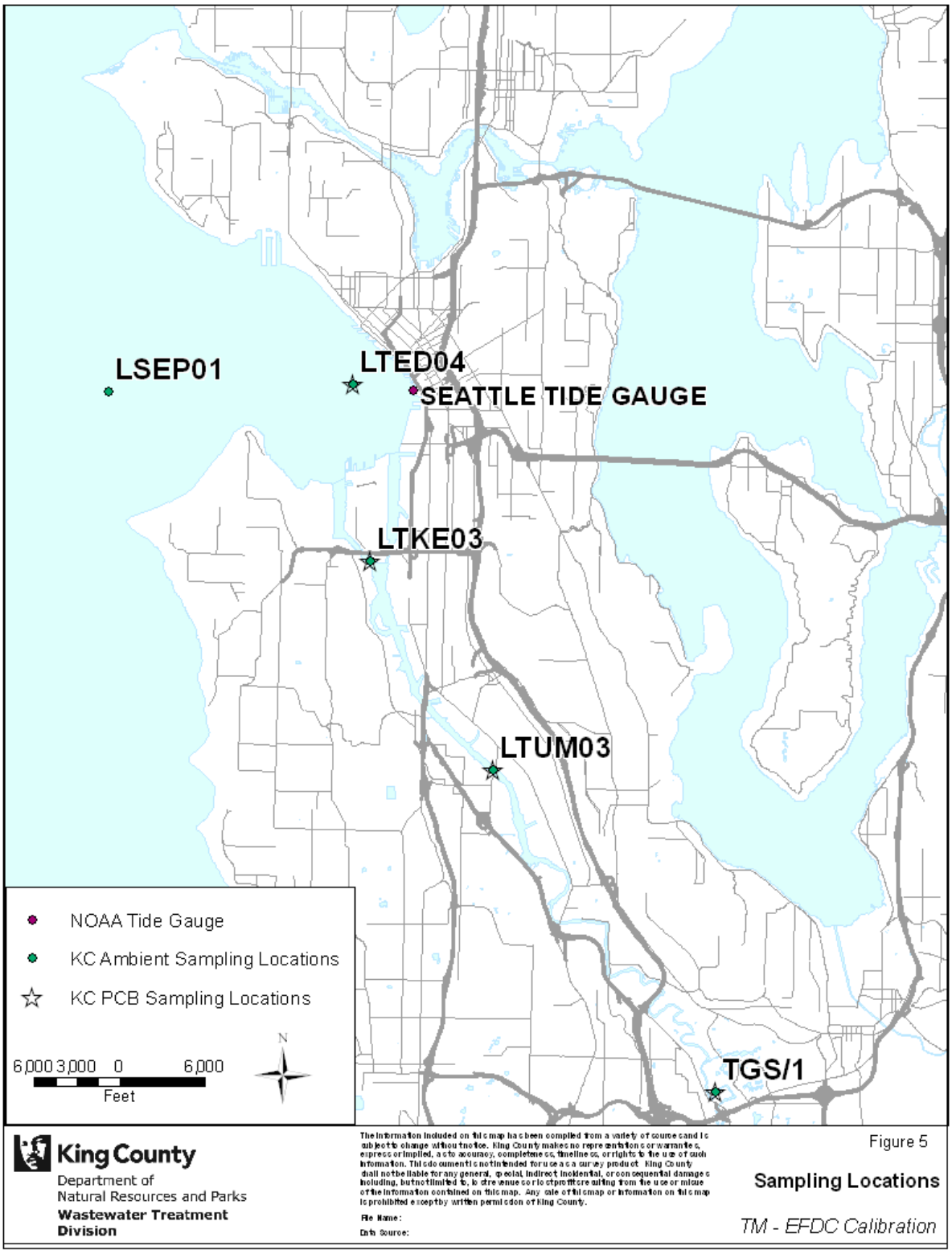

Figure 5. Sampling locations for ambient water properties and low level PCB congener data.

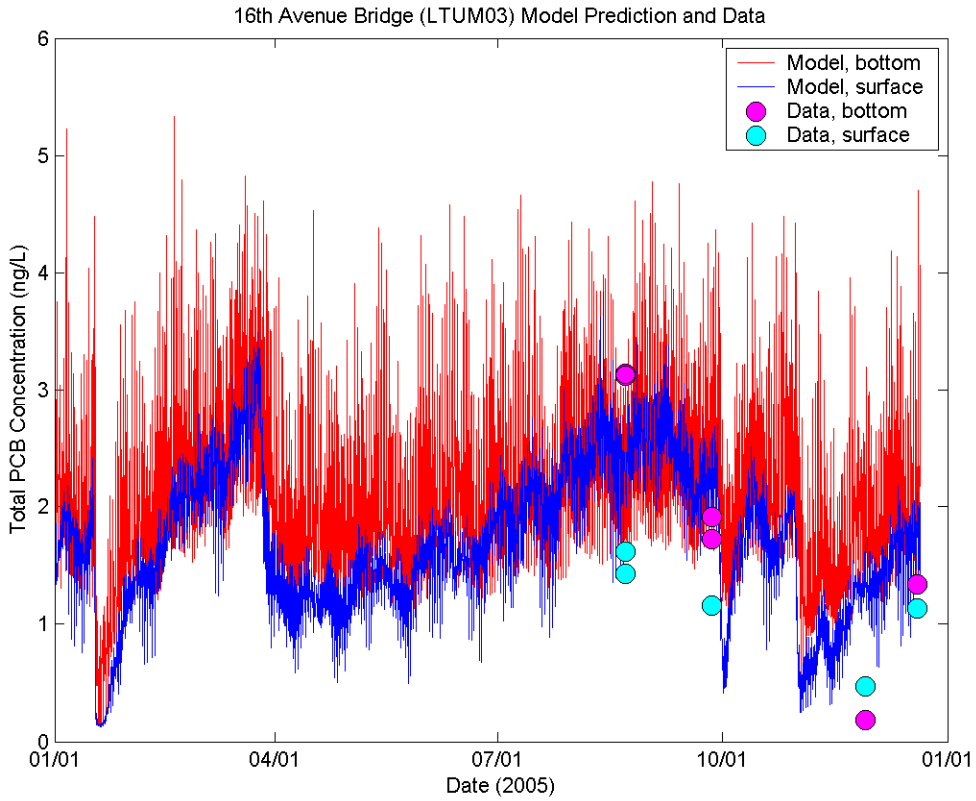

Figure 6. Model calibration for total PCBs at LTUM03 sampling location.

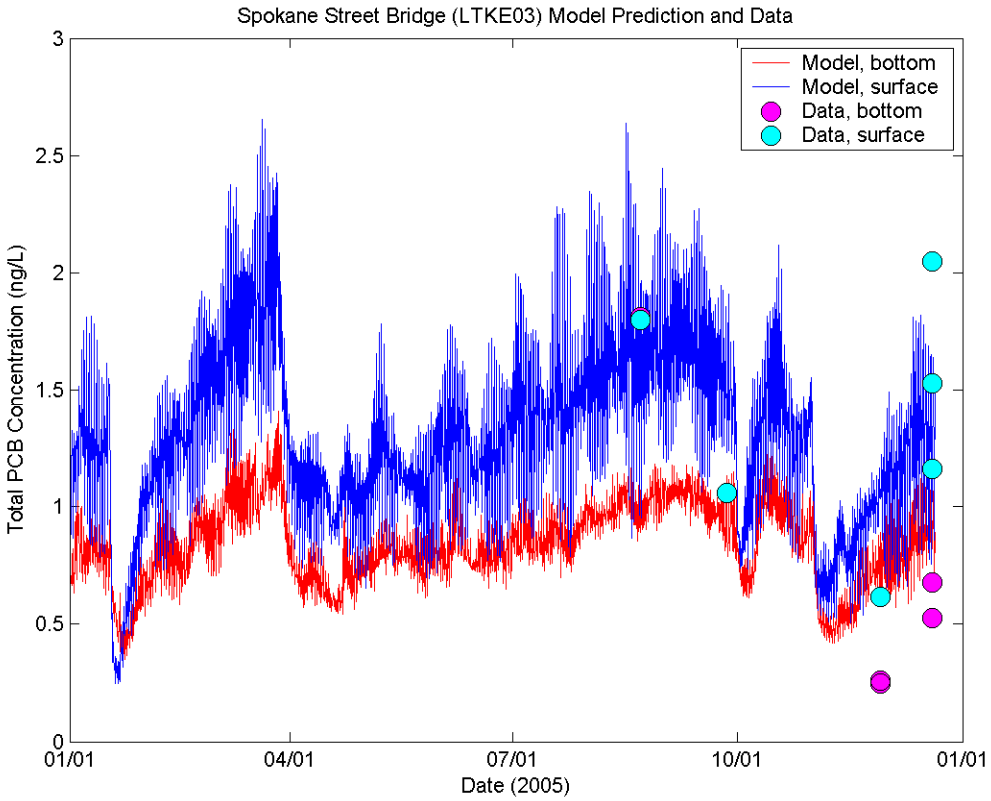

Figure 7. Model calibration for total PCBs at LTKE03 sampling location.

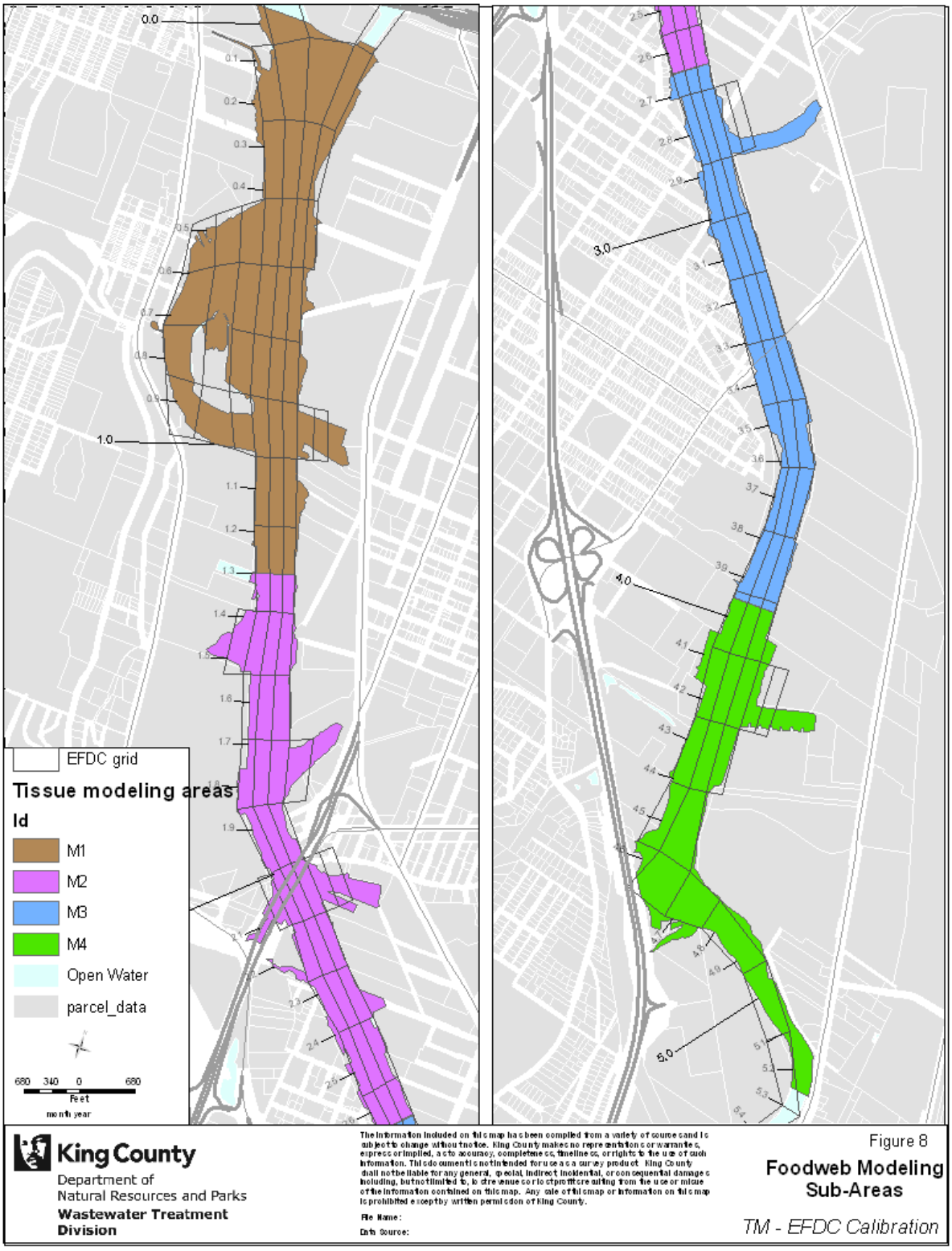

Figure 8. The EFDC grid and the four tissue modeling areas used in the LDW Food Web Model.

Table 1. EFDC Water Column Total PCB monthly averages (ng/L) for entire LDW and four modeling areas.

	EFDC Water Column Total PCB Averages (ng/L)				
	LDW	Area 1	Area 2	Area 3	Area 4
Jan	1.05	0.88	1.07	1.59	1.23
Feb	1.21	1.01	1.23	1.82	1.46
Mar	1.78	1.46	1.79	2.60	2.37
Apr	1.18	1.01	1.22	1.74	1.30
May	1.15	0.98	1.17	1.70	1.29
Jun	1.25	1.05	1.26	1.87	1.50
Jul	1.40	1.14	1.40	2.13	1.83
Aug	1.64	1.30	1.64	2.47	2.32
Sep	1.71	1.37	1.71	2.54	2.40
Oct	1.38	1.15	1.40	2.01	1.71
Nov	0.99	0.84	1.02	1.47	1.10
Dec	1.23	1.04	1.25	1.81	1.43

Table 2. EFDC Total PCB monthly averages (ng/L) within the bottom 30% of the water column for entire LDW and four modeling areas.

	Bottom 3 Model Layers Only EFDC Water Column Total PCB Averages (ng/L)				
	LDW	Area 1	Area 2	Area 3	Area 4
Jan	1.19	0.88	1.07	2.34	1.66
Feb	1.36	1.01	1.21	2.65	1.98
Mar	1.82	1.35	1.62	3.30	2.93
Apr	1.34	1.00	1.24	2.57	1.85
May	1.30	0.97	1.18	2.53	1.81
Jun	1.38	1.01	1.23	2.70	2.03
Jul	1.47	1.06	1.30	2.88	2.29
Aug	1.63	1.16	1.45	3.03	2.75
Sep	1.69	1.23	1.51	3.09	2.85
Oct	1.48	1.10	1.33	2.74	2.24
Nov	1.15	0.86	1.06	2.23	1.60
Dec	1.39	1.05	1.25	2.63	1.94

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Appendix A - Diagonal/Duwamish Sediments

Sediment remediation occurred in the vicinity of the Diagonal/Duwamish CSO/storm drain in 2004/2005. The dredging and capping at the Diagonal/Duwamish project took place between November 2003 and March 2004, with an additional sand placement occurring in February 2005. Water samples were collected for PCB analysis between August and December of 2005. To provide a more realistic simulation of PCB concentrations, the sediments in the vicinity of this remediation work were updated to reflect sediment conditions after capping/dredging but prior to placement of the sand-layer around the southern portion of the remediation area. These sediment concentrations were specified from samples taken on the cap in June 2004 (year 0) and the perimeter in January 31 - February 2, 2005 (year 1).

Following the placement of the thin-layer of sand in February 2005, samples were taken from the thin-layer placement and the original cap in March and April 2005, respectively. The perimeter, thin-layer placement and cap stations were not sampled again until March 2006. At the time the model was configured, the sediment data collected in March 2006 was not yet available. This March 2006 data is likely to be more reflective of sediment concentrations in the perimeter and thin-layer placement areas during the period in which water samples were collected (August - December 2005). It would appear that using the post thin-layer placement samples (March 2005) and the year 1 cap samples (April 2005) would more closely match the sediment concentrations during the period of time when water samples were collected (that were used for model calibration). A comparison of the sediment concentrations including the post thin-layer data collected in March and April 2005 (Figure A6) with the data used in the model (Figure A5) appears quite similar, and unlikely to make a noticeable difference in model predictions at the scale the model was used for.

The following methodology was used to update the sediment grain size and PCB concentrations.

A review of the results at the perimeter sampling locations indicated sizeable changes in sediment grain size and total PCBs from pre- to post- remediation (Table A1). The sand composition changed by more than 8% at all stations analyzed, and changed by more than 20% at stations DUD_8C, DUD_9C, DUD_12C, and DUD_20C. As a result, the sediment characteristics were updated in the area surrounding the remediation, as well as the remediation site. Determination of the area affected by the remediation work was done by best professional judgment, as samples are not available to delineate the affected region. Delineation was done by creating a simple polygon around the remediation site and surrounding sediment samples (Figure A1). Thiessen polygons were created from the LDWG baseline data set, and data points to be removed were identified based on the assumed affected area (Figure A2). The final data set is shown with thiessen polygons in Figure A3.

Sediment grain size and total PCB concentrations in the EFDC model were determined by a simple average of the data points within each grid cell. The sampling points and EFDC sediment concentrations by grid cell are shown using data prior to remediation (Figure A4) and post remediation (Figure A5).

The effect of the thin layer placement on sediment concentrations is shown in Figure A6 based on the samples collected in March and April 2005 on thin layer placement and dredged/capped areas. This may be more representative of sediment conditions in these areas at the time water samples were collected, however it was not used in the model. These sediment differences would not likely results in any appreciable differences in PCB water column concentration predictions at the resolution (or scale) at which the EFDC model predictions were used in the FWM.

Table A1. Sediment Characteristics at Perimeter stations Pre- and Post- Dredge/Capping

Pre-Remediation					Post-Dredging/Capping, Pre-Thin Layer Placement				
Locator	Sample Date		Value	units	Locator	Sample Date		Value	units
DUD_7C	10/20/2003	total PCB	428	ug/kg dw	DUD_7C	1/31/2005	total PCB	397	ug/kg dw
		Gravel	3.5	%			Gravel	3.7	%
		Sand	34.9	%			Sand	43	%
		Silt	51	%			Silt	33.8	%
		Clay	10.7	%			Clay	12.4	%
DUD_8C	10/21/2003	total PCB	5026	ug/kg dw	DUD_8C	2/1/2005	total PCB	809	ug/kg dw
		Gravel	0.85	%			Gravel	7	%
		Sand	25.6	%			Sand	66.1	%
		Silt	65.1	%			Silt	23.4	%
		Clay	8.5	%			Clay	9.8	%
DUD_9C	10/21/2003	total PCB	103	ug/kg dw	DUD_9C	1/31/2005	total PCB	137	ug/kg dw
		Gravel	2.8	%			Gravel	0.4	%
		Sand	79.3	%			Sand	59	%
		Silt	12.9	%			Silt	26.7	%
		Clay	4.9	%			Clay	11.2	%
DUD_10C	10/21/2003	total PCB	373	ug/kg dw	DUD_10C	2/1/2005	total PCB	328	ug/kg dw
		Gravel	3.6	%			Gravel	1.2	%
		Sand	54.7	%			Sand	62.9	%
		Silt	29.2	%			Silt	22.7	%
		Clay	12.7	%			Clay	9	%
DUD_12C	10/21/2003	total PCB	263	ug/kg dw	DUD_12C	2/2/2005	total PCB	334	ug/kg dw
		Gravel	1 J	%			Gravel	0.9 J	%
		Sand	45.4	%			Sand	69.2	%
		Silt	38.8	%			Silt	22.7	%
		Clay	14.9	%			Clay	9.1	%
EST231	9/19/1997	total PCB	230	ug/kg dw	DUD_20C	2/2/2005	total PCB	458	ug/kg dw
		Gravel	3	%	(30 ft East)		Gravel	0.3	%
		Sand	33	%			Sand	63.2	%
		Silt	40	%			Silt	24.7	%
		Clay	23	%			Clay	15	%
DR057	8/31/1998	total PCB	139	ug/kg dw	DUD_20C	2/2/2005	total PCB	458	ug/kg dw
		Gravel	0.38	%			Gravel	0.3	%
		Sand	38	%			Sand	63.2	%
		Silt	42	%			Silt	24.7	%
		Clay	20.7	%			Clay	15	%

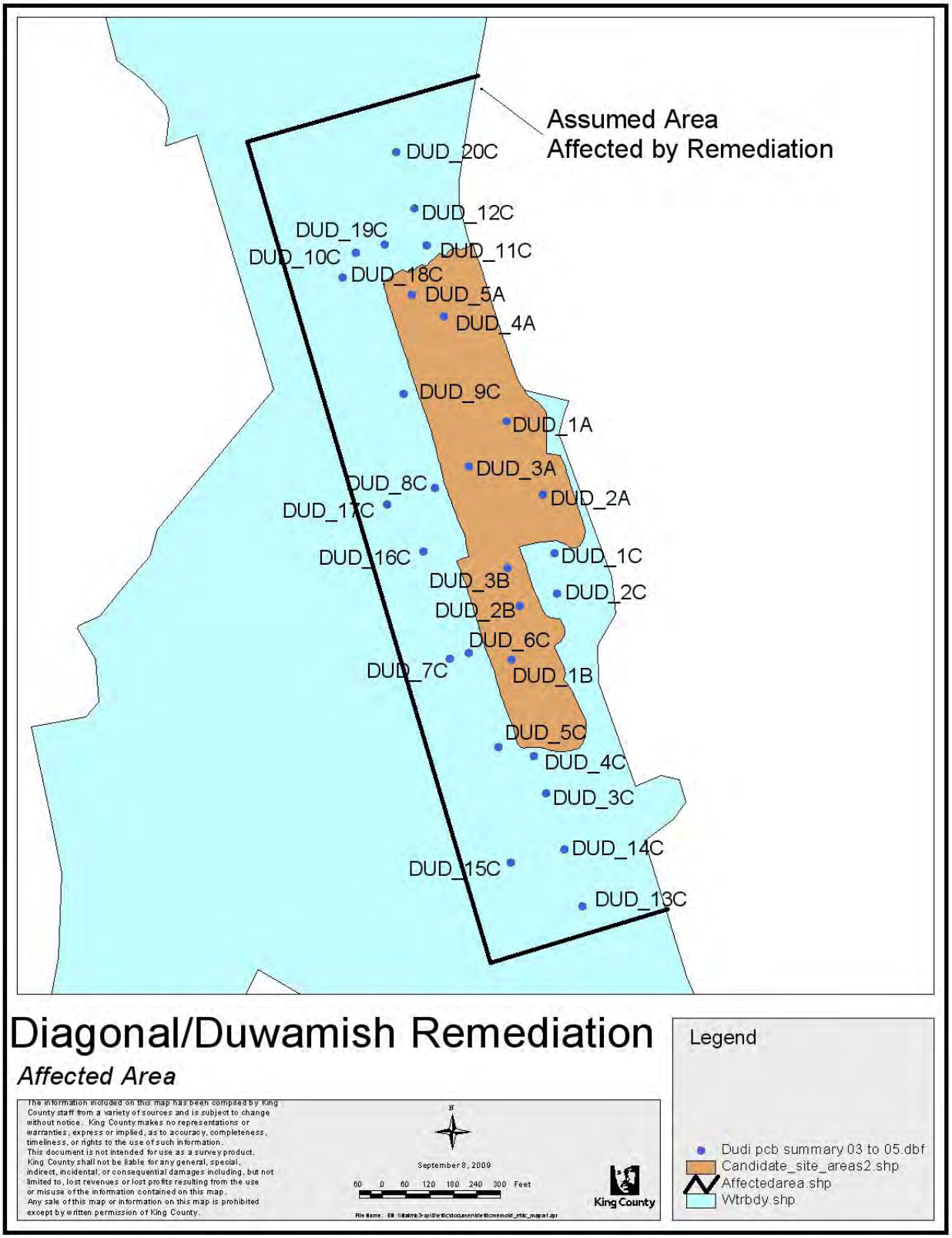

Figure A1. Area identified as potentially affected by sediment remediation project

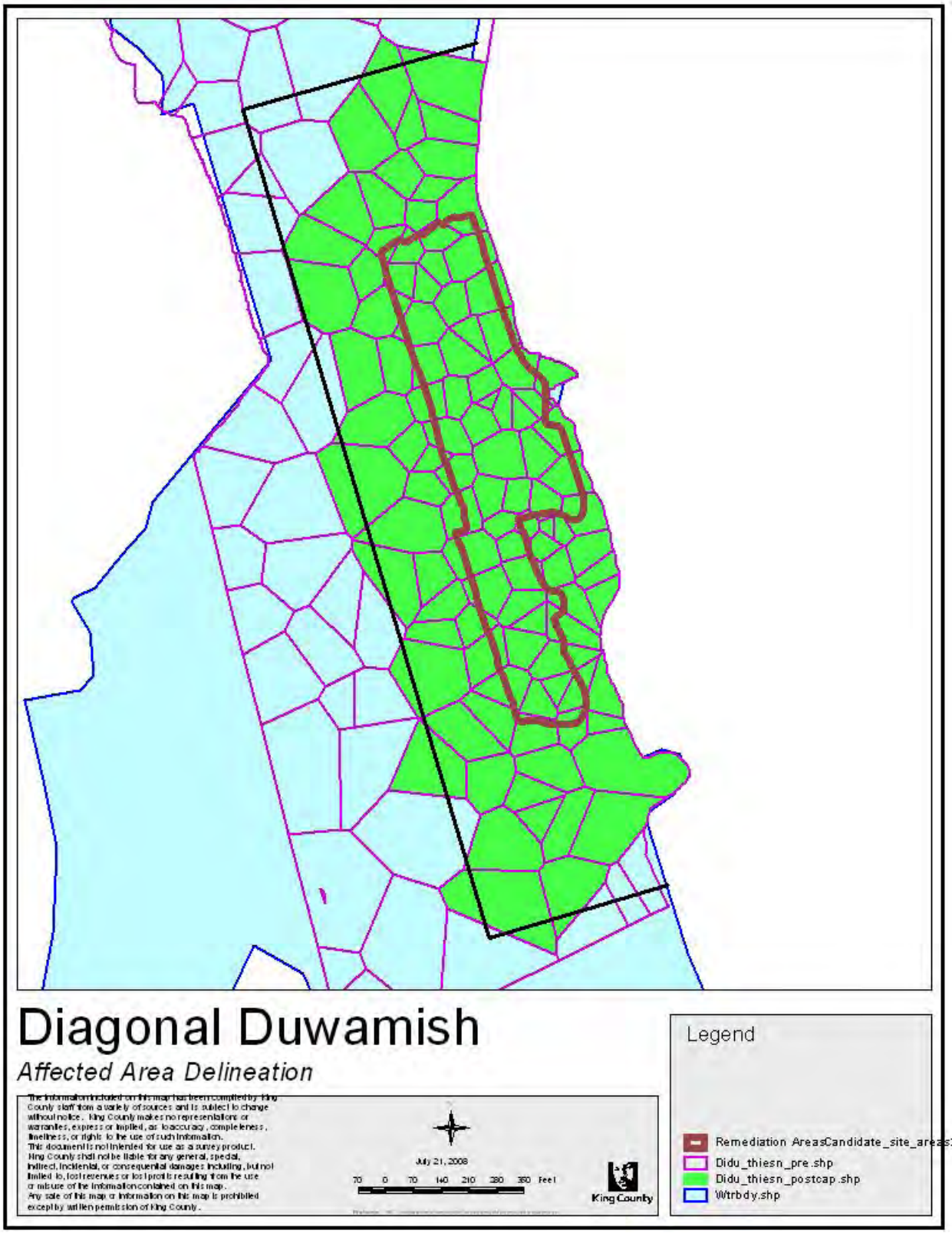

Figure A2. Data points as represented by Theissen polygons replaced by post-remediation sediment parameters

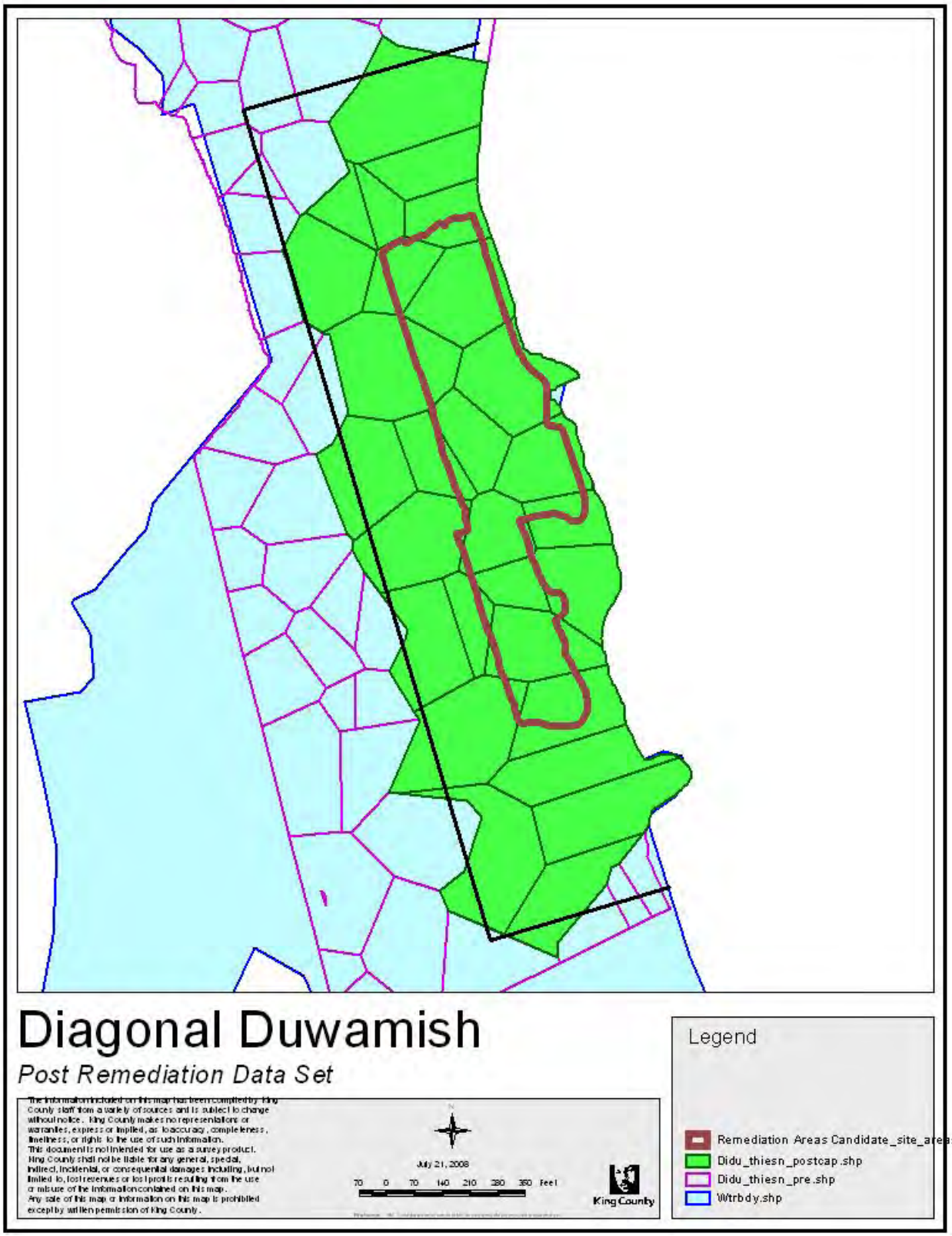

Figure A3. Data points as represented by Theissen polygons used to characterize post-remediation sediment parameters

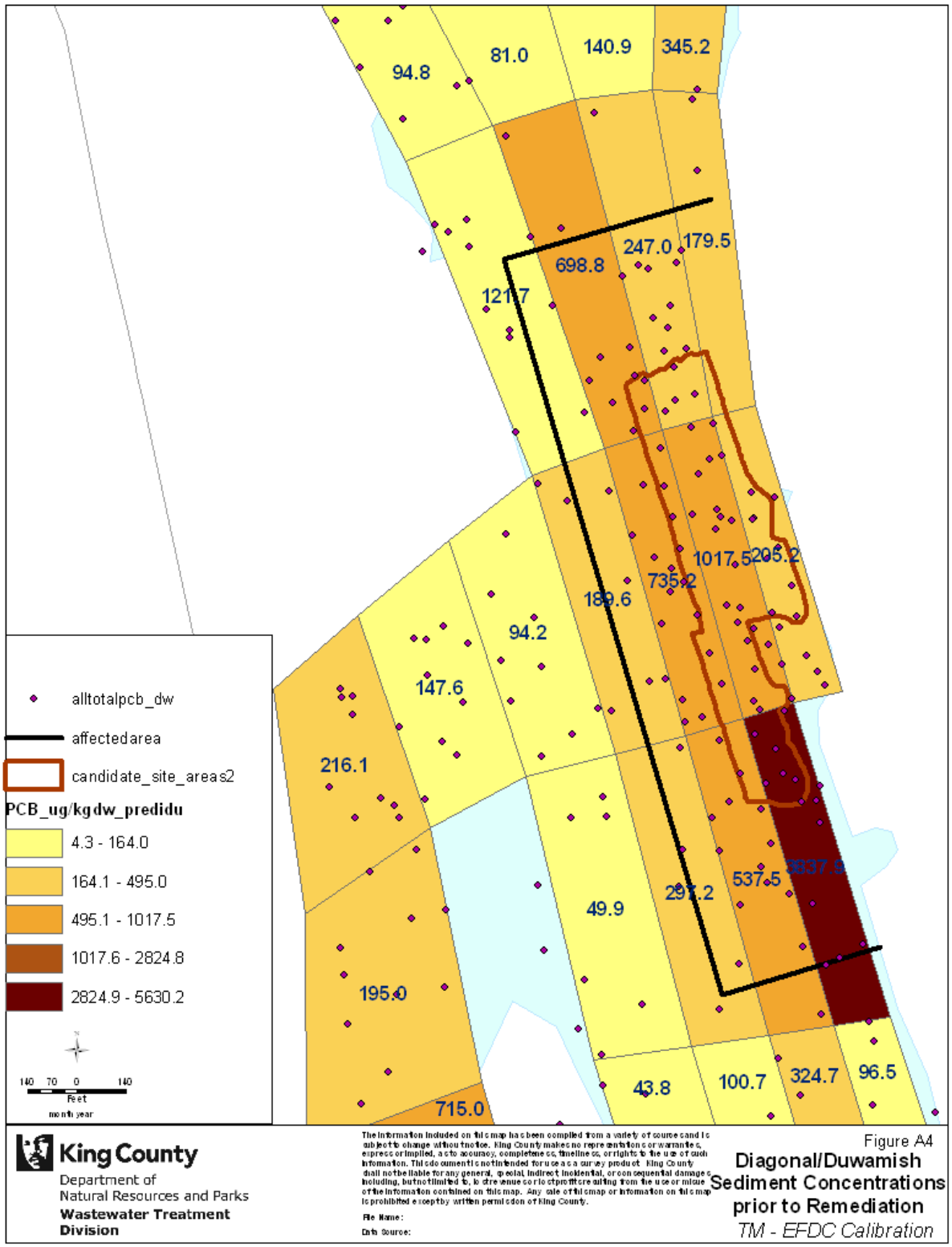

Figure A4. PCB sediment concentrations by EFDC grid cell using pre-remediation values.

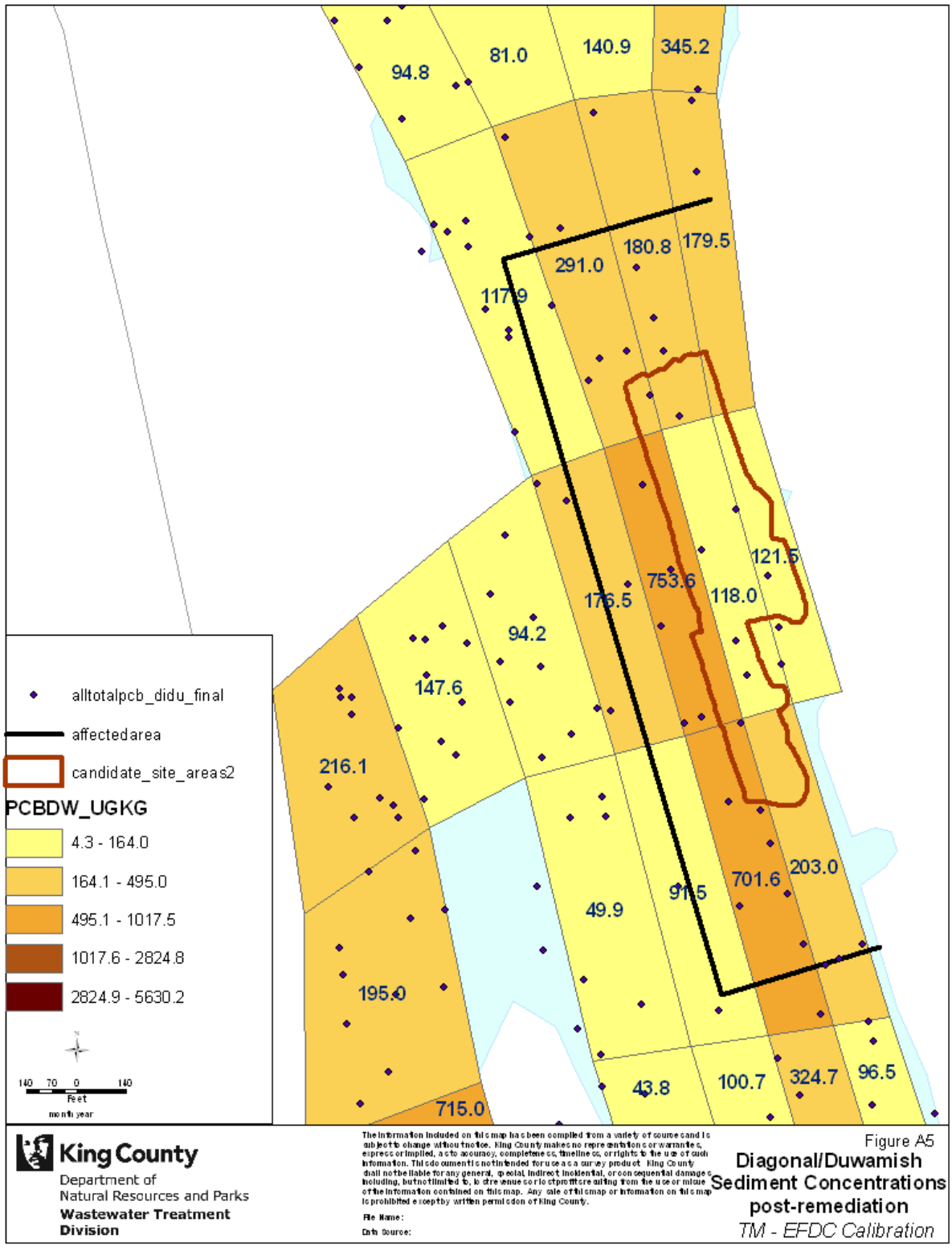

Figure A5. PCB sediment concentrations by EFDC grid cell using post-dredging/capping but pre-thin layer placement values.

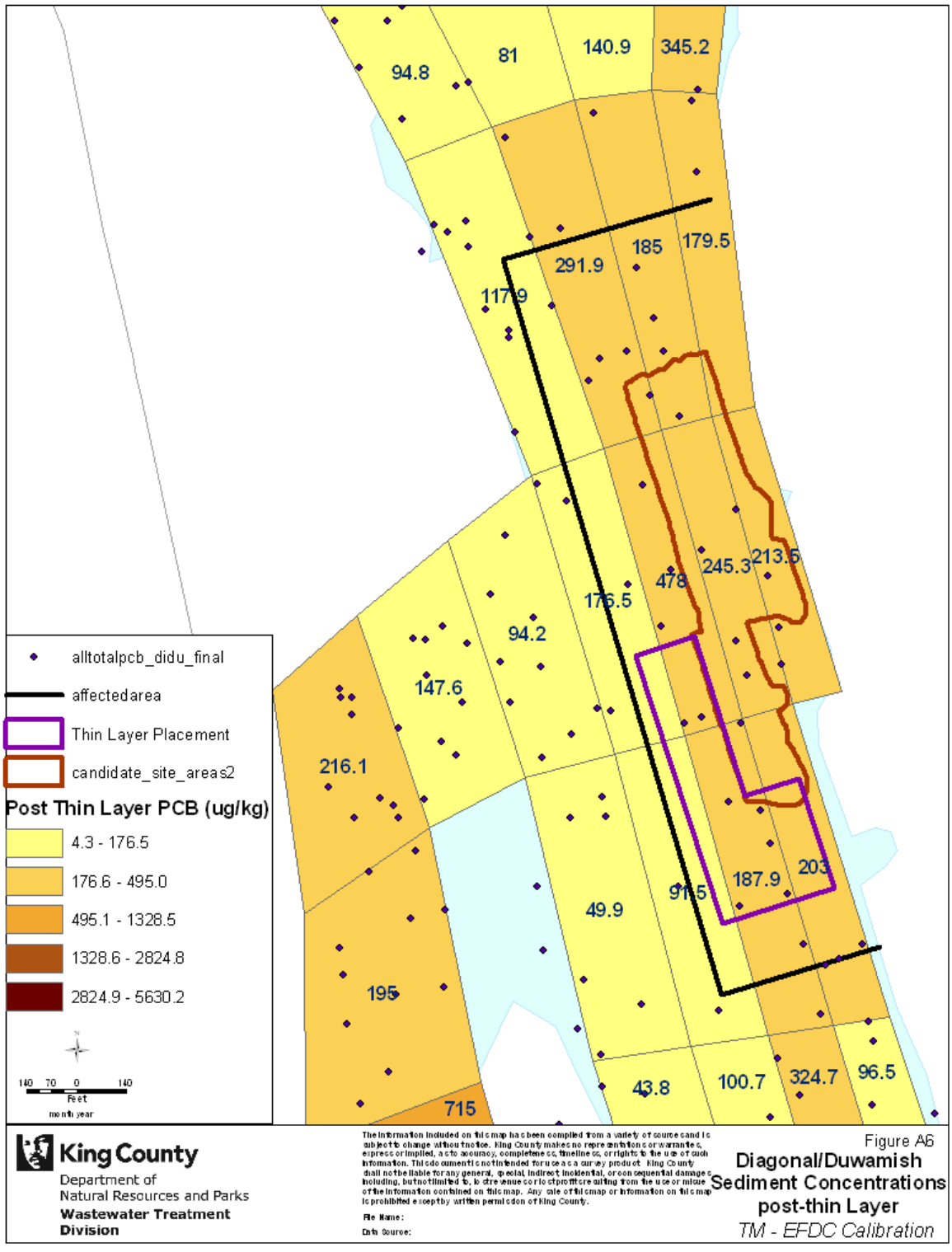

Figure A6. PCB sediment concentrations by EFDC grid cell using post-dredging/capping and post-thin layer placement values based on 2005 samples. These values were not used in the model.

Harbor I.
LTKE03
0.0
0.1
B1b
B1a
C1_North
C1
0.2
0.3
1A
1B
0.4
0.5
1C
1D
0.6
C3-1_North
C3-1
C3-2
C2-1
C2-1_North
C3-2_North
B3a
1E
C2-2
C2-2_North
B2a
B2b
Kellogg I.
Slip 1
0.9
1.0
B3b
1.1
1.2
1.3
B4b
1.4
C4_North
C4
B4a
B5b
1.5
1.6
Slip 2
1.7
2B
2A
C5
C5_North
1.8
1.9
2C
2D
2.0
2:0
Slip 3
2C
C6
2D
C6_North
B6a
2:1
B6b
2:2
B5a-2
2E
2F
2.3
2.4
2.5
2.6
B7b
2.7
Slip 4
C8
C8_North
C7_North
C7-2
2.8
C9
C7-1
2.9
C11_North
3.0
3A
3B
B7a
3.1
3.2
3C
3D
3.3
LTUM03
3.4
C9_North
C10-1_North
B8a
3.5
3E
3F
C10-1
C10-2
3.6
3.7
C10-2_North
C12_North
3.8
3.9
4:0
B9b
4:1
B8b
Slip 6
4A
4B
4.2
B8b
4.3
4B
Slip 6
4A
B10b
4.4
4.5
B9a
Upper Turning Basin
4.6
4D
4C
B10a
4.7
4.8
4.9
4E
5.0
5.1
5.2
5.3
5.4
5.5
5.6
5.7
N
N
N

Tissue sampling sites
- Benthic Invertebrates
- Softshell clam
- King County water quality and PCB water sampling sites
- Tissue sampling areas and subareas

Clam beach habitat quality
- Low
- Medium
- High

Tissue modeling areas
- M1
- M2
- M3
- M4
- River mile
- Navigation channel

0 0.1 0.2 Miles

0 0.1 0.2 Kilometers

Scale is the same for each inset map

Map D.3-1. LDW modeling areas and tissue and water sampling locations

Wind Ward environmental LLC

Prepared by CEH, 07/07/2010; MAP 2756; W:\Projects\00-08-06_Duwamish_Ri\data\gis\Phase2 Ri\Food Web Model

Appendix E. Data Selection for the RI Baseline Surface Sediment Dataset, Data Quality Review Summaries, Data Management Rules, Additional Statistical Information, Summary Data Tables, and Arsenic and cPAH Concentrations in Sediment Associated with Tissue RBTCs

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E.1 Data Selection for the RI Baseline Surface Sediment Dataset

Baseline surface sediment data were used in the remedial investigation (RI) to describe the nature and extent of contamination in surface sediment and for analysis of risks associated with surface sediment in the baseline HHRA and ERA. These baseline surface sediment data represent conditions in the LDW prior to removal actions at the Duwamish/Diagonal early action been developed continuously over the course of the LDW RI process as new data from the LDW have been obtained. The baseline surface sediment dataset used in the HHRA and ERA was finalized prior to the collection of Round 3 surface sediment data in October 2006, whereas the baseline surface sediment dataset used for describing the nature and extent of contamination in the RI includes Round 3 data. The rationale for the inclusion or exclusion of certain data has been documented in memoranda to the US Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology) (Windward 2005d, e, 2006).

This appendix describes the process for selecting surface sediment chemistry data for the RI baseline dataset in greater detail than presented in Section 4.1 of the RI. The following criteria were used to determine which surface sediment data would be included in the RI baseline dataset (Windward 2006):

- The data must meet the data quality objectives (DQOs), as described in Section 4.1.1 of the RI.
- Surface sediment samples collected from areas that have subsequently been subject to maintenance dredging activities were not included.
- If a sediment sampling location was re-sampled at a later date within 10 ft of the original location, either as part of a monitoring program or to characterize nature and extent of contamination, the more recent data replaced the older data. However, surface sediment samples collected before removal actions at the Duwamish/Diagonal EAA and the Boeing Developmental Center south storm drain outfall were included to represent baseline (pre-early action) conditions.
- Sediment samples collected within 200 ft of the perimeter of the Duwamish/Diagonal EAA after the removal action were not included because the sediment could have been influenced by the removal action.
- The sediment sample depth interval must be the top 15 cm or less. At 24 locations in the Norfolk area, samples were collected from the 0-to-2-cm depth in addition to the 0-to-10-cm depth on either the same date or a later date. Only data from the 0-to-10-cm depth were included in the RI baseline dataset.

Subsections E.1.1 through E.1.3 below specifically address application of these criteria to the following types of sediment chemistry data: 1) data collected from dredged

areas, 2) data collected from re-sampled locations that are less than 10 ft apart, and 3) data collected from EAAs at Duwamish/Diagonal and Boeing Developmental Center south storm drain outfall near the Norfolk combined sewer overflow (CSO). Tables in Section E.2.0 list chemistry datasets acceptable and not acceptable for all uses in the RI, including data quality review summaries. Section E.2.0 also lists sediment samples and sampling events excluded from the RI baseline dataset (Windward 2005d, e, 2006, 2007). Section E.3.0 describes data management rules and Section E.4.0 presents tables of summary statistics for surface sediment, subsurface sediment, tissue, surface water, seep water, and porewater chemistry data used in both the risk assessments and the RI.

E.1.1 SURFACE SEDIMENT DATA COLLECTED FROM DREDGED AREAS

Surface sediment data that were collected within dredged area boundaries prior to dredging were excluded from the RI baseline surface sediment dataset because they are not representative of present conditions. This decision was originally documented in the Phase 1 RI (Windward 2003a). Table E.1-1 and Map 2-4 shows dredge events that were conducted since 1986 and Maps 4-7a through 4-7d show all dredging events that took place outside the navigation channel between 1992 and 2005. Specific locations and the samples associated with those locations that were excluded because of these dredging events are listed in Section E.2.0.

There are two exceptions to the dredge exclusion statement above, both associated with EAAs at Duwamish/Diagonal and Boeing Developmental Center south storm drain outfall (Windward 2003b), as noted in Table E.1-1. The relationship between the dredging associated with these two EAAs and the RI baseline surface sediment dataset is described in Section E.1.3.

Table E.1-1. Dredging events outside of navigation channel

DREDGING EVENT	YEAR OF DREDGING	LOCATION (RIVER MILE)
Morton	1992	RM 2.86 – RM 2.97 west
South Park Marina	1993	RM 3.36 – RM 3.44 west
Lone Star Northwest	1993	RM 1.43 – RM 1.52 west
Terminal 115	1993	RM 1.78 – RM 1.95 west
Lone Star – Hardie/Kaiser	1996	RM 1.55 – RM 1.75 east
Crowley	1996	RM 2.8 – RM 2.85 east
Hurlen-Boyer	1998	RM 2.39 – RM 2.49 west and RM 2.64 – RM 2.77 west
James Hardie Gypsum	1999	RM 1.56 – RM 1.75 east
Duwamish Yacht Club	1999	RM 4.03 – RM 4.15 west
Norfolk (EBDRP)	1999	RM 4.85 – RM 4.95 east
Glacier Ready-mix Facility	2001	RM 1.7 east
Boeing Developmental Center south storm drain outfall[a]	2003	RM 4.9 east

Dredging Event	Year of Dredging	Location (River Mile)
Duwamish/Diagonal[a]	2003/2004	RM 0.4 – RM 0.6 east
Boyer		RM 2.45 – RM 2.47 west
Delta Marine	2004	RM 4.17 – RM 4.24 west
Lehigh Northwest	2004	RM 1.02 – RM 1.09 east
Terminal 103	2005	RM 0.0 – RM 0.07 west
Glacier NW	2005	RM 1.42 – RM 1.54 west

[a] Data associated with this removal action were handled differently in assembling the RI baseline sediment dataset than data associated with the other dredging events listed in this table, as described in Section E.1.3.

EBDRP – Elliott Bay/Duwamish Restoration Program

RM – river mile

In addition to the dredging events listed in Table E.1-1, upstream portions of the Lower Duwamish Waterway (LDW) navigation channel between river mile (RM) 3.35 and the Upper Turning Basin at RM 4.7 have been dredged periodically by the US Army Corps of Engineers (USACE) to maintain sufficient depth for vessel traffic and to serve as a sediment trap for sediments entering the LDW from upstream. The maintenance dredging events that have occurred in this portion of the navigation channel since 1990 are listed in Table E.1-2. The upstream portion of the LDW between RM 4.2 and RM 4.7 is dredged frequently (i.e., every 2 to 4 years) because sediments entering the LDW from the upper Duwamish and Green rivers are deposited in and near the Upper Turning Basin. All surface sediment samples collected from the navigation channel and Upper Turning Basin from approximately RM 4.2 to RM 4.7 were included in the baseline dataset RI because they were assumed to represent "current" conditions given the frequent dredging of this area.

The sediment in this region of the LDW navigation channel (e.g., RM 4.2 to RM 4.7) generally does not contain chemicals at concentrations greater than the Dredged Material Management Program (DMMP) guidelines and is therefore suitable for open-water disposal in Elliott Bay. Surface sediment samples that were collected from the navigation channel prior to dredging in 1999 between RM 3.35 and RM 4.2, an area that has not been dredged frequently, were excluded from the RI baseline surface sediment dataset because these sediments do not represent current conditions. This convention was originally adopted during the Phase 1 RI (Windward 2003a) as a result of meetings between the Lower Duwamish Waterway Group (LDWG), the US EPA, Ecology, and the USACE.

Table E.1-2. Navigation channel dredging events conducted by the USACE

YEAR	LOCATION (RIVER MILE)
1990	RM 4.0 – RM 4.65
1992	RM 3.35 – RM 4.65
1994	RM 4.2 – RM 4.65
1996	RM 4.18 – RM 4.6
1997	RM 4.2 – RM 4.6
1999	RM 3.35 – RM 4.65
2002	RM 4.3 – RM 4.65
2004	RM 4.3 – RM 4.65

E.1.2 SURFACE SEDIMENT DATA COLLECTED FROM RESAMPLED LOCATIONS

The Phase 2 surface sediment sampling conducted in the LDW in 2005 and 2006 included many sampling locations that were intended to re-occupy previously sampled locations (Windward 2005a, b, c). The primary rationale for resampling these locations was to evaluate whether elevated surface sediment chemical concentrations that existed in the past still exist and to test for toxicity at some locations with historically elevated chemical concentrations (Windward 2005c). Historical surface sampling locations have also been re-sampled for similar reasons during other more recent surface sediment sampling events conducted either by a subset of LDWG members or by other parties. For the purposes of defining the RI baseline surface sediment dataset, surface sediment chemistry data from previously sampled locations within 10 ft of a more recent sediment sampling location were not included in the RI baseline dataset; they were superseded and replaced by the corresponding newer data from those locations because it was assumed that the more recent results would more accurately represent current conditions.

Because there is inherent measurement error[1] in the differential global positioning systems used in the sampling surveys, the exact locations of two samples with coordinates within 10 ft of each other cannot be determined. LDWG assumed that two samples with coordinates within 10 ft of each other represented the same location.[2] If the coordinates for the newer sampling location were more than 10 ft from the original coordinates, it was not considered a true reoccupation and was evaluated as a separate station.

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[1] The differential global positioning system used for Phase 1 and Phase 2 surface sediment sampling has a measurement error of approximately 3-6 ft.

[2] Given the inherent measurement error, it is possible that samples ostensibly collected within 10 ft of each other may have been less than or more than 10 ft apart, but the distance likely did not exceed 20 ft for samples collected after 2001. Prior to 2001, GPS technology was less accurate so measurement errors may have been greater.

Table E.1-3 presents a list of all the newer surface sediment samples that superseded older surface sediment samples from locations within 10 ft. In some cases among the historical data, as shown in Table E.1-3, more than one sample was collected at a single location. In other cases, two samples from two different events or multiple samples from a single event[3] were collected within 10 ft of a more recently sampled location. In such cases, all the older samples were superseded and replaced by the newer sample. If an older sample was replaced by a newer sample, results for all analytes in the older sample were deleted and replaced by results for all analytes in the newer sample. In some cases, the newer sample was analyzed for fewer analytes than was the older sample. At one of the locations where this occurred (SD-DUW90 at RM 3.6 within the Boeing Plant 2/Jorgensen Forge EAA), the lead concentration (1,300 mg/kg dw) in the older sample was greater than the CSL. Data for this location were replaced with data from location SD-343, which did not include results for lead (see Table E.1-3). Four locations where data were replaced (DR021, DR065, DR187, and DR238) had results for dioxins and furans, but the newer samples were not analyzed for dioxins and furans. Although these older dioxin and furan data were not included in the baseline RI dataset, they are discussed in Section 4.2.6.1. A data summary for all omitted analytes is presented in Table E.1-4. Raw data for all surface sediment samples, including older samples that were replaced by newer samples, are presented in a CD accompanying the RI. The feasibility study (FS) surface sediment dataset will include data for chemicals analyzed in older samples that were not analyzed in newer samples; these data will be included in FS analyses and maps.

[3] An extreme example of this situation is shown in Table E.1-3, where 10 samples from Harbor Island RI station K-05 were superseded by a single more recently collected sample (LDW-SS10-010). The large number of samples at station K-05 is an artifact of the manner in which the original Harbor Island RI database was constructed by the study authors. Unique sample IDs were created for different analyte classes, even though only two field samples were collected on September 27 and October 14, 1991.

Table E.1-3. Newer surface sediment samples that superseded older surface sediment samples if the sample locations were less than 10 ft apart

Newer Sample				River Mile	Older Sample				Nominal Distance Between New and Old Coordinates (ft)
Sample	Event	Location	Sampling Date		Sample	Event	Location	Sampling Date	
LDW-SS1-010	LDWRI-SurfSedRound1	LDW-SS1	1/17/05	0.0	K-11	Harbor Island RI	K-11	9/30/91	0.6
LDW-SS4-010	LDWRI-SurfSedRound1	LDW-SS4	1/17/05	0.0	K-07	Harbor Island RI	K-07	9/30/91	1.4
LDW-SS5-010	LDWRI-SurfSedRound1	LDW-SS5	1/17/05	0.0	SD-DR076-0000	EPA SI	DR076	8/24/98	1.5
LDW-SS10-010	LDWRI-SurfSedRound1	LDW-SS10	1/17/05	0.2	K-05-1	Harbor Island RI	K-05	10/14/91	1.3
LDW-SS10-010	LDWRI-SurfSedRound1	LDW-SS10	1/17/05	0.2	K-05-1-B	Harbor Island RI	K-05	10/14/91	1.3
LDW-SS10-010	LDWRI-SurfSedRound1	LDW-SS10	1/17/05	0.2	K-05-1-D1	Harbor Island RI	K-05	9/27/91	1.3
LDW-SS10-010	LDWRI-SurfSedRound1	LDW-SS10	1/17/05	0.2	K-05-1-D2	Harbor Island RI	K-05	10/14/91	1.3
LDW-SS10-010	LDWRI-SurfSedRound1	LDW-SS10	1/17/05	0.2	K-05-2	Harbor Island RI	K-05	10/14/91	1.3
LDW-SS10-010	LDWRI-SurfSedRound1	LDW-SS10	1/17/05	0.2	K-05-2-D1	Harbor Island RI	K-05	9/27/91	1.3
LDW-SS10-010	LDWRI-SurfSedRound1	LDW-SS10	1/17/05	0.2	K-05-2-D2	Harbor Island RI	K-05	10/14/91	1.3
LDW-SS10-010	LDWRI-SurfSedRound1	LDW-SS10	1/17/05	0.2	K-05-3	Harbor Island RI	K-05	10/14/91	1.3
LDW-SS10-010	LDWRI-SurfSedRound1	LDW-SS10	1/17/05	0.2	K-05-3-D1	Harbor Island RI	K-05	9/27/91	1.3
LDW-SS10-010	LDWRI-SurfSedRound1	LDW-SS10	1/17/05	0.2	K-05-3-D2	Harbor Island RI	K-05	10/14/91	1.3
LDW-SS12-010	LDWRI-SurfSedRound1	LDW-SS12	1/17/05	0.2	SD-DR035-0000	EPA SI	DR035	8/11/98	2.1
LDW-SS15-010	LDWRI-SurfSedRound1	LDW-SS15	1/17/05	0.3	SD-DR079-0000	EPA SI	DR079	8/24/98	1.7
LDW-SS17-010	LDWRI-SurfSedRound1	LDW-SS17	1/24/05	0.3	L7279-11	Duw/Diag-1.5	DUD042	11/11/95	3.3
L7279-3	Duw/Diag-1.5	DUD032	11/9/95	0.4	L4288-27	Duw/Diag-1	DUD032	8/12/94	0.0
L12059-1	KC WQA	DD-1	9/24/97	0.4	L4288-30	Duw/Diag-1	DUD001	8/17/94	4.5
L12666-1	KC WQA	DD-1	9/24/97	0.4	L4288-30	Duw/Diag-1	DUD001	8/17/94	4.5
L12666-2	KC WQA	DD-2	9/24/97	0.4	L4288-5	Duw/Diag-1	DUD006	8/10/94	4.2
L12666-3	KC WQA	DD-2	9/24/97	0.4	L4288-5	Duw/Diag-1	DUD006	8/10/94	4.2
L12059-3	KC WQA	DD-3	9/24/97	0.5	L4288-21	Duw/Diag-1	DUD022	8/10/94	4.3
L12666-4	KC WQA	DD-3	9/24/97	0.5	L4288-21	Duw/Diag-1	DUD022	8/10/94	4.3
L12666-5	KC WQA	DD-4	9/24/97	0.5	L4288-28	Duw/Diag-1	DUD034	8/12/94	4.5
L12666-6	KC WQA	DD-4	9/24/97	0.5	L4288-28	Duw/Diag-1	DUD034	8/12/94	4.5
L12059-5	KC WQA	DD-5	9/24/97	0.5	L7279-8	Duw/Diag-1.5	DUD039	11/9/95	4.2
L12666-7	KC WQA	DD-5	9/24/97	0.5	L7279-8	Duw/Diag-1.5	DUD039	11/9/95	4.2

Table E.1-3, cont. Newer surface sediment samples that superseded older surface sediment samples if the sample locations were less than 10 ft apart

Newer Sample				River Mile	Older Sample				Nominal Distance Between New and Old Coordinates (ft)
Sample	Event	Location	Sampling Date		Sample	Event	Location	Sampling Date	
L29990-4	DuwDiagOct2003	DUD_4C	10/23/03	0.6	L7279-4	Duw/Diag-1.5	DUD036	11/11/95	6.0
L29990-5	DuwDiagOct2003	DUD_4C	10/23/03	0.6	L7279-4	Duw/Diag-1.5	DUD036	11/11/95	6.0
LDW-SS200-010	LDWRI-SurfSedRound1	LDW-SS27	1/18/05	0.8	EST21-03	NOAA SiteChar	EST219	9/17/97	4.5
LDW-SS27-010	LDWRI-SurfSedRound1	LDW-SS27	1/18/05	0.8	EST21-03	NOAA SiteChar	EST219	9/17/97	4.5
LDW-SSB2b-010	LDWRI-SurfSedRound2	LDW-SSB2b	3/11/05	0.8	SD-DR085-0000	EPA SI	DR085	8/31/98	5.6
SD-DR048-0000	EPA SI	DR048	8/12/98	0.9	WST20-02	NOAA SiteChar	WST367	9/19/97	6.3
LDW-SS32-010	LDWRI-SurfSedRound1	LDW-SS32	1/18/05	0.9	SD-DR019-0000	EPA SI	DR019	8/17/98	0.6
LDW-SS31-010	LDWRI-SurfSedRound1	LDW-SS31	1/21/05	0.9	SD-DR020-0000	EPA SI	DR020	8/17/98	1.0
LDW-SS319-010	LDWRI-SurfaceSedimentRound3	LDW-SS319	10/4/2006	0.9	SD-DR021-0000	EPA SI	DR021	8/17/98	6.7
LDW-SS37-010	LDWRI-SurfSedRound1	LDW-SS37	1/18/05	1.0	SD-DR087-0000	EPA SI	DR087	8/12/98	2.5
LDW-SS40-010	LDWRI-SurfSedRound1	LDW-SS40	1/18/05	1.1	SD-DR088-0000	EPA SI	DR088	8/31/98	1.1
LDW-SS44-010	LDWRI-SurfSedRound1	LDW-SS44	1/21/05	1.2	SD-DR053-0000-CC	EPA SI	DR053	8/31/98	1.6
LDW-B4b-S	LDWRI-Benthic	B4b	8/28/04	1.3	SD-DR028-0000	EPA SI	DR028	8/17/98	2.3
LDW-SS48-010	LDWRI-SurfSedRound1	LDW-SS48	1/18/05	1.3	SS-2	DuwamishShipyard	SS-2	8/17/93	1.5
LDW-SS202-010	LDWRI-SurfSedRound1	LDW-SS50	1/24/05	1.3	SD-DR030-0000	EPA SI	DR030	8/17/98	1.9
LDW-SS50-010	LDWRI-SurfSedRound1	LDW-SS50	1/24/05	1.3	SD-DR030-0000	EPA SI	DR030	8/17/98	1.9
LDW-SS51-010	LDWRI-SurfSedRound1	LDW-SS51	1/18/05	1.3	SD-DR160-0000	EPA SI	DR160	8/12/98	2.4
LDW-SS49-010	LDWRI-SurfSedRound1	LDW-SS49	1/26/05	1.4	SS-6	DuwamishShipyard	SS-3	8/17/93	8.0
LDW-SS49-010	LDWRI-SurfSedRound1	LDW-SS49	1/26/05	1.4	SS-3	DuwamishShipyard	SS-3	8/17/93	8.0
LDW-SS55-010	LDWRI-SurfSedRound1	LDW-SS55	1/24/05	1.4	SS-4	DuwamishShipyard	SS-4	8/17/93	3.0
LDW-SS57-010	LDWRI-SurfSedRound1	LDW-SS57	1/24/05	1.4	SD-DR123-0000	EPA SI	DR123	9/14/98	6.7
LDW-SS52-010	LDWRI-SurfSedRound1	LDW-SS52	1/25/05	1.4	SD-DR065-0000	EPA SI	DR065	8/17/98	1.2
LDW-SS63-010	LDWRI-SurfSedRound1	LDW-SS63	1/21/05	1.7	SD-DR097-0000	EPA SI	DR097	8/20/98	9.7
LDW-SS70-010	LDWRI-SurfSedRound1	LDW-SS70	1/21/05	1.8	SD-DR131-0000-CC	EPA SI	DR131	8/13/98	1.3
LDW-SS75-010	LDWRI-SurfSedRound1	LDW-SS75	1/21/05	1.9	SD0056	Boeing SiteChar	R7	10/15/97	5.7
LDW-SS76-010	LDWRI-SurfSedRound1	LDW-SS76	1/20/05	2.0	SD-DR106-0000	EPA SI	DR106	8/19/98	2.3
LDW-SS79-010	LDWRI-SurfSedRound1	LDW-SS79	1/24/05	2.0	CH07-01	NOAA SiteChar	CH0023	10/16/97	1.7
LDW-SS81-010	LDWRI-SurfSedRound2	LDW-SS81	3/8/05	2.1	SD-DR113-0000-CC	EPA SI	DR113	8/19/98	1.1

Table E.1-3, cont. Newer surface sediment samples that superseded older surface sediment samples if the sample locations were less than 10 ft apart

Newer Sample				River Mile	Older Sample				Nominal Distance Between New and Old Coordinates (ft)
Sample	Event	Location	Sampling Date		Sample	Event	Location	Sampling Date	
LDW-B5a-S2	LDWRI-Benthic	B5a-2	9/24/04	2.2	WIT11-01	NOAA SiteChar	WIT280	10/3/97	9.8
SD-DR141-0000-CC	EPA SI	DR141	8/20/98	2.3	WST14-01	NOAA SiteChar	WST342	10/23/97	3.9
LDW-SS88-010	LDWRI-SurfSedRound1	LDW-SS88	1/25/05	2.5	EIT09-01	NOAA SiteChar	EIT074	11/3/97	7.2
LDW-SS92-010	LDWRI-SurfSedRound1	LDW-SS92	1/25/05	2.7	EST13-05	NOAA SiteChar	EST180	10/6/97	2.4
LDW-SS94-010	LDWRI-SurfSedRound1	LDW-SS94	1/21/05	2.7	SD-DR175-0000	EPA SI	DR175	8/20/98	0.7
LDW-SS102-010	LDWRI-SurfSedRound1	LDW-SS102	1/24/05	3.0	SD-DR198-0000	EPA SI	DR198	8/20/98	2.8
LDW-SS104-010	LDWRI-SurfSedRound1	LDW-SS104	1/25/05	3.1	SD-DR202-0000	EPA SI	DR202	8/27/98	1.5
T117-SE10-SG	T117BoundaryDefinition	T117-SE-10-G	12/8/03	3.5	WST09-02	NOAA SiteChar	WST323	10/21/97	1.2
SD-309-0000	JorgensenAugust2004	SD-309-S	8/16/04	3.6	EST11-03	NOAA SiteChar	EST152	9/24/97	3.5
SD-320-0000	JorgensenAugust2004	SD-320-S	8/16/04	3.6	SD2B-DUW92-0000	Plant 2 RFI-2b	SD-DUW92	4/2/96	4.8
SD-334-0000	JorgensenAugust2004	SD-334-S	8/26/04	3.6	EST11-04	NOAA SiteChar	EST154	9/24/97	9.1
SD-343-0000	JorgensenAugust2004	SD-343-S	8/27/04	3.6	SD2B-DUW90-0000	Plant 2 RFI-2b	SD-DUW90	4/4/96	6.1
SWY17	Plant2-TransformPhase1	SD-SWY17	9/9/03	3.6	SD-SWY07-0000	Plant 2 RFI-1	SD-SWY07	6/13/95	7.0
LDW-SS110-010	LDWRI-SurfSedRound1	LDW-SS110	1/25/05	3.6	SD-323-0000	JorgensenAugust 2004	SD-323-S	8/17/04	3.4
LDW-SS111-010	LDWRI-SurfSedRound1	LDW-SS111	1/19/05	3.6	SD-DR186-0000	EPA SI	DR186	8/27/98	1.0
LDW-SS113b-010	LDWRI-SurfSedRound1	LDW-SS113b	1/20/05	3.7	SD0009	Boeing SiteChar	R21	10/9/97	1.4
LDW-SS115-010	LDWRI-SurfSedRound1	LDW-SS115	1/25/05	3.7	SD-DR187-0000	EPA SI	DR187	8/27/98	3.0
LDW-SS117-010	LDWRI-SurfSedRound1	LDW-SS117	1/20/05	3.8	SD0013	Boeing SiteChar	R24	10/10/97	1.2
LDW-SS119-010	LDWRI-SurfSedRound1	LDW-SS119	1/19/05	3.8	SD0021	Boeing SiteChar	R30	10/11/97	2.3
LDW-SS121-010	LDWRI-SurfSedRound1	LDW-SS121	1/25/05	3.9	EIT06-02	NOAA SiteChar	EIT061	9/29/97	4.0
LDW-SS123-010	LDWRI-SurfSedRound1	LDW-SS123	1/24/05	3.9	EST09-04	NOAA SiteChar	EST144	9/25/97	1.1
LDW-SS203-010	LDWRI-SurfSedRound1	LDW-SS123	1/24/05	3.9	EST09-04	NOAA SiteChar	EST144	9/25/97	1.1
LDW-SS125-010	LDWRI-SurfSedRound1	LDW-SS125	1/20/05	4.0	SD-DR238-0000	EPA SI	DR238	8/27/98	1.1
LDW-B8b-S	LDWRI-Benthic	B8b	8/19/04	4.1	EST07-07	NOAA SiteChar	EST135	11/12/97	2.7
LDW-SS126-010	LDWRI-SurfSedRound1	LDW-SS126	1/20/05	4.1	RPL-A11-05-02	Rhône-Poulenc RFI-2	A11-05	8/18/94	2.1
LDW-SS126-010	LDWRI-SurfSedRound1	LDW-SS126	1/20/05	4.1	RPL-A11-10-02	Rhône-Poulenc RFI-2	A11-05	8/18/94	2.1
Upper SB-01	RhônePoulenc2004	SB-1	8/25/04	4.2	SD-DR242-0000-CC	EPA SI	DR242	8/24/98	9.5

Table E.1-3, cont. Newer surface sediment samples that superseded older surface sediment samples if the sample locations were less than 10 ft apart

Newer Sample				River Mile	Older Sample				Nominal Distance Between New and Old Coordinates (ft)
Sample	Event	Location	Sampling Date		Sample	Event	Location	Sampling Date	
Upper SB-15	RhônePoulenc2004	SB-1	8/25/04	4.2	SD-DR242-0000-CC	EPA SI	DR242	8/24/98	9.5
LDW-SS127-010	LDWRI-SurfSedRound1	LDW-SS127	1/20/05	4.2	SD0032	Boeing SiteChar	R40	10/13/97	1.0
LDW-SS129-010	LDWRI-SurfSedRound1	LDW-SS129	1/20/05	4.2	SD0033	Boeing SiteChar	R42	10/13/97	8.4
LDW-SS130-010	LDWRI-SurfSedRound1	LDW-SS130	1/20/05	4.2	SD0070	Boeing SiteChar	R45	10/16/97	0.5
Upper SH-04	RhônePoulenc2004	SH-04	8/24/04	4.3	06-intsed-2	Rhône-Poulenc RFI-3	06-intsed-2	7/1/96	8.6
Upper SH-02	RhônePoulenc2004	SH-02	8/25/04	4.3	07-intsed-1	Rhône-Poulenc RFI-3	07-intsed-1	7/1/96	9.7
LDW-B10b-S	LDWRI-Benthic	B10b	8/19/04	4.3	SD-DR286-0000-CC	EPA SI	DR286	8/26/98	3.2
LDW-SS148-010	LDWRI-SurfSedRound2	LDW-SS148	3/9/05	4.7	SD-DR271-0000	EPA SI	DR271	9/15/98	2.0
L20703-2	Norfolk-monit4	NFK501	4/24/01	4.9	L15421-1	Norfolk-monit1	NFK501	4/23/99	8.7
L23995-6	Norfolk-monit5	NFK503	4/30/02	4.9	L16628-6	Norfolk-monit2a	NFK503	10/8/99	4.2
L23995-6	Norfolk-monit5	NFK503	4/30/02	4.9	L17647-6	Norfolk-monit3	NFK503	4/6/00	3.3
L23995-6	Norfolk-monit5	NFK503	4/30/02	4.9	L20703-6	Norfolk-monit4	NFK503	4/24/01	4.0
288131	Ecology-Norfolk	2	7/9/02	4.9	L4321-2	Norfolk-cleanup1	NFK002	8/18/94	8.5
288132	Ecology-Norfolk	3	7/9/02	4.9	L4321-2	Norfolk-cleanup1	NFK002	8/18/94	9.5
288133	Ecology-Norfolk	4	7/9/02	4.9	L4321-2	Norfolk-cleanup1	NFK002	8/18/94	8.7
288134	Ecology-Norfolk	5	7/9/02	4.9	SD0079	Boeing SiteChar	R87	10/18/97	5.3
288134	Ecology-Norfolk	5	7/9/02	4.9	L17311-1	Norfolk-monit2b	NFK506	2/10/00	6.3
288136	Ecology-Norfolk	7	7/9/02	4.9	SD0079	Boeing SiteChar	R87	10/18/97	6.4
288136	Ecology-Norfolk	7	7/9/02	4.9	L17311-1	Norfolk-monit2b	NFK506	2/10/00	6.3
288148	Ecology-Norfolk	7	7/9/02	4.9	SD0079	Boeing SiteChar	R87	10/18/97	6.4
288148	Ecology-Norfolk	7	7/9/02	4.9	L17311-1	Norfolk-monit2b	NFK506	2/10/00	5.4
LDW-SS341-010	LDWRI-SurfaceSedimentRound3	LDW-SS341	10/3/2006	4.9	288139	Ecology-Norfolk	10	7/9/02	8.9
LDW-SS341-010	LDWRI-SurfaceSedimentRound3	LDW-SS341	10/3/06	4.9	L17315-3	Norfolk-monit2b	NFK503	2/8/00	7.6
LDW-SS341-010	LDWRI-SurfaceSedimentRound3	LDW-SS341	10/3/06	4.9	L28052-6	Norfolk-monit6	NFK503	4/23/03	4.3
LDW-SS341-010	LDWRI-SurfaceSedimentRound3	LDW-SS341	10/3/06	4.9	L31635-6	Norfolk-monit7	NFK503	4/5/04	1.8
LDW-SS342-010	LDWRI-SurfaceSedimentRound3	LDW-SS342	10/3/06	4.9	L16628-4	Norfolk-monit2a	NFK502	10/8/99	7.8
LDW-SS342-010	LDWRI-SurfaceSedimentRound3	LDW-SS342	10/3/06	4.9	L17647-4	Norfolk-monit3	NFK502	4/6/00	9.3
LDW-SS342-010	LDWRI-SurfaceSedimentRound3	LDW-SS342	10/3/06	4.9	L20703-4	Norfolk-monit4	NFK502	4/24/01	4.1

Table E.1-3, cont. Newer surface sediment samples that superseded older surface sediment samples if the sample locations were less than 10 ft apart

Newer Sample				River Mile	Older Sample				Nominal Distance Between New and Old Coordinates (ft)
Sample	Event	Location	Sampling Date		Sample	Event	Location	Sampling Date	
LDW-SS342-010	LDWRI-SurfaceSedimentRound3	LDW-SS342	10/3/06	4.9	L23995-4	Norfolk-monit5	NFK502	4/30/02	2.8
LDW-SS342-010	LDWRI-SurfaceSedimentRound3	LDW-SS342	10/3/06	4.9	L28052-4	Norfolk-monit6	NFK502	4/23/03	4.7
LDW-SS342-010	LDWRI-SurfaceSedimentRound3	LDW-SS342	10/3/06	4.9	L31635-4	Norfolk-monit7	NFK502	4/5/04	1.8
LDW-SS343-010	LDWRI-SurfaceSedimentRound3	LDW-SS343	10/3/06	4.9	288146	Ecology-Norfolk	17	7/9/02	1.0
LDW-SS343-010	LDWRI-SurfaceSedimentRound3	LDW-SS343	10/3/06	4.9	L17315-1	Norfolk-monit2b	NFK501	2/8/00	3.4
LDW-SS343-010	LDWRI-SurfaceSedimentRound3	LDW-SS343	10/3/06	4.9	L23995-2	Norfolk-monit5	NFK501	4/30/02	3.6
LDW-SS343-010	LDWRI-SurfaceSedimentRound3	LDW-SS343	10/3/06	4.9	L28052-2	Norfolk-monit6	NFK501	4/23/03	4.4
LDW-SS343-010	LDWRI-SurfaceSedimentRound3	LDW-SS343	10/3/06	4.9	L31635-2	Norfolk-monit7	NFK501	4/5/04	1.4
LDW-SS344-010	LDWRI-SurfaceSedimentRound3	LDW-SS344	10/3/06	4.9	L15421-4	Norfolk-monit1	NFK504	4/23/99	1.1
LDW-SS344-010	LDWRI-SurfaceSedimentRound3	LDW-SS344	10/3/06	4.9	L17647-8	Norfolk-monit3	NFK504	4/6/00	6.6
LDW-SS344-010	LDWRI-SurfaceSedimentRound3	LDW-SS344	10/3/06	4.9	L20703-8	Norfolk-monit4	NFK504	4/24/01	6.8
LDW-SS344-010	LDWRI-SurfaceSedimentRound3	LDW-SS344	10/3/06	4.9	L23995-8	Norfolk-monit5	NFK504	4/30/02	8.9
LDW-SS344-010	LDWRI-SurfaceSedimentRound3	LDW-SS344	10/3/06	4.9	L28052-8	Norfolk-monit6	NFK504	4/23/03	7.2
LDW-SS344-010	LDWRI-SurfaceSedimentRound3	LDW-SS344	10/3/06	4.9	L31635-8	Norfolk-monit7	NFK504	4/5/04	3.0

Note: Sampling location coordinates are Washington State Plane North, US survey ft, NAD83.
Ecology – Washington State Department of Ecology
EPA – US Environmental Protection Agency
LDW – Lower Duwamish Waterway
NOAA – National Oceanic and Atmospheric Administration
RCRA – Resource Conservation and Recovery Act
RFI – RCRA facility investigation
RI – remedial investigation
SI – site investigation

Table E.1-4. Summary of data omitted from the RI baseline dataset if an older sample was replaced by a newer sample with fewer analytes

Chemical	Number of Samples Omitted	Number of Samples in RI Baseline Dataset	Detection Frequency of Omitted Chemicals	Dry-Weight Concentration				OC-Normalized Concentration				Number of Detected Concentrations > SMS		Number of RLs > SMS	
				Min Detect	Max Detect	RL Range	Unit	Min Detect	Max Detect	RL Range	Unit	> SQS and ≤ CSL	> CSL	>SQS and ≤ CSL	> CSL
Metals and trace elements															
Arsenic	4	856	4/4	7.1	18.0	na	mg/kg dw	na	na	na	na	0	0	0	0
Cadmium	4	842	2/4	0.40	0.70	0.4 – 0.48	mg/kg dw	na	na	na	na	0	0	0	0
Chromium	4	854	4/4	25	110 J	na	mg/kg dw	na	na	na	na	0	0	0	0
Copper	4	856	4/4	27.0	97 J	na	mg/kg dw	na	na	na	na	0	0	0	0
Lead	4	856	4/4	13	1,300	na	mg/kg dw	na	na	na	na	0	1	0	0
Mercury	6	874	5/6	0.060 J	0.270	0.09	mg/kg dw	na	na	na	na	0	0	0	0
Nickel	4	816	4/4	20.0	75	na	mg/kg dw	na	na	na	na	nc	nc	nc	nc
Silver	7	830	3/7	0.37	0.70	0.4 – 0.9	mg/kg dw	na	na	na	na	0	0	0	0
Vanadium	3	600	3/3	57	81	na	mg/kg dw	na	na	na	na	nc	nc	nc	nc
Zinc	4	853	4/4	68.0	280	na	mg/kg dw	na	na	na	na	0	0	0	0
Organometals															
Tributyltin as ion	15	173	15/15	8.0 J	432 J	na	µg/kg dw	na	na	na	na	nc	nc	nc	nc
PAHs															
2-Methylnaphthalene	4	822	0/4	nd	nd	20 – 110	µg/kg dw	nd	nd	0.57 – 4.9	mg/kg OC	0	0	0	0
Acenaphthene	3	831	0/3	nd	nd	18 – 110	µg/kg dw	nd	nd	1.2 – 4.4	mg/kg OC	0	0	0	0
Anthracene	3	831	0/3	nd	nd	20 – 110	µg/kg dw	nd	nd	1.2 – 4.4	mg/kg OC	0	0	0	0
Benzo(a)anthracene	3	831	3/3	64	110	na	µg/kg dw	3.8	7.86	na	mg/kg OC	0	0	0	0
Benzo(a)pyrene	2	824	2/2	76	160	na	µg/kg dw	4.5	6.4	na	mg/kg OC	0	0	0	0
Benzo(g,h,i)perylene	3	831	2/3	70	140 J	110	µg/kg dw	4.1	10.0 J	4.4	mg/kg OC	0	0	0	0
Benzofluoranthenes	3	825	3/3	173	390	na	µg/kg dw	10	19.5 J	na	mg/kg OC	0	0	0	0
Chrysene	3	831	3/3	120	160	na	µg/kg dw	6.4	10.0	na	mg/kg OC	0	0	0	0
Dibenzo(a,h)anthracene	3	831	0/3	nd	nd	20 – 110	µg/kg dw	nd	nd	1.2 – 4.9	mg/kg OC	0	0	0	0

Table E.1-4, cont. Summary of chemicals omitted if an older sample was replaced by a newer sample with fewer analytes

Chemical	Number of Samples Omitted	Number of Samples in RI Baseline Dataset	Detection Frequency of Omitted Chemicals	Dry-Weight Concentration				OC-Normalized Concentration				Number of Detected Concentrations > SMS		Number of RLs > SMS	
				Min Detect	Max Detect	RL Range	Unit	Min Detect	Max Detect	RL Range	Unit	> SQS and ≤ CSL	> CSL	>SQS and ≤ CSL	> CSL
Dibenzofuran	3	830I	0/3	nd	nd	20 – 110	µg/kg dw	nd	nd	1.2 – 4.4	mg/kg OC	0	0	0	0
Fluoranthene	3	831	3/3	130	290	na	µg/kg dw	7.6	20.7	na	mg/kg OC	0	0	0	0
Fluorene	3	831	0/3	nd	nd	20 – 110	µg/kg dw	nd	nd	1.2 – 4.4	mg/kg OC	0	0	0	0
Indeno(1,2,3-cd)pyrene	3	831	2/3	76	140	110	µg/kg dw	4.5	10.0	4.4	mg/kg OC	0	0	0	0
Naphthalene	4	822	0/4	nd	nd	20 – 110	µg/kg dw	nd	nd	0.57 – 4.9	mg/kg OC	0	0	0	0
Phenanthrene	3	831	3/3	110	120 J	na	µg/kg dw	4.4	8.57 J	na	mg/kg OC	0	0	0	0
Pyrene	3	831	3/3	190	280 J	na	µg/kg dw	7.6	20.0 J	na	mg/kg OC	0	0	0	0
Total HPAH	3	831	3/3	930	1,373 J	na	µg/kg dw	51	98.1 J	na	mg/kg OC	0	0	0	0
Total LPAH	3	831	3/3	110	120 J	na	µg/kg dw	4.4	8.57 J	na	mg/kg OC	0	0	0	0
Carcinogenic PAHs -	3	831	3/3	68 J	240	na	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Total PAH	3	831	3/3	1,040	1,493 J	na	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Phthalates															
Bis(2-ethylhexyl)phthalate	3	835	3/3	220	430	na	µg/kg dw	8.8	30.7	na	mg/kg OC	0	0	0	0
Butyl benzyl phthalate	4	826	2/4	22 J	50	26 – 110	µg/kg dw	1.3 J	1.4	1.9 – 4.4	mg/kg OC	0	0	0	0
Dimethyl phthalate	4	826	1/4	30	30	18 – 110	µg/kg dw	0.86	0.86	1.2 – 4.4	mg/kg OC	0	0	0	0
Other SVOCs															
1,2,4-Trichlorobenzene	4	820	0/4	nd	nd	2.1 – 110	µg/kg dw	nd	nd	0.15 – 4.4	mg/kg OC	0	0	1	1
1,2-Dichlorobenzene	4	820	0/4	nd	nd	2.1 – 110	µg/kg dw	nd	nd	0.15 – 4.4	mg/kg OC	0	0	0	1
1,4-Dichlorobenzene	4	820	1/4	19.0 J	19.0 J	20 – 110	µg/kg dw	1.36 J	1.36 J	0.57 – 4.4	mg/kg OC	0	0	1	0
2,4-Dimethylphenol	4	817	0/4	nd	nd	20 – 330	µg/kg dw	na	na	na	na	0	0	0	2
4-Methylphenol	3	834	0/3	nd	nd	20 – 110	µg/kg dw	na	na	na	na	0	0	0	0
Benzoic acid	3	825	0/3	nd	nd	180 – 1,100	µg/kg dw	na	na	na	na	0	0	0	1
Benzyl alcohol	4	816	0/4	nd	nd	20 – 540	µg/kg dw	na	na	na	na	0	0	0	1
Hexachlorobenzene	4	823	0/4	nd	nd	1 – 110	µg/kg dw	nd	nd	0.059 – 4.4	mg/kg OC	0	0	1	1
n-Nitrosodiphenylamine	4	822	0/4	nd	nd	20 – 110	µg/kg dw	nd	nd	1.1 – 4.4	mg/kg OC	0	0	0	0
Pentachlorophenol	3	788	0/3	nd	nd	43 – 540	µg/kg dw	na	na	na	na	0	0	1	0

Table E.1-4, cont. Summary of chemicals omitted if an older sample was replaced by a newer sample with fewer analytes

Chemical	Number of Samples Omitted	Number of Samples in RI Baseline Dataset	Detection Frequency of Omitted Chemicals	Dry-Weight Concentration				OC-Normalized Concentration				Number of Detected Concentrations > SMS		Number of RLs > SMS	
				Min Detect	Max Detect	RL Range	Unit	Min Detect	Max Detect	RL Range	Unit	> SQS and ≤ CSL	> CSL	>SQS and ≤ CSL	> CSL
Phenol	3	834	0/3	nd	nd	20 – 220	µg/kg dw	na	na	na	na	0	0	0	0
Pesticides															
4,4'-DDD	17	210	7/17	3.80	8.00	2 – 20	µg/kg dw	na	na	na	na	nc	nc	nc	nc
4,4'-DDE	17	210	3/17	1.0	5.30	1.9 – 10	µg/kg dw	na	na	na	na	nc	nc	nc	nc
4,4'-DDT	17	210	1/17	4.0 J	4.0 J	1.9 – 20	µg/kg dw	na	na	na	na	nc	nc	nc	nc
DDTs	17	210	9/17	3.80	12.00	2 – 20	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Aldrin	17	210	0/17			0.99 – 10	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Dieldrin	17	210	1/17	3.50	3.50	1.9 – 20	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Total aldrin/dieldrin	17	210	1/17	3.50	3.50	1.9 – 20	µg/kg dw	na	na	na	na	nc	nc	nc	nc
alpha-BHC	17	210	0/17	nd	nd	0.99 – 10	µg/kg dw	na	na	na	na	nc	nc	nc	nc
beta-BHC	17	210	0/17	nd	nd	0.99 – 10	µg/kg dw	na	na	na	na	nc	nc	nc	nc
gamma-BHC	17	210	1/17	8.60	8.60	0.99 – 10	µg/kg dw	na	na	na	na	nc	nc	nc	nc
delta-BHC	11	166	0/11	nd	nd	0.99 – 3.7	µg/kg dw	na	na	na	na	nc	nc	nc	nc
alpha-Chlordane	11	160	0/11	nd	nd	1 – 37	µg/kg dw	na	na	na	na	nc	nc	nc	nc
gamma-Chlordane	11	160	0/11	nd	nd	1 – 37	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Chlordane	6	50	0/6	nd	nd	12 – 15	µg/kg dw	na	na	na	na	nc	nc	nc	nc
alpha-Endosulfan	11	158	0/11	nd	nd	0.99 – 10	µg/kg dw	na	na	na	na	nc	nc	nc	nc
beta-Endosulfan	11	160	0/11	nd	nd	2 – 20	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Endosulfan	6	52	0/6	nd	nd	1.9 – 2.5	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Endosulfan sulfate	17	208	0/17	nd	nd	1.9 – 20	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Endrin	17	210	0/17	nd	nd	1.9 – 20	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Endrin aldehyde	16	198	1/16	14	14	1.9 – 10	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Endrin ketone	11	148	0/11	nd	nd	2 – 20	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Heptachlor	17	210	0/17	nd	nd	0.99 – 10	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Heptachlor epoxide	17	210	0/17	nd	nd	0.99 – 10	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Methoxychlor	17	210	1/17	10	10	1 – 37	µg/kg dw	na	na	na	na	nc	nc	nc	nc

Table E.1-4, cont. Summary of chemicals omitted if an older sample was replaced by a newer sample with fewer analytes

Chemical	Number of Samples Omitted	Number of Samples in RI Baseline Dataset	Detection Frequency of Omitted Chemicals	Dry-Weight Concentration				OC-Normalized Concentration				Number of Detected Concentrations > SMS		Number of RLs > SMS	
				Min Detect	Max Detect	RL Range	Unit	Min Detect	Max Detect	RL Range	Unit	> SQS and ≤ CSL	> CSL	>SQS and ≤ CSL	> CSL
Toxaphene	17	208	0/17	nd	nd	10 – 500	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Total chlordane	11	160	0/11	nd	nd	1 – 37	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Volatile organic compounds															
Acetone	8	49	0/8	nd	nd	23 – 120	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Carbon disulfide	8	49	4/8	1.4 J	2.9 J	4.6 – 6	µg/kg dw	na	na	na	na	nc	nc	nc	nc
p-Cymene	8	44	0/8	nd	nd	1.8 – 3.4	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Dichloromethane	8	49	0/8	nd	nd	6.3 – 17	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Methyl ethyl ketone	8	49	2/8	10.6	10.6	4.6 – 6.8	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Tetrachloroethene	8	49	0/8	nd	nd	1.8 – 3.4	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Toluene	8	49	2/8	0.34 J	6.4	1.8 – 3.4	µg/kg dw	na	na	na	na	nc	nc	nc	nc
Dioxin/furan															
Dioxin/furan TEQ	4	51	4/4	3.1 J	13 J	na	ng/kg dw	na	na	na	na	nc	nc	nc	nc

Note: Raw data for all surface sediment samples, including older samples that were replaced by newer samples, are presented in a CD accompanying the RI.

BHC – benzene hexachloride
CSL – cleanup screening level
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
J – estimated concentration
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
na – not applicable
nc – no criteria
nd – not detected
OC – organic carbon
PAH – polycyclic aromatic hydrocarbon
RI – remedial investigation
RL – reporting limit
SMS – Washington State Sediment Management Standards
SQS – sediment quality standards
SVOC – semivolatile organic compound
TEQ – toxic equivalent

Two samples collected at locations very close to each other (i.e., within 10 ft) at different times reflect both the spatial and temporal heterogeneity of the chemical concentrations in the sediment. If such samples were collected at essentially the same time, as in the case of field replicates, then any differences in chemical concentrations can be attributed to spatial heterogeneity or variability resulting from laboratory procedures. If such samples were collected several years apart, it is not possible to distinguish between temporal and spatial heterogeneity as the cause of any differences in chemical concentrations. The decision to exclude the older data from the RI baseline surface sediment dataset in favor of data from newer co-located samples is based on the assumption that for two co-located (i.e., within 10 ft) samples collected at least 6 months apart, any differences in analyte concentrations are primarily a reflection of a temporal trend, and not of spatial variation. Therefore, for co-located samples collected within 6 months of each other, both were kept in the RI baseline surface sediment dataset and the results averaged for that location. For co-located samples collected more than 6 months apart, the most recent samples were retained in the RI baseline surface sediment dataset, and the earlier sample(s) were not included. The 6-month cutoff was based on best professional judgment.

As an example of data collected within a short time-frame, five locations (Kellogg Island [RM 0.7 west], Brandon [RM 1.2 east], 8th Ave [RM 2.8 west], South Park [RM 3.3 west], and Hamm Creek [RM 4.4 west]) were sampled repeatedly over a 13-week period in 1997 to assess short-term variability in sediment characteristics relative to combined sewer overflow/storm drain (CSO/SD) flows entering the LDW as part of the King County water quality assessment (WQA) (King County 1999). Because the sampling period was relatively short (i.e., months compared to years for most monitoring programs), all of these samples were included in the baseline surface sediment dataset and all results for a given chemical collected at each single location were averaged. This convention is consistent with the data averaging procedures used for field duplicates and replicates collected at any single location (see Section E.3.0).

A sediment removal action was conducted by King County in 1999 at the Norfolk EAA. Four locations have been sampled annually at this site following dredging and backfilling with clean sediments. These locations were also sampled as part of the surface sediment sampling event conducted in 2006 for the RI. The most recent samples (from 2006) from these monitoring locations were included in the RI baseline surface sediment dataset to most accurately reflect current conditions. Several other locations within the removal area were sampled only once in previous years, but are considered to be part of the Norfolk monitoring program put in place after the removal action. Although the data from those locations may be somewhat older than the most recent monitoring data, they were included in the RI baseline surface sediment dataset because they characterize locations other than the four primary sampling locations.

Not all of the samples from the four primary monitoring locations on the Norfolk cap were collected within 10 ft of each other. In several instances, the coordinates for the

most recent occupation of the four primary monitoring stations are more than 10 ft (maximum of 34 ft) from the coordinates for previous occupations of these same monitoring stations. In these instances, the older samples, with a few exceptions, were included in the baseline dataset because they were collected more than 10 ft away from the most recently sampled locations as discussed in detail in Windward (2006). When older samples were collected within 10 ft of a newer sample, only the newer sample was included in the RI baseline dataset.

E.1.3 SURFACE SEDIMENT DATA COLLECTED IN THE VICINITY OF REMOVAL ACTIONS AT THE DUWAMISH/DIAGONAL EAA AND THE BOEING DEVELOPMENTAL CENTER SOUTH STORM DRAIN

Dredging occurred at the Duwamish/Diagonal EAA during the 2003/2004 dredging season. The pre-dredging data within the removal area were used to characterize baseline. There have been 11 separate sampling events associated with the Duwamish/ Diagonal area, as listed in Table E.1-5. The first three sampling events took place between August 1994 and September 1996, prior to the dredging that occurred between October 2003 and March 2004 (Table E.1-5). Samples collected during these first three events were included in the RI baseline surface sediment dataset. Similarly, the data from the perimeter sampling conducted prior to dredging in October 2003 were also included in the RI baseline surface sediment dataset.

Table E.1-5. Duwamish/Diagonal sampling events

EVENT NAME	DESCRIPTION	DATE	INCLUDED IN BASELINE?
Duw/Diag-1	Phase 1 site assessment	Aug 1994	yes
Duw/Diag-1.5	Phase 1.5 site assessment	Nov 1995	yes
Duw/Diag-2	Phase 2 site assessment	May-Sep 1996	yes
DuwDiagOctober2003	Perimeter monitoring – pre-dredge	Oct 2003	yes
DuwDiagMarch2004	Perimeter monitoring – post-dredge	Mar 2004	no
DuwDiagJune2004	Baseline cap monitoring – year 0	June 2004	no
DuwDiagJan2005	Perimeter monitoring – 1 year post-dredge before thin-layer cap placement	Jan-Feb 2005	no
LDWRI-SurfaceSediment	Phase 2 RI sampling conducted by LDWG	Jan-Feb 2005	no[a]
DuwDiagMar2005	Perimeter monitoring – 1 year post-dredge after thin-layer cap placement	Mar 2005	no
DuwDiagApril2005	Cap monitoring – year 1	April 2005	no
DuwDiagAugust2005	Cap monitoring – year 1	August 2005	no
DuwDiagMar2006	Cap monitoring – year 2	March 2006	no
DuwDiagonal April2007	Cap monitoring – year 3	April 2007	no

[a] Only samples from the five locations described in the text below were excluded from the RI baseline surface sediment dataset. The other samples collected by LDWG in Jan-Feb 2005 were included in the RI baseline surface sediment dataset.

LDWG – Lower Duwamish Waterway Group

RI – remedial investigation

The perimeter locations sampled in October 2003 were also sampled in March 2004 and January and February 2005 as part of continued post-dredge monitoring (King County et al. 2005). These sampling events, and the other three King County Duwamish/ Diagonal sampling events listed in Table E.1-5, were conducted to monitor conditions within and adjacent to the removal action area. In addition, LDWG collected surface sediment samples in this area during January and February 2005 (Windward 2005a, b). The results for these LDWG samples also likely reflect post-removal conditions in the area outside the dredge boundary that was affected by the dredging activity. Based on a review of the post-removal monitoring data collected by King County, 200 ft was selected as a reasonable distance from the dredge boundary for delineating the area potentially influenced by the removal action. Five locations sampled by LDWG (Windward 2005a, b) were within this 200-ft perimeter: LDW-SS18, LDW-SS20, LDW-SS21, LDW-SS22, and LDW-SS25.[4] The post-removal data collected by King County at Duwamish/Diagonal and the LDWG Phase 2 data from the five locations described above will be used in the FS to represent post-removal conditions, but they are not relevant to baseline conditions and were excluded from the RI baseline surface sediment dataset. A list of all samples, including those from the Duwamish/Diagonal area, and whether they were included in the RI baseline surface sediment dataset is provided in Table E.3-1 in Section E.3.

Decisions regarding the samples associated with the removal action conducted at the Boeing Developmental Center south storm drain outfall just north of the Norfolk CSO/SD outfall (PPC 2003) followed the same logic described above for the Duwamish/Diagonal area. This area was within the area previously identified as the Norfolk EAA. Surface sediment samples collected within the removal area boundary prior to the removal were included in the RI baseline surface sediment dataset, while samples collected on top of the cap placed over the removal area were not.

E.1.4 REFERENCES

King County. 1999. King County combined sewer overflow water quality assessment for the Duwamish River and Elliott Bay. Vol 1: Overview and interpretation, plus appendices. King County Department of Natural Resources, Seattle, WA.

King County, Anchor, EcoChem. 2005. Duwamish/Diagonal CSO/SD sediment remediation project closure report. Prepared for the Elliott Bay Duwamish Restoration Program Panel. King County Department of Natural Resources, Anchor Environmental LLC, and EcoChem, Inc., Seattle, WA.

[4] Two of these locations (LDW-SS18 and LDW-SS20) were sampled by King County as part of their 1-year post-dredge perimeter monitoring. LDWG received splits of these samples from King County and conducted additional analyses (i.e., dioxins/furans and tributyltin) that were not included in the King County analyses.

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E.2 Data Quality Review Summaries and Surface Sediment Data Excluded from the Baseline Dataset

Table E.2-1. Chemistry datasets acceptable for all uses in the RI, including data quality review summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Sediment Chemistry							
Duwamish Diagonal March 2006 cap monitoring – year 2, perimeter sediment characterization, and ENR cap sediment characterization – year 1	*DuwDiagMarch 2006*	*2006*	*RM 0.4-0.6 east*	*Grain size, TOC, metals, SVOCs, PCB Aroclors, organochlorine pesticides*	*23 samples and 3 field duplicate samples; 8 grab samples collected with 6" coring device; 18 samples composited using equal aliquots of 3-10 grab samples collected using a van Veen grab sampler (0-10 cm)*	*QC consistent with previous King County events approved for all uses by EPA; validation qualifiers will be added to database*	*King County (2006a, b, 2007)*
Boeing Developmental Center 2005 Annual Sampling of South Storm Drain System – Year 2	*Boeing Developmental Center-2005*	*2005*	*RM 4.9 east*	*PCB Aroclors, TOC, total solids*	*3 surface (0-2 cm) sediment grab samples (1 field duplicate sample) collected using disposable plastic spoons*	*QC consistent with EPA guidelines; no validation qualifiers needed*	*Calibre (2006)*
Duwamish Diagonal Jan-Feb 2005 post-dredge perimeter - before thin-layer cap placement	*DuwDiagJan 2005*	*2005*	*RM 0.4-0.6 east*	*Grain size, TOC, metals, SVOCs, PCB Aroclors, organochlorine pesticides*	*22 grab surface (0-10 cm) sediment samples (2 field replicates) using van Veen grab sampler*	*QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database*	*King County (2005d)*
Duwamish Diagonal Mar 2005 post-dredge perimeter - after thin-layer cap placement	*DuwDiagMarch2005*	*2005*	*RM 0.4-0.6 east*	*Grain size, TOC, metals, SVOCs, PCB Aroclors, organochlorine pesticides*	*8 surface sediment samples (1 replicate) using a diver-actuated coring device from the top 10 cm of sediment*	*QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database*	*King County (2005c)*
Duwamish Diagonal April 2005 baseline cap monitoring - year 1	*DuwDiagApril 2005*	*2005*	*RM 0.4-0.6 east*	*TOC, grain size, metals, SVOCs, PCB Aroclors, organochlorine pesticides*	*7 surface sediment grab samples (1 replicate) using van Veen grab samplers from the top 10 cm of sediment*	*QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database*	*King County (2005b)*

Table E.2-1, cont. Chemistry datasets acceptable for all uses in the RI, including data quality review summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Boeing Developmental Center 2004 Annual Sampling of South Storm Drain System – year 1	*Boeing DevelopmentalCenter-2004*	*2004*	*RM 4.9 east*	*PCB Aroclors, TOC, total solids*	*3 surface (0-2 cm) sediment grab samples (1 field duplicate sample) collected using disposable plastic spoons*	*QC consistent with EPA guidelines; no validation qualifiers needed*	Calibre (2005)
Triad approach (immunoassay as a real-time measure) to characterize PCB in a Washington riverine sediment site	*Jorgensen August2004*	*2004*	*RM 3.5-3.7 east*	*TOC, SVOCs, grain size, mercury, lead*	*18 surface sediment samples (2 duplicate samples) using the van Veen sampler (<10 cm) and 50 subsurface sediment samples from 17 locations collected by vibracorer (1-6 ft, samples generally at 1-ft intervals)*	*data validation consistent with EPA guidelines; validation qualifiers for all fixed laboratory analyses added to database; field screening data may be used for informational purposes only*	*Herrera (2005)* EPA (2005a, 2004)
Upriver (Area 1) sediment characterization	*JorgensenApril2004*	*2004*	*RM 3.6-3.7 east*	*metals, PCB Aroclors, TOC, grain size*	*75 subsurface sediment samples from 22 sediment cores (2 duplicate cores) from 20 locations using the MudMole (6.8 to 10.6-ft cores; samples generally at 1-ft intervals)*	*data validation consistent with EPA guidelines; validation qualifiers added to database*	*MCS (2004c)*
Rhône-Poulenc surface/subsurface sediment	*RhônePoulenc2004*	*2004*	*RM 4.0-4.3 east*	*VOCs, metals, pesticides, PCB Aroclors*	*50 sediment samples (8 duplicate samples) from 21 locations using a clam gun; cores were divided into upper (0-10 cm) and lower (> 10 cm) samples*	*data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database*	*EPA (2005b)*
Duwamish Diagonal June 2004 baseline cap monitoring - year 0 (post-cap placement)	*DuwDiagJune 2004*	*2004*	*RM 0.4-0.6 east*	*TOC, grain size, metals, PCB Aroclors, SVOCs*	*8 surface sediment grab samples from the top 10 cm of sediment using the van Veen grab sampler*	*QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database*	*King County (2005e)*
Boeing Plant 2 DSOA additional vertical characterization - Phase 2	*DSOAvertchar2*	*2004*	*RM 2.9-3.2 east*	*PCB Aroclors, TOC*	*28 subsurface samples from 15 sediment cores (2 duplicate samples) from 15 locations using the MudMole (3.7 to 10.6-ft cores; samples generally at 1-ft intervals)*	*data validation consistent with EPA guidelines; validation qualifiers added to database*	*MCS (2004a)*
Boeing Plant 2 DSOA additional vertical characterization - Phase 3	*DSOAvertchar3*	*2004*	*RM 3.0-3.4 east*	*PCB Aroclors, TOC*	*5 sediment cores from 4 new locations and one reoccupied location using the MudMole (5.4 to 9.9-ft cores; samples generally at 1-ft intervals)*	*data validation consistent with EPA guidelines; all data, as reported are acceptable for use*	*MCS (2004b)*

Table E.2-1, cont. Chemistry datasets acceptable for all uses in the RI, including data quality review summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Boyer Towing dock replacement	Boyer Towing	2004	RM 2.4 west	metals, SVOCs, PCB Aroclors, conventionals	4 surface (0-10 cm) and 4 subsurface (30-60 cm) sediment samples collected with push core	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	WR Consulting (2004)
PSDDA characterization at the Lehigh Northwest Duwamish Waterway Facility	Lehigh NW	2004	RM 1.1 east	metals, SVOCs, PCB Aroclors, organochlorine pesticides, conventionals	3 sediment core samples (2 from 0-120 cm, 1 from 120-150 cm) collected with impact corer	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	MCS (2004d)
Slip 4 early action area site characterization	Slip4-EarlyAction	2004	Slip 4 (RM 2.8-2.9 east)	PCB Aroclors, mercury	29 grab samples (van Veen) from 0-10 cm; 58 core samples (vibracorer) taken from 11 locations; 4-6 samples taken at each location to a depth of 360 cm	data validation and data quality review consistent with EPA guidelines; data collected under existing LDW RI AOC, so no data quality review is needed in this memorandum	Integral (2004)
Additional vertical characterization, Duwamish Sediment Other Area	DSOAvert char2	2004	RM 2.8-3.7 east	PCB Aroclors	28 core samples (vibracorer) taken from 15 locations; 1-3 samples from each location from 60-144 cm	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	MCS Environmental (2004a)
Norfolk CSO sediment remediation project five-year monitoring program: Annual monitoring report - year 5, April 2004.	Norfolk-	2004	RM 4.9-5.0 east	metals, PCB Aroclors, SVOCs	Composites of 3 grab samples (van Veen) at each of 4 locations; 4 samples from 0-2 cm; 4 samples from 0-10 cm	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (2005a)
Duwamish/Diagonal pre- and post-cleanup monitoring data	DuwDiag-Dredge Monitoring	2003-2004	RM 0.4-0.6 east	metals, PCB Aroclors, organochlorine pesticides, SVOCs	24 composite samples from 10 grab samples (van Veen) from 0-10 cm at 12 locations, sampled both before dredging and after dredging	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County et al. (2005)
Terminal 117 early action area site characterization	T117 Boundary Definition	2003-2004	RM 3.6-3.7 west	PCB Aroclors; metals, SVOCs on selected samples	46 grab samples (power grab or by hand from intertidal) from 0-10 cm; 101 core samples (vibracorer) from 18 locations, 3-6 samples collected at each core location to a depth of 300 cm [c]	data validation and data quality review consistent with EPA guidelines; data collected under existing LDW RI AOC, so no data quality review is needed in this memorandum	Windward et al. (2004a, b)

Table E.2-1, cont. Chemistry datasets acceptable for all uses in the RI, including data quality review summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Final preliminary site investigation report for the South Park Bridge project	*SouthPark Bridge*	*2003*	*RM 3.3-3.4*	*metals, TBT, VOCs, SVOCs, organochlorine pesticides, PCB Aroclors, TOC*	*11 subsurface sediment samples from 2 locations (rotary drill unit) from depths up to 100 ft (samples collected at 2.5 ft intervals in top 10 ft, and at several deeper 2.5 ft intervals to 100 ft)*	*data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers as reported are acceptable for use*	*Wilbur Consulting (2004)*
Norfolk CSO sediment remediation project five-year monitoring program: Annual monitoring report - year 4, April 2003.	Norfolk-	2003	RM 4.9-5.0 east	metals, PCB Aroclors, SVOCs	Composites of 3 grab samples (van Veen) at each of 4 locations; 4 samples from 0-2 cm; 4 samples from 0-10 cm	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (2003)
Sediment characterization results for the Duwamish River navigational channel turning basin	Turning-basin	2003	RM 4.2-4.7	metals, PCB Aroclors, organochlorine pesticides, SVOCs	5 core samples (vibracorer) taken down to depths of 144 to 390 cm	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	Anchor (2003)
Boeing Plant 2 transformer investigation – Phase 1	Plant 2-Transformer Phase1	2003	RM 3.6 east	PCB Aroclors	5 surface grab samples (by hand) taken from 0-5 cm; 46 core samples (vibracorer) taken from 13 locations; 3-5 samples at each location from 0-240 cm [b]	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	Floyd Snider McCarthy (2004)
PSDDA dredged sediment characterization for Glacier NW	*Glacier NW*	*2002*	*RM 1.5 west*	*metals, PCB Aroclors, organochlorine pesticides, SVOCs*	*4 composite sediment samples from eleven cores collected by vibracorer from 0-172 cm*	*data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database*	*PIE (2002)*
Norfolk combined sewer overflow (Duwamish River) sediment cap recontamination. Phase I investigation.	Ecology-	2002	RM 4.9-5.0 east	PCB Aroclors	20 grab samples (van Veen) from 0-10 cm	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	Ecology (2003)
Norfolk CSO sediment remediation project five-year monitoring program: Annual monitoring report - year 3, April 2002.	Norfolk-monit5	2002	RM 4.9-5.0 east	metals, PCB Aroclors, SVOCs	Composites of 3 grab samples (van Veen) at each of 4 locations; 4 samples from 0-2 cm; 4 samples from 0-10 cm	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (2002)

Table E.2-1, cont. Chemistry datasets acceptable for all uses in the RI, including data quality review summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Data report, DSOA vertical characterization and outfall 12 data collection. Duwamish sediment other area, Boeing Plant 2	DSOAvert char	2001	RM 2.8-3.7 east	PCB Aroclors	125 core samples (vibracorer) from 37 locations; 2-6 samples at each location, most locations starting at 60 cm down to depths of 150-280 cm	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	Pentec (2001)
Norfolk CSO five-year monitoring program, Year Two, April 2001	Norfolk-	2001	RM 4.9-5.0 east	metals, PCB Aroclors, SVOCs	Composites of 3 grab samples (van Veen) at each of 4 locations; 4 samples from 0-2 cm; 4 samples from 0-10 cm	validation qualifiers added to database	King County (2001b)
Norfolk CSO five-year monitoring program – Twelve-month post construction	Norfolk-	2000	RM 4.9-5.0 east	metals, PCB Aroclors, SVOCs	Composites of 3 grab samples (van Veen) at each of 4 locations; 4 samples from 0-2 cm; 4 samples from 0-10 cm	validation qualifiers added to database	King County (2000c)
Norfolk CSO five-year monitoring program – Supplemental nearshore sampling	Norfolk-b	2000	RM 4.9-5.0 east	PCB Aroclors	Composites of 3 grab samples (van Veen) at each of 3 locations; 3 samples from 0-2 cm; 3 samples from 0-10 cm	validation qualifiers added to database	King County (2000b)
Outfall and nearshore sediment sampling report, Duwamish Facility	James Hardie	2000	RM 1.5 east	metals, PCB Aroclors, SVOCs	9 grab samples (van Veen or by hand in intertidal) from 0-10 cm	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	Weston (2000)
PSDDA sediment characterization of Duwamish River navigation channel: FY2000 operations and maintenance dredging data report	PSDDA99	1999	RM 1.9-3.4	metals, PCB Aroclors, organochlorine pesticides, SVOCs	20 composite core samples (vibracorer) taken from 18 locations; three borings made at each location; 18 samples from 0 to 120 cm; 2 samples from 120 to 240 cm	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	Striplin (SEA 2000b, a)
Norfolk CSO five-year monitoring program – Six-month post construction	Norfolk-a	1999	RM 4.9-5.0 east	metals, PCB Aroclors, SVOCs	Composites of 3 grab samples (van Veen) at each of 4 locations; 4 samples from 0-2 cm; 4 samples from 0-10 cm	validation qualifiers added to database	King County (2000d)
Norfolk CSO five-year monitoring program – Post backfill	Norfolk-	1999	RM 4.9-5.0 east	metals, PCB Aroclors, SVOCs	Composites of 3 grab samples (van Veen) at each of 4 locations; 4 samples from 0-10 cm	validation qualifiers added to database	King County (1999b)

Table E.2-1, cont. Chemistry datasets acceptable for all uses in the RI, including data quality review summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
PSDDA sediment characterization of Duwamish River navigation channel: FY99 operations and maintenance dredging data report.	PSDDA98	1998	RM 3.5-4.6	metals, PCB Aroclors, organochlorine pesticides, SVOCs	10 core samples (vibracorer) taken from 12 locations; 7 samples taken from 0 to 60-90 cm, each from single location; 3 samples taken from 2 or 3 locations (0-60 cm, 0-120 cm, and 120-360 cm)	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	Striplin (1998)
EPA Site Inspection: Lower Duwamish River	EPA SI	1998	entire LDW study area	metals, organochlorine pesticides, PCB Aroclors & selected congeners, dioxins & furans, TBT, SVOCs, VOCs	300 grab samples from 0-10 cm (van Veen); 33 core samples (vibracorer) from 0-60 and 60-120 cm from 17 locations	data collected by EPA for Superfund program; acceptable for all uses	Weston (1999)
King County combined sewer overflow water quality assessment for the Duwamish River and Elliott Bay	KC WQA	1997	Duwamish/Diagonal (RM 0.5-0.6 east); Kellogg Island (RM 0.7 west); Brandon CSO (RM 1.1 east); 8th Ave CSO (RM 2.8 west); South Park (RM 3.3 east); Hamm Creek (RM 4.4 west)	metals, PCB Aroclors, SVOCs, TBT	0-10 cm grab samples (van Veen) from 14 locations; single samples from 5 Duwamish/Diagonal locations and 4 Kellogg Island locations; weekly samples from Kellogg Island (9 samples), Brandon (13 samples), 8th Ave (9 samples), South Park (4 samples), Hamm Creek (4 samples)	validation qualifiers added to database	King County (1999a)
Duwamish Waterway Phase 1 site characterization	Boeing SiteChar	1997	RM 1.8-2.0 west; Slip 4 (RM 2.8-2.9 east); RM 3.6-4.0; RM 4.2-5.0 east	metals, PCB Aroclors, SVOCs	88[b] grab samples (van Veen) from 0-10 cm	accepted by EPA for all uses	Exponent (1998)
Duwamish Waterway sediment characterization study	NOAA SiteChar	1997	entire LDW study area	total PCBs, selected PCB congeners, total PCTs	328 grab samples (van Veen) from 0-10 cm	validation qualifiers added to database; congener data not appropriate for use in Phase 2 risk assessments	NOAA (1997, 1998)
Seaboard Lumber site, Phase 2 site investigation	Seaboard-	1996	RM 0.4-0.7 west	metals, PCB Aroclors, SVOCs	20 grab samples (van Veen) from 0-10 cm	accepted by EPA for all uses	Herrera (1997)
RCRA Facility Investigation Duwamish Waterway sediment investigation, Plant 2 – Phase 2b	Plant 2 RFI-2b	1996	RM 2.8-3.7 east	metals, PCB Aroclors, SVOCs	39 grab samples (van Veen) from 0-10 cm; 44 core samples (vibracorer) from 15 locations – 2 to 4 samples per core, up to 480 cm below mudline	validation qualifiers J+/J- changed to JH/JL; accepted by EPA for all uses	Weston (1998)

Table E.2-1, cont. Chemistry datasets acceptable for all uses in the RI, including data quality review summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Duwamish/Diagonal cleanup Study – Phase 2	Duw/-2	1996	RM 0.4-0.6 east	metals, PCB Aroclors, SVOCs, TPH	36 grab samples (van Veen) from 0-10 cm; 53 core samples (vibracorer) from 15 locations – 1 to 6 samples per core, up to 270 cm below mudline	validation qualifiers added to database	King County (2000a)
Duwamish/Diagonal cleanup Study – Phase 1.5	Duw/-1.5	1995	RM 0.4-0.6 east	metals, PCB Aroclors, SVOCs, TBT	12 grab samples (van Veen) from 0-10 cm	validation qualifiers added to database	King County (2000a)
Norfolk CSO sediment cleanup study – Phase 3	Norfolk-	1995	RM 4.9-5.0 east	PCB Aroclors	16 grab samples (van Veen) from 0-10 cm	validation qualifiers added to database	King County (1996)
Norfolk CSO sediment cleanup study – Phase 2	Norfolk-	1995	RM 4.9-5.0 east	metals, organochlorine pesticides, PCB Aroclors and selected congeners, SVOCs, VOCs, TPH	12 grab samples (van Veen) from 0-10 cm; 27 core samples (vibracorer) from 3 locations at 30 or 60 cm intervals up to 180 cm below mudline	validation qualifiers added to database	King County (1996)
RCRA Facility Investigation Duwamish Waterway sediment investigation, Plant 2 – Phase 2a	Plant 2 RFI-2a	1995	RM 2.8-3.7 east	metals, PCB Aroclors SVOCs	54 grab samples (van Veen) from 0-10 cm	validation qualifiers J+/J- changed to JH/JL; accepted by EPA for all uses	Weston (1998)
RCRA Facility Investigation Duwamish Waterway sediment investigation, Plant 2 – Phase 1	Plant 2 RFI-1	1995	RM 2.8-3.7 east	metals, PCB Aroclors, TPH, SVOCs, VOCs	65 grab samples (van Veen) from 0-10 cm; 22 core samples (vibracorer) from 12 locations at 15-45 cm intervals down to 135 cm below mudline	validation qualifiers J+/J- changed to JH/JL; accepted by EPA for all uses	Weston (1998)
Duwamish/Diagonal cleanup Study – Phase 1	Duw/-1	1994	RM 0.4-0.6 east	metals, organochlorine pesticides, PCB Aroclors, SVOCs, TBT	38 grab samples (van Veen) from 0-10 cm; 2 grab samples (van Veen) from 0-15 cm; 12 core samples (vibracorer) from 2 locations at 15-30 cm intervals down to 150 cm below mudline	validation qualifiers added to database	King County (2001a)
Norfolk CSO sediment cleanup study – Phase 1	Norfolk-	1994	RM 2.8-3.7 east	metals, organochlorine pesticides, SVOCs, PCB Aroclors, VOCs	21 grab samples (van Veen) from 0-10 cm; 3 core samples from 1 location – 15-30, 30-45, and 45-60 cm	validation qualifiers added to database	King County (1996)

Table E.2-1, cont. Chemistry datasets acceptable for all uses in the RI, including data quality review summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Rhône-Poulenc RCRA Facility Investigation for the Marginal Way facility – Round 2	Rhône-RFI-2	1994	Slip 6 (RM 4.2 east)	metals, SVOCs, PCB Aroclors 1254 and 1260, organochlorine pesticides	7 grab samples (van Veen) from 0-2 cm	accepted by EPA for all uses	Rhône-Poulenc (1995)
Results of sampling and analysis, sediment monitoring plan, Duwamish Shipyard, Inc.	Duwamish	1993	RM 1.4-1.5 west	metals, SVOCs, TBT	5 grab samples (van Veen) from 0-10 cm	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	Hart Crowser (1993)
Harbor Island Remedial Investigation	Harbor Island RI	1991	RM 0.0-0.4	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs, TPH, TBT	34 grab samples (van Veen) from 0-10 cm	data collected by EPA for Superfund program; acceptable for all uses	Weston (1993)
Tissue Chemistry							
East Waterway, Harbor Island Superfund site: Technical memorandum: Tissue chemistry results for juvenile chinook salmon collected from Kellogg Island and East Waterway.	EW-Salmon	2002	Kellogg Island (RM 0.8-0.9 west)	PCB Aroclors, mercury	12 composite samples of whole-body juvenile chinook salmon (6 from LDW, 6 from East Waterway) collected by beach seine; each sample consisted of 6-7 fish	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	Windward (2002)
NMFS Duwamish injury assessment project	NOAA-salmon2	2000	Kellogg Island (RM 0.8-0.9 west), Slip 4 (RM 2.8 east)	PCB congeners, organochlorine pesticides (salmon); PCB Aroclors (shiner perch)	29 samples of whole-body juvenile chinook salmon collected by beach seine (9 were composites of 3-10 fish, 20 were individual fish); 6 composite samples of chinook salmon stomach contents; 2 composite samples of whole-body shiner perch	neither EPA nor LDWG plan to conduct a review of the salmon portion of this dataset because LDWG's 2003 juvenile chinook salmon sampling results make the effort required for such a review unwarranted, as documented by Windward (2005a); therefore, these data will not be used in Phase 2; the shiner perch portion of the dataset has been previously approved for all uses by EPA (2003)	NMFS (2002)

Table E.2-1, cont. Chemistry datasets acceptable for all uses in the RI, including data quality review summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Waterway Sediment Operable Unit Harbor Island Superfund Site	WSOU	1998	RM 0.4-0.9 (crab), RM 2.0-4.4 (English sole), RM 0.0-0.2 (striped perch)	Hg, TBT, PCB Aroclors	3 English sole skinless fillet composite samples (5 fish/composite caught by trawl); 3 red rock crab edible meat composite samples (5 crab/composite caught by crab trap); 1 Dungeness crab edible meat sample (1 individual caught by crab trap); 3 striped perch skinless fillet samples (5 fish/composite for 2 samples, 1 individual fish for 1 sample; caught by diver)	collected under EPA oversight for a previously conducted Superfund risk assessment; previously approved for all uses by EPA (2003)	ESG (1999)
King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay	KC WQA	1996-1997	RM 0.5-0.9	metals, TBT, SVOCs, PCB Aroclors	3 English sole skinless fillet composite samples (20 fish/composite caught by trawl); 3 English sole whole-body composite samples[d] (20 fish/composite caught by trawl); 2 Dungeness crab edible meat composite samples (3 crabs/sample caught by crab trap); 1 Dungeness crab hepatopancreas composite sample (3 crabs caught by crab trap); 4 amphipod composite samples (caught by benthic sledge); 3 shiner surfperch whole-body composite samples (10 fish/sample caught by trawl); 22 mussels edible meat composite samples (20 mussels/sample collected by hand) [e]	add validation qualifiers; English sole whole-body composite samples not acceptable for all uses because they don't truly represent whole bodies	King County (1999a)
Puget Sound Ambient Monitoring Program – annual sampling	PSAMP-fish	1992	RM 0.4-1.3	SVOCs, organochlorine pesticides, PCB Aroclors, As, Cu, Pb, Hg	3 English sole skinless fillet (10-20 fish/sample collected by trawl)	acceptable for all uses	West et al. (2001)
		1995	RM 0.4-1.3	organochlorine pesticides, PCB Aroclors, As, Cu, Pb, Hg	3 English sole skinless fillet composite samples (10-20 fish/sample collected by trawl)	acceptable for all uses	

Table E.2-1, cont. Chemistry datasets acceptable for all uses in the RI, including data quality review summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
		1997	RM 0.4-1.3	Hg, organochlorine pesticides	3 English sole skinless fillet composite samples (10-20 fish/sample collected by trawl)	acceptable for all uses	
Elliott Bay/Duwamish River Fish Tissue Investigation	EVS 95	1995	RM 1.1-1.4	PCB Aroclors, Hg, MeHg, TBT	3 English sole skinless fillet composite samples (6 fish/sample collected by trawl)	collected under EPA oversight for a previously conducted Superfund risk assessment; previously approved for all uses by EPA (2003)	Battelle (1996); EVS (unpublished) ; Frontier Geosciences (1996)
Contaminant exposure and associated biochemical effects in outmigrant juvenile chinook salmon from urban and non-urban estuaries of Puget Sound	NOAA-salmon	1989-1990	RM 0.7	organochlorine pesticides, PCB Aroclors, PAHs	14 composite samples of whole-body juvenile chinook salmon collected by beach seine (2-10 fish/sample); 6 composite samples of stomach contents (10 fish/sample) [f]	neither EPA nor LDWG plan to conduct a review of this dataset because LDWG's 2003 juvenile chinook salmon sampling results make the effort required for such a review unwarranted; therefore, these data will not be used in Phase 2	Varanasi et al. (1993)
Other Chemistry							
Duwamish River/Elliott Bay/Green River Water Column PCB Congener Survey	*KC 2005 Water Sampling*	*2005*	*RM 0 and 3.3*	*PCB congeners, conventional parameters*	*28 water samples collected over 4 months at 4 locations; 2 locations in the Duwamish River were sampled at both surface and bottom depths of the water column; all samples analyzed for PCB congeners and conventional field parameters*	*QC consistent with previous King County events approved for all uses; validation qualifiers added to database; Windward evaluated field and laboratory replicate samples for method blank contamination*	Mickelson and Williston (2006)
Rhône-Poulenc porewater	*Rhô nePoulenc2004*	*2004*	*RM 4.0-4.3 east*	*VOCs, metals, pesticides, PCB Aroclors*	*16 porewater samples for chemistry parameters (1 duplicate sample, and 1 additional sample analyzed only for field parameters) collected using a piezometer or a seepage meter*	*data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database*	*EPA (2005b)*
RCRA Facility Investigation Duwamish Waterway sediment investigation, Plant 2 – Phase 1	Plant 2 RFI-1	1995	RM 2.8 – 3.7 east	metals, PCB Aroclors, TPH, SVOCs, VOCs	22 seep water	comprehensive data quality review not warranted because EPA has previously approved these data for all uses in the RCRA program	Weston (1998)

Table E.2-1, cont. Chemistry datasets acceptable for all uses in the RI, including data quality review summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Rhône-Poulenc RCRA Facility Investigation for the Marginal Way facility – Round 3	Rhône-RFI-3	1995	Slip 6 (RM 4.2 east)	VOCs	7 seep water	comprehensive data quality review not warranted because EPA has previously approved these data for all uses in the RCRA program	Rhône-(1996)
Supplemental remedial investigation and feasibility study. Great Western International	Great Western Apr-94	1994	RM 2.2 east	VOCs	6 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Hart Crowser (1994a)
	Great Western Jul-94	1994		VOCs	9 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Hart Crowser (1994b)
	Great Western Nov-94	1994		VOCs	7 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Hart Crowser (1996)
	Great Western May-95	1995		VOCs	7 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Hart Crowser (1996)
	Great Western-1995 Annual	1995		VOCs	7 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Hart Crowser (1996)
	Great Western-1996 Annual	1996		VOCs	5 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Hart Crowser (1997)

Table E.2-1, cont. Chemistry datasets acceptable for all uses in the RI, including data quality review summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
	Great Western-1997 Annual	1997		VOCs	4 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Terra Vac, Floyd & Snider (2000)
	Great Western-1998 Annual	1998		VOCs	9 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Terra Vac, Floyd & Snider (2000)
Supplemental remedial investigation and feasibility study. Great Western International (cont.)	Great Western-Embayment Study	1998		VOCs	10 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Terra Vac, Floyd & Snider (2000)
	Great Western-1999 Annual	1999		VOCs, SVOCs	5 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Terra Vac, Floyd & Snider (2000)
King County combined sewer overflow water quality assessment for the Duwamish River and Elliott Bay [g]	KC WQA	1996-1997	Duwamish/Diagonal CSO (RM 0.5 east), Brandon CSO (RM 1.1 east), SW Michigan CSO (RM 2.0 east), Norfolk CSO (RM 4.9 east) [h]	metals, SVOCs, conventionals, PCB Aroclors	1,249 surface water samples collected using Niskin and van Dorn samplers. Samples were collected from multiple depths (near-surface and near-bottom) and up to 3 locations horizontally across the waterway. Samples were collected weekly and also during storm events. [h]	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (1999a)

Note: *New datasets discussed in this memorandum are shown in italics*

[a] All events listed on this table are: 1) considered acceptable for all uses in Phase 2, even if not specifically mentioned, 2) acceptable for some uses, but not others, as noted, or 3) undergoing additional review by EPA; acceptability determination is still pending

[b] Sample total does not include three reference samples that were collected upstream of the study area

[c] Does not include soil, groundwater, and seep data collected concurrently during this investigation

[d] Samples are of remnant tissues following the subsampling of fillet tissue. In addition, livers were removed from some fish in the composite samples.

[e] Sample counts do not include data from cooked crab and English sole samples or data from caged mussel deployments. These data will not be used in the Phase 2 RI

[f] Six composite samples of juvenile chinook salmon livers were also analyzed, but these data will not be used in the Phase 2 RI.

Table E.2-1, cont. Chemistry datasets acceptable for all uses in the RI, including data quality review summaries

[g] Only water chemistry data. Sediment and tissue chemistry data from this sampling event were previously reviewed in Windward (2005b).

[h] Samples collected outside the LDW study area were also included in this sampling event

AOC – administrative order on consent
CSO – combined sewer overflow
MeHg – methylmercury
MTCA – Model Toxics Control Act
NOAA – National Oceanic and Atmospheric Administration
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PCT – polychlorinated terphenyl
RCRA – Resource Conservation and Recovery Act
SVOC – semivolatile organic compound
TBT – tributyltin
TPH – total petroleum hydrocarbons
VOC – volatile organic compound

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Table E.2-1, cont. Chemistry datasets acceptable for all uses in the RI, including data quality review summaries

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Table E.2-2. Chemistry datasets not acceptable for all uses in the RI, including data quality review summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Action/ Conclusions	Reference
Sediment Chemistry							
Dredge material characterization Duwamish Yacht Club	Duwam Yacht Club	1999	RM 4.1 west	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs, TBT	6 core samples (vibracorer), each made from 2 separate cores collected to 50-65 cm	not reviewed by Windward; sediment characterized has been dredged	Hart Crowser (1999)
Sediment sampling and analysis James Hardie Gypsum Inc. – Round 1	Hardie Gypsum-1	1999	RM 1.6-1.7 east	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs	5 core samples (vibracorer) made from single cores down to 120 cm	not reviewed by Windward; sediment characterized has been dredged	Spearman (1999)
Sediment sampling and analysis James Hardie Gypsum Inc. – Round 2	Hardie Gypsum-2	1999	RM 1.6-1.7 east	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs	9 core samples (vibracorer) made from single cores down to 90 cm	not reviewed by Windward; sediment characterized has been dredged	Spearman (1999)
Dredge material characterization Hurlen Construction Company & Boyer Alaska Barge Lines berthing areas	Hurlen-	1998	RM 2.4-2.7 west	metals, organochlorine pesticides, PCB Aroclors, SVOCs, TBT, TPH	6 core samples (vibracorer), 2 from Boyer, 4 from Hurlen, each made from 2 separate cores collected to 60-120 cm	not reviewed by Windward; sediment characterized has been dredged	Hart Crowser (1998)
Sediment quality in Puget Sound. Year 2 – Central Puget Sound	PSAMP/	1998	RM 0.5, 0.6, 1.8	metals, PCB Aroclors, organochlorine pesticides, SVOCs, TBT	3 grab samples (van Veen) collected from 0-2 cm	LDWG did not conduct a review of this dataset because the QA/QC information was not readily available. The effort that would have been required to obtain this QA/QC information was not justified for the purposes of the Phase 2 RI and risk assessments.	Ecology (2000)
RCRA facility investigation (RFI) report for the Marginal Way facility. Round 3 data and sewer sediment technical memorandum.	RhôneRFI3	1996	RM 4.2 east	metals, phenols (4 samples)	16 grab samples collected by hand from 0-10 cm	data validation consistent with EPA guidelines, but laboratory Form 1s not present in data report; Phase 2 RI DQOs not met, so not acceptable for all uses	Rhône-Poulenc (1996)

Table E.2-2, cont. Chemistry datasets not acceptable for all uses in the RI, including data quality review summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Action/ Conclusions	Reference
Proposed dredging of Slip No. 4, Duwamish River, Seattle, WA	Slip4-wley	1996	RM 2.8 east	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs, TBT	4 core samples (vibracorer) composited from sediment at 9 locations collected to a depth of 70-130 cm	not reviewed by Windward; sediment characterized has been dredged	PTI (1996)
1996 USACE Duwamish O&M	PSDDA96	1996	RM 4.2-4.6	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs,	4 core samples (vibracorer) collected to a depth of 120 cm	not reviewed by Windward; sediment characterized has been dredged	Striplin (1996)
Lone Star Northwest and James Hardie Gypsum – Kaiser dock upgrade	Lone Star-Gypsum	1995	RM 1.6 east	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs	5 core samples (vibracorer); 4 collected to a depth of 120-150 cm, 1 at 120-360 cm	not reviewed by Windward; sediment characterized has been dredged	Hartman (1995)
Rhône-Poulenc RCRA Facility Investigation for the Marginal Way facility – Round 1	Rhône-RFI-1	1994	RM 4.2 east	metals, SVOCs, PCB Aroclors, organochlorine pesticides	7 grab samples (van Veen) collected from 0-15 cm	data validation consistent with EPA guidelines, but laboratory Form 1s not present in data report; Phase 2 RI DQOs not met, so not acceptable for all uses	Rhône-Poulenc (1995)
Lone Star Northwest – West Terminal US ACOE – Seattle	Lone Star 92	1992	RM 1.5 east	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs	1 core sample (vibracorer), made from 2 separate cores collected to 120 cm	not reviewed by Windward; sediment characterized has been dredged	Hartman (1992)
Sediment sampling and analysis, South Park Marina, Duwamish Waterway, Seattle, Washington.	South Park Marina	1991	RM 3.5 west	metals, SVOCs, PCB Aroclors, organochlorine pesticides	2 core samples (vibracorer), each made from 2 separate cores collected to 120 cm	data not reviewed because of age of data; sediment characterized has been dredged	Spearman (1991)
Tissue chemistry							
Preliminary exposure assessment of dioxin-like chlorobiphenyls in great blue herons of the lower Duwamish River	Heron	1998	heron colony west of RM 0.5 west	PCB congeners	6 samples taken from 5 great blue heron eggs collected by hand from nest (5 egg samples, 1 egg yolk sample)	no formal data validation conducted, laboratory Form 1s not present in data report; EPA determined QA/QC data were not readily available	Krausmann (2002)

Table E.2-2, cont. Chemistry datasets not acceptable for all uses in the RI, including data quality review summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Action/ Conclusions	Reference
Puget Sound Ambient Monitoring Program – annual sampling	PSAMP- fish	1992	RM 0.7	SVOCs, organochlorine pesticides, PCB Aroclors, As, Cu, Pb, Hg	6 coho salmon and 6 chinook salmon composite fillet samples (5 fish/composite caught by gill net)	Adult salmon; data were summarized in the Phase 1 RI, but were not used in the risk assessments because almost all the chemicals in these fish are associated with exposure outside the LDW	West et al. (2001)
		1993 – 1996	RM 0.7	organochlorine pesticides, PCB Aroclors, As, Cu, Pb, Hg	1993: 5 coho salmon and 6 chinook salmon composite fillet samples (5 fish/composite caught by gill net); 1994: 5 coho salmon composite fillet samples and 6 chinook salmon filet samples (5 composite, 1 individual) (5 fish/composite caught by gill net); 1995: 7 coho salmon (6 composite, 1 individual) and 15 chinook salmon filet samples (13 composite, 2 individual) (5 fish/composite caught by gill net); 1996: 19 coho salmon (5 composite, 14 individual) and 49 chinook salmon fillet samples (all individual) (5 fish/composite caught by gill net)		
		1998	RM 0.7	Hg, organochlorine pesticides	13 coho salmon composite fillet samples (5 fish/composite caught by gill net)		

DQO– data quality objective
EPA – US Environmental Protection Agency
NOAA – National Oceanic and Atmospheric Administration
PCB – polychlorinated biphenyl
PSAMP – Puget Sound Ambient Monitoring Program
QA/QC – quality assurance/quality control
RM – river mile
SVOC – semivolatile organic compound
TBT – tributyltin
TPH – total petroleum hydrocarbons
VOC – volatile organic compound

Table E.2-2, cont. Chemistry datasets not acceptable for all uses in the RI, including data quality review summaries

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Table E.2-3. LDW surface sediment samples collected since 1990 excluded from the RI baseline dataset

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion	Sample No.
Boeing SiteChar	R21	194955	1275772	10/9/97	SD0009		10	superseded by LDW-SS113b - 1 ft away	1112
Boeing SiteChar	R24	194553	1275818	10/10/97	SD0013		10	superseded by LDW-SS117 - 1 ft away	1116
Boeing SiteChar	R30	194391	1276226	10/11/97	SD0021		10	superseded by LDW-SS119 - 2 ft away	1124
Boeing SiteChar	R40	193044	1277453	10/13/97	SD0032		10	superseded by LDW-SS127 - 1ft away	1135
Boeing SiteChar	R42	192917	1277567	10/13/97	SD0033		10	superseded by LDW-SS129 - 8ft away	1136
Boeing SiteChar	R45	192810	1277407	10/16/97	SD0070		10	superseded by LDW-SS130 - less than 1ft away	1173
Boeing SiteChar	R7	201578	1269271	10/15/97	SD0056		10	superseded by LDW-SS75 - 6 ft away	1159
Boeing SiteChar	R86	190215	1278519	10/19/97	SD0091		10	sample falls inside 1999 Norfolk dredge area - exclude	1194
Boeing SiteChar	R87	190257	1278543	10/18/97	SD0079		10	superseded by Ecology-Norfolk 5 and 7	1182
Duw/Diag-1	DUD001	209120	1267153	8/17/94	L4288-30		10	superseded by KC WQA loc. DD-1 - exclude	1214
Duw/Diag-1	DUD006	209059	1267092	8/10/94	L4288-5		10	superseded by KC WQA loc. DD-2 - exclude	1219
Duw/Diag-1	DUD022	208929	1267040	8/10/94	L4288-21		10	superseded by KC WQA loc. DD-3 - exclude	1253
Duw/Diag-1	DUD032	208978	1266889	8/12/94	L4288-27		10	superseded by 1995 location DUD032, samp L7279-3 - exclude	1268
Duw/Diag-1	DUD034	208785	1266933	8/12/94	L4288-28		10	superseded by KC WQA loc. DD-4 - exclude	1271
Duw/Diag-1.5	DUD036	208245	1267118	11/11/95	L7279-4		10	superseded by DUD_4C - exclude	1273
Duw/Diag-1.5	DUD039	208606	1266844	11/9/95	L7279-8		10	superseded by KC WQA loc. DD-5 - exclude	1276
Duw/Diag-1.5	DUD042	209785	1266880	11/11/95	L7279-11		10	superseded by LDW-SS17 - 3 ft away	1279
DuwamishShipyard	SS-2	204599	1268050	8/17/93	SS-2		7.5	superseded by LDW-SS48, use most recent data	18472
DuwamishShipyard	SS-3	204476	1268107	8/17/93	SS-3		7.5	superseded by LDW-SS49, use most recent data	18473
DuwamishShipyard	SS-3	204476	1268107	8/17/93	SS-6	duplicate	7.5	superseded by LDW-SS49, use most recent data	18493
DuwamishShipyard	SS-4	204181	1268184	8/17/93	SS-4		7.5	superseded by LDW-SS55, use most recent data	18474
DuwamishShipyard	SS-5	203667	1268323	8/17/93	SS-5		7.5	inside 2005 Glacier NW dredge area	18475
DuwDiagApril2005	DUD_1A	209089	1267047	4/27/05	L35394-1		8	on top of dredged area cap, not appropriate for baseline group - exclude	30979
DuwDiagApril2005	DUD_1B	208484	1267060	4/27/05	L35394-7		10	on top of dredged area cap, not appropriate for baseline group - exclude	30985
DuwDiagApril2005	DUD_2A	208902	1267139	4/27/05	L35394-2		5	on top of dredged area cap, not appropriate for baseline group - exclude	30980
DuwDiagApril2005	DUD_3A	208973	1266951	4/27/05	L35394-3		6	on top of dredged area cap, not appropriate for baseline group - exclude	30981
DuwDiagApril2005	DUD_4A	209354	1266888	4/27/05	L35394-4		10	on top of dredged area cap, not appropriate for baseline group - exclude	30982
DuwDiagApril2005	DUD_5A	209410	1266805	4/27/05	L35394-5		8	on top of dredged area cap, not appropriate for baseline group - exclude	30983
DuwDiagApril2005	DUD_5A	209410	1266805	4/27/05	L35394-6		7	on top of dredged area cap, not appropriate for	30984

Table E.2-3, cont. LDW surface sediment samples collected since 1990 excluded from the RI baseline dataset

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion	Sample No.
								baseline group - exclude	
DuwDiagJan2005	DUD_10C	209517	1266663	2/1/05	L34524-12		8	post-remediation, not appropriate for baseline group - exclude	30952
DuwDiagJan2005	DUD_11C	209535	1266844	2/1/05	L34524-13		7	post-remediation, not appropriate for baseline group - exclude	30953
DuwDiagJan2005	DUD_12C	209630	1266813	2/2/05	L34524-14		9	post-remediation, not appropriate for baseline group - exclude	30954
DuwDiagJan2005	DUD_13C	207853	1267236	2/2/05	L34524-15		10	post-remediation, not appropriate for baseline group - exclude	30955
DuwDiagJan2005	DUD_14C	208000	1267196	2/2/05	L34524-16		10	post-remediation, not appropriate for baseline group - exclude	30956
DuwDiagJan2005	DUD_15C	207970	1267059	2/2/05	L34524-17		10	post-remediation, not appropriate for baseline group - exclude	30957
DuwDiagJan2005	DUD_16C	208764	1266837	2/2/05	L34524-18		10	post-remediation, not appropriate for baseline group - exclude	30958
DuwDiagJan2005	DUD_17C	208885	1266739	2/2/05	L34524-19		10	post-remediation, not appropriate for baseline group - exclude	30959
DuwDiagJan2005	DUD_18C	209451	1266630	2/2/05	L34524-20		7	post-remediation, not appropriate for baseline group - exclude	30961
DuwDiagJan2005	DUD_19C	209545	1266746	2/1/05	L34524-21		5	post-remediation, not appropriate for baseline group - exclude	30962
DuwDiagJan2005	DUD_1C	208754	1267168	2/1/05	L34524-1		6	post-remediation, not appropriate for baseline group - exclude	30949
DuwDiagJan2005	DUD_20C	209779	1266769	2/2/05	L34524-22		8	post-remediation, not appropriate for baseline group - exclude	30963
DuwDiagJan2005	DUD_2C	208651	1267175	1/31/05	L34524-2		9	post-remediation, not appropriate for baseline group - exclude	30960
DuwDiagJan2005	DUD_3C	208144	1267146	1/31/05	L34524-3		10	post-remediation, not appropriate for baseline group - exclude	30964
DuwDiagJan2005	DUD_4C	208239	1267116	1/31/05	L34524-4		7	post-remediation, not appropriate for baseline group - exclude	30965
DuwDiagJan2005	DUD_4C	208239	1267116	1/31/05	L34524-5	replicate	7	post-remediation, not appropriate for baseline group - exclude	30966
DuwDiagJan2005	DUD_5C	208263	1267025	1/31/05	L34524-6		10	post-remediation, not appropriate for baseline group - exclude	30967
DuwDiagJan2005	DUD_6C	208501	1266950	1/31/05	L34524-7		9	post-remediation, not appropriate for baseline group - exclude	30968
DuwDiagJan2005	DUD_7C	208486	1266902	1/31/05	L34524-8		9	post-remediation, not appropriate for baseline group - exclude	30969
DuwDiagJan2005	DUD_8C	208920	1266864	2/1/05	L34524-10	replicate	7	post-remediation, not appropriate for baseline group - exclude	30950
DuwDiagJan2005	DUD_8C	208920	1266864	2/1/05	L34524-9		6	post-remediation, not appropriate for baseline group - exclude	30970
DuwDiagJan2005	DUD_9C	209157	1266784	1/31/05	L34524-11		7	post-remediation, not appropriate for baseline group - exclude	30951
DuwDiagJune2004	DUD_1A	209089	1267047	6/1/04	L32085-1		6	on top of dredged area cap, not appropriate for	30837

Table E.2-3, cont. LDW surface sediment samples collected since 1990 excluded from the RI baseline dataset

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion	Sample No.
								baseline group - exclude	
DuwDiagJune2004	DUD_1B	208484	1267060	6/1/04	L32085-7		6	on top of dredged area cap, not appropriate for baseline group - exclude	30842
DuwDiagJune2004	DUD_2A	208902	1267139	6/1/04	L32085-2		5	on top of dredged area cap, not appropriate for baseline group - exclude	30838
DuwDiagJune2004	DUD_2B	208621	1267079	6/1/04	L32085-8		5	on top of dredged area cap, not appropriate for baseline group - exclude	30843
DuwDiagJune2004	DUD_3B	208716	1267049	6/1/04	L32085-9		6	on top of dredged area cap, not appropriate for baseline group - exclude	30844
DuwDiagJune2004	DUD_4A	209354	1266888	6/1/04	L32085-4		10	on top of dredged area cap, not appropriate for baseline group - exclude	30839
DuwDiagJune2004	DUD_5A	209410	1266805	6/1/04	L32085-5		10	on top of dredged area cap, not appropriate for baseline group - exclude	30840
DuwDiagJune2004	DUD_5A	209410	1266805	6/1/04	L32085-6		10	on top of dredged area cap, not appropriate for baseline group - exclude	30841
DuwDiagMarch2005	DUD_14C	208000	1267196	3/16/05	L34971-16		10	on top of dredged area cap, not appropriate for baseline group - exclude	30971
DuwDiagMarch2005	DUD_15C	207970	1267059	3/16/05	L34971-17		10	on top of dredged area cap, not appropriate for baseline group - exclude	30972
DuwDiagMarch2005	DUD_3C	208144	1267146	3/16/05	L34971-3		10	on top of dredged area cap, not appropriate for baseline group - exclude	30973
DuwDiagMarch2005	DUD_4C	208239	1267116	3/16/05	L34971-4		9	on top of dredged area cap, not appropriate for baseline group - exclude	30974
DuwDiagMarch2005	DUD_4C	208239	1267116	3/16/05	L34971-5		9	on top of dredged area cap, not appropriate for baseline group - exclude	30975
DuwDiagMarch2005	DUD_5C	208263	1267025	3/24/05	L34971-6		10	on top of dredged area cap, not appropriate for baseline group - exclude	30976
DuwDiagMarch2005	DUD_6C	208501	1266950	3/24/05	L34971-7		10	on top of dredged area cap, not appropriate for baseline group - exclude	30977
DuwDiagMarch2005	DUD_7C	208486	1266902	3/24/05	L34971-8		10	on top of dredged area cap, not appropriate for baseline group - exclude	30978
DuwDiagonal-March2004	DUD_10C	209517	1266663	3/30/04	L31520-12		10	collected immediately post-dredging event - exclude	37980
DuwDiagonal-March2004	DUD_11C	209535	1266844	3/30/04	L31520-13		10	collected immediately post-dredging event - exclude	37981
DuwDiagonal-March2004	DUD_12C	209630	1266813	3/30/04	L31520-14		10	collected immediately post-dredging event - exclude	37982
DuwDiagonal-March2004	DUD_1C	208754	1267168	3/29/04	L31520-1		10	collected immediately post-dredging event - exclude	37990
DuwDiagonal-March2004	DUD_2C	208651	1267175	3/29/04	L31520-2		10	collected immediately post-dredging event - exclude	37983
DuwDiagonal-March2004	DUD_3C	208144	1267146	3/29/04	L31520-3		10	collected immediately post-dredging event - exclude	37984
DuwDiagonal-March2004	DUD_4C	208239	1267116	3/29/04	L31520-4		10	collected immediately post-dredging event - exclude	37985
DuwDiagonal-March2004	DUD_4C	208239	1267116	3/29/04	L31520-5	replicate	10	collected immediately post-dredging event -	37993

Table E.2-3, cont. LDW surface sediment samples collected since 1990 excluded from the RI baseline dataset

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion	Sample No.
								exclude	
DuwDiagonal-March2004	DUD_5C	208263	1267025	3/29/04	L31520-6		10	collected immediately post-dredging event - exclude	37986
DuwDiagonal-March2004	DUD_6C	208501	1266950	3/30/04	L31520-15	replicate	10	collected immediately post-dredging event - exclude	37992
DuwDiagonal-March2004	DUD_6C	208501	1266950	3/30/04	L31520-7		10	collected immediately post-dredging event - exclude	37987
DuwDiagonal-March2004	DUD_7C	208486	1266902	3/30/04	L31520-8		10	collected immediately post-dredging event - exclude	37988
DuwDiagonal-March2004	DUD_8C	208920	1266864	3/30/04	L31520-10	replicate	10	collected immediately post-dredging event - exclude	37994
DuwDiagonal-March2004	DUD_8C	208920	1266864	3/30/04	L31520-9		10	collected immediately post-dredging event - exclude	37989
DuwDiagonal-March2004	DUD_9C	209157	1266784	3/30/04	L31520-11		10	collected immediately post-dredging event - exclude	37991
Ecology-Norfolk	10	190201	1278537	7/9/02	288139		10	superseded by LDW-SS341- 9 ft away	18307
Ecology-Norfolk	17	190168	1278591	7/9/02	288146		10	superseded by LDW-SS343 - 1 ft away	18314
EPA SI	DR019	206530	1268204	8/17/98	SD-DR019-0000		10	superseded by LDW-SS32, less than 1ft away	784
EPA SI	DR020	206549	1268450	8/17/98	SD-DR020-0000		10	superseded by LDW-SS31, 1 ft away	785
EPA SI	DR021	206718	1267822	8/17/98	SD-DR021-0000		10	superseded by LDW-SS319 - 7 ft away	786
EPA SI	DR022	206228	1267936	8/17/98	SD-DR022-0000-CC		10	sample falls within 2004 Lehigh NW dredge, so exclude	789
EPA SI	DR028	204607	1268471	8/17/98	SD-DR028-0000		10	superseded by LDWB4b2 ft away - exclude	797
EPA SI	DR030	204436	1268521	8/17/98	SD-DR030-0000		10	superseded by LDW-SS50, 2ft away	798
EPA SI	DR031	211452	1265523	8/11/98	SD-DR031-0000		10	north of RM 0	799
EPA SI	DR035	210194	1266104	8/11/98	SD-DR035-0000		10	superseded by LDW-SS12, 2 ft away	803
EPA SI	DR053	204908	1267941	8/31/98	SD-DR053-0000-CC		10	superseded by LDW-SS44, 2ft away	823
EPA SI	DR065	204315	1268452	8/17/98	SD-DR065-0000		10	superseded by LDW-SS52, 1ft away	837
EPA SI	DR076	211210	1265996	8/24/98	SD-DR076-0000		10	superseded by LDW-SS5, 2 ft away	849
EPA SI	DR079	209860	1266467	8/24/98	SD-DR079-0000		10	superseded by LDW-SS15, 2 ft away	852
EPA SI	DR085	207054	1267392	8/31/98	SD-DR085-0000		10	superseded by LDW-SSB2b - 6 ft away	858
EPA SI	DR087	206171	1267735	8/12/98	SD-DR087-0000		10	superseded by LDW-SS37, 3 ft away	860
EPA SI	DR088	205507	1267960	8/31/98	SD-DR088-0000		10	superseded by LDW-SS40, 1ft away	861
EPA SI	DR093	203278	1268849	8/17/98	SD-DR093-0000		10	sample inside 1999 James Hardie dredge area, exclude	866
EPA SI	DR096	203090	1269369	9/2/98	SD-DR096-0000		10	sample inside 1999 Glacier ready mix dredge area, exclude	869
EPA SI	DR097	203284	1269528	8/20/98	SD-DR097-0000		10	superseded by LDW-SS63, 10 ft away	870
EPA SI	DR106	201545	1270217	8/19/98	SD-DR106-0000		10	superseded by LDW-SS76, 1ft away	881

Table E.2-3, cont. LDW surface sediment samples collected since 1990 excluded from the RI baseline dataset

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion	Sample No.
EPA SI	DR113	200851	1270429	8/19/98	SD-DR113-0000-CC		10	superseded by LDW-SS81, 1 ft away	892
EPA SI	DR123	203890	1267968	9/14/98	SD-DR123-0000		10	superseded by LDW-SS57, 7 ft away	902
EPA SI	DR125	204137	1268161	8/31/98	SD-DR125-0000		10	sample inside Glacier NW 2005 dredge area - exclude	904
EPA SI	DR131	201998	1268809	8/13/98	SD-DR131-0000-CC		10	superseded by LDW-SS70, 1 ft away	910
EPA SI	DR142	199659	1271055	8/20/98	SD-DR142-0000		10	sample inside 1998 Hurlen-Boyer Dredge area - exclude	923
EPA SI	DR143	199472	1271243	8/31/98	SD-DR143-0000		10	sample inside 1998 Hurlen-Boyer Dredge area - exclude	924
EPA SI	DR145	203146	1268825	8/17/98	SD-DR145-0000		10	inside 1999 James Hardie Dredge area - exclude	926
EPA SI	DR160	204365	1268236	8/12/98	SD-DR160-0000		10	superseded by LDW-SS51, 2 ft away	941
EPA SI	DR163	203131	1268774	8/27/98	SD-DR163-0000		10	inside 1999 James Hardie Dredge area - exclude	944
EPA SI	DR175	198641	1272581	8/20/98	SD-DR175-0000		10	superseded by LDW-SS94, 1 ft away	958
EPA SI	DR186	195288	1275958	8/27/98	SD-DR186-0000		10	superseded by LDW-SS111, 1 ft away	969
EPA SI	DR187	194730	1276134	8/27/98	SD-DR187-0000		10	superseded by LDW-SS115, 3 ft away	970
EPA SI	DR191	198744	1271964	8/13/98	SD-DR191-0000		10	sample falls within 1998 Hurlen-Boyer Dredge area - exclude	974
EPA SI	DR192	198507	1272251	8/13/98	SD-DR192-0000		10	sample falls within 1998 Hurlen-Boyer Dredge area - exclude	975
EPA SI	DR198	197314	1273506	8/20/98	SD-DR198-0000		10	superseded by LDW-SS102, 3 ft away	981
EPA SI	DR202	197040	1273815	8/27/98	SD-DR202-0000		10	superseded by LDW-SS104, 2 ft away	985
EPA SI	DR228	196122	1275015	9/1/98	SD-DR228-0000		10	sample inside 1999 USACE dredge - exclude	1017
EPA SI	DR229	195739	1275490	8/27/98	SD-DR229-0000		10	sample inside 1999 USACE dredge - exclude	1018
EPA SI	DR230	194778	1275907	8/25/98	SD-DR230-0000		10	sample inside 1999 USACE dredge - exclude	1019
EPA SI	DR234	196363	1274835	8/19/98	SD-DR234-0000		10	sample inside 1999 USACE dredge - exclude	1023
EPA SI	DR235	195030	1275851	8/26/98	SD-DR235-0000		10	sample inside 1999 USACE dredge - exclude	1024
EPA SI	DR238	193348	1276577	8/27/98	SD-DR238-0000		10	superseded by LDW-SS125, 1 ft away	1027
EPA SI	DR242	192929	1277477	8/24/98	SD-DR242-0000-CC		10	superseded by RhônePoulenc2004 loc. SB-1 - exclude	1031
EPA SI	DR255	190300	1278369	9/15/98	SD-DR255-0000		10	Inside 1999 Norfolk Dredge area - exclude	1046
EPA SI	DR256	190118	1278608	9/15/98	SD-DR256-0000		10	Inside 1999 Norfolk Dredge area - exclude	1047
EPA SI	DR260	193122	1276042	9/2/98	SD-DR260-0000		10	Inside Duwamish YC dredge, 1999 - exclude	1051
EPA SI	DR261	192860	1276181	8/25/98	SD-DR261-0000		10	Inside Duwamish YC dredge, 1999 - exclude	1052
EPA SI	DR271	189995	1277573	9/15/98	SD-DR271-0000		10	superseded by LDW-SS148, 2 ft away	1064
EPA SI	DR282	194054	1276089	8/25/98	SD-DR282-0000		10	sample inside 1999 USACE dredge - exclude	1075
EPA SI	DR283	193104	1276196	8/25/98	SD-DR283-0000		10	Inside Duwamish YC 1999 dredge - exclude	1076

Table E.2-3, cont. LDW surface sediment samples collected since 1990 excluded from the RI baseline dataset

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion	Sample No.
EPA SI	DR286	191854	1276508	8/26/98	SD-DR286-0000-CC		10	superseded by LDW-B10b, 3 ft away	1081
EPA SI	DR288	193668	1276259	8/25/98	SD-DR288-0000		10	sample inside 1999 USACE dredge - exclude	1083
Harbor Island RI	K-05	210286	1266258	9/27/91	K-05-1-D1		2	superseded by LDW-SS10, 1 ft away	714
Harbor Island RI	K-05	210286	1266258	9/27/91	K-05-1-D1	field duplicate	2	superseded by LDW-SS10, 1 ft away	13549
Harbor Island RI	K-05	210286	1266258	9/27/91	K-05-2-D1	field duplicate	2	superseded by LDW-SS10, 1 ft away	13553
Harbor Island RI	K-05	210286	1266258	9/27/91	K-05-3-D1	field duplicate	2	superseded by LDW-SS10, 1 ft away	13557
Harbor Island RI	K-05	210286	1266258	10/14/91	K-05-1		2	superseded by LDW-SS10, 1 ft away	13548
Harbor Island RI	K-05	210286	1266258	10/14/91	K-05-1-B		2	superseded by LDW-SS10, 1 ft away	713
Harbor Island RI	K-05	210286	1266258	10/14/91	K-05-1-D2		2	superseded by LDW-SS10, 1 ft away	715
Harbor Island RI	K-05	210286	1266258	10/14/91	K-05-1-D2	field duplicate	2	superseded by LDW-SS10, 1 ft away	13550
Harbor Island RI	K-05	210286	1266258	10/14/91	K-05-2		2	superseded by LDW-SS10, 1 ft away	13552
Harbor Island RI	K-05	210286	1266258	10/14/91	K-05-2-D2	field duplicate	2	superseded by LDW-SS10, 1 ft away	13554
Harbor Island RI	K-05	210286	1266258	10/14/91	K-05-3		2	superseded by LDW-SS10, 1 ft away	13556
Harbor Island RI	K-05	210286	1266258	10/14/91	K-05-3-D2	field duplicate	2	superseded by LDW-SS10, 1 ft away	13558
Harbor Island RI	K-07	211229	1266883	9/30/91	K-07		2	superseded by LDW-SS4,1 ft away	717
Harbor Island RI	K-08	211686	1267033	9/30/91	K-08		2	north of RM 0	718
Harbor Island RI	K-11	211372	1266032	9/30/91	K-11		2	superseded by LDW-SS1, less than 1 ft away	723
Harbor Island RI	K-12	211610	1265764	9/30/91	K-12		2	north of RM 0	724
Harbor Island RI	K-13	211863	1265485	9/30/91	K-13		2	north of RM 0	725
JorgensenAugust2004	SD-323-S	195348	1275946	8/17/04	SD-323-0000		10	superseded by LDW-SS10 - exclude	31033
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-1		10	Coordinates uncertain and do not meet project DQOs - exclude	4127
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-2		10	Coordinates uncertain and do not meet project DQOs - exclude	4128
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-3		10	Coordinates uncertain and do not meet project DQOs - exclude	4129
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-4		10	Coordinates uncertain and do not meet project DQOs - exclude	4130
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-5		10	Coordinates uncertain and do not meet project DQOs - exclude	4131
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-6		10	Coordinates uncertain and do not meet project DQOs - exclude	4132
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-7		10	Coordinates uncertain and do not meet project DQOs - exclude	4133

Table E.2-3, cont. LDW surface sediment samples collected since 1990 excluded from the RI baseline dataset

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion	Sample No.
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-8		10	Coordinates uncertain and do not meet project DQOs - exclude	4134
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-9		10	Coordinates uncertain and do not meet project DQOs - exclude	4135
KC WQA	West Marginal Way - Amphipods	207348	1266548	7/23/98	L13898-1		10	Coordinates uncertain and do not meet project DQOs - exclude	4137
KC WQA	West Marginal Way - Amphipods	207348	1266548	7/23/98	L13898-2		10	Coordinates uncertain and do not meet project DQOs - exclude	4138
KC WQA	West Marginal Way - Amphipods	207348	1266548	7/23/98	L13898-3		10	Coordinates uncertain and do not meet project DQOs - exclude	4139
LDWRI-SurfaceSedimentRound1	LDW-SS18	209531	1266844	2/1/05	LDW-SS18-010		10	Collected within 200 ft of Duwamish/Diagonal dredging - exclude because reflects post-remediation conditions in this area	29969
LDWRI-SurfaceSedimentRound1	LDW-SS20	209158	1266779	2/2/05	LDW-SS20-010		10	Collected within 200 ft of Duwamish/Diagonal dredging - exclude because reflects post-remediation conditions in this area	29970
LDWRI-SurfaceSedimentRound1	LDW-SS22	208754	1267170	1/17/05	LDW-SS22-010		10	Collected within 200 ft of Duwamish/Diagonal dredging - exclude because reflects post-remediation conditions in this area	29971
LDWRI-SurfaceSedimentRound2	LDW-SS21	209139	1266686	3/8/05	LDW-SS21-010		10	Collected within 200 ft of Duwamish/Diagonal dredging - exclude because reflects post-remediation conditions in this area	30171
LDWRI-SurfaceSedimentRound2	LDW-SS25	208202	1267285	3/10/05	LDW-SS25-010		10	Collected within 200 ft of Duwamish/Diagonal dredging - exclude because reflects post-remediation conditions in this area	30173
NOAA SiteChar	CH0005	194120	1276106	10/9/97	CH02-01		10	sample inside 1999 USACE dredge - exclude	29
NOAA SiteChar	CH0009	195697	1275667	10/15/97	CH03-01		10	sample inside 1999 USACE dredge - exclude	33
NOAA SiteChar	CH0010	195402	1275830	10/15/97	CH03-02		10	sample inside 1999 USACE dredge - exclude	34
NOAA SiteChar	CH0011	195146	1275866	10/15/97	CH03-03		10	sample inside 1999 USACE dredge - exclude	35
NOAA SiteChar	CH0012	194742	1275998	10/15/97	CH03-04		10	sample inside 1999 USACE dredge - exclude	36
NOAA SiteChar	CH0017	196259	1274916	11/13/97	CH04-04		10	sample inside 1999 USACE dredge - exclude	41
NOAA SiteChar	CH0023	201244	1269902	10/16/97	CH07-01		10	superseded by LDW-SS79, 2 ft away	47
NOAA SiteChar	EIT061	194079	1276332	9/29/97	EIT06-02		10	superseded by LDW-SS121, 4 ft away	85
NOAA SiteChar	EIT074	199309	1271869	11/3/97	EIT09-01		10	superseded by LDW-SS88, 7 ft away	98
NOAA SiteChar	EST135	192760	1276632	11/12/97	EST07-07		10	superseded by LDW-B8b, 3 ft away	159
NOAA SiteChar	EST144	193933	1276329	9/25/97	EST09-04		10	superseded by LDW-SS123, 1 ft away	168
NOAA SiteChar	EST152	195584	1275858	9/24/97	EST11-03		10	superseded by Jorgenson 2004 location SD-309-S - exclude	178
NOAA SiteChar	EST154	195474	1275881	9/24/97	EST11-04		10	superseded by Jorgenson 2004 location SD-334-S - exclude	180
NOAA SiteChar	EST180	198751	1272435	10/6/97	EST13-05		10	superseded by LDW-SS92, 2 ft away	204
NOAA SiteChar	EST202	205988	1267994	9/17/97	EST19-01		10	sample inside Lehigh NW 2004 dredge - exclude	226
NOAA SiteChar	EST219	207310	1267542	9/17/97	EST21-03		10	superseded by LDW-SS27, 5 ft away	243

Table E.2-3, cont. LDW surface sediment samples collected since 1990 excluded from the RI baseline dataset

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion	Sample No.
NOAA SiteChar	WIT280	200290	1270188	10/3/97	WIT11-01		10	superseded by LDW-B5a, 10 ft away	296
NOAA SiteChar	WST313	192989	1276092	10/20/97	WST06-01		10	sample inside 1999 Duwamish YC dredge - exclude	335
NOAA SiteChar	WST316	193828	1276100	10/1/97	WST07-02		10	sample inside 1999 USACE dredge - exclude	339
NOAA SiteChar	WST317	193461	1276205	10/15/97	WST07-03		10	sample inside 1999 USACE dredge - exclude	340
NOAA SiteChar	WST318	195552	1275619	10/2/97	WST08-01		10	sample inside 1999 USACE dredge - exclude	342
NOAA SiteChar	WST319	195294	1275737	10/2/97	WST08-02		10	sample inside 1999 USACE dredge - exclude	343
NOAA SiteChar	WST320	195074	1275811	10/2/97	WST08-03		10	sample inside 1999 USACE dredge - exclude	344
NOAA SiteChar	WST321	194891	1275832	10/2/97	WST08-04		10	sample inside 1999 USACE dredge - exclude	345
NOAA SiteChar	WST323	195779	1275215	10/21/97	WST09-02		10	superseded by T117-SE-10-G - exclude	347
NOAA SiteChar	WST341	198722	1272031	10/21/97	WST13-03		10	inside Hurlen-Boyer 1998 dredge - exclude	365
NOAA SiteChar	WST342	199913	1270839	10/23/97	WST14-01		10	superseded by EPA SI location DR141 - exclude	366
NOAA SiteChar	WST344	199541	1271195	10/10/97	WST14-02		10	inside Hurlen-Boyer 1998 dredge - exclude	368
NOAA SiteChar	WST367	206409	1266994	9/19/97	WST20-02		10	superseded by EPA SI location DR048 - exclude	391
Norfolk-cleanup1	NFK001	190277	1278459	8/18/94	L4321-1		10	inside 1999 Norfolk dredge area - exclude	1355
Norfolk-cleanup1	NFK002	190237	1278506	8/18/94	L4321-2		10	superseded by Ecology - Norfolk locations 2,3 and 4 - exclude	1364
Norfolk-cleanup1	NFK004	190165	1278594	8/18/94	L4321-4		10	inside 1999 Norfolk dredge area - exclude	1373
Norfolk-cleanup1	NFK007	190249	1278415	8/22/94	L4321-7		10	inside 1999 Norfolk dredge area - exclude	1376
Norfolk-cleanup1	NFK008	190203	1278497	8/17/94	L4321-8		10	inside 1999 Norfolk dredge area - exclude	1377
Norfolk-cleanup1	NFK009	190154	1278564	8/17/94	L4321-9		10	inside 1999 Norfolk dredge area - exclude	1378
Norfolk-cleanup1	NFK009	190154	1278564	8/31/94	L4321-25		15	inside 1999 Norfolk dredge area - exclude	1368
Norfolk-cleanup1	NFK012	190158	1278480	8/18/94	L4321-13		10	inside 1999 Norfolk dredge area - exclude	1358
Norfolk-cleanup1	NFK013	190089	1278542	8/19/94	L4321-14		10	inside 1999 Norfolk dredge area - exclude	1359
Norfolk-cleanup1	NFK014	190015	1278609	8/19/94	L4321-16	field duplicate	10	inside 1999 Norfolk dredge area - exclude	14478
Norfolk-cleanup2	NFK201	190294	1278424	8/23/95	L6725-1		10	inside 1999 Norfolk dredge area - exclude	1379
Norfolk-cleanup2	NFK202	190219	1278524	8/23/95	L6725-2		10	inside 1999 Norfolk dredge area - exclude	1388
Norfolk-cleanup2	NFK203	190129	1278619	8/23/95	L6725-3		10	inside 1999 Norfolk dredge area - exclude	1397
Norfolk-cleanup2	NFK205	190234	1278457	8/28/95	L6725-5		10	inside 1999 Norfolk dredge area - exclude	1402
Norfolk-cleanup3	NFK201	190294	1278424	12/5/95	L7462-16		10	inside 1999 Norfolk dredge area - exclude	1419
Norfolk-cleanup3	NFK312	190314	1278384	12/5/95	L7462-12		10	inside 1999 Norfolk dredge area - exclude	1415
Norfolk-cleanup3	NFK314	190257	1278407	12/6/95	L7462-14		10	inside 1999 Norfolk dredge area - exclude	1417
Norfolk-cleanup3	NFK315	190186	1278524	12/5/95	L7462-15		10	inside 1999 Norfolk dredge area - exclude	1418
Norfolk-monit1	NFK501	190150	1278591	4/23/99	L15421-1		10	superseded by April-01 sample from this location	1466
Norfolk-monit1	NFK504	190083	1278626	4/23/99	L15421-4		10	superseded by LDW-SS344 - 1 ft away	1463

Table E.2-3, cont. LDW surface sediment samples collected since 1990 excluded from the RI baseline dataset

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion	Sample No.
Norfolk-monit2a	NFK501	190160	1278569	10/8/99	L16628-1		2	only 0-2 cm depth, 10 cm depth preferred	1474
Norfolk-monit2a	NFK502	190164	1278512	10/8/99	L16628-3		2	only 0-2 cm depth, 10 cm depth preferred	1472
Norfolk-monit2a	NFK502	190164	1278512	10/8/99	L16628-4		10	superseded by LDW-SS342 - 8 ft away	1471
Norfolk-monit2a	NFK503	190181	1278543	10/8/99	L16628-5		2	only 0-2 cm depth, 10 cm depth preferred	1470
Norfolk-monit2a	NFK503	190181	1278543	10/8/99	L16628-6		10	superseded by April-02 sample from this location	1469
Norfolk-monit2a	NFK504	190086	1278619	10/8/99	L16628-7		2	only 0-2 cm depth, 10 cm depth preferred	1468
Norfolk-monit2b	NFK501	190166	1278593	2/8/00	L17315-1		2	superseded by LDW-SS343 - 3 ft away	1475
Norfolk-monit2b	NFK503	190197	1278548	2/8/00	L17315-3		2	superseded by LDW-SS341 - 2 ft away	1477
Norfolk-monit2b	NFK506	190257	1278543	2/10/00	L17311-1		10	superseded by Ecology - Norfolk locations 5 and 7 - exclude	12074
Norfolk-monit3	NFK501	190142	1278573	4/6/00	L17647-1		2	only 0-2 cm depth, 10 cm depth preferred	1485
Norfolk-monit3	NFK502	190165	1278511	4/6/00	L17647-3		2	only 0-2 cm depth, 10 cm depth preferred	1483
Norfolk-monit3	NFK502	190165	1278511	4/6/00	L17647-4		10	superseded by LDW-SS342 - 9 ft away	1482
Norfolk-monit3	NFK503	190179	1278543	4/6/00	L17647-5		2	only 0-2 cm depth, 10 cm depth preferred	1481
Norfolk-monit3	NFK503	190179	1278543	4/6/00	L17647-6		10	superseded by April-02 sample from this location	1480
Norfolk-monit3	NFK504	190076	1278628	4/6/00	L17647-7		2	only 0-2 cm depth, 10 cm depth preferred	1479
Norfolk-monit3	NFK504	190076	1278628	4/6/00	L17647-8		10	superseded by LDW-SS344 - 7 ft away	1478
Norfolk-monit4	NFK501	190153	1278583	4/24/01	L20703-1		2	only 0-2 cm depth, 10 cm depth preferred	8458
Norfolk-monit4	NFK502	190156	1278512	4/24/01	L20703-3		2	only 0-2 cm depth, 10 cm depth preferred	8460
Norfolk-monit4	NFK502	190156	1278512	4/24/01	L20703-4		10	superseded by LDW-SS342 - 4 ft away	8461
Norfolk-monit4	NFK503	190177	1278549	4/24/01	L20703-5		2	only 0-2 cm depth, 10 cm depth preferred	8462
Norfolk-monit4	NFK503	190177	1278549	4/24/01	L20703-6		10	superseded by April-02 sample from this location	8463
Norfolk-monit4	NFK504	190075	1278625	4/24/01	L20703-7		2	only 0-2 cm depth, 10 cm depth preferred	8464
Norfolk-monit4	NFK504	190075	1278625	4/24/01	L20703-8		10	superseded by LDW-SS344 - 7 ft away	8465
Norfolk-monit5	NFK501	190165	1278589	4/30/02	L23995-1		2	only 0-2 cm depth, 10 cm depth preferred	18461
Norfolk-monit5	NFK501	190165	1278589	4/30/02	L23995-2		10	superseded by LDW-SS343 - 4 ft away	18462
Norfolk-monit5	NFK502	190156	1278513	4/30/02	L23995-3		2	only 0-2 cm depth, 10 cm depth preferred	18463
Norfolk-monit5	NFK502	190156	1278513	4/30/02	L23995-4		10	superseded by LDW-SS342 - 3 ft away	18464
Norfolk-monit5	NFK503	190177	1278545	4/30/02	L23995-5		2	only 0-2 cm depth, 10 cm depth preferred	18465
Norfolk-monit5	NFK504	190074	1278622	4/30/02	L23995-7		2	only 0-2 cm depth, 10 cm depth preferred	18467
Norfolk-monit5	NFK504	190074	1278622	4/30/02	L23995-8		10	superseded by LDW-SS344 - 9 ft away	18468
Norfolk-monit6	NFK501	190167	1278586	4/23/03	L28052-1		2	only 0-2 cm depth, 10 cm depth preferred	18744
Norfolk-monit6	NFK501	190167	1278586	4/23/03	L28052-2		10	superseded by LDW-SS343 - 4 ft away	18745
Norfolk-monit6	NFK502	190156	1278511	4/23/03	L28052-3		2	only 0-2 cm depth, 10 cm depth preferred	18746
Norfolk-monit6	NFK502	190156	1278511	4/23/03	L28052-4		10	superseded by LDW-SS342 - 5 ft away	18747

Table E.2-3, cont. LDW surface sediment samples collected since 1990 excluded from the RI baseline dataset

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion	Sample No.
Norfolk-monit6	NFK503	190197	1278543	4/23/03	L28052-5		2	only 0-2 cm depth, 10 cm depth preferred	18748
Norfolk-monit6	NFK503	190197	1278543	4/23/03	L28052-6		10	superseded by LDW-SS341 - 4 ft away	18749
Norfolk-monit6	NFK504	190076	1278622	4/23/03	L28052-7		2	only 0-2 cm depth, 10 cm depth preferred	18750
Norfolk-monit6	NFK504	190076	1278622	4/23/03	L28052-8		10	superseded by LDW-SS344 - 7 ft away	18751
Norfolk-monit7	NFK501	190169	1278589	4/5/04	L31635-1		2	only 0-2 cm depth, 10 cm depth preferred	18752
Norfolk-monit7	NFK501	190169	1278589	4/5/04	L31635-2		10	superseded by LDW-SS343 - 1 ft away	18753
Norfolk-monit7	NFK502	190156	1278515	4/5/04	L31635-3		2	only 0-2 cm depth, 10 cm depth preferred	18754
Norfolk-monit7	NFK502	190156	1278515	4/5/04	L31635-4		10	superseded by LDW-SS342 - 2 ft away	18755
Norfolk-monit7	NFK503	190194	1278543	4/5/04	L31635-5		2	only 0-2 cm depth, 10 cm depth preferred	18756
Norfolk-monit7	NFK503	190194	1278543	4/5/04	L31635-6		10	superseded by LDW-SS341 - 2 ft away	18757
Norfolk-monit7	NFK504	190079	1278627	4/5/04	L31635-7		2	only 0-2 cm depth, 10 cm depth preferred	18758
Norfolk-monit7	NFK504	190079	1278627	4/5/04	L31635-8		10	superseded by LDW-SS344 - 3 ft away	18759
Plant 2 RFI-1	SD-SWY07	195628	1275855	6/13/95	SD-SWY07-0000		9	superseded by Plant2-Transformer Phase1 loc. SD-SWY17. Exclude	587
Plant 2 RFI-2b	SD-DUW83	195679	1275624	4/3/96	SD2B-DUW83-0000		9	sample inside 1999 USACE dredge - exclude	668
Plant 2 RFI-2b	SD-DUW90	195533	1275877	4/4/96	SD2B-DUW90-0000		9	superseded by Jorgenson August 2004 loc SD-343-S - exclude	675
Plant 2 RFI-2b	SD-DUW92	195387	1275932	4/2/96	SD2B-DUW92-0000		9	superseded by Jorgenson August 2004 loc SD-320-S - exclude	677
PSAMP/NOAA98	203	208455	1266636	6/22/98	203		2	not acceptable for all phase 2 uses - insufficient QA/QC available - exclude	1997
PSAMP/NOAA98	204	208272	1267209	6/22/98	204		2	not acceptable for all phase 2 uses - insufficient QA/QC available - exclude	1998
PSAMP/NOAA98	205	202467	1269112	6/23/98	205		2	not acceptable for all phase 2 uses - insufficient QA/QC available - exclude	1999
Rhône-Poulenc RFI-1	A11-01	192748	1276772	3/3/94	RPL-A11-01-01		15	not acceptable for all phase 2 uses - insufficient QA/QC available - exclude	1462
Rhône-Poulenc RFI-1	A11-02	192817	1276678	3/3/94	RPL-A11-02-01		15	not acceptable for all phase 2 uses - insufficient QA/QC available - exclude	1460
Rhône-Poulenc RFI-1	A11-03	192906	1276719	3/3/94	RPL-A11-03-01		15	not acceptable for all phase 2 uses - insufficient QA/QC available - exclude	1458
Rhône-Poulenc RFI-1	A11-03	192906	1276719	3/3/94	RPL-A11-08-01	duplicate	15	not acceptable for all phase 2 uses - insufficient QA/QC available - exclude	1449
Rhône-Poulenc RFI-1	A11-04	193038	1276583	3/3/94	RPL-A11-04-01		15	not acceptable for all phase 2 uses - insufficient QA/QC available - exclude	1447
Rhône-Poulenc RFI-1	A11-05	193145	1276637	3/3/94	RPL-A11-05-01		15	not acceptable for all phase 2 uses - insufficient QA/QC available - exclude	1455
Rhône-Poulenc RFI-1	A11-06	193383	1276536	3/3/94	RPL-A11-06-01		15	not acceptable for all phase 2 uses - insufficient QA/QC available - exclude	1453
Rhône-Poulenc RFI-1	A11-07	193521	1276514	3/3/94	RPL-A11-07-01		15	not acceptable for all phase 2 uses - insufficient QA/QC available - exclude	1451

Table E.2-3, cont. LDW surface sediment samples collected since 1990 excluded from the RI baseline dataset

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion	Sample No.
Rhône-Poulenc RFI-2	A11-05	193145	1276637	8/18/94	RPL-A11-05-02		2	superseded by LDW-SS126, 2 ft away	1454
Rhône-Poulenc RFI-2	A11-05	193145	1276637	8/18/94	RPL-A11-10-02	field duplicate	2	superseded by LDW-SS126, 2 ft away	1448
Rhône-Poulenc RFI-3	06-intsed-2	193293	1276681	7/1/96	06-intsed-2		10	superseded by RhônePoulenc2004 loc. SH-04 - exclude	18402
Rhône-Poulenc RFI-3	07-intsed-1	193466	1276645	7/1/96	07-intsed-1		10	superseded by RhônePoulenc2004 loc. SH-02 - exclude	18403

Note: Sampling location coordinates are Washington State Plane North, US survey ft, NAD83.

DQO – data quality objective
Ecology – Washington State Department of Ecology
EPA – US Environmental Protection Agency
ID – identification
KC – King County
LDW – Lower Duwamish Waterway
NOAA – National Oceanic and Atmospheric Administration
QA – quality assurance
QC – quality control
RI – remedial investigation
RFI – RCRA facility investigation
SI – site investigation
RCRA – Resource Conservation and Recovery Act
USACE – US Army Corps of Engineers
WQA – water quality assessment

E.3 Data Management Rules

E.3.1 Averaging Duplicate or Replicate Samples

Chemical concentrations obtained from the analysis of laboratory duplicates or replicates (two or more analyses on the same sample) were averaged for a closer representation of the "true" concentration as compared to the results of a single analysis. Averaging rules were dependent on whether the individual results were detected concentrations or reporting limits (RLs) for undetected analytes. If all concentrations were detects for a given parameter, the values were simply averaged arithmetically. If all concentrations were undetected for a given parameter, the minimum RL was reported. If the concentrations were a mixture of detected concentrations and RLs, any two or more detected concentrations were averaged arithmetically and RLs were ignored. If there was a single detected concentration and one or more RLs, the detected concentration was reported. The latter two rules were applied regardless of whether the RLs were higher or lower than the detected concentration.

Identical averaging rules were applied in situations where multiple sediment samples were collected from the same location at the same time, such as field duplicate samples, or when multiple sediment samples were collected at a single location (i.e., a location with specific x and y coordinates) within a 6-month period. In these instances, a single "average" result for each chemical was generated for that sediment sampling location.

E.3.2 Selection of Best Results

In some instances, the laboratory generates more than one result for a chemical for a given sample. Multiple results can occur for several reasons, including: 1) the original result did not meet the laboratory's internal quality control (QC) guidelines, and a reanalysis was performed; 2) the original result did not meet other project data quality objectives, such as a sufficiently low RL, and a reanalysis was performed; or 3) two different analytical methods were used for that chemical. In each case, a single best result was selected for use. The procedures for selecting the best result differed depending on whether a single or multiple analytical methods were used for that chemical.

For the same analytical method, if the results were:

- Detected and not qualified, then the result from the lowest dilution was selected, unless multiple results from the same dilution were available, in which case, the result with the highest concentration was selected.
- A combination of estimated and unqualified detected results, then the unqualified result was selected. This situation most commonly occurred when the original result was outside of the calibration range, thus requiring a dilution. The diluted result within the calibration range is preferentially selected.

- All estimated, then the "best result" was selected using best professional judgment in consideration of the rationale for qualification. For example, a result qualified based on laboratory replicate results outside of QC objectives for precision would be preferred to a qualified result that was outside the calibration range.
- A combination of detected and undetected results, then the detected result was selected. If there was more than one detected result, the applicable rules for multiple results (as discussed above) were followed.
- All undetected results, then the lowest RL was selected.

If the multiple results were from different analytical methods, then the result from the preferred method specified in the quality assurance project plan (QAPP) or based on the consensus of the professional opinions of project chemists was selected.

The following rules were applied to multiple results from the analyses of a single sample by different analytical methods:

- For detected concentrations analyzed by the semivolatile organic compound (SVOC) full-scan and selected ion monitoring (SIM) methods, the highest detected concentration was selected. If the result by one method was detected and the result by the other method was not detected, then the detected result was selected for reporting, regardless of the method. If results were reported as non-detected by both methods, the undetected result with the lowest RL was selected. The SIM method is more analytically sensitive than the full-scan SVOC method, and the undetected results were generally reported at a lower RL by the SIM method than by the full-scan method. Therefore, the SIM method was selected for non-detected results unless an analytical dilution or analytical interferences elevated the SIM RL above the SVOC full-scan RL.
- Hexachlorobenzene and hexachlorocyclopentadiene were analyzed by US Environmental Protection Agency (EPA) Methods 8081A, 8270, and 8270-SIM. The result from the method with the greatest sensitivity (i.e., lowest RL) was selected if all results were undetected. EPA Method 8081A results were generally selected, when available, because the standard laboratory RLs from this analysis are significantly lower than those from EPA Methods 8270 and 8270-SIM. When chemicals were detected, the detected result with the highest concentration was selected unless the detected concentration was qualified as estimated or tentatively identified, in which case the rule designating treatment of qualified and unqualified data would apply.
- A subset of the fish and crab tissue samples were analyzed for bis(2-ethylhexyl) phthalate using EPA Method 8270D and for pentachlorophenol using EPA Method 8041, with a silica gel cleanup, to achieve RLs lower than those achieved in the original analyses using EPA Method 8270-SIM. The re-analysis results for

these two analytes were selected for reporting because of the greater sensitivity of the re-analysis methods for these analytes.

E.3.3 SIGNIFICANT FIGURES AND ROUNDING

The analytical laboratories reported results with various numbers of significant figures depending on the instrument, parameter, and the concentration relative to the RL. The reported (or assessed) precision of each observation was explicitly stored in the project database as a record of the number of significant figures assigned by the laboratory. The tracking of significant figures became important when calculating averages and performing other data summaries.

When a calculation involved addition, such as totaling polychlorinated biphenyls (PCBs) or polycyclic aromatic hydrocarbons (PAHs), the calculation was only as precise as the least precise number that went into the calculation. For example (assuming two significant figures):

210 + 19 = 229, but this would be reported as 230 because 19 is only reported to 2 significant digits, and the enhanced precision of the trailing zero in the number 210 is not significant.

When a calculation involved multiplication or division, such as carbon normalization, the original figures for each value were carried through the calculation (i.e., individual values were not adjusted to a standard number of significant figures; instead, the appropriate adjustment was made to the resultant value at the end of the calculation). The result was rounded at the end of the calculation to reflect the value used in the calculation with the fewest significant figures. For example:

59.9 x 1.2 = 71.88 would be reported as 72 because there are two significant figures in the number 1.2.

When rounding, if the number following the last significant figure was less than 5, the digit was left unchanged. If the number following the last significant figure was equal to or greater than 5, the digit was increased by 1.

E.3.4 CALCULATING TOTALS

Total PCBs, total DDTs (dichlorodiphenyltrichloroethane), total PAHs, and total chlordane were calculated by summing the detected values for the individual components (i.e., Aroclor mixtures or individual congeners for total PCBs, DDT isomers for total DDTs, specific individual PAH compounds for total PAHs, and specific individual chlordane compounds for total chlordane). For individual samples in which none of the individual components was detected, the total value was given a value equal to the highest RL of an individual component, and assigned a U-qualifier, indicating no detected concentrations.

E.3.5 CALCULATION OF PCB CONGENER TOXIC EQUIVALENTS

PCB congener toxic equivalents (TEQs) were calculated using the World Health Organization (WHO) consensus toxic equivalency factor (TEF) values for fish, birds, and mammals (Van den Berg et al. 1998; Van den Berg et al. 2006) as presented in Table E.3-1. The TEQ was calculated as the sum of each PCB congener concentration multiplied by the corresponding TEF value. When the PCB congener concentration was reported as non-detected, then the TEF was multiplied by half the RL.

Table E.3-1. PCB congener TEF values

PCB CONGENER NUMBER	TEF VALUE FOR FISH (unitless)[a]	TEF VALUE FOR BIRDS (unitless)[a]	TEF VALUE FOR MAMMALS (unitless)[b]
77	0.0001	0.05	0.0001
81	0.0005	0.1	0.0003
105	<0.000005	0.0001	0.00003
114	<0.000005	0.0001	0.00003
118	<0.000005	0.00001	0.00003
123	<0.000005	0.00001	0.00003
126	0.005	0.1	0.1
156	<0.000005	0.0001	0.00003
157	<0.000005	0.0001	0.00003
167	<0.000005	0.00001	0.00003
169	0.00005	0.001	0.03
189	<0.000005	0.00001	0.00003

[a] From Van den Berg et al. (1998).

[b] From Van den Berg et al. (2006).

PCB – polychlorinated biphenyl

TEF – toxic equivalency factor

E.3.6 CALCULATION OF DIOXIN/FURAN CONGENER TEQS

Dioxin/furan congener TEQs were calculated using the WHO consensus TEF values for fish, birds, and mammals (Van den Berg et al. 1998; Van den Berg et al. 2006) as presented in Table E.3-2. The TEQ was calculated as the sum of each dioxin/furan congener concentration multiplied by the corresponding TEF value. When the dioxin/furan congener concentration was reported as undetected, then the TEF was multiplied by half the RL.

Table E.3-2. Dioxin/furan congener TEF values

Dioxin/Furan Congener	TEF Value for Fish (unitless)[a]	TEF Value for Birds (unitless)[a]	TEF Value for Mammals (unitless)[b]
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.01	0.01	0.01
1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin	0.001	<0.001	0.01
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.01	0.01	0.01
1,2,3,4,7,8-Hexachlorodibenzofuran	0.1	0.1	0.1
1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin	0.5	0.05	0.1
1,2,3,6,7,8-Hexachlorodibenzofuran	0.1	0.1	0.1
1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin	0.01	0.01	0.1
1,2,3,7,8,9-Hexachlorodibenzofuran	0.1	0.1	0.1
1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin	0.01	0.1	0.1
1,2,3,7,8-Pentachlorodibenzofuran	0.05	0.1	0.03
1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin	1	1	1
2,3,4,6,7,8-Hexachlorodibenzofuran	0.1	0.1	0.1
2,3,4,7,8-Pentachlorodibenzofuran	0.5	1	0.3
2,3,7,8-Tetrachlorodibenzofuran	0.05	1	0.1
2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	1	1	1
Octachlorodibenzofuran	<0.0001	0.0001	0.0003
Octachlorodibenzo-*p*-dioxin	<0.0001	0.0001	0.0003

[a] From Van den Berg et al. (1998).

[b] From Van den Berg et al. (2006).

TEF – toxic equivalency factor

E.3.7 Calculation of Carcinogenic Polycyclic Aromatic Hydrocarbons

Carcinogenic polycyclic aromatic hydrocarbons (cPAH) values were calculated using potency equivalency factor (PEF) values (California EPA 1994) based on the individual PAH component's relative toxicity to benzo(a)pyrene. PEF values are presented in Table E.3-3. The cPAH was calculated as the sum of each individual PAH concentration multiplied by the corresponding PEF value. When the individual PAH component concentration was reported as non-detected, then the PEF was multiplied by half the RL.

Table E.3-3. cPAH PEF values

cPAH	PEF VALUE (unitless)[a]
Benzo(a)pyrene	1
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.1
Chrysene	0.01
Dibenz(a,h)anthracene	0.4
Indeno(1,2,3-cd)pyrene	0.1

[a] PEFs for cPAHs were defined by the California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (California EPA 1994). PEFs are available for PAHs that were not analyzed in LDW sediments. The PEFs for these compounds are not shown here and were not used in the RI. The PEF was determined by California EPA by dividing the inhalation unit risk factor for this compound by the inhalation unit risk factor for benzo[a]pyrene.

cPAH – carcinogenic polycyclic aromatic hydrocarbon
PEF – potency equivalency factor

E.3.8 REFERENCES

California EPA. 1994. Health effects of benzo(a)pyrene. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Berkeley, CA.

Van den Berg M, Birnbaum LS, Denison M, De Vito M, Farland W, Feeley M, Fiedler H, Hakansson H, Hanberg A, Haws L, Rose M, Safe S, Schrenk D, Tohyama C, Tritscher A, Tuomisto J, Tysklind M, Walker N, Peterson RE. 2006. The 2005 World Health Organization reevaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds. Tox Sci 93(2):223-241.

E.4 Total PCB Data for Fish and Crab Tissue Composite Samples

Tables E.4-1 and E.4-2 present total PCB concentrations (Aroclor sum), lipid percents, and lipid-normalized PCB concentrations (Aroclor sum) for fish and crab tissue samples collected in 2004 and 2005, respectively. Tables E.4-3 through E.4-5 present total PCB concentrations (PCB congener sum), lipid percents, and lipid-normalized PCB concentrations (PCB congener sum) for each composite fish and crab tissue sample collected in 2004, 2005, and 2007, respectively. The data are shown in Figures E.4-1 through E.4-12.

Table E.4-1. Concentrations of PCBs (Aroclor sum) and lipids in LDW fish and crab tissue samples collected in 2004

Tissue Type	Area	Sample ID	Total PCBs (µg/kg ww)	Lipid (%)	Lipid-Normalized PCBs (mg/kg lipid)[a]
English sole – whole body	T1	LDW-T1-M-ES-WB-comp-1	2,700	4.3	63
		LDW-T1-M-ES-WB-comp-2	3,000	5.0	60
		LDW-T1-M-ES-WB-comp-3	4,200	6.8	62
		LDW-T1-M-ES-WB-comp-4	4,200	5.7	74
		LDW-T1-M-ES-WB-comp-5	3,100	5.3	58
		LDW-T1-M-ES-WB-comp-6	4,700	6.3	75
	T2	LDW-T2-M-ES-WB-comp-1	4,200	8.7	48
		LDW-T2-M-ES-WB-comp-2	3,900	6.6	59
		LDW-T2-M-ES-WB-comp-3	4,200 J	7.6	55 J
		LDW-T2-M-ES-WB-comp-4	3,600	6.2	58
		LDW-T2-M-ES-WB-comp-5	3,900	7.6	51
		LDW-T2-M-ES-WB-comp-6	3,300	5.7	58
	T3	LDW-T3-M-ES-WB-comp-1	3,500	6.6	53
		LDW-T3-M-ES-WB-comp-2	1,870	4.7	40
		LDW-T3-M-ES-WB-comp-3	4,300	5.5	78
		LDW-T3-M-ES-WB-comp-4	1,720	3.5	49
		LDW-T3-M-ES-WB-comp-5	1,320	2.6	51
		LDW-T3-M-ES-WB-comp-6	2,700	6.2	44
	T4	LDW-T4-M-ES-WB-comp-1	1,800	5.9	31
		LDW-T4-M-ES-WB-comp-2	1,660	6.2	27
		LDW-T4-M-ES-WB-comp-3	1,640	4.8	34
Starry flounder – whole body	T4	LDW-T4-M-SF-WB-comp-1	660	2.1	31
		LDW-T4-M-SF-WB-comp-2	450	2.1	21
		LDW-T4-M-SF-WB-comp-3	600	2.5	24

Tissue Type	Area	Sample ID	Total PCBs (µg/kg ww)	Lipid (%)	Lipid-Normalized PCBs (mg/kg lipid)[a]
English sole – fillet	T1	LDW-T1-M-ES-FL-comp-1	1,600	3.1	52
		LDW-T1-M-ES-FL-comp-2	1,330	2.6	51
	T2	LDW-T2-M-ES-FL-comp-1	2,010	3.4	59
		LDW-T2-M-ES-FL-comp-2	1,840	4.3	43
	T3	LDW-T3-M-ES-FL-comp-1	850	1.6	53
		LDW-T3-M-ES-FL-comp-2	1,640	3.6	46
	T4	LDW-T4-M-ES-FL-comp-1	710	1.7	42
Starry flounder – fillet	T4	LDW-T4-M-SF-FL-comp-1	450	2.6	17
Pacific staghorn sculpin – whole body	T1	LDW-T1-A-PS-WB-comp-1	580	2.1	28
		LDW-T1-B-PS-WB-comp-1	620 J	2.3	27 J
		LDW-T1-C-PS-WB-comp-1	750 J	1.8	42 J
		LDW-T1-D-PS-WB-comp-1	750	2.4	31
		LDW-T1-E-PS-WB-comp-1	790	2.4	33
		LDW-T1-F-PS-WB-comp-1	860	2.4	36
	T2	LDW-T2-A-PS-WB-comp-1	620	2.2	28
		LDW-T2-B-PS-WB-comp-1	710	2.4	30
		LDW-T2-C-PS-WB-comp-1	660 J	2.7	24 J
		LDW-T2-D-PS-WB-comp-1	660	2.3	29
		LDW-T2-E-PS-WB-comp-1	1,260	2.3	55
		LDW-T2-F-PS-WB-comp-1	720	1.8	40
	T3	LDW-T3-A-PS-WB-comp-1	830	2.1	40
		LDW-T3-B-PS-WB-comp-1	1,220	1.9	64
		LDW-T3-C-PS-WB-comp-1	810	1.8	45
		LDW-T3-D-PS-WB-comp-1	2,800	1.8	160
		LDW-T3-E-PS-WB-comp-1	1,180	2.0	59
		LDW-T3-F-PS-WB-comp-1	2,300	1.9	120
	T4	LDW-T4-A-PS-WB-comp-1	660	2.4	28
		LDW-T4-B-PS-WB-comp-1	780	2.2	35
		LDW-T4-C-PS-WB-comp-1	510	1.3	39
		LDW-T4-D-PS-WB-comp-1	1,330	2.5	53
		LDW-T4-D-PS-WB-comp-2	710	2.2	32
		LDW-T4-E-PS-WB-comp-1	670	1.8	37

Tissue Type	Area	Sample ID	Total PCBs (µg/kg ww)	Lipid (%)	Lipid-Normalized PCBs (mg/kg lipid)[a]
Shiner surfperch – whole body	T1	LDW-T1-A-SS-WB-comp-1	970	5.0	19
		LDW-T1-B-SS-WB-comp-1	1,120 J	2.7	41 J
		LDW-T1-C-SS-WB-comp-1	1,670	4.1	41
		LDW-T1-D-SS-WB-comp-1	1,830	3.3	55
		LDW-T1-E-SS-WB-comp-1	1,270	2.3	55
		LDW-T1-F-SS-WB-comp-1	1,460	2.8	52
	T2	LDW-T2-A-SS-WB-comp-1	1,590	4.4	36
		LDW-T2-B-SS-WB-comp-1	1,570	2.5	63
		LDW-T2-C-SS-WB-comp-1	1,260	2.6	48
		LDW-T2-D-SS-WB-comp-1	1,450	3.8	38
		LDW-T2-E-SS-WB-comp-1	18,400 J	5.6	330 J
		LDW-T2-F-SS-WB-comp-1	1,620	4.9	33
	T3	LDW-T3-A-SS-WB-comp-1	1,280	3.7	35
		LDW-T3-B-SS-WB-comp-1	2,600	5.6	46
		LDW-T3-C-SS-WB-comp-1	1,410	3.4	41
		LDW-T3-D-SS-WB-comp-1	4,000	3.8	110
		LDW-T3-E-SS-WB-comp-1	8,800	3.1	280
		LDW-T3-F-SS-WB-comp-1	4,900	4.6	110
	T4	LDW-T4-A-SS-WB-comp-1	640	3.0	21
		LDW-T4-B-SS-WB-comp-1	960	3.3	29
		LDW-T4-B-SS-WB-comp-2	880	5.6	16
		LDW-T4-C-SS-WB-comp-1	920	5.3	17
		LDW-T4-C-SS-WB-comp-2	660	3.2	21
		LDW-T4-D-SS-WB-comp-1	710	4.3	17
Pile perch – fillet	All areas	LDW-M-M-PP-FL-comp-1	300	1.1	27
Striped perch – fillet	T3 and T4	LDW-M-M-SP-FL-comp-1	630	1.4	45
Dungeness crab – edible meat	T1	LDW-T1-M-DC-EM-comp-1	207 J	0.34	61 J
		LDW-T1-M-DC-EM-comp-2	206 J	0.39	53 J
		LDW-T1-M-DC-EM-comp-3	290	0.28	100
	T3	LDW-T3-M-DC-EM-comp-1	226	0.23	98
		LDW-T3-M-DC-EM-comp-2	300	0.40	75
		LDW-T3-M-DC-EM-comp-3	212	0.47	45
	T4	LDW-T4-M-DC-EM-comp-1	240 J	0.72	33 J
Dungeness crab – hepatopancreas	T1	LDW-T1-M-DC-HP-comp-1	4,000	4.6	87
	T3	LDW-T3-M-DC-HP-comp-1	4,500	6.3	71
	T4	LDW-T4-M-DC-HP-comp-1	5,500	7.9	70

Tissue Type	Area	Sample ID	Total PCBs (µg/kg ww)	Lipid (%)	Lipid-Normalized PCBs (mg/kg lipid)[a]
Dungeness crab – whole body (calculated)[b]	T1	LDW-T1-M-DC-WB-comp-1 Calculated	1,400 JM	1.7 M	82 JM
		LDW-T1-M-DC-WB-comp-2 Calculated	1,400 JM	1.7 M	82 JM
		LDW-T1-M-DC-WB-comp-3 Calculated	1,400 M	1.6 M	88 M
	T3	LDW-T3-M-DC-WB-comp-1 Calculated	1,600 M	2.1 M	76 M
		LDW-T3-M-DC-WB-comp-2 Calculated	1,600 M	2.2 M	73 M
		LDW-T3-M-DC-WB-comp-3 Calculated	1,500 M	2.3 M	65 M
	T4	LDW-T4-M-DC-WB-comp-1 Calculated	1,900 JM	2.9 M	66 JM
Slender crab – edible meat	T1	LDW-T1-M-SC-EM-comp-1	390 J	0.74	53 J
		LDW-T1-M-SC-EM-comp-2	220	0.54	41
		LDW-T1-M-SC-EM-comp-3	210 J	0.43	49 J
	T2	LDW-T2-M-SC-EM-comp-1	180	0.23	78
		LDW-T2-M-SC-EM-comp-2	210 J	0.41	51 J
		LDW-T2-M-SC-EM-comp-3	260 J	0.43	60 J
		LDW-T2-M-SC-EM-comp-4	108	0.47	23
		LDW-T2-M-SC-EM-comp-5	230 J	0.34	68 J
		LDW-T2-M-SC-EM-comp-6	180 J	0.26	69 J
	T3	LDW-T3-M-SC-EM-comp-1	146	0.52	28
		LDW-T3-M-SC-EM-comp-2	168	0.51	33
		LDW-T3-M-SC-EM-comp-3	220	0.45	49
Slender crab – hepatopancreas	T1	LDW-T1-M-SC-HP-comp-1	1,490 J	1.9	78 J
	T2	LDW-T2-M-SC-HP-comp-1	1,950 J	2.7	72 J
		LDW-T2-M-SC-HP-comp-2	2,190 J	3.6	61 J
	T3	LDW-T3-M-SC-HP-comp-1	1,640	2.2	75
Slender crab – whole body (calculated)[b]	T1	LDW-T1-M-SC-WB-comp-1 Calculated	731 JM	1.1 M	66 JM
		LDW-T1-M-SC-WB-comp-2 Calculated	614 JM	0.96 M	64 JM
		LDW-T1-M-SC-WB-comp-3 Calculated	607 JM	0.89 M	68 JM
	T2	LDW-T2-M-SC-WB-comp-1 Calculated	729 JM	1.0 M	73 JM
		LDW-T2-M-SC-WB-comp-2 Calculated	749 JM	1.1 M	68 JM
		LDW-T2-M-SC-WB-comp-3 Calculated	784 JM	1.1 M	71 JM
		LDW-T2-M-SC-WB-comp-4 Calculated	753 JM	1.4 M	54 JM
		LDW-T2-M-SC-WB-comp-5 Calculated	838 JM	1.4 M	60 JM
		LDW-T2-M-SC-WB-comp-6 Calculated	803 JM	1.3 M	62 JM
	T3	LDW-T3-M-SC-WB-comp-1 Calculated	609 M	1.0 M	61 M
		LDW-T3-M-SC-WB-comp-2 Calculated	624 M	1.0 M	62 M
		LDW-T3-M-SC-WB-comp-3 Calculated	660 M	0.99 M	67 M

[a] Lipid-normalized concentrations (in units of mg PCBs/kg lipid) represent the wet-weight total PCB concentration (in units of mg/kg ww) divided by the decimal fraction corresponding to the percent lipid (e.g., 2.0% lipid = 0.02).

[b] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of whole body crab (i.e., edible meat plus hepatopancreas). Concentrations in whole-body crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

J – estimated concentration

JM – calculated concentration from an estimated concentration

LDW – Lower Duwamish Waterway

M – calculated concentration

PCB – polychlorinated biphenyl

ww – wet weight

Table E.4-2. Concentrations of total PCBs (Aroclor sum) and lipids in LDW fish and crab tissue samples collected in 2005

Tissue Type	Area	Sample ID	Total PCBs (µg/kg ww)	Lipid (%)	Lipid-Normalized PCBs (mg/kg lipid)[a]
English sole – fillet (skin on)	T1	LDW-05-T1-M-ES-FL-Comp1	1,150	2.95	39
		LDW-05-T1-M-ES-FL-Comp2	1,450	5.09	28
		LDW-05-T1-M-ES-FL-Comp3	920	3.03	30
	T2	LDW-05-T2-M-ES-FL-Comp1	890	3.91	23
		LDW-05-T2-M-ES-FL-Comp2	1,400	4.62	30
		LDW-05-T2-M-ES-FL-Comp3	850	3.42	25
	T3	LDW-05-T3-M-ES-FL-Comp1	860	4.12	21
		LDW-05-T3-M-ES-FL-Comp2	450	2.04	22
		LDW-05-T3-M-ES-FL-Comp3	720	3.26	22
	T4	LDW-05-T4-M-ES-FL-Comp1	530	2.82	19
English sole – remainder	T1	LDW-05-T1-M-ES-RM-Comp1	2,100	7.81	27
		LDW-05-T1-M-ES-RM-Comp2	1,900	6.93	27
		LDW-05-T1-M-ES-RM-Comp3	1,540	5.51	28
	T2	LDW-05-T2-M-ES-RM-Comp1	2,100	7.03	30
		LDW-05-T2-M-ES-RM-Comp2	1,900	5.50	35
		LDW-05-T2-M-ES-RM-Comp3	2,000	6.84	29
	T3	LDW-05-T3-M-ES-RM-Comp1	2,700	10.4	26
		LDW-05-T3-M-ES-RM-Comp2	730	3.92	19
		LDW-05-T3-M-ES-RM-Comp3	1,140	6.67	17
	T4	LDW-05-T4-M-ES-RM-Comp1	1,130	8.24	14
English sole – whole body	T1	LDW-05-T1-M-ES-WB-Comp1	1,120	4.01	28
		LDW-05-T1-M-ES-WB-Comp2	2,200	4.42	50
		LDW-05-T1-M-ES-WB-Comp3	1,630	3.13	52
	T2	LDW-05-T2-M-ES-WB-Comp1	2,200	4.89	45
		LDW-05-T2-M-ES-WB-Comp2	2,200	6.83	32
		LDW-05-T2-M-ES-WB-Comp3	2,400	6.23	39
	T3	LDW-05-T3-M-ES-WB-Comp1	2,200	6.15	36
		LDW-05-T3-M-ES-WB-Comp2	880	4.77	18
		LDW-05-T3-M-ES-WB-Comp3	1,630	4.43	37
	T4	LDW-05-T4-M-ES-WB-Comp1	1,180	5.62	21
		LDW-05-T4-M-ES-WB-Comp2	940	3.85	24

Tissue Type	Area	Sample ID	Total PCBs (µg/kg ww)	Lipid (%)	Lipid-Normalized PCBs (mg/kg lipid)[a]
English sole – whole body (calculated)[b]	T1	LDW-05-T1-M-ES-WB-Comp1 Calculated	1,770 M	6.14 M	29 M
		LDW-05-T1-M-ES-WB-Comp2 Calculated	1,700 M	6.12 M	28 M
		LDW-05-T1-M-ES-WB-Comp3 Calculated	1,310 M	4.60 M	28 M
	T2	LDW-05-T2-M-ES-WB-Comp1 Calculated	1,620 M	5.79 M	28 M
		LDW-05-T2-M-ES-WB-Comp2 Calculated	1,700 M	5.10 M	33 M
		LDW-05-T2-M-ES-WB-Comp3 Calculated	1,590 M	5.62 M	28 M
	T3	LDW-05-T3-M-ES-WB-Comp1 Calculated	1,860 M	7.53 M	25 M
		LDW-05-T3-M-ES-WB-Comp2 Calculated	610 M	3.09 M	20 M
		LDW-05-T3-M-ES-WB-Comp3 Calculated	950 M	5.14 M	18 M
	T4	LDW-05-T4-M-ES-WB-Comp1 Calculated	910 M	6.25 M	15 M
Pacific staghorn sculpin – whole body	T1	LDW-05-T1-C-PS-WB-Comp1	720 J	2.17	33 J
	T2	LDW-05-T2-E-PS-WB-Comp1	620	1.92	32
	T3	LDW-05-T3-F-PS-WB-Comp1	590	1.34	44
	T4	LDW-05-T4-C-PS-WB-Comp1	430	1.18	36
Shiner surfperch – whole body	T1	LDW-05-T1-A-SS-WB-Comp1	720	5.75	13
		LDW-05-T1-B-SS-WB-Comp1	660	6.01	11
		LDW-05-T1-C-SS-WB-Comp1	880	5.08	17
		LDW-05-T1-D-SS-WB-Comp1	530 J	6.15	8.6 J
		LDW-05-T1-E-SS-WB-Comp1	960 J	6.16	16 J
		LDW-05-T1-F-SS-WB-Comp1	930	4.31	22
	T2	LDW-05-T2-A-SS-WB-Comp1	770	5.70	14
		LDW-05-T2-B-SS-WB-Comp1	1,300	5.79	22
		LDW-05-T2-C-SS-WB-Comp1	2,000	4.74	42
		LDW-05-T2-D-SS-WB-Comp1	1,160	5.10	23
		LDW-05-T2-E-SS-WB-Comp1	1,900	5.99	32
		LDW-05-T2-F-SS-WB-Comp1	660	5.26	13
	T3	LDW-05-T3-A-SS-WB-Comp1	1,500	4.98	30
		LDW-05-T3-B-SS-WB-Comp1	700	5.26	13
		LDW-05-T3-C-SS-WB-Comp1	1,250	5.59	22
		LDW-05-T3-D-SS-WB-Comp1	2,400	6.92	35
		LDW-05-T3-E-SS-WB-Comp1	820	5.21	16
		LDW-05-T3-F-SS-WB-Comp1	2,100	6.70	31
	T4	LDW-05-T4-A-SS-WB-Comp1	600	6.16	9.7
		LDW-05-T4-B-SS-WB-Comp1	580	6.93	8.4
		LDW-05-T4-C-SS-WB-Comp1	600	6.16	9.7
		LDW-05-T4-D-SS-WB-Comp1	540	6.26	8.6

Tissue Type	Area	Sample ID	Total PCBs (µg/kg ww)	Lipid (%)	Lipid-Normalized PCBs (mg/kg lipid)[a]
Dungeness crab – edible meat	T1	LDW-05-T1-M-DC-EM-Comp1	20 U	0.191 J	10 U
	T3	LDW-05-T3-M-DC-EM-Comp1	20 U	0.146 J	14 U
	T4	LDW-05-T4-M-DC-EM-Comp1	20 U	0.232 J	8.6 U
Dungeness crab – hepatopancreas	T1	LDW-05-T1-M-DC-HP-Comp1	1,420	8.14 J	17 J
	T3	LDW-05-T3-M-DC-HP-Comp1	1,310	4.28 J	31 J
	T4	LDW-05-T4-M-DC-HP-Comp1	1,320	5.52 J	24 J
Dungeness crab – whole body (calculated)[c]	T1	LDW-05-T1-M-DC-WB-Comp1 Calculated	454 M	2.66 JM	17 JM
	T3	LDW-05-T3-M-DC-WB-Comp1 Calculated	420 M	1.43 JM	29 JM
	T4	LDW-05-T4-M-DC-WB-Comp1 Calculated	423 M	1.87 JM	23 JM
Slender crab – edible meat	T2	LDW-05-T2-M-SC-EM-Comp1	64	0.315 J	20 J
Slender crab – hepatopancreas	T2	LDW-05-T2-M-SC-HP-Comp1	660	2.47 J	27 J
Slender crab – whole body (calculated)[c]	T2	LDW-05-T2-M-SC-WB-Comp1 Calculated	250 M	0.983 JM	25 JM

[a] Lipid-normalized concentrations (in units of mg PCBs/kg lipid) represent the wet-weight total PCB concentration (in units of mg/kg ww) divided by the decimal fraction corresponding to the percent lipid (e.g., 2.0% lipid = 0.02).

[b] Concentrations in "whole body" samples were estimated using results from separate analyses of fillet and remainder composite samples (i.e., all remaining tissue and fluids after fillets were removed from the specimens). The estimated English sole "whole-body" concentrations were based on the relative weights and total PCB concentrations in skin-on fillet and remainder tissues.

[c] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of whole body crab (i.e., edible meat plus hepatopancreas). Concentrations in whole-body crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

J – estimated concentration

JM – calculated concentration from an estimated concentration

LDW – Lower Duwamish Waterway

M – calculated concentration

PCB – polychlorinated biphenyl

U – not detected at the reporting limit shown

ww – wet weight

Table E.4-3. Concentrations of total PCBs (Aroclor sum) and lipids in LDW fish and crab tissue samples collected in 2007

Tissue Type	Area	Sample ID	Total PCBs (µg/kg ww)	Lipids (% ww)	Lipid-Normalized Total PCBs (mg/kg lipid)[a]
English sole – whole body	T1	LDW-07-T1-M-ES-WB-comp1	410	4.62	8.9
		LDW-07-T1-M-ES-WB-comp2	780	7.20	11
		LDW-07-T1-M-ES-WB-comp3	460	6.85	6.7
		LDW-07-T1-M-ES-WB-comp4	720	6.50	11
		LDW-07-T1-M-ES-WB-comp5	420	3.83	11
		LDW-07-T1-M-ES-WB-comp6	360	7.22	5.0
	T2	LDW-07-T2-A-ES-WB-comp1	550	5.46	10
		LDW-07-T2-A-ES-WB-comp2	870 J	9.00	9.7 J
		LDW-07-T2-A-ES-WB-comp3	630	5.82	11
		LDW-07-T2-A-ES-WB-comp4	750	8.07	9.3
		LDW-07-T2-A-ES-WB-comp5	380	4.46	8.5
		LDW-07-T2-A-ES-WB-comp6	980	5.82	17
	T3	LDW-07-T3-M-ES-WB-comp1	910 J	4.43	21 J
		LDW-07-T3-M-ES-WB-comp2	660 J	2.34	28 J
		LDW-07-T3-M-ES-WB-comp3	760 J	6.64	11 J
		LDW-07-T3-M-ES-WB-comp4	1,600 J	10.9	15 J
		LDW-07-T3-M-ES-WB-comp5	830 J	9.90	8.4 J
		LDW-07-T3-M-ES-WB-comp6	600	4.40	14
	T4	LDW-07-T4-M-ES-WB-comp1	300	4.62	6.5
Shiner perch – whole body	T1	LDW-07-T1-A-SS-WB-comp1	200 J	2.57	7.8 J
		LDW-07-T1-B-SS-WB-comp1	220 J	2.20	10 J
		LDW-07-T1-C-SS-WB-comp1	360 J	4.94	7.3 J
		LDW-07-T1-D-SS-WB-comp1	250	1.80	14
		LDW-07-T1-E-SS-WB-comp1	270 J	3.99	6.8 J
		LDW-07-T1-F-SS-WB-comp1	310 J	3.30	9.4 J
	T2	LDW-07-T2-A-SS-WB-comp1	320 J	2.90	11 J
		LDW-07-T2-B-SS-WB-comp1	290 J	4.40	6.6 J
		LDW-07-T2-C-SS-WB-comp1	400 J	3.32	12 J
		LDW-07-T2-D-SS-WB-comp1	400 J	4.86	8.2 J
		LDW-07-T2-E-SS-WB-comp1	470 J	4.46	11 J
		LDW-07-T2-F-SS-WB-comp1	610 J	4.31	14 J

Tissue Type	Area	Sample ID	Total PCBs (µg/kg ww)	Lipids (% ww)	Lipid-Normalized Total PCBs (mg/kg lipid)[a]
Shiner perch – whole body (cont.	T3	LDW-07-T3-A-SS-WB-comp1	430 J	3.70	12 J
		LDW-07-T3-B-SS-WB-comp1	780 J	4.41	18 J
		LDW-07-T3-C-SS-WB-comp1	520 J	4.54	11 J
		LDW-07-T3-D-SS-WB-comp1	780 J	3.79	21 J
		LDW-07-T3-E-SS-WB-comp1	740 J	3.43	22 J
		LDW-07-T3-F-SS-WB-comp1	1,330 J	4.94	27 J
	T4	LDW-07-T4-A-SS-WB-comp1	260 J	4.78	5.4 J
		LDW-07-T4-B-SS-WB-comp1	300 J	3.62	8.3 J
		LDW-07-T4-C-SS-WB-comp1	290 J	4.16	7.0 J
		LDW-07-T4-D-SS-WB-comp1	410 J	4.77	8.6 J
Starry flounder – whole body	T4	LDW-07-T4-M-SF-WB-comp1	240	3.29	7.3
		LDW-07-T4-M-SF-WB-comp2	170	0.917	19
		LDW-07-T4-M-SF-WB-comp3	156	1.64	9.5
English sole – fillet with skin	T1	LDW-07-T1-M-ES-FL-comp1	270	3.00	9.0
		LDW-07-T1-M-ES-FL-comp2	500	4.11	12
		LDW-07-T1-M-ES-FL-comp3	260	2.85	9.1
	T2	LDW-07-T2-A-ES-FL-comp1	350	3.14	11
		LDW-07-T2-A-ES-FL-comp2	170	2.14	7.9
		LDW-07-T2-A-ES-FL-comp3	360	3.63	9.9
	T3	LDW-07-T3-M-ES-FL-comp1	490	3.26	15
		LDW-07-T3-M-ES-FL-comp2	380	2.96	13
		LDW-07-T3-M-ES-FL-comp3	340	1.77	19
Starry flounder – fillet with skin	T4	LDW-07-T4-M-SF-FL-comp1	63	2.23	2.8
Dungeness crab – hepatopancreas	T1	LDW-07-T1-M-DC-HP-comp1	280	3.72	7.5
	T3	LDW-07-T3-M-DC-HP-comp1	420	4.56	9.2
		LDW-07-T3-M-DC-HP-comp2	520	6.00	8.7
		LDW-07-T3-M-DC-HP-comp3	1,020	6.87	15
Dungeness crab – edible meat	T1	LDW-07-T1-M-DC-EM-comp1	15	0.440	3.4
	T3	LDW-07-T3-M-DC-EM-comp1	39	0.508	7.7
		LDW-07-T3-M-DC-EM-comp2	40	0.644	6.2
		LDW-07-T3-M-DC-EM-comp3	51 J	0.531	9.6 J
Dungeness crab – whole body (calculated)[b]	T1	LDW-07-T1-M-DC-WB-comp1 Calculated	97 M	1.46 M	6.6 M
	T3	LDW-07-T3-M-DC-WB-comp1 Calculated	160 M	1.76 M	9.1 M
		LDW-07-T3-M-DC-WB-comp2 Calculated	190 M	2.30 M	8.3 M
		LDW-07-T3-M-DC-WB-comp3 Calculated	351 JM	2.50 M	14 JM

Tissue Type	Area	Sample ID	Total PCBs (µg/kg ww)	Lipids (% ww)	Lipid-Normalized Total PCBs (mg/kg lipid)[a]
Slender crab – hepatopancreas	T1	LDW-07-T1-M-SC-HP-comp1	480	2.79	17
		LDW-07-T1-M-SC-HP-comp2	480	1.71	28
		LDW-07-T1-M-SC-HP-comp3	660	1.64	40
	T2	LDW-07-T2-M-SC-HP-comp1	250	3.90	6.4
		LDW-07-T2-M-SC-HP-comp2	270	4.10	6.6
		LDW-07-T2-M-SC-HP-comp3	270	3.07	8.8
Slender crab – edible meat	T1	LDW-07-T1-M-SC-EM-comp1	41	0.444	9.2
		LDW-07-T1-M-SC-EM-comp2	41 J	0.428	9.6 J
		LDW-07-T1-M-SC-EM-comp3	48 J	0.408	12 J
	T2	LDW-07-T2-M-SC-EM-comp1	40	0.592	6.8
		LDW-07-T2-M-SC-EM-comp2	27	0.452	6.0
		LDW-07-T2-M-SC-EM-comp3	46 J	0.628	7.3 J
Slender crab – whole body (calculated)[b]	T1	LDW-07-T1-M-SC-WB-comp1 Calculated	180 M	1.17 M	15 M
		LDW-07-T1-M-SC-WB-comp2 Calculated	180 JM	0.825 M	22 JM
		LDW-07-T1-M-SC-WB-comp3 Calculated	240 JM	0.790 M	30 JM
	T2	LDW-07-T2-M-SC-WB-comp1 Calculated	110 M	1.62 M	6.8 M
		LDW-07-T2-M-SC-WB-comp2 Calculated	100 M	1.58 M	6.3 M
		LDW-07-T2-M-SC-WB-comp3 Calculated	120 JM	1.39 M	8.6 JM

[a] Lipid-normalized concentrations (in units of mg PCBs/kg lipid) represent the wet-weight total PCB concentration (in units of mg/kg ww) divided by the decimal fraction corresponding to the percent lipid (e.g., 2.0% lipid = 0.02).

[b] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of whole body crab (i.e., edible meat plus hepatopancreas). Concentrations in whole-body crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

J – estimated concentration
JM – calculated concentration from an estimated concentration
LDW – Lower Duwamish Waterway
M – calculated concentration
PCB – polychlorinated biphenyl
ww – wet weight

Table E.4-4. Concentrations of PCBs (PCB congener sum) and lipids in LDW fish and crab tissue samples collected in 2004

Tissue Type	Area	Sample ID	Total PCBs (µg/kg ww)	Lipid (%)	Lipid-Normalized PCBs (mg PCBs/kg lipid)[a]
English sole – fillet	T1	LDW-T1-M-ES-FL-comp-2	858 J	2.6	33 J
		LDW-T1-M-ES-FL-comp-1	1,119 J	3.1	36 J
	T2	LDW-T2-M-ES-FL-comp-2	1,265 J	4.3	29 J
		LDW-T2-M-ES-FL-comp-1	1,269 J	3.4	37 J
	T3	LDW-T3-M-ES-FL-comp-1	641 J	1.6	40 J
		LDW-T3-M-ES-FL-comp-2	1,023 J	3.6	28 J
	T4	LDW-T4-M-ES-FL-comp-1	510 J	1.7	30 J
English sole – whole body	T1	LDW-T1-M-ES-WB-comp-2	1,614 J	5	32 J
		LDW-T1-M-ES-WB-comp-4	2,481 J	5.7	44 J
	T2	LDW-T2-M-ES-WB-comp-5	2,126 J	7.6	28 J
		LDW-T2-M-ES-WB-comp-3	2,712 J	7.6	36 J
	T3	LDW-T3-M-ES-WB-comp-2	1,419 J	4.7	30 J
		LDW-T3-M-ES-WB-comp-3	2,457 J	5.5	45 J
	T4	LDW-T4-M-ES-WB-comp-1	1,361 J	5.9	23 J
Shiner surfperch – whole body	T1	LDW-T1-A-SS-WB-comp-1	700 J	5	14 J
		LDW-T1-F-SS-WB-comp-1	877 J	2.8	31 J
	T2	LDW-T2-B-SS-WB-comp-1	1,055 J	2.5	42 J
		LDW-T2-E-SS-WB-comp-1	12,228 J	5.6	218 J
	T3	LDW-T3-C-SS-WB-comp-1	1,009 J	3.4	30 J
		LDW-T3-F-SS-WB-comp-1	3,522 J	4.6	77 J
		LDW-T3-E-SS-WB-comp-1	8010 J	3.1	258 J
	T4	LDW-T4-D-SS-WB-comp-1	532 J	4.3	12J
		LDW-T4-B-SS-WB-comp-1	770 J	3.3	23 J
Dungeness crab – edible meat	T1	LDW-T1-M-DC-EM-comp-2	111 J	0.39	28 J
	T3	LDW-T3-M-DC-EM-comp-1	149 J	0.23	65 J
	T4	LDW-T4-M-DC-EM-comp-1	149 J	0.72	21 J
Dungeness crab – hepatopancreas	T3	LDW-T3-M-DC-HP-comp-1	3,620 J	6.3	57.5 J
	T4	LDW-T4-M-DC-HP-comp-1	3,618 J	7.9	45.8 J
Dungeness crab – whole body (calculated)[b]	T3	LDW-T3-M-DC-WB-comp-1 Calculated	1,226 JM	2.1	58 JM
	T4	LDW-T4-M-DC-WB-comp-1 Calculated	1,224 JM	2.9	42 JM

Tissue Type	Area	Sample ID	Total PCBs (µg/kg ww)	Lipid (%)	Lipid-Normalized PCBs (mg PCBs/kg lipid)[a]
Slender crab – edible meat	T1	LDW-T1-M-SC-EM-comp-2	175 J	0.54	32 J
		LDW-T1-M-SC-EM-comp-1	187 J	0.74	25 J
	T2	LDW-T2-M-SC-EM-comp-6	130 J	0.26	50 J
		LDW-T2-M-SC-EM-comp-5	181 J	0.34	53 J
	T3	LDW-T3-M-SC-EM-comp-2	134 J	0.51	26 J
Slender crab – hepatopancreas	T1	LDW-T1-M-SC-HP-comp-1	790 J	1.9	41.6 J
	T2	LDW-T2-M-SC-HP-comp-2	1,050 J	3.6	29.2 J
Slender crab – whole body (calculated)[b]	T1	LDW-T1-M-SC-WB-comp-1 Calculated	373.6 JM	1.1	34 JM
		LDW-T1-M-SC-WB-comp-2 Calculated	365.5 JM	0.96	38 JM
	T2	LDW-T2-M-SC-WB-comp-6 Calculated	449.18 JM	1.40	32 JM
		LDW-T2-M-SC-WB-comp-5 Calculated	414.06JM	1.30	32 JM

[a] Lipid-normalized concentrations (in units of mg PCBs/kg lipid) represent the wet-weight total PCB concentration (in units of mg/kg ww) divided by the decimal fraction corresponding to the percent lipid (e.g., 2.0% lipid = 0.02).

[b] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of whole body crab (i.e., edible meat plus hepatopancreas). Concentrations in whole-body crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

J – estimated concentration

JM – calculated concentration from an estimated concentration

LDW – Lower Duwamish Waterway

PCB – polychlorinated biphenyl

ww – wet weight

Table E.4-5. Concentrations of PCBs (PCB congener sum) and lipids in LDW fish tissue samples collected in 2005

Tissue Type	Area	Sample ID	Total PCBs (µg/kg ww)	Lipid (%)	Lipid-Normalized PCBs (mg PCBs/kg lipid)[a]
English sole - whole body	T1	LDW-05-T1-M-ES-WB-Comp3	2,589 J	3.13	83
	T2	LDW-05-T2-M-ES-WB-Comp3	3,214 J	6.23	52
	T3	LDW-05-T3-M-ES-WB-Comp2	1,433 J	4.77	30
Shiner surfperch - whole body	T1	LDW-05-T1-B-SS-WB-Comp1	683 J	6.01	11
	T2	LDW-05-T2-B-SS-WB-Comp1	1,047 J	5.79	18
	T3	LDW-05-T3-D-SS-WB-Comp1	2,048 J	6.92	30

[a] Lipid-normalized concentrations (in units of mg PCBs/kg lipid) represent the wet-weight total PCB concentration (in units of mg/kg ww) divided by the decimal fraction corresponding to the percent lipid (e.g., 2.0% lipid = 0.02).

J – estimated concentration

LDW – Lower Duwamish Waterway

PCB – polychlorinated biphenyl

ww – wet weight

Table E.4-6. Concentrations of PCBs (PCB congener sum) and lipids in LDW fish and crab tissue samples collected in 2007

Tissue Type	Area	Sample ID	Total PCBs (µg/kg ww)	Lipid (%)	Lipid-Normalized PCBs (mg PCBs/kg lipid)[a]
English sole – whole body	T1	LDW-07-T1-M-ES-WB-comp3	1,165 J	6.85	17.0
		LDW-07-T1-M-ES-WB-comp5	774 J	3.83	20.2
	T2	LDW-07-T2-A-ES-WB-comp2	1,632 J	9.00	18.1
		LDW-07-T2-A-ES-WB-comp4	1,603 J	8.07	19.9
	T3	LDW-07-T3-M-ES-WB-comp4	2,928 J	10.9	26.9
		LDW-07-T3-M-ES-WB-comp6	1,032 J	4.40	23.5
Shiner surfperch – whole body	T1	LDW-07-T1-B-SS-WB-comp1	974 J	2.20	44.3
		LDW-07-T1-C-SS-WB-comp1	504.1 J	4.94	10.2
	T2	LDW-07-T2-B-SS-WB-comp1	401.6	4.40	9.13
		LDW-07-T2-E-SS-WB-comp1	648.3 J	4.46	14.5
	T3	LDW-07-T3-E-SS-WB-comp1	1,103 J	3.43	32.2
		LDW-07-T3-F-SS-WB-comp1	2,462 J	4.94	49.8
Dungeness crab – edible meat	T1	LDW-07-T1-M-DC-EM-comp1	49.45 J	0.440	11.2 J
	T3	LDW-07-T3-M-DC-EM-comp3	86.2 J	0.531	16.2 J
Dungeness crab – hepatopancreas	T1	LDW-07-T1-M-DC-HP-comp1	612.1 J	3.72	16.5
Dungeness crab – whole body (calculated)[b]	T1	LDW-07-T1-M-DC-WB-comp1-calculated	223.9 JM	1.46 M	15.3 JM
Slender crab – edible meat	T1	LDW-07-T1-M-SC-EM-comp2	112 J	0.428	26.2
	T2	LDW-07-T2-M-SC-EM-comp1	86.2 J	0.592	14.6

[a] Lipid-normalized concentrations (in units of mg PCBs/kg lipid) represent the wet-weight total PCB concentration (in units of mg/kg ww) divided by the decimal fraction corresponding to the percent lipid (e.g., 2.0% lipid = 0.02).

[b] Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of whole body crab (i.e., edible meat plus hepatopancreas). Concentrations in whole-body crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

J – estimated concentration

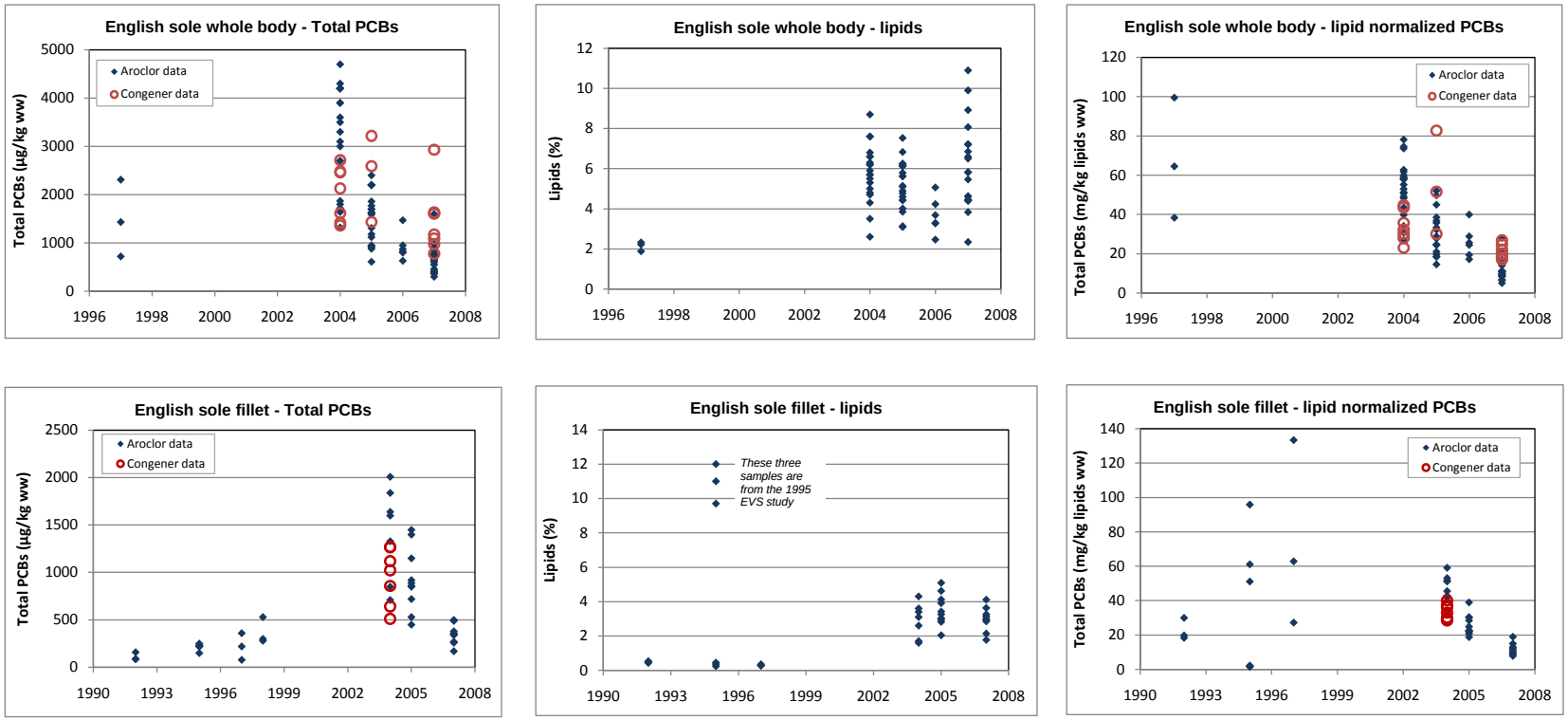
JM – calculated concentration from an estimated concentration

LDW – Lower Duwamish Waterway

M – calculated concentration

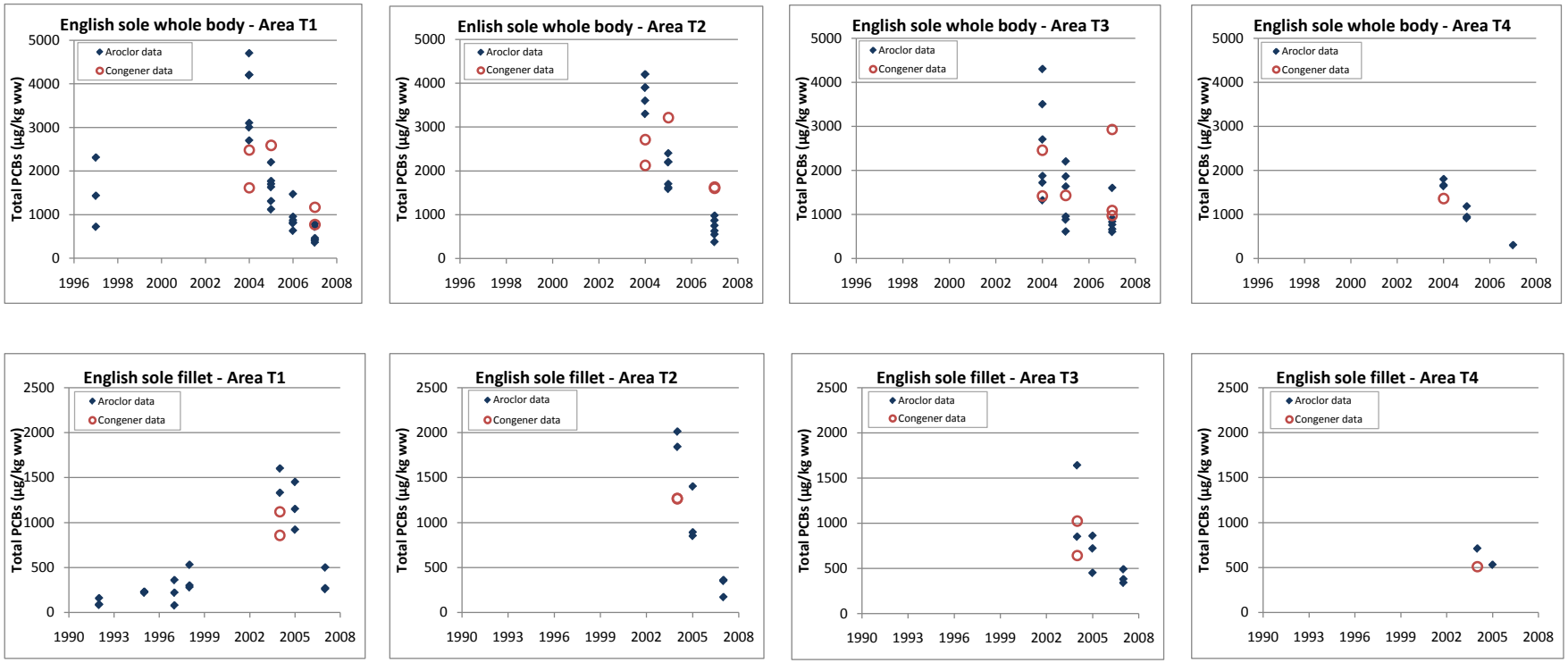
PCB – polychlorinated biphenyl

ww – wet weight



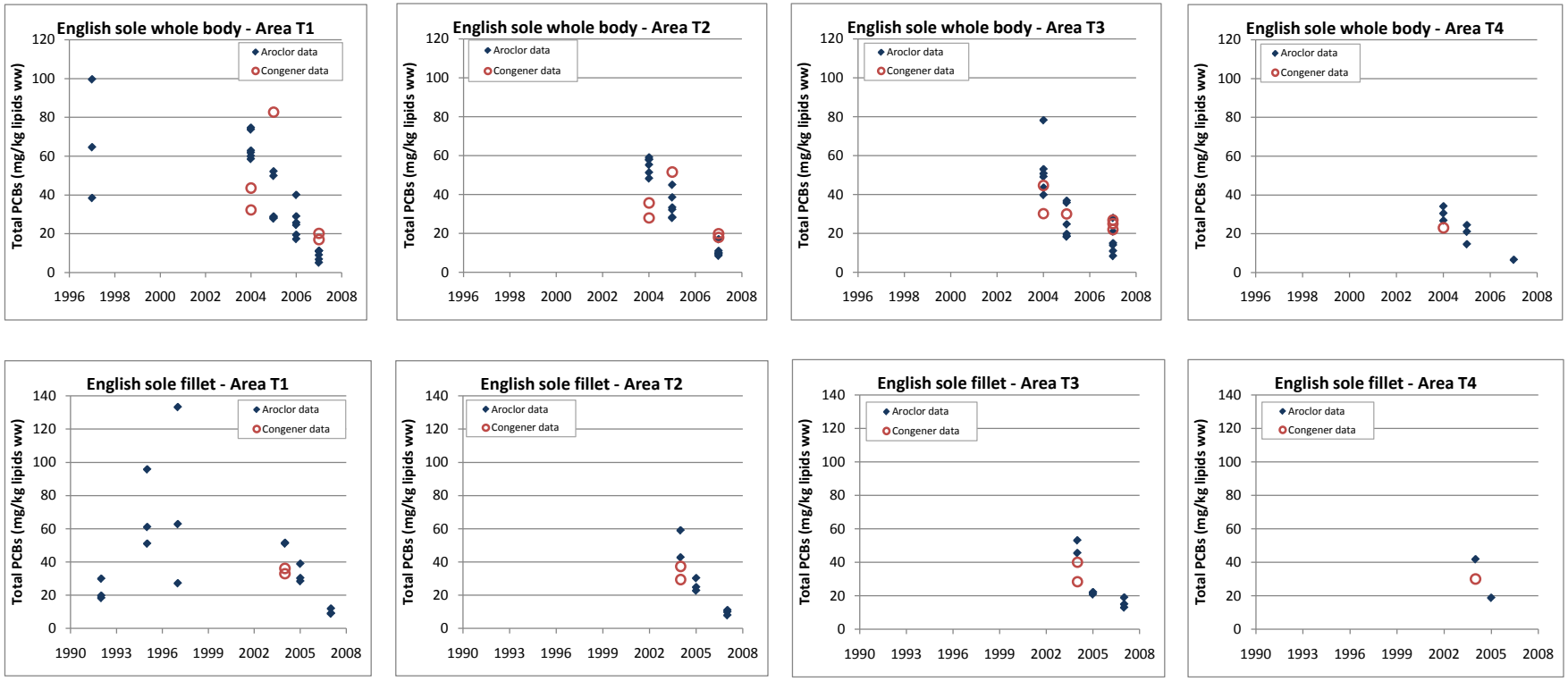
Note: English sole whole body samples from 1997 consisted of tissue remaining after subsamples were removed. In addition, livers were removed from some fish in these composite samples.

Figure E.4-1. Concentrations of total PCBs (ww), lipids, and lipid-normalized PCBs in English sole samples collected throughout the LDW



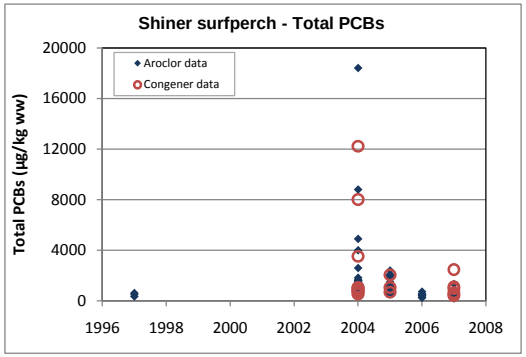
Note: English sole whole body samples from 1997 consisted of tissue remaining after subsamples were removed. In addition, livers were removed from some fish in these composite samples.

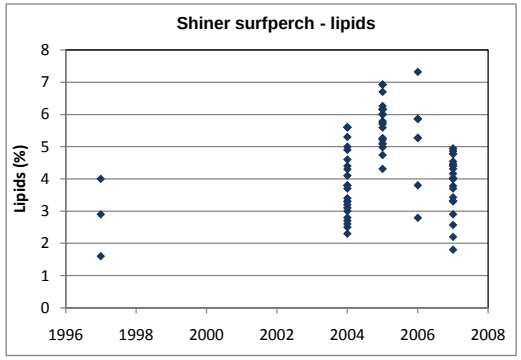
Figure E.4-2. Concentrations of total PCBs (ww) in English sole samples collected in each of the four tissue sampling areas (T1, T2, T3, and T4)

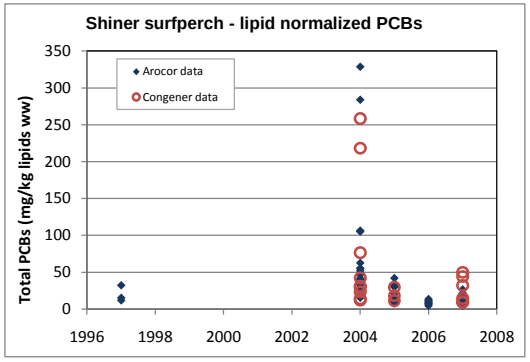


Note: English sole whole body samples from 1997 consisted of tissue remaining after subsamples were removed. In addition, livers were removed from some fish in these composite samples.

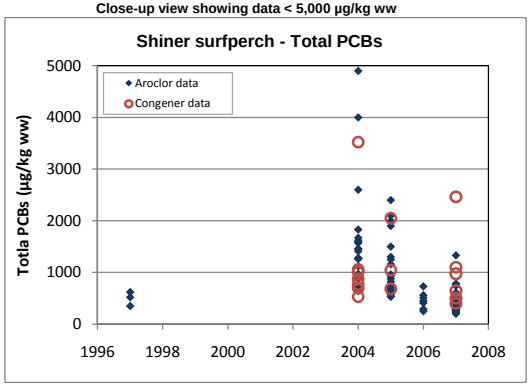
Figure E.4-3. Concentrations of lipid-normalized PCBs in English sole samples collected in each of the four tissue sampling areas (T1, T2, T3, and T4)







Close-up view showing data < 5,000 µg/kg ww



Close-up view showing data < 120 mg/kg-lipids ww

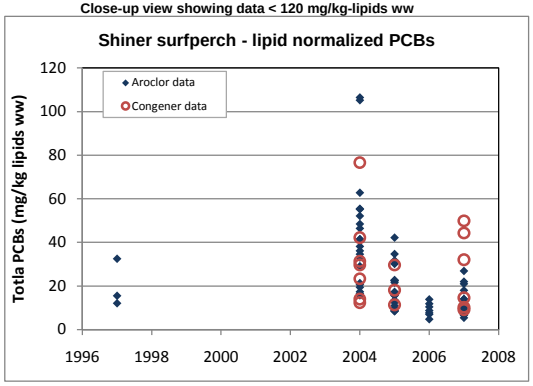


Figure E.4-4. Concentrations of total PCBs (ww), lipids, and lipid-normalized PCBs in shiner surfperch whole-body samples collected throughout the LDW

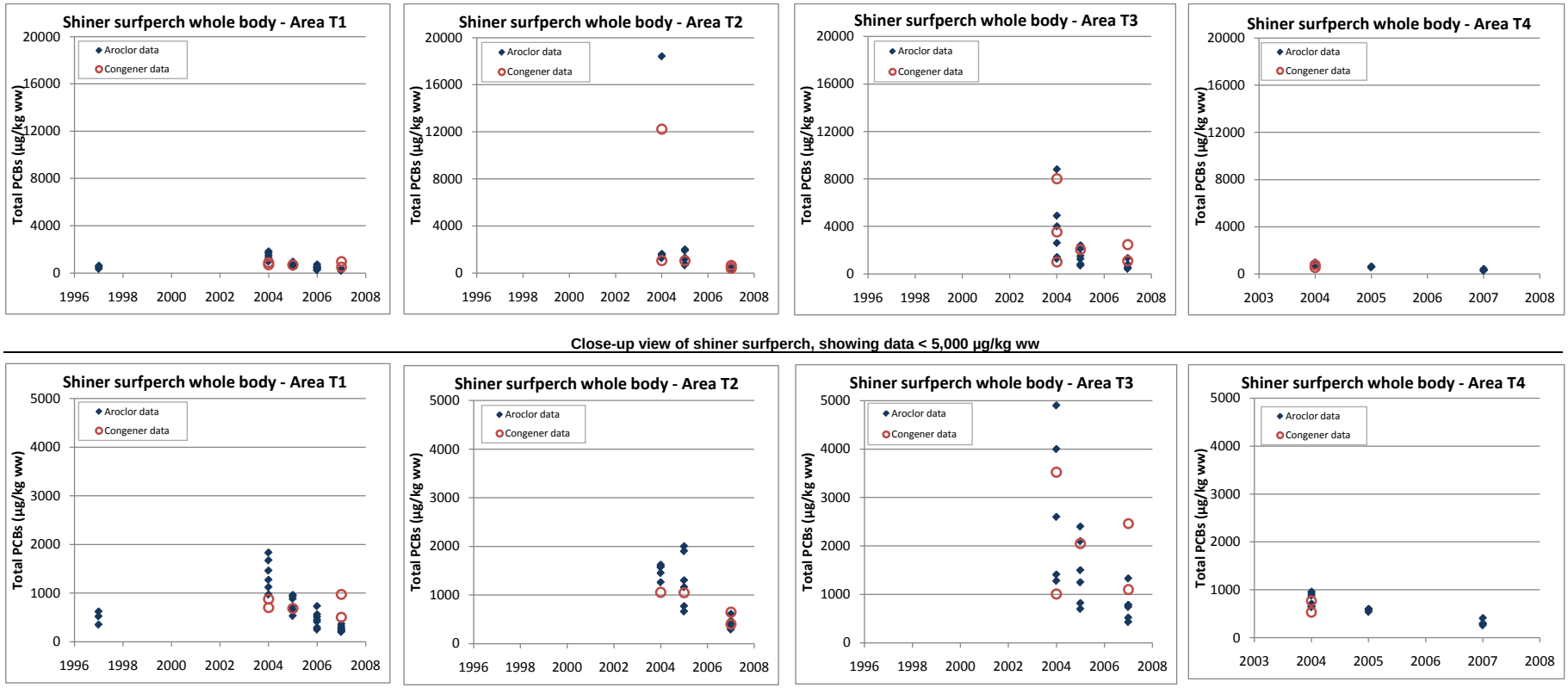


Figure E.4-5. Concentrations of total PCBs (ww) in shiner surfperch whole-body samples collected in each of the four tissue sampling areas (T1, T2, T3, and T4)

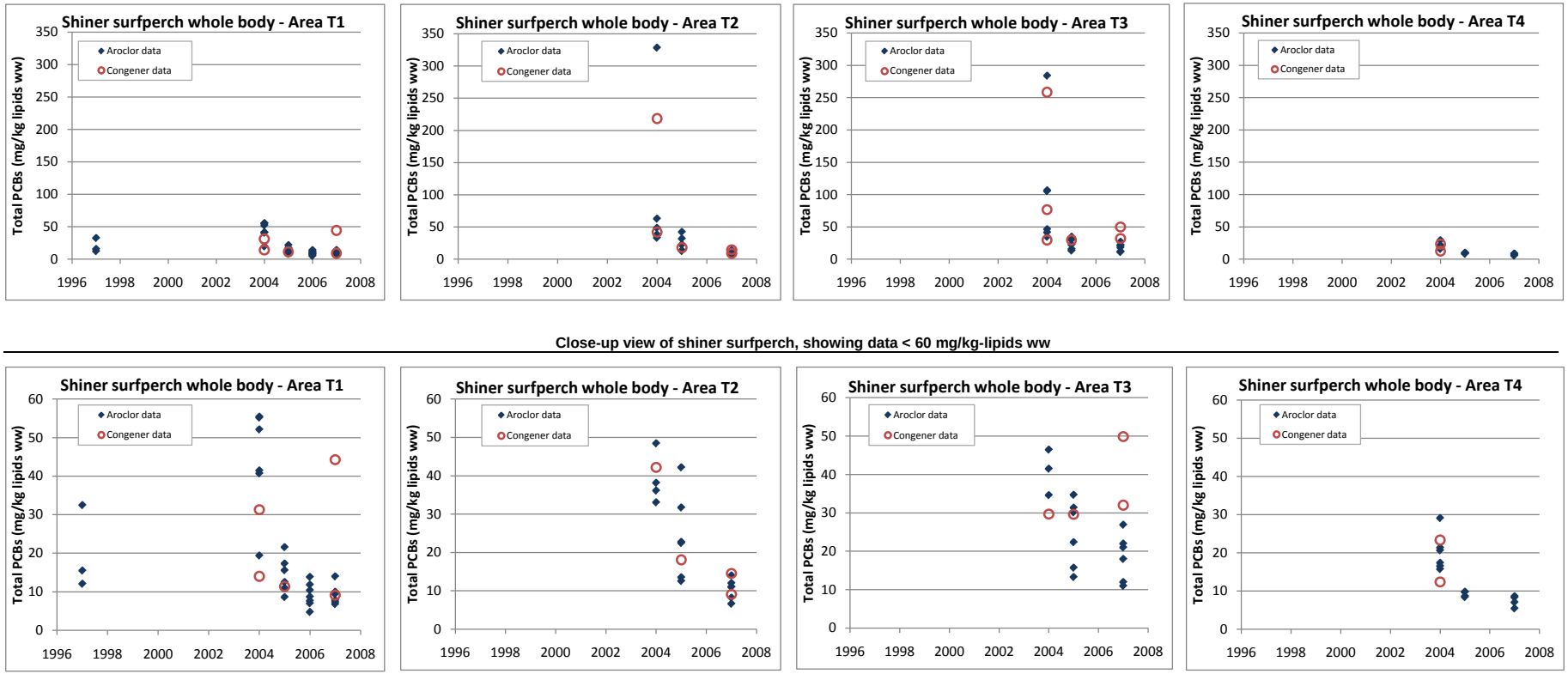


Figure E.4-6. Concentrations of lipid-normalized PCBs in shiner surfperch whole-body samples collected in each of the four tissue sampling areas (T1, T2, T3, and T4)

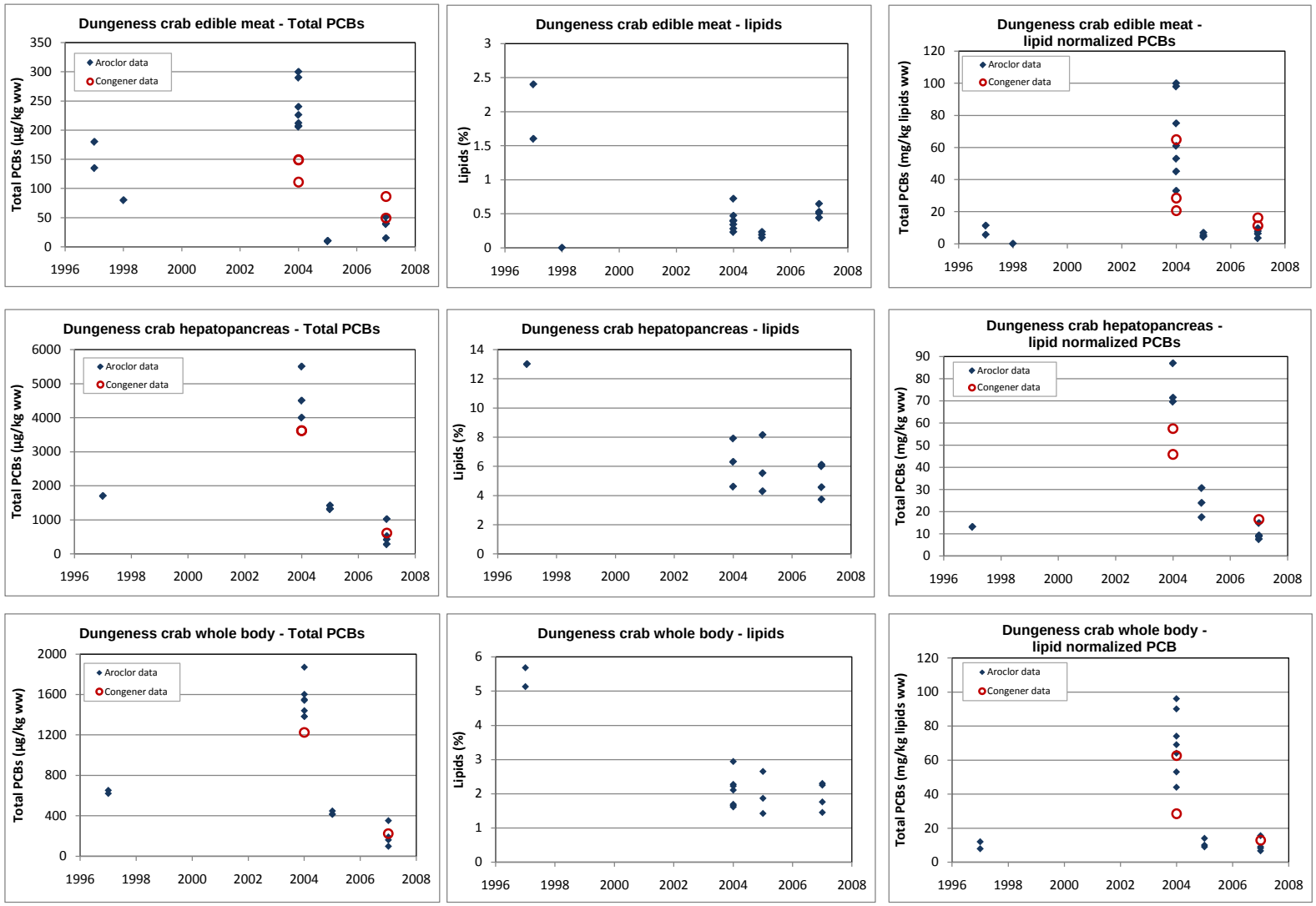


Figure E.4-7. Concentrations of total PCBs (ww), lipids, and lipid-normalized PCBs in Dungeness crab samples collected throughout the LDW

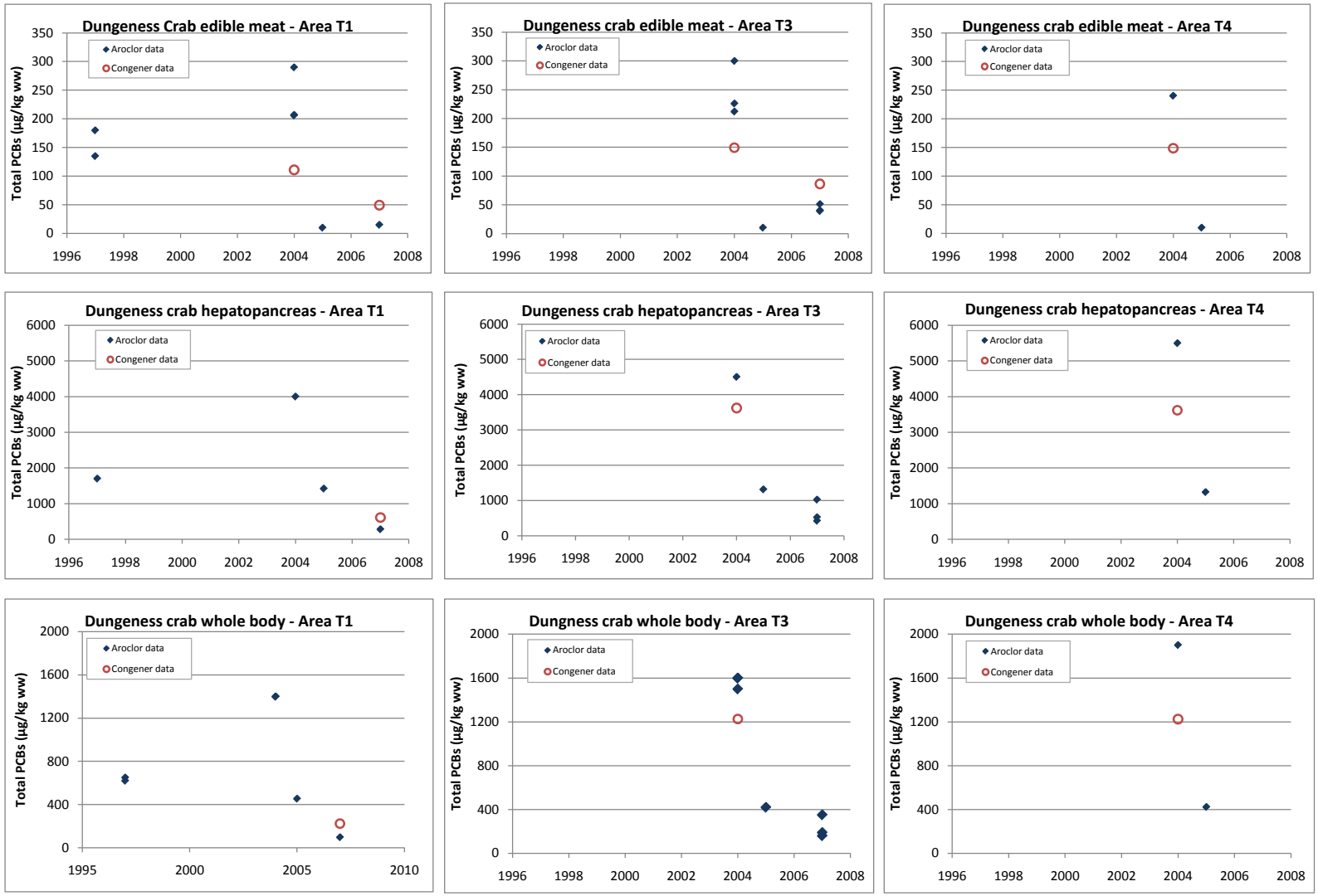


Figure E.4-8. Concentrations of total PCBs (ww) in Dungeness crab samples collected in each of three tissue sampling areas (T1, T3, and T4; no Dungeness crab were collected in Area T2)

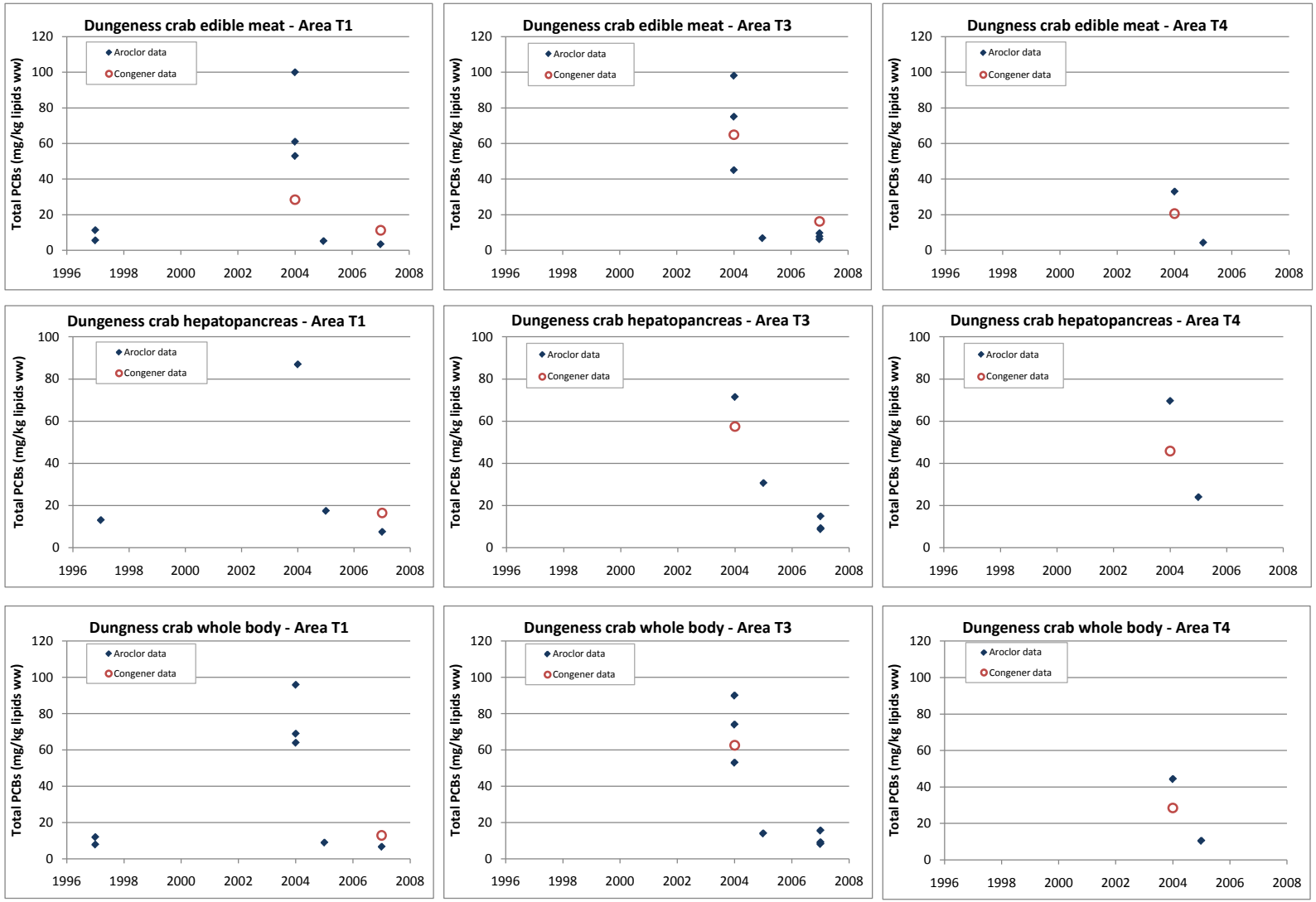


Figure E.4-9. Concentrations of lipid-normalized PCBs in Dungeness crab samples collected in each of three tissue sampling areas (T1, T3, and T4; no Dungeness crab were collected in Area T2)

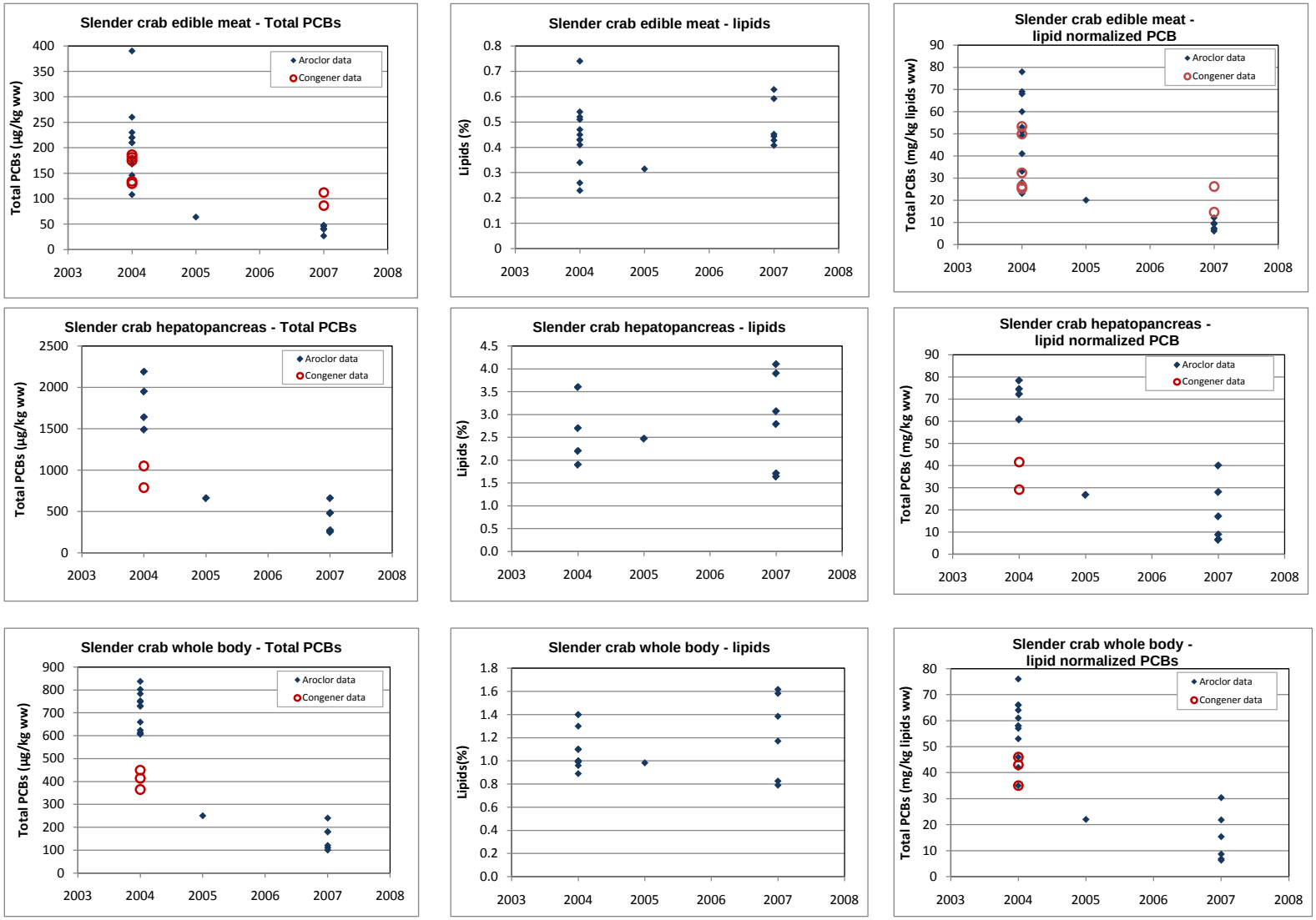


Figure E.4-10. Concentrations of total PCBs (ww), lipids, and lipid-normalized PCBs in slender crab samples collected throughout the LDW

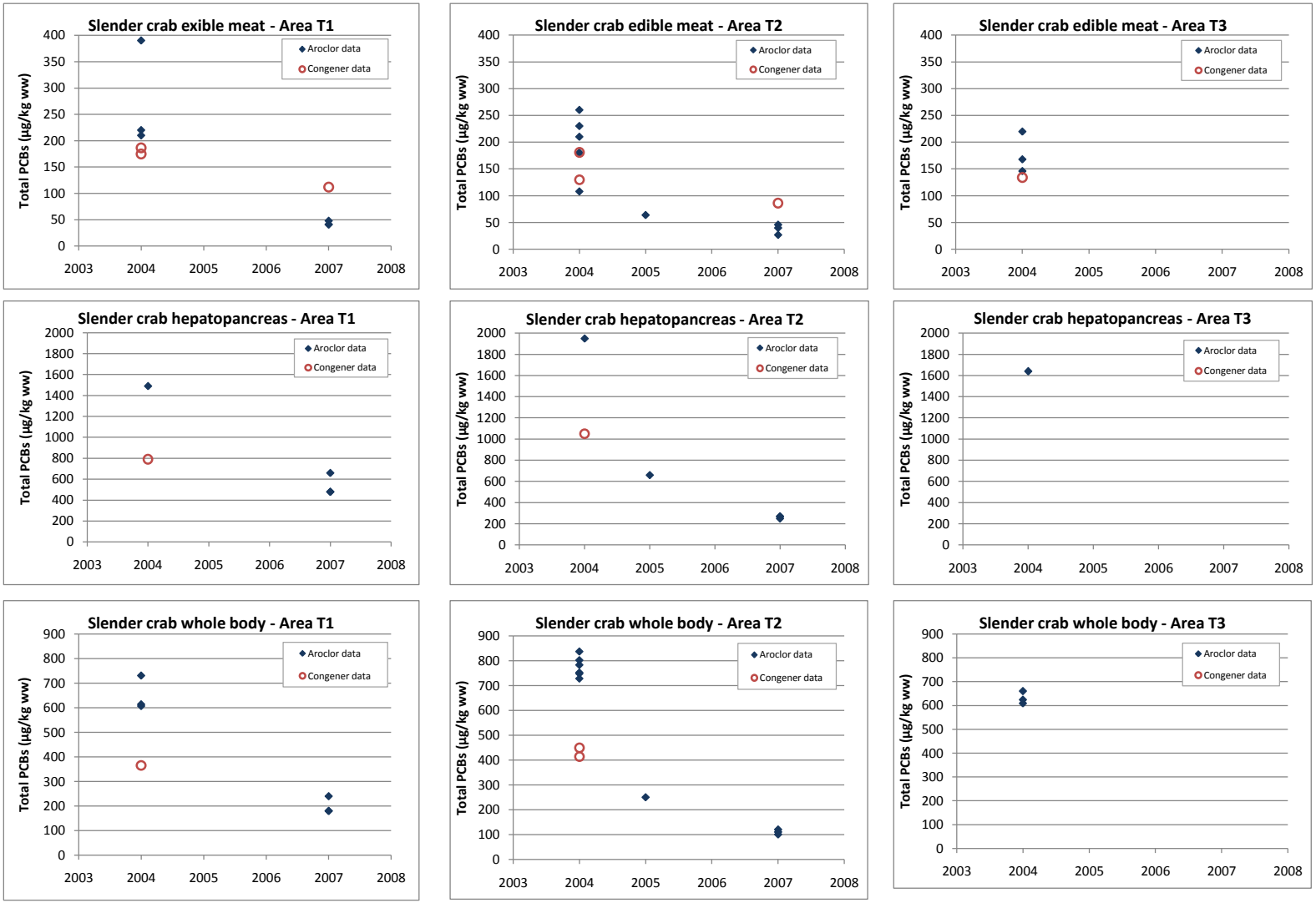


Figure E.4-11. Concentrations of total PCBs (ww) in slender crab samples collected in each of three tissue sampling areas (T1, T2, and T3; no slender crab were collected in Area T4)

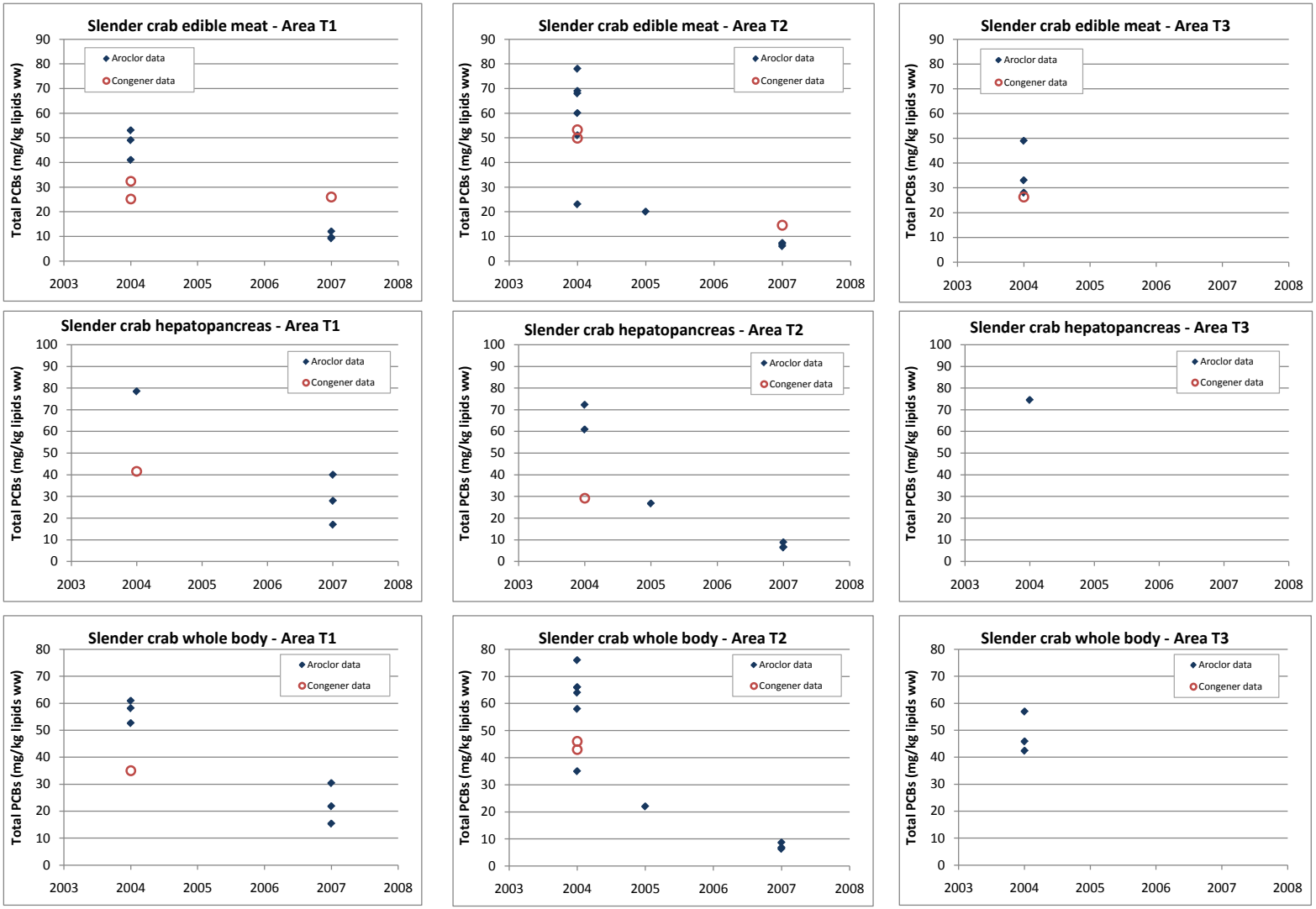


Figure E.4-12. Concentrations of lipid-normalized PCBs in slender crab samples collected in each of three tissue sampling areas (T1, T2, and T3; no slender crab were collected in Area T4)

E.5 Statistical Details for Selected Analyses

This section of the appendix presents output from statistical analyses conducted in Statistical Package for the Social Sciences (SPSS), Version 15.0, and Microsoft Excel® to support Sections 4 and 8 of the RI. This output is provided at the request of EPA to allow a reader familiar with statistical methods involving linear modeling to review the raw output from analyses whose general results and conclusions are presented in Sections 4 and 8. This section also provides results of some additional analyses that were conducted to support the selection of analyses for the RI but were not presented in the RI. This section is intended to serve as a supplement to the RI and does not include textual discussion or explanation that might be needed by readers less familiar with linear modeling methods.

Tables E.5-1 through E.5-7 and Figures E.5-1 and E.5-2 provide the statistical output of tests described in Section 4 to evaluate differences among mean total PCB concentrations (sum of Aroclors in mg/kg ww) in the four sampling areas for whole-body English sole and shiner surfperch. Two-way Analyses of Variance (ANOVAs) were conducted with the factors year (2004, 2005, and 2007), area (T1 through T4) and year-by-area interaction to test for differences between areas across years and to test for differences in the direction of changes over time in tissue concentrations in the different areas. These tests were followed by *post hoc* Tukey honestly significant difference (HSD) multiple comparisons and one-way ANOVA testing for effects of area within year to identify differences between areas. Data were log(10) transformed and rankit transformed[5] (Conover 1980) to help homogenize variances in order to better meet the assumptions of the ANOVA and to determine which transformation had the most power to detect differences. Analyses were conducted for both wet-weight total PCB concentrations and lipid-normalized total PCB concentrations. Tables E.5-5 and E.5-6 present groups of areas with statistically homogenous mean total PCB concentrations based on the *post hoc* Tukey test for English sole and shiner surfperch, respectively. The Tukey test examines differences between areas averaged over years. Table E.5-7 presents p values from the one-way ANOVAs (within year) for English sole and shiner surfperch. In all tables, only the results of log-transformed data are presented except when conclusions about significance differed for rankit-transformed data, in which case results for both transformations are presented. The remaining tables and figures in this appendix (Tables E.5-8 through E.5-15; Figures E.5-3 through E.5-5) provide additional information

[5] The rankit transformation converts the rank of each sample value into the expected value of corresponding ranks in a sample from the standard normal distribution the same size as the data set. This transformation is commonly used to make data meet the assumptions of a statistical test and has the effect of making the statistical test nonparametric. See Conover (1980) for additional information.

related to the regressions presented in Section 8 (Section 8.3.2) to evaluate the relationship between arsenic and cPAH TEQ[6] concentrations in clam tissue and sediment.

Table E.5-1. Results of Levene's test for homogeneity of variance in two-way ANOVA of log(10)- and rankit-transformed total PCB and lipid-normalized PCB concentrations in whole-body English sole

Dependent Variable	F Statistic	df1	df2	Significance (p value)
Log[total PCBs (µg/kg ww)]	2.583	11	49	0.011
Log[total PCBs (µg/kg lipid)]	2.097	11	49	0.038
Rankit transformation of total PCBs (µg/kg ww)	1.552	11	49	0.144
Rankit transformation of total PCBs (µg/kg lipid)	1.137	11	49	0.355

Note: The Levene's test examines the null hypothesis that the error variance of the dependent variable is equal across groups using the following design: intercept+area+year+area*year. P value is the significance of differences among means within a group.

ANOVA – analysis of variance

df1 – degrees of freedom for numerator of F Test (number of groups being tested – 1)

df2 – degrees of freedom for denominator of F test (number of samples – number of groups)

PCB – polychlorinated biphenyl

ww – wet weight

[6] Total cPAHs were calculated by summing the products of concentrations and compound-specific PEFs for individual cPAH compounds, as discussed in detail in Appendix E, Section E.3.

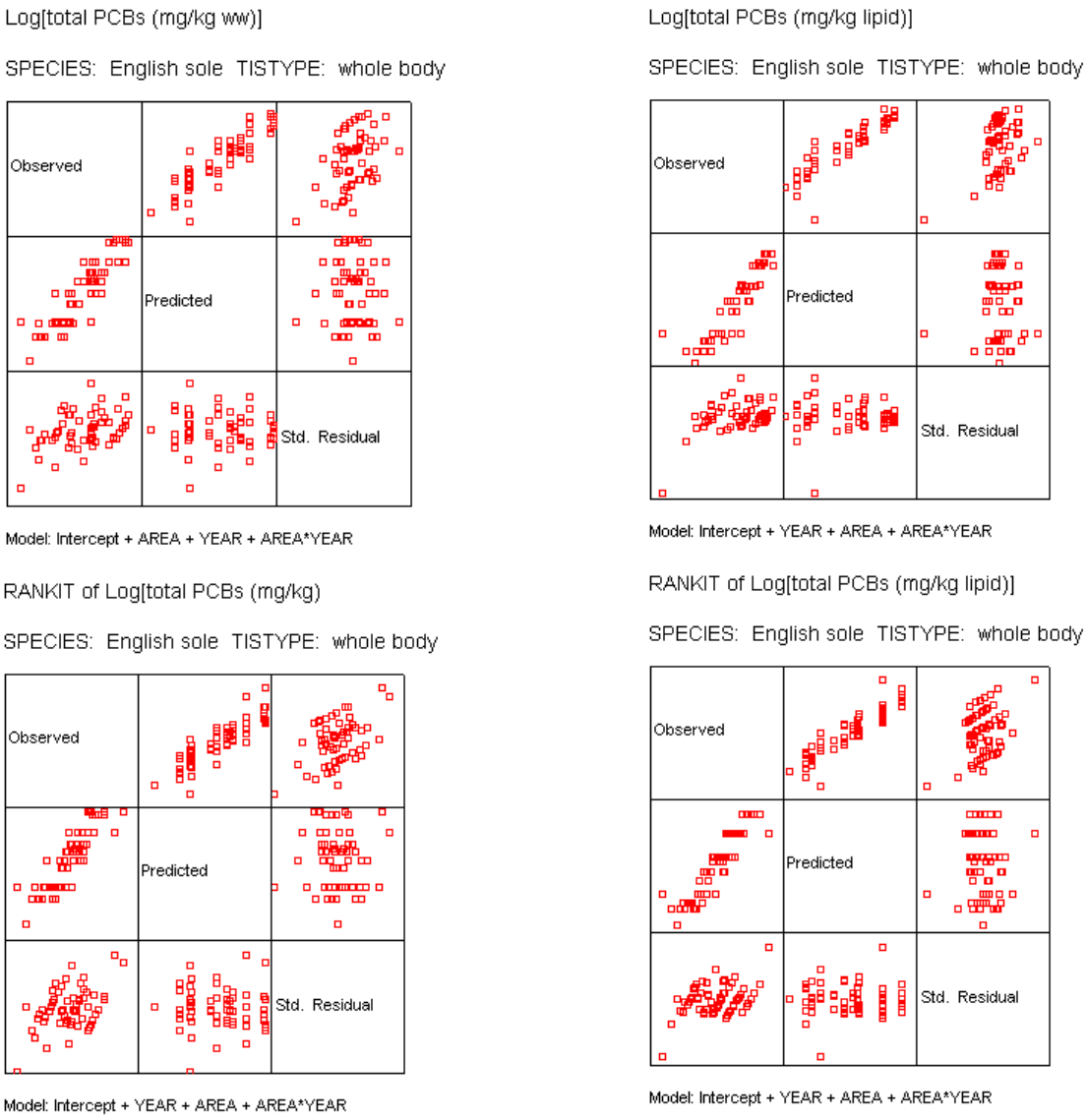


Figure E.5-1. Residual plots from two-way ANOVAs of log(10)- and rankit-transformed for total PCB and lipid-normalized PCB concentrations in whole-body English sole

Table E.5-2. Results of two-way ANOVA of log(10)- and rankit-transformed total PCB and lipid-normalized PCB concentrations in whole-body English sole

Dependent Variable	Source[a]	Type III Sum of Squares	df	Mean Square	F Statistic	Significance (p value)
Log[total PCBs (µg/kg ww)]	corrected model	5.534	11	0.503	21.059	0.000
	intercept	435.890	1	435.890	18247.337	0.000
	area	0.477	3	0.159	6.655	0.001
	year	3.620	2	1.810	75.768	0.000
	area * year	0.195	6	0.032	1.357	0.251
	error	1.171	49	0.024		
	total	609.864	61			
	corrected total	6.704	60			
Log[total PCBs (µg/kg lipid)]	corrected model	5.645	11	0.513	21.314	0.000
	intercept	84.369	1	84.369	3504.223	0.000
	area	0.254	3	0.085	3.513	0.022
	year	3.567	2	1.783	74.072	0.000
	area * year	0.179	6	0.030	1.241	0.302
	error	1.180	49	0.024		
	total	127.139	61			
	corrected total	6.824	60			
Rankit transformation of total PCBs (µg/kg ww)	corrected model	49.714	11	4.519	16.436	0.000
	intercept	0.442	1	0.442	1.608	0.211
	area	3.980	3	1.327	4.825	0.005
	year	33.252	2	16.626	60.463	0.000
	area * year	1.649	6	0.275	.999	0.437
	error	13.474	49	0.275		
	total	63.335	61			
	corrected total	63.188	60			

Dependent Variable	Source[a]	Type III Sum of Squares	df	Mean Square	F Statistic	Significance (p value)
Rankit transformation of total PCBs (µg/kg lipid)	corrected model	54.201	11	4.927	22.841	0.000
	intercept	0.726	1	0.726	3.366	0.073
	area	3.342	3	1.114	5.164	0.004
	year	33.269	2	16.634	77.109	0.000
	area * year	2.755	6	0.459	2.128	0.067
	error	10.571	49	0.216		
	total	64.784	61			
	corrected total	64.772	60			

Note: P value is the significance of differences among means within a group.

[a] Corrected model and corrected total sums of squares are model and total sums of squares-corrected for the mean.

df – degrees of freedom

PCB – polychlorinated biphenyl

ww – wet weight

Table E.5-3. Results of Levene's test for homogeneity of variance in two-way ANOVA of log(10)- and rankit-transformed total PCB and lipid-normalized PCB concentrations in whole-body shiner surfperch

Dependent Variable	F Statistic	df1	df2	Significance (p value)
Log[total PCBs (µg/kg ww)]	2.804	11	56	0.006
Log[total PCBs (µg/kg lipid)]	2.363	11	56	0.018
Rankit transformation of total PCBs (µg/kg ww)	1.739	11	56	0.088
Rankit transformation of total PCBs (µg/kg lipid)	1.219	11	56	0.297

Note: The Levene's test tests the null hypothesis that the error variance of the dependent variable is equal across groups using the following design: intercept+ area+year+area*year. P value is the significance of differences among means within a group.

df1 – degrees of freedom for numerator of F Test (number of groups being tested – 1)

df2 – degrees of freedom for denominator of F test (number of samples – number of groups)

PCB – polychlorinated biphenyl

ww – wet weight

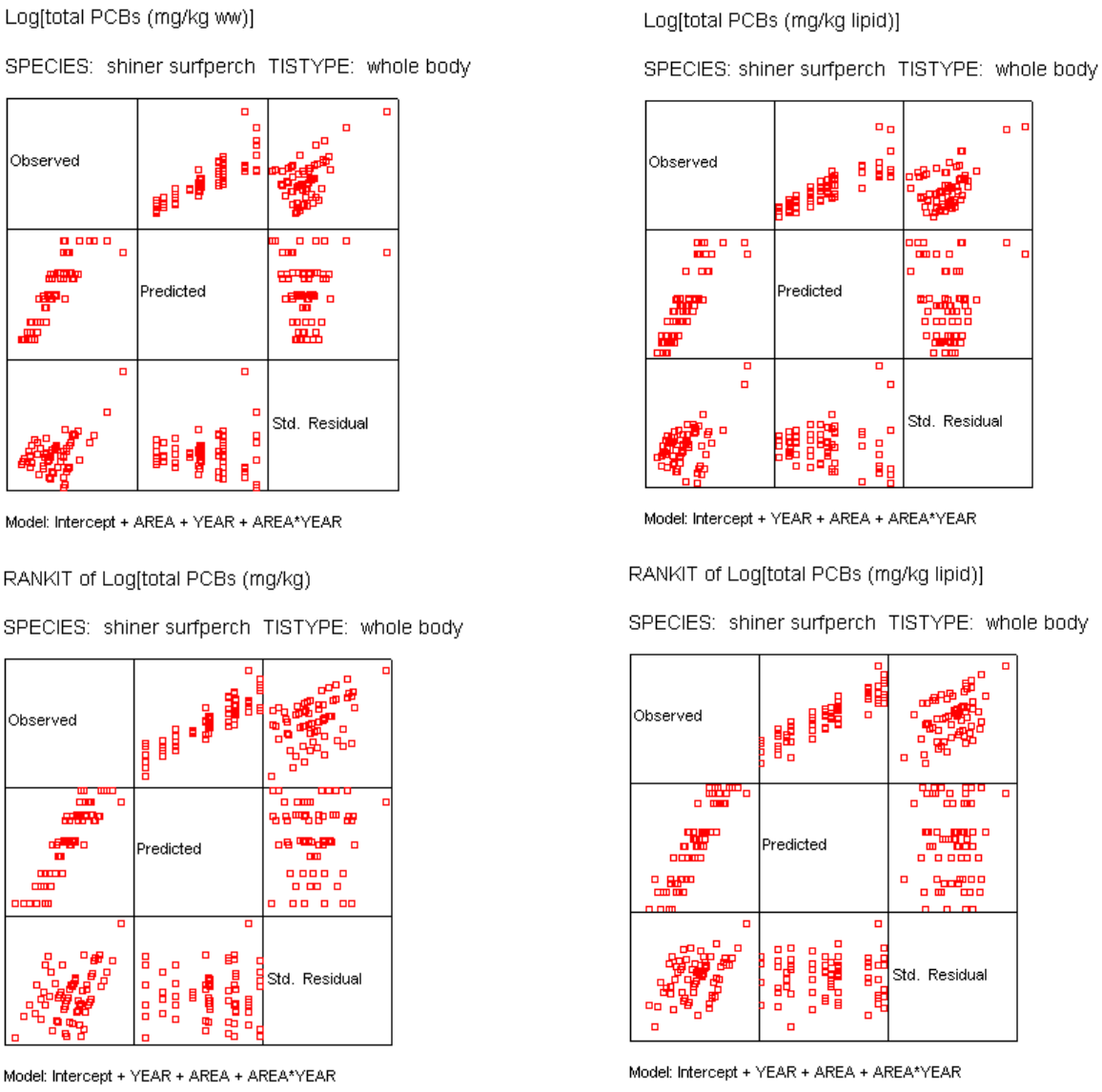


Figure E.5-2. Residual plots from two-way ANOVAs of log(10)- and rankit-transformed total PCB and lipid-normalized PCB concentrations in whole-body shiner surfperch

Table E.5-4. Results of two-way ANOVA using log(10)- and rankit-transformed total PCB and lipid-normalized PCB concentrations in whole-body shiner surfperch

Dependent Variable	Source[a]	Type III Sum of Squares	df	Mean Square	F Statistic	Significance (p value)
Log[total PCBs (µg/kg ww)]	corrected model	6.735	11	0.612	14.423	0.000
	intercept	567.637	1	567.637	13371.703	0.000
	area	1.910	3	0.637	14.999	0.000
	year	4.466	2	2.233	52.597	0.000
	area * year	0.260	6	0.043	1.020	0.422
	error	2.377	56	0.042		
	total	596.807	68			
	corrected total	9.112	67			
Log[total PCBs (µg/kg lipid)]	corrected model	6.837	11	0.622	15.686	0.000
	intercept	109.694	1	109.694	2768.253	0.000
	area	1.826	3	0.609	15.359	0.000
	year	4.871	2	2.435	61.461	0.000
	area * year	0.202	6	0.034	0.849	0.538
	error	2.219	56	0.040		
	total	125.215	68			
	corrected total	9.056	67			
Rankit transformation of total PCBs (µg/kg ww)	corrected model	55.171	11	5.016	21.194	0.000
	intercept	0.213	1	0.213	0.902	0.346
	area	14.866	3	4.955	20.939	0.000
	year	36.832	2	18.416	77.819	0.000
	area * year	2.729	6	0.455	1.922	0.093
	error	13.253	56	0.237		
	total	69.192	68			
	corrected total	68.423	67			
Rankit transformation of total PCBs (µg/kg lipid)	corrected model	51.695	11	4.700	20.859	0.000
	intercept	0.068	1	0.068	0.302	0.585
	area	14.529	3	4.843	21.495	0.000
	year	37.338	2	18.669	82.860	0.000
	area * year	1.509	6	0.252	1.117	0.365
	error	12.617	56	0.225		
	total	65.015	68			
	corrected total	64.313	67			

Note: P value is the significance of differences among means within a group.

[a] Corrected model and corrected total sums of squares are model and total sums of squares-corrected for the mean.

df – degrees of freedom ww – wet weight

PCB – polychlorinated biphenyl

Table E.5-5. Results of *post hoc* Tukey test to identify groups of areas with statistically homogeneous mean concentrations of log(10)-transformed total PCBs in whole-body English sole (averaged over all years)

Area	n	Mean Concentration		
		Log(total PCB µg/kg ww)		Log(total PCB mg/kg lipid)
		Group 1 (p value = 0.176)	Group 2 (p value = 0.152)	Group 1 (p value = 0.181)
T4	7	3.0251		1.3051
T3	18	3.0989	3.0989	1.3942
T1	18	3.1512	3.1512	1.4269
T2	18		3.2297	1.4308

Note: P value is the significance of differences among means within a group.
n – number of samples
PCB – polychlorinated biphenyl
ww – wet weight

Table E.5-6. Results of *post hoc* Tukey test to identify groups of areas with statistically homogeneous mean concentrations of log(10)-transformed total PCBs in whole-body shiner surfperch (averaged over all years)

Area	n	Mean Concentration				
		Log(total PCB, µg/kg ww)		Log(total PCB, mg/kg lipid)		
		Group 1 (p value = 0.797)	Group 2 (p value = 0.205)	Group 1 (p value = 0.104)	Group 2 (p value = 0.171)	Group 3 (p value = 0.301)
T4	14	2.7419		1.0721		
T1	18	2.8070		1.2320	1.2320	
T2	18		3.0126		1.3752	1.3752
T3	18		3.1538			1.4964

Note: P value is the significance of differences among means within a group. n – number of samples
PCB – polychlorinated biphenyl
ww – wet weight

Table E.5-7. Significance of differences (p values) between areas within years based on separate, *post hoc* one-way ANOVA using Sidak's correction for multiple comparisons for whole-body English sole and shiner surfperch

Year	Areas Compared		Significance (p value)			
			Log(total PCBs µg/kg ww)		Log(total PCBs mg/kg lipid)	
			English Sole	Shiner Surfperch	English Sole	Shiner Surfperch
2004	T1	T2	1.00	0.33	0.96	0.69
		T3	0.26	**0.03**	0.83	0.13
		T4	**0.03**	0.27	**0.02**	**0.04**
	T2	T1	1.00	0.33	0.96	0.69
		T3	0.13	0.86	1.00	0.92
		T4	**0.01**	**0.00**	0.13	**0.00**
	T3	T1	0.26	**0.03**	0.83	0.13
		T2	0.13	0.86	1.00	0.92
		T4	0.73	**0.00**	0.24	**0.00**
	T4	T1	**0.03**	0.27	**0.02**	**0.04**
		T2	**0.01**	**0.00**	0.13	**0.00**
		T3	0.73	**0.00**	0.24	**0.00**
2005	T1	T2	0.92	0.49	1.00	0.40
		T3	0.77	0.26	0.50	0.29
		T4	0.38	0.94	0.17	0.66
	T2	T1	0.92	0.49	1.00	0.40
		T3	0.18	1.00	0.57	1.00
		T4	0.07	0.12	0.20	0.02
	T3	T1	0.77	0.26	0.50	0.29
		T2	0.18	1.00	0.57	1.00
		T4	0.97	0.05	0.94	**0.02**
	T4	T1	0.38	0.94	0.17	0.66
		T2	0.07	0.12	0.20	**0.02**
		T3	0.97	**0.05**	0.94	**0.02**

Year	Areas Compared		Significance (p value)			
			Log(total PCBs µg/kg ww)		Log(total PCBs mg/kg lipid)	
			English Sole	Shiner Surfperch	English Sole	Shiner Surfperch
2007	T1	T2	0.71	0.47	0.89	0.99
		T3	0.59	**0.00**	0.46	0.07
		T4	0.73	0.99	0.98	0.99
	T2	T1	0.71	0.47	0.89	0.99
		T3	1.00	0.22	0.99	0.26
		T4	0.25	0.95	0.77	0.81
	T3	T1	0.59	**0.00**	0.46	0.07
		T2	1.00	0.22	0.99	0.26
		T4	0.21	0.05	0.53	**0.03**
	T4	T1	0.73	0.99	0.98	0.99
		T2	0.25	0.95	0.77	0.81
		T3	0.21	0.05	0.53	**0.03**

Note: P value is the significance of differences among means within a group. ANOVA – Analysis of Variance
PCB – polychlorinated biphenyl
ww – wet weight
Bold identifies significant p values (i.e., p value < 0.05).

Table E.5-8. Clam tissue and sediment arsenic data used for regressions in Table 8-15 of the main body of the RI

Area	Year	Concentration by Sample Type			
		Clam Tissue (inorganic arsenic mg/kg ww)[a]	Intertidal Sediment (total arsenic mg/kg dw)[b]	Buffer Sediment (total arsenic mg/kg dw)[c]	Co-Located Sediment (total arsenic mg/kg dw)[a, d]
C1	2004	0.132	7.9	11	3.53
C2-1	2004	0.648	6	7.8	5.79
C3-1	2004	0.885	9	11	4.63
C4	2004	3.27	51	35	49.00
C5	2004	0.795	4.9	8.9	4.72
C6	2004	1.85	7	7.9	5.52
C7	2004	2.11	11	13	6.80
C9	2004	0.233	5.8	7.3	3.94
C1	2007	0.690	7.9	11	4.884
C2-1	2007	2.75	6	7.8	4.53
C2-2	2007	1.73	6	7.8	3.569
C3-1	2007	2.22	9	11	5.303
C3-2	2007	1.58	9	11	5.274
C4	2007	6.65	51	35	172.18
C5	2007	1.82	4.9	8.9	14.073
C6	2007	4.41	7	7.9	22.404
C7	2007	6.40	11	13	10.092
C8	2007	4.10	14	13	27.715
C9	2007	2.78	5.8	7.3	5.622
C10-1	2007	2.68	11	10	37.473
C10-2	2007	2.08	11	10	7.66
C11	2007	1.37	8.4	8.8	22.308
C12	2007	11.3	410	310	67.63

[a] Clam tissue sampling locations are shown on Map 8-1 (in the map folio), as are the co-located sediment exposure areas over which SWACs were calculated.

[b] Intertidal sediment refers to sediment collected from the intertidal areas where clams were collected.

[c] Buffer sediment refers to sediment collected from larger areas that surround the intertidal areas (approximately two times the intertidal area itself).

[d] Co-located sediment refers to sediment collected from the actual locations where clams were collected.

dw – dry weight

ww – wet weight

Table E.5-9. Regression results for inorganic arsenic in clam tissue vs. log(10)-transformed total arsenic in co-located sediment in Table 8-15 of the main body of the RI (2004 data only)

Model Summary

R	R Square	Adjusted R Square	Std Error of the Estimate
0.872	0.761	0.721	0.57090

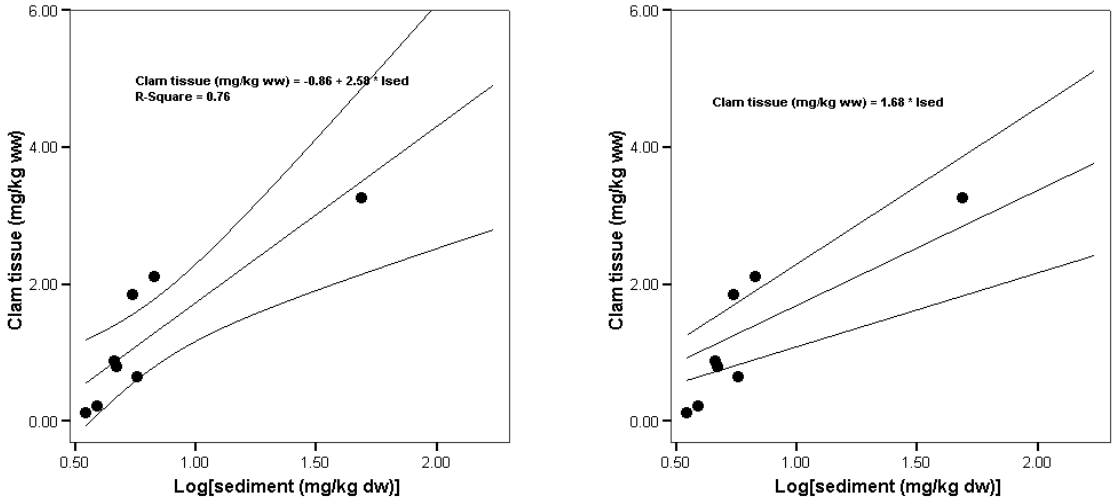
ANOVA

Model Component	Sum of Squares	df	Mean Square	F Statistic	Significance (p value)
Regression	6.211	1	6.211	19.055	.005
Residual	1.956	6	0.326		
Total	8.166	7			

Coefficients

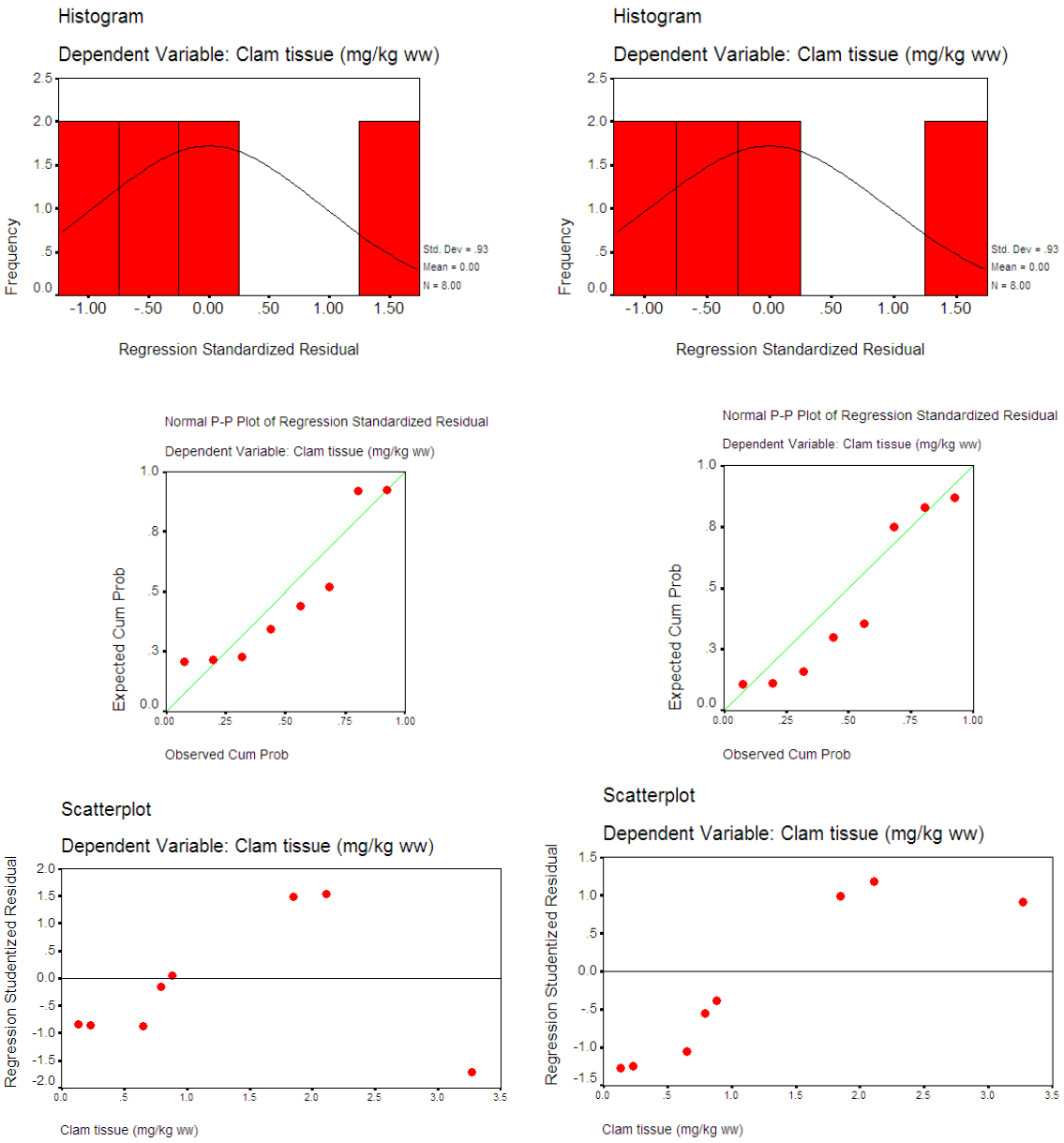
Variable	Unstandardized Coefficients		Standardized Coefficients	T Statistic	Significance (p value)	95% Confidence Interval for B	
	B	Std Error	Beta			Lower Bound	Upper Bound
Constant (intercept)	-0.856	0.521		-1.643	0.152	-2.130	0.419
Log[sediment (µg/kg dw)] (slope)	2.576	0.590	0.872	4.365	0.005	1.132	4.019

Note: P value is the significance of differences among means within a group.
ANOVA – analysis of variance
B – coefficient of intercept or slope
df1 – degrees of freedom for numerator
df2 – degrees of freedom for denominator
R – correlation coefficient
R square – coefficient of determination



Note: Graphs demonstrate effect of removing non significant intercept from previous regression on fit at lower sediment concentrations.

Figure E.5-3. Regression of inorganic arsenic in clam tissue vs. log(10)-transformed total arsenic in co-located sediment regression (2004 data only) with (left) and without (right) intercept



Note: Plots on left correspond to regression including intercept; plots on right correspond to regression through origin.

Figure E.5-4. Regression residuals for inorganic arsenic in clam tissue vs. log(10)-transformed total arsenic in co-located sediment regression (2004 data only): histogram, P-P plot, and scatter plot of regression residuals vs. predicted tissue values using the Shapiro-Wilk normality test

Table E.5-10. Shapiro-Wilk test for normality of residuals in Figure E.5-2, full regression (not through origin)

Residual	Statistic	df	Significance (p value)
Standardized residual	0.805	8	0.032
Studentized residual	0.891	8	0.237

Note: P value is the significance of differences among means within a group.
df – degrees of freedom

Table E.5-11. Regression results for inorganic arsenic in clam tissue vs. log(10)-transformed total arsenic in co-located sediment in Table 8-15 in the main body of the RI: 2004 and 2007 data

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.713	0.508	0.484	1.82911

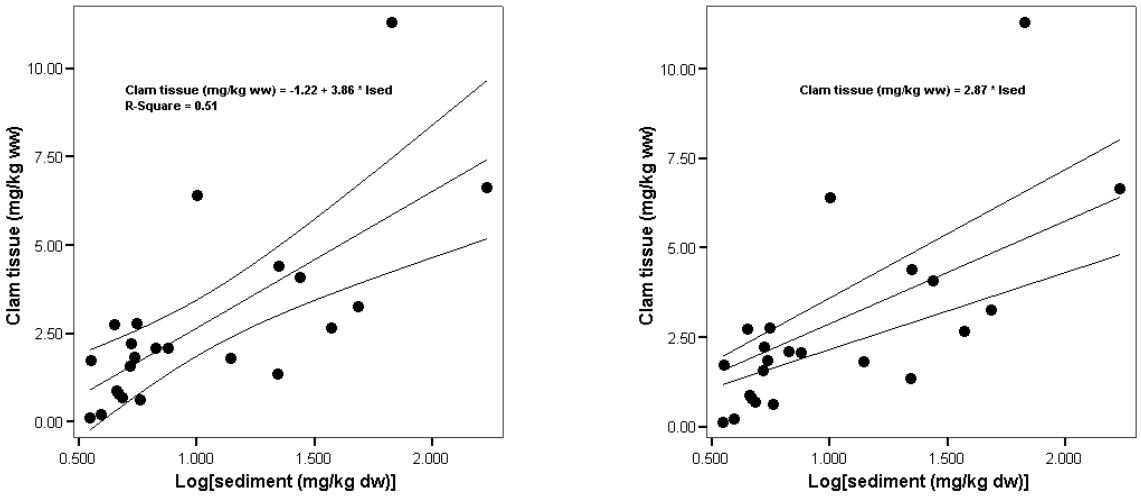
ANOVA

Model Component	Sum of Squares	df	Mean Square	F Statistic	Significance (p value)
Regression	72.484	1	72.484	21.665	0.000
Residual	70.259	21	3.346		
Total	142.743	22			

Coefficients

Variable	Unstandardized Coefficients		Standardized Coefficients	T Statistic	Significance (p value)	95% Confidence Interval for B	
	B	Std Error	Beta			Lower Bound	Upper Bound
Constant (Intercept)	-1.217	0.927		-1.312	0.204	-3.145	0.711
Log[sediment (mg/kg dw)]	3.863	0.830	0.713	4.655	0.000	2.137	5.588

Note: P value is the significance of differences among means within a group.
ANOVA – analysis of variance
B – coefficient of intercept or slope
df1 – degrees of freedom for numerator
df2 – degrees of freedom for denominator
R – correlation coefficient
R square – coefficient of determination



Note; Graphs demonstrate effect of removing non-significant intercept from previous regression on fit at lower sediment concentrations.

Figure E.5-5. Regression of inorganic arsenic in clam tissue vs. log(10)-transformed total arsenic in co-located sediment regression (2004 and 2007) with (left) and without (right) intercept

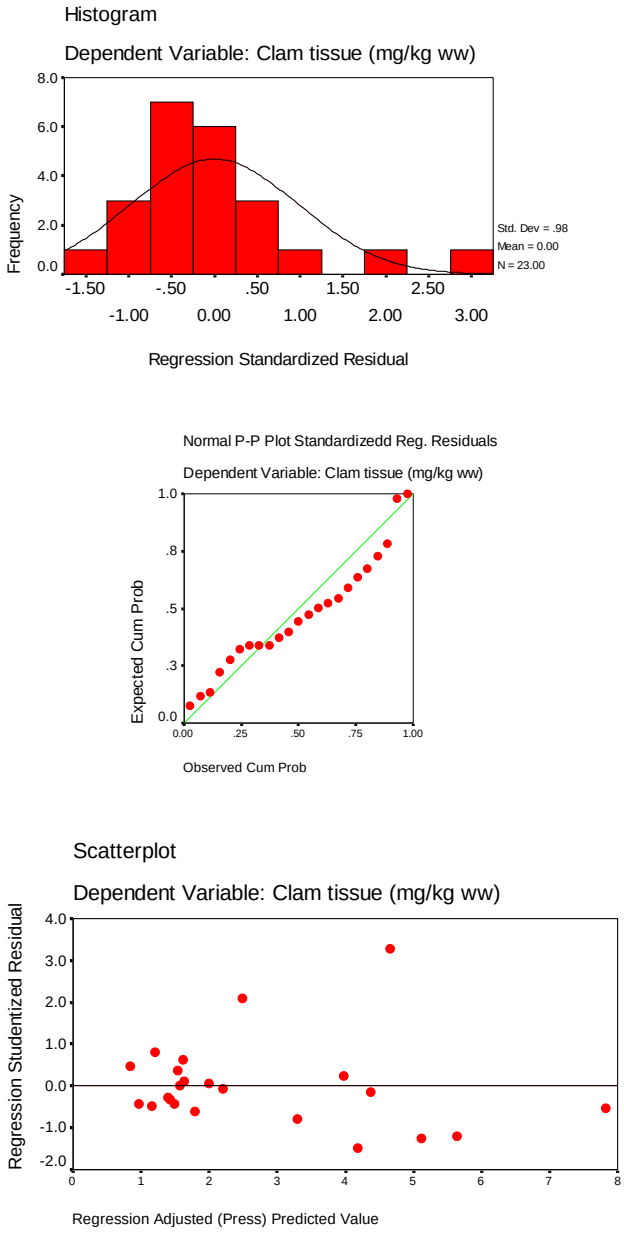


Figure E.5-6. Plots of regression residuals for inorganic arsenic in clam tissue vs. log(10)-transformed total arsenic in co-located sediment regression 2004 to 2007: histogram, P-P plot, and scatter plot of regression residuals vs. predicted tissue values

Table E.5-12. Shapiro-Wilk test of normality of residuals in Figure E.5-4, regression

Residual	Shapiro-Wilk		
	Statistic	df	Significance (p value)
Standardized residual	0.873	23	0.007
Studentized residual	0.864	23	0.005

Note: P value is the significance of differences among means within a group.
df – degrees of freedom

Table E.5-13. Clam tissue and sediment cPAH data used for regressions in Table 8-19 in the main body of the RI

Location	Concentration by Sample Type			
	Clam Tissue (µg/kg ww)[a]	Intertidal Sediment (µg/kg dw)[b]	Buffer Sediment (µg/kg dw)[c]	Co-Located Sediment (µg/kg dw)[a, d]
C2-1	6.8	270	340	220
C10-2	7.6	350	240	190
C10-1	8.3	350	240	290
C2-2	9.3	270	340	34
C3-2	9.7	680	610	110
C6	10	70	80	64
C3-1	11	680	610	130
C1	12	260	370	23
C4	13	500	570	260
C9	14	80	140	63
C7-2	18	1,020	1,680	170
C5	23	320	320	520
C7-1	24	1,020	1,680	220
C8	44	5,170	1,680	7,100

Note: Total cPAHs were calculated by summing the products of concentrations and compound-specific PEFs for individual cPAH compounds, as discussed in detail in Appendix E, Section E.3.

[a] Clam tissue sampling locations are shown on Map 8-2 (in the map folio), as are the co-located sediment exposure areas over which SWACs were calculated.

[b] Intertidal sediment refers to sediment collected from the intertidal areas where clams were collected.

[c] Buffer sediment refers to sediment collected from larger areas that surround the intertidal areas (approximately two times the intertidal area itself).

[d] Co-located sediment refers to sediment collected from the actual locations where clams were collected.

cPAH – carcinogenic polycyclic aromatic hydrocarbon
dw – dry weight

Table E.5-14. Regression results for cPAH in clam tissue vs. log(10)-transformed cPAH in co-located sediment in Table 8-19 in the main body of the RI

Model Summary

R	R Square	Adjusted R Square	Std Error of the Estimate	Change Statistics			
				F Statistic	df1	df2	Sig F Change
0.771	0.594	0.560	6.575	17.546	1	12	.001

ANOVA

Model Component	Sum of Squares	df	Mean Square	F Statistic	Significance (p value)
Regression	758.607	1	758.607	17.546	0.001
Residual	518.828	12	43.236		
Total	1277.435	13			

Coefficients

Variable	Unstandardized Coefficients		Standardized Coefficients	T Statistic	Significance (p value)	95% Confidence Interval for B	
	B	Std Error	Beta			Lower Bound	Upper Bound
Constant (intercept)	-13.542	7.048		-1.921	0.079	-28.899	1.815
Log[sediment (µg/kg dw)] (slope)	12.792	3.054	0.771	4.189	0.001	6.138	19.445

Note: Total cPAHs were calculated by summing the products of concentrations and compound-specific PEFs for individual cPAH compounds, as discussed in detail in Appendix E, Section E.3. P value is the significance of differences among means within a group.

ANOVA – analysis of variance

B – coefficient of intercept or slope

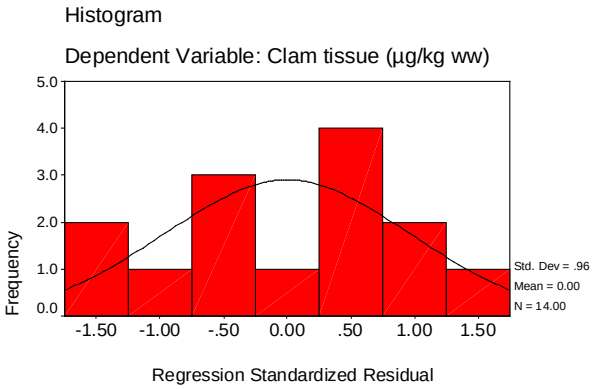
cPAH – carcinogenic polycyclic aromatic hydrocarbon

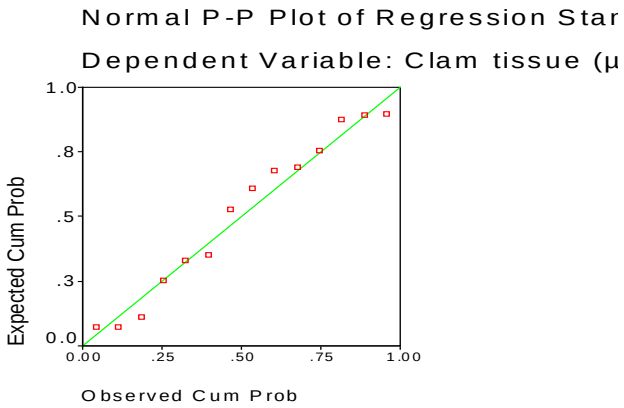
df1 – degrees of freedom for numerator

df2 – degrees of freedom for denominator

R – correlation coefficient

R square – coefficient of determination





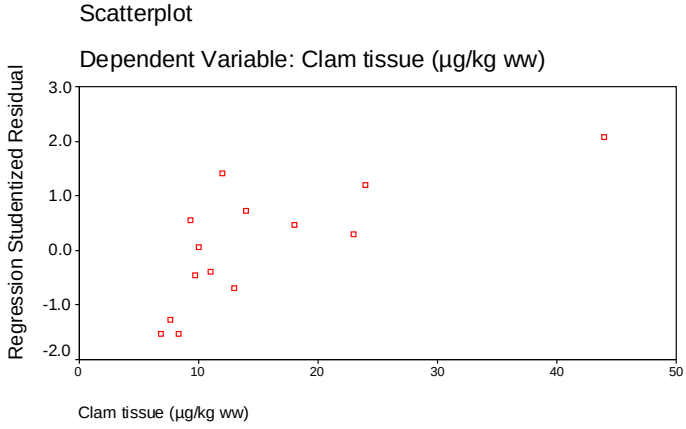


Figure E.5-7. Regression residuals for cPAH in clam tissue vs. log(10)-transformed cPAH in co-located sediment regression: histogram, P-P plot, and scatter plot of regression residuals vs. predicted tissue values

Table E.5-15. Shapiro-Wilk test for normality of residuals in Figure E.5-5

RESIDUAL	STATISTIC	DF	SIGNIFICANCE (p value)
Standardized residual	0.938	14	0.398
Studentized residual	0.938	14	0.397

Note: Total cPAHs were calculated by summing the products of concentrations and compound-specific PEFs for individual cPAH compounds, as discussed in detail in Appendix E, Section E.3. P value is the significance of differences among means within a group.

df – degrees of freedom

REFERENCES

Conover WJ. 1980. Practical nonparametric statistics. 2nd ed. John Wiley & Sons, New York, NY.

E.6 Summary Data Tables

ACRONYMS AND ABBREVIATIONS FOR ALL TABLES

Acronym	Definition
2LAET	second lowest apparent effects threshold
BHC	hexachlorocyclohexane
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSL	cleanup screening level
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
dw	dry weight
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
ID	identification
LAET	lowest apparent effects threshold
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
na	not analyzed or not applicable
nc	not calculated
nd	not detected
nr	not reported
nv	no value
OC	organic carbon
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
RL	reporting limit
SD	storm drain
SMS	Washington State Sediment Management Standards
SQS	sediment quality standard
SVOC	semivolatile organic compound
TOC	total organic carbon
VOC	volatile organic compound
WQS	Washington State Water Quality Standard

DATA QUALIFIERS

C	concentration represents co-elution
J	estimated concentration
M	calculated result
N	tentative identification
U	not detected at reporting limit shown
UJ	not detected at estimated reporting limit shown

NOTES FOR ALL TABLES

Calculated mean concentration is the average of detected concentrations and one-half the RL concentration for non-detected results.

Reporting limits are based only on non-detect samples.

Results for PCB congeners that co-elute with each other are attributed to the PCB congener with the lowest IUPAC number. For example, PCB-129, PCB-160, and PCB-163 co-elute with each other. The concentration for this trio of PCB congeners is shown with PCB-129. For PCB-160 and PCB-163, C129 is shown rather than a concentration to indicate that these PCB congeners co-elute with PCB-129. A similar convention is used for other co-eluting PCB congeners.

E.6.1 SURFACE SEDIMENT

Table E.6.1-1. Summary statistics for surface sediment data

Chemical	Detection Frequency		Concentration						Maximum Detect Location
	Ratio	%	Minimum Detect	Maximum Detect	Median Detect	Calculated Mean	RL or Range of RLs	Unit	
Metals and trace elements									
Aluminum	447/447	100	2,800	110,000	19,000	19,000	na	mg/kg dw	SS-SWY01 SS-SWY02
Antimony	139/593	23	0.09 J	122 J	5	4	0.2 – 31	mg/kg dw	B3b
Arsenic	794/852	93	1.2	1,100	12	17	3.1 – 31	mg/kg dw	LDW-SS114
Barium	414/414	100	9.40	7,400	73	130	na	mg/kg dw	DR027
Beryllium	447/457	98	0.10	0.730	0.4	0.4	0.10 – 0.70	mg/kg dw	DUD203
Cadmium	584/838	70	0.030 J	120	0.5	1	0.04 – 2.5	mg/kg dw	SS-SWY01
Calcium	414/414	100	1,800	49,000	6,000	6,900	nc	mg/kg dw	DR004
Chromium	850/850	100	4.8	1,100 J	30	40	na	mg/kg dw	SS-SWY06
Chromium VI	1/4	25	14 J	14 J	14	6.1	1.1 – 10	mg/kg dw	K-10
Cobalt	597/597	100	2.82	140	9	9	na	mg/kg dw	SD-04115
Copper	852/852	100	5	12,000 J	50	100	na	mg/kg dw	SS-SWY01 SS-SWY02
Iron	445/445	100	8,100	160,000	28,000	28,000	na	mg/kg dw	SS-SWY06
Lead	852/852	100	2	23,000	40	100	na	mg/kg dw	SS-SWY02
Magnesium	424/424	100	2,000	17,000	7,300	7,000	na	mg/kg dw	SD-04913 DR124
Manganese	442/442	100	78.0	3,300	310	340	na	mg/kg dw	SS-SWY02
Mercury	746/868	86	0.021	4.6 J	0.2	0.2	0.02 – 0.10	mg/kg dw	SD-04408
Methylmercury	20/20	100	0.040 J	5.6	0.76	1.1	na	µg/kg dw	NFK004A
Molybdenum	243/302	80	0.3	75	1	3	0.3 – 5.3	mg/kg dw	LDW-SS48
Nickel	812/812	100	5	910	20	30	na	mg/kg dw	SS-SWY06
Potassium	425/425	100	380	11,000	2,400	2,300	na	mg/kg dw	DR209
Selenium	275/670	41	0.2 J	28	6	5	0.20 – 40	mg/kg dw	DR018
Silver	499/823	61	0.020	270	0.4	1	0.046 – 5	mg/kg dw	SS-SWY02
Sodium	414/414	100	580	23,000	9,900	9,400	na	mg/kg dw	DR292
Thallium	319/674	47	0.010 J	32 J	0.1	3	0.030 – 53	mg/kg dw	DUD_2C
Tin	161/249	65	1.0 J	350	5.0	6.0	1.0 – 8	mg/kg dw	DR254
Vanadium	597/597	100	15	150	57	58	na	mg/kg dw	SD-04115
Zinc	849/849	100	16	9,700	110	190	na	mg/kg dw	SS-SWY01
Organometals									

Table E.6.1-1, cont. Summary statistics for surface sediment data

Chemical	Detection Frequency		Concentration						Maximum Detect Location
	Ratio	%	Minimum Detect	Maximum Detect	Median Detect	Calculated Mean	RL or Range of RLs	Unit	
Monobutyltin as ion	90/119	76	0.12 J	120	8.3	14	1.0 – 85	µg/kg dw	B3b
Dibutyltin as ion	108/149	72	0.39 J	560	11	22	1.0 – 49	µg/kg dw	LDW-SS46
Tributyltin as ion	142/158	90	0.28 J	3,000	28	90	1.0 – 5.3	µg/kg dw	LDW-SS46
Tetrabutyltin as ion	15/118	13	0.27 J	58	2.0	3.3	0.60 – 20	µg/kg dw	B1b
Butyltin (total)	29/37	78	70.0	600	190	180	15 – 24	µg/kg dw	DUD027
Alkylated PAHs									
C1-Chrysenes	20/20	100	12	2,100	57	220	na	µg/kg dw	B3b
C1-Dibenzothiophenes	14/20	70	4.6 J	59	12	13	5.0 – 5.5	µg/kg dw	B4a
C1-Fluoranthene/Pyrene	19/20	95	18	4,900	100	490	4.9	µg/kg dw	B3b
C1-Fluorenes	10/20	50	4.5 J	150	6.1	14	5.0 – 7.8	µg/kg dw	B4a
C1-Phenanthrenes/ Anthracenes	20/20	100	8.0	1,700	38	180	na	µg/kg dw	B4a
C2-Chrysenes	20/20	100	8.1	680	51	94	na	µg/kg dw	B3b
C2-Dibenzothiophenes	15/20	75	4.3 J	190	12	24	5.0 – 5.4	µg/kg dw	B4a
C2-Fluorenes	16/20	80	3.4 J	250	11	27	5.0 – 5.4	µg/kg dw	B4a
C2-Naphthalenes	20/20	100	6.2	100	17	21	na	µg/kg dw	B4a
C2-Phenanthrenes/ Anthracenes	20/20	100	8.5	840	35	100	na	µg/kg dw	B4a
C3-Chrysenes	20/20	100	7.3	370	41	63	na	µg/kg dw	B3b
C3-Dibenzothiophenes	16/20	80	7.6	150	21	29	4.9 – 5	µg/kg dw	B3b
C3-Fluorenes	18/20	90	3.9 J	220	15	33	5.0	µg/kg dw	B4a
C3-Naphthalenes	20/20	100	4.4 J	310	26	42	na	µg/kg dw	B4a
C3-Phenanthrenes/ Anthracenes	20/20	100	6.8	420	32	71	na	µg/kg dw	B4a
C4-Chrysenes	17/20	85	7.7	130	21	30	4.9 – 5.0	µg/kg dw	B3b
C4-Naphthalenes	20/20	100	6.0	250	19	34	na	µg/kg dw	B4a
C4-Phenanthrenes/ Anthracenes	20/20	100	5.6	180	29	43	na	µg/kg dw	B3b
PAHs									
1-Methylnaphthalene	23/64	36	1.9 J	110	5.9	26	60 – 110	µg/kg dw	LDW-SS312
2-Chloronaphthalene	0/781	0	nd	nd	nd	29	8.6 – 2,000	µg/kg dw	nd
2-Methylnaphthalene	139/818	17	1.0 J	3,300	30	40	1.0 – 2,000	µg/kg dw	LDW-SS35
Acenaphthene	304/828	37	1.0 J	5,200	40	70	1.8 – 2,000	µg/kg dw	LDW-SS35
Acenaphthylene	128/818	16	1.3 J	500	30	31	1.8 – 2,000	µg/kg dw	LDW-SS312
Anthracene	576/828	70	2.0	10,000	84	100	13 – 2,000	µg/kg dw	LDW-SS95
Benzo(a)anthracene	748/828	90	7.3 J	8,400	200	320	6.4 – 200	µg/kg dw	T117-SE-37-G
Benzo(a)pyrene	747/822	91	6.5	7,900	200	310	6.4 – 350	µg/kg dw	T117-SE-37-G
Benzo(b)fluoranthene	755/822	92	6.6 J	8,200	300	400	6.4 – 450	µg/kg dw	T117-SE-37-G
Benzo(e)pyrene	20/20	100	16	1,300	69	210	na	µg/kg dw	B4a B3b

Table E.6.1-1, cont. Summary statistics for surface sediment data

Chemical	Detection Frequency		Concentration						Maximum Detect Location
	Ratio	%	Minimum Detect	Maximum Detect	Median Detect	Calculated Mean	RL or Range of RLs	Unit	
Benzo(g,h,i)perylene	682/823	83	6.1	3,800	100	200	13 – 2,000	µg/kg dw	C8
Benzo(k)fluoranthene	728/822	89	8.4	8,800	200	300	19 – 450	µg/kg dw	T117-SE-37-G
Benzofluoranthenes (total-calc'd)	757/822	92	6.6 J	17,000	460	740	nc	µg/kg dw	T117-SE-37-G
Chrysene	773/828	93	12	7,700	300	500	18 – 170	µg/kg dw	T117-SE-37-G
Dibenzo(a,h)anthracene	436/828	53	1.6 J	1,500	50	60	1.0 – 2,000	µg/kg dw	C8
Dibenzofuran	248/827	30	1.0 J	4,200	30	50	1.7 – 2,000	µg/kg dw	T117-SE-37-G
Fluoranthene	797/828	96	18	24,000	400	900	19 – 340	µg/kg dw	T117-SE-37-G
Fluorene	382/828	46	1.4 J	6,800	43	79	1.8 – 2,000	µg/kg dw	LDW-SS95
Indeno(1,2,3-cd)pyrene	726/823	88	6.5	4,300	100	200	6.4 – 1,600	µg/kg dw	C8
Naphthalene	152/818	19	3.0 J	5,300	35	49	1.0 – 2,000	µg/kg dw	LDW-SS35
Perylene	20/20	100	9.0	350	47	67	na	µg/kg dw	B3b
Phenanthrene	759/828	92	7.1	28,000	200	400	18 – 200	µg/kg dw	T117-SE-37-G
Pyrene	788/828	95	19	16,000	400	700	18 – 170	µg/kg dw	DR044 T117-SE-37-G
Total HPAH	803/828	97	20	85,000	2,000	4,000	nc	µg/kg dw	T117-SE-37-G
Total LPAH	763/828	92	9.1	44,000	300	700	nc	µg/kg dw	LDW-SS95
Carcinogenic PAHs - Mammal	780/828	94	9.7 J	11,000	300	500	9.0 – 130	µg/kg dw	T117-SE-37-G
Total PAH	805/828	97	20	128,000	2,000	4,000	nc	µg/kg dw	T117-SE-37-G
Phthalates									
Bis(2-ethylhexyl)phthalate	674/832	81	5.4	14,000	300	600	15 – 1,500	µg/kg dw	DUD005
Butyl benzyl phthalate	425/822	52	2.0	7,100	40	80	1.8 – 2,000	µg/kg dw	SD-04116
Diethyl phthalate	41/832	5	2.0 J	150	10	30	1.8 – 2,000	µg/kg dw	SD-322-S
Dimethyl phthalate	156/822	19	2.0 J	200	20	20	1.8 – 2,000	µg/kg dw	R23
Di-n-butyl phthalate	189/822	23	3.0 J	3,800	40	60	1.8 – 2,000	µg/kg dw	SD-04115
Di-n-octyl phthalate	49/832	6	1.8	1,000	40	38	1.8 – 2,000	µg/kg dw	LDW-SS70
Other SVOCs									
1,2,4-Trichlorobenzene	5/816	1	1.6 J	72 J	2.9	20	0.40 – 2,000	µg/kg dw	DUD027
1,2-Dichlorobenzene	17/816	2	1.3 J	520 J	2.4	20	0.40 – 2,000	µg/kg dw	DR008
1,2-Diphenylhydrazine	0/107	0	nd	nd	nd	64	15 – 880	µg/kg dw	nd
1,3-Dichlorobenzene	3/805	<1	2.0 J	11 J	2.5	22	0.40 – 2,000	µg/kg dw	DUD012
1,4-Dichlorobenzene	39/816	5	1.7 J	1,600 J	7.3	20	0.20 – 2,000	µg/kg dw	DUD027
2,4,5-Trichlorophenol	0/771	0	nd	nd	nd	130	8.6 – 4,900	µg/kg dw	nd
2,4,6-Trichlorophenol	0/771	0	nd	nd	nd	120	8.6 – 2,000	µg/kg dw	nd
2,4-Dichlorophenol	0/771	0	nd	nd	nd	79	8.6 – 2,000	µg/kg dw	nd
2,4-Dimethylphenol	5/813	1	6.1	290 J	17	33	6.0 – 2,000	µg/kg dw	DD-2
2,4-Dinitrophenol	0/757	0	nd	nd	nd	210	61 – 4,900	µg/kg dw	nd

Table E.6.1-1, cont. Summary statistics for surface sediment data

Chemical	Detection Frequency		Concentration						Maximum Detect Location
	Ratio	%	Minimum Detect	Maximum Detect	Median Detect	Calculated Mean	RL or Range of RLs	Unit	
2,4-Dinitrotoluene	0/771	0	nd	nd	nd	110	4.6 – 2,000	µg/kg dw	nd
2,6-Dinitrotoluene	0/771	0	nd	nd	nd	110	8.6 – 2,000	µg/kg dw	nd
2-Chlorophenol	0/771	0	nd	nd	nd	29	8.6 – 2,000	µg/kg dw	nd
2-Methylphenol	7/821	1	8.6	58 J	14	28	6.0 – 2,000	µg/kg dw	WQA8AVE
2-Nitroaniline	0/757	0	nd	nd	nd	110	18 – 4,900	µg/kg dw	nd
2-Nitrophenol	0/771	0	nd	nd	nd	99	8.6 – 3,200	µg/kg dw	nd
3,3'-Dichlorobenzidine	0/732	0	nd	nd	nd	120	31 – 2,000	µg/kg dw	nd
3-Nitroaniline	0/749	0	nd	nd	nd	130	18 – 4,900	µg/kg dw	nd
4,6-Dinitro-o-cresol	0/757	0	nd	nd	nd	200	61 – 4,900	µg/kg dw	nd
4-Bromophenyl phenyl ether	1/771	<1	31	31	31	29	8.6 – 2,000	µg/kg dw	LDW-SS23
4-Chloro-3-methylphenol	1/757	<1	6.4 J	6.4 J	6.4	70	8.6 – 2,000	µg/kg dw	C6
4-Chloroaniline	0/726	0	nd	nd	nd	80	8.6 – 2,000	µg/kg dw	nd
4-Chlorophenyl phenyl ether	0/771	0	nd	nd	nd	27	8.6 – 2,000	µg/kg dw	nd
4-Methylphenol	82/831	10	4.8 J	4,600 J	34	44	8.6 – 2,000	µg/kg dw	DUD207
4-Nitroaniline	0/745	0	nd	nd	nd	110	18 – 4,900	µg/kg dw	nd
4-Nitrophenol	0/757	0	nd	nd	nd	110	61 – 4,900	µg/kg dw	nd
Aniline	1/295	<1	13 J	13 J	13	33	18 – 290	µg/kg dw	B6b
Benzaldehyde	6/10	60	120 J	380	200	200	170	µg/kg dw	SB-4
Benzidine	0/7	0	nd	nd	nd	540	310 – 1,700	µg/kg dw	nd
Benzoic acid	70/822	9	54 J	4,500	220	200	13 – 3,000	µg/kg dw	NFK305
Benzyl alcohol	15/812	2	8.2 J	670	27	46	9.2 – 690	µg/kg dw	LDW-SS24
Biphenyl	20/20	100	0.86 J	33	3.0	4.5	na	µg/kg dw	B4a
bis(2-chloroethoxy)methane	1/771	<1	40	40	40	33	8.6 – 2,000	µg/kg dw	DR188
bis(2-chloroethyl)ether	0/771	0	nd	nd	nd	37	8.6 – 2,000	µg/kg dw	nd
bis(2-chloroisopropyl)ether	0/771	0	nd	nd	nd	34	8.6 – 2,000	µg/kg dw	nd
Caffeine	0/26	0	nd	nd	nd	160	6.8 – 2,000	µg/kg dw	nd
Caprolactam	1/10	10	27 J	27 J	27	520	830 – 1,500	µg/kg dw	SB-5
Carbazole	382/737	52	3.2 J	4,200	50	80	19 – 2,000	µg/kg dw	LDW-SS95
Coprostanol	42/102	41	260 J	50,000 J	770	1,000	21 – 2,000	µg/kg dw	DUD027
Dibenzothiophene	20/20	100	0.81 J	150	4.0	13	na	µg/kg dw	B4a
Hexachlorobenzene	46/819	6	0.4 J	95 J	1	10	0.11 – 2,000	µg/kg dw	LDW-SS68
Hexachlorobutadiene	0/818	0	nd	nd	nd	23	0.96 – 2,000	µg/kg dw	nd
Hexachlorocyclopentadiene	1/718	<1	100 J	100 J	100	110	32 – 2,000	µg/kg dw	DR009
Hexachloroethane	0/799	0	nd	nd	nd	33	1.5 – 2,000	µg/kg dw	nd
Isophorone	2/781	<1	26	430	230	31	8.6 – 2,000	µg/kg dw	SH-06
Methyl isobutyl ketone	0/41	0	nd	nd	nd	17	3.0 – 1,100	µg/kg dw	nd

Table E.6.1-1, cont. Summary statistics for surface sediment data

Chemical	Detection Frequency		Concentration						Maximum Detect Location
	Ratio	%	Minimum Detect	Maximum Detect	Median Detect	Calculated Mean	RL or Range of RLs	Unit	
Nitrobenzene	0/771	0	nd	nd	nd	29	8.6 – 2,000	µg/kg dw	nd
N-Nitrosodimethylamine	0/335	0	nd	nd	nd	61	30 – 1,800	µg/kg dw	nd
N-Nitroso-di-n-propylamine	0/771	0	nd	nd	nd	42	8.6 – 2,000	µg/kg dw	nd
N-Nitrosodiphenylamine	23/818	3	6.5	230	8.0	27	1.8 – 2,000	µg/kg dw	DUD021
Pentachlorophenol	12/785	2	14 J	410	100	96	7.6 – 4,900	µg/kg dw	LDW-SSB4a
Phenol	257/831	31	10 J	2,800	70	90	7.3 – 790	µg/kg dw	B8a
Pyridine	0/12	0	nd	nd	nd	440	160 – 2,400	µg/kg dw	nd
Retene	9/16	56	99 J	310 J	230	320	290 – 2,000	µg/kg dw	SB-3
Polychlorinated biphenyls									
PCB-018	72/235	31	1,000 J	170,000 J	2,000	2,700	1,000 – 24,000	ng/kg dw	DR178
PCB-028	137/249	55	1,000 J	160,000 J	2,000	3,700	1,000 – 8,000	ng/kg dw	DR157
PCB-044	163/249	65	1,000 J	190,000 J	2,000	4,200	1,000 – 2,000	ng/kg dw	DR178
PCB-055	181/249	73	1,000 J	890,000 J	3,000	10,000	1,000 – 13,000	ng/kg dw	DR178
PCB-066	217/297	73	73.6	3,060,000	6,000	25,000	1,000 – 250,000	ng/kg dw	LDW-SS109
PCB-077	66/594	11	10.4	80,500	670	790	110 – 15,000	ng/kg dw	LDW-SS109
PCB-081	48/297	16	0.396 J	6,970	22.8	480	1,000 – 10,000	ng/kg dw	LDW-SS109
PCB-090	48/48	100	180 C	11,700,000 C	11,800	327,000	na	ng/kg dw	LDW-SS109
PCB-101	536/592	91	410 J	5,600,000 J	10,000	49,000	120 – 10,000	ng/kg dw	EIT070
PCB-105	431/590	73	61.4	3,660,000	3,000	13,000	120 – 19,000	ng/kg dw	LDW-SS109
PCB-110	310/345	90	220 J	14,500,000 C	8,000	83,000	120 – 6,600	ng/kg dw	LDW-SS109
PCB-113	48/48	100	C90	C90	na	na	na	na	na
PCB-114	53/297	18	2.75	207,000	210	1,400	1,000 – 12,000	ng/kg dw	LDW-SS109
PCB-115	48/48	100	C110	C110	na	na	na	na	na
PCB-118	490/593	83	154	12,000,000	5,600	40,000	120 – 8,300	ng/kg dw	LDW-SS109
PCB-123	48/297	16	2.79	138,000	191	1,290	1,000 – 31,000	ng/kg dw	LDW-SS109
PCB-126	56/593	9	0.758 J	7,980	40	380	100 – 5,000	ng/kg dw	LDW-SS109
PCB-128	293/541	54	350 J	620,000 J	3,000	7,600	130 – 13,000	ng/kg dw	EIT070
PCB-129	48/48	100	320 C	14,000,000 C	16,200	403,000	na	ng/kg dw	LDW-SS109
PCB-138	529/594	89	210 J	1,400,000	7,000	20,000	130 – 19,000	ng/kg dw	EIT070
PCB-153	541/591	92	258 C	9,090,000C	10,000	57,000	120 – 11,000	ng/kg dw	LDW-SS109
PCB-156	257/594	43	27.5 C	1,790,000 C	1,200	5,600	80 – 10,000	ng/kg dw	LDW-SS109
PCB-157	109/592	18	410	56,000	1,900	830	80 – 27,000	ng/kg dw	EIT070
PCB-160	48/48	100	C129	C129	na	na	na	na	na
PCB-163	48/48	100	C129	C129	na	na	na	na	na
PCB-167	84/297	28	10.6	515,000	1,000	3,100	1,000 – 10,000	ng/kg dw	LDW-SS109
PCB-168	48/48	100	C153	C153	na	na	na	na	na

Table E.6.1-1, cont. Summary statistics for surface sediment data

Chemical	Detection Frequency		Concentration						Maximum Detect Location
	Ratio	%	Minimum Detect	Maximum Detect	Median Detect	Calculated Mean	RL or Range of RLs	Unit	
PCB-169	0/594	0	nd	nd	nd	410	0.399 – 10,000	ng/kg dw	nd
PCB-170	415/546	76	190 J	460,000	3,700	9,000	80 – 14,000	ng/kg dw	WES236
PCB-180	496/594	84	155 C	1,600,000 C	5,600	21,000	110 – 9,500	ng/kg dw	LDW-SS109
PCB-187	207/249	83	1,000	360,000 J	3,000	6,000	1,000 – 6,000	ng/kg dw	DR207
PCB-189	72/594	12	3.06	65,700	290	640	110 – 10,000	ng/kg dw	LDW-SS109
PCB-193	48/48	100	C180	C180	na	na	na	na	na
PCB-195	31/249	12	1,000 J	49,000 J	1,000	1,100	1,000 – 10,000	ng/kg dw	DR207
PCB-206	41/249	16	1,000	27,000	1,000	920	1,000 – 10,000	ng/kg dw	DR217
PCB-209	7/249	3	1,000	2,000	1,000	540	1,000 – 10,000	ng/kg dw	DR007 DR081
Aroclor-1016	0/1020	0	nd	nd	nd	30	0.87 – 3,400	µg/kg dw	nd
Aroclor-1221	0/894	0	nd	nd	nd	31	1.9 – 5,500	µg/kg dw	nd
Aroclor-1232	0/894	0	nd	nd	nd	25	0.87 – 3,400	µg/kg dw	nd
Aroclor-1242	108/1021	11	7.8 J	2,700	41	49	0.87 – 6,100	µg/kg dw	LDW-SS143
Aroclor-1248	228/1030	22	6.3	220,000	82	360	0.87 – 4,300	µg/kg dw	NFK305
Aroclor-1254	817/1022	80	2.2	110,000	80	500	1.3 – 4,300	µg/kg dw	LDW-SS109
Aroclor-1254/1260	8/8	100	37	800	120	180	na	µg/kg dw	SH-05
Aroclor-1260	823/1022	81	1.2 J	38,000	80	600	3.9 – 15,000	µg/kg dw	T117-SE-21-G
Aroclor-1262	2/12	17	270	840	560	97	3.3 – 20	µg/kg dw	SD-SWY12
Aroclor-1268	1/11	9	460 J	460 J	460	47	3.3 – 20	µg/kg dw	SD-DUW44
PCBs (total calc'd)	1243/1327	94	1.6 J	220,000	150	1,200	nc	µg/kg dw	NFK305
PCBs + PCTs (total)	294/297	99	1.6	26,000	110	400	0.56 – 0.63	µg/kg dw	EIT070
PCTs (total)	258/299	86	1.8 J	5,600	16	49	1.6 – 8.1	µg/kg dw	EIT076
PCB TEQ - Bird	48/48	100	0.646 J	6,210	30.3	289	na	ng/kg dw	LDW-SS109
PCB TEQ - Fish	48/48	100	0.00635 J	143.0	0.285	4.45	na	ng/kg dw	LDW-SS109
PCB TEQ - Mammal	48/48	100	0.0908 J	1,380	3.50	45.9	na	ng/kg dw	LDW-SS109
Pesticides									
2,4'-DDD	5/93	5	1.6 JN	10 JN	7.0	2.0	0.97 – 34	µg/kg dw	C10-1
2,4'-DDE	2/93	2	2.8 JN	11 JN	6.9	1.7	0.97 – 34	µg/kg dw	B7a
2,4'-DDT	29/93	31	0.24 JN	11 JN	3.9	5.1	1.9 – 460	µg/kg dw	C7-2
4,4'-DDD	66/193	34	0.29 JN	840	4.1	11	0.81 – 540	µg/kg dw	DR178
4,4'-DDE	29/193	15	0.28 JN	370 J	3.1	6.8	0.81 – 800	µg/kg dw	DR178
4,4'-DDT	40/193	21	0.48 JN	1,700	8.0	14	0.81 – 56	µg/kg dw	DR178
DDTs (total-calc'd)	76/193	39	0.72 JN	2,900 J	8.5	28	nc	µg/kg dw	DR178
Aldrin	4/193	2	0.014 J	1.6 JN	0.60	1.1	0.40 – 56	µg/kg dw	B3b
Dieldrin	8/193	4	0.099 J	280	6.5	3.6	0.81 – 91	µg/kg dw	DR178

Table E.6.1-1, cont. Summary statistics for surface sediment data

Chemical	Detection Frequency		Concentration						Maximum Detect Location
	Ratio	%	Minimum Detect	Maximum Detect	Median Detect	Calculated Mean	RL or Range of RLs	Unit	
Total aldrin/dieldrin	11/193	6	0.113 J	280	2.3	3.6	nc	µg/kg dw	DR178
alpha-BHC	3/193	2	0.14 J	1.8 JN	0.81	1.1	0.40 – 56	µg/kg dw	B8a
beta-BHC	4/193	2	0.087 J	13	1.6	1.2	0.40 – 56	µg/kg dw	DR178
gamma-BHC	11/193	6	0.050 J	6.7 JN	1.2	1.2	0.40 – 56	µg/kg dw	C8
delta-BHC	3/155	2	0.081 J	11 JN	0.42	1.1	0.40 – 56	µg/kg dw	C8
alpha-Chlordane	13/149	9	0.10 JN	36	0.25	1.4	0.72 – 30	µg/kg dw	LDW-SS85
gamma-Chlordane	25/149	17	0.20 JN	200	3.2	4.9	0.72 – 96	µg/kg dw	DR178
Chlordane	5/44	11	25	62	40	17	7.7 – 330	µg/kg dw	DUD005
Total chlordane	28/149	19	0.20 JN	230	2.8	6.9	nc	µg/kg dw	DR178
alpha-Endosulfan	9/147	6	0.18 JN	71 JN	0.29	1.8	0.40 – 100	µg/kg dw	C8
beta-Endosulfan	3/149	2	0.47 J	10 JN	0.54	2.5	0.81 – 200	µg/kg dw	B5a-2
Endosulfan	1/46	2	0.11 J	0.11 J	0.11	2.2	0.81 – 56	µg/kg dw	SH-06
Endosulfan sulfate	3/191	2	0.63 JN	25 JN	0.84	2.2	0.81 – 200	µg/kg dw	B7a
Endrin	4/193	2	0.99 JN	9.1	3.0	2.2	0.81 – 200	µg/kg dw	SH-06
Endrin aldehyde	6/182	3	0.28 JN	130	6.3	3.6	0.81 – 250	µg/kg dw	DR178
Endrin ketone	7/137	5	0.83 JN	110 JN	1.5	3.6	0.81 – 200	µg/kg dw	C10-2
Heptachlor	6/193	3	0.12 J	5.2	1.8	1.3	0.43 – 70	µg/kg dw	K-03
Heptachlor epoxide	5/193	3	0.47 JN	4.9 JN	1.0	2.7	0.40 – 510	µg/kg dw	B5b
Methoxychlor	11/193	6	0.34 JN	99	2.0	6.7	0.97 – 330	µg/kg dw	DR178
Mirex	3/93	3	0.29 JN	1.0 JN	0.37	1.3	0.97 – 34	µg/kg dw	C10-2
Cis-Nonachlor	0/58	0	nd	nd	nd	4.6	1.9 – 330	µg/kg dw	nd
Trans-Nonachlor	0/58	0	nd	nd	nd	1.5	1.9 – 34	µg/kg dw	nd
Oxychlordane	0/58	0	nd	nd	nd	1.6	1.9 – 34	µg/kg dw	nd
Toxaphene	2/191	1	340 JN	6,300 JN	3,300	110	1.0 – 4,300	µg/kg dw	B8a
Grain size									
Fractional % (>9525 µm)	0/249	0	nd	nd	nd	0.0050	0.01	% dw	nd
Fractional % phi >-3 (>8,000 µm)	4/5	80	1.5	4	2	2	0.1	% dw	R22
Fractional % phi >-2 (>4,000 µm)	12/13	92	0.2	3	0.6	0.9	0.1	% dw	DUD_5C
Fractional % phi >-1 (>2,000 µm)	274/294	93	0.010	81.5	2	6	0.1	% dw	JHGSA-SD1-02-0010
Fractional % phi -3-(-2) (4,000-8,000 µm)	11/12	92	0.20	2	1	1	0.1	% dw	R18 R22
Fractional % phi -2-(-1) (2,000-4,000 µm)	210/290	72	0.010	14	0.4	0.9	0.01 – 0.1	% dw	DR209
Fractional % phi -1-0 (1,000-2,000 µm)	744/805	92	0.020 J	37	2	2	0.01 – 0.1	% dw	DR257
Fractional % phi 0-1 (500-1,000 µm)	809/823	98	0.2	63	3	6	0.01	% dw	DR298
Fractional % phi 1-2 (250-500 µm)	812/824	99	0.44 J	63.9	9	10	0.01	% dw	LDW-SS156

Table E.6.1-1, cont. Summary statistics for surface sediment data

Chemical	Detection Frequency		Concentration						Maximum Detect Location
	Ratio	%	Minimum Detect	Maximum Detect	Median Detect	Calculated Mean	RL or Range of RLs	Unit	
Fractional % phi 2-3 (125-250 µm)	818/824	99	0.46 J	39.4	8	10	0.01	% dw	LDW-SS144
Fractional % phi 3-4 (62.5-125 µm)	827/830	100	0.090	36	9	10	0.01 – 0.1	% dw	DR167
Fractional % phi 4-5 (31.2-62.5 µm)	810/821	99	0.060 J	31	10	10	0.01 – 0.1	% dw	R69 R88
Fractional % phi 5-6 (15.6-31.2 µm)	803/820	98	0.1	49	10	10	0.01 – 0.1	% dw	R14
Fractional % phi 6-7 (7.8-15.6 µm)	805/820	98	0.030 J	42.3	10	10	0.01 – 0.1	% dw	DUD_2C
Fractional % phi 7-8 (3.9-7.8 µm)	801/820	98	0.070 J	22.6	6	7	0.01 – 0.1	% dw	DUD_8C
Fractional % phi 8-9 (1.95-3.9 µm)	799/820	97	0.1	26	3	4	0.01 – 0.1	% dw	SD-2
Fractional % phi 9+ (<1.95 µm)	6/6	100	1.45	10.7	9.50	7.19	na	% dw	T117-SE-86-G
Fractional % phi 9-10 (0.98-1.95 µm)	792/820	97	0.010	12	2	3	0.01 – 0.1	% dw	SD-2
Fractional % phi 10+ (<0.98 µm)	770/814	95	0.23 J	23.6	5	5	0.01 – 0.1	% dw	LDW-SS315
Fractional % Sieve #10 (2,000-4,750 µm)	109/179	61	1.0	25	2.0	2.2	0.01	% dw	SD-04402
Fractional % Sieve 3/8in (4,750-9,525 µm)	54/249	22	0.020	59	1.1	0.77	0.01	% dw	DR124
Fractional % Sieve #4 (>4,750 µm)	78/179	44	1.0	47	3.0	3.9	0.01	% dw	SD-04107 SD-SWY05
Gravel (total calc'd)	606/764	79	0.010	81.5	2	4	nc	% dw	JHGSA-SD1-02-0010
Sand (total calc'd)	1247/1247	100	0.22	100	40	40	nc	% dw	NFK014 EST103 DR297
Silt (total calc'd)	1240/1251	99	0.1	80	50	40	nc	% dw	R38 R48
Clay (total calc'd)	1226/1250	98	0.1	55	10	10	nc	% dw	SD-2
Gravel	298/423	70	0.010	60	0.8	3	0.01 – 0.1	% dw	EIT070
Coarse Sand (4750-2000 microns)	11/11	100	0.200	24.5	11.8	10.3	na	% dw	T117-SE-37-G
Medium Sand (2000-425 microns)	11/11	100	3.80	52.3	12.9	18.2	na	% dw	T117-SE-89-G
Fine Sand (425-75 microns)	11/11	100	2.70	71.1	19.3	21.4	na	% dw	T117-SE-08-G
Fines (percent silt+clay)	812/821	99	0.1	100	60	50	0.01 – 0.1	% dw	R48
Conventional parameters									
Total organic carbon (TOC)	1336/1336	100	0.032	11.5	2	2	na	% dw	SG01
Total solids	551/551	100	29	94.0	55	57	na	% ww	NFK302
Total solids (preserved)	160/160	100	30.60	92.00	50.90	52.83	na	% ww	LDW-SS151
Sulfides (total)	134/229	59	2.0 J	7,700	100	200	0.68 – 46	mg/kg dw	LDW-SS78
Acid volatile sulfides	41/52	79	88 J	6,100 J	1,700	1,600	48 – 89	mg/kg dw	DUD010
Ammonia	14/14	100	5.40	20.3	8.6	11	na	mg/kg dw	DUD032
Ammonia (total as nitrogen)	156/160	98	0.18	39.1	6.4	8.1	0.10 – 0.12	mg-N/kg	LDW-SS72

Table E.6.1-1, cont. Summary statistics for surface sediment data

Chemical	Detection Frequency		Concentration						Maximum Detect Location
	Ratio	%	Minimum Detect	Maximum Detect	Median Detect	Calculated Mean	RL or Range of RLs	Unit	
Cyanide	0/4	0	nd	nd	nd	0.24	0.44 – 0.51	mg/kg dw	nd
Moisture	5/5	100	34.4	48.8	37.6	39.5	na	% ww	T117-SE-08-G
pH	154/154	100	4.6	8.7	7.4	7.5	na	pH	SD-04907
Salinity	14/14	100	14	27.0	27	24	na	g/kg ww	DUD018 DUD033 DUD031 DUD029 DUD025 DUD021 DUD016 DUD023
Volatile organic compounds									
1,1,1,2-Tetrachloroethane	0/36	0	nd	nd	nd	8.7	1.5 – 530	µg/kg dw	nd
1,1,1-Trichloroethane	0/41	0	nd	nd	nd	8.2	1.4 – 530	µg/kg dw	nd
1,1,2,2-Tetrachloroethane	0/41	0	nd	nd	nd	8.2	1.4 – 530	µg/kg dw	nd
1,1,2-Trichloroethane	0/41	0	nd	nd	nd	15	1.4 – 1,100	µg/kg dw	nd
1,1,2-Trichlorotrifluoroethane	0/39	0	nd	nd	nd	20	1.5 – 1,100	µg/kg dw	nd
1,1-Dichloroacetone	0/34	0	nd	nd	nd	45	3.0 – 2,700	µg/kg dw	nd
1,1-Dichloroethane	0/41	0	nd	nd	nd	8.2	1.4 – 530	µg/kg dw	nd
1,1-Dichloroethene	0/41	0	nd	nd	nd	16	1.4 – 1,100	µg/kg dw	nd
1,1-Dichloropropene	0/36	0	nd	nd	nd	8.7	1.5 – 530	µg/kg dw	nd
1,2,3-Trichlorobenzene	0/36	0	nd	nd	nd	18	2.4 – 1,100	µg/kg dw	nd
1,2,3-Trichloropropane	0/36	0	nd	nd	nd	18	1.5 – 1,100	µg/kg dw	nd
1,2,4-Trimethylbenzene	0/36	0	nd	nd	nd	8.7	1.5 – 530	µg/kg dw	nd
1,2-Dibromo-3-chloropropane	0/36	0	nd	nd	nd	20	4.6 – 1,100	µg/kg dw	nd
1,2-Dibromoethane (EDB)	0/36	0	nd	nd	nd	17	1.5 – 1,100	µg/kg dw	nd
1,2-Dichloroethane	0/41	0	nd	nd	nd	8.2	1.4 – 530	µg/kg dw	nd
1,2-Dichloroethene (total)	0/2	0	nd	nd	nd	12	23 – 24	µg/kg dw	nd
1,2-Dichloropropane	0/41	0	nd	nd	nd	8.2	1.4 – 530	µg/kg dw	nd
1,3,5-Trimethylbenzene	0/36	0	nd	nd	nd	8.7	1.5 – 530	µg/kg dw	nd
1,3-Dichloropropane	0/36	0	nd	nd	nd	8.7	1.5 – 530	µg/kg dw	nd
1-Chlorobutane	0/36	0	nd	nd	nd	8.7	1.5 – 530	µg/kg dw	nd
2,2-Dichloropropane	0/36	0	nd	nd	nd	8.7	1.5 – 530	µg/kg dw	nd
2-Chloroethyl vinyl ether	0/3	0	nd	nd	nd	4.7	7.0 – 12	µg/kg dw	nd
2-Chlorotoluene	0/36	0	nd	nd	nd	8.7	1.5 – 530	µg/kg dw	nd
2-Hexanone	0/41	0	nd	nd	nd	29	3.0 – 2,100	µg/kg dw	nd

Table E.6.1-1, cont. Summary statistics for surface sediment data

Chemical	Detection Frequency		Concentration						Maximum Detect Location
	Ratio	%	Minimum Detect	Maximum Detect	Median Detect	Calculated Mean	RL or Range of RLs	Unit	
2-Nitropropane	0/36	0	nd	nd	nd	44	7.6 – 2,700	µg/kg dw	nd
4-Chlorotoluene	0/36	0	nd	nd	nd	8.7	1.5 – 530	µg/kg dw	nd
Acetone	3/41	7	110 J	1,000 J	160	310	11 – 21,000	µg/kg dw	DR047
Allyl chloride	0/36	0	nd	nd	nd	17	1.5 – 1,100	µg/kg dw	nd
Benzene	0/41	0	nd	nd	nd	8.2	1.4 – 530	µg/kg dw	nd
Bromobenzene	0/36	0	nd	nd	nd	8.7	1.5 – 530	µg/kg dw	nd
Bromochloromethane	0/36	0	nd	nd	nd	17	1.5 – 1,100	µg/kg dw	nd
Bromodichloromethane	0/41	0	nd	nd	nd	8.2	1.4 – 530	µg/kg dw	nd
Bromoform	0/41	0	nd	nd	nd	37	1.4 – 2,700	µg/kg dw	nd
Bromomethane	0/41	0	nd	nd	nd	72	2.8 – 5,300	µg/kg dw	nd
Carbon disulfide	12/41	29	0.84 J	4.0 J	1.4	16	1.4 – 1,100	µg/kg dw	DR178
Carbon tetrachloride	0/41	0	nd	nd	nd	8.2	1.4 – 530	µg/kg dw	nd
Chloroacetonitrile	0/2	0	nd	nd	nd	7.9	7.6 – 24	µg/kg dw	nd
Chlorobenzene	0/41	0	nd	nd	nd	8.2	1.4 – 530	µg/kg dw	nd
Chloroethane	0/41	0	nd	nd	nd	140	2.8 – 11,000	µg/kg dw	nd
Chloroform	0/41	0	nd	nd	nd	8.2	1.4 – 530	µg/kg dw	nd
Chloromethane	0/41	0	nd	nd	nd	16	1.5 – 1,100	µg/kg dw	nd
cis-1,2-Dichloroethene	0/39	0	nd	nd	nd	8.1	1.4 – 530	µg/kg dw	nd
cis-1,3-Dichloropropene	0/41	0	nd	nd	nd	8.7	1.4 – 560	µg/kg dw	nd
p-Cymene	3/36	8	1.6 J	25	1.6	9.3	1.5 – 530	µg/kg dw	DR111
Dibromochloromethane	0/41	0	nd	nd	nd	36	1.4 – 2,700	µg/kg dw	nd
Dibromomethane	0/36	0	nd	nd	nd	17	1.5 – 1,100	µg/kg dw	nd
Dichlorodifluoromethane	0/7	0	nd	nd	nd	1.0	1.5 – 3.3	µg/kg dw	nd
Dichloromethane	1/41	2	1,600	1,600	1,600	44	2.8 – 21	µg/kg dw	DR008
Diethyl ether	0/36	0	nd	nd	nd	17	1.5 – 1,100	µg/kg dw	nd
Ethyl Methacrylate	0/36	0	nd	nd	nd	17	1.5 – 1,100	µg/kg dw	nd
Ethylbenzene	0/41	0	nd	nd	nd	8.2	1.4 – 530	µg/kg dw	nd
Iodomethane	0/36	0	nd	nd	nd	17	1.5 – 1,100	µg/kg dw	nd
Isopropylbenzene	0/36	0	nd	nd	nd	12	2.3 – 530	µg/kg dw	nd
Methacrylonitrile	0/36	0	nd	nd	nd	20	4.6 – 1,100	µg/kg dw	nd
Methyl Acrylate	0/36	0	nd	nd	nd	12	2.3 – 530	µg/kg dw	nd
Methyl ethyl ketone	15/41	37	5.3	35	14	21	3.0 – 1,100	µg/kg dw	DR154
Methyl Methacrylate	0/36	0	nd	nd	nd	9.4	2.3 – 530	µg/kg dw	nd
n-Butylbenzene	0/36	0	nd	nd	nd	8.7	1.5 – 530	µg/kg dw	nd
n-Propylbenzene	0/36	0	nd	nd	nd	8.7	1.5 – 530	µg/kg dw	nd
Pentachloroethane	0/36	0	nd	nd	nd	17	1.5 – 1,100	µg/kg dw	nd

Table E.6.1-1, cont. Summary statistics for surface sediment data

Chemical	Detection Frequency		Concentration						Maximum Detect Location
	Ratio	%	Minimum Detect	Maximum Detect	Median Detect	Calculated Mean	RL or Range of RLs	Unit	
sec-Butylbenzene	0/36	0	nd	nd	nd	8.7	1.5 – 530	µg/kg dw	nd
Styrene	0/41	0	nd	nd	nd	15	1.4 – 1,100	µg/kg dw	nd
Tert-butyl methyl ether	0/36	0	nd	nd	nd	8.9	1.5 – 530	µg/kg dw	nd
tert-Butylbenzene	0/36	0	nd	nd	nd	8.7	1.5 – 530	µg/kg dw	nd
Tetrachloroethene	2/41	5	0.21 J	0.52 J	0.36	8.2	1.4 – 530	µg/kg dw	DR297
Toluene	3/41	7	1.0 J	2.2 J	1.5	8.3	1.4 – 530	µg/kg dw	DR011
trans-1,2-Dichloroethene	0/39	0	nd	nd	nd	8.1	1.4 – 530	µg/kg dw	nd
trans-1,3-Dichloropropene	0/41	0	nd	nd	nd	8.4	1.4 – 500	µg/kg dw	nd
trans-1,4-Dichloro-2-butene	0/34	0	nd	nd	nd	46	7.6 – 2,700	µg/kg dw	nd
Trichloroethene	0/41	0	nd	nd	nd	8.2	1.4 – 530	µg/kg dw	nd
Trichlorofluoromethane	0/39	0	nd	nd	nd	77	1.5 – 5,300	µg/kg dw	nd
Vinyl acetate	0/3	0	nd	nd	nd	4.7	7.0 – 12	µg/kg dw	nd
Vinyl chloride	0/41	0	nd	nd	nd	37	1.5 – 2,700	µg/kg dw	nd
Xylene (ortho)	0/39	0	nd	nd	nd	8.1	1.4 – 530	µg/kg dw	nd
Xylene (meta & para)	0/39	0	nd	nd	nd	17	1.4 – 1,100	µg/kg dw	nd
Xylene (total)	0/2	0	nd	nd	nd	12	23 – 24	µg/kg dw	nd
Total Xylenes	0/39	0	nd	nd	nd	17	nc	µg/kg dw	nd
Dioxin/furan									
2,3,7,8-TCDD	22/47	47	0.0890 J	30.6	0.78	1.6	0.27 – 1.1	ng/kg dw	LDW-SS84
1,2,3,7,8-PeCDD	24/47	51	0.284 J	57.1	2.2	4.7	0.53 – 4.1	ng/kg dw	LDW-SS84
1,2,3,4,7,8-HxCDD	24/47	51	0.382 J	124	3.6	9.2	0.72 – 5.4	ng/kg dw	LDW-SS56
1,2,3,6,7,8-HxCDD	39/47	83	1.73 J	3,400	13	120	0.74 – 4.1	ng/kg dw	LDW-SS56
1,2,3,7,8,9-HxCDD	35/47	74	1.19 J	315	10	27	0.84 – 4.8	ng/kg dw	LDW-SS56
1,2,3,4,6,7,8-HpCDD	45/47	96	41.4 J	73,700	290	2,800	0.99 – 1.1	ng/kg dw	LDW-SS56
OCDD	47/47	100	7.8 J	241,000	2,700	18,000	na	ng/kg dw	LDW-SS56
2,3,7,8-TCDF	38/47	81	0.426 J	397	2.1	14	0.18 – 1.4	ng/kg dw	LDW-SS37
1,2,3,7,8-PeCDF	23/47	49	0.214 J	69.3	1.30	5.02	0.28 – 5.0	ng/kg dw	LDW-SS56
2,3,4,7,8-PeCDF	24/47	51	0.392 J	230	3.8	17	0.44 – 5.4	ng/kg dw	LDW-SS56
1,2,3,4,7,8-HxCDF	34/47	72	0.694 J	2,530	9.4	130	0.29 – 4.2	ng/kg dw	LDW-SS56
1,2,3,6,7,8-HxCDF	24/47	51	0.335 J	365	3.6	23	0.22 – 4.3	ng/kg dw	LDW-SS56
1,2,3,7,8,9-HxCDF	22/47	47	0.0730 J	33.8 J	0.340	1.97	0.12 – 2.4	ng/kg dw	LDW-SS56
2,3,4,6,7,8-HxCDF	24/47	51	0.307 J	302 J	2.4	14	0.29 – 2.5	ng/kg dw	LDW-SS56
1,2,3,4,6,7,8-HpCDF	44/47	94	6.71	40,300	52	1,200	0.62 – 7.7	ng/kg dw	LDW-SS56
1,2,3,4,7,8,9-HpCDF	31/47	66	0.421 J	3,720	6.6	120	0.77 – 4.2	ng/kg dw	LDW-SS56
OCDF	46/47	98	12.5	93,700	160	3,000	0.74	ng/kg dw	LDW-SS56
Total TCDD	19/24	79	0.95	18	5.2	4.6	0.34 – 1.1	ng/kg dw	DR008

Table E.6.1-1, cont. Summary statistics for surface sediment data

Chemical	Detection Frequency		Concentration						Maximum Detect Location
	Ratio	%	Minimum Detect	Maximum Detect	Median Detect	Calculated Mean	RL or Range of RLs	Unit	
Total PeCDD	1/24	4	49	49	49	3.7	1.4 – 8.5	ng/kg dw	DR008
Total HxCDD	22/24	92	7.5	1,100	69	100	1.1 – 1.7	ng/kg dw	DR008
Total HpCDD	22/24	92	120	11,000	540	940	0.99 – 1.9	ng/kg dw	DR008
Total TCDF	22/24	92	3.0	95	26	26	0.28 – 0.32	ng/kg dw	DR008
Total PeCDF	21/24	88	4.9	180	23	28	0.71 – 3.9	ng/kg dw	DR008
Total HxCDF	22/24	92	6.2	1,200	44	92	0.36 – 0.45	ng/kg dw	DR008
Total HpCDF	22/24	92	18	3,900	120	280	0.84 – 2.2	ng/kg dw	DR008
Dioxin/furan TEQ - Bird	47/47	100	1.4 J	1,230 J	8.6	77	na	ng/kg dw	LDW-SS56
Dioxin/furan TEQ - Fish	47/47	100	1.110 J	1,130 J	6.3	57	na	ng/kg dw	LDW-SS56
Dioxin/furan TEQ - Mammal	47/47	100	1.1 J	2,100 J	10	93	na	ng/kg dw	LDW-SS56
Petroleum groups									
Gasoline	2/7	29	130	260	200	59	10	mg/kg dw	SD-04122
TPH - Gasoline Range	0/2	0	nd	nd	nd	10	20	mg/kg dw	nd
TPH - Diesel Range	2/2	100	68	81	75	75	na	mg/kg dw	SD-04121
TPH - Diesel #2 Range	0/5	0	nd	nd	nd	5.0	10	mg/kg dw	nd
Lube Oils	0/4	0	nd	nd	nd	5.0	10	mg/kg dw	nd
TPH - Heavy Fuel Oil Range	2/3	67	250	370	310	210	10	mg/kg dw	SD-04121
TPH	49/55	89	23	23,000	560	1,700	20	mg/kg dw	SS-SWY05 SS-SWY06
Total Petroleum Hydrocarbons	2/2	100	68	81	75	75	nc	mg/kg dw	SD-04121

Table E.6.1-2. Summary surface sediment statistics and comparisons to SMS criteria for chemicals with OC-normalized criteria

Chemical[a]	Detection Frequency[b]		Concentration (mg/kg OC)					Maximum Detect Location	SMS Criteria (mg/kg OC)		Comparison to SMS Criteria (Number of Locations)			
	Ratio	%	Minimum Detect	Maximum Detect	Median Detect	Calculated Mean	RL or Range of RLs		SQS	CSL	Detect > SQS and ≤ CSL	Detect > CSL	Nondetect > SQS and ≤ CSL	Nondetect > CSL
PAHs														
2-Methylnaphthalene	123/753	16	0.090	160	1	2	0.059 – 94	LDW-SS35	38	64	0	2	6	1
Acenaphthene	283/760	37	0.064 J	260	2	3	0.059 – 94	LDW-SS35	16	57	14	3	9	2
Acenaphthylene	118/753	16	0.12 J	9.2	1.5	1.6	0.059 – 94	B4a	66	66	0	0	0	1
Anthracene	548/760	72	0.10	380	4	7	0.65 – 94	LDW-SS95	220	1,200	2	0	0	0
Benzo(a)anthracene	712/760	94	0.44	440	10	20	0.29 – 34	T117-SE-37-G	110	270	7	1	0	0
Benzo(a)pyrene	710/756	94	0.25	420	10	20	0.29 – 68	T117-SE-37-G	99	210	3	3	0	0
Benzo(g,h,i)perylene	648/755	86	0.22	180	6	8	0.65 – 94	R23 and C8	31	78	10	3	4	1
Total benzofluoranthenes	715/754	95	0.49 J	890	20	40	nc	T117-SE-37-G	230	450	4	2	0	0
Chrysene	731/760	96	0.86	410	20	20	0.67 – 34	T117-SE-37-G	110	460	19	0	0	0
Dibenzo(a,h)anthracene	413/760	54	0.080	71	2	3	0.034 – 170	R23 and C8	12	33	12	4	8	6
Dibenzofuran	232/759	31	0.10 J	220	2	3	0.059 – 94	T117-SE-37-G	15	58	6	3	9	2
Fluoranthene	750/760	99	0.92	1,300	20	50	0.67 – 68	T117-SE-37-G	160	1,200	30	1	0	0
Fluorene	357/760	47	0.090	290	2.1	4.0	0.059 – 94	T117-SE-37-G	23	79	10	3	8	1
Indeno(1,2,3-cd)pyrene	689/755	91	0.23	200	7	9	0.29 – 59	C8	34	88	16	4	1	0
Naphthalene	135/753	18	0.13 J	260	1.6	2.3	0.059 – 94	LDW-SS35	99	170	0	1	0	0
Phenanthrene	719/760	95	0.36	1,500	10	20	0.67 – 34	T117-SE-37-G	100	480	20	3	0	0
Pyrene	743/760	98	0.87	840	20	40	0.67 – 34	T117-SE-37-G	1,000	1,400	0	0	0	0
Total HPAH	754/760	99	1.6 J	4,500	100	200	nc	T117-SE-37-G	960	5,300	19	0	0	0
Total LPAH	721/760	95	0.46	2,300	10	30	nc	T117-SE-37-G	370	780	2	3	0	0
Phthalates														
Bis(2-ethylhexyl)phthalate	637/764	83	0.20	390	20	20	0.88 – 170	DUD026	47	78	48	49	2	2
Butyl benzyl phthalate	406/757	54	0.071	530 J	2	4	0.060 – 94	SD-DUW48	4.9	64	62	6	65	1
Diethyl phthalate	40/764	5	0.14 J	20	0.7	1	0.059 – 94	DUD007	61	110	0	0	1	0
Dimethyl phthalate	149/757	20	0.14 J	15	1	1	0.059 – 94	LDW-SS14	53	53	0	0	0	2
Di-n-butyl phthalate	176/757	23	0.29 J	140	2	3	0.059 – 94	SD-04915	220	1,700	0	0	0	0
Di-n-octyl phthalate	44/764	6	0.11	35	1.9	2.0	0.059 – 170	SD-04102	58	4,500	0	0	5	0
Other SVOCs														
1,2,4-Trichlorobenzene	4/751	1	0.057 J	0.61 J	0.11	0.88	0.020 – 94	DUD012	0.81	1.8	0	0	231	116

Table E.6.1-2, cont. Summary surface sediment statistics and comparisons to SMS criteria for chemicals with OC-normalized criteria

Chemical[a]	Detection Frequency[b]		Concentration (mg/kg OC)					Maximum Detect Location	SMS Criteria (mg/kg OC)		Comparison to SMS Criteria (Number of Locations)			
	Ratio	%	Minimum Detect	Maximum Detect	Median Detect	Calculated Mean	RL or Range of RLs		SQS	CSL	Detect > SQS and ≤ CSL	Detect > CSL	Nondetect > SQS and ≤ CSL	Nondetect > CSL
1,2-Dichlorobenzene	15/751	2	0.068 J	2.9 J	0.10	0.88	0.020 – 94	DUD012	2.3	2.3	0	1	0	99
1,4-Dichlorobenzene	34/751	5	0.097 J	65	0.36	1.0	0.023 – 94	R88	3.1	9	0	2	77	15
Hexachlorobenzene	45/753	6	0.02 J	3.8	0.08	0.8	0.0095 – 94	B7a	0.38	2.3	4	2	283	94
Hexachlorobutadiene	0/753	0	nd	nd	nd	nd	0.028 – 94	nd	3.9	6.2	0	0	20	78
N-Nitrosodiphenylamine	21/753	3	0.23	7.9	0.37	1.4	0.059 – 94	DUD021	11	11	0	0	0	17
Polychlorinated biphenyls														
PCBs (total calc'd)	1145/1203	95	0.11 J	10,000	8	60	nc	NFK305	12	65	285	160	0	0

[a] Data for chemicals with dry weight SMS criteria are presented in Table E.6.1-1.

[b] Surface sediment sample locations were not included if the TOC content was < 0.5% or > 4.0%. Data from these locations were compared to LAETs and 2LAETs in Table E.6.1-3.

Table E.6.1-3. Summary surface sediment statistics and comparisons to SMS criteria for chemicals with dry weight criteria

Chemical	Detection Frequency		Concentration (						Maximum Detect Location	SMS Criteria			Comparison to SMS Criteria[a] (Number of Locations)			
	Ratio	%	Minimum Detect	Maximum Detect	Median Detect	Calculated Mean	RL or Range of RLs	Unit		SQS	CSL	Unit	Detect > SQS and ≤ CSL	Detect > CSL	Nondetect > SQS and ≤ CSL	Nondetect > CSL
Metals and trace elements																
Arsenic	794/852	93	1.2	1,100	12	17	3.1 – 31	mg/kg dw	LDW-SS114	57	93	mg/kg dw	5	9	0	0
Cadmium	584/838	70	0.030 J	120	0.5	1	0.04 – 2.5	mg/kg dw	SS-SWY01	5.1	6.7	mg/kg dw	2	11	0	0
Chromium	850/850	100	4.8	1,100 J	30	40	na	mg/kg dw	SS-SWY06	260	270	mg/kg dw	1	8	0	0
Copper	852/852	100	5	12,000 J	50	100	na	mg/kg dw	SS-SWY01 SS-SWY02	390	390	mg/kg dw	0	12	0	0
Lead	852/852	100	2	23,000	40	100	na	mg/kg dw	SS-SWY02	450	530	mg/kg dw	2	19	0	0
Mercury	746/868	86	0.021	4.6 J	0.2	0.2	0.02 – 0.10	mg/kg dw	SD-04408	0.41	0.59	mg/kg dw	16	27	0	0
Silver	499/823	61	0.020	270	0.4	1	0.046 – 5	mg/kg dw	SS-SWY02	6.1	6.1	mg/kg dw	0	10	0	0
Zinc	849/849	100	16	9,700	110	190	na	mg/kg dw	SS-SWY01	410	960	mg/kg dw	26	16	0	0
Other SVOCs																
2,4-Dimethylphenol	5/813	1	6.1	290 J	17	33	6.0 – 2,000	µg/kg dw	DD-2	29	29	µg/kg dw	0	1	0	222
2-Methylphenol	7/821	1	8.6	58 J	14	28	6.0 – 2,000	µg/kg dw	WQA8AVE	63	63	µg/kg dw	0	0	0	114
4-Methylphenol	82/831	10	4.8 J	4,600 J	34	44	8.6 – 2,000	µg/kg dw	DUD207	670	670	µg/kg dw	0	4	0	9
Benzoic acid	70/822	9	54 J	4,500	220	200	13 – 3,000	µg/kg dw	NFK305	650	650	µg/kg dw	0	8	0	107
Benzyl alcohol	15/812	2	8.2 J	670	27	46	9.2 – 690	µg/kg dw	LDW-SS24	57	73	µg/kg dw	2	3	7	106
Pentachlorophenol	12/785	2	14 J	410	100	96	7.6 – 4,900	µg/kg dw	LDW-SSB4a	360	690	µg/kg dw	1	0	88	29
Phenol	257/831	31	10 J	2,800	70	90	7.3 – 790	µg/kg dw	B8a	420	1,200	µg/kg dw	17	6	5	0

Table E.6.1-4. Summary surface sediment statistics and comparisons to AETs for surface sediment samples with TOC < 0.5% or > 4%

Chemical	Detection Frequency		Concentration (µg/kg dw)						Maximum Detect Location	AET Value (µg/kg dw)		Comparison to AET Value (Number of Locations)			
	Ratio	%	Minimum Detect	Maximum Detect	Mean Detect	Calculated Mean	Median Detect	RL or Range of RLs		LAET	2LAET	Detect > LAET and ≤ 2LAET	Detect> 2LAET	Nondetect > LAET and ≤ 2LAET	Nondetect >2LAET
PAHs															
2-Methylnaphthalene	16/65	25	1.0 J	2,400	210	72	40	19 – 290	DUD027	670	1,400	0	1	0	0
Acenaphthene	21/68	31	1.4 J	630	130	56	53	13 – 300	SD-04104	500	730	1	0	0	0
Acenaphthylene	10/65	15	4.0 J	500	110	36	41	2.0 – 290	LDW-SS312	1,300	1,300	0	0	0	0
Anthracene	28/68	41	8.2	910	230	110	150	19 – 290	DR050	960	4,400	0	0	0	0
Benzo(a)anthracene	36/68	53	16	2,600	590	320	360	6.4 – 170	LDW-SS24	1,300	1,600	2	3	0	0
Benzo(a)pyrene	37/66	56	10 J	3,200	530	310	250	6.4 – 350	LDW-SS312	1,600	3,000	2	1	0	0
Benzo(g,h,i)perylene	34/68	50	8.0 J	1,600	310	170	200	19 – 350	LDW-SS312	670	720	0	5	0	0
Total benzofluoranthenes	42/68	62	20	4,900	1,100	670	490	19 – 77	DUD005	3,200	3,600	1	3	0	0
Chrysene	42/68	62	30	3,600	740	460	290	19 – 77	LDW-SS24	1,400	2,800	6	2	0	0
Dibenzo(a,h)anthracene	23/68	34	2.0 J	460 J	150	68	130	6.1 – 290	SB-5	230	540	4	0	2	0
Dibenzofuran	16/68	24	1.0 J	360	89	42	58	19 – 300	SD-04104	540	700	0	0	0	0
Fluoranthene	47/68	69	20	6,700	1,200	830	400	19 – 77	DR050	1,700	2,500	2	9	0	0
Fluorene	25/68	37	2.3 J	506	130	64	64	19 – 300	DUD027	540	1,000	0	0	0	0
Indeno(1,2,3-cd)pyrene	37/68	54	7.0 J	1,600	330	190	190	6.4 – 290	LDW-SS312	600	690	0	5	0	0
Naphthalene	17/65	26	3.0 J	4,100	320	110	66	1.5 – 530	DUD027	2,100	2,400	0	1	0	0
Phenanthrene	40/68	59	18	3,400	650	390	260	19 – 170	LDW-SS312	1,500	5,400	4	0	0	0
Pyrene	45/68	66	24 J	4,800	1,000	690	390	19 – 77	LDW-SS312	2,600	3,300	2	4	0	0
Total HPAH	49/68	72	20	26,300	5,000	3,600	1,700	19 – 77	LDW-SS312	12,000	17,000	5	4	0	0
Total LPAH	42/68	62	30	7,400 J	1,100	670	350	19 – 170	DUD027	5,200	13,000	1	0	0	0
Phthalates															
Bis(2-ethylhexyl)phthalate	37/68	54	10 J	14,000	2,100	1,200	190	19 – 1,500	DUD005	1,300	1,900	0	10	1	0
Butyl benzyl phthalate	19/65	29	9.3	1,900	290	99	100	3.0 – 290	DUD005	63	900	9	2	10	0
Diethyl phthalate	1/68	1	7.2	7.2	7.2	26	7.2	2.0 – 300	LDW-SS86	200	1,200	0	0	3	0
Dimethyl phthalate	7/65	11	6.2	180	49	22	30	2.0 – 290	DUD005	71	160	0	1	8	3
Di-n-butyl phthalate	13/65	20	5.0 J	400	140	49	59	3.0 – 290	DUD005	1,400	5,100	0	0	0	0

Table E.6.1-4, cont. Summary surface sediment statistics and comparisons to AETs for surface sediment datasamples with TOC < 0.5% or > 4%

Chemical	Detection Frequency		Concentration (µg/kg dw)						Maximum Detect Location	AET Value (µg/kg dw)		Comparison to AET Value (Number of Locations)			
	Ratio	%	Minimum Detect	Maximum Detect	Mean Detect	Calcu-lated Mean	Median Detect	RL or Range of RLs		LAET	2LAET	Detect > LAET and ≤ 2LAET	Detect> 2LAET	Nondetect > LAET and ≤ 2LAET	Nondetect >2LAET
Di-n-octyl phthalate	5/68	7	20	555	230	60	87	2.0 – 1,500	DD-2	6,200	na	0	0	0	0
Other SVOCs															
1,2,4-Trichlorobenzene	1/65	2	72 J	72 J	72	23	72	0.85 – 1,100	DUD027	31	51	0	1	0	12
1,2-Dichlorobenzene	2/65	3	150 J	520 J	340	24	340	0.85 – 290	DR008	35	50	0	2	0	11
1,4-Dichlorobenzene	5/65	8	9.3 J	1,600 J	350	45	44	0.85 – 530	DUD027	110	120	0	1	0	3
Hexachlorobenzene	1/66	2	0.97 J	0.97 J	0.97	14	0.97	0.85 – 290	NFK502-Apr-99	22	70	0	0	0	11
Hexachlorobutadiene	0/65	0	nd	nd	nd	25	nd	0.97 – 530	nd	11	120	0	0	38	10
N-Nitrosodiphenylamine	2/65	3	95	110	100	29	100	3.0 – 400	DUD010	28	40	0	2	34	16
Polychlorinated biphenyls															
PCBs (total calc'd)	98/124	79	1.6 J	56,000 J	1,600	1,200	94	0.60 – 40	DUD027	130	1,000	29	14	0	0

E.6.2 SUBSURFACE SEDIMENT

Table E.6.2-1. Summary statistics for subsurface sediment data in 1-ft depth intervals down to 10 ft below mudline

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements								
Aluminum	0 to 1	26/26	100	3,410	18,500	10,000	na	mg/kg dw
	1 to 2	1/1	100	9,400 J	9,400 J	9,400	na	mg/kg dw
	2 to 3	4/4	100	7,900 J	21,000	16,000	na	mg/kg dw
	3 to 4	1/1	100	6,500 J	6,500 J	6,500	na	mg/kg dw
Antimony	0 to 1	3/41	7	20 J	30 J	6	3.7 – 10	mg/kg dw
	1 to 2	3/38	8	16 J	40 J	6	3.0 – 10	mg/kg dw
	2 to 3	0/9	0	nd	nd	3	3.8 – 10	mg/kg dw
	3 to 4	0/9	0	nd	nd	3	3.6 – 8	mg/kg dw
	8 to 9	0/1	0	nd	nd	3	6	mg/kg dw
Arsenic	0 to 1	60/63	95	4.7	707	30	6 – 6.2	mg/kg dw
	1 to 2	46/59	78	5.2	281	20	4.5 – 8.00	mg/kg dw
	2 to 3	7/10	70	5.9	161	20	6.0 – 6.1	mg/kg dw
	3 to 4	4/9	44	9	21	8	6.0 – 7	mg/kg dw
	8 to 9	1/1	100	8	8	8	na	mg/kg dw
Barium	0 to 1	26/26	100	8.34	68.0	43	na	mg/kg dw
	1 to 2	1/1	100	35.0	35.0	35.0	na	mg/kg dw
	2 to 3	4/4	100	17.0	69	44	na	mg/kg dw
	3 to 4	1/1	100	12.0	12.0	12.0	na	mg/kg dw
Beryllium	0 to 1	25/25	100	0.13	0.49	0.3	na	mg/kg dw
	1 to 2	1/1	100	0.28	0.28	0.28	na	mg/kg dw
	2 to 3	4/4	100	0.20	0.31	0.27	na	mg/kg dw
	3 to 4	1/1	100	0.21	0.21	0.21	na	mg/kg dw
Cadmium	0 to 1	52/78	67	0.3	4.5	0.6	0.2 – 0.9	mg/kg dw
	1 to 2	51/80	64	0.3	7.6	0.8	0.2 – 0.5	mg/kg dw
	2 to 3	11/19	58	0.3	18.7	2	0.20 – 0.38	mg/kg dw
	3 to 4	1/9	11	0.8	0.8	0.2	0.2 – 0.36	mg/kg dw
	4 to 5	3/9	33	0.50	3.8 J	0.73	0.20 – 0.30	mg/kg dw
	6 to 7	0/5	0	nd	nd	0.11	0.20 – 0.30	mg/kg dw
	8 to 9	1/4	25	0.70	0.70	0.3	0.20	mg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Calcium	0 to 1	25/25	100	1,950	5,600	3,900	na	mg/kg dw
	2 to 3	3/3	100	4,800 J	5,800	5,300	na	mg/kg dw
Chromium	0 to 1	86/86	100	6.67	143 J	31	na	mg/kg dw
	1 to 2	80/80	100	9.96	135	30	na	mg/kg dw
	2 to 3	20/20	100	10.9	300	60	na	mg/kg dw
	3 to 4	9/9	100	8.9	24.2	15	na	mg/kg dw
	4 to 5	9/9	100	9.9	140 J	31	na	mg/kg dw
	6 to 7	5/5	100	10	19.1	13	na	mg/kg dw
	8 to 9	4/4	100	8.3	26.5	14	na	mg/kg dw
Chromium VI	0 to 1	0/1	0	nd	nd	7.5	15	mg/kg dw
	2 to 3	0/1	0	nd	nd	7.5	15	mg/kg dw
Cobalt	0 to 1	64/64	100	2.54	18	8.1	na	mg/kg dw
	1 to 2	37/37	100	4.2	15.6	8.6	na	mg/kg dw
	2 to 3	9/9	100	3.9	11	6.8	na	mg/kg dw
	3 to 4	8/8	100	3.5	8.1	5.3	na	mg/kg dw
	8 to 9	1/1	100	3.3	3.3	3.3	na	mg/kg dw
Copper	0 to 1	86/86	100	10.9	327	73	na	mg/kg dw
	1 to 2	80/80	100	7.1	339	64	na	mg/kg dw
	2 to 3	20/20	100	9.20	599	92	na	mg/kg dw
	3 to 4	9/9	100	9.00	37.9	16	na	mg/kg dw
	4 to 5	9/9	100	7.4	67.3	21	na	mg/kg dw
	6 to 7	5/5	100	9.0	26.8	15	na	mg/kg dw
	8 to 9	4/4	100	7.5	31.9	14	na	mg/kg dw
Iron	0 to 1	26/26	100	7,130	38,800	26,000	na	mg/kg dw
	1 to 2	1/1	100	16,000 J	16,000 J	16,000	na	mg/kg dw
	2 to 3	4/4	100	11,000 J	32,000	21,000	na	mg/kg dw
	3 to 4	1/1	100	9,800 J	9,800 J	9,800	na	mg/kg dw
Lead	0 to 1	84/84	100	4.9	639	50	na	mg/kg dw
	1 to 2	73/80	91	2.8	514	70	2.0 – 3	mg/kg dw
	2 to 3	18/19	95	3	356	80	2.0	mg/kg dw
	3 to 4	5/9	56	3	37 J	8	2 – 3.6	mg/kg dw
	4 to 5	8/9	89	3.0	64	16	2.0	mg/kg dw
	6 to 7	2/5	40	3.0	11	3.4	2.0	mg/kg dw
	8 to 9	1/4	25	43	43	10	2.0	mg/kg dw
Magnesium	0 to 1	25/25	100	1,640	9,320	6,100	na	mg/kg dw
	2 to 3	3/3	100	3,300 J	5,900	4,700	na	mg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Manganese	0 to 1	26/26	100	86.5	886	310	na	mg/kg dw
	1 to 2	1/1	100	160	160	160	na	mg/kg dw
	2 to 3	4/4	100	110	450	240	na	mg/kg dw
	3 to 4	1/1	100	98.0	98.0	98.0	na	mg/kg dw
Mercury	0 to 1	81/84	96	0.05	0.71	0.2	0.05 – 0.100	mg/kg dw
	1 to 2	54/66	82	0.06	0.6	0.2	0.040 – 0.0600	mg/kg dw
	2 to 3	13/19	68	0.070	0.64	0.2	0.030 – 0.060	mg/kg dw
	3 to 4	2/9	22	0.07	0.17	0.05	0.020 – 0.06	mg/kg dw
	4 to 5	3/10	30	0.060	0.24 J	0.065	0.040 – 0.060	mg/kg dw
	6 to 7	2/5	40	0.050	0.16	0.055	0.040 – 0.050	mg/kg dw
	8 to 9	1/3	33	0.19	0.19	0.080	0.050	mg/kg dw
Molybdenum	0 to 1	30/40	75	0.9	11	2	0.6 – 2.4	mg/kg dw
	1 to 2	27/38	71	0.6	16	2	0.6 – 1	mg/kg dw
	2 to 3	3/7	43	0.7	1.8	0.9	0.6 – 2.5	mg/kg dw
	3 to 4	3/9	33	0.8	1.5	0.7	0.6 – 2.4	mg/kg dw
	8 to 9	1/1	100	0.7	0.7	0.7	na	mg/kg dw
Nickel	0 to 1	65/65	100	4.8	36	20	na	mg/kg dw
	1 to 2	53/53	100	6.92	51.1	20	na	mg/kg dw
	2 to 3	10/10	100	9	32	20	na	mg/kg dw
	3 to 4	9/9	100	6 J	25	10	na	mg/kg dw
	8 to 9	1/1	100	5	5	5	na	mg/kg dw
Potassium	0 to 1	26/26	100	430	3,210	2,000	na	mg/kg dw
	1 to 2	1/1	100	700	700	700	na	mg/kg dw
	2 to 3	4/4	100	600	2,000	1,300	na	mg/kg dw
	3 to 4	1/1	100	370	370	370	na	mg/kg dw
Selenium	0 to 1	0/41	0	nd	nd	4	6 – 20	mg/kg dw
	1 to 2	0/38	0	nd	nd	4	5.0 – 10	mg/kg dw
	2 to 3	1/10	10	8.0	8.0	4	1.0 – 8	mg/kg dw
	3 to 4	0/9	0	nd	nd	3	6.0 – 8	mg/kg dw
	8 to 9	0/1	0	nd	nd	3	6	mg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Silver	0 to 1	15/62	24	0.500	3.0	0.5	0.4 – 1	mg/kg dw
	1 to 2	23/80	29	0.5	2.6	0.5	0.3 – 1	mg/kg dw
	2 to 3	8/19	42	0.060	7.3	0.9	0.40 – 0.5	mg/kg dw
	3 to 4	1/9	11	0.61	0.61	0.2	0.3 – 0.5	mg/kg dw
	4 to 5	1/9	11	1.2	1.2	0.30	0.30 – 0.40	mg/kg dw
	6 to 7	0/5	0	nd	nd	0.18	0.30 – 0.40	mg/kg dw
	8 to 9	0/4	0	nd	nd	0.2	0.30 – 0.40	mg/kg dw
Sodium	0 to 1	25/25	100	1,570 J	16,900 J	9,000	na	mg/kg dw
	2 to 3	3/3	100	1,300	7,100	4,200	na	mg/kg dw
Thallium	0 to 1	0/41	0	nd	nd	4	6 – 24	mg/kg dw
	1 to 2	0/38	0	nd	nd	4	6 – 20	mg/kg dw
	2 to 3	1/10	10	0.080	0.080	4	6.0 – 25	mg/kg dw
	3 to 4	0/9	0	nd	nd	4	6 – 24	mg/kg dw
	8 to 9	0/1	0	nd	nd	3	6	mg/kg dw
Tin	2 to 3	1/1	100	2.0	2.0	2.0	na	mg/kg dw
Vanadium	0 to 1	64/64	100	18	85	59	na	mg/kg dw
	1 to 2	37/37	100	39.6	84.3	62.6	na	mg/kg dw
	2 to 3	9/9	100	47.0	67	56	na	mg/kg dw
	3 to 4	8/8	100	36.1	71.5	45.4	na	mg/kg dw
	8 to 9	1/1	100	37.5	37.5	37.5	na	mg/kg dw
Zinc	0 to 1	86/86	100	18.6	1,260	100	na	mg/kg dw
	1 to 2	80/80	100	20.2	2,050	200	na	mg/kg dw
	2 to 3	19/19	100	22.3	1,770	280	na	mg/kg dw
	3 to 4	9/9	100	18.5	69	34	na	mg/kg dw
	4 to 5	9/9	100	20.8	324 J	101	na	mg/kg dw
	6 to 7	5/5	100	22.0	47.0	30.1	na	mg/kg dw
	8 to 9	4/4	100	17.6	84.7	36.3	na	mg/kg dw
Organometals								
Monobutyltin as ion	0 to 1	3/11	27	6.1	12	4.1	3.9 – 4.0	µg/kg dw
	1 to 2	4/10	40	4.5	13	4.1	3.8 – 4.1	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
	3 to 4	0/1	0	nd	nd	1.9	3.8	µg/kg dw
	8 to 9	0/1	0	nd	nd	1.9	3.8	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Dibutyltin as ion	0 to 1	9/11	82	6.4	72	18	5.7	µg/kg dw
	1 to 2	5/10	50	15	64	17	5.4 – 5.8	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
	3 to 4	0/1	0	nd	nd	2.7	5.4	µg/kg dw
	8 to 9	0/1	0	nd	nd	2.7	5.4	µg/kg dw
Tributyltin as ion	0 to 1	11/11	100	5.5	220	92	na	µg/kg dw
	1 to 2	6/14	43	21	350	60	3.6 – 5.4	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
	3 to 4	0/1	0	nd	nd	1.8	3.6	µg/kg dw
	8 to 9	0/1	0	nd	nd	1.8	3.6	µg/kg dw
Tetrabutyltin as ion	2 to 3	0/1	0	nd	nd	1.5	3.0	µg/kg dw
PAHs								
1-Methylnaphthalene	0 to 1	2/39	5	20	46	28	20 – 160	µg/kg dw
	1 to 2	2/37	5	44	160	28	19 – 130	µg/kg dw
	2 to 3	1/6	17	120 J	120 J	38	20 – 99	µg/kg dw
	3 to 4	0/8	0	nd	nd	9.8	19 – 20	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
2-Chloronaphthalene	0 to 1	1/64	2	16 J	16 J	57	19 – 310	µg/kg dw
	1 to 2	0/41	0	nd	nd	20	18 – 130	µg/kg dw
	2 to 3	0/10	0	nd	nd	39	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	9.8	19 – 20	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
2-Methylnaphthalene	0 to 1	6/41	15	21	69	31	20 – 180	µg/kg dw
	1 to 2	3/45	7	24	86	20	19 – 130	µg/kg dw
	2 to 3	1/10	10	120 J	120 J	51	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	12	19 – 54	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
Acenaphthene	0 to 1	13/64	20	14 J	200	64	20 – 310	µg/kg dw
	1 to 2	11/45	24	13 J	1,400	70	19 – 130	µg/kg dw
	2 to 3	1/10	10	810 J	810 J	120	14 – 400	µg/kg dw
	3 to 4	1/9	11	210	210	32	14 – 20	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Acenaphthylene	0 to 1	13/41	32	12 J	280	38	20 – 180	µg/kg dw
	1 to 2	10/45	22	11 J	160	30	18 – 130	µg/kg dw
	2 to 3	1/10	10	10 J	10 J	39	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	9.8	19 – 20	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
Anthracene	0 to 1	43/64	67	14 J	520	110	20 – 280	µg/kg dw
	1 to 2	26/45	58	11 J	1,600	100	19 – 60	µg/kg dw
	2 to 3	2/10	20	35 J	230 J	61	20 – 400	µg/kg dw
	3 to 4	1/9	11	14 J	14 J	10	19 – 20	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
Benzo(a)anthracene	0 to 1	56/64	88	12 J	3,600	360	20 – 180	µg/kg dw
	1 to 2	33/45	73	14 J	3,100	300	19 – 39	µg/kg dw
	2 to 3	5/10	50	12 J	440	100	20 – 99	µg/kg dw
	3 to 4	2/9	22	12 J	20	11	19 – 20	µg/kg dw
	4 to 5	1/1	100	50 J	50 J	50	na	µg/kg dw
Benzo(a)pyrene	0 to 1	54/64	84	25	3,100	390	20 – 370	µg/kg dw
	1 to 2	32/45	71	20 J	5,300	300	19 – 39	µg/kg dw
	2 to 3	3/10	30	39 J	390	81	20 – 400	µg/kg dw
	3 to 4	2/9	22	11 J	36 J	14	19 – 34	µg/kg dw
	4 to 5	1/1	100	49 J	49 J	49	na	µg/kg dw
Benzo(b)fluoranthene	0 to 1	60/64	94	13 J	4,100	640	20 – 820	µg/kg dw
	1 to 2	33/45	73	12 J	6,400	400	19 – 39	µg/kg dw
	2 to 3	5/10	50	11 J	950	180	20 – 99	µg/kg dw
	3 to 4	2/9	22	9.9 J	57 J	17	19 – 54	µg/kg dw
	4 to 5	1/1	100	60 J	60 J	60	na	µg/kg dw
Benzo(g,h,i)perylene	0 to 1	49/64	77	16 J	910	180	20 – 370	µg/kg dw
	1 to 2	26/43	60	12 J	1,000	90	19 – 60	µg/kg dw
	2 to 3	1/10	10	130	130	48	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	11	19 – 34	µg/kg dw
	4 to 5	1/1	100	34 J	34 J	34	na	µg/kg dw
Benzo(k)fluoranthene	0 to 1	56/64	88	11 J	3,500	420	20 – 180	µg/kg dw
	1 to 2	33/45	73	12 J	3,800	300	19 – 39	µg/kg dw
	2 to 3	4/10	40	10 J	360	84	20 – 400	µg/kg dw
	3 to 4	2/9	22	13 J	32 J	15	19 – 54	µg/kg dw
	4 to 5	1/1	100	38 J	38 J	38	na	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Benzofluoranthenes (total-calc'd)	0 to 1	60/64	94	24 J	7,600	1,100	nc	µg/kg dw
	1 to 2	33/45	73	24 J	10,200	800	nc	µg/kg dw
	2 to 3	5/10	50	21 J	950	230	nc	µg/kg dw
	3 to 4	2/9	22	23 J	89 J	22	nc	µg/kg dw
	4 to 5	1/1	100	98 J	98 J	98	na	µg/kg dw
Chrysene	0 to 1	57/64	89	12 J	4,300	500	20 – 180	µg/kg dw
	1 to 2	34/45	76	13 J	4,800	400	19.0 – 39	µg/kg dw
	2 to 3	6/10	60	14 J	460	110	20 – 99	µg/kg dw
	3 to 4	2/9	22	12 J	30	12	19 – 20	µg/kg dw
	4 to 5	1/1	100	59 J	59 J	59	na	µg/kg dw
Dibenzo(a,h)anthracene	0 to 1	31/64	48	12 J	660 J	170	20 – 910	µg/kg dw
	1 to 2	9/45	20	11 J	360	30	19 – 130	µg/kg dw
	2 to 3	0/10	0	nd	nd	40	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	12	19 – 54	µg/kg dw
	4 to 5	1/1	100	18	18	18	na	µg/kg dw
Dibenzofuran	0 to 1	5/64	8	20	120	63	20 – 310	µg/kg dw
	1 to 2	5/45	11	26	1,200	50	19 – 130	µg/kg dw
	2 to 3	1/10	10	250 J	250 J	63	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	11	19 – 34	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
Fluoranthene	0 to 1	59/64	92	36	8,100	980	54 – 340	µg/kg dw
	1 to 2	37/45	82	16 J	5,600	600	19.0 – 20.0	µg/kg dw
	2 to 3	7/10	70	40	1,300 J	320	20	µg/kg dw
	3 to 4	3/9	33	14 J	58	19	19 – 20	µg/kg dw
	4 to 5	1/1	100	110	110	110	na	µg/kg dw
Fluorene	0 to 1	15/64	23	19 J	180	67	20 – 310	µg/kg dw
	1 to 2	10/45	22	20	1,900	80	18 – 130	µg/kg dw
	2 to 3	1/10	10	290 J	290 J	67	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	9.8	19 – 20	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
Indeno(1,2,3-cd)pyrene	0 to 1	53/64	83	19 J	1,000	230	20 – 330	µg/kg dw
	1 to 2	26/43	60	13 J	1,500	100	19 – 60	µg/kg dw
	2 to 3	1/10	10	130	130	48	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	11	19 – 34	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Naphthalene	0 to 1	9/42	21	14 J	120	34	9.9 – 180	µg/kg dw
	1 to 2	9/46	20	15 J	370	40	8.3 – 130	µg/kg dw
	2 to 3	1/11	9	330 J	330 J	66	9.2 – 400	µg/kg dw
	3 to 4	0/10	0	nd	nd	11	7.8 – 54	µg/kg dw
	4 to 5	0/2	0	nd	nd	19	8.3 – 66	µg/kg dw
	5 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 7	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	7 to 8	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	8 to 9	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	9 to 10	1/1	100	18	18	18	na	µg/kg dw
Phenanthrene	0 to 1	54/64	84	12 J	1,400	280	58 – 180	µg/kg dw
	1 to 2	34/45	76	16 J	3,700	300	19 – 20.0	µg/kg dw
	2 to 3	4/10	40	20	960 J	140	20 – 400	µg/kg dw
	3 to 4	2/9	22	10 J	29	12	19 – 20	µg/kg dw
	4 to 5	1/1	100	47 J	47 J	47	na	µg/kg dw
Pyrene	0 to 1	59/64	92	38	6,700	880	35 – 170	µg/kg dw
	1 to 2	37/45	82	13 J	9,200	800	19 – 20.0	µg/kg dw
	2 to 3	7/10	70	28	1,300	280	20	µg/kg dw
	3 to 4	4/9	44	11 J	90	23	19 – 20	µg/kg dw
	4 to 5	1/1	100	160	160	160	na	µg/kg dw
Total HPAH	0 to 1	60/64	94	122 J	34,700	4,600	nc	µg/kg dw
	1 to 2	38/45	84	13 J	40,000	3,000	nc	µg/kg dw
	2 to 3	7/10	70	115 J	4,400	1,100	nc	µg/kg dw
	3 to 4	4/9	44	21 J	323 J	63	nc	µg/kg dw
	4 to 5	1/1	100	580 J	580 J	580	na	µg/kg dw
Total LPAH	0 to 1	54/64	84	12 J	2,100 J	410	nc	µg/kg dw
	1 to 2	34/45	76	24 J	7,500	500	nc	µg/kg dw
	2 to 3	4/10	40	20	2,630 J	310	nc	µg/kg dw
	3 to 4	2/9	22	43 J	220 J	39	nc	µg/kg dw
	4 to 5	1/1	100	47 J	47 J	47	na	µg/kg dw
Carcinogenic PAHs - Mammal	0 to 1	60/64	94	19 J	4,400	620	18 – 400	µg/kg dw
	1 to 2	34/45	76	19 J	7,000	460	17 – 35	µg/kg dw
	2 to 3	6/10	60	18	530	130	18 – 90	µg/kg dw
	3 to 4	2/9	22	19 J	52 J	16	17 – 36	µg/kg dw
	4 to 5	1/1	100	75 J	75 J	75	na	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Total PAH	0 to 1	61/64	95	24	36,200	5,000	nc	µg/kg dw
	1 to 2	38/45	84	13 J	42,600 J	4,000	nc	µg/kg dw
	2 to 3	7/10	70	135 J	5,000 J	1,400	nc	µg/kg dw
	3 to 4	4/9	44	21 J	366 J	92	nc	µg/kg dw
	4 to 5	1/1	100	630 J	630 J	630	na	µg/kg dw
Phthalates								
Bis(2-ethylhexyl)phthalate	0 to 1	44/64	69	22	2,100	610	27 – 1,400	µg/kg dw
	1 to 2	24/45	53	13 J	3,900	400	19 – 400	µg/kg dw
	2 to 3	7/10	70	20 J	820	160	20 – 59	µg/kg dw
	3 to 4	2/9	22	17 J	24	12	19 – 20	µg/kg dw
	4 to 5	1/1	100	290	290	290	na	µg/kg dw
Butyl benzyl phthalate	0 to 1	33/41	80	5.9	610	64	5.9 – 180	µg/kg dw
	1 to 2	22/45	49	14	400	40	5.8 – 36	µg/kg dw
	2 to 3	3/10	30	6.6	10	30	5.9 – 400	µg/kg dw
	3 to 4	2/9	22	6.4	7.7	4.6	5.8 – 20	µg/kg dw
	4 to 5	1/1	100	18	18	18	na	µg/kg dw
Diethyl phthalate	0 to 1	1/64	2	2,700	2,700	100	20 – 310	µg/kg dw
	1 to 2	0/45	0	nd	nd	20	19 – 130	µg/kg dw
	2 to 3	0/10	0	nd	nd	39	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	11	19 – 34	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
Dimethyl phthalate	0 to 1	3/41	7	13 J	1,700	69	13 – 180	µg/kg dw
	1 to 2	1/45	2	16 J	16 J	20	12 – 130	µg/kg dw
	2 to 3	0/10	0	nd	nd	38	14 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	9.5	14 – 20	µg/kg dw
	4 to 5	0/1	0	nd	nd	3.3	6.6	µg/kg dw
Di-n-butyl phthalate	0 to 1	11/41	27	10 J	200	37	20 – 180	µg/kg dw
	1 to 2	8/45	18	11 J	140	30	19 – 180	µg/kg dw
	2 to 3	5/10	50	13 J	280	76	20 – 400	µg/kg dw
	3 to 4	4/9	44	11 J	94	28	19 – 25	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
Di-n-octyl phthalate	0 to 1	2/64	3	25	2,000	250	19 – 1,600	µg/kg dw
	1 to 2	2/45	4	79 J	220	30	18 – 110	µg/kg dw
	2 to 3	0/10	0	nd	nd	39	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	9.8	19 – 20	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Other SVOCs								
1,2,4-Trichlorobenzene	0 to 1	5/42	12	3.6 J	18 J	6.7	5.8 – 180	µg/kg dw
	1 to 2	6/46	13	4.1 J	17 J	5	5.8 – 20.0	µg/kg dw
	2 to 3	0/11	0	nd	nd	26	5.9 – 400	µg/kg dw
	3 to 4	0/10	0	nd	nd	3.7	5.8 – 20	µg/kg dw
	4 to 5	0/2	0	nd	nd	3.7	6.6 – 8.3	µg/kg dw
	5 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 7	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	7 to 8	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	8 to 9	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	9 to 10	0/1	0	nd	nd	4.2	8.4	µg/kg dw
1,2-Dichlorobenzene	0 to 1	4/42	10	1.7 J	17	6.0	2.0 – 180	µg/kg dw
	1 to 2	4/46	9	2.9 J	9.6	5	0.78 – 20.0	µg/kg dw
	2 to 3	0/11	0	nd	nd	25	0.86 – 400	µg/kg dw
	3 to 4	0/10	0	nd	nd	2.5	0.86 – 6.0	µg/kg dw
	4 to 5	1/2	50	10	10	5.4	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
1,2-Diphenylhydrazine	0 to 1	1/24	4	100 J	100 J	110	64 – 310	µg/kg dw
	1 to 2	0/1	0	nd	nd	30	60	µg/kg dw
	2 to 3	0/1	0	nd	nd	33	66	µg/kg dw
	3 to 4	0/1	0	nd	nd	33	66	µg/kg dw
1,3-Dichlorobenzene	0 to 1	0/42	0	nd	nd	27	0.83 – 180	µg/kg dw
	1 to 2	0/42	0	nd	nd	20	0.78 – 130	µg/kg dw
	2 to 3	0/11	0	nd	nd	34	0.86 – 400	µg/kg dw
	3 to 4	0/10	0	nd	nd	8.0	0.86 – 20	µg/kg dw
	4 to 5	0/2	0	nd	nd	2.1	1.7 – 6.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,4-Dichlorobenzene	0 to 1	15/42	36	3.0 J	750 J	25	2.0 – 180	µg/kg dw
	1 to 2	9/46	20	3.5 J	17 J	5	1.7 – 20	µg/kg dw
	2 to 3	2/11	18	2.1 J	3.0 J	25	1.8 – 400	µg/kg dw
	3 to 4	0/10	0	nd	nd	2.5	0.86 – 6.0	µg/kg dw
	4 to 5	1/2	50	7.9	7.9	4.4	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
2,4,5-Trichlorophenol	0 to 1	0/41	0	nd	nd	140	98 – 890	µg/kg dw
	1 to 2	0/41	0	nd	nd	110	97 – 650	µg/kg dw
	2 to 3	0/10	0	nd	nd	200	98 – 2,000	µg/kg dw
	3 to 4	0/9	0	nd	nd	51	96 – 140	µg/kg dw
	4 to 5	0/1	0	nd	nd	170	330	µg/kg dw
2,4,6-Trichlorophenol	0 to 1	0/41	0	nd	nd	140	98 – 890	µg/kg dw
	1 to 2	0/41	0	nd	nd	110	97 – 650	µg/kg dw
	2 to 3	0/10	0	nd	nd	200	98 – 2,000	µg/kg dw
	3 to 4	0/9	0	nd	nd	51	96 – 140	µg/kg dw
	4 to 5	0/1	0	nd	nd	170	330	µg/kg dw
2,4-Dichlorophenol	0 to 1	0/41	0	nd	nd	130	33 – 780	µg/kg dw
	1 to 2	0/41	0	nd	nd	110	30 – 650	µg/kg dw
	2 to 3	0/10	0	nd	nd	140	34 – 1,200	µg/kg dw
	3 to 4	0/9	0	nd	nd	45	34 – 99	µg/kg dw
	4 to 5	0/1	0	nd	nd	170	330	µg/kg dw
2,4-Dimethylphenol	0 to 1	2/41	5	25 J	27 J	9.8	5.8 – 350	µg/kg dw
	1 to 2	3/45	7	9.5 J	14 J	6	5.8 – 30	µg/kg dw
	2 to 3	0/10	0	nd	nd	58	5.9 – 790	µg/kg dw
	3 to 4	0/9	0	nd	nd	5.1	5.8 – 34	µg/kg dw
	4 to 5	0/1	0	nd	nd	3.3	6.6	µg/kg dw
2,4-Dinitrophenol	0 to 1	0/41	0	nd	nd	280	64 – 1,800	µg/kg dw
	1 to 2	0/41	0	nd	nd	200	60 – 1,300	µg/kg dw
	2 to 3	0/10	0	nd	nd	380	66 – 4,000	µg/kg dw
	3 to 4	0/9	0	nd	nd	91	66 – 200	µg/kg dw
	4 to 5	0/1	0	nd	nd	330	660	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
2,4-Dinitrotoluene	0 to 1	0/41	0	nd	nd	140	13 – 890	µg/kg dw
	1 to 2	0/41	0	nd	nd	110	12 – 650	µg/kg dw
	2 to 3	0/10	0	nd	nd	190	14 – 2,000	µg/kg dw
	3 to 4	0/9	0	nd	nd	44	14 – 99	µg/kg dw
	4 to 5	0/1	0	nd	nd	170	330	µg/kg dw
2,6-Dinitrotoluene	0 to 1	0/41	0	nd	nd	140	13 – 890	µg/kg dw
	1 to 2	0/41	0	nd	nd	110	12 – 650	µg/kg dw
	2 to 3	0/10	0	nd	nd	190	14 – 2,000	µg/kg dw
	3 to 4	0/9	0	nd	nd	44	14 – 99	µg/kg dw
	4 to 5	0/1	0	nd	nd	170	330	µg/kg dw
2-Chlorophenol	0 to 1	0/41	0	nd	nd	28	20 – 180	µg/kg dw
	1 to 2	0/41	0	nd	nd	20	19 – 130	µg/kg dw
	2 to 3	0/10	0	nd	nd	41	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	12	19 – 66	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
2-Methylphenol	0 to 1	10/41	24	3.0 J	160	11	5.8 – 180	µg/kg dw
	1 to 2	4/45	9	9.3 J	16 J	6	5.8 – 30	µg/kg dw
	2 to 3	0/10	0	nd	nd	34	5.9 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	4.5	5.8 – 34	µg/kg dw
	4 to 5	0/1	0	nd	nd	3.3	6.6	µg/kg dw
2-Nitroaniline	0 to 1	0/41	0	nd	nd	140	98 – 890	µg/kg dw
	1 to 2	0/41	0	nd	nd	110	97 – 650	µg/kg dw
	2 to 3	0/10	0	nd	nd	190	98 – 2,000	µg/kg dw
	3 to 4	0/9	0	nd	nd	51	96 – 140	µg/kg dw
	4 to 5	0/1	0	nd	nd	170	330	µg/kg dw
2-Nitrophenol	0 to 1	0/41	0	nd	nd	140	33 – 890	µg/kg dw
	1 to 2	0/41	0	nd	nd	110	30 – 650	µg/kg dw
	2 to 3	0/10	0	nd	nd	190	34 – 2,000	µg/kg dw
	3 to 4	0/9	0	nd	nd	45	34 – 99	µg/kg dw
	4 to 5	0/1	0	nd	nd	170	330	µg/kg dw
3,3'-Dichlorobenzidine	0 to 1	0/41	0	nd	nd	140	33 – 890	µg/kg dw
	1 to 2	0/41	0	nd	nd	110	30 – 650	µg/kg dw
	2 to 3	0/10	0	nd	nd	190	34 – 2,000	µg/kg dw
	3 to 4	0/9	0	nd	nd	45	34 – 99	µg/kg dw
	4 to 5	0/1	0	nd	nd	170	330	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
3-Nitroaniline	0 to 1	0/41	0	nd	nd	140	98 – 890	µg/kg dw
	1 to 2	0/41	0	nd	nd	110	97 – 650	µg/kg dw
	2 to 3	0/10	0	nd	nd	200	98 – 2,000	µg/kg dw
	3 to 4	0/9	0	nd	nd	51	96 – 140	µg/kg dw
	4 to 5	0/1	0	nd	nd	170	330	µg/kg dw
4,6-Dinitro-o-cresol	0 to 1	0/41	0	nd	nd	280	64 – 1,800	µg/kg dw
	1 to 2	0/41	0	nd	nd	200	60 – 1,300	µg/kg dw
	2 to 3	0/10	0	nd	nd	380	66 – 4,000	µg/kg dw
	3 to 4	0/9	0	nd	nd	91	66 – 200	µg/kg dw
	4 to 5	0/1	0	nd	nd	330	660	µg/kg dw
4-Bromophenyl phenyl ether	0 to 1	0/41	0	nd	nd	28	13 – 180	µg/kg dw
	1 to 2	0/41	0	nd	nd	20	12 – 130	µg/kg dw
	2 to 3	0/10	0	nd	nd	39	14 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	9.5	14 – 20	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
4-Chloro-3-methylphenol	0 to 1	0/41	0	nd	nd	130	64 – 780	µg/kg dw
	1 to 2	0/41	0	nd	nd	110	39.0 – 650	µg/kg dw
	2 to 3	0/10	0	nd	nd	110	40 – 790	µg/kg dw
	3 to 4	0/9	0	nd	nd	47	66 – 99	µg/kg dw
	4 to 5	0/1	0	nd	nd	170	330	µg/kg dw
4-Chloroaniline	0 to 1	2/50	4	47 J	230 J	130	98 – 780	µg/kg dw
	1 to 2	0/41	0	nd	nd	110	59.0 – 650	µg/kg dw
	2 to 3	0/10	0	nd	nd	140	60 – 1,200	µg/kg dw
	3 to 4	0/9	0	nd	nd	47	66 – 99	µg/kg dw
	4 to 5	0/1	0	nd	nd	170	330	µg/kg dw
4-Chlorophenyl phenyl ether	0 to 1	0/41	0	nd	nd	28	19 – 180	µg/kg dw
	1 to 2	0/41	0	nd	nd	20	18 – 130	µg/kg dw
	2 to 3	0/10	0	nd	nd	39	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	9.8	19 – 20	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
4-Methylphenol	0 to 1	2/64	3	17 J	42 J	59	20 – 310	µg/kg dw
	1 to 2	1/45	2	24	24	20	19 – 130	µg/kg dw
	2 to 3	0/10	0	nd	nd	39	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	11	19 – 34	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
4-Nitroaniline	0 to 1	0/41	0	nd	nd	140	98 – 890	µg/kg dw
	1 to 2	0/41	0	nd	nd	110	97 – 650	µg/kg dw
	2 to 3	0/10	0	nd	nd	190	98 – 2,000	µg/kg dw
	3 to 4	0/9	0	nd	nd	51	96 – 140	µg/kg dw
	4 to 5	0/1	0	nd	nd	170	330	µg/kg dw
4-Nitrophenol	0 to 1	0/41	0	nd	nd	140	64 – 890	µg/kg dw
	1 to 2	0/41	0	nd	nd	110	60 – 650	µg/kg dw
	2 to 3	0/10	0	nd	nd	190	66 – 2,000	µg/kg dw
	3 to 4	0/9	0	nd	nd	47	66 – 99	µg/kg dw
	4 to 5	0/1	0	nd	nd	170	330	µg/kg dw
Aniline	0 to 1	0/49	0	nd	nd	39	20 – 230	µg/kg dw
	1 to 2	0/38	0	nd	nd	24	19 – 130	µg/kg dw
	2 to 3	0/7	0	nd	nd	22	20 – 99	µg/kg dw
	3 to 4	0/9	0	nd	nd	12	19 – 66	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
Benzaldehyde	0 to 1	10/23	43	110 J	320	200	130 – 290	µg/kg dw
Benzoic acid	0 to 1	40/64	62	52 J	2,000 J	580	59 – 2,700	µg/kg dw
	1 to 2	23/45	51	48 J	450 J	100	59 – 200	µg/kg dw
	2 to 3	5/10	50	66	110 J	310	100 – 4,000	µg/kg dw
	3 to 4	6/9	67	35 J	130	62	58 – 140	µg/kg dw
	4 to 5	0/1	0	nd	nd	300	590	µg/kg dw
Benzyl alcohol	0 to 1	10/41	24	18 J	200	43	29 – 890	µg/kg dw
	1 to 2	7/45	16	19 J	210	20	19 – 99	µg/kg dw
	2 to 3	0/10	0	nd	nd	140	29 – 2,000	µg/kg dw
	3 to 4	0/9	0	nd	nd	15	29 – 34	µg/kg dw
	4 to 5	0/1	0	nd	nd	17	33	µg/kg dw
bis(2-chloroethoxy)methane	0 to 1	0/41	0	nd	nd	28	20 – 180	µg/kg dw
	1 to 2	0/41	0	nd	nd	20	19 – 130	µg/kg dw
	2 to 3	0/10	0	nd	nd	40	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	11	19 – 34	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
bis(2-chloroethyl)ether	0 to 1	0/41	0	nd	nd	28	19 – 180	µg/kg dw
	1 to 2	0/41	0	nd	nd	20	18 – 130	µg/kg dw
	2 to 3	0/10	0	nd	nd	44	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	9.8	19 – 20	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
bis(2-chloroisopropyl)ether	0 to 1	0/41	0	nd	nd	28	20 – 180	µg/kg dw
	1 to 2	0/41	0	nd	nd	20	19 – 130	µg/kg dw
	2 to 3	0/10	0	nd	nd	42	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	12	19 – 66	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
Caprolactam	0 to 1	0/23	0	nd	nd	600	670 – 1,600	µg/kg dw
Carbazole	0 to 1	5/25	20	78.0	240 J	120	130 – 280	µg/kg dw
	1 to 2	0/4	0	nd	nd	10	20.0 – 30	µg/kg dw
	2 to 3	0/4	0	nd	nd	69	20 – 400	µg/kg dw
	3 to 4	0/1	0	nd	nd	17	34	µg/kg dw
Coprostanol	0 to 1	0/1	0	nd	nd	65	130	µg/kg dw
	1 to 2	0/1	0	nd	nd	60	120	µg/kg dw
	2 to 3	0/1	0	nd	nd	70	140	µg/kg dw
	3 to 4	0/1	0	nd	nd	70	140	µg/kg dw
Hexachlorobenzene	0 to 1	1/41	2	5.9	5.9	5.0	0.83 – 180	µg/kg dw
	1 to 2	1/45	2	10	10	4	0.78 – 20.0	µg/kg dw
	2 to 3	0/10	0	nd	nd	28	0.86 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	2.1	0.86 – 6.0	µg/kg dw
	4 to 5	0/1	0	nd	nd	3.3	6.6	µg/kg dw
Hexachlorobutadiene	0 to 1	0/42	0	nd	nd	7.3	0.98 – 350	µg/kg dw
	1 to 2	0/46	0	nd	nd	4	0.98 – 30	µg/kg dw
	2 to 3	0/11	0	nd	nd	49	5.9 – 790	µg/kg dw
	3 to 4	0/10	0	nd	nd	3.9	0.96 – 34	µg/kg dw
	4 to 5	0/2	0	nd	nd	3.7	6.6 – 8.3	µg/kg dw
	5 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 7	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	7 to 8	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	8 to 9	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	9 to 10	1/1	100	13	13	13	na	µg/kg dw
Hexachlorocyclopentadiene	0 to 1	0/62	0	nd	nd	290	98 – 1,400	µg/kg dw
	1 to 2	0/40	0	nd	nd	110	97 – 650	µg/kg dw
	2 to 3	0/9	0	nd	nd	210	98 – 2,000	µg/kg dw
	3 to 4	0/8	0	nd	nd	49	96 – 99	µg/kg dw
	4 to 5	0/1	0	nd	nd	170	330	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Hexachloroethane	0 to 1	0/41	0	nd	nd	30	20 – 350	µg/kg dw
	1 to 2	0/41	0	nd	nd	20	19 – 130	µg/kg dw
	2 to 3	0/10	0	nd	nd	64	20 – 790	µg/kg dw
	3 to 4	0/9	0	nd	nd	11	19 – 34	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
Isophorone	0 to 1	0/64	0	nd	nd	59	20 – 310	µg/kg dw
	1 to 2	0/41	0	nd	nd	20	19 – 130	µg/kg dw
	2 to 3	0/10	0	nd	nd	39	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	11	19 – 34	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
Methyl isobutyl ketone	0 to 1	0/4	0	nd	nd	3.7	5.9 – 9.9	µg/kg dw
	1 to 2	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	2 to 3	0/3	0	nd	nd	3.9	6.8 – 9.2	µg/kg dw
	3 to 4	0/2	0	nd	nd	3.6	6.7 – 7.8	µg/kg dw
	4 to 5	0/2	0	nd	nd	9.1	8.3 – 28	µg/kg dw
	5 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 7	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	7 to 8	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	8 to 9	0/1	0	nd	nd	4.7	9.4	µg/kg dw
	9 to 10	0/1	0	nd	nd	4.2	8.4	µg/kg dw
Nitrobenzene	0 to 1	0/41	0	nd	nd	28	20 – 180	µg/kg dw
	1 to 2	0/41	0	nd	nd	20	19 – 130	µg/kg dw
	2 to 3	0/10	0	nd	nd	39	20 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	11	19 – 34	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
N-Nitrosodimethylamine	0 to 1	0/40	0	nd	nd	19	29 – 130	µg/kg dw
	1 to 2	0/38	0	nd	nd	20	29 – 120	µg/kg dw
	2 to 3	0/7	0	nd	nd	23	29 – 140	µg/kg dw
	3 to 4	0/9	0	nd	nd	21	29 – 140	µg/kg dw
	4 to 5	0/1	0	nd	nd	17	33	µg/kg dw
N-Nitroso-di-n-propylamine	0 to 1	3/41	7	30	320	28	29 – 180	µg/kg dw
	1 to 2	2/41	5	21 J	70	21	29 – 99	µg/kg dw
	2 to 3	0/10	0	nd	nd	42	29 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	15	29 – 34	µg/kg dw
	4 to 5	0/1	0	nd	nd	17	33	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
N-Nitrosodiphenylamine	0 to 1	1/41	2	33	33	24	8.2 – 320	µg/kg dw
	1 to 2	0/45	0	nd	nd	30	5.8 – 620	µg/kg dw
	2 to 3	0/10	0	nd	nd	48	5.9 – 400	µg/kg dw
	3 to 4	0/9	0	nd	nd	6.0	5.8 – 34	µg/kg dw
	4 to 5	0/1	0	nd	nd	16	32	µg/kg dw
Pentachlorophenol	0 to 1	15/64	23	16 J	930 J	430	29 – 3,100	µg/kg dw
	1 to 2	8/45	18	17 J	120 J	28	29 – 100	µg/kg dw
	2 to 3	1/10	10	26 J	26 J	140	29 – 2,000	µg/kg dw
	3 to 4	0/9	0	nd	nd	15	29 – 34	µg/kg dw
	4 to 5	0/1	0	nd	nd	17	33	µg/kg dw
Phenol	0 to 1	17/64	27	14 J	3,100	130	20 – 350	µg/kg dw
	1 to 2	9/45	20	15 J	150	30	19 – 130	µg/kg dw
	2 to 3	1/10	10	13 J	13 J	69	20 – 790	µg/kg dw
	3 to 4	2/9	22	13 J	13 J	17	19 – 140	µg/kg dw
	4 to 5	0/1	0	nd	nd	33	66	µg/kg dw
Retene	0 to 1	18/23	78	120 J	300 J	200	300 – 370	µg/kg dw
Polychlorinated biphenyls								
PCB-018	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-044	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-055	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-066	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-077	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-081	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-101	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-105	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-114	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-118	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-123	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-126	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-128	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-138	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-153	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-156	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-157	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-167	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-169	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-170	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-180	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-187	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-189	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-195	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-206	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
PCB-209	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
Aroclor-1016	0 to 1	0/96	0	nd	nd	170	3.9 – 14,000	µg/kg dw
	1 to 2	0/101	0	nd	nd	20	3.8 – 440	µg/kg dw
	2 to 3	0/104	0	nd	nd	50	0.10 – 2,800	µg/kg dw
	3 to 4	0/49	0	nd	nd	10	3.8 – 190	µg/kg dw
	4 to 5	0/57	0	nd	nd	27	3.9 – 1,100	µg/kg dw
	5 to 6	0/18	0	nd	nd	20	3.9 – 350	µg/kg dw
	6 to 7	0/21	0	nd	nd	10	17 – 39	µg/kg dw
	7 to 8	0/5	0	nd	nd	9.7	19 – 20	µg/kg dw
	8 to 9	0/10	0	nd	nd	9.6	3.9 – 39	µg/kg dw
Aroclor-1221	0 to 1	0/117	0	nd	nd	220	3.9 – 27,000	µg/kg dw
	1 to 2	0/101	0	nd	nd	20	3.8 – 440	µg/kg dw
	2 to 3	0/99	0	nd	nd	60	0.10 – 1,900	µg/kg dw
	3 to 4	0/49	0	nd	nd	20	3.8 – 380	µg/kg dw
	4 to 5	0/56	0	nd	nd	40	3.9 – 760	µg/kg dw
	5 to 6	0/18	0	nd	nd	20	3.9 – 120	µg/kg dw
	6 to 7	0/21	0	nd	nd	18	19 – 78	µg/kg dw
	7 to 8	0/5	0	nd	nd	15	19 – 39	µg/kg dw
	8 to 9	0/9	0	nd	nd	16	3.9 – 40	µg/kg dw
Aroclor-1232	0 to 1	0/117	0	nd	nd	140	3.9 – 14,000	µg/kg dw
	1 to 2	0/101	0	nd	nd	20	3.8 – 440	µg/kg dw
	2 to 3	0/99	0	nd	nd	30	0.10 – 930	µg/kg dw
	3 to 4	0/49	0	nd	nd	10	3.8 – 190	µg/kg dw
	4 to 5	0/56	0	nd	nd	53	3.9 – 3,800	µg/kg dw
	5 to 6	0/18	0	nd	nd	30	3.9 – 810	µg/kg dw
	6 to 7	0/21	0	nd	nd	10	17 – 39	µg/kg dw
	7 to 8	0/5	0	nd	nd	9.7	19 – 20	µg/kg dw
	8 to 9	0/9	0	nd	nd	8.6	3.9 – 20	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Aroclor-1242	0 to 1	21/118	18	5.2	820	150	3.9 – 14,000	µg/kg dw
	1 to 2	6/93	6	16	810	32	3.8 – 440	µg/kg dw
	2 to 3	4/99	4	44	2,300	70	0.10 – 2,800	µg/kg dw
	3 to 4	0/45	0	nd	nd	10	3.8 – 190	µg/kg dw
	4 to 5	1/57	2	160	160	40	14.6 – 2,300	µg/kg dw
	5 to 6	0/17	0	nd	nd	22	7.7 – 460	µg/kg dw
	6 to 7	0/21	0	nd	nd	10	17 – 39	µg/kg dw
	7 to 8	0/5	0	nd	nd	9.7	19 – 20	µg/kg dw
	8 to 9	0/10	0	nd	nd	9.6	3.9 – 39	µg/kg dw
Aroclor-1248	0 to 1	55/118	47	5.1	13,000	350	3.9 – 14,000	µg/kg dw
	1 to 2	53/101	52	5.0	1,500	100	3.8 – 570	µg/kg dw
	2 to 3	28/104	27	14 J	7,200	400	0.10 – 6,000	µg/kg dw
	3 to 4	9/49	18	97	2,500	100	3.8 – 190	µg/kg dw
	4 to 5	4/57	7	46.1	190	52	3.9 – 2,600	µg/kg dw
	5 to 6	2/18	11	63.2	110	50	3.9 – 1,200	µg/kg dw
	6 to 7	3/21	14	420	710	86	17 – 39	µg/kg dw
	7 to 8	2/5	40	82	370	96	19 – 20	µg/kg dw
	8 to 9	1/10	10	110	110	20	3.9 – 39	µg/kg dw
Aroclor-1254	0 to 1	86/101	85	5.7	81,000	1,500	6.7 – 15,000	µg/kg dw
	1 to 2	80/101	79	8.5 J	3,300	300	3.8 – 20	µg/kg dw
	2 to 3	61/104	59	4 J	26,000	1,000	0.10 – 2,000	µg/kg dw
	3 to 4	35/49	71	0.52 J	4,300	400	3.8 – 430	µg/kg dw
	4 to 5	20/57	35	24 J	4,800	210	18 – 200	µg/kg dw
	5 to 6	10/18	56	22	4,100	270	18 – 92	µg/kg dw
	6 to 7	4/21	19	34	1,300	150	17 – 100	µg/kg dw
	7 to 8	2/5	40	300	380	140	19 – 20	µg/kg dw
	8 to 9	2/10	20	260 J	360	69	3.9 – 20	µg/kg dw
Aroclor-1254/1260	0 to 1	16/17	94	34	1,700	190	85	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Aroclor-1260	0 to 1	79/101	78	7.8	51,000	1,900	6.9 – 3,400	µg/kg dw
	1 to 2	72/101	71	5.6	2,000	100	3.8 – 210	µg/kg dw
	2 to 3	67/104	64	6.3 J	26,000	820	0.10 – 1,800	µg/kg dw
	3 to 4	31/49	63	35.4	6,600	300	3.8 – 510	µg/kg dw
	4 to 5	23/57	40	16	6,400	390	18 – 380	µg/kg dw
	5 to 6	11/18	61	21.6	640	100	17 – 52	µg/kg dw
	6 to 7	6/21	29	21	610	80	17 – 300	µg/kg dw
	7 to 8	2/5	40	160	160	70	19 – 20	µg/kg dw
	8 to 9	2/10	20	25	220	32	3.9 – 39	µg/kg dw
Aroclor-1262	0 to 1	0/22	0	nd	nd	5.3	6.5 – 23	µg/kg dw
	8 to 9	1/1	100	120 J	120 J	120	na	µg/kg dw
Aroclor-1268	0 to 1	0/22	0	nd	nd	5.3	6.5 – 23	µg/kg dw
Total PCBs	0 to 1	114/118	97	13.5	108,000	3,000	nc	µg/kg dw
	1 to 2	83/101	82	19.6	6,500	500	nc	µg/kg dw
	2 to 3	75/104	72	4 J	32,000	2,000	nc	µg/kg dw
	3 to 4	36/49	73	0.52 J	9,100	810	nc	µg/kg dw
	4 to 5	26/57	46	23	6,400	600	nc	µg/kg dw
	5 to 6	13/18	72	22	4,700	370	nc	µg/kg dw
	6 to 7	6/21	29	21	2,400	310	nc	µg/kg dw
	7 to 8	2/5	40	540	910	300	nc	µg/kg dw
	8 to 9	3/10	30	25	690	120	nc	µg/kg dw
Organochlorine pesticides								
2,4'-DDD	0 to 1	0/10	0	nd	nd	3.4	2.0 – 17	µg/kg dw
	1 to 2	0/8	0	nd	nd	4.3	2.0 – 18	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.98	1.9 – 2.0	µg/kg dw
2,4'-DDE	0 to 1	0/10	0	nd	nd	11	2.0 – 100	µg/kg dw
	1 to 2	0/8	0	nd	nd	4.6	2.0 – 18	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.98	1.9 – 2.0	µg/kg dw
2,4'-DDT	0 to 1	0/10	0	nd	nd	3.4	2.0 – 17	µg/kg dw
	1 to 2	0/8	0	nd	nd	4.3	2.0 – 18	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.98	1.9 – 2.0	µg/kg dw
4,4'-DDD	0 to 1	1/11	9	2.7	2.7	3.4	2.0 – 17	µg/kg dw
	1 to 2	0/9	0	nd	nd	5.2	1.5 – 26	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.90	1.6 – 2.0	µg/kg dw
	3 to 4	0/3	0	nd	nd	1.2	1.6 – 3.4	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
4,4'-DDE	0 to 1	1/11	9	5.1 J	5.1 J	7.3	2.0 – 90	µg/kg dw
	1 to 2	0/9	0	nd	nd	6.1	1.5 – 50	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.65	1.0 – 1.6	µg/kg dw
	3 to 4	0/3	0	nd	nd	0.92	1.6 – 2.0	µg/kg dw
4,4'-DDT	0 to 1	1/11	9	2.8	2.8	21	2.0 – 160	µg/kg dw
	1 to 2	0/9	0	nd	nd	15	1.5 – 100	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.90	1.6 – 2.0	µg/kg dw
	3 to 4	0/3	0	nd	nd	5.9	1.6 – 32	µg/kg dw
DDTs (total-calc'd)	0 to 1	1/11	9	10.6 J	10.6 J	22	nc	µg/kg dw
	1 to 2	0/9	0	nd	nd	15	nc	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.90	nc	µg/kg dw
	3 to 4	0/3	0	nd	nd	5.9	nc	µg/kg dw
Aldrin	0 to 1	0/11	0	nd	nd	1.6	0.98 – 8.7	µg/kg dw
	1 to 2	0/9	0	nd	nd	2.0	0.98 – 9.2	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.65	1.0 – 1.6	µg/kg dw
	3 to 4	0/3	0	nd	nd	0.59	0.96 – 1.6	µg/kg dw
Dieldrin	0 to 1	1/11	9	1.8	1.8	3.9	2.0 – 31	µg/kg dw
	1 to 2	0/9	0	nd	nd	4.1	1.5 – 18	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.90	1.6 – 2.0	µg/kg dw
	3 to 4	0/3	0	nd	nd	0.92	1.6 – 2.0	µg/kg dw
Total aldrin/dieldrin	0 to 1	1/11	9	1.8	1.8	3.9	nc	µg/kg dw
	1 to 2	0/9	0	nd	nd	4.1	nc	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.90	nc	µg/kg dw
	3 to 4	0/3	0	nd	nd	0.92	nc	µg/kg dw
alpha-BHC	0 to 1	0/11	0	nd	nd	1.6	0.98 – 8.7	µg/kg dw
	1 to 2	0/9	0	nd	nd	2.0	0.98 – 9.2	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.65	1.0 – 1.6	µg/kg dw
	3 to 4	0/3	0	nd	nd	0.59	0.96 – 1.6	µg/kg dw
beta-BHC	0 to 1	0/11	0	nd	nd	1.7	0.98 – 8.7	µg/kg dw
	1 to 2	0/9	0	nd	nd	3.0	0.98 – 24	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.65	1.0 – 1.6	µg/kg dw
	3 to 4	0/3	0	nd	nd	0.59	0.96 – 1.6	µg/kg dw
gamma-BHC	0 to 1	0/11	0	nd	nd	1.7	0.98 – 8.7	µg/kg dw
	1 to 2	0/9	0	nd	nd	2.0	0.98 – 9.2	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.65	1.0 – 1.6	µg/kg dw
	3 to 4	0/3	0	nd	nd	0.59	0.96 – 1.6	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
delta-BHC	0 to 1	2/10	20	7.0	23	4.4	0.98 – 8.7	µg/kg dw
	1 to 2	2/8	25	19	60	11	0.98 – 9.2	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.79	0.96 – 2.2	µg/kg dw
alpha-Chlordane	0 to 1	0/10	0	nd	nd	1.7	0.98 – 8.7	µg/kg dw
	1 to 2	0/8	0	nd	nd	2.4	0.98 – 9.2	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.49	0.96 – 0.98	µg/kg dw
gamma-Chlordane	0 to 1	0/10	0	nd	nd	8.8	1.0 – 75	µg/kg dw
	1 to 2	0/8	0	nd	nd	7.4	0.98 – 47	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
	3 to 4	0/2	0	nd	nd	1.1	0.96 – 3.3	µg/kg dw
Chlordane	0 to 1	1/1	100	29.0	29.0	29.0	na	µg/kg dw
	1 to 2	0/1	0	nd	nd	3.8	7.5	µg/kg dw
	2 to 3	0/1	0	nd	nd	4.2	8.4	µg/kg dw
	3 to 4	0/1	0	nd	nd	4.2	8.4	µg/kg dw
alpha-Endosulfan	0 to 1	0/10	0	nd	nd	1.7	0.98 – 8.7	µg/kg dw
	1 to 2	0/8	0	nd	nd	2.2	0.98 – 9.2	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.50	1.0	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.49	0.96 – 0.98	µg/kg dw
beta-Endosulfan	0 to 1	0/10	0	nd	nd	3.4	2.0 – 17	µg/kg dw
	1 to 2	0/8	0	nd	nd	4.5	2.0 – 18	µg/kg dw
	2 to 3	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.98	1.9 – 2.0	µg/kg dw
Endosulfan	0 to 1	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.75	1.5	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
Endosulfan sulfate	0 to 1	0/10	0	nd	nd	5.6	2.0 – 39	µg/kg dw
	1 to 2	0/8	0	nd	nd	4.7	2.0 – 18	µg/kg dw
	2 to 3	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.98	1.9 – 2.0	µg/kg dw
Endrin	0 to 1	0/11	0	nd	nd	14	1.6 – 140	µg/kg dw
	1 to 2	0/9	0	nd	nd	8.0	1.5 – 86	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.90	1.6 – 2.0	µg/kg dw
	3 to 4	0/3	0	nd	nd	0.92	1.6 – 2.0	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Endrin aldehyde	0 to 1	0/11	0	nd	nd	3.2	1.6 – 17	µg/kg dw
	1 to 2	0/9	0	nd	nd	4.6	1.5 – 23	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.90	1.6 – 2.0	µg/kg dw
	3 to 4	0/3	0	nd	nd	0.92	1.6 – 2.0	µg/kg dw
Endrin ketone	0 to 1	0/10	0	nd	nd	3.4	2.0 – 17	µg/kg dw
	1 to 2	0/8	0	nd	nd	4.3	2.0 – 18	µg/kg dw
	2 to 3	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.98	1.9 – 2.0	µg/kg dw
Heptachlor	0 to 1	0/11	0	nd	nd	1.7	0.98 – 8.7	µg/kg dw
	1 to 2	0/9	0	nd	nd	2.0	0.98 – 9.2	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.65	1.0 – 1.6	µg/kg dw
	3 to 4	0/3	0	nd	nd	0.59	0.96 – 1.6	µg/kg dw
Heptachlor epoxide	0 to 1	0/11	0	nd	nd	8.9	0.98 – 95	µg/kg dw
	1 to 2	0/9	0	nd	nd	5.3	0.99 – 62	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.65	1.0 – 1.6	µg/kg dw
	3 to 4	0/3	0	nd	nd	0.59	0.96 – 1.6	µg/kg dw
Methoxychlor	0 to 1	0/11	0	nd	nd	16	8.1 – 87	µg/kg dw
	1 to 2	0/9	0	nd	nd	20	7.5 – 92	µg/kg dw
	2 to 3	0/2	0	nd	nd	2.4	1.0 – 8.4	µg/kg dw
	3 to 4	0/3	0	nd	nd	4.6	8.4 – 9.8	µg/kg dw
Mirex	0 to 1	0/10	0	nd	nd	3.4	2.0 – 17	µg/kg dw
	1 to 2	0/8	0	nd	nd	4.3	2.0 – 18	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.98	1.9 – 2.0	µg/kg dw
Cis-Nonachlor	0 to 1	0/10	0	nd	nd	3.5	2.0 – 17	µg/kg dw
	1 to 2	0/8	0	nd	nd	4.3	2.0 – 18	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.98	1.9 – 2.0	µg/kg dw
Oxychlordane	0 to 1	0/10	0	nd	nd	3.4	2.0 – 17	µg/kg dw
	1 to 2	0/8	0	nd	nd	4.3	2.0 – 18	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.98	1.9 – 2.0	µg/kg dw
Toxaphene	0 to 1	0/11	0	nd	nd	160	16 – 870	µg/kg dw
	1 to 2	0/9	0	nd	nd	190	15 – 920	µg/kg dw
	2 to 3	0/2	0	nd	nd	6.5	10 – 16	µg/kg dw
	3 to 4	0/3	0	nd	nd	35	16 – 98	µg/kg dw
Trans-Nonachlor	0 to 1	0/10	0	nd	nd	3.4	2.0 – 17	µg/kg dw
	1 to 2	0/8	0	nd	nd	4.3	2.0 – 18	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.98	1.9 – 2.0	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Total chlordane	0 to 1	0/10	0	nd	nd	9.2	nc	µg/kg dw
	1 to 2	0/8	0	nd	nd	7.9	nc	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.50	nc	µg/kg dw
	3 to 4	0/2	0	nd	nd	1.3	nc	µg/kg dw
Grain size								
Fractional % (>9525 µm)	2 to 3	0/1	0	nd	nd	0.0050	0.010	% dw
	0 to 1	48/59	81	0.100 J	30.9	3	0.100	% dw
	1 to 2	49/58	84	0.100 J	44.4	3	0.100	% dw
	2 to 3	7/7	100	0.1	24.6 J	4	na	% dw
	3 to 4	10/10	100	0.1	40.6	8	na	% dw
Fractional % phi -2-(-1) (2000-4000 µm)	2 to 3	1/1	100	0.010	0.010	0.010	na	% dw
Fractional % phi -1-0 (1000-2000 µm)	0 to 1	74/74	100	0.1	10.7	2	na	% dw
	1 to 2	57/60	95	0.1	5.1	1	0.1	% dw
	2 to 3	11/11	100	0.010 J	10	2	na	% dw
	3 to 4	10/10	100	0.1	6.4	3	na	% dw
	4 to 5	0/1	0	nd	nd	0.0050	0.010	% dw
Fractional % phi 0-1 (500-1000 µm)	0 to 1	74/74	100	0.800 J	31.2	5	na	% dw
	1 to 2	59/59	100	0.2	29.9	4	na	% dw
	2 to 3	11/11	100	0.25 J	32	9	na	% dw
	3 to 4	10/10	100	1.7	41.4	10	na	% dw
	4 to 5	1/1	100	11	11	11	na	% dw
	8 to 9	1/1	100	4.0	4.0	4.0	na	% dw
Fractional % phi 1-2 (250-500 µm)	0 to 1	74/74	100	0.600 J	49.3	10	na	% dw
	1 to 2	58/59	98	0.700 J	58.1	9	0.1	% dw
	2 to 3	11/11	100	0.50 J	30	14	na	% dw
	3 to 4	10/10	100	2.9	50	27	na	% dw
	4 to 5	1/1	100	45	45	45	na	% dw
	8 to 9	1/1	100	31	31	31	na	% dw
Fractional % phi 2-3 (125-250 µm)	0 to 1	74/74	100	1.2	33.3	8.4	na	% dw
	1 to 2	59/59	100	0.900 J	36.6	8.4	na	% dw
	2 to 3	11/11	100	3.0 J	38.5	15	na	% dw
	3 to 4	10/10	100	3.9	40.6	19	na	% dw
	4 to 5	1/1	100	14	14	14	na	% dw
	8 to 9	1/1	100	35	35	35	na	% dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Fractional % phi 3-4 (62.5-125 µm)	0 to 1	74/74	100	2.50	30.2	9.9	na	% dw
	1 to 2	60/60	100	1.0	40	12	na	% dw
	2 to 3	11/11	100	2.0	39.4	16	na	% dw
	3 to 4	10/10	100	0.8	42.8	10	na	% dw
	4 to 5	1/1	100	17	17	17	na	% dw
	8 to 9	1/1	100	15	15	15	na	% dw
Fractional % phi 4-5 (31.2-62.5 µm)	0 to 1	74/74	100	0.400 J	25.7 J	12	na	% dw
	1 to 2	60/60	100	0.8	23.6	10	na	% dw
	2 to 3	11/11	100	2.0	27	10	na	% dw
	3 to 4	10/10	100	0.2	23.4	8	na	% dw
	4 to 5	1/1	100	6.0	6.0	6.0	na	% dw
	8 to 9	1/1	100	10	10	10	na	% dw
Fractional % phi 5-6 (15.6-31.2 µm)	0 to 1	74/74	100	0.700	37.1 J	15	na	% dw
	1 to 2	59/59	100	0.1	46.4 J	20	na	% dw
	2 to 3	11/11	100	2.0	24.4 J	10	na	% dw
	3 to 4	8/8	100	0.1	13.6	5	na	% dw
	4 to 5	1/1	100	2.0	2.0	2.0	na	% dw
	8 to 9	1/1	100	1.0	1.0	1.0	na	% dw
Fractional % phi 6-7 (7.8-15.6 µm)	0 to 1	73/74	99	0.600	24.9 J	13	0.010	% dw
	1 to 2	59/59	100	0.1	27.2 J	10	na	% dw
	2 to 3	11/11	100	1.1	20.8 J	7.8	na	% dw
	3 to 4	8/8	100	0.2	6.5	3	na	% dw
	4 to 5	1/1	100	3.0	3.0	3.0	na	% dw
	8 to 9	1/1	100	1.0	1.0	1.0	na	% dw
Fractional % phi 7-8 (3.9-7.8 µm)	0 to 1	74/74	100	0.500	14.8	6.7	na	% dw
	1 to 2	59/59	100	0.1	16.4	7	na	% dw
	2 to 3	11/11	100	1.0	9.3	4.4	na	% dw
	3 to 4	8/8	100	0.1	4.2	2	na	% dw
	4 to 5	1/1	100	1.0	1.0	1.0	na	% dw
Fractional % phi 8-9 (1.95-3.9 µm)	0 to 1	73/74	99	0.300	9.1	4	0.010	% dw
	1 to 2	59/59	100	0.1	10.4	4	na	% dw
	2 to 3	11/11	100	0.5	5.9	3	na	% dw
	3 to 4	7/8	88	0.4 J	2.3	1	0.1	% dw
	4 to 5	0/1	0	nd	nd	0.0050	0.010	% dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Fractional % phi 9-10 (0.98-1.95 µm)	0 to 1	74/74	100	0.200	7.10 J	3	na	% dw
	1 to 2	58/59	98	0.2	7.6	3	0.1	% dw
	2 to 3	11/11	100	0.4 J	3.4	2	na	% dw
	3 to 4	7/8	88	0.1 J	1.3	0.7	0.1	% dw
	4 to 5	0/1	0	nd	nd	0.0050	0.010	% dw
	8 to 9	1/1	100	1.0	1.0	1.0	na	% dw
Fractional % phi 10+ (<0.98 µm)	0 to 1	73/74	99	0.300	16.1	6.2	0.010	% dw
	1 to 2	58/59	98	0.6	17.0	6	0.100	% dw
	2 to 3	11/11	100	0.6 J	7.5	3	na	% dw
	3 to 4	8/8	100	0.5 J	4.3	2	na	% dw
	4 to 5	0/1	0	nd	nd	0.0050	0.010	% dw
Fractional % Sieve #10 (2000-4750 µm)	0 to 1	1/1	100	13	13	13	na	% dw
	2 to 3	1/1	100	3.0	3.0	3.0	na	% dw
	4 to 5	0/1	0	nd	nd	0.0050	0.010	% dw
	8 to 9	1/1	100	1.0	1.0	1.0	na	% dw
Fractional % Sieve 3/8 in. (4,750-9,525 µm)	2 to 3	1/1	100	0.19 J	0.19 J	0.19	na	% dw
Fractional % Sieve #4 (>4750 µm)	0 to 1	1/1	100	56	56	56	na	% dw
	2 to 3	1/1	100	6.0	6.0	6.0	na	% dw
	4 to 5	0/1	0	nd	nd	0.0050	0.010	% dw
	8 to 9	1/1	100	1.0	1.0	1.0	na	% dw
Gravel (total calc'd)	0 to 1	49/60	82	0.100 J	69	4	nc	% dw
	1 to 2	49/58	84	0.100 J	44.4	3	nc	% dw
	2 to 3	9/9	100	0.1	24.6 J	5	na	% dw
	3 to 4	10/10	100	0.1	40.6	8	na	% dw
	4 to 5	0/1	0	nd	nd	0.0050	nc	% dw
	8 to 9	1/1	100	2.0	2.0	2.0	na	% dw
Sand (total calc'd)	0 to 1	75/75	100	10.50 J	89.2	35	na	% dw
	1 to 2	61/61	100	5.8	97.4	35	na	% dw
	2 to 3	12/12	100	28 J	91.0	59	na	% dw
	3 to 4	11/11	100	30.0	99	75	na	% dw
	4 to 5	1/1	100	87	87	87	na	% dw
	8 to 9	1/1	100	85	85	85	na	% dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Silt (total calc'd)	0 to 1	75/75	100	2.600 J	76.7 J	46	na	% dw
	1 to 2	61/61	100	1.1	76.6 J	49	na	% dw
	2 to 3	12/12	100	7.0	61	31	na	% dw
	3 to 4	11/11	100	0.6	45.5	10	na	% dw
	4 to 5	1/1	100	12.0	12.0	12.0	na	% dw
	8 to 9	1/1	100	12	12	12	na	% dw
Clay (total calc'd)	0 to 1	75/75	100	0.8	31.1	10	na	% dw
	1 to 2	60/60	100	0.1	31.9	10	na	% dw
	2 to 3	12/12	100	0.1	16.8	7	na	% dw
	3 to 4	9/9	100	0.1	7.9	3	na	% dw
	4 to 5	0/1	0	nd	nd	0.0050	nc	% dw
	8 to 9	1/1	100	1.0	1.0	1.0	na	% dw
Gravel	0 to 1	1/1	100	27.0	27.0	27.0	na	% dw
	1 to 2	2/2	100	1.70	22.0	11.9	na	% dw
	2 to 3	1/1	100	0.6	0.6	0.6	na	% dw
	3 to 4	1/1	100	2.3	2.3	2.3	na	% dw
Coarse Sand (4750-2000 microns)	1 to 2	1/1	100	2.10	2.10	2.10	na	% dw
Medium Sand (2000-425 microns)	1 to 2	1/1	100	3.10	3.10	3.10	na	% dw
Fine Sand (425-75 microns)	1 to 2	1/1	100	8.30	8.30	8.30	na	% dw
Fines (percent silt+clay)	0 to 1	74/74	100	3.900 J	89.4 J	60	na	% dw
	1 to 2	60/60	100	1.8	94.0	63	na	% dw
	2 to 3	11/11	100	10.0	72	40	na	% dw
	3 to 4	10/10	100	1.2	50.6	18	na	% dw
	4 to 5	1/1	100	12.0	12.0	12.0	na	% dw
	8 to 9	1/1	100	13	13	13	na	% dw
Conventional parameters								
Total Organic Carbon (TOC)	0 to 1	118/118	100	0.0481	6.3	1.9	na	% dw
	1 to 2	101/101	100	0.116	3.93	1.6	na	% dw
	2 to 3	103/103	100	0.022	17	1	na	% dw
	3 to 4	50/50	100	0.030	3.7	1.1	na	% dw
	4 to 5	57/57	100	0.011	4.4	0.9	na	% dw
	5 to 6	18/18	100	0.07	3.1	1	na	% dw
	6 to 7	21/21	100	0.023	2.3	0.8	na	% dw
	7 to 8	5/5	100	0.089	0.96	0.45	na	% dw
	8 to 9	10/10	100	0.028	2.1	0.39	na	% dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Total solids	0 to 1	118/118	100	42.60	88.5	59	na	% ww
	1 to 2	86/86	100	37.40	89.50	61.8	na	% ww
	2 to 3	83/83	100	26.0	92.60	73.4	na	% ww
	3 to 4	35/35	100	53.90	87.2	76.2	na	% ww
	4 to 5	56/56	100	57.40	86.9	76.5	na	% ww
	5 to 6	18/18	100	58.40	85.9	73.5	na	% ww
	6 to 7	22/22	100	53.90	87.6	75.9	na	% ww
	7 to 8	6/6	100	52.80	87.3	76.7	na	% ww
	8 to 9	10/10	100	51.11	89.1	77.0	na	% ww
	9 to 10	1/1	100	59.29	59.29	59.29	na	% ww
Sulfides (total)	0 to 1	0/1	0	nd	nd	0.55	1.1	mg/kg dw
	2 to 3	0/1	0	nd	nd	0.65	1.3	mg/kg dw
Cyanide	0 to 1	0/1	0	nd	nd	0.070	0.14	mg/kg dw
	2 to 3	1/1	100	0.35	0.35	0.35	na	mg/kg dw
Moisture	0 to 1	18/18	100	31.22	121.6	75.49	na	% dw
	1 to 2	1/1	100	81.6	81.6	81.6	na	% ww
	1 to 2	22/22	100	23.41	161.7	65.29	na	% dw
	2 to 3	4/4	100	22.31	48.20	36.61	na	% dw
	3 to 4	1/1	100	30.90	30.90	30.90	na	% dw
pH	0 to 1	1/1	100	8.1	8.1	8.1	na	pH
	2 to 3	1/1	100	7.3	7.3	7.3	na	pH
Specific Gravity	0 to 1	18/18	100	2.56	2.69	2.64	na	g/cc
	1 to 2	22/22	100	2.37	2.71	2.6	na	g/cc
	2 to 3	4/4	100	2.64	2.69	2.67	na	g/cc
	3 to 4	1/1	100	2.69	2.69	2.69	na	g/cc
Volatile organic compounds								
1,1,1,2-Tetrachloroethane	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,1,1-Trichloroethane	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
1,1,2,2-Tetrachloroethane	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
1,1,2-Trichloroethane	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,1,2-Trichlorotrifluoroethane	0 to 1	0/4	0	nd	nd	1.5	2.3 – 4.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	2 to 3	0/3	0	nd	nd	1.6	2.7 – 3.7	µg/kg dw
	3 to 4	0/2	0	nd	nd	1.5	2.7 – 3.1	µg/kg dw
	4 to 5	0/2	0	nd	nd	3.6	3.3 – 11	µg/kg dw
	5 to 6	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	6 to 7	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	7 to 8	0/1	0	nd	nd	1.9	3.8	µg/kg dw
	8 to 9	0/1	0	nd	nd	1.9	3.7	µg/kg dw
	9 to 10	0/1	0	nd	nd	1.7	3.4	µg/kg dw
1,1-Dichloroethane	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
1,1-Dichloroethene	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,1-Dichloropropene	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
1,2,3-Trichlorobenzene	0 to 1	0/1	0	nd	nd	5.0	9.9	µg/kg dw
	1 to 2	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	2 to 3	0/1	0	nd	nd	4.6	9.2	µg/kg dw
	3 to 4	0/1	0	nd	nd	3.9	7.8	µg/kg dw
	4 to 5	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	5 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 7	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	7 to 8	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	8 to 9	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	9 to 10	0/1	0	nd	nd	4.2	8.4	µg/kg dw
1,2,3-Trichloropropane	0 to 1	0/1	0	nd	nd	2.0	4.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	2 to 3	0/1	0	nd	nd	1.9	3.7	µg/kg dw
	3 to 4	0/1	0	nd	nd	1.6	3.1	µg/kg dw
	4 to 5	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	5 to 6	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	6 to 7	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	7 to 8	0/1	0	nd	nd	1.9	3.8	µg/kg dw
	8 to 9	0/1	0	nd	nd	1.9	3.8	µg/kg dw
	9 to 10	0/1	0	nd	nd	1.7	3.4	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,2,4-Trimethylbenzene	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	1/1	100	420	420	420	na	µg/kg dw
1,2-Dibromo-3-chloropropane	0 to 1	0/1	0	nd	nd	5.0	9.9	µg/kg dw
	1 to 2	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	2 to 3	0/1	0	nd	nd	4.6	9.2	µg/kg dw
	3 to 4	0/1	0	nd	nd	3.9	7.8	µg/kg dw
	4 to 5	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	5 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 7	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	7 to 8	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	8 to 9	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	9 to 10	0/1	0	nd	nd	4.2	8.4	µg/kg dw
1,2-Dibromoethane (EDB)	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,2-Dichloroethane	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
1,2-Dichloropropane	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
1,3,5-Trimethylbenzene	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	1/1	100	1.9	1.9	1.9	na	µg/kg dw
	9 to 10	1/1	100	180	180	180	na	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,3-Dichloropropane	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
2,2-Dichloropropane	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
2-Chloroethyl vinyl ether	0 to 1	0/4	0	nd	nd	3.7	5.9 – 9.9	µg/kg dw
	1 to 2	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	2 to 3	0/3	0	nd	nd	3.9	6.8 – 9.2	µg/kg dw
	3 to 4	0/2	0	nd	nd	3.6	6.7 – 7.8	µg/kg dw
	4 to 5	0/2	0	nd	nd	9.1	8.3 – 28	µg/kg dw
	5 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 7	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	7 to 8	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	8 to 9	0/1	0	nd	nd	4.7	9.4	µg/kg dw
	9 to 10	0/1	0	nd	nd	4.2	8.4	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
2-Chlorotoluene	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
2-Hexanone	0 to 1	0/4	0	nd	nd	3.7	5.9 – 9.9	µg/kg dw
	1 to 2	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	2 to 3	0/3	0	nd	nd	3.9	6.8 – 9.2	µg/kg dw
	3 to 4	0/2	0	nd	nd	3.6	6.7 – 7.8	µg/kg dw
	4 to 5	0/2	0	nd	nd	9.1	8.3 – 28	µg/kg dw
	5 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 7	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	7 to 8	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	8 to 9	0/1	0	nd	nd	4.7	9.4	µg/kg dw
	9 to 10	0/1	0	nd	nd	4.2	8.4	µg/kg dw
4-Chlorotoluene	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Acetone	0 to 1	2/4	50	17	59	21	6.6 – 10	µg/kg dw
	1 to 2	1/1	100	40	40	40	na	µg/kg dw
	2 to 3	2/3	67	41	53	32	6.8	µg/kg dw
	3 to 4	1/2	50	38	38	21	6.7	µg/kg dw
	4 to 5	1/2	50	94	94	56	37	µg/kg dw
	5 to 6	1/1	100	100	100	100	na	µg/kg dw
	6 to 7	1/1	100	120	120	120	na	µg/kg dw
	7 to 8	1/1	100	190	190	190	na	µg/kg dw
	8 to 9	1/1	100	440	440	440	na	µg/kg dw
	9 to 10	1/1	100	550	550	550	na	µg/kg dw
Acrolein	0 to 1	0/1	0	nd	nd	50	99	µg/kg dw
	1 to 2	0/1	0	nd	nd	42	83	µg/kg dw
	2 to 3	0/1	0	nd	nd	46	92	µg/kg dw
	3 to 4	0/1	0	nd	nd	39	78	µg/kg dw
	4 to 5	0/1	0	nd	nd	42	83	µg/kg dw
	5 to 6	0/1	0	nd	nd	42	83	µg/kg dw
	6 to 7	0/1	0	nd	nd	41	82	µg/kg dw
	7 to 8	0/1	0	nd	nd	48	95	µg/kg dw
	8 to 9	0/1	0	nd	nd	47	94	µg/kg dw
	9 to 10	0/1	0	nd	nd	42	84	µg/kg dw
Acrylonitrile	0 to 1	0/1	0	nd	nd	5.0	9.9	µg/kg dw
	1 to 2	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	2 to 3	0/1	0	nd	nd	4.6	9.2	µg/kg dw
	3 to 4	0/1	0	nd	nd	3.9	7.8	µg/kg dw
	4 to 5	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	5 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 7	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	7 to 8	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	8 to 9	0/1	0	nd	nd	4.7	9.4	µg/kg dw
	9 to 10	0/1	0	nd	nd	4.2	8.4	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Benzene	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	1/1	100	4.4	4.4	4.4	na	µg/kg dw
	8 to 9	1/1	100	12	12	12	na	µg/kg dw
	9 to 10	1/1	100	41	41	41	na	µg/kg dw
Bromobenzene	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
Bromochloromethane	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Bromodichloromethane	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
Bromoethane	0 to 1	0/1	0	nd	nd	2.0	4.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	2 to 3	0/1	0	nd	nd	1.9	3.7	µg/kg dw
	3 to 4	0/1	0	nd	nd	1.6	3.1	µg/kg dw
	4 to 5	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	5 to 6	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	6 to 7	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	7 to 8	0/1	0	nd	nd	1.9	3.8	µg/kg dw
	8 to 9	0/1	0	nd	nd	1.9	3.7	µg/kg dw
	9 to 10	0/1	0	nd	nd	1.7	3.4	µg/kg dw
Bromoform	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Bromomethane	0 to 1	0/4	0	nd	nd	1.2	2.0 – 2.9	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	1.3	1.8 – 3.0	µg/kg dw
	3 to 4	0/2	0	nd	nd	1.1	1.6 – 2.7	µg/kg dw
	4 to 5	0/2	0	nd	nd	3.2	1.7 – 11	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
Carbon disulfide	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	1/1	100	4.0	4.0	4.0	na	µg/kg dw
	2 to 3	2/3	67	6.3	18	8.3	1.4	µg/kg dw
	3 to 4	1/2	50	3.0	3.0	1.8	1.3	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	1/1	100	2.2	2.2	2.2	na	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	1/1	100	2.8	2.8	2.8	na	µg/kg dw
	8 to 9	1/1	100	5.3	5.3	5.3	na	µg/kg dw
	9 to 10	1/1	100	1.9	1.9	1.9	na	µg/kg dw
Carbon tetrachloride	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Chlorobenzene	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
Chloroethane	0 to 1	0/4	0	nd	nd	1.2	2.0 – 2.9	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	1.3	1.8 – 3.0	µg/kg dw
	3 to 4	0/2	0	nd	nd	1.1	1.6 – 2.7	µg/kg dw
	4 to 5	0/2	0	nd	nd	3.2	1.7 – 11	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
Chloroform	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Chloromethane	0 to 1	0/4	0	nd	nd	1.2	2.0 – 2.9	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	1.3	1.8 – 3.0	µg/kg dw
	3 to 4	0/2	0	nd	nd	1.1	1.6 – 2.7	µg/kg dw
	4 to 5	0/2	0	nd	nd	3.2	1.7 – 11	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
cis-1,2-Dichloroethene	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	1/2	50	2.3	2.3	1.6	1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	1/1	100	2.2	2.2	2.2	na	µg/kg dw
	7 to 8	1/1	100	8.1	8.1	8.1	na	µg/kg dw
	8 to 9	1/1	100	16	16	16	na	µg/kg dw
	9 to 10	1/1	100	46	46	46	na	µg/kg dw
cis-1,3-Dichloropropene	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
p-Cymene	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	1/1	100	4.5	4.5	4.5	na	µg/kg dw
	9 to 10	1/1	100	100	100	100	na	µg/kg dw
Dibromochloromethane	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
Dibromomethane	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Dichloromethane	0 to 1	0/4	0	nd	nd	1.5	2.3 – 4.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	2 to 3	0/3	0	nd	nd	1.6	3.0 – 3.7	µg/kg dw
	3 to 4	0/2	0	nd	nd	1.5	2.7 – 3.1	µg/kg dw
	4 to 5	0/2	0	nd	nd	3.6	3.3 – 11	µg/kg dw
	5 to 6	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	6 to 7	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	7 to 8	0/1	0	nd	nd	1.9	3.8	µg/kg dw
	8 to 9	0/1	0	nd	nd	1.9	3.7	µg/kg dw
	9 to 10	0/1	0	nd	nd	1.7	3.4	µg/kg dw
Ethylbenzene	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	1/1	100	240	240	240	na	µg/kg dw
Iodomethane	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Isopropylbenzene	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	1/1	100	72	72	72	na	µg/kg dw
Methyl ethyl ketone	0 to 1	1/4	25	21	21	7.7	5.9 – 7.2	µg/kg dw
	1 to 2	1/1	100	13	13	13	na	µg/kg dw
	2 to 3	2/3	67	12	13	9.5	6.8	µg/kg dw
	3 to 4	1/2	50	12	12	7.7	6.7	µg/kg dw
	4 to 5	1/2	50	28	28	21	28	µg/kg dw
	5 to 6	1/1	100	26	26	26	na	µg/kg dw
	6 to 7	1/1	100	30	30	30	na	µg/kg dw
	7 to 8	1/1	100	49	49	49	na	µg/kg dw
	8 to 9	1/1	100	100	100	100	na	µg/kg dw
	9 to 10	1/1	100	100	100	100	na	µg/kg dw
n-Butylbenzene	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	1/1	100	58	58	58	na	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
n-Propylbenzene	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	1/1	100	68	68	68	na	µg/kg dw
sec-Butylbenzene	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	1/1	100	57	57	57	na	µg/kg dw
Styrene	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
tert-Butylbenzene	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/1	0	nd	nd	0.90	1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	1/1	100	6.1	6.1	6.1	na	µg/kg dw
Tetrachloroethene	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
Toluene	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	1/3	33	1.8	1.8	1.1	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	1/1	100	1.8	1.8	1.8	na	µg/kg dw
	7 to 8	1/1	100	2.0	2.0	2.0	na	µg/kg dw
	8 to 9	1/1	100	40	40	40	na	µg/kg dw
	9 to 10	1/1	100	2,500	2,500	2,500	na	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
trans-1,2-Dichloroethene	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	1/1	100	22	22	22	na	µg/kg dw
trans-1,3-Dichloropropene	0 to 1	0/4	0	nd	nd	0.74	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	0/2	0	nd	nd	0.73	1.3 – 1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
trans-1,4-Dichloro-2-butene	0 to 1	0/1	0	nd	nd	5.0	9.9	µg/kg dw
	1 to 2	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	2 to 3	0/1	0	nd	nd	4.6	9.2	µg/kg dw
	3 to 4	0/1	0	nd	nd	3.9	7.8	µg/kg dw
	4 to 5	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	5 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 7	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	7 to 8	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	8 to 9	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	9 to 10	0/1	0	nd	nd	4.2	8.4	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Trichloroethene	0 to 1	1/4	25	3.6 J	3.6 J	1.5	1.2 – 2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	0.78	1.4 – 1.8	µg/kg dw
	3 to 4	1/2	50	23	23	12	1.6	µg/kg dw
	4 to 5	0/2	0	nd	nd	1.8	1.7 – 5.6	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
Trichlorofluoromethane	0 to 1	0/4	0	nd	nd	1.2	2.0 – 2.9	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	1.3	1.8 – 3.0	µg/kg dw
	3 to 4	0/2	0	nd	nd	1.1	1.6 – 2.7	µg/kg dw
	4 to 5	0/2	0	nd	nd	3.2	1.7 – 11	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	0/1	0	nd	nd	0.85	1.7	µg/kg dw
Vinyl acetate	0 to 1	0/4	0	nd	nd	3.7	5.9 – 9.9	µg/kg dw
	1 to 2	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	2 to 3	0/3	0	nd	nd	3.9	6.8 – 9.2	µg/kg dw
	3 to 4	0/2	0	nd	nd	3.6	6.7 – 7.8	µg/kg dw
	4 to 5	0/2	0	nd	nd	9.1	8.3 – 28	µg/kg dw
	5 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 7	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	7 to 8	0/1	0	nd	nd	4.8	9.5	µg/kg dw
	8 to 9	0/1	0	nd	nd	4.7	9.4	µg/kg dw
	9 to 10	0/1	0	nd	nd	4.2	8.4	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Vinyl chloride	0 to 1	0/4	0	nd	nd	1.2	2.0 – 2.9	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/3	0	nd	nd	1.3	1.8 – 3.0	µg/kg dw
	3 to 4	0/2	0	nd	nd	1.1	1.6 – 2.7	µg/kg dw
	4 to 5	0/2	0	nd	nd	3.2	1.7 – 11	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	2.8	5.6	µg/kg dw
	7 to 8	1/1	100	29	29	29	na	µg/kg dw
	8 to 9	1/1	100	44	44	44	na	µg/kg dw
	9 to 10	1/1	100	450	450	450	na	µg/kg dw
Xylene (ortho)	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.80	1.4 – 1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	1/1	100	490	490	490	na	µg/kg dw
Xylene (meta & para)	0 to 1	0/1	0	nd	nd	1.0	2.0	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.80	1.4 – 1.8	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	1.9	µg/kg dw
	9 to 10	1/1	100	1,200	1,200	1,200	na	µg/kg dw
Xylene (total)	0 to 1	0/3	0	nd	nd	1.3	2.3 – 2.9	µg/kg dw
	2 to 3	0/1	0	nd	nd	1.5	3.0	µg/kg dw
	3 to 4	0/1	0	nd	nd	1.4	2.7	µg/kg dw
	4 to 5	0/1	0	nd	nd	5.5	11	µg/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Total Xylenes (calc'd)	0 to 1	0/1	0	nd	nd	1.0	nc	µg/kg dw
	1 to 2	0/1	0	nd	nd	0.85	nc	µg/kg dw
	2 to 3	0/2	0	nd	nd	0.80	nc	µg/kg dw
	3 to 4	0/1	0	nd	nd	0.80	nc	µg/kg dw
	4 to 5	0/1	0	nd	nd	0.85	nc	µg/kg dw
	5 to 6	0/1	0	nd	nd	0.85	nc	µg/kg dw
	6 to 7	0/1	0	nd	nd	0.80	nc	µg/kg dw
	7 to 8	0/1	0	nd	nd	0.95	nc	µg/kg dw
	8 to 9	0/1	0	nd	nd	0.95	nc	µg/kg dw
	9 to 10	1/1	100	1,700	1,700	1,700	na	µg/kg dw
Dioxins/furans								
2,3,7,8-TCDD	0 to 1	7/7	100	0.325	0.754	0.551	na	ng/kg dw
	1 to 2	4/7	57	0.408	0.524	0.322	0.0467 – 0.454	ng/kg dw
1,2,3,7,8-PeCDD	0 to 1	7/7	100	0.883 J	2.80	1.69	na	ng/kg dw
	1 to 2	7/7	100	0.0640 J	2.84	1.45	na	ng/kg dw
1,2,3,4,7,8-HxCDD	0 to 1	7/7	100	1.40	4.14	2.68	na	ng/kg dw
	1 to 2	6/7	86	0.171 J	5.55	2.51	0.106	ng/kg dw
1,2,3,6,7,8-HxCDD	0 to 1	7/7	100	6.56	44.5	19.9	na	ng/kg dw
	1 to 2	7/7	100	0.430 J	19.9	11.9	na	ng/kg dw
1,2,3,7,8,9-HxCDD	0 to 1	7/7	100	5.28	14.9	9.44	na	ng/kg dw
	1 to 2	7/7	100	0.331 J	15.1	8.25	na	ng/kg dw
1,2,3,4,6,7,8-HpCDD	0 to 1	7/7	100	186	1,270	560	na	ng/kg dw
	1 to 2	7/7	100	12.9	740	354	na	ng/kg dw
OCDD	0 to 1	7/7	100	1,510	10,700	5,010	na	ng/kg dw
	1 to 2	7/7	100	100	6,840	2,840	na	ng/kg dw
2,3,7,8-TCDF	0 to 1	5/7	71	0.451	2.21	1.25	0.621 – 2.30	ng/kg dw
	1 to 2	5/7	71	0.0740 J	1.41	0.743	0.0467 – 0.637	ng/kg dw
1,2,3,7,8-PeCDF	0 to 1	7/7	100	0.361 J	5.82	1.78	na	ng/kg dw
	1 to 2	6/7	86	0.0930 J	1.32	0.780	0.0467	ng/kg dw
2,3,4,7,8-PeCDF	0 to 1	7/7	100	1.01	21.3	5.38	na	ng/kg dw
	1 to 2	7/7	100	0.109 J	2.80	1.64	na	ng/kg dw
1,2,3,4,7,8-HxCDF	0 to 1	7/7	100	3.73	152	30.5	na	ng/kg dw
	1 to 2	7/7	100	0.205 J	13.0	6.28	na	ng/kg dw
1,2,3,6,7,8-HxCDF	0 to 1	7/7	100	1.32	24.3	6.13	na	ng/kg dw
	1 to 2	7/7	100	0.135 J	3.81	2.04	na	ng/kg dw

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,2,3,7,8,9-HxCDF	0 to 1	4/7	57	0.226 J	2.36	0.526	0.113 – 0.251	ng/kg dw
	1 to 2	3/7	43	0.239 J	0.342 J	0.178	0.0440 – 0.537	ng/kg dw
2,3,4,6,7,8-HxCDF	0 to 1	7/7	100	1.01	9.55	3.34	na	ng/kg dw
	1 to 2	7/7	100	0.146 J	2.57	1.52	na	ng/kg dw
1,2,3,4,6,7,8-HpCDF	0 to 1	7/7	100	31.7	508	147	na	ng/kg dw
	1 to 2	7/7	100	2.16	110	51.2	na	ng/kg dw
1,2,3,4,7,8,9-HpCDF	0 to 1	7/7	100	2.26	66.2	15.7	na	ng/kg dw
	1 to 2	7/7	100	0.127 J	8.85	4.25	na	ng/kg dw
OCDF	0 to 1	7/7	100	83.3	1,640	471	na	ng/kg dw
	1 to 2	7/7	100	3.51	444	180	na	ng/kg dw
Dioxin/furan TEQ - Bird	0 to 1	7/7	100	5.19 J	52.5 J	17.1	na	ng/kg dw
	1 to 2	7/7	100	0.400 J	13.3 J	7.52	na	ng/kg dw
Dioxin/furan TEQ - Fish	0 to 1	7/7	100	4.36 J	40.5 J	13.5	na	ng/kg dw
	1 to 2	7/7	100	0.357 J	10.9 J	6.33	na	ng/kg dw
Dioxin/furan TEQ - Mammal	0 to 1	7/7	100	6.71 J	54.1 J	20.2	na	ng/kg dw
	1 to 2	7/7	100	0.485 J	20.1 J	10.6	na	ng/kg dw
Petroleum groups								
TPH	0 to 1	2/2	100	310	400	360	na	mg/kg dw
	2 to 3	3/5	60	100	2,000	470	20	mg/kg dw
	3 to 4	1/1	100	30	30	30	na	mg/kg dw
	4 to 5	1/1	100	160	160	160	na	mg/kg dw
Geotechnical								
Liquid Limit	0 to 1	14/14	100	37.8	77.3	61.2	na	% dw
	1 to 2	14/14	100	52.9	95.4	65.2	na	% dw
Plastic Limit	0 to 1	14/14	100	23.3	52.6	35.0	na	% dw
	1 to 2	14/14	100	28.8	73.2	39.2	na	% dw
Plasticity Index	0 to 1	14/14	100	12.7	41.6	26.2	na	% dw
	1 to 2	14/14	100	13.8	45.4	26	na	% dw
Bulk Density (dry)	0 to 1	18/18	100	40.7	98.6	60.4	na	pcf
	1 to 2	22/22	100	31.4	102.5	66.7	na	pcf
	2 to 3	4/4	100	71.8	107.6	85.6	na	pcf
	3 to 4	1/1	100	96.3	96.3	96.3	na	pcf
Bulk Density (wet)	0 to 1	18/18	100	88.9	131.5	100	na	pcf
	1 to 2	22/22	100	77.5	129.5	104	na	pcf
	2 to 3	4/4	100	106.4	131.6	115.7	na	pcf
	3 to 4	1/1	100	126.1	126.1	126.1	na	pcf

Table E.6.2-1, cont. Subsurface sediment data, 1-ft intervals

Chemical	Depth Interval[a]	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Porosity	0 to 1	18/18	100	0.41	0.75	0.64	na	S.U.
	1 to 2	22/22	100	0.39	0.81	0.60	na	S.U.
	2 to 3	4/4	100	0.36	0.56	0.49	na	S.U.
	3 to 4	1/1	100	0.43	0.43	0.43	na	S.U.

[a] Data were assigned to sample intervals by first rounding (to the nearest foot) the top and bottom depths of each sample (in feet below mudline) and then assigning the data to the appropriate sampling interval category (i.e., 0-to-1-ft intervals to a depth of 10 ft below mudline). Data from dredged areas were not included.

[b] Surface sediment data were compared to the LAET and 2LAET instead of the SQS and CSL, respectively, if the TOC content was <0.5% or >4.0%.

Table E.6.2-2. Summary statistics for subsurface sediment data in 2-ft depth intervals down to 10 ft below mudline

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements								
Aluminum	0 to 2	19/19	100	10,000 J	30,000	22,000	na	mg/kg dw
	2 to 4	15/15	100	7,200 J	33,000	23,000	na	mg/kg dw
Antimony	0 to 2	8/73	11	11 J	58 J	7	3.0 – 10	mg/kg dw
	2 to 4	9/70	13	0.400	590 J	20	3.6 – 40	mg/kg dw
	4 to 6	3/5	60	14 J	30 J	20	8 – 10	mg/kg dw
	6 to 8	3/4	75	13 J	280 J	100	6	mg/kg dw
	8 to 10	0/3	0	nd	nd	4	7.00 – 9	mg/kg dw
Arsenic	0 to 2	71/76	93	5.3	494	30	5.0 – 7	mg/kg dw
	2 to 4	60/73	82	5.0	2,000	60	6 – 8.00	mg/kg dw
	4 to 6	5/6	83	14	270	100	7.00	mg/kg dw
	6 to 8	4/4	100	20	1,890	700	na	mg/kg dw
	8 to 10	2/3	67	14	21	13	7.00	mg/kg dw
Barium	0 to 2	19/19	100	48	350	110	na	mg/kg dw
	2 to 4	15/15	100	14.5	640	130	na	mg/kg dw
Beryllium	0 to 2	19/19	100	0.20	0.53	0.37	na	mg/kg dw
	2 to 4	15/15	100	0.23	0.56	0.39	na	mg/kg dw
	8 to 10	1/1	100	0.20	0.20	0.20	na	mg/kg dw
Cadmium	0 to 2	72/97	74	0.22	18	0.9	0.20 – 0.5	mg/kg dw
	2 to 4	47/73	64	0.3	15	1	0.2 – 0.8	mg/kg dw
	4 to 6	6/6	100	0.7	4.0	2	na	mg/kg dw
	6 to 8	3/4	75	1.4	20.4	6	0.3	mg/kg dw
	8 to 10	2/3	67	0.12	1.9	1.1	0.30	mg/kg dw
Calcium	0 to 2	18/18	100	4,500	28,000	9,400	na	mg/kg dw
	2 to 4	14/14	100	5,200 J	19,000	8,100	na	mg/kg dw
Chromium	0 to 2	97/97	100	11.4 J	210 J	40	na	mg/kg dw
	2 to 4	73/73	100	8.1	386	37	na	mg/kg dw
	4 to 6	6/6	100	22	92	52	na	mg/kg dw
	6 to 8	4/4	100	13.0	160	72	na	mg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
	8 to 10	3/3	100	11.20	54.7	33.6	na	mg/kg dw
Cobalt	0 to 2	73/73	100	4.3	30	9	na	mg/kg dw
	2 to 4	68/68	100	3.2	100	10	na	mg/kg dw
	4 to 6	5/5	100	8.2	22	12	na	mg/kg dw
	6 to 8	4/4	100	5.5	106	40	na	mg/kg dw
	8 to 10	2/2	100	7.3	9.6	8.5	na	mg/kg dw
Copper	0 to 2	97/97	100	10.7	800	80	na	mg/kg dw
	2 to 4	73/73	100	7.6	2,940	100	na	mg/kg dw
	4 to 6	6/6	100	29.7	663	185	na	mg/kg dw
	6 to 8	4/4	100	23.2	1,950	922	na	mg/kg dw
	8 to 10	3/3	100	15.00	89.4	52.8	na	mg/kg dw
Iron	0 to 2	19/19	100	16,000 J	65,000 J	32,000	na	mg/kg dw
	2 to 4	15/15	100	10,000 J	56,000 J	31,000	na	mg/kg dw
Lead	0 to 2	95/97	98	3	772	80	2.5 – 3	mg/kg dw
	2 to 4	65/73	89	3	3,520 J	100	2 – 3	mg/kg dw
	4 to 6	6/6	100	18.0	1,210	320	na	mg/kg dw
	6 to 8	4/4	100	42	1,350	610	na	mg/kg dw
	8 to 10	3/3	100	3.00	89	57	na	mg/kg dw
Magnesium	0 to 2	18/18	100	4,400	11,000	7,700	na	mg/kg dw
	2 to 4	14/14	100	6,000	9,900	7,800	na	mg/kg dw
Manganese	0 to 2	19/19	100	160	940	330	na	mg/kg dw
	2 to 4	15/15	100	104	590	310	na	mg/kg dw
Mercury	0 to 2	102/107	95	0.05	10	0.3	0.04 – 0.07	mg/kg dw
	2 to 4	68/84	81	0.07	1.4	0.3	0.020 – 0.06	mg/kg dw
	4 to 6	9/15	60	0.080	0.98	0.31	0.050 – 0.060	mg/kg dw
	6 to 8	6/15	40	0.075	4.34	0.5	0.040 – 0.060	mg/kg dw
	8 to 10	3/12	25	0.025	0.89	0.1	0.050 – 0.080	mg/kg dw
Molybdenum	0 to 2	45/56	80	0.6	14	2	0.6 – 1	mg/kg dw
	2 to 4	34/55	62	0.7	113	4	0.6 – 2.4	mg/kg dw
	4 to 6	5/5	100	1.0	16	6	na	mg/kg dw
	6 to 8	4/4	100	1.0	166	59	na	mg/kg dw
	8 to 10	2/2	100	1.3	2.3	1.8	na	mg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Nickel	0 to 2	76/76	100	7 J	37	20	na	mg/kg dw
	2 to 4	70/70	100	6	226	20	na	mg/kg dw
	4 to 6	5/5	100	13	34	24	na	mg/kg dw
	6 to 8	4/4	100	10	69	40	na	mg/kg dw
	8 to 10	3/3	100	12.00	24	20	na	mg/kg dw
Potassium	0 to 2	19/19	100	900	3,900	2,700	na	mg/kg dw
	2 to 4	15/15	100	490	3,900	2,800	na	mg/kg dw
Selenium	0 to 2	6/74	8	0.70 J	14	4	1.0 – 20	mg/kg dw
	2 to 4	5/69	7	0.60 J	1.0 J	4	2.0 – 40	mg/kg dw
	4 to 6	0/5	0	nd	nd	6	7 – 20	mg/kg dw
	6 to 8	0/4	0	nd	nd	9	6 – 40	mg/kg dw
	8 to 10	0/3	0	nd	nd	4	7.00 – 9	mg/kg dw
Silver	0 to 2	52/97	54	0.050	3.3	0.6	0.4 – 1	mg/kg dw
	2 to 4	34/73	47	0.080	5	0.8	0.3 – 1	mg/kg dw
	4 to 6	4/6	67	1.4	4.3	2	0.400 – 1	mg/kg dw
	6 to 8	3/4	75	2	3	2	0.4	mg/kg dw
	8 to 10	2/3	67	0.5	2.3	1	0.40	mg/kg dw
Sodium	0 to 2	18/18	100	1,800	14,000	9,700	na	mg/kg dw
	2 to 4	14/14	100	4,200	14,000	9,800	na	mg/kg dw
Thallium	0 to 2	10/74	14	0.030 J	13	3	0.080 – 20	mg/kg dw
	2 to 4	12/69	17	0.030 J	7.0	4	0.080 – 40	mg/kg dw
	4 to 6	0/5	0	nd	nd	6	7 – 20	mg/kg dw
	6 to 8	0/4	0	nd	nd	9	6 – 40	mg/kg dw
	8 to 10	0/3	0	nd	nd	4	7.00 – 9	mg/kg dw
Tin	0 to 2	16/16	100	3.0	35	8.3	na	mg/kg dw
	2 to 4	14/14	100	3.0	46	10	na	mg/kg dw
Vanadium	0 to 2	73/73	100	37	87	65	na	mg/kg dw
	2 to 4	68/68	100	26	223	64	na	mg/kg dw
	4 to 6	5/5	100	39.8	95.1	71	na	mg/kg dw
	6 to 8	4/4	100	41.0	112	78	na	mg/kg dw
	8 to 10	2/2	100	63.9	75.4	69.7	na	mg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Zinc	0 to 2	97/97	100	21	1,660	200	na	mg/kg dw
	2 to 4	73/73	100	16.2 J	4,720	300	na	mg/kg dw
	4 to 6	6/6	100	69.0	1,430	630	na	mg/kg dw
	6 to 8	4/4	100	88.4	4,550	2,600	na	mg/kg dw
	8 to 10	3/3	100	21.00	186	115	na	mg/kg dw
Organometals								
Monobutyltin as ion	0 to 2	12/26	46	4.5	120 J	14	1.0 – 18	µg/kg dw
	2 to 4	5/25	20	6.0	170 J	12	1.0 – 65	µg/kg dw
	4 to 6	0/3	0	nd	nd	3.9	7.8 – 7.9	µg/kg dw
	6 to 8	2/2	100	9.1	46	28	na	µg/kg dw
	8 to 10	0/1	0	nd	nd	1.8379	3.6757	µg/kg dw
Dibutyltin as ion	0 to 2	20/26	77	6.4	250	27	1.0 – 5.7	µg/kg dw
	2 to 4	12/25	48	7.0	220	28	1.0 – 5.7	µg/kg dw
	4 to 6	1/3	33	92	92	34	11	µg/kg dw
	6 to 8	2/2	100	520	960	740	na	µg/kg dw
	8 to 10	0/1	0	nd	nd	2.2627	4.5253	µg/kg dw
Tributyltin as ion	0 to 2	22/27	81	3.0	2,500	160	1.0 – 4.9	µg/kg dw
	2 to 4	16/26	62	10	2,100	170	1.0 – 3.8	µg/kg dw
	4 to 6	3/3	100	14	1,000	350	na	µg/kg dw
	6 to 8	2/2	100	3,400	6,200	4,800	na	µg/kg dw
	8 to 10	0/1	0	nd	nd	2.6285	5.2569	µg/kg dw
Tetrabutyltin as ion	0 to 2	2/12	17	5.0 J	39	8.9	3.0 – 15	µg/kg dw
	2 to 4	2/10	20	5.0 J	40	9.9	3.0 – 15	µg/kg dw
PAHs								
1-Methylnaphthalene	0 to 2	5/55	9	25	160	25	19 – 110	µg/kg dw
	2 to 4	6/54	11	37	2,600	77	19 – 100	µg/kg dw
	4 to 6	3/9	33	70	110	50	65 – 66	µg/kg dw
	6 to 8	2/5	40	84	400	120	65 – 66	µg/kg dw
	8 to 10	0/4	0	nd	nd	31	61 – 66	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
2-Chloronaphthalene	0 to 2	0/73	0	nd	nd	19	18 – 110	µg/kg dw
	2 to 4	0/72	0	nd	nd	18	19 – 140	µg/kg dw
	4 to 6	0/10	0	nd	nd	30	20.0 – 66	µg/kg dw
	6 to 8	0/5	0	nd	nd	33	65 – 66	µg/kg dw
	8 to 10	0/5	0	nd	nd	27	20.0 – 66	µg/kg dw
2-Methylnaphthalene	0 to 2	10/74	14	20	86	22	19 – 110	µg/kg dw
	2 to 4	9/73	12	30	4,500	89	19 – 100	µg/kg dw
	4 to 6	3/10	30	63 J	82	42	20.0 – 66	µg/kg dw
	6 to 8	2/5	40	110	610	160	65 – 66	µg/kg dw
	8 to 10	0/5	0	nd	nd	26	5.40 – 66	µg/kg dw
Acenaphthene	0 to 2	26/74	35	12 J	1,400	57	19 – 110	µg/kg dw
	2 to 4	24/73	33	16 J	4,600	120	14 – 100	µg/kg dw
	4 to 6	4/10	40	190	1,000	240	20.0 – 66	µg/kg dw
	6 to 8	4/5	80	51 J	1,200	480	65	µg/kg dw
	8 to 10	1/5	20	99	99	39	5.40 – 62	µg/kg dw
Acenaphthylene	0 to 2	21/74	28	11 J	280	27	19.0 – 110	µg/kg dw
	2 to 4	13/73	18	11 J	95	21	19 – 100	µg/kg dw
	4 to 6	1/10	10	56 J	56 J	33	20.0 – 66	µg/kg dw
	6 to 8	2/5	40	63 J	98	52	65 – 66	µg/kg dw
	8 to 10	0/5	0	nd	nd	26	5.40 – 66	µg/kg dw
Anthracene	0 to 2	58/74	78	20	1,100	110	19 – 60	µg/kg dw
	2 to 4	49/73	67	14 J	1,900	130	19 – 99	µg/kg dw
	4 to 6	8/10	80	52 J	580	210	20.0 – 66	µg/kg dw
	6 to 8	4/5	80	140	1,700	720	65	µg/kg dw
	8 to 10	4/5	80	40 J	63	40	5.40	µg/kg dw
Benzo(a)anthracene	0 to 2	71/74	96	13 J	3,600	310	20	µg/kg dw
	2 to 4	54/73	74	12 J	4,500	300	19 – 64	µg/kg dw
	4 to 6	9/10	90	39.0	1,600	420	66	µg/kg dw
	6 to 8	4/5	80	250	3,700	1,500	65	µg/kg dw
	8 to 10	4/5	80	84	140	84	5.40	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Benzo(a)pyrene	0 to 2	69/74	93	18 J	3,700	340	20	µg/kg dw
	2 to 4	55/73	75	13 J	4,000	290	19 – 39	µg/kg dw
	4 to 6	9/10	90	36.0	820	270	66	µg/kg dw
	6 to 8	4/5	80	200	2,800	1,100	65	µg/kg dw
	8 to 10	4/5	80	61	200	87	5.40	µg/kg dw
Benzo(b)fluoranthene	0 to 2	71/74	96	13 J	4,700	480	20	µg/kg dw
	2 to 4	56/73	77	11 J	5,000	390	19 – 54	µg/kg dw
	4 to 6	9/10	90	61.0	1,400	410	66	µg/kg dw
	6 to 8	4/5	80	290	3,500	1,500	65	µg/kg dw
	8 to 10	4/5	80	45 J	210	89	5.40	µg/kg dw
Benzo(g,h,i)perylene	0 to 2	62/74	84	15.0 J	800	100	19 – 60	µg/kg dw
	2 to 4	46/70	66	11 J	830	88	19 – 99	µg/kg dw
	4 to 6	8/9	89	71	210	110	66	µg/kg dw
	6 to 8	4/5	80	76	1,000	380	65	µg/kg dw
	8 to 10	4/5	80	35 J	100	48	5.40	µg/kg dw
Benzo(k)fluoranthene	0 to 2	71/74	96	12 J	3,500	370	20	µg/kg dw
	2 to 4	56/73	77	10 J	4,100	310	19 – 54	µg/kg dw
	4 to 6	9/10	90	34.0	740	240	66	µg/kg dw
	6 to 8	4/5	80	160	1,700	800	65	µg/kg dw
	8 to 10	4/5	80	63 J	230	92	5.40	µg/kg dw
Benzofluoranthenes (total-calc'd)	0 to 2	71/74	96	24 J	7,700	850	nc	µg/kg dw
	2 to 4	56/73	77	21 J	9,100	700	nc	µg/kg dw
	4 to 6	9/10	90	95.0	2,100	640	nc	µg/kg dw
	6 to 8	4/5	80	450	5,200	2,300	nc	µg/kg dw
	8 to 10	4/5	80	117 J	440	180	nc	µg/kg dw
Chrysene	0 to 2	71/74	96	13 J	4,300	440	20	µg/kg dw
	2 to 4	55/73	75	14 J	7,200	430	19 – 39	µg/kg dw
	4 to 6	9/10	90	66.0	1,700	470	66	µg/kg dw
	6 to 8	4/5	80	310	3,900	1,600	65	µg/kg dw
	8 to 10	4/5	80	94	190	110	5.40	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Dibenzo(a,h)anthracene	0 to 2	31/74	42	11 J	270	37	19 – 110	µg/kg dw
	2 to 4	26/73	36	11 J	270	32	19 – 140	µg/kg dw
	4 to 6	8/10	80	36	110	54	6.6 – 20.0	µg/kg dw
	6 to 8	5/5	100	6.5	400 J	180	na	µg/kg dw
	8 to 10	4/5	80	19	50	24	5.40	µg/kg dw
Dibenzofuran	0 to 2	15/74	20	20	1,200	45	20 – 110	µg/kg dw
	2 to 4	16/73	22	20	1,700	56	19 – 100	µg/kg dw
	4 to 6	4/10	40	100	380	110	20.0 – 66	µg/kg dw
	6 to 8	3/5	60	80	710	240	65	µg/kg dw
	8 to 10	0/5	0	nd	nd	26	5.40 – 66	µg/kg dw
Fluoranthene	0 to 2	72/74	97	13 J	8,100	810	20	µg/kg dw
	2 to 4	60/73	82	12 J	13,000	830	19 – 20	µg/kg dw
	4 to 6	10/10	100	70	5,000	1,700	na	µg/kg dw
	6 to 8	4/5	80	730	10,000	4,400	65	µg/kg dw
	8 to 10	5/5	100	28.00	350	250	na	µg/kg dw
Fluorene	0 to 2	31/74	42	12 J	1,900	64	20 – 110	µg/kg dw
	2 to 4	26/73	36	13 J	4,300	110	19 – 100	µg/kg dw
	4 to 6	5/10	50	39 J	630	180	20.0 – 66	µg/kg dw
	6 to 8	4/5	80	120	1,400	430	65	µg/kg dw
	8 to 10	2/5	40	38 J	42 J	29	5.40 – 62	µg/kg dw
Indeno(1,2,3-cd)pyrene	0 to 2	62/74	84	12.0 J	1,100	120	19 – 60	µg/kg dw
	2 to 4	47/70	67	10 J	1,200	110	19 – 60	µg/kg dw
	4 to 6	8/9	89	55 J	180	92	66	µg/kg dw
	6 to 8	4/5	80	70	1,000	360	65	µg/kg dw
	8 to 10	4/5	80	34 J	97	45	5.40	µg/kg dw
Naphthalene	0 to 2	19/75	25	12 J	220	31	8.3 – 110	µg/kg dw
	2 to 4	21/74	28	12 J	3,400	100	7.8 – 100	µg/kg dw
	4 to 6	5/11	45	60 J	410	100	8.3 – 66	µg/kg dw
	6 to 8	3/6	50	45 J	1,200	260	8.2 – 65	µg/kg dw
	8 to 10	0/5	0	nd	nd	26	5.40 – 66	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Phenanthrene	0 to 2	72/74	97	14 J	1,900	250	20	µg/kg dw
	2 to 4	56/73	77	20	13,000	450	19 – 38	µg/kg dw
	4 to 6	9/10	90	81	1,400	490	20.0	µg/kg dw
	6 to 8	4/5	80	460	5,600	2,400	65	µg/kg dw
	8 to 10	5/5	100	12.00	150	100	na	µg/kg dw
Pyrene	0 to 2	72/74	97	17 J	6,100	780	20	µg/kg dw
	2 to 4	62/73	85	9.9 J	8,900	750	19 – 20	µg/kg dw
	4 to 6	10/10	100	70	10,000	2,200	na	µg/kg dw
	6 to 8	5/5	100	53 J	9,700	4,300	na	µg/kg dw
	8 to 10	5/5	100	30.0	470	250	na	µg/kg dw
Total HPAH	0 to 2	72/74	97	80	27,900	3,600	nc	µg/kg dw
	2 to 4	62/73	85	9.9 J	47,000	3,500	nc	µg/kg dw
	4 to 6	10/10	100	140	22,000	5,900	nc	µg/kg dw
	6 to 8	5/5	100	60 J	38,000 J	16,000	nc	µg/kg dw
	8 to 10	5/5	100	58.0	2,040	1,100	nc	µg/kg dw
Total LPAH	0 to 2	72/74	97	15 J	3,800 J	450	nc	µg/kg dw
	2 to 4	56/73	77	20	27,000 J	880	nc	µg/kg dw
	4 to 6	9/10	90	141 J	3,900	1,200	nc	µg/kg dw
	6 to 8	4/5	80	770 J	9,800	4,300	nc	µg/kg dw
	8 to 10	5/5	100	12.00	275 J	180	na	µg/kg dw
Carcinogenic PAHs - Mammal	0 to 2	71/74	96	41.6 J	4,900	520	18	µg/kg dw
	2 to 4	56/73	77	18 J	5,600	440	17 – 35	µg/kg dw
	4 to 6	9/10	90	54.1	1,300	410	48	µg/kg dw
	6 to 8	5/5	100	48	4,000 J	1,600	na	µg/kg dw
	8 to 10	4/5	80	93 J	290	130	4.89	µg/kg dw
Total PAH	0 to 2	73/74	99	24	29,500 J	4,000	nc	µg/kg dw
	2 to 4	62/73	85	9.9 J	57,000 J	4,400	nc	µg/kg dw
	4 to 6	10/10	100	281 J	23,000 J	7,100	nc	µg/kg dw
	6 to 8	5/5	100	60 J	46,000 J	20,000	nc	µg/kg dw
	8 to 10	5/5	100	70.0	2,210	1,240	na	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Phthalates								
Bis(2-ethylhexyl)phthalate	0 to 2	65/74	88	12 J	2,400	390	20 – 530	µg/kg dw
	2 to 4	51/73	70	13 J	3,900	460	19 – 280	µg/kg dw
	4 to 6	8/10	80	56 J	2,200	570	20.0 – 65	µg/kg dw
	6 to 8	4/5	80	1,000	3,800	1,400	65	µg/kg dw
	8 to 10	2/5	40	72.00	260	85	61 – 66	µg/kg dw
Butyl benzyl phthalate	0 to 2	51/74	69	5.9	610	42	5.8 – 110	µg/kg dw
	2 to 4	34/73	47	5.8 J	180	24	5.8 – 42	µg/kg dw
	4 to 6	5/10	50	12 J	48	18	6.5 – 36	µg/kg dw
	6 to 8	4/5	80	15 J	35 J	22	6.5	µg/kg dw
	8 to 10	0/5	0	nd	nd	4.5	6.1 – 20.0	µg/kg dw
Diethyl phthalate	0 to 2	0/74	0	nd	nd	19	19 – 110	µg/kg dw
	2 to 4	0/73	0	nd	nd	18	19 – 140	µg/kg dw
	4 to 6	0/10	0	nd	nd	30	20.0 – 66	µg/kg dw
	6 to 8	0/5	0	nd	nd	33	65 – 66	µg/kg dw
	8 to 10	0/5	0	nd	nd	27	20.0 – 66	µg/kg dw
Dimethyl phthalate	0 to 2	5/74	7	9.9 J	84	20	12 – 110	µg/kg dw
	2 to 4	4/73	5	30	8,800	140	14 – 140	µg/kg dw
	4 to 6	2/10	20	20	210	28	6.5 – 44	µg/kg dw
	6 to 8	3/5	60	16	69 J	22	6.5	µg/kg dw
	8 to 10	0/5	0	nd	nd	21	6.6 – 62	µg/kg dw
Di-n-butyl phthalate	0 to 2	19/74	26	10 J	200	28	19.0 – 180	µg/kg dw
	2 to 4	15/73	21	10 J	87	22	19 – 140	µg/kg dw
	4 to 6	1/10	10	67	67	34	20.0 – 66	µg/kg dw
	6 to 8	0/5	0	nd	nd	33	65 – 66	µg/kg dw
	8 to 10	1/5	20	42 J	42 J	29	22.00 – 66	µg/kg dw
Di-n-octyl phthalate	0 to 2	5/74	7	25	220	22	18 – 110	µg/kg dw
	2 to 4	3/73	4	14 J	110	19	19 – 140	µg/kg dw
	4 to 6	0/10	0	nd	nd	30	20.0 – 66	µg/kg dw
	6 to 8	2/5	40	56 J	57 J	42	65 – 66	µg/kg dw
	8 to 10	0/5	0	nd	nd	27	20.0 – 66	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Other SVOCs								
1,2,4-Trichlorobenzene	0 to 2	11/76	14	3.9 J	13 J	6.2	5.8 – 110	µg/kg dw
	2 to 4	4/74	5	4.1 J	110 J	7.4	5.8 – 25.0	µg/kg dw
	4 to 6	2/11	18	11	18	6.0	6.5 – 20.0	µg/kg dw
	6 to 8	3/6	50	9.8	14	7.6	6.5 – 8.2	µg/kg dw
	8 to 10	0/5	0	nd	nd	3.0	5.40 – 6.6	µg/kg dw
1,2-Dichlorobenzene	0 to 2	8/76	11	1.7 J	20	5.8	1.7 – 110	µg/kg dw
	2 to 4	8/74	11	3.6 J	150	7.9	0.86 – 42	µg/kg dw
	4 to 6	2/11	18	10	12	5.1	1.7 – 20.0	µg/kg dw
	6 to 8	3/6	50	12	160	42	1.6 – 6.6	µg/kg dw
	8 to 10	0/5	0	nd	nd	2.6	1.10 – 6.6	µg/kg dw
1,2-Diphenylhydrazine	0 to 2	0/1	0	nd	nd	30	60	µg/kg dw
	2 to 4	0/1	0	nd	nd	33	66	µg/kg dw
1,3-Dichlorobenzene	0 to 2	0/76	0	nd	nd	18	0.78 – 110	µg/kg dw
	2 to 4	0/74	0	nd	nd	17	0.86 – 140	µg/kg dw
	4 to 6	1/11	9	12	12	4.5	1.7 – 20.0	µg/kg dw
	6 to 8	2/6	33	6.5	7.2	4.1	1.6 – 6.6	µg/kg dw
	8 to 10	0/5	0	nd	nd	19	1.10 – 62	µg/kg dw
1,4-Dichlorobenzene	0 to 2	16/76	21	3.0 J	380 J	11	1.7 – 110	µg/kg dw
	2 to 4	13/74	18	2.1 J	38	6.5	1.6 – 42	µg/kg dw
	4 to 6	7/11	64	3.9 J	31	7.3	1.7 – 20.0	µg/kg dw
	6 to 8	4/6	67	4.0 J	24	9.5	1.6 – 6.5	µg/kg dw
	8 to 10	0/5	0	nd	nd	19	1.10 – 6.6	µg/kg dw
2,4,5-Trichlorophenol	0 to 2	0/73	0	nd	nd	100	97 – 560	µg/kg dw
	2 to 4	0/72	0	nd	nd	99	96 – 700	µg/kg dw
	4 to 6	0/10	0	nd	nd	150	100 – 330	µg/kg dw
	6 to 8	0/5	0	nd	nd	170	330	µg/kg dw
	8 to 10	0/5	0	nd	nd	130	98.00 – 330	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
2,4,6-Trichlorophenol	0 to 2	0/73	0	nd	nd	100	97 – 560	µg/kg dw
	2 to 4	0/72	0	nd	nd	99	96 – 700	µg/kg dw
	4 to 6	0/10	0	nd	nd	150	100 – 330	µg/kg dw
	6 to 8	0/5	0	nd	nd	170	330	µg/kg dw
	8 to 10	0/5	0	nd	nd	130	98.00 – 330	µg/kg dw
2,4-Dichlorophenol	0 to 2	0/73	0	nd	nd	87	30 – 560	µg/kg dw
	2 to 4	0/72	0	nd	nd	84	34 – 700	µg/kg dw
	4 to 6	0/10	0	nd	nd	150	60.0 – 330	µg/kg dw
	6 to 8	0/5	0	nd	nd	170	330	µg/kg dw
	8 to 10	0/5	0	nd	nd	130	59.00 – 330	µg/kg dw
2,4-Dimethylphenol	0 to 2	5/74	7	9.5 J	27 J	8.9	5.8 – 330	µg/kg dw
	2 to 4	5/73	7	6.3 J	46	7.4	5.8 – 42	µg/kg dw
	4 to 6	3/10	30	6.5 J	9.2	5.3	6.5 – 20.0	µg/kg dw
	6 to 8	4/5	80	8.5 J	24 J	15	6.5	µg/kg dw
	8 to 10	3/5	60	3.7 J	10	6.5	6.6 – 20.0	µg/kg dw
2,4-Dinitrophenol	0 to 2	1/73	1	300	300	190	60 – 1,100	µg/kg dw
	2 to 4	0/72	0	nd	nd	180	66 – 1,400	µg/kg dw
	4 to 6	0/10	0	nd	nd	300	200 – 660	µg/kg dw
	6 to 8	0/5	0	nd	nd	330	650 – 660	µg/kg dw
	8 to 10	0/5	0	nd	nd	270	200 – 660	µg/kg dw
2,4-Dinitrotoluene	0 to 2	0/73	0	nd	nd	100	12 – 560	µg/kg dw
	2 to 4	0/72	0	nd	nd	98	14 – 700	µg/kg dw
	4 to 6	0/10	0	nd	nd	150	100 – 330	µg/kg dw
	6 to 8	0/5	0	nd	nd	170	330	µg/kg dw
	8 to 10	0/5	0	nd	nd	130	98.00 – 330	µg/kg dw
2,6-Dinitrotoluene	0 to 2	0/73	0	nd	nd	100	12 – 560	µg/kg dw
	2 to 4	0/72	0	nd	nd	98	14 – 700	µg/kg dw
	4 to 6	0/10	0	nd	nd	150	100 – 330	µg/kg dw
	6 to 8	0/5	0	nd	nd	170	330	µg/kg dw
	8 to 10	0/5	0	nd	nd	130	98.00 – 330	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
2-Chlorophenol	0 to 2	0/73	0	nd	nd	19	20 – 110	µg/kg dw
	2 to 4	0/72	0	nd	nd	18	19 – 140	µg/kg dw
	4 to 6	0/10	0	nd	nd	30	20.0 – 66	µg/kg dw
	6 to 8	0/5	0	nd	nd	33	65 – 66	µg/kg dw
	8 to 10	0/5	0	nd	nd	27	20.0 – 66	µg/kg dw
2-Methylphenol	0 to 2	14/74	19	3.0 J	160	9.3	5.8 – 220	µg/kg dw
	2 to 4	7/73	10	4.2 J	10	6.0	5.8 – 42	µg/kg dw
	4 to 6	0/10	0	nd	nd	3.9	6.5 – 20.0	µg/kg dw
	6 to 8	4/5	80	5.9 J	12	6.9	6.5	µg/kg dw
	8 to 10	0/5	0	nd	nd	4.5	6.1 – 20.0	µg/kg dw
2-Nitroaniline	0 to 2	0/73	0	nd	nd	94	100 – 560	µg/kg dw
	2 to 4	0/72	0	nd	nd	89	96 – 700	µg/kg dw
	4 to 6	0/10	0	nd	nd	150	100 – 330	µg/kg dw
	6 to 8	0/5	0	nd	nd	170	330	µg/kg dw
	8 to 10	0/5	0	nd	nd	130	98.00 – 330	µg/kg dw
2-Nitrophenol	0 to 2	0/73	0	nd	nd	93	30 – 560	µg/kg dw
	2 to 4	0/72	0	nd	nd	88	34 – 700	µg/kg dw
	4 to 6	0/10	0	nd	nd	150	100 – 330	µg/kg dw
	6 to 8	0/5	0	nd	nd	170	330	µg/kg dw
	8 to 10	0/5	0	nd	nd	130	98.00 – 330	µg/kg dw
3,3'-Dichlorobenzidine	0 to 2	0/73	0	nd	nd	100	30 – 560	µg/kg dw
	2 to 4	0/72	0	nd	nd	98	34 – 700	µg/kg dw
	4 to 6	0/10	0	nd	nd	150	100 – 330	µg/kg dw
	6 to 8	0/5	0	nd	nd	170	330	µg/kg dw
	8 to 10	0/5	0	nd	nd	130	98.00 – 330	µg/kg dw
3-Nitroaniline	0 to 2	0/73	0	nd	nd	110	100 – 660	µg/kg dw
	2 to 4	0/72	0	nd	nd	99	96 – 700	µg/kg dw
	4 to 6	0/10	0	nd	nd	150	120 – 330	µg/kg dw
	6 to 8	0/5	0	nd	nd	170	330	µg/kg dw
	8 to 10	0/5	0	nd	nd	140	120.0 – 330	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
4,6-Dinitro-o-cresol	0 to 2	0/73	0	nd	nd	190	60 – 1,100	µg/kg dw
	2 to 4	0/72	0	nd	nd	180	66 – 1,400	µg/kg dw
	4 to 6	0/10	0	nd	nd	300	200 – 660	µg/kg dw
	6 to 8	0/5	0	nd	nd	330	650 – 660	µg/kg dw
	8 to 10	0/5	0	nd	nd	270	200 – 660	µg/kg dw
4-Bromophenyl phenyl ether	0 to 2	0/73	0	nd	nd	21	12 – 110	µg/kg dw
	2 to 4	0/72	0	nd	nd	20	14 – 140	µg/kg dw
	4 to 6	0/10	0	nd	nd	30	20.0 – 66	µg/kg dw
	6 to 8	0/5	0	nd	nd	33	65 – 66	µg/kg dw
	8 to 10	0/5	0	nd	nd	27	20.0 – 66	µg/kg dw
4-Chloro-3-methylphenol	0 to 2	0/73	0	nd	nd	84	40 – 560	µg/kg dw
	2 to 4	0/72	0	nd	nd	81	39.0 – 700	µg/kg dw
	4 to 6	0/10	0	nd	nd	150	40.0 – 330	µg/kg dw
	6 to 8	0/5	0	nd	nd	170	330	µg/kg dw
	8 to 10	0/5	0	nd	nd	130	39.00 – 330	µg/kg dw
4-Chloroaniline	0 to 2	1/73	1	230 J	230 J	90	60 – 560	µg/kg dw
	2 to 4	0/72	0	nd	nd	84	59.0 – 700	µg/kg dw
	4 to 6	0/10	0	nd	nd	150	60.0 – 330	µg/kg dw
	6 to 8	0/5	0	nd	nd	170	330	µg/kg dw
	8 to 10	0/5	0	nd	nd	130	59.00 – 330	µg/kg dw
4-Chlorophenyl phenyl ether	0 to 2	0/73	0	nd	nd	19	18 – 110	µg/kg dw
	2 to 4	0/72	0	nd	nd	18	19 – 140	µg/kg dw
	4 to 6	0/10	0	nd	nd	30	20.0 – 66	µg/kg dw
	6 to 8	0/5	0	nd	nd	33	65 – 66	µg/kg dw
	8 to 10	0/5	0	nd	nd	27	20.0 – 66	µg/kg dw
4-Methylphenol	0 to 2	3/74	4	13 J	42 J	19	20 – 110	µg/kg dw
	2 to 4	3/73	4	23	110 J	19	19 – 140	µg/kg dw
	4 to 6	1/10	10	42 J	42 J	31	20.0 – 66	µg/kg dw
	6 to 8	2/5	40	37 J	48 J	37	65 – 66	µg/kg dw
	8 to 10	0/5	0	nd	nd	27	20.0 – 66	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
4-Nitroaniline	0 to 2	0/73	0	nd	nd	94	100 – 560	µg/kg dw
	2 to 4	0/72	0	nd	nd	89	96 – 700	µg/kg dw
	4 to 6	0/10	0	nd	nd	150	100 – 330	µg/kg dw
	6 to 8	0/5	0	nd	nd	170	330	µg/kg dw
	8 to 10	0/5	0	nd	nd	130	98.00 – 330	µg/kg dw
4-Nitrophenol	0 to 2	0/73	0	nd	nd	93	60 – 560	µg/kg dw
	2 to 4	0/72	0	nd	nd	89	66 – 700	µg/kg dw
	4 to 6	0/10	0	nd	nd	150	100 – 330	µg/kg dw
	6 to 8	0/5	0	nd	nd	170	330	µg/kg dw
	8 to 10	0/5	0	nd	nd	130	98.00 – 330	µg/kg dw
Aniline	0 to 2	2/56	4	33 J	36 J	22	20 – 110	µg/kg dw
	2 to 4	0/55	0	nd	nd	21	19 – 140	µg/kg dw
	4 to 6	0/9	0	nd	nd	33	65 – 66	µg/kg dw
	6 to 8	0/5	0	nd	nd	33	65 – 66	µg/kg dw
	8 to 10	0/4	0	nd	nd	31	61 – 66	µg/kg dw
Benzoic acid	0 to 2	41/74	55	50 J	490	140	58 – 1,100	µg/kg dw
	2 to 4	32/73	44	54 J	3,000 J	150	58 – 350	µg/kg dw
	4 to 6	0/10	0	nd	nd	280	200 – 590	µg/kg dw
	6 to 8	1/5	20	320 J	320 J	300	590	µg/kg dw
	8 to 10	0/5	0	nd	nd	260	200 – 620	µg/kg dw
Benzyl alcohol	0 to 2	11/74	15	18 J	200	30	19.0 – 550	µg/kg dw
	2 to 4	7/73	10	20 J	34 J	21	20.0 – 210	µg/kg dw
	4 to 6	1/10	10	52	52	19	20.0 – 33	µg/kg dw
	6 to 8	0/5	0	nd	nd	17	33	µg/kg dw
	8 to 10	0/5	0	nd	nd	16	20.0 – 38	µg/kg dw
bis(2-chloroethoxy)methane	0 to 2	0/73	0	nd	nd	21	19 – 110	µg/kg dw
	2 to 4	0/72	0	nd	nd	20	19 – 140	µg/kg dw
	4 to 6	0/10	0	nd	nd	30	20.0 – 66	µg/kg dw
	6 to 8	0/5	0	nd	nd	33	65 – 66	µg/kg dw
	8 to 10	0/5	0	nd	nd	27	20.0 – 66	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
bis(2-chloroethyl)ether	0 to 2	0/73	0	nd	nd	22	18 – 220	µg/kg dw
	2 to 4	0/72	0	nd	nd	20	19 – 140	µg/kg dw
	4 to 6	0/10	0	nd	nd	31	40.0 – 66	µg/kg dw
	6 to 8	0/5	0	nd	nd	33	65 – 66	µg/kg dw
	8 to 10	0/5	0	nd	nd	29	39.00 – 66	µg/kg dw
bis(2-chloroisopropyl)ether	0 to 2	0/73	0	nd	nd	21	19 – 110	µg/kg dw
	2 to 4	0/72	0	nd	nd	20	19 – 140	µg/kg dw
	4 to 6	0/10	0	nd	nd	30	20.0 – 66	µg/kg dw
	6 to 8	0/5	0	nd	nd	33	65 – 66	µg/kg dw
	8 to 10	0/5	0	nd	nd	27	20.0 – 66	µg/kg dw
Carbazole	0 to 2	9/18	50	20	190	39	20 – 110	µg/kg dw
	2 to 4	7/18	39	20	200	30	20.0 – 34	µg/kg dw
	4 to 6	0/1	0	nd	nd	10.0	20.0	µg/kg dw
	8 to 10	0/1	0	nd	nd	10.0	20.0	µg/kg dw
Coprostanol	0 to 2	0/1	0	nd	nd	60	120	µg/kg dw
	2 to 4	0/1	0	nd	nd	70	140	µg/kg dw
Hexachlorobenzene	0 to 2	2/74	3	5.9	10	5.1	0.78 – 110	µg/kg dw
	2 to 4	0/73	0	nd	nd	4.7	0.86 – 42	µg/kg dw
	4 to 6	0/10	0	nd	nd	3.9	6.5 – 20.0	µg/kg dw
	6 to 8	1/5	20	4.6 J	4.6 J	3.5	6.5 – 6.6	µg/kg dw
	8 to 10	0/5	0	nd	nd	4.5	6.1 – 20.0	µg/kg dw
Hexachlorobutadiene	0 to 2	0/75	0	nd	nd	5.9	0.98 – 220	µg/kg dw
	2 to 4	0/74	0	nd	nd	4.9	0.96 – 42	µg/kg dw
	4 to 6	0/11	0	nd	nd	4.0	6.5 – 20.0	µg/kg dw
	6 to 8	1/6	17	5.9 J	5.9 J	3.9	6.5 – 8.2	µg/kg dw
	8 to 10	0/5	0	nd	nd	3.0	5.40 – 6.6	µg/kg dw
Hexachlorocyclopentadiene	0 to 2	0/72	0	nd	nd	94	100 – 560	µg/kg dw
	2 to 4	0/71	0	nd	nd	89	96 – 700	µg/kg dw
	4 to 6	0/10	0	nd	nd	150	100 – 330	µg/kg dw
	6 to 8	0/5	0	nd	nd	170	330	µg/kg dw
	8 to 10	0/5	0	nd	nd	130	98.00 – 330	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Hexachloroethane	0 to 2	0/74	0	nd	nd	19	20 – 220	µg/kg dw
	2 to 4	0/73	0	nd	nd	18	19 – 140	µg/kg dw
	4 to 6	0/10	0	nd	nd	30	20.0 – 66	µg/kg dw
	6 to 8	0/5	0	nd	nd	33	65 – 66	µg/kg dw
	8 to 10	0/5	0	nd	nd	27	20.0 – 66	µg/kg dw
Isophorone	0 to 2	0/73	0	nd	nd	19	20 – 110	µg/kg dw
	2 to 4	0/72	0	nd	nd	18	19 – 140	µg/kg dw
	4 to 6	0/10	0	nd	nd	30	20.0 – 66	µg/kg dw
	6 to 8	0/5	0	nd	nd	33	65 – 66	µg/kg dw
	8 to 10	0/5	0	nd	nd	27	20.0 – 66	µg/kg dw
Methyl isobutyl ketone	0 to 2	0/2	0	nd	nd	4.3	8.3 – 8.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	3.9	7.8	µg/kg dw
	4 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 8	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	8 to 10	0/1	0	nd	nd	2.70	5.40	µg/kg dw
Nitrobenzene	0 to 2	0/73	0	nd	nd	19	20 – 110	µg/kg dw
	2 to 4	0/72	0	nd	nd	18	19 – 140	µg/kg dw
	4 to 6	0/10	0	nd	nd	30	20.0 – 66	µg/kg dw
	6 to 8	0/5	0	nd	nd	33	65 – 66	µg/kg dw
	8 to 10	0/5	0	nd	nd	27	20.0 – 66	µg/kg dw
N-Nitrosodimethylamine	0 to 2	0/56	0	nd	nd	18	29 – 120	µg/kg dw
	2 to 4	0/55	0	nd	nd	21	29 – 210	µg/kg dw
	4 to 6	0/9	0	nd	nd	16	32 – 33	µg/kg dw
	6 to 8	0/5	0	nd	nd	17	33	µg/kg dw
	8 to 10	0/4	0	nd	nd	16	30 – 33	µg/kg dw
N-Nitroso-di-n-propylamine	0 to 2	5/73	7	26 J	320	25	29 – 220	µg/kg dw
	2 to 4	1/72	1	41	41	20	29 – 210	µg/kg dw
	4 to 6	0/10	0	nd	nd	17	32 – 40.0	µg/kg dw
	6 to 8	0/5	0	nd	nd	20	33 – 69	µg/kg dw
	8 to 10	0/5	0	nd	nd	16	30 – 39.00	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
N-Nitrosodiphenylamine	0 to 2	1/74	1	33	33	23	6 – 870	µg/kg dw
	2 to 4	0/73	0	nd	nd	81	5.8 – 7,300	µg/kg dw
	4 to 6	0/10	0	nd	nd	73	20.0 – 510	µg/kg dw
	6 to 8	0/5	0	nd	nd	380	6.5 – 2,600	µg/kg dw
	8 to 10	0/5	0	nd	nd	18	20.0 – 65	µg/kg dw
Pentachlorophenol	0 to 2	17/74	23	17 J	730	45	29 – 550	µg/kg dw
	2 to 4	10/73	14	18 J	190	33	29 – 180	µg/kg dw
	4 to 6	9/10	90	36	63	44	100	µg/kg dw
	6 to 8	4/5	80	45	800	280	33	µg/kg dw
	8 to 10	1/5	20	19 J	19 J	23	30 – 98.00	µg/kg dw
Phenol	0 to 2	20/74	27	14 J	180	35	19 – 220	µg/kg dw
	2 to 4	17/73	23	13 J	110	25	19 – 140	µg/kg dw
	4 to 6	0/10	0	nd	nd	31	20.0 – 73	µg/kg dw
	6 to 8	0/5	0	nd	nd	33	65 – 66	µg/kg dw
	8 to 10	0/5	0	nd	nd	27	20.0 – 66	µg/kg dw
Polychlorinated biphenyls								
PCB-018	0 to 2	10/16	62	1.0	7.0	2.2	1.0	µg/kg dw
	2 to 4	8/14	57	1.0	270 J	22	1.0	µg/kg dw
PCB-028	0 to 2	10/16	62	2.0	13	3.6	1.0	µg/kg dw
	2 to 4	10/14	71	1.0	220	20	1.0	µg/kg dw
PCB-044	0 to 2	12/16	75	1.0	18	5.1	1.0	µg/kg dw
	2 to 4	10/14	71	2.0	52	9.1	1.0	µg/kg dw
PCB-055	0 to 2	13/16	81	1.0	38	8.8	1.0	µg/kg dw
	2 to 4	10/14	71	3.0	150	19	1.0	µg/kg dw
PCB-066	0 to 2	13/16	81	2.0	120	17	1.0	µg/kg dw
	2 to 4	10/14	71	5.0	140	25	1.0	µg/kg dw
PCB-077	0 to 2	0/16	0	nd	nd	0.66	1.0 – 4.0	µg/kg dw
	2 to 4	0/14	0	nd	nd	0.93	1.0 – 9.0	µg/kg dw
PCB-081	0 to 2	0/16	0	nd	nd	0.50	1.0	µg/kg dw
	2 to 4	0/14	0	nd	nd	0.54	1.0 – 2.0	µg/kg dw
PCB-101	0 to 2	12/16	75	1.0	130	16	1.0	µg/kg dw
	2 to 4	10/14	71	4.0	90	17	1.0	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-105	0 to 2	10/16	62	2.0	43	5.6	1.0	µg/kg dw
	2 to 4	10/14	71	1.0	33	7.1	1.0	µg/kg dw
PCB-114	0 to 2	2/16	12	2.0	5.0 J	1.0	1.0 – 4.0	µg/kg dw
	2 to 4	0/14	0	nd	nd	0.71	1.0 – 3.0	µg/kg dw
PCB-118	0 to 2	13/16	81	1.0	110	13	1.0	µg/kg dw
	2 to 4	10/14	71	3.0	70	15	1.0	µg/kg dw
PCB-123	0 to 2	0/16	0	nd	nd	1.1	1.0 – 10	µg/kg dw
	2 to 4	0/14	0	nd	nd	0.96	1.0 – 7.0	µg/kg dw
PCB-126	0 to 2	2/16	12	1.0	2.0	0.63	1.0	µg/kg dw
	2 to 4	1/14	7	4.0	4.0	0.75	1.0	µg/kg dw
PCB-128	0 to 2	10/16	62	2.0	27	3.8	1.0	µg/kg dw
	2 to 4	10/14	71	1.0	17	4.0	1.0	µg/kg dw
PCB-138	0 to 2	14/16	88	2.0	160	24	1.0	µg/kg dw
	2 to 4	10/14	71	1.0	110	27	1.0	µg/kg dw
PCB-153	0 to 2	13/16	81	2.0	98	17	1.0	µg/kg dw
	2 to 4	10/14	71	4.0	78	18	1.0	µg/kg dw
PCB-156	0 to 2	8/16	50	1.0 J	16	2.3	1.0	µg/kg dw
	2 to 4	7/14	50	1.0	10	2.5	1.0	µg/kg dw
PCB-157	0 to 2	1/16	6	3.0	3.0	0.66	1.0	µg/kg dw
	2 to 4	4/14	29	1.0	3.0	1.0	1.0	µg/kg dw
PCB-167	0 to 2	4/16	25	1.0	8.0	1.2	1.0	µg/kg dw
	2 to 4	5/14	36	1.0 J	5.0	1.5	1.0	µg/kg dw
PCB-169	0 to 2	0/16	0	nd	nd	0.50	1.0	µg/kg dw
	2 to 4	0/14	0	nd	nd	0.50	1.0	µg/kg dw
PCB-170	0 to 2	9/16	56	3.0	29	5.3	1.0 – 7.0	µg/kg dw
	2 to 4	9/14	64	2.0	28	7.3	1.0 – 2.0	µg/kg dw
PCB-180	0 to 2	13/16	81	1.0	53	8.9	1.0	µg/kg dw
	2 to 4	10/14	71	3.0	41	12	1.0	µg/kg dw
PCB-187	0 to 2	12/16	75	1.0	28	5.1	1.0	µg/kg dw
	2 to 4	10/14	71	2.0	21	7.1	1.0	µg/kg dw
PCB-189	0 to 2	0/16	0	nd	nd	0.50	1.0	µg/kg dw
	2 to 4	1/14	7	1.0	1.0	0.54	1.0	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-195	0 to 2	5/16	31	1.0 J	6.0	1.0	1.0	µg/kg dw
	2 to 4	6/14	43	1.0	4.0 J	1.4	1.0	µg/kg dw
PCB-206	0 to 2	5/16	31	1.0	3.0	0.84	1.0	µg/kg dw
	2 to 4	6/14	43	1.0	3.0	1.2	1.0	µg/kg dw
PCB-209	0 to 2	0/16	0	nd	nd	0.50	1.0	µg/kg dw
	2 to 4	2/14	14	1.0	1.0	0.57	1.0	µg/kg dw
Aroclor-1016	0 to 2	0/137	0	nd	nd	120	0.10 – 24,000	µg/kg dw
	2 to 4	0/135	0	nd	nd	30	0.10 – 900	µg/kg dw
	4 to 6	0/60	0	nd	nd	40	3.8 – 1,700	µg/kg dw
	6 to 8	0/30	0	nd	nd	22	3.9 – 310	µg/kg dw
	8 to 10	0/24	0	nd	nd	8.0	3.8 – 20	µg/kg dw
Aroclor-1221	0 to 2	0/126	0	nd	nd	25	0.10 – 920	µg/kg dw
	2 to 4	0/135	0	nd	nd	30	0.10 – 900	µg/kg dw
	4 to 6	0/59	0	nd	nd	40	3.8 – 1,700	µg/kg dw
	6 to 8	0/30	0	nd	nd	24	3.9 – 310	µg/kg dw
	8 to 10	0/24	0	nd	nd	8.4	3.8 – 39.00	µg/kg dw
Aroclor-1232	0 to 2	0/126	0	nd	nd	24	0.10 – 920	µg/kg dw
	2 to 4	0/135	0	nd	nd	30	0.10 – 900	µg/kg dw
	4 to 6	0/59	0	nd	nd	50	3.8 – 1,700	µg/kg dw
	6 to 8	0/30	0	nd	nd	22	3.9 – 310	µg/kg dw
	8 to 10	0/24	0	nd	nd	8.0	3.8 – 20	µg/kg dw
Aroclor-1242	0 to 2	24/137	18	5.2	1,500	150	0.10 – 24,000	µg/kg dw
	2 to 4	21/129	16	13	2,500	70	0.10 – 900	µg/kg dw
	4 to 6	12/59	20	38	900	97	3.8 – 1,700	µg/kg dw
	6 to 8	3/30	10	370	820	69	3.9 – 310	µg/kg dw
	8 to 10	0/24	0	nd	nd	8.0	3.8 – 20	µg/kg dw
Aroclor-1248	0 to 2	69/137	50	5.1	1,300	270	0.10 – 24,000	µg/kg dw
	2 to 4	52/135	39	14 J	7,200	300	0.10 – 6,600	µg/kg dw
	4 to 6	7/60	12	26	150	130	3.8 – 5,700	µg/kg dw
	6 to 8	8/30	27	31	430	67	3.9 – 310	µg/kg dw
	8 to 10	2/24	8	22	65.00	12	3.8 – 69	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Aroclor-1254	0 to 2	119/137	87	5.7	35,000	1,400	0.10 – 130,000	µg/kg dw
	2 to 4	102/135	76	0.52 J	9,000	600	0.10 – 110	µg/kg dw
	4 to 6	44/60	73	3.9 J	12,000	660	3.8 – 44	µg/kg dw
	6 to 8	15/30	50	4.5 J	2,600	310	19 – 58	µg/kg dw
	8 to 10	6/24	25	14 J	250	29	3.8 – 39	µg/kg dw
Aroclor-1260	0 to 2	123/137	90	6.1	890,000	7,300	0.10 – 4,900	µg/kg dw
	2 to 4	104/135	77	6.3 J	6,400 J	400	0.10 – 160	µg/kg dw
	4 to 6	45/60	75	19	2,900	330	3.8 – 44	µg/kg dw
	6 to 8	18/30	60	18 J	1,200	160	3.9 – 20	µg/kg dw
	8 to 10	10/24	42	18 J	290	39	3.9 – 20	µg/kg dw
Total PCBs	0 to 2	130/137	95	12.9	890,000	8,300	nc	µg/kg dw
	2 to 4	106/135	79	3 J	19,000 J	1,200	nc	µg/kg dw
	4 to 6	47/60	78	3.9 J	15,000	1,100	nc	µg/kg dw
	6 to 8	20/30	67	4.5 J	3,800	560	nc	µg/kg dw
	8 to 10	12/24	50	14 J	540	65	nc	µg/kg dw
Organochlorine pesticides								
2,4'-DDD	0 to 2	0/12	0	nd	nd	3.0	2.0 – 18	µg/kg dw
	2 to 4	0/13	0	nd	nd	3.5	1.9 – 29	µg/kg dw
2,4'-DDE	0 to 2	0/12	0	nd	nd	8.3	2.0 – 82	µg/kg dw
	2 to 4	0/13	0	nd	nd	7.8	1.9 – 81	µg/kg dw
2,4'-DDT	0 to 2	0/12	0	nd	nd	3.0	2.0 – 18	µg/kg dw
	2 to 4	0/13	0	nd	nd	3.5	1.9 – 29	µg/kg dw
4,4'-DDD	0 to 2	3/21	14	2.7	8.0 J	2.7	2.0 – 18	µg/kg dw
	2 to 4	3/21	14	2.0 J	10	4.2	1.6 – 39	µg/kg dw
	8 to 10	0/1	0	nd	nd	1.00	2.00	µg/kg dw
4,4'-DDE	0 to 2	6/21	29	1.0	10 J	6.6	1.0 – 83	µg/kg dw
	2 to 4	3/21	14	7.0	18 J	6.1	1.0 – 81	µg/kg dw
	8 to 10	0/1	0	nd	nd	1.00	2.00	µg/kg dw
4,4'-DDT	0 to 2	1/21	5	2.8	2.8	11	2.0 – 150	µg/kg dw
	2 to 4	0/21	0	nd	nd	8.7	1.6 – 140	µg/kg dw
	8 to 10	0/1	0	nd	nd	4.40	8.80	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
DDTs (total-calc'd)	0 to 2	6/21	29	1.0	18 J	13	nc	µg/kg dw
	2 to 4	3/21	14	10.0	20 J	12	nc	µg/kg dw
	8 to 10	0/1	0	nd	nd	4.40	nc	µg/kg dw
Aldrin	0 to 2	0/21	0	nd	nd	1.1	0.98 – 9.1	µg/kg dw
	2 to 4	0/21	0	nd	nd	1.3	0.96 – 14	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.600	1.20	µg/kg dw
Dieldrin	0 to 2	1/21	5	1.8	1.8	2.6	2.0 – 28	µg/kg dw
	2 to 4	0/21	0	nd	nd	2.7	1.6 – 29	µg/kg dw
	8 to 10	0/1	0	nd	nd	4.30	8.60	µg/kg dw
Total aldrin/dieldrin	0 to 2	1/21	5	1.8	1.8	2.6	nc	µg/kg dw
	2 to 4	0/21	0	nd	nd	2.7	nc	µg/kg dw
	8 to 10	0/1	0	nd	nd	4.30	nc	µg/kg dw
alpha-BHC	0 to 2	0/20	0	nd	nd	1.1	0.98 – 9.1	µg/kg dw
	2 to 4	0/20	0	nd	nd	1.3	0.96 – 14	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.50	0.99	µg/kg dw
beta-BHC	0 to 2	0/20	0	nd	nd	1.2	0.98 – 9.1	µg/kg dw
	2 to 4	0/20	0	nd	nd	1.3	0.98 – 14	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.50	0.99	µg/kg dw
gamma-BHC	0 to 2	0/21	0	nd	nd	1.2	0.98 – 9.1	µg/kg dw
	2 to 4	0/21	0	nd	nd	1.3	0.96 – 14	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.50	0.99	µg/kg dw
delta-BHC	0 to 2	2/12	17	13	1,100	94	1.0 – 9.1	µg/kg dw
	2 to 4	2/13	15	8.3	29	4.4	0.96 – 14	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.50	0.99	µg/kg dw
alpha-Chlordane	0 to 2	0/20	0	nd	nd	1.1	0.98 – 9.1	µg/kg dw
	2 to 4	0/20	0	nd	nd	1.4	0.98 – 14	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.50	0.99	µg/kg dw
gamma-Chlordane	0 to 2	0/19	0	nd	nd	4.9	0.98 – 62	µg/kg dw
	2 to 4	0/19	0	nd	nd	5.3	0.98 – 82	µg/kg dw
	8 to 10	0/1	0	nd	nd	1.50	3.00	µg/kg dw
Chlordane	0 to 2	1/1	100	29.0	29.0	29.0	na	µg/kg dw
	2 to 4	0/1	0	nd	nd	4.2	8.4	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
alpha-Endosulfan	0 to 2	0/19	0	nd	nd	1.1	0.98 – 9.1	µg/kg dw
	2 to 4	0/19	0	nd	nd	1.3	0.96 – 14	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.50	0.99	µg/kg dw
beta-Endosulfan	0 to 2	0/19	0	nd	nd	2.3	2.0 – 18	µg/kg dw
	2 to 4	0/19	0	nd	nd	2.7	1.9 – 29	µg/kg dw
	8 to 10	0/1	0	nd	nd	1.00	2.00	µg/kg dw
Endosulfan	0 to 2	0/1	0	nd	nd	0.75	1.5	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
Endosulfan sulfate	0 to 2	0/19	0	nd	nd	3.9	2.0 – 54	µg/kg dw
	2 to 4	0/19	0	nd	nd	3.7	2.0 – 32	µg/kg dw
	8 to 10	0/1	0	nd	nd	1.00	2.00	µg/kg dw
Endrin	0 to 2	0/20	0	nd	nd	10	1.5 – 150	µg/kg dw
	2 to 4	0/20	0	nd	nd	4.3	1.6 – 54	µg/kg dw
	8 to 10	0/1	0	nd	nd	1.00	2.00	µg/kg dw
Endrin aldehyde	0 to 2	1/20	5	10	10	3.6	1.5 – 25	µg/kg dw
	2 to 4	0/20	0	nd	nd	3.5	1.6 – 29	µg/kg dw
	8 to 10	0/1	0	nd	nd	1.00	2.00	µg/kg dw
Endrin ketone	0 to 2	0/19	0	nd	nd	2.3	2.0 – 18	µg/kg dw
	2 to 4	0/19	0	nd	nd	2.7	1.9 – 29	µg/kg dw
	8 to 10	0/1	0	nd	nd	1.00	2.00	µg/kg dw
Heptachlor	0 to 2	0/21	0	nd	nd	1.4	0.98 – 10	µg/kg dw
	2 to 4	0/21	0	nd	nd	1.3	0.96 – 14	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.50	0.99	µg/kg dw
Heptachlor epoxide	0 to 2	0/20	0	nd	nd	5.6	0.98 – 80	µg/kg dw
	2 to 4	0/20	0	nd	nd	5.4	0.98 – 120	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.50	0.99	µg/kg dw
Methoxychlor	0 to 2	0/20	0	nd	nd	9.5	1.0 – 91	µg/kg dw
	2 to 4	0/20	0	nd	nd	12	1.0 – 140	µg/kg dw
	8 to 10	0/1	0	nd	nd	4.95	9.90	µg/kg dw
Mirex	0 to 2	0/12	0	nd	nd	3.0	2.0 – 18	µg/kg dw
	2 to 4	0/13	0	nd	nd	3.5	1.9 – 29	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Cis-Nonachlor	0 to 2	0/12	0	nd	nd	3.0	2.0 – 18	µg/kg dw
	2 to 4	0/13	0	nd	nd	3.5	1.9 – 29	µg/kg dw
Oxychlordane	0 to 2	0/12	0	nd	nd	4.6	2.0 – 53	µg/kg dw
	2 to 4	0/13	0	nd	nd	6.3	1.9 – 100	µg/kg dw
Toxaphene	0 to 2	0/20	0	nd	nd	93	10 – 910	µg/kg dw
	2 to 4	0/20	0	nd	nd	110	10 – 1,400	µg/kg dw
	8 to 10	0/1	0	nd	nd	49.50	99.00	µg/kg dw
Trans-Nonachlor	0 to 2	0/12	0	nd	nd	3.0	2.0 – 18	µg/kg dw
	2 to 4	0/13	0	nd	nd	3.5	1.9 – 29	µg/kg dw
Total chlordane	0 to 2	0/20	0	nd	nd	5.1	nc	µg/kg dw
	2 to 4	0/20	0	nd	nd	5.8	nc	µg/kg dw
	8 to 10	0/1	0	nd	nd	1.50	nc	µg/kg dw
Grain size								
Fractional % (>9,525 µm)	0 to 2	0/16	0	nd	nd	0.0050	0.010	% dw
	2 to 4	0/14	0	nd	nd	0.0050	0.010	% dw
Fractional % phi >-1 (>2,000 µm)	0 to 2	73/81	90	0.100 J	33.6	3	0.1	% dw
	2 to 4	54/54	100	0.1	32.7	5	na	% dw
	4 to 6	7/7	100	0.20	2.8	1.0	na	% dw
Fractional % phi -2-(-1) (2,000-4,000 µm)	0 to 2	12/16	75	0.030	3.8 J	0.52	0.010	% dw
	2 to 4	11/14	79	0.010	1.5	0.29	0.010	% dw
Fractional % phi -1-0 (1,000-2,000 µm)	0 to 2	107/108	99	0.020 J	11	1	0.010	% dw
	2 to 4	78/78	100	0.080 J	22.5	2	na	% dw
	4 to 6	8/9	89	0.30	2.9	0.98	0.010	% dw
	6 to 8	6/6	100	0.100	0.500	0.200	na	% dw
Fractional % phi 0-1 (500-1,000 µm)	0 to 2	108/108	100	0.1	30.6	4	na	% dw
	2 to 4	77/77	100	0.2	39.2	6	na	% dw
	4 to 6	8/8	100	1.0	15	5.8	na	% dw
Fractional % phi 1-2 (250-500 µm)	0 to 2	108/108	100	0.70	61.1	9	na	% dw
	2 to 4	77/77	100	0.36 J	68.7	10	na	% dw
	4 to 6	8/8	100	6.1	66	22	na	% dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Fractional % phi 2-3 (125-250 µm)	0 to 2	108/108	100	0.7	29.5	8	na	% dw
	2 to 4	77/77	100	0.5	47.9	10	na	% dw
	4 to 6	8/8	100	6.9	30	17	na	% dw
Fractional % phi 3-4 (62.5-125 µm)	0 to 2	108/108	100	0.10 J	27.6	9.9	na	% dw
	2 to 4	80/80	100	0.3	36.8	10	na	% dw
	4 to 6	9/9	100	0.90	30	13	na	% dw
	6 to 8	6/6	100	3.20	42.8	24.9	na	% dw
Fractional % phi 4-5 (31.2-62.5 µm)	0 to 2	108/108	100	1.2	29	10	na	% dw
	2 to 4	80/80	100	0.100 J	25.3 J	9	na	% dw
	4 to 6	9/9	100	0.60	15	8.1	na	% dw
	6 to 8	6/6	100	0.800 J	18.5	11.8	na	% dw
Fractional % phi 5-6 (15.6-31.2 µm)	0 to 2	107/107	100	0.8	44	20	na	% dw
	2 to 4	76/76	100	0.100 J	41.1	10	na	% dw
	4 to 6	9/9	100	0.20	19	9.6	na	% dw
	6 to 8	6/6	100	0.500 J	17.1 J	9.30	na	% dw
Fractional % phi 6-7 (7.8-15.6 µm)	0 to 2	107/107	100	0.7	37.7	20	na	% dw
	2 to 4	76/76	100	0.1	32.8	10	na	% dw
	4 to 6	9/9	100	0.10	21	8.8	na	% dw
	6 to 8	6/6	100	0.600 J	17.9 J	7.00	na	% dw
Fractional % phi 7-8 (3.9-7.8 µm)	0 to 2	107/107	100	0.6	16	7	na	% dw
	2 to 4	76/76	100	0.100 J	17.5	7	na	% dw
	4 to 6	9/9	100	0.10	13	5.4	na	% dw
	6 to 8	6/6	100	0.600 J	18.2 J	5.65	na	% dw
Fractional % phi 8-9 (1.95-3.9 µm)	0 to 2	106/107	99	0.3	9.0	4	0.010	% dw
	2 to 4	76/76	100	0.010	11.5	4	na	% dw
	4 to 6	9/9	100	0.10	6.0	2.8	na	% dw
	6 to 8	6/6	100	0.400 J	12.0 J	3.65	na	% dw
Fractional % phi 9+ (<1.95 µm)	0 to 2	1/1	100	0.100 J	0.100 J	0.100	na	% dw
Fractional % phi 9-10 (0.98-1.95 µm)	0 to 2	105/107	98	0.1	6.4	3	0.010	% dw
	2 to 4	75/76	99	0.010	9.0	3	0.1	% dw
	4 to 6	9/9	100	0.10	4.0	1.8	na	% dw
	6 to 8	6/6	100	0.300 J	6.90 J	2.13	na	% dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Fractional % phi 10+ (<0.98 µm)	0 to 2	107/107	100	0.7	15.8	7	na	% dw
	2 to 4	76/76	100	0.400 J	20.2	7	na	% dw
	4 to 6	9/9	100	0.60	8.4	4.2	na	% dw
	6 to 8	6/6	100	0.300 J	10.9 J	3.55	na	% dw
Fractional % Sieve #10 (2,000-4,750 µm)	0 to 2	4/6	67	2.0	10	4.0	0.010	% dw
	4 to 6	0/1	0	nd	nd	0.0050	0.010	% dw
Fractional % Sieve 3/8 in. (4,750-9,525 µm)	0 to 2	3/16	19	0.47 J	12 J	1.3	0.010	% dw
	2 to 4	2/14	14	0.53	0.65	0.089	0.010	% dw
Fractional % Sieve #4 (>4,750 µm)	0 to 2	4/6	67	1.0	46	9.8	0.010	% dw
	4 to 6	0/1	0	nd	nd	0.0050	0.010	% dw
Gravel (total calc'd)	0 to 2	90/103	87	0.030	51	4	nc	% dw
	2 to 4	65/68	96	0.010	32.7	4	nc	% dw
	4 to 6	7/8	88	0.20	2.8	0.88	nc	% dw
Sand (total calc'd)	0 to 2	109/109	100	2.8	94.4	33	nc	% dw
	2 to 4	81/81	100	2.20	99.2	40	nc	% dw
	4 to 6	9/9	100	20.7	97	55	nc	% dw
	6 to 8	6/6	100	3.30	42.9	25.1	nc	% dw
Silt (total calc'd)	0 to 2	109/109	100	3.4	82.8	50	nc	% dw
	2 to 4	81/81	100	0.400 J	84.7	40	nc	% dw
	4 to 6	9/9	100	1.00	58	32	nc	% dw
	6 to 8	6/6	100	2.500 J	61.9 J	33.7	nc	% dw
Clay (total calc'd)	0 to 2	108/108	100	0.5	29.8	10	nc	% dw
	2 to 4	77/77	100	0.1	39.9	10	nc	% dw
	4 to 6	9/9	100	0.80	17.6	8.8	nc	% dw
	6 to 8	6/6	100	1.000 J	29.8 J	9.33	nc	% dw
Gravel	0 to 2	1/1	100	24.5	24.5	24.5	na	% dw
	2 to 4	4/4	100	0.100 J	1.0	0.4	na	% dw
	4 to 6	1/1	100	0.100	0.100	0.100	na	% dw
	6 to 8	6/6	100	0.100 J	0.100 J	0.100	na	% dw
Coarse Sand (4,750-2,000 microns)	2 to 4	3/3	100	0.600	31.7	11.1	na	% dw
	4 to 6	1/1	100	1.80	1.80	1.80	na	% dw
	6 to 8	6/6	100	0.500	2.80	1.15	na	% dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Medium Sand (2,000-425 microns)	2 to 4	3/3	100	1.60	60.0	21.7	na	% dw
	4 to 6	1/1	100	4.80	4.80	4.80	na	% dw
	6 to 8	6/6	100	0.900	39.6	8.37	na	% dw
Fine Sand (425-75 microns)	2 to 4	3/3	100	5.40	65.1	25.6	na	% dw
	4 to 6	1/1	100	24.4	24.4	24.4	na	% dw
	6 to 8	6/6	100	3.40	47.8	22.4	na	% dw
Fines (percent silt+clay)	0 to 2	108/108	100	4.7	97.2	64	na	% dw
	2 to 4	80/80	100	1.000 J	96.5	56	na	% dw
	4 to 6	9/9	100	1.80	76	41	na	% dw
	6 to 8	6/6	100	3.500 J	91.7 J	43.1	na	% dw
Conventional parameters								
Total organic carbon (TOC)	0 to 2	137/137	100	0.23	3.46	1.9	na	% dw
	2 to 4	135/135	100	0.061	9	1.8	na	% dw
	4 to 6	60/60	100	0.064	4.01	1	na	% dw
	6 to 8	30/30	100	0.059	3.24	1.2	na	% dw
	8 to 10	24/24	100	0.13	2.8	1.2	na	% dw
Total solids	0 to 2	110/110	100	40.00	85.6	60	na	% ww
	2 to 4	107/107	100	38.50	85.1	66	na	% ww
	4 to 6	60/60	100	47.60	84.25	67	na	% ww
	6 to 8	31/31	100	55.50	83.40	69.3	na	% ww
	8 to 10	24/24	100	54.58	81.2	68.8	na	% ww
Total solids (preserved)	0 to 2	1/1	100	38.63	38.63	38.63	na	% ww
Total volatile solids	0 to 2	1/1	100	7.98	7.98	7.98	na	% dw
	2 to 4	1/1	100	7.53	7.53	7.53	na	% dw
Sulfides (total)	0 to 2	2/2	100	74 J	4,600	2,300	na	mg/kg dw
Cyanide	0 to 2	0/1	0	nd	nd	0.30	0.60	mg/kg dw
	2 to 4	0/1	0	nd	nd	31	61	mg/kg dw
	4 to 6	0/1	0	nd	nd	32	63	mg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Moisture	0 to 2	23/23	100	23.17	132.1	67.7	na	% dw
	2 to 4	3/3	100	25.7	59.3	39.3	na	% ww
	2 to 4	43/43	100	19.85	127.0	67	na	% dw
	4 to 6	1/1	100	60.0	60.0	60.0	na	% ww
	6 to 8	6/6	100	29.1	55.3	44.5	na	% ww
pH	0 to 2	3/3	100	6.8	9.2	8.0	na	pH
Salinity	0 to 2	2/2	100	25.3	25.5	25.4	na	ppt
	2 to 4	2/2	100	25.3	26.2	25.8	na	ppt
	4 to 6	1/1	100	25.3	25.3	25.3	na	ppt
	6 to 8	1/1	100	25.1	25.1	25.1	na	ppt
	8 to 10	1/1	100	25.7	25.7	25.7	na	ppt
Specific Gravity	0 to 2	23/23	100	2.57	2.73	2.7	na	g/cc
	2 to 4	45/45	100	2.06	2.8	2.6	na	g/cc
	6 to 8	1/1	100	2.6	2.6	2.6	na	g/cc
Conductivity	0 to 2	2/2	100	40,200	40,400	40,300	na	umhos/cm
	2 to 4	2/2	100	39,900	41,400	40,700	na	umhos/cm
	4 to 6	1/1	100	40,000	40,000	40,000	na	umhos/cm
	6 to 8	1/1	100	39,600	39,600	39,600	na	umhos/cm
	8 to 10	1/1	100	40,700	40,700	40,700	na	umhos/cm
Volatile organic compounds								
1,1,1,2-Tetrachloroethane	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
1,1,1-Trichloroethane	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,1,2,2-Tetrachloroethane	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
1,1,2-Trichloroethane	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
1,1,2-Trichlorotrifluoroethane	0 to 2	0/2	0	nd	nd	1.7	3.3 – 3.5	µg/kg dw
	2 to 4	0/1	0	nd	nd	1.6	3.1	µg/kg dw
	4 to 6	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	6 to 8	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	8 to 10	0/1	0	nd	nd	1.10	2.20	µg/kg dw
1,1-Dichloroethane	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
1,1-Dichloroethene	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
1,1-Dichloropropene	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,2,3-Trichlorobenzene	0 to 2	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	2 to 4	0/1	0	nd	nd	3.9	7.8	µg/kg dw
	4 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 8	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	8 to 10	0/1	0	nd	nd	2.70	5.40	µg/kg dw
1,2,3-Trichloropropane	0 to 2	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	2 to 4	0/1	0	nd	nd	1.6	3.1	µg/kg dw
	4 to 6	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	6 to 8	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	8 to 10	0/1	0	nd	nd	1.10	2.20	µg/kg dw
1,2,4-Trimethylbenzene	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	1/1	50	420	420	0.550	1.10	µg/kg dw
1,2-Dibromo-3-chloropropane	0 to 2	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	2 to 4	0/1	0	nd	nd	3.9	7.8	µg/kg dw
	4 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 8	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	8 to 10	0/1	0	nd	nd	2.70	5.40	µg/kg dw
1,2-Dibromoethane (EDB)	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
1,2-Dichloroethane	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,2-Dichloropropane	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
1,3,5-Trimethylbenzene	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	1/1	0	nd	nd	0.550	1.10	µg/kg dw
1,3-Dichloropropane	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
2,2-Dichloropropane	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
2-Chloroethyl vinyl ether	0 to 2	0/2	0	nd	nd	4.3	8.3 – 8.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	3.9	7.8	µg/kg dw
	4 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 8	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	8 to 10	0/1	0	nd	nd	2.70	5.40	µg/kg dw
2-Chlorotoluene	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
2-Hexanone	0 to 2	0/2	0	nd	nd	4.3	8.3 – 8.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	3.9	7.8	µg/kg dw
	4 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 8	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	8 to 10	0/1	0	nd	nd	2.70	5.40	µg/kg dw
4-Chlorotoluene	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Acetone	0 to 2	1/2	50	50	50	31	25	µg/kg dw
	2 to 4	1/1	100	40	40	40	na	µg/kg dw
	4 to 6	1/1	100	100	100	97	na	µg/kg dw
	6 to 8	1/1	100	160	160	160	na	µg/kg dw
	8 to 10	1/1	100	39.00	39.00	39.00	na	µg/kg dw
Acrolein	0 to 2	0/1	0	nd	nd	42	83	µg/kg dw
	2 to 4	0/1	0	nd	nd	39	78	µg/kg dw
	4 to 6	0/1	0	nd	nd	42	83	µg/kg dw
	6 to 8	0/1	0	nd	nd	41	82	µg/kg dw
	8 to 10	0/1	0	nd	nd	27.00	54.00	µg/kg dw
Acrylonitrile	0 to 2	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	2 to 4	0/1	0	nd	nd	3.9	7.8	µg/kg dw
	4 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 8	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	8 to 10	0/1	0	nd	nd	2.70	5.40	µg/kg dw
Benzene	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	1/1	100	4.4	4.4	4.4	na	µg/kg dw
	8 to 10	0/1	nd	nd	nd	0.550	1.10	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Bromobenzene	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Bromochloromethane	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Bromodichloromethane	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Bromoethane	0 to 2	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	2 to 4	0/1	0	nd	nd	1.6	3.1	µg/kg dw
	4 to 6	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	6 to 8	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	8 to 10	0/1	0	nd	nd	1.10	2.20	µg/kg dw
Bromoform	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Bromomethane	0 to 2	0/2	0	nd	nd	1.3	1.7 – 3.5	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Carbon disulfide	0 to 2	½	50	4.0	4.0	2.5	1.8	µg/kg dw
	2 to 4	1/1	100	4.7	4.7	4.7	na	µg/kg dw
	4 to 6	1/1	100	2.2	2.2	2.2	na	µg/kg dw
	6 to 8	1/1	100	2.8	2.8	2.8	na	µg/kg dw
	8 to 10	1/1	100	2.20	2.20	2.20	na	µg/kg dw
Carbon tetrachloride	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Chlorobenzene	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Chloroethane	0 to 2	0/2	0	nd	nd	1.3	1.7 – 3.5	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Chloroform	0 to 2	½	50	1.8	1.8	1.3	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	nd	nd	nd	0.550	1.10	µg/kg dw
Chloromethane	0 to 2	0/2	0	nd	nd	1.3	1.7 – 3.5	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
cis-1,2-Dichloroethene	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	1/1	100	5.2	5.2	5.2	na	µg/kg dw
	8 to 10	0/1	nd	nd	nd	0.550	1.10	µg/kg dw
cis-1,3-Dichloropropene	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
p-Cymene	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	1/1	100	15.00	15.00	15.00	na	µg/kg dw
Dibromochloromethane	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Dibromomethane	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Dichloromethane	0 to 2	0/2	0	nd	nd	1.8	3.3 – 4.0	µg/kg dw
	2 to 4	0/1	0	nd	nd	1.6	3.1	µg/kg dw
	4 to 6	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	6 to 8	0/1	0	nd	nd	1.7	3.3	µg/kg dw
	8 to 10	0/1	0	nd	nd	1.10	2.20	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Ethylbenzene	0 to 2	0/3	0	nd	nd	0.93	1.7 – 2.1	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Iodomethane	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Isopropylbenzene	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Methyl ethyl ketone	0 to 2	1/2	50	17	17	11	8.8	µg/kg dw
	2 to 4	1/1	100	12	12	12	na	µg/kg dw
	4 to 6	1/1	100	27	27	27	na	µg/kg dw
	6 to 8	1/1	100	40	40	40	na	µg/kg dw
	8 to 10	0/1	0	nd	nd	2.70	5.40	µg/kg dw
n-Butylbenzene	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
n-Propylbenzene	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
sec-Butylbenzene	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Styrene	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
tert-Butylbenzene	0 to 2	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Tetrachloroethene	0 to 2	0/3	0	nd	nd	0.93	1.7 – 2.1	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Toluene	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	1/1	100	1.9	1.9	1.9	na	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
trans-1,2-Dichloroethene	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
trans-1,3-Dichloropropene	0 to 2	0/2	0	nd	nd	0.88	1.7 – 1.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
trans-1,4-Dichloro-2-butene	0 to 2	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	2 to 4	0/1	0	nd	nd	3.9	7.8	µg/kg dw
	4 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 8	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	8 to 10	0/1	0	nd	nd	2.70	5.40	µg/kg dw
Trichloroethene	0 to 2	0/3	0	nd	nd	0.93	1.7 – 2.1	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Trichlorofluoromethane	0 to 2	0/2	0	nd	nd	1.3	1.7 – 3.5	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Vinyl acetate	0 to 2	0/2	0	nd	nd	4.3	8.3 – 8.8	µg/kg dw
	2 to 4	0/1	0	nd	nd	3.9	7.8	µg/kg dw
	4 to 6	0/1	0	nd	nd	4.2	8.3	µg/kg dw
	6 to 8	0/1	0	nd	nd	4.1	8.2	µg/kg dw
	8 to 10	0/1	0	nd	nd	2.70	5.40	µg/kg dw
Vinyl chloride	0 to 2	0/2	0	nd	nd	1.3	1.7 – 3.5	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	1/1	100	29	29	29	na	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Xylene (ortho)	0 to 2	0/3	0	nd	nd	0.93	1.7 – 2.1	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	8 to 10	0/1	0	nd	nd	0.550	1.10	µg/kg dw
Xylene (meta & para)	0 to 2	0/3	0	nd	nd	0.93	1.7 – 2.1	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	1.6	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	1.7	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	1.6	µg/kg dw
Total Xylenes (calc'd)	0 to 2	0/3	0	nd	nd	0.93	nc	µg/kg dw
	2 to 4	0/1	0	nd	nd	0.80	nc	µg/kg dw
	4 to 6	0/1	0	nd	nd	0.85	nc	µg/kg dw
	6 to 8	0/1	0	nd	nd	0.80	nc	µg/kg dw
	8 to 10	0/2	0	nd	nd	0.550	nc	µg/kg dw
Dioxins/furans								
2,3,7,8-TCDD	0 to 2	8/8	100	0.325	1.88	0.678	na	ng/kg dw
	2 to 4	7/8	88	0.302	0.920	0.550	0.0440	ng/kg dw
	4 to 6	1/1	100	0.890 J	0.890 J	0.890	na	ng/kg dw
	6 to 8	1/1	100	3.36	3.36	3.36	na	ng/kg dw
	8 to 10	1/1	100	0.324	0.324	0.324	na	ng/kg dw
1,2,3,7,8-PeCDD	0 to 2	8/8	100	0.474 J	3.78	1.85	na	ng/kg dw
	2 to 4	6/8	75	1.15	2.69	1.62	0.0440 – 0.0471	ng/kg dw
	4 to 6	1/1	100	3.61	3.61	3.61	na	ng/kg dw
	6 to 8	1/1	100	10.5	10.5	10.5	na	ng/kg dw
	8 to 10	1/1	100	1.07	1.07	1.07	na	ng/kg dw
1,2,3,4,7,8-HxCDD	0 to 2	8/8	100	0.80 J	6.08	3.12	na	ng/kg dw
	2 to 4	6/8	75	1.53	3.90	2.20	0.0440 – 0.0471	ng/kg dw
	4 to 6	1/1	100	7.19 J	7.19 J	7.19	na	ng/kg dw
	6 to 8	1/1	100	11.2	11.2	11.2	na	ng/kg dw
	8 to 10	1/1	100	0.700 J	0.700 J	0.700	na	ng/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,2,3,6,7,8-HxCDD	0 to 2	8/8	100	3.50 J	37.7	18.7	na	ng/kg dw
	2 to 4	7/8	88	0.103 J	24.4	14.8	0.0471	ng/kg dw
	4 to 6	1/1	100	169	169	169	na	ng/kg dw
	6 to 8	1/1	100	184	184	184	na	ng/kg dw
	8 to 10	1/1	100	4.62	4.62	4.62	na	ng/kg dw
1,2,3,7,8,9-HxCDD	0 to 2	8/8	100	2.88 J	18.6	10.1	na	ng/kg dw
	2 to 4	6/8	75	6.53	13.5	8.14	0.0471 – 0.0660	ng/kg dw
	4 to 6	1/1	100	23.7	23.7	23.7	na	ng/kg dw
	6 to 8	1/1	100	52.3	52.3	52.3	na	ng/kg dw
	8 to 10	1/1	100	2.24	2.24	2.24	na	ng/kg dw
1,2,3,4,6,7,8-HpCDD	0 to 2	8/8	100	100	924	515	na	ng/kg dw
	2 to 4	7/8	88	2.56	732	419	0.307	ng/kg dw
	4 to 6	1/1	100	4,930	4,930	4,930	na	ng/kg dw
	6 to 8	1/1	100	5,930	5,930	5,930	na	ng/kg dw
	8 to 10	1/1	100	72.4	72.4	72.4	na	ng/kg dw
OCDD	0 to 2	8/8	100	970	8,220	4,460	na	ng/kg dw
	2 to 4	8/8	100	2.92	7,140	3,830	na	ng/kg dw
	4 to 6	1/1	100	36,300	36,300	36,300	na	ng/kg dw
	6 to 8	1/1	100	62,000	62,000	62,000	na	ng/kg dw
	8 to 10	1/1	100	453	453	453	na	ng/kg dw
2,3,7,8-TCDF	0 to 2	7/8	88	0.0740 J	6.09	1.59	0.621	ng/kg dw
	2 to 4	4/8	50	1.17	1.66	0.868	0.0440 – 1.26	ng/kg dw
	4 to 6	1/1	100	4.02	4.02	4.02	na	ng/kg dw
	6 to 8	1/1	100	3.32	3.32	3.32	na	ng/kg dw
	8 to 10	1/1	100	1.44	1.44	1.44	na	ng/kg dw
1,2,3,7,8-PeCDF	0 to 2	8/8	100	0.410 J	4.40	1.69	na	ng/kg dw
	2 to 4	6/8	75	0.961	2.47	1.17	0.0440 – 0.0471	ng/kg dw
	4 to 6	1/1	100	18.1	18.1	18.1	na	ng/kg dw
	6 to 8	1/1	100	3.24	3.24	3.24	na	ng/kg dw
	8 to 10	1/1	100	1.19	1.19	1.19	na	ng/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
2,3,4,7,8-PeCDF	0 to 2	8/8	100	0.61 J	17.6	5.27	na	ng/kg dw
	2 to 4	7/8	88	0.0670 J	7.65	3.09	0.0471	ng/kg dw
	4 to 6	1/1	100	61.8	61.8	61.8	na	ng/kg dw
	6 to 8	1/1	100	5.92	5.92	5.92	na	ng/kg dw
	8 to 10	1/1	100	2.74	2.74	2.74	na	ng/kg dw
1,2,3,4,7,8-HxCDF	0 to 2	8/8	100	2.72 J	77	21.0	na	ng/kg dw
	2 to 4	7/8	88	0.176 J	52.1	16.0	0.0471	ng/kg dw
	4 to 6	1/1	100	467	467	467	na	ng/kg dw
	6 to 8	1/1	100	40.6	40.6	40.6	na	ng/kg dw
	8 to 10	1/1	100	2.88	2.88	2.88	na	ng/kg dw
1,2,3,6,7,8-HxCDF	0 to 2	8/8	100	0.80 J	12.3 J	5.09	na	ng/kg dw
	2 to 4	6/8	75	2.89	9.78	3.86	0.0440 – 0.0471	ng/kg dw
	4 to 6	1/1	100	76.0	76.0	76.0	na	ng/kg dw
	6 to 8	1/1	100	12.7	12.7	12.7	na	ng/kg dw
	8 to 10	1/1	100	2.71	2.71	2.71	na	ng/kg dw
1,2,3,7,8,9-HxCDF	0 to 2	6/8	75	0.239 J	2.36	0.537	0.047 – 0.113	ng/kg dw
	2 to 4	5/8	62	0.217 J	0.413 J	0.397	0.0440 – 3.02	ng/kg dw
	4 to 6	1/1	100	8.02	8.02	8.02	na	ng/kg dw
	6 to 8	1/1	100	0.983 J	0.983 J	0.983	na	ng/kg dw
	8 to 10	1/1	100	0.128 J	0.128 J	0.128	na	ng/kg dw
2,3,4,6,7,8-HxCDF	0 to 2	8/8	100	0.58 J	6.29	2.91	na	ng/kg dw
	2 to 4	6/8	75	2.15	4.87	2.40	0.0440 – 0.0471	ng/kg dw
	4 to 6	1/1	100	28.2	28.2	28.2	na	ng/kg dw
	6 to 8	1/1	100	9.77	9.77	9.77	na	ng/kg dw
	8 to 10	1/1	100	2.99	2.99	2.99	na	ng/kg dw
1,2,3,4,6,7,8-HpCDF	0 to 2	8/8	100	18.6	273	121	na	ng/kg dw
	2 to 4	7/8	88	0.743 J	314	97.3	0.0471	ng/kg dw
	4 to 6	1/1	100	2,490	2,490	2,490	na	ng/kg dw
	6 to 8	1/1	100	873	873	873	na	ng/kg dw
	8 to 10	1/1	100	65.0	65.0	65.0	na	ng/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,2,3,4,7,8,9-HpCDF	0 to 2	8/8	100	1.19 J	33.8	11.8	na	ng/kg dw
	2 to 4	6/8	75	5.17	33.0	9.32	0.0471 – 0.0930	ng/kg dw
	4 to 6	1/1	100	299	299	299	na	ng/kg dw
	6 to 8	1/1	100	63.4	63.4	63.4	na	ng/kg dw
	8 to 10	1/1	100	1.88	1.88	1.88	na	ng/kg dw
OCDF	0 to 2	8/8	100	51.7	1,050	416	na	ng/kg dw
	2 to 4	8/8	100	0.0875 J	1,410	349	na	ng/kg dw
	4 to 6	1/1	100	13,500	13,500	13,500	na	ng/kg dw
	6 to 8	1/1	100	4,420	4,420	4,420	na	ng/kg dw
	8 to 10	1/1	100	148	148	148	na	ng/kg dw
Dioxin/furan TEQ - Bird	0 to 2	8/8	100	2.80 J	43.0 J	16.2	na	ng/kg dw
	2 to 4	8/8	100	0.178 J	22.9	11.5	na	ng/kg dw
	4 to 6	1/1	100	172 J	172 J	172	na	ng/kg dw
	6 to 8	1/1	100	59.4 J	59.4 J	59.4	na	ng/kg dw
	8 to 10	1/1	100	7.67 J	7.67 J	7.67	na	ng/kg dw
Dioxin/furan TEQ - Fish	0 to 2	8/8	100	2.36 J	29.2 J	12.3	na	ng/kg dw
	2 to 4	8/8	100	0.129 J	18.5	9.33	na	ng/kg dw
	4 to 6	1/1	100	138 J	138 J	138	na	ng/kg dw
	6 to 8	1/1	100	53.5 J	53.5 J	53.5	na	ng/kg dw
	8 to 10	1/1	100	4.99 J	4.99 J	4.99	na	ng/kg dw
Dioxin/furan TEQ - Mammal	0 to 2	8/8	100	3.60 J	38.7 J	18.3	na	ng/kg dw
	2 to 4	8/8	100	0.147 J	27.1	14.5	na	ng/kg dw
	4 to 6	1/1	100	194 J	194 J	194	na	ng/kg dw
	6 to 8	1/1	100	136 J	136 J	136	na	ng/kg dw
	8 to 10	1/1	100	5.60 J	5.60 J	5.60	na	ng/kg dw
Petroleum groups								
Gasoline	0 to 2	0/1	0	nd	nd	12	24	mg/kg dw
	2 to 4	0/1	0	nd	nd	12	24	mg/kg dw
	4 to 6	0/1	0	nd	nd	13	25	mg/kg dw
TPH - Diesel Range	8 to 10	1/1	100	19	19	19	na	mg/kg dw

Table E.6.2-2, cont. Subsurface sediment data, 2-ft intervals

Chemical	Depth Interval	Detection Frequency		Concentration				
		Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
TPH - Diesel #2 Range	0 to 2	0/1	0	nd	nd	30	60	mg/kg dw
	2 to 4	0/1	0	nd	nd	31	61	mg/kg dw
	4 to 6	0/1	0	nd	nd	32	63	mg/kg dw
TPH - Motor Oil Range	8 to 10	1/1	100	22	22	22	na	mg/kg dw
TPH - Heavy Fuel Oil Range	0 to 2	0/1	0	nd	nd	60	120	mg/kg dw
	2 to 4	0/1	0	nd	nd	60	120	mg/kg dw
	4 to 6	0/1	0	nd	nd	65	130	mg/kg dw
TPH	0 to 2	6/6	100	26	4,300	1,200	na	mg/kg dw
Geotechnical								
Liquid Limit	0 to 2	12/12	100	49.9	96.2	69.6	na	% dw
	2 to 4	32/32	100	0.100	165	62.0	na	% dw
	6 to 8	3/3	100	0.100	49.4	16.5	na	% dw
Plastic Limit	0 to 2	12/12	100	27.4	60.2	38.4	na	% dw
	2 to 4	32/32	100	0.100	63.4	35.9	na	% dw
	6 to 8	3/3	100	0.100	27.4	9.20	na	% dw
Plasticity Index	0 to 2	12/12	100	17.0	49.9	31.2	na	% dw
	2 to 4	32/32	100	0.10	119	26	na	% dw
	6 to 8	3/3	100	0.10	22	7.4	na	% dw
Bulk Density (dry)	0 to 2	23/23	100	37.9	100.0	64.9	na	pcf
	2 to 4	43/43	100	36.2	112.5	65	na	pcf
Bulk Density (wet)	0 to 2	23/23	100	82.1	127.7	103	na	pcf
	2 to 4	43/43	100	75.0	134.8	100	na	pcf
Porosity	0 to 2	23/23	100	0.41	0.76	0.61	na	S.U.
	2 to 4	43/43	100	0.34	0.79	0.61	na	S.U.

[a] Data were assigned to sample intervals by first rounding (to the nearest foot) the top and bottom depths of each sample (in feet below mudline) and then assigning the data to the appropriate sampling interval category (i.e., 0-to-2-ft intervals to a depth of 10 ft below mudline). If there were data for two 1-ft intervals at a particular location, the concentrations were averaged to obtain an estimated concentration for the corresponding 2-ft interval category (e.g., if a location had data for both the 0-to-1- and 1-to-2 ft intervals, the concentrations were averaged for an estimated concentration for the 0-to-2-ft interval). Data from dredged areas were not included.

[b] Surface sediment data were compared to the LAET and 2LAET instead of the SQS and CSL, respectively, if the TOC content was <0.5% or >4.0%.

Table E.6.2-3. Summary statistics for subsurface sediment data in all depth intervals

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Aluminum	82/82	100	3,410	33,000	20,000	na	mg/kg dw
Antimony	31/254	12	0.400	590 J	10	0.040 - 40	mg/kg dw
Arsenic	267/325	82	3.9	2,000	40	3.0 - 10.0	mg/kg dw
Barium	82/82	100	8.34	640	82	na	mg/kg dw
Beryllium	90/92	98	0.10	0.590	0.3	0.10 - 0.10	mg/kg dw
Cadmium	257/388	66	0.0880	20.4	1	0.18 - 0.9	mg/kg dw
Calcium	78/78	100	1,950	28,000	6,300	na	mg/kg dw
Chromium	397/397	100	6.67	386	40	na	mg/kg dw
Chromium VI	0/2	0	nd	nd	7.5	15	mg/kg dw
Cobalt	251/251	100	2.54	106	9	na	mg/kg dw
Copper	397/397	100	7.1	2,940	80	na	mg/kg dw
Iron	82/82	100	7,130	65,000 J	27,000	na	mg/kg dw
Lead	361/394	92	2.8	3,520 J	80	2 - 3.6	mg/kg dw
Magnesium	78/78	100	1,640	11,000	6,400	na	mg/kg dw
Manganese	82/82	100	82	940	290	na	mg/kg dw
Mercury	341/436	78	0.020	10	0.2	0.020 - 0.100	mg/kg dw
Molybdenum	128/187	68	0.6	166	4	0.6 - 2.5	mg/kg dw
Nickel	317/317	100	4.8	226	20	na	mg/kg dw
Potassium	77/77	100	370	3,900	2,200	na	mg/kg dw
Selenium	18/252	7	0.20 J	14	4	1.0 - 40	mg/kg dw
Silver	166/372	45	0.050	7.5	0.7	0.30 - 1	mg/kg dw
Sodium	78/78	100	720	16,900 J	8,000	na	mg/kg dw
Thallium	23/247	9	0.030 J	13	4	0.080 - 40	mg/kg dw
Tin	31/31	100	2.0	46	8.8	na	mg/kg dw
Vanadium	251/251	100	18	223	62	na	mg/kg dw

Table E.6.2-3, cont. Summary statistics for subsurface sediment data in all depth intervals

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Zinc	396/396	100	16.2 J	4,720	200	na	mg/kg dw
Organometals							
Monobutyltin as ion	21/84	25	4.5	170 J	9.5	1.0 - 65	µg/kg dw
Dibutyltin as ion	41/84	49	6.4	960	38	1.0 - 11	µg/kg dw
Tributyltin as ion	58/95	61	0.55 J	6,200	210	1.0 - 5.4	µg/kg dw
Tetrabutyltin as ion	4/23	17	5.0 J	40	9.0	3.0 - 15	µg/kg dw
PAHs							
1-Methylnaphthalene	18/185	10	20	2,600	45	19 - 160	µg/kg dw
2-Chloronaphthalene	1/270	<1	16 J	16 J	30	18 - 400	µg/kg dw
2-Methylnaphthalene	43/281	15	2.9 J	4,500	40	1.6 - 400	µg/kg dw
Acenaphthene	94/304	31	1.3 J	4,600	80	4.30 - 400	µg/kg dw
Acenaphthylene	53/281	19	10 J	280	20	1.9 - 400	µg/kg dw
Anthracene	200/304	66	4.3 J	1,900	100	4.30 - 400	µg/kg dw
Benzo(a)anthracene	243/304	80	12 J	4,500	300	4.30 - 180	µg/kg dw
Benzo(a)pyrene	237/304	78	11 J	5,300	300	4.30 - 400	µg/kg dw
Benzo(b)fluoranthene	247/304	81	9.9 J	6,400	400	4.30 - 820	µg/kg dw
Benzo(g,h,i)perylene	207/298	69	11 J	1,000	100	4.30 - 400	µg/kg dw
Benzo(k)fluoranthene	242/304	80	10 J	4,100	300	4.30 - 400	µg/kg dw
Total benzofluoranthenes	248/304	82	21 J	10,200	700	nc	µg/kg dw
Chrysene	247/304	81	12 J	7,200	400	4.30 - 180	µg/kg dw
Dibenzo(a,h)anthracene	119/304	39	3.2 J	660 J	60	4.30 - 910	µg/kg dw
Dibenzofuran	58/304	19	2.9 J	1,700	50	1.7 - 400	µg/kg dw
Fluoranthene	262/304	86	12 J	13,000	800	4.30 - 340	µg/kg dw
Fluorene	104/304	34	4.9 J	4,300	80	2.3 - 400	µg/kg dw
Indeno(1,2,3-cd)pyrene	212/298	71	10 J	1,500	100	4.30 - 400	µg/kg dw
Naphthalene	70/293	24	1.9 J	3,400	50	1.7 - 400	µg/kg dw
Phenanthrene	244/304	80	10 J	13,000	300	4.30 - 400	µg/kg dw

Table E.6.2-3, cont. Summary statistics for subsurface sediment data in all depth intervals

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Pyrene	266/304	88	9.9 J	10,000	800	4.30 - 170	µg/kg dw
Total HPAH (calc'd)	268/304	88	9.9 J	47,000	3,000	nc	µg/kg dw
Total LPAH (calc'd)	244/304	80	12.00	27,000 J	600	nc	µg/kg dw
Carcinogenic PAHs	252/304	83	18	7,000	400	3.89 - 400	µg/kg dw
Total PAH (calc'd)	269/304	88	9.9 J	57,000 J	4,000	nc	µg/kg dw
Phthalates							
Bis(2-ethylhexyl)phthalate	216/306	71	12 J	5,100	500	19 - 2,400	µg/kg dw
Butyl benzyl phthalate	147/283	52	5.6 J	610	30	5.8 - 400	µg/kg dw
Diethyl phthalate	1/306	<1	2,700	2,700	40	4.6 - 400	µg/kg dw
Dimethyl phthalate	20/283	7	4.2 J	8,800	60	2.4 - 400	µg/kg dw
Di-n-butyl phthalate	60/283	21	6.5 J	280	30	10 - 400	µg/kg dw
Di-n-octyl phthalate	14/306	5	14 J	2,000	70	1.6 - 1,600	µg/kg dw
Other SVOCs							
1,2,4-Trichlorobenzene	27/293	9	3.6 J	110 J	7	0.87 - 400	µg/kg dw
1,2-Dichlorobenzene	31/292	11	0.98 J	160	7	0.78 - 400	µg/kg dw
1,2-Diphenylhydrazine	1/32	3	100 J	100 J	93	60 - 310	µg/kg dw
1,3-Dichlorobenzene	6/288	2	1 J	12	20	0.78 - 400	µg/kg dw
1,4-Dichlorobenzene	56/292	19	2.1 J	750 J	9	0.86 - 400	µg/kg dw
2,4,5-Trichlorophenol	0/247	0	nd	nd	120	95.00 - 2,000	µg/kg dw
2,4,6-Trichlorophenol	0/247	0	nd	nd	120	95.00 - 2,000	µg/kg dw
2,4-Dichlorophenol	0/247	0	nd	nd	100	30 - 1,200	µg/kg dw
2,4-Dimethylphenol	21/281	7	3.7 J	46	10	5.8 - 790	µg/kg dw
2,4-Dinitrophenol	1/247	<1	300	300	200	60 - 4,000	µg/kg dw
2,4-Dinitrotoluene	0/247	0	nd	nd	110	12 - 2,000	µg/kg dw
2,6-Dinitrotoluene	0/247	0	nd	nd	110	12 - 2,000	µg/kg dw
2-Chlorophenol	0/247	0	nd	nd	20	19 - 400	µg/kg dw
2-Methylphenol	29/281	10	3.0 J	160	9	4.5 - 400	µg/kg dw

Table E.6.2-3, cont. Summary statistics for subsurface sediment data in all depth intervals

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
2-Nitroaniline	0/247	0	nd	nd	110	95.00 - 2,000	µg/kg dw
2-Nitrophenol	0/247	0	nd	nd	110	30 - 2,000	µg/kg dw
3,3'-Dichlorobenzidine	0/247	0	nd	nd	110	30 - 2,000	µg/kg dw
3-Nitroaniline	0/247	0	nd	nd	120	96 - 2,000	µg/kg dw
4,6-Dinitro-o-cresol	0/247	0	nd	nd	200	60 - 4,000	µg/kg dw
4-Bromophenyl phenyl ether	0/247	0	nd	nd	20	12 - 400	µg/kg dw
4-Chloro-3-methylphenol	0/247	0	nd	nd	97	38.00 - 790	µg/kg dw
4-Chloroaniline	2/256	1	47 J	230 J	100	57.00 - 1,200	µg/kg dw
4-Chlorophenyl phenyl ether	0/247	0	nd	nd	20	18 - 400	µg/kg dw
4-Methylphenol	15/304	5	8.6 J	110 J	30	3.8 - 400	µg/kg dw
4-Nitroaniline	0/247	0	nd	nd	110	95.00 - 2,000	µg/kg dw
4-Nitrophenol	0/247	0	nd	nd	110	60 - 2,000	µg/kg dw
Aniline	0/203	0	nd	nd	27	19 - 230	µg/kg dw
Benzaldehyde	10/23	43	110 J	320	200	130 - 290	µg/kg dw
Benzoic acid	122/304	40	35 J	3,000 J	200	58 - 4,000	µg/kg dw
Benzyl alcohol	32/281	11	7.7 J	210	30	4.9 - 2,000	µg/kg dw
bis(2-chloroethoxy)methane	0/247	0	nd	nd	20	19 - 400	µg/kg dw
bis(2-chloroethyl)ether	0/247	0	nd	nd	20	18 - 400	µg/kg dw
bis(2-chloroisopropyl)ether	0/247	0	nd	nd	20	19 - 400	µg/kg dw
Caprolactam	0/23	0	nd	nd	600	670 - 1,600	µg/kg dw
Carbazole	22/85	26	20	240 J	60	19.00 - 400	µg/kg dw
Coprostanol	0/9	0	nd	nd	77	120 - 220	µg/kg dw
Hexachlorobenzene	3/280	1	4.6 J	10	6	0.78 - 400	µg/kg dw
Hexachlorobutadiene	2/293	1	5.9 J	13	8	0.96 - 790	µg/kg dw
Hexachlorocyclopentadiene	0/265	0	nd	nd	150	34 - 2,000	µg/kg dw
Hexachloroethane	0/277	0	nd	nd	20	2.9 - 790	µg/kg dw
Isophorone	0/270	0	nd	nd	30	19.00 - 400	µg/kg dw

Table E.6.2-3, cont. Summary statistics for subsurface sediment data in all depth intervals

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Methyl isobutyl ketone	1/32	3	7.8	7.8	4.5	4.60 - 39	µg/kg dw
Nitrobenzene	0/247	0	nd	nd	20	19 - 400	µg/kg dw
N-Nitrosodimethylamine	0/194	0	nd	nd	21	29 - 220	µg/kg dw
N-Nitroso-di-n-propylamine	7/247	3	21 J	320	22	29 - 400	µg/kg dw
N-Nitrosodiphenylamine	1/281	<1	33	33	50	2.9 - 7,300	µg/kg dw
Pentachlorophenol	54/304	18	16 J	930 J	130	12 - 3,100	µg/kg dw
Phenol	57/304	19	12 J	3,100	50	4.4 - 790	µg/kg dw
Retene	18/23	78	120 J	300 J	200	300 - 370	µg/kg dw
Polychlorinated biphenyls							
PCB-018	18/31	58	1.0 J	270 J	11	1.0	µg/kg dw
PCB-028	20/31	65	1.0	220	11	1.0	µg/kg dw
PCB-044	22/31	71	1.0	52	6.8	1.0	µg/kg dw
PCB-055	23/31	74	1.0	150	13	1.0	µg/kg dw
PCB-066	23/31	74	2.0	140	20	1.0	µg/kg dw
PCB-077	3/34	9	1.42	3.28	0.92	1.0 - 9.0	µg/kg dw
PCB-081	3/34	9	0.970	1.10	0.56	1.0 - 2.0	µg/kg dw
PCB-101	22/31	71	1.0	130	16	1.0	µg/kg dw
PCB-105	23/34	68	1.0	43	7.0	1.0	µg/kg dw
PCB-114	5/34	15	0.628	5.0 J	0.87	1.0 - 4.0	µg/kg dw
PCB-118	26/34	76	1.0	110	18	1.0	µg/kg dw
PCB-123	3/34	9	0.421	0.710	0.96	1.0	µg/kg dw
PCB-126	6/34	18	0.0485	4.0	0.62	1.0	µg/kg dw
PCB-128	20/31	65	1.0	27	3.8	1.0	µg/kg dw
PCB-138	24/31	77	1.0	160	25	1.0	µg/kg dw
PCB-153	23/31	74	2.0	98	17	1.0	µg/kg dw
PCB-156	18/34	53	1.0	16	2.7	1.0	µg/kg dw
PCB-157	8/34	24	0.803	3.0	0.85	1.0	µg/kg dw

Table E.6.2-3, cont. Summary statistics for subsurface sediment data in all depth intervals

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-167	12/34	35	1.0 J	8.0	1.4	1.0	µg/kg dw
PCB-169	1/34	3	0.0545 J	0.0545 J	0.46	0.0599 - 1.0	µg/kg dw
PCB-170	21/34	62	2.0	29	6.7	1.0 - 7.0	µg/kg dw
PCB-180	26/34	76	1.0	53	12	1.0	µg/kg dw
PCB-187	22/31	71	1.0	28	5.9	1.0	µg/kg dw
PCB-189	4/34	12	0.416	1.0	0.51	1.0	µg/kg dw
PCB-195	11/31	35	1.0	6.0	1.2	1.0	µg/kg dw
PCB-206	11/31	35	1.0	3.0	1.0	1.0	µg/kg dw
PCB-209	2/31	6	1.0	1.0	0.53	1.0	µg/kg dw
Aroclor-1016	0/799	0	nd	nd	60	0.10 - 24,000	µg/kg dw
Aroclor-1221	0/763	0	nd	nd	60	0.10 - 27,000	µg/kg dw
Aroclor-1232	0/763	0	nd	nd	50	0.10 - 14,000	µg/kg dw
Aroclor-1242	90/803	11	5.2	2,500	90	0.10 - 24,000	µg/kg dw
Aroclor-1248	234/821	29	4.4 J	13,000	200	0.10 - 24,000	µg/kg dw
Aroclor-1254	518/804	64	0.52 J	81,000	800	0.10 - 130,000	µg/kg dw
Aroclor-1254/1260	16/17	94	34	1,700	190	85	µg/kg dw
Aroclor-1260	509/804	63	5.6	890,000	2,000	0.10 - 15,000	µg/kg dw
Aroclor-1262	6/28	21	120 J	13,000	870	6.5 - 23	µg/kg dw
Aroclor-1268	0/22	0	nd	nd	5.3	6.5 - 23	µg/kg dw
PCBs (total calc'd)	609/821	74	0.52 J	890,000	3,000	nc	µg/kg dw
PCB TEQ - Bird	3/3	100	0.181 J	0.288	0.234	na	µg/kg dw
PCB TEQ - Fish	3/3	100	0.001200 J	0.001900	0.00156	na	µg/kg dw
PCB TEQ - Mammal	3/3	100	0.00875 J	0.01430	0.0117	na	µg/kg dw
Organochlorine pesticides							
2,4'-DDD	0/40	0	nd	nd	3.8	1.9 - 29	µg/kg dw
2,4'-DDE	0/40	0	nd	nd	8.7	1.9 - 100	µg/kg dw
2,4'-DDT	0/40	0	nd	nd	3.8	1.9 - 29	µg/kg dw

Table E.6.2-3, cont. Summary statistics for subsurface sediment data in all depth intervals

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
4,4'-DDD	13/95	14	0.27 J	10	3.1	1.5 - 39	µg/kg dw
4,4'-DDE	14/95	15	0.45 J	18 J	5.2	0.62 - 90	µg/kg dw
4,4'-DDT	5/95	5	0.64 J	2.8	10	0.96 - 160	µg/kg dw
DDTs (total-calc'd)	16/95	17	0.27 J	20 J	12	nc	µg/kg dw
Aldrin	1/95	1	1.5 J	1.5 J	1.2	0.33 - 16.00	µg/kg dw
Dieldrin	3/95	3	0.80 J	1.8	3.7	0.14 - 95.00	µg/kg dw
Total aldrin/dieldrin (calc'd)	4/95	4	0.80 J	1.8	3.7	nc	µg/kg dw
alpha-BHC	3/71	4	0.20 J	0.47 J	1.3	0.086 - 14	µg/kg dw
beta-BHC	0/66	0	nd	nd	1.5	0.96 - 24	µg/kg dw
gamma-BHC	0/95	0	nd	nd	1.1	0.099 - 14	µg/kg dw
delta-BHC	7/48	15	7.0	1,100	27	0.96 - 14	µg/kg dw
alpha-Chlordane	1/89	1	0.44 J	0.44 J	1.2	0.052 - 14	µg/kg dw
gamma-Chlordane	4/87	5	0.22 J	0.71 J	4.4	0.92 - 82	µg/kg dw
Chlordane	1/6	17	29.0	29.0	13	7.5 - 35	µg/kg dw
Total chlordane (calc'd)	4/89	4	0.22 J	1.59 J	4.8	nc	µg/kg dw
alpha-Endosulfan	0/62	0	nd	nd	1.4	0.96 - 14	µg/kg dw
beta-Endosulfan	0/62	0	nd	nd	3.1	1.90 - 29	µg/kg dw
Endosulfan	0/4	0	nd	nd	0.79	1.5 - 1.6	µg/kg dw
Endosulfan sulfate	0/62	0	nd	nd	4.3	1.90 - 69	µg/kg dw
Endrin	0/66	0	nd	nd	7.3	1.5 - 150	µg/kg dw
Endrin aldehyde	1/66	2	10	10	3.6	1.5 - 29	µg/kg dw
Endrin ketone	0/62	0	nd	nd	3.1	1.90 - 29	µg/kg dw
Heptachlor	2/95	2	0.25 J	1.3	1.2	0.097 - 14	µg/kg dw
Heptachlor epoxide	0/66	0	nd	nd	5.4	0.96 - 120	µg/kg dw
Methoxychlor	0/66	0	nd	nd	12	1.0 - 140	µg/kg dw
Mirex	0/40	0	nd	nd	3.8	1.9 - 29	µg/kg dw
Toxaphene	0/66	0	nd	nd	120	10 - 1,400	µg/kg dw

Table E.6.2-3, cont. Summary statistics for subsurface sediment data in all depth intervals

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Trans-Nonachlor	1/45	2	0.44 J	0.44 J	3.4	0.53 - 29	µg/kg dw
Grain size							
Fractional % (>9525 µm)	0/31	0	nd	nd	0.0050	0.010	% dw
Fractional % phi >-1 (>2000 µm)	217/245	89	0.1	44.4	3	0.100	% dw
Fractional % phi -2-(-1) (2,000-4,000 µm)	24/31	77	0.010	3.8 J	0.40	0.010	% dw
Fractional % phi -1-0 (1,000-2,000 µm)	344/362	95	0.010 J	22.5	2	0.010 - 0.1	% dw
Fractional % phi 0-1 (500-1,000 µm)	352/354	99	0.1	41.4	6	0.010	% dw
Fractional % phi 1-2 (250-500 µm)	353/354	100	0.36 J	68.7	10	0.1 - 0.1	% dw
Fractional % phi 2-3 (125-250 µm)	354/354	100	0.5	47.9	10	na	% dw
Fractional % phi 3-4 (62.5-125 µm)	362/362	100	0.10 J	42.8	10	na	% dw
Fractional % phi 4-5 (31.2-62.5 µm)	354/355	100	0.100 J	29	10	0.010	% dw
Fractional % phi 5-6 (15.6-31.2 µm)	344/345	100	0.1	46.4 J	10	0.010	% dw
Fractional % phi 6-7 (7.8-15.6 µm)	344/346	99	0.1	37.7	10	0.010	% dw
Fractional % phi 7-8 (3.9-7.8 µm)	341/344	99	0.10	18.2 J	6	0.010	% dw
Fractional % phi 8-9 (1.95-3.9 µm)	339/345	98	0.010	12.0 J	4	0.010 - 0.1	% dw
Fractional % phi 9+ (<1.95 µm)	1/1	100	0.100 J	0.100 J	0.100	na	% dw
Fractional % phi 9-10 (0.98-1.95 µm)	333/345	97	0.010	9.0	3	0.010 - 0.1	% dw
Fractional % phi 10+ (<0.98 µm)	333/344	97	0.300	20.2	6	0.010 - 0.100	% dw
Fractional % Sieve #10 (2,000-4,750 µm)	23/45	51	1.0	13	1.4	0.010	% dw
Fractional % Sieve 3/8 in. (4,750-9,525 µm)	6/31	19	0.19 J	12 J	0.70	0.010	% dw
Fractional % Sieve #4 (>4,750 µm)	16/43	37	1.0	56	3.4	0.010	% dw
Gravel (total calc'd)	267/322	83	0.010	69	3	nc	% dw
Sand (total calc'd)	378/378	100	2.20	100	42	na	% dw
Silt (total calc'd)	373/374	100	0.400 J	84.7	40	nc	% dw
Clay (total calc'd)	363/365	99	0.1	39.9	10	nc	% dw
Gravel	23/24	96	0.100 J	27.0	3	0.010 - 0.010	% dw
Coarse sand (4750-2000 microns)	11/11	100	0.500	31.7	4.02	na	% dw

Table E.6.2-3, cont. Summary statistics for subsurface sediment data in all depth intervals

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Medium sand (2000-425 microns)	11/11	100	0.900	60.0	11.2	na	% dw
Fine sand (425-75 microns)	11/11	100	3.40	65.1	22.1	na	% dw
Fines (percent silt+clay)	355/355	100	1.0	97.2	56	na	% dw
Conventional parameters							
Total organic carbon (TOC)	825/825	100	0.011	17	1	na	% dw
Total solids	701/701	100	26.0	92.60	67	na	% ww
Total solids (preserved)	1/1	100	38.63	38.63	38.63	na	% ww
Total volatile solids	31/31	100	0.77	8.6	6.3	na	% dw
Sulfides (total)	30/32	94	74 J	4,600	1,300	1.1 - 1.3	mg/kg dw
Ammonia (total as nitrogen)	28/28	100	13	200	89	na	mg-N/kg dw
Cyanide	1/5	20	0.35	0.35	13	0.14 - 63	mg/kg dw
Moisture	108/108	100	19.85	161.7	67	na	% dw
Moisture	13/13	100	25.7	81.6	45	na	% ww
pH	5/5	100	6.8	9.2	7.9	na	pH
Salinity	8/8	100	24.6	26.2	25.4	na	ppt
Specific gravity	111/111	100	2.06	2.8	2.6	na	g/cc
Conductivity	8/8	100	38,900	41,400	40,000	na	µmhos/cm
Volatile organic compounds							
1,1,1,2-Tetrachloroethane	0/24	0	nd	nd	0.88	0.90 - 9.6	µg/kg dw
1,1,1-Trichloroethane	0/32	0	nd	nd	0.90	0.90 - 9.6	µg/kg dw
1,1,2,2-Tetrachloroethane	0/32	0	nd	nd	0.90	0.90 - 9.6	µg/kg dw
1,1,2-Trichloroethane	0/32	0	nd	nd	0.90	0.90 - 9.6	µg/kg dw
1,1,2-Trichlorotrifluoroethane	0/31	0	nd	nd	1.5	1.80 - 11	µg/kg dw
1,1-Dichloroethane	0/32	0	nd	nd	0.90	0.90 - 9.6	µg/kg dw
1,1-Dichloroethene	2/32	6	120	320	15	0.90 - 9.6	µg/kg dw
1,1-Dichloropropene	0/24	0	nd	nd	0.88	0.90 - 9.6	µg/kg dw
1,2,3-Trichlorobenzene	0/24	0	nd	nd	4.2	4.60 - 39	µg/kg dw

Table E.6.2-3, cont. Summary statistics for subsurface sediment data in all depth intervals

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,2,3-Trichloropropane	0/24	0	nd	nd	1.5	1.80 - 9.6	µg/kg dw
1,2,4-Trimethylbenzene	3/24	13	14 J	580 J	44	0.90 - 39	µg/kg dw
1,2-Dibromo-3-chloropropane	0/24	0	nd	nd	4.2	4.60 - 39	µg/kg dw
1,2-Dibromoethane (EDB)	0/24	0	nd	nd	1.5	0.90 - 39	µg/kg dw
1,2-Dichloroethane	0/32	0	nd	nd	0.90	0.90 - 9.6	µg/kg dw
1,2-Dichloropropane	0/32	0	nd	nd	0.90	0.90 - 9.6	µg/kg dw
1,3,5-Trimethylbenzene	4/24	17	1.9	350 J	24	0.90 - 39	µg/kg dw
1,3-Dichloropropane	0/24	0	nd	nd	0.88	0.90 - 9.6	µg/kg dw
2,2-Dichloropropane	0/24	0	nd	nd	0.88	0.90 - 9.6	µg/kg dw
2-Chloroethyl vinyl ether	0/31	0	nd	nd	3.9	4.60 - 28	µg/kg dw
2-Chlorotoluene	0/24	0	nd	nd	1.5	0.90 - 39	µg/kg dw
2-Hexanone	0/32	0	nd	nd	4.3	4.60 - 39	µg/kg dw
4-Chlorotoluene	0/24	0	nd	nd	1.5	0.90 - 39	µg/kg dw
Acetone	26/32	81	8.20	640	110	6.6 - 37	µg/kg dw
Acrolein	0/23	0	nd	nd	35	46.00 - 99	µg/kg dw
Acrylonitrile	0/23	0	nd	nd	3.5	4.60 - 9.9	µg/kg dw
Benzene	5/32	16	4.4	62	5.7	0.90 - 9.6	µg/kg dw
Bromobenzene	0/24	0	nd	nd	0.88	0.90 - 9.6	µg/kg dw
Bromochloromethane	0/24	0	nd	nd	0.88	0.90 - 9.6	µg/kg dw
Bromodichloromethane	0/32	0	nd	nd	0.90	0.90 - 9.6	µg/kg dw
Bromoethane	0/23	0	nd	nd	1.4	1.80 - 4.0	µg/kg dw
Bromoform	0/32	0	nd	nd	0.90	0.90 - 9.6	µg/kg dw
Bromomethane	0/32	0	nd	nd	1.1	0.90 - 11	µg/kg dw
Carbon disulfide	16/32	50	1.30	18	2.8	0.90 - 9.6	µg/kg dw
Carbon tetrachloride	0/32	0	nd	nd	0.90	0.90 - 9.6	µg/kg dw
Chlorobenzene	0/32	0	nd	nd	0.90	0.90 - 9.6	µg/kg dw
Chloroethane	0/32	0	nd	nd	1.1	0.90 - 11	µg/kg dw

Table E.6.2-3, cont. Summary statistics for subsurface sediment data in all depth intervals

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Chloroform	1/32	3	1.8	1.8	0.93	0.90 - 9.6	µg/kg dw
Chloromethane	0/32	0	nd	nd	1.1	0.90 - 11	µg/kg dw
cis-1,2-Dichloroethene	7/32	22	2.2	200,000	11,000	0.90 - 9.6	µg/kg dw
cis-1,3-Dichloropropene	0/32	0	nd	nd	0.90	0.90 - 9.6	µg/kg dw
p-Cymene	5/24	21	4.1 J	130 J	12	0.90 - 39	µg/kg dw
Dibromochloromethane	0/32	0	nd	nd	0.90	0.90 - 9.6	µg/kg dw
Dibromomethane	0/24	0	nd	nd	0.88	0.90 - 9.6	µg/kg dw
Dichlorodifluoromethane	0/1	0	nd	nd	4.8	9.6	µg/kg dw
Dichloromethane	10/32	31	1.5 J	5.90	2.3	1.90 - 11	µg/kg dw
Ethylbenzene	3/58	5	27	360 J	12	0.75 - 9.6	µg/kg dw
Iodomethane	0/23	0	nd	nd	0.71	0.90 - 2.0	µg/kg dw
Isopropylbenzene	3/24	13	3.9 J	87 J	8.2	0.90 - 39	µg/kg dw
Methyl ethyl ketone	14/32	44	9.60	100	17	4.60 - 28	µg/kg dw
n-Butylbenzene	2/24	8	58	78 J	7.1	0.90 - 39	µg/kg dw
n-Propylbenzene	3/24	13	1.8 J	100 J	8.5	0.90 - 39	µg/kg dw
sec-Butylbenzene	2/24	8	57	57	6.2	0.90 - 39	µg/kg dw
Styrene	0/32	0	nd	nd	0.90	0.90 - 9.6	µg/kg dw
tert-Butylbenzene	1/24	4	6.1	6.1	1.8	0.90 - 39	µg/kg dw
Tetrachloroethene	0/58	0	nd	nd	0.76	0.41 - 9.6	µg/kg dw
Toluene	7/32	22	1.8	8,300	410	0.90 - 9.6	µg/kg dw
trans-1,2-Dichloroethene	3/32	9	22	1,700 J	85	0.90 - 9.6	µg/kg dw
trans-1,3-Dichloropropene	0/32	0	nd	nd	0.90	0.90 - 9.6	µg/kg dw
trans-1,4-Dichloro-2-butene	0/23	0	nd	nd	3.5	4.60 - 9.9	µg/kg dw
Trichloroethene	4/58	7	3.6 J	23	1.5	0.37 - 9.6	µg/kg dw
Trichlorofluoromethane	0/32	0	nd	nd	1.1	0.90 - 11	µg/kg dw
Vinyl acetate	0/31	0	nd	nd	3.9	4.60 - 28	µg/kg dw
Vinyl chloride	5/32	16	29	60,000	3,400	0.90 - 11	µg/kg dw

Table E.6.2-3, cont. Summary statistics for subsurface sediment data in all depth intervals

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Xylene (ortho)	3/52	6	31	610 J	22	0.90 - 9.6	µg/kg dw
Xylene (meta & para)	3/41	7	74 J	4,700	150	1.1 - 9.6	µg/kg dw
Total Xylenes	3/94	3	105 J	5,300 J	76	0.90 - 11	µg/kg dw
Dioxins/furans							
2,3,7,8-TCDD	22/26	85	0.302	3.36	0.653	0.0440 - 0.454	ng/kg dw
1,2,3,7,8-PeCDD	24/26	92	0.0640 J	10.5	2.07	0.0440 - 0.0471	ng/kg dw
1,2,3,4,7,8-HxCDD	23/26	88	0.171 J	11.2	3.04	0.0440 - 0.106	ng/kg dw
1,2,3,6,7,8-HxCDD	25/26	96	0.103 J	184	28.3	0.0471	ng/kg dw
1,2,3,7,8,9-HxCDD	24/26	92	0.331 J	52.3	11.0	0.0471 - 0.0660	ng/kg dw
1,2,3,4,6,7,8-HpCDD	25/26	96	2.56	5,930	831	0.307	ng/kg dw
OCDD	26/26	100	2.92	62,000	7,400	na	ng/kg dw
2,3,7,8-TCDF	18/26	69	0.0740 J	6.09	1.38	0.0440 - 2.30	ng/kg dw
1,2,3,7,8-PeCDF	23/26	88	0.0930 J	18.1	2.08	0.0440 - 0.0471	ng/kg dw
2,3,4,7,8-PeCDF	25/26	96	0.0670 J	61.8	6.23	0.0471	ng/kg dw
1,2,3,4,7,8-HxCDF	25/26	96	0.176 J	467	36.0	0.0471	ng/kg dw
1,2,3,6,7,8-HxCDF	24/26	92	0.135 J	76.0	7.37	0.0440 - 0.0471	ng/kg dw
1,2,3,7,8,9-HxCDF	16/26	62	0.128 J	8.02	0.684	0.0440 - 3.02	ng/kg dw
2,3,4,6,7,8-HxCDF	24/26	92	0.146 J	28.2	3.86	0.0440 - 0.0471	ng/kg dw
1,2,3,4,6,7,8-HpCDF	25/26	96	0.743 J	2,490	226	0.0471	ng/kg dw
1,2,3,4,7,8,9-HpCDF	24/26	92	0.127 J	299	23.2	0.0471 - 0.0930	ng/kg dw
OCDF	26/26	100	0.0875 J	13,500	1,020	na	ng/kg dw
Dioxin/furan TEQ - Bird	26/26	100	0.1780 J	172.0 J	21.0	na	ng/kg dw
Dioxin/furan TEQ - Fish	26/26	100	0.1290 J	138.0 J	16.9	na	ng/kg dw
Dioxin/furan TEQ - Mammal	26/26	100	0.1470 J	194.0 J	27.2	na	ng/kg dw
Petroleum groups							
Gasoline	0/3	0	nd	nd	12	24 - 25	mg/kg dw
TPH - Gasoline range	0/2	0	nd	nd	10	20	mg/kg dw

Table E.6.2-3, cont. Summary statistics for subsurface sediment data in all depth intervals

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
TPH - Diesel range	6/13	46	19.00	130.0	35	5.00 - 25	mg/kg dw
TPH - Diesel #2 range	0/3	0	nd	nd	31	60 - 63	mg/kg dw
TPH-Non-petroleum hydrocarbon as diesel	0/2	0	nd	nd	50	100	mg/kg dw
TPH-Petroleum hydrocarbon as diesel	1/2	50	110	110	80	100	mg/kg dw
TPH - Lube oil range	0/2	0	nd	nd	50	100	mg/kg dw
TPH - Motor oil range	6/11	55	22.00	230.0	63.5	10.0	mg/kg dw
TPH - Heavy fuel oil range	0/5	0	nd	nd	57	100 - 130	mg/kg dw
TPH - Jet fuel as Jet A	0/2	0	nd	nd	13	25	mg/kg dw
TPH - Jet fuel as JP-4	0/2	0	nd	nd	10	20	mg/kg dw
TPH - Kerosene range	0/2	0	nd	nd	13	25	mg/kg dw
TPH - Mineral spirits range	0/2	0	nd	nd	13	25	mg/kg dw
TPH	13/15	87	26	4,300	680	20	mg/kg dw
Geotechnical							
Liquid limit	76/76	100	0.100	165	62.0	na	% dw
Plastic limit	76/76	100	0.100	73.2	35.7	na	% dw
Plasticity index	76/76	100	0.10	119	26	na	% dw
Bulk density (dry)	108/108	100	31.4	112.5	65	na	pcf
Bulk density (wet)	108/108	100	75.0	134.8	100	na	pcf
Porosity	108/108	100	0.34	0.81	0.61	na	S.U.

Table E.6.2-4. Summary subsurface sediment statistics and comparisons to SMS criteria for chemicals with OC-normalized criteria

Chemical[a]	Detection Frequency[b]		Concentration					SMS Criteria			Comparison to SMS Criteria (Number of Samples)			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	Range of RLs	Unit	SQS	CSL	Unit	Detect > SQS and ≤ CSL	Detect > CSL	Nondetect > SQS and ≤ CSL	Nondetect > CSL
PAHs														
2-Methylnaphthalene	41/243	17	0.13 J	19	2	0.21 - 12	mg/kg OC	38	64	mg/kg OC	0	0	0	0
Acenaphthene	89/261	34	0.11 J	120	4	0.378 - 28	mg/kg OC	16	57	mg/kg OC	9	1	3	0
Acenaphthylene	50/243	21	0.52 J	6.0	1	0.080 - 12	mg/kg OC	66	66	mg/kg OC	0	0	0	0
Anthracene	193/261	74	0.30 J	75	6	0.380 - 28	mg/kg OC	220	1,200	mg/kg OC	0	0	0	0
Benzo(a)anthracene	233/261	89	0.62 J	200	10	0.380 - 26	mg/kg OC	110	270	mg/kg OC	4	0	0	0
Benzo(a)pyrene	228/261	87	0.85 J	200	10	0.380 - 57	mg/kg OC	99	210	mg/kg OC	4	0	0	0
Benzo(g,h,i)perylene	200/256	78	0.641 J	53	6	0.380 - 57	mg/kg OC	31	78	mg/kg OC	5	0	2	0
Benzofluoranthenes (total-calc'd)	236/261	90	1.2 J	410	40	nc	mg/kg OC	230	450	mg/kg OC	4	0	0	0
Chrysene	237/261	91	0.62 J	340	20	0.380 - 26	mg/kg OC	110	460	mg/kg OC	5	0	0	0
Dibenzo(a,h)anthracene	116/261	44	0.23 J	38 J	3	0.378 - 9.5	mg/kg OC	12	33	mg/kg OC	20	1	0	0
Dibenzofuran	56/261	21	0.13 J	100	3	0.23 - 28	mg/kg OC	15	58	mg/kg OC	6	1	4	0
Fluoranthene	247/261	95	0.83 J	580	41	0.50 - 52	mg/kg OC	160	1,200	mg/kg OC	14	0	0	0
Fluorene	100/261	38	0.18 J	160	4	0.31 - 28	mg/kg OC	23	79	mg/kg OC	4	1	2	0
Indeno(1,2,3-cd)pyrene	203/256	79	0.513 J	58	7	0.380 - 12	mg/kg OC	34	88	mg/kg OC	5	0	0	0
Naphthalene	65/243	27	0.098 J	87	3	0.23 - 12	mg/kg OC	99	170	mg/kg OC	0	0	0	0
Phenanthrene	235/261	90	0.62 J	330	16	0.50 - 28	mg/kg OC	100	480	mg/kg OC	5	0	0	0
Pyrene	250/261	96	1.0 J	520	42	0.50 - 26	mg/kg OC	1,000	1,400	mg/kg OC	0	0	0	0
Total HPAH (calc'd)	251/261	96	1.9 J	2,100	180	nc	mg/kg OC	960	5,300	mg/kg OC	6	0	0	0
Total LPAH (calc'd)	235/261	90	0.62 J	650	29	nc	mg/kg OC	370	780	mg/kg OC	3	0	0	0
Phthalates														
Bis(2-ethylhexyl)phthalate	196/263	75	0.95 J	200	20	0.51 - 140	mg/kg OC	47	78	mg/kg OC	22	16	6	5
Butyl benzyl phthalate	143/245	58	0.33	26	2	0.20 - 18	mg/kg OC	4.9	64	mg/kg OC	14	0	5	0
Diethyl phthalate	1/263	<1	410	410	3	0.20 - 28	mg/kg OC	61	110	mg/kg OC	0	1	0	0
Dimethyl phthalate	20/245	8	0.14 J	340	3	0.11 - 14	mg/kg OC	53	53	mg/kg OC	0	1	0	0
Di-n-butyl phthalate	50/245	20	0.51 J	16	2	0.53 - 14	mg/kg OC	220	1,700	mg/kg OC	0	0	0	0
Di-n-octyl phthalate	13/263	5	0.99 J	140	4	0.071 - 140	mg/kg OC	58	4,500	mg/kg OC	1	0	5	0
Other SVOCs														
1,2,4-Trichlorobenzene	25/242	10	0.13 J	2.1	0.3	0.087 - 5.5	mg/kg OC	0.81	1.8	mg/kg OC	2	1	48	6
1,2-Dichlorobenzene	29/241	12	0.13 J	9.9	0.4	0.054 - 5.5	mg/kg OC	2.3	2.3	mg/kg OC	0	3	0	5
1,4-Dichlorobenzene	52/241	22	0.12 J	2.0	0.3	0.054 - 5.5	mg/kg OC	3.1	9	mg/kg OC	0	0	2	0

Table E.6.2-4, cont. Summary subsurface sediment statistics and comparisons to SMS criteria for chemicals with OC-normalized criteria

Chemical[a]	Detection Frequency[b]		Concentration					SMS Criteria			Comparison to SMS Criteria (Number of Samples)			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	Range of RLs	Unit	SQS	CSL	Unit	Detect > SQS and ≤ CSL	Detect > CSL	Nondetect > SQS and ≤ CSL	Nondetect > CSL
Hexachlorobenzene	3/242	1	0.23 J	0.70	0.3	0.032 - 5.5	mg/kg OC	0.38	2.3	mg/kg OC	1	0	122	5
Hexachlorobutadiene	1/243	<1	0.30 J	0.30 J	0.3	0.032 - 11	mg/kg OC	3.9	6.2	mg/kg OC	0	0	1	2
N-Nitrosodiphenylamine	0/243	0	nd	nd	2	0.13 - 80	mg/kg OC	11	11	mg/kg OC	0	0	0	13
Polychlorinated biphenyls														
PCBs (total calc'd)	553/645	86	0.092 J	29,000	100	nc	mg/kg OC	12	65	mg/kg OC	192	162	2	0

[a] Data for chemicals with dry weight SMS criteria are presented in Table E.6.2-1.

[b] Subsurface sediment sample samples were not included if the TOC content was < 0.5% or > 4.0%.

Table E.6.2-5. Summary subsurface sediment statistics and comparisons to SMS criteria expressed in dry weight units

Chemical	Detection Frequency		Concentration					Criteria			Comparison to Criteria (Number of Samples)			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	SQS/LAET	CSL/2LAET	Criteria Unit	Detect > SQS/LAET and ≤ CSL/2LAET	Detect > CSL/2LAET	Nondetect > SQS/LAET and ≤ CSL/2LAET	Nondetect > CSL/2LAET
Metals and trace elements														
Arsenic	267/325	82	3.9	2,000	40	3.0 - 10.0	mg/kg dw	57	93	mg/kg dw	6	19	0	0
Cadmium	257/388	66	0.0880	20.4	1	0.18 - 0.9	mg/kg dw	5.1	6.7	mg/kg dw	1	8	0	0
Chromium	397/397	100	6.67	386	40	na	mg/kg dw	260	270	mg/kg dw	0	2	0	0
Copper	397/397	100	7.1	2,940	80	na	mg/kg dw	390	390	mg/kg dw	0	10	0	0
Lead	361/394	92	2.8	3,520 J	80	2 - 3.6	mg/kg dw	450	530	mg/kg dw	3	10	0	0
Mercury	341/436	78	0.020	10	0.2	0.020 - 0.100	mg/kg dw	0.41	0.59	mg/kg dw	22	31	0	0
Silver	166/372	45	0.050	7.5	0.7	0.30 - 1	mg/kg dw	6.1	6.1	mg/kg dw	0	2	0	0
Zinc	396/396	100	16.2 J	4,720	200	na	mg/kg dw	410	960	mg/kg dw	15	15	0	0
PAHs														
2-Methylnaphthalene	43/281	15	2.9 J	4,500	40	1.6 - 400	µg/kg dw	670	1,400	µg/kg dw	0	1	0	0
Acenaphthene	94/304	31	1.3 J	4,600	80	4.30 - 400	µg/kg dw	500	730	µg/kg dw	9	2	3	0
Acenaphthylene	53/281	19	10 J	280	20	1.9 - 400	µg/kg dw	1,300	1,300	µg/kg dw	0	0	0	0
Anthracene	200/304	66	4.3 J	1,900	100	4.30 - 400	µg/kg dw	960	4,400	µg/kg dw	1	0	0	0
Benzo(a)anthracene	243/304	80	12 J	4,500	300	4.30 - 180	µg/kg dw	1,300	1,600	µg/kg dw	5	1	0	0
Benzo(a)pyrene	237/304	78	11 J	5,300	300	4.30 - 400	µg/kg dw	1,600	3,000	µg/kg dw	4	1	0	0
Benzo(g,h,i)perylene	207/298	69	11 J	1,000	100	4.30 - 400	µg/kg dw	670	720	µg/kg dw	5	0	2	0
Benzofluoranthenes (total-calc'd)	248/304	82	21 J	10,200	700	nc	µg/kg dw	3,200	3,600	µg/kg dw	4	1	0	0
Chrysene	247/304	81	12 J	7,200	400	4.30 - 180	µg/kg dw	1,400	2,800	µg/kg dw	6	1	0	0
Dibenzo(a,h)anthracene	119/304	39	3.2 J	660 J	60	4.30 - 910	µg/kg dw	230	540	µg/kg dw	20	1	1	5
Dibenzofuran	58/304	19	2.9 J	1,700	50	1.7 - 400	µg/kg dw	540	700	µg/kg dw	6	2	4	0
Fluoranthene	262/304	86	12 J	13,000	800	4.30 - 340	µg/kg dw	1,700	2,500	µg/kg dw	14	2	0	0
Fluorene	104/304	34	4.9 J	4,300	80	2.3 - 400	µg/kg dw	540	1,000	µg/kg dw	4	2	2	0
Indeno(1,2,3-cd)pyrene	212/298	71	10 J	1,500	100	4.30 - 400	µg/kg dw	600	690	µg/kg dw	7	0	0	0
Naphthalene	70/293	24	1.9 J	3,400	50	1.7 - 400	µg/kg dw	2,100	2,400	µg/kg dw	0	1	0	0
Phenanthrene	244/304	80	10 J	13,000	300	4.30 - 400	µg/kg dw	1,500	5,400	µg/kg dw	5	1	0	0
Pyrene	266/304	88	9.9 J	10,000	800	4.30 - 170	µg/kg dw	2,600	3,300	µg/kg dw	0	2	0	0
Total HPAH (calc'd)	268/304	88	9.9 J	47,000	3,000	nc	µg/kg dw	12,000	17,000	µg/kg dw	6	2	0	0
Total LPAH (calc'd)	244/304	80	12.00	27,000 J	600	nc	µg/kg dw	5,200	13,000	µg/kg dw	3	1	0	0

Table E.6.2-5, cont. Summary subsurface sedment statistics and comparisons to SMS criteria for chemicals with dry weight criteria

Chemical	Detection Frequency		Concentration					Criteria			Comparison to Criteria (Number of Samples)			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	SQS/LAET	CSL/2LAET	Criteria Unit	Detect > SQS/LAET and ≤ CSL/2LAET	Detect > CSL/2LAET	Nondetect > SQS/LAET and ≤ CSL/2LAET	Nondetect > CSL/2LAET
Phthalates														
Bis(2-ethylhexyl)phthalate	216/306	71	12 J	5,100	500	19 - 2,400	µg/kg dw	1,300	1,900	µg/kg dw	25	17	6	5
Butyl benzyl phthalate	147/283	52	5.6 J	610	30	5.8 - 400	µg/kg dw	63	900	µg/kg dw	16	0	7	0
Diethyl phthalate	1/306	<1	2,700	2,700	40	4.6 - 400	µg/kg dw	200	1,200	µg/kg dw	0	1	1	0
Dimethyl phthalate	20/283	7	4.2 J	8,800	60	2.4 - 400	µg/kg dw	71	160	µg/kg dw	0	1	2	2
Di-n-butyl phthalate	60/283	21	6.5 J	280	30	10 - 400	µg/kg dw	1,400	5,100	µg/kg dw	0	0	0	0
Di-n-octyl phthalate	14/306	5	14 J	2,000	70	1.6 - 1,600	µg/kg dw	6,200	nv	µg/kg dw	1	na	5	na
Other SVOCs														
1,2,4-Trichlorobenzene	27/293	9	3.6 J	110 J	7	0.87 - 400	µg/kg dw	31	51	µg/kg dw	2	2	48	8
1,2-Dichlorobenzene	31/292	11	0.98 J	160	7	0.78 - 400	µg/kg dw	35	50	µg/kg dw	0	3	1	7
1,4-Dichlorobenzene	56/292	19	2.1 J	750 J	9	0.86 - 400	µg/kg dw	110	120	µg/kg dw	0	1	2	2
2,4-Dimethylphenol	21/281	7	3.7 J	46	10	5.8 - 790	µg/kg dw	29	29	µg/kg dw	0	1	0	16
2-Methylphenol	29/281	10	3.0 J	160	9	4.5 - 400	µg/kg dw	63	63	µg/kg dw	0	1	0	4
4-Methylphenol	15/304	5	8.6 J	110 J	30	3.8 - 400	µg/kg dw	670	670	µg/kg dw	0	0	0	0
Benzoic acid	122/304	40	35 J	3,000 J	200	58 - 4,000	µg/kg dw	650	650	µg/kg dw	0	13	0	16
Benzyl alcohol	32/281	11	7.7 J	210	30	4.9 - 2,000	µg/kg dw	57	73	µg/kg dw	2	5	14	11
Hexachlorobenzene	3/280	1	4.6 J	10	6	0.78 - 400	µg/kg dw	22	70	µg/kg dw	1	0	123	7
Hexachlorobutadiene	2/293	1	5.9 J	13	8	0.96 - 790	µg/kg dw	11	120	µg/kg dw	1	0	8	4
Hexachloroethane	0/277	0	nd	nd	20	2.9 - 790	µg/kg dw	1,400	14,000	µg/kg dw	0	0	0	0
N-Nitrosodiphenylamine	1/281	<1	33	33	50	2.9 - 7,300	µg/kg dw	28	40	µg/kg dw	1	0	5	19
Pentachlorophenol	54/304	18	16 J	930 J	130	12 - 3,100	µg/kg dw	360	690	µg/kg dw	1	4	2	23
Phenol	57/304	19	12 J	3,100	50	4.4 - 790	µg/kg dw	420	1,200	µg/kg dw	1	1	1	0
Polychlorinated biphenyls														
PCBs (total calc'd)	609/821	74	0.52 J	890,000	3,000	nc	µg/kg dw	130	1,000	µg/kg dw	211	174	3	0

E.6.3 TISSUE

Table E.6.3-1. Summary statistics for amphipod, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	3/4	75	0.024	0.069	0.033	0.023	mg/kg ww
Arsenic	4/4	100	0.96	1.5	1.2	na	mg/kg ww
Cadmium	4/4	100	0.017	0.15	0.058	na	mg/kg ww
Chromium	4/4	100	0.45 J	0.56 J	0.52	na	mg/kg ww
Copper	4/4	100	9.8	30	19	na	mg/kg ww
Lead	4/4	100	0.95	7.4	3.7	na	mg/kg ww
Mercury	4/4	100	0.0067	0.017	0.011	na	mg/kg ww
Nickel	4/4	100	0.48	0.77 J	0.60	na	mg/kg ww
Silver	4/4	100	0.060 J	0.099	0.080	na	mg/kg ww
Thallium	0/2	0	nd	nd	0.011	0.020 – 0.023	mg/kg ww
Zinc	4/4	100	7.9	26	14	na	mg/kg ww
Organometals							
Monobutyltin as ion	2/2	100	2.8 J	10 J	6.4	na	µg/kg ww
Dibutyltin as ion	2/2	100	2.1 J	2.8 J	2.5	na	µg/kg ww
Tributyltin as ion	4/4	100	18	36	29	na	µg/kg ww
Tetrabutyltin as ion	0/2	0	nd	nd	0.20	0.40	µg/kg ww
PAHs							
2-Chloronaphthalene	0/4	0	nd	nd	12	24	µg/kg ww
2-Methylnaphthalene	0/4	0	nd	nd	32	64	µg/kg ww
Acenaphthene	0/4	0	nd	nd	8.0	16	µg/kg ww
Acenaphthylene	0/4	0	nd	nd	12	24	µg/kg ww
Anthracene	0/4	0	nd	nd	12	24	µg/kg ww
Benzo(a)anthracene	0/4	0	nd	nd	12	24	µg/kg ww
Benzo(a)pyrene	0/4	0	nd	nd	20	40	µg/kg ww
Benzo(b)fluoranthene	0/4	0	nd	nd	32	64	µg/kg ww
Benzo(g,h,i)perylene	0/4	0	nd	nd	20	40	µg/kg ww
Benzo(k)fluoranthene	0/4	0	nd	nd	32	64	µg/kg ww
Total benzofluoranthenes	0/4	0	nd	nd	32	nc	µg/kg ww

Table E.6.3-1, cont. Summary statistics for amphipod, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Chrysene	0/4	0	nd	nd	12	24	µg/kg ww
Dibenzo(a,h)anthracene	0/4	0	nd	nd	32	64	µg/kg ww
Dibenzofuran	0/4	0	nd	nd	20	40	µg/kg ww
Fluoranthene	1/4	25	84	84	30	24	µg/kg ww
Fluorene	0/4	0	nd	nd	12	24	µg/kg ww
Indeno(1,2,3-cd)pyrene	0/4	0	nd	nd	20	40	µg/kg ww
Naphthalene	0/4	0	nd	nd	32	64	µg/kg ww
Phenanthrene	0/4	0	nd	nd	12	24	µg/kg ww
Pyrene	1/4	25	160	160	49	24	µg/kg ww
Total HPAH	1/4	25	240	240	84	nc	µg/kg ww
Total LPAH	0/4	0	nd	nd	32	nc	µg/kg ww
Carcinogenic PAHs – Mammal	0/4	0	nd	nd	22	43	µg/kg ww
Total PAH	1/4	25	240	240	84	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	2/4	50	170	530	180	24	µg/kg ww
Butyl benzyl phthalate	0/2	0	nd	nd	12	24	µg/kg ww
Diethyl phthalate	0/4	0	nd	nd	20	40	µg/kg ww
Dimethyl phthalate	0/4	0	nd	nd	8.0	16	µg/kg ww
Di-n-butyl phthalate	0/4	0	nd	nd	20	40	µg/kg ww
Di-n-octyl phthalate	0/4	0	nd	nd	12	24	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/4	0	nd	nd	12	24	µg/kg ww
1,2-Dichlorobenzene	0/4	0	nd	nd	12	24	µg/kg ww
1,2-Diphenylhydrazine	0/4	0	nd	nd	40	80	µg/kg ww
1,3-Dichlorobenzene	0/4	0	nd	nd	12	24	µg/kg ww
1,4-Dichlorobenzene	0/4	0	nd	nd	12	24	µg/kg ww
2,4,5-Trichlorophenol	0/4	0	nd	nd	80	160	µg/kg ww
2,4,6-Trichlorophenol	0/4	0	nd	nd	80	160	µg/kg ww
2,4-Dichlorophenol	0/4	0	nd	nd	20	40	µg/kg ww
2,4-Dimethylphenol	0/4	0	nd	nd	20	40	µg/kg ww
2,4-Dinitrophenol	0/4	0	nd	nd	40	80	µg/kg ww
2,4-Dinitrotoluene	0/4	0	nd	nd	8.0	16	µg/kg ww

Table E.6.3-1, cont. Summary statistics for amphipod, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
2,6-Dinitrotoluene	0/4	0	nd	nd	8.0	16	µg/kg ww
2-Chlorophenol	0/4	0	nd	nd	40	80	µg/kg ww
2-Methylphenol	0/4	0	nd	nd	20	40	µg/kg ww
2-Nitroaniline	0/4	0	nd	nd	80	160	µg/kg ww
2-Nitrophenol	0/4	0	nd	nd	20	40	µg/kg ww
3,3'-Dichlorobenzidine	0/4	0	nd	nd	20	40	µg/kg ww
3-Nitroaniline	0/4	0	nd	nd	80	160	µg/kg ww
4,6-Dinitro-o-cresol	0/4	0	nd	nd	40	80	µg/kg ww
4-Bromophenyl phenyl ether	0/4	0	nd	nd	8.0	16	µg/kg ww
4-Chloro-3-methylphenol	0/2	0	nd	nd	40	80	µg/kg ww
4-Chloroaniline	0/4	0	nd	nd	40	80	µg/kg ww
4-Chlorophenyl phenyl ether	0/4	0	nd	nd	12	24	µg/kg ww
4-Methylphenol	0/4	0	nd	nd	20	40	µg/kg ww
4-Nitroaniline	0/4	0	nd	nd	80	160	µg/kg ww
4-Nitrophenol	0/2	0	nd	nd	40	80	µg/kg ww
Aniline	0/2	0	nd	nd	40	80	µg/kg ww
Benzoic acid	0/4	0	nd	nd	80	160	µg/kg ww
Benzyl alcohol	0/4	0	nd	nd	20	40	µg/kg ww
bis(2-chloroethoxy)methane	0/4	0	nd	nd	20	40	µg/kg ww
bis(2-chloroethyl)ether	0/4	0	nd	nd	12	24	µg/kg ww
bis(2-chloroisopropyl)ether	0/4	0	nd	nd	40	80	µg/kg ww
Caffeine	0/4	0	nd	nd	4.0	8.0	µg/kg ww
Carbazole	0/4	0	nd	nd	20	40	µg/kg ww
Coprostanol	0/4	0	nd	nd	80	160	µg/kg ww
Hexachlorobenzene	0/4	0	nd	nd	12	24	µg/kg ww
Hexachlorobutadiene	0/4	0	nd	nd	20	40	µg/kg ww
Hexachloroethane	0/4	0	nd	nd	20	40	µg/kg ww
Isophorone	0/4	0	nd	nd	20	40	µg/kg ww
Nitrobenzene	0/4	0	nd	nd	20	40	µg/kg ww
N-Nitrosodimethylamine	0/4	0	nd	nd	80	160	µg/kg ww
N-Nitroso-di-n-propylamine	0/2	0	nd	nd	20	40	µg/kg ww
N-Nitrosodiphenylamine	0/4	0	nd	nd	20	40	µg/kg ww

Table E.6.3-1, cont. Summary statistics for amphipod, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Pentachlorophenol	0/4	0	nd	nd	20	40	µg/kg ww
Phenol	2/4	50	1,400	2,200	940	160	µg/kg ww
Polychlorinated biphenyls							
Aroclor-1016	0/4	0	nd	nd	4.0	8.0	µg/kg ww
Aroclor-1221	0/4	0	nd	nd	4.0	8.0	µg/kg ww
Aroclor-1232	0/4	0	nd	nd	4.0	8.0	µg/kg ww
Aroclor-1242	0/4	0	nd	nd	4.0	8.0	µg/kg ww
Aroclor-1248	4/4	100	23	29	27	na	µg/kg ww
Aroclor-1254	4/4	100	36	300	130	na	µg/kg ww
Aroclor-1260	4/4	100	43	120	76	na	µg/kg ww
Total PCBs	4/4	100	106	410	230	nc	µg/kg ww
Conventional parameters							
Total solids	2/2	100	18	18	18	na	% ww
Lipid	4/4	100	0.66	5.3	3.0	na	% ww

Table E.6.3-2. Summary statistics for benthic invertebrates, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	20/20	100	0.0013 J	0.172	0.02	na	mg/kg ww
Arsenic	20/20	100	0.573	17.40	2.34	na	mg/kg ww
Cadmium	20/20	100	0.0175 J	0.202 J	0.060	na	mg/kg ww
Chromium	20/20	100	0.08	3.90	1	na	mg/kg ww
Cobalt	20/20	100	0.0514 J	0.5520 J	0.216	na	mg/kg ww
Copper	20/20	100	1.940 J	21.8	8.52	na	mg/kg ww
Lead	20/20	100	0.1430	14.60	1.77	na	mg/kg ww
Mercury	18/20	90	0.002 J	0.044	0.01	0.004 – 0.009	mg/kg ww
Molybdenum	20/20	100	0.0563	0.4330	0.154	na	mg/kg ww
Nickel	20/20	100	0.094	2.950	0.68	na	mg/kg ww
Selenium	20/20	100	0.055	0.603	0.22	na	mg/kg ww
Silver	20/20	100	0.0126 J	0.1650 J	0.051	na	mg/kg ww
Thallium	20/20	100	0.0006 J	0.0068	0.003	na	mg/kg ww
Vanadium	20/20	100	0.26	3.04	1.2	na	mg/kg ww
Zinc	20/20	100	8.22	43.6	20.9	na	mg/kg ww
Organometals							
Monobutyltin as ion	9/20	45	2.4 J	30	5.3	4.6 – 9.4	µg/kg ww
Dibutyltin as ion	15/20	75	2.2 J	24	8.5	4.8 – 5.0	µg/kg ww
Tributyltin as ion	19/20	95	3.8 J	92	28	5.0	µg/kg ww
Tetrabutyltin as ion	0/20	0	nd	nd	2.8	1.6 – 11	µg/kg ww
Alkylated PAHs							
C1-Chrysenes	5/20	25	36	240	37	25 – 50	µg/kg ww
C1-Dibenzothiophenes	1/20	5	46	46	16	25 – 50	µg/kg ww
C1-Fluoranthene/pyrene	12/20	60	39	560	88	25 – 46	µg/kg ww
C1-Fluorenes	2/20	10	34	39	17	25 – 50	µg/kg ww
C1-Phenanthrenes/anthracenes	7/20	35	26	140	42	25 – 50	µg/kg ww
C2-Chrysenes	1/20	5	140	140	21	25 – 50	µg/kg ww
C2-Dibenzothiophenes	1/20	5	36	36	15	25 – 50	µg/kg ww
C2-Fluorenes	4/20	20	36	84	24	25 – 50	µg/kg ww
C2-Naphthalenes	1/20	5	68	68	17	25 – 50	µg/kg ww
C2-Phenanthrenes/anthracenes	6/20	30	28	110	34	25 – 50	µg/kg ww
C3-Chrysenes	0/20	0	nd	nd	14	25 – 50	µg/kg ww
C3-Dibenzothiophenes	0/20	0	nd	nd	14	25 – 50	µg/kg ww
C3-Fluorenes	4/20	20	37	92	23	25 – 50	µg/kg ww

Table E.6.3-2, cont. Summary statistics for benthic invertebrates, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
C3-Naphthalenes	1/20	5	120	120	20	25 – 50	µg/kg ww
C3-Phenanthrenes/anthracenes	7/20	35	35	71	28	25 – 50	µg/kg ww
C4-Chrysenes	0/20	0	nd	nd	14	25 – 50	µg/kg ww
C4-Naphthalenes	1/20	5	110	110	19	25 – 50	µg/kg ww
C4-Phenanthrenes/anthracenes	4/20	20	29	55	20	25 – 50	µg/kg ww
PAHs							
1-Methylnaphthalene	19/20	95	0.75 J	5.0 J	3.1	50	µg/kg ww
2-Chloronaphthalene	0/20	0	nd	nd	110	200 – 400	µg/kg ww
2-Methylnaphthalene	20/20	100	1.0 J	5.6 J	2.3	na	µg/kg ww
Acenaphthene	20/20	100	0.61 J	35	7.0	na	µg/kg ww
Acenaphthylene	19/20	95	0.40 J	12 J	3.1	25	µg/kg ww
Anthracene	20/20	100	1.0 J	110	17	na	µg/kg ww
Benzo(a)anthracene	20/20	100	0.93 J	270	44	na	µg/kg ww
Benzo(a)pyrene	17/20	85	2.0 J	190	28	25	µg/kg ww
Benzo(b)fluoranthene	20/20	100	1.5 J	290	40	na	µg/kg ww
Benzo(e)pyrene	20/20	100	3.8 J	250	37	na	µg/kg ww
Benzo(g,h,i)perylene	20/20	100	1.1 J	88	15	na	µg/kg ww
Benzo(k)fluoranthene	20/20	100	1.6 J	220	30	na	µg/kg ww
Total benzofluoranthenes	20/20	100	3.4 J	510	70	na	µg/kg ww
Chrysene	20/20	100	8.2 J	780	88	na	µg/kg ww
Dibenzo(a,h)anthracene	15/20	75	0.61 J	25 J	6.7	25	µg/kg ww
Dibenzofuran	19/20	95	0.72 J	32	5.9	25	µg/kg ww
Fluoranthene	20/20	100	10 J	680	140	na	µg/kg ww
Fluorene	20/20	100	0.83 J	57	9.7	na	µg/kg ww
Indeno(1,2,3-cd)pyrene	19/20	95	0.80 J	87	15	25	µg/kg ww
Naphthalene	20/20	100	3.4 J	7.3 J	5.8	na	µg/kg ww
Perylene	13/20	65	3.2 J	69	18	25	µg/kg ww
Phenanthrene	20/20	100	3.7 J	320	51	na	µg/kg ww
Pyrene	20/20	100	11 J	570	140	na	µg/kg ww
Total HPAH	20/20	100	36 J	3,200 J	540	na	µg/kg ww
Total LPAH	20/20	100	12.4 J	450 J	93	na	µg/kg ww
Carcinogenic PAHs – Mammal	20/20	100	4.2 J	290 J	44	na	µg/kg ww
Total PAH	20/20	100	48 J	3,630 J	640	na	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	5/20	25	1,100 J	2,200 J	1,400	2,500	µg/kg ww
Butyl benzyl phthalate	1/20	5	190 J	190 J	120	200 – 400	µg/kg ww
Diethyl phthalate	0/20	0	nd	nd	230	390 – 790	µg/kg ww

Table E.6.3-2, cont. Summary statistics for benthic invertebrates, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Dimethyl phthalate	0/20	0	nd	nd	110	200 – 400	µg/kg ww
Di-n-butyl phthalate	0/20	0	nd	nd	110	200 – 400	µg/kg ww
Di-n-octyl phthalate	0/20	0	nd	nd	110	200 – 400	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/20	0	nd	nd	110	200 – 400	µg/kg ww
1,2-Dichlorobenzene	0/20	0	nd	nd	110	200 – 400	µg/kg ww
1,3-Dichlorobenzene	0/20	0	nd	nd	110	200 – 400	µg/kg ww
1,4-Dichlorobenzene	0/20	0	nd	nd	110	200 – 400	µg/kg ww
2,4,5-Trichlorophenol	1/20	5	75 J	75 J	220	390 – 790	µg/kg ww
2,4,6-Trichlorophenol	1/20	5	47 J	47 J	220	390 – 790	µg/kg ww
2,4-Dichlorophenol	0/20	0	nd	nd	230	390 – 790	µg/kg ww
2,4-Dimethylphenol	1/20	5	71 J	71 J	220	390 – 790	µg/kg ww
2,4-Dinitrophenol	0/20	0	nd	nd	2,300	3,900 – 7,900	µg/kg ww
2,4-Dinitrotoluene	0/20	0	nd	nd	230	390 – 790	µg/kg ww
2,6-Dinitrotoluene	0/20	0	nd	nd	110	200 – 400	µg/kg ww
2-Chlorophenol	0/20	0	nd	nd	230	390 – 790	µg/kg ww
2-Methylphenol	0/20	0	nd	nd	230	390 – 790	µg/kg ww
2-Nitroaniline	0/20	0	nd	nd	570	970 – 2,000	µg/kg ww
2-Nitrophenol	0/20	0	nd	nd	110	200 – 400	µg/kg ww
3,3'-Dichlorobenzidine	0/20	0	nd	nd	5,700	9,700 – 20,000	µg/kg ww
3-Nitroaniline	0/20	0	nd	nd	1,100	2,000 – 4,000	µg/kg ww
4,6-Dinitro-o-cresol	0/20	0	nd	nd	1,100	2,000 – 4,000	µg/kg ww
4-Bromophenyl phenyl ether	0/20	0	nd	nd	110	200 – 400	µg/kg ww
4-Chloro-3-methylphenol	0/20	0	nd	nd	570	970 – 2,000	µg/kg ww
4-Chloroaniline	1/20	5	53 J	53 J	550	970 – 2,000	µg/kg ww
4-Chlorophenyl phenyl ether	0/20	0	nd	nd	110	200 – 400	µg/kg ww
4-Methylphenol	6/20	30	77 J	44,000	2,400	400 – 790	µg/kg ww
4-Nitroaniline	0/20	0	nd	nd	570	970 – 2,000	µg/kg ww
4-Nitrophenol	2/20	10	280 J	2,300 J	1,100	2,000 – 4,000	µg/kg ww
Aniline	0/20	0	nd	nd	2,300	3,900 – 7,900	µg/kg ww
Benzidine	0/20	0	nd	nd	14,000	25,000 – 50,000	µg/kg ww
Benzoic acid	19/20	95	990 J	14,000	3,700	4,000	µg/kg ww
Benzyl alcohol	8/20	40	57 J	1,100	160	200 – 400	µg/kg ww
Biphenyl	20/20	100	1.4 J	5.3 J	2.6	na	µg/kg ww
bis(2-chloroethoxy)methane	0/20	0	nd	nd	110	200 – 400	µg/kg ww
bis(2-chloroethyl)ether	0/20	0	nd	nd	110	200 – 400	µg/kg ww
bis(2-chloroisopropyl)ether	0/20	0	nd	nd	110	200 – 400	µg/kg ww

Table E.6.3-2, cont. Summary statistics for benthic invertebrates, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Carbazole	0/20	0	nd	nd	570	970 – 2,000	µg/kg ww
Dibenzothiophene	15/20	75	0.69 J	26	9.0	25 – 50	µg/kg ww
Hexachlorobenzene	0/20	0	nd	nd	5.4	9.7 – 18	µg/kg ww
Hexachlorobutadiene	0/20	0	nd	nd	110	200 – 400	µg/kg ww
Hexachlorocyclopentadiene	0/20	0	nd	nd	14,000	25,000 – 50,000	µg/kg ww
Hexachloroethane	0/20	0	nd	nd	110	200 – 400	µg/kg ww
Isophorone	0/20	0	nd	nd	110	200 – 400	µg/kg ww
Nitrobenzene	0/20	0	nd	nd	110	200 – 400	µg/kg ww
N-Nitrosodimethylamine	0/20	0	nd	nd	110	200 – 400	µg/kg ww
N-Nitroso-di-n-propylamine	1/20	5	3,700	3,700	350	200 – 2,300	µg/kg ww
N-Nitrosodiphenylamine	1/20	5	170 J	170 J	120	200 – 400	µg/kg ww
Pentachlorophenol	5/20	25	1,100 J	4,700	1,400	2,000 – 4,000	µg/kg ww
Phenol	9/20	45	91 J	580	250	99 – 990	µg/kg ww
Polychlorinated biphenyls							
PCB-001	7/8	88	1.30 J	45.0	8.93	0.382	ng/kg ww
PCB-002	4/8	50	1.45 J	2.51 J	1.15	0.259 – 1.06	ng/kg ww
PCB-003	4/8	50	3.39 J	15.1	3.84	0.442 – 1.75	ng/kg ww
PCB-004	8/8	100	8.72	275	74.2	na	ng/kg ww
PCB-005	8/8	100	0.201 J	12.8	3.10	na	ng/kg ww
PCB-006	8/8	100	7.28	233	70.7	na	ng/kg ww
PCB-007	8/8	100	0.753 J	44.8	12.0	na	ng/kg ww
PCB-008	8/8	100	16.5	1,040	288	na	ng/kg ww
PCB-009	8/8	100	1.09 J	46.6	12.8	na	ng/kg ww
PCB-010	8/8	100	0.632 J	20.5	5.19	na	ng/kg ww
PCB-011	7/8	88	9.66	35.2	16.8	4.45	ng/kg ww
PCB-012	8/8	100	4.05 CJ	97.8 C	31.5	na	ng/kg ww
PCB-013	8/8	100	C12	C12	nc	na	ng/kg ww
PCB-014	1/8	12	0.226 J	0.226 J	0.188	0.128 – 0.662	ng/kg ww
PCB-015	8/8	100	22.7	798	229	na	ng/kg ww
PCB-016	8/8	100	28.8	1,380	338	na	ng/kg ww
PCB-017	8/8	100	71.0	2,780	633	na	ng/kg ww
PCB-018	8/8	100	130 C	3,520 C	926	na	ng/kg ww
PCB-019	8/8	100	15.4	386	112	na	ng/kg ww
PCB-020	8/8	100	358 C	14,800 C	3,490	na	ng/kg ww
PCB-021	8/8	100	58.9 C	3,580 C	944	na	ng/kg ww
PCB-022	8/8	100	71.5	2,940	749	na	ng/kg ww
PCB-023	8/8	100	0.243 J	4.74 J	1.56	na	ng/kg ww

Table E.6.3-2, cont. Summary statistics for benthic invertebrates, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-024	8/8	100	1.73 J	39.2	11.9	na	ng/kg ww
PCB-025	8/8	100	65.8	910	331	na	ng/kg ww
PCB-026	8/8	100	172 C	2,410 C	766	na	ng/kg ww
PCB-027	8/8	100	29.3	381	122	na	ng/kg ww
PCB-028	8/8	100	C20	C20	nc	na	ng/kg ww
PCB-029	8/8	100	C26	C26	nc	na	ng/kg ww
PCB-030	8/8	100	C18	C18	nc	na	ng/kg ww
PCB-031	8/8	100	261	12,400	2,720	na	ng/kg ww
PCB-032	8/8	100	58.6	2,400	601	na	ng/kg ww
PCB-033	8/8	100	C21	C21	nc	na	ng/kg ww
PCB-034	8/8	100	2.30 J	72.9	16.8	na	ng/kg ww
PCB-035	8/8	100	1.95 J	112	35.2	na	ng/kg ww
PCB-036	3/8	38	0.320 J	1.08 J	0.402	0.268 – 0.424	ng/kg ww
PCB-037	8/8	100	58.2	2,370	658	na	ng/kg ww
PCB-038	8/8	100	0.775 J	28.1	8.00	na	ng/kg ww
PCB-039	8/8	100	2.50 J	142	31.7	na	ng/kg ww
PCB-040	8/8	100	174 C	11,900 C	2,600	na	ng/kg ww
PCB-041	8/8	100	C40	C40	nc	na	ng/kg ww
PCB-042	8/8	100	98.0	5,470	1,400	na	ng/kg ww
PCB-043	8/8	100	19.0	779	195	na	ng/kg ww
PCB-044	8/8	100	634 C	22,800 C	5,820	na	ng/kg ww
PCB-045	8/8	100	74.7 C	2,750 C	689	na	ng/kg ww
PCB-046	8/8	100	13.2	592	164	na	ng/kg ww
PCB-047	8/8	100	C44	C44	nc	na	ng/kg ww
PCB-048	8/8	100	70.2	3,870	894	na	ng/kg ww
PCB-049	8/8	100	556 C	19,100 C	5,160	na	ng/kg ww
PCB-050	8/8	100	111 C	2,460 C	657	na	ng/kg ww
PCB-051	8/8	100	C45	C45	nc	na	ng/kg ww
PCB-052	8/8	100	1,350	30,400	8,900	na	ng/kg ww
PCB-053	8/8	100	C50	C50	nc	na	ng/kg ww
PCB-054	8/8	100	1.47 J	27.9	9.00	na	ng/kg ww
PCB-055	8/8	100	4.30	195	77.5	na	ng/kg ww
PCB-056	8/8	100	178	9,420	2,350	na	ng/kg ww
PCB-057	8/8	100	9.96	135	52.7	na	ng/kg ww
PCB-058	8/8	100	4.80	101	33.7	na	ng/kg ww
PCB-059	8/8	100	60.3 C	2,070 C	567	na	ng/kg ww
PCB-060	8/8	100	95.4	3,510	1,070	na	ng/kg ww

Table E.6.3-2, cont. Summary statistics for benthic invertebrates, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-061	8/8	100	938 C	38,500 C	10,200	na	ng/kg ww
PCB-062	8/8	100	C59	C59	nc	na	ng/kg ww
PCB-063	8/8	100	30.4	1,020	278	na	ng/kg ww
PCB-064	8/8	100	217	10,600	2,380	na	ng/kg ww
PCB-065	8/8	100	C44	C44	nc	na	ng/kg ww
PCB-066	8/8	100	585	26,500	6,920	na	ng/kg ww
PCB-067	8/8	100	16.8	547	196	na	ng/kg ww
PCB-068	8/8	100	13.2	171	72.7	na	ng/kg ww
PCB-069	8/8	100	C49	C49	nc	na	ng/kg ww
PCB-070	8/8	100	C61	C61	nc	na	ng/kg ww
PCB-071	8/8	100	C40	C40	nc	na	ng/kg ww
PCB-072	8/8	100	23.9	345	129	na	ng/kg ww
PCB-073	0/8	0	nd	nd	0.0578	0.0237 – 0.278	ng/kg ww
PCB-074	8/8	100	C61	C61	nc	na	ng/kg ww
PCB-075	8/8	100	C59	C59	nc	na	ng/kg ww
PCB-076	8/8	100	C61	C61	nc	na	ng/kg ww
PCB-077	8/8	100	33.3	1,440	431	na	ng/kg ww
PCB-078	0/8	0	nd	nd	0.233	0.386 – 0.538	ng/kg ww
PCB-079	8/8	100	13.4	280	122	na	ng/kg ww
PCB-080	0/8	0	nd	nd	0.204	0.335 – 0.467	ng/kg ww
PCB-081	8/8	100	2.24 J	67.6	25.6	na	ng/kg ww
PCB-082	8/8	100	55.1	2,550	925	na	ng/kg ww
PCB-083	8/8	100	1,220 C	24,200 C	10,700	na	ng/kg ww
PCB-084	8/8	100	221	4,400	2,040	na	ng/kg ww
PCB-085	8/8	100	290 C	6,250 C	2,350	na	ng/kg ww
PCB-086	8/8	100	659 C	18,200 C	7,660	na	ng/kg ww
PCB-087	8/8	100	C86	C86	nc	na	ng/kg ww
PCB-088	8/8	100	216 C	4,700 C	1,860	na	ng/kg ww
PCB-089	7/8	88	5.53	427	91.5	0.398	ng/kg ww
PCB-090	8/8	100	1,380 C	49,400 C	18,300	na	ng/kg ww
PCB-091	8/8	100	C88	C88	nc	na	ng/kg ww
PCB-092	8/8	100	425	8,230	3,350	na	ng/kg ww
PCB-093	8/8	100	1,420 C	36,300 C	12,500	na	ng/kg ww
PCB-094	8/8	100	6.38	157	47.6	na	ng/kg ww
PCB-095	8/8	100	C93	C93	nc	na	ng/kg ww
PCB-096	8/8	100	6.18	163	51.0	na	ng/kg ww
PCB-097	8/8	100	C86	C86	nc	na	ng/kg ww

Table E.6.3-2, cont. Summary statistics for benthic invertebrates, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-098	8/8	100	C93	C93	nc	na	ng/kg ww
PCB-099	8/8	100	C83	C83	nc	na	ng/kg ww
PCB-100	8/8	100	C93	C93	nc	na	ng/kg ww
PCB-101	8/8	100	C90	C90	nc	na	ng/kg ww
PCB-102	8/8	100	C93	C93	nc	na	ng/kg ww
PCB-103	8/8	100	20.1	464	206	na	ng/kg ww
PCB-104	8/8	100	0.267 J	4.31 J	1.89	na	ng/kg ww
PCB-105	8/8	100	434	8,210	3,960	na	ng/kg ww
PCB-106	0/8	0	nd	nd	0.190	0.338 – 0.441	ng/kg ww
PCB-107	8/8	100	50.2 C	875 C	448	na	ng/kg ww
PCB-108	8/8	100	C86	C86	nc	na	ng/kg ww
PCB-109	8/8	100	131	2,210	987	na	ng/kg ww
PCB-110	8/8	100	1,620 C	31,300 C	14,000	na	ng/kg ww
PCB-111	8/8	100	1.92 J	40.1	12.6	na	ng/kg ww
PCB-112	0/8	0	nd	nd	0.146	0.164 – 0.402	ng/kg ww
PCB-113	8/8	100	C90	C90	nc	na	ng/kg ww
PCB-114	8/8	100	25.5	526	224	na	ng/kg ww
PCB-115	8/8	100	C110	C110	nc	na	ng/kg ww
PCB-116	8/8	100	C85	C85	nc	na	ng/kg ww
PCB-117	8/8	100	C85	C85	nc	na	ng/kg ww
PCB-118	8/8	100	1,340	28,000	13,300	na	ng/kg ww
PCB-119	8/8	100	C86	C86	nc	na	ng/kg ww
PCB-120	8/8	100	10.4	254	82.4	na	ng/kg ww
PCB-121	6/8	75	0.699 J	16.9	4.13	0.241 – 0.278	ng/kg ww
PCB-122	8/8	100	14.5	299	136	na	ng/kg ww
PCB-123	8/8	100	24.5	433	207	na	ng/kg ww
PCB-124	8/8	100	C107	C107	nc	na	ng/kg ww
PCB-125	8/8	100	C86	C86	nc	na	ng/kg ww
PCB-126	8/8	100	2.60	52.5	23.8	na	ng/kg ww
PCB-127	8/8	100	4.96	66.5	33.4	na	ng/kg ww
PCB-128	8/8	100	294 C	7,120 C	2,580	na	ng/kg ww
PCB-129	8/8	100	2,610 C	120,000 C	30,100	na	ng/kg ww
PCB-130	8/8	100	141	3,980	1,280	na	ng/kg ww
PCB-131	8/8	100	9.33	434	155	na	ng/kg ww
PCB-132	8/8	100	449	24,300	6,350	na	ng/kg ww
PCB-133	8/8	100	48.6	1,600	431	na	ng/kg ww
PCB-134	8/8	100	92.4 C	3,380 C	957	na	ng/kg ww

Table E.6.3-2, cont. Summary statistics for benthic invertebrates, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-135	8/8	100	847 C	51,600 C	11,300	na	ng/kg ww
PCB-136	8/8	100	207	13,300	2,950	na	ng/kg ww
PCB-137	8/8	100	107	1,430	765	na	ng/kg ww
PCB-138	8/8	100	C129	C129	nc	na	ng/kg ww
PCB-139	8/8	100	42.4 C	757 C	331	na	ng/kg ww
PCB-140	8/8	100	C139	C139	nc	na	ng/kg ww
PCB-141	8/8	100	288	30,500	6,110	na	ng/kg ww
PCB-142	0/8	0	nd	nd	0.197	0.130 – 0.478	ng/kg ww
PCB-143	8/8	100	C134	C134	nc	na	ng/kg ww
PCB-144	8/8	100	73.9	6,110	1,390	na	ng/kg ww
PCB-145	8/8	100	0.620 J	8.44 J	3.92	na	ng/kg ww
PCB-146	8/8	100	427	20,600	4,970	na	ng/kg ww
PCB-147	8/8	100	1,680 C	108,000 C	25,100	na	ng/kg ww
PCB-148	8/8	100	5.69	170	46.6	na	ng/kg ww
PCB-149	8/8	100	C147	C147	nc	na	ng/kg ww
PCB-150	8/8	100	3.48	85.3	33.6	na	ng/kg ww
PCB-151	8/8	100	C135	C135	nc	na	ng/kg ww
PCB-152	8/8	100	1.59 J	21.6	10.0	na	ng/kg ww
PCB-153	8/8	100	2,470 C	155,000 C	36,400	na	ng/kg ww
PCB-154	8/8	100	C135	C135	nc	na	ng/kg ww
PCB-155	8/8	100	0.219 J	5.55 J	1.89	na	ng/kg ww
PCB-156	8/8	100	195 C	6,100 C	1,900	na	ng/kg ww
PCB-157	8/8	100	C156	C156	nc	na	ng/kg ww
PCB-158	8/8	100	225	10,700	2,650	na	ng/kg ww
PCB-159	0/8	0	nd	nd	0.158	0.0984 – 0.385	ng/kg ww
PCB-160	8/8	100	C129	C129	nc	na	ng/kg ww
PCB-161	0/8	0	nd	nd	0.142	0.0923 – 0.343	ng/kg ww
PCB-162	8/8	100	6.03	127	48.4	na	ng/kg ww
PCB-163	8/8	100	C129	C129	nc	na	ng/kg ww
PCB-164	8/8	100	129	6,750	1,570	na	ng/kg ww
PCB-165	8/8	100	1.59 J	37.9	10.8	na	ng/kg ww
PCB-166	8/8	100	C128	C128	nc	na	ng/kg ww
PCB-167	8/8	100	79.0	2,550	802	na	ng/kg ww
PCB-168	8/8	100	C153	C153	nc	na	ng/kg ww
PCB-169	0/8	0	nd	nd	22.1	3.22 – 200	ng/kg ww
PCB-170	8/8	100	481	42,700	8,150	na	ng/kg ww
PCB-171	8/8	100	153 C	15,000 C	2,840	na	ng/kg ww

Table E.6.3-2, cont. Summary statistics for benthic invertebrates, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-172	8/8	100	82.6	7,650	1,460	na	ng/kg ww
PCB-173	8/8	100	C171	C171	nc	na	ng/kg ww
PCB-174	8/8	100	393	44,500	8,260	na	ng/kg ww
PCB-175	8/8	100	22.0	2,130	408	na	ng/kg ww
PCB-176	8/8	100	53.7	6,110	1,180	na	ng/kg ww
PCB-177	8/8	100	359	28,900	5,700	na	ng/kg ww
PCB-178	8/8	100	141	12,400	2,350	na	ng/kg ww
PCB-179	8/8	100	238	20,600	3,970	na	ng/kg ww
PCB-180	8/8	100	1,200 C	118,000 C	21,600	na	ng/kg ww
PCB-181	8/8	100	4.26	141	39.9	na	ng/kg ww
PCB-182	8/8	100	4.73	168	52.2	na	ng/kg ww
PCB-183	8/8	100	401 C	38,400 C	7,590	na	ng/kg ww
PCB-184	8/8	100	0.375 J	8.43	3.01	na	ng/kg ww
PCB-185	8/8	100	C183	C183	nc	na	ng/kg ww
PCB-186	0/8	0	nd	nd	0.149	0.0883 – 0.731	ng/kg ww
PCB-187	8/8	100	836	69,700	13,900	na	ng/kg ww
PCB-188	8/8	100	1.23 J	27.6	8.98	na	ng/kg ww
PCB-189	8/8	100	14.7	1,170	234	na	ng/kg ww
PCB-190	8/8	100	117	11,400	2,100	na	ng/kg ww
PCB-191	8/8	100	20.7	2,020	384	na	ng/kg ww
PCB-192	0/8	0	nd	nd	0.197	0.119 – 0.983	ng/kg ww
PCB-193	8/8	100	C180	C180	nc	na	ng/kg ww
PCB-194	8/8	100	137	19,200	3,340	na	ng/kg ww
PCB-195	8/8	100	73.9	9,860	1,660	na	ng/kg ww
PCB-196	8/8	100	91.2	11,700	2,090	na	ng/kg ww
PCB-197	8/8	100	24.4 C	3,120 C	554	na	ng/kg ww
PCB-198	8/8	100	177 C	22,400 C	4,130	na	ng/kg ww
PCB-199	8/8	100	C198	C198	nc	na	ng/kg ww
PCB-200	8/8	100	C197	C197	nc	na	ng/kg ww
PCB-201	8/8	100	27.8	2,840	532	na	ng/kg ww
PCB-202	8/8	100	49.2	4,060	805	na	ng/kg ww
PCB-203	8/8	100	134	14,800	2,730	na	ng/kg ww
PCB-204	8/8	100	0.112 J	2.70 J	0.752	na	ng/kg ww
PCB-205	8/8	100	7.46	944	169	na	ng/kg ww
PCB-206	8/8	100	41.7	3,280	653	na	ng/kg ww
PCB-207	8/8	100	6.69	552	103	na	ng/kg ww
PCB-208	8/8	100	12.2	647	149	na	ng/kg ww

Table E.6.3-2, cont. Summary statistics for benthic invertebrates, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-209	8/8	100	9.08	139	68.2	na	ng/kg ww
Total PCB congeners	8/8	100	32,130 J	1,346,000 J	394,000	na	ng/kg ww
Aroclor-1016	0/20	0	nd	nd	54	97 – 180	µg/kg ww
Aroclor-1221	0/20	0	nd	nd	110	200 – 360	µg/kg ww
Aroclor-1232	0/20	0	nd	nd	54	97 – 180	µg/kg ww
Aroclor-1242	0/20	0	nd	nd	54	97 – 180	µg/kg ww
Aroclor-1248	0/20	0	nd	nd	54	97 – 180	µg/kg ww
Aroclor-1254	18/20	90	60 J	730	170	99 – 100	µg/kg ww
Aroclor-1260	2/20	10	660	1,400	150	97 – 180	µg/kg ww
Total PCBs	19/20	95	60 J	1,400	270	nc	µg/kg ww
PCB TEQ – Bird	8/8	100	2.230 J	85.5	27.3	na	ng/kg ww
PCB TEQ – Fish	8/8	100	0.02810 J	0.647	0.279	na	ng/kg ww
PCB TEQ – Mammal	8/8	100	0.376 J	8.62 J	3.72	na	ng/kg ww
Pesticides							
2,4'-DDD	6/20	30	4.1 JN	43 JN	9.2	9.7 – 21	µg/kg ww
2,4'-DDE	3/20	15	3.0 JN	11 JN	6.5	9.7 – 45	µg/kg ww
2,4'-DDT	11/20	55	7.4 JN	83 JN	20	9.7 – 34	µg/kg ww
4,4'-DDD	6/20	30	2.2 JN	13 JN	5.1	9.7 – 18	µg/kg ww
4,4'-DDE	14/20	70	1.4 JN	39 JN	6.0	9.8 – 10	µg/kg ww
4,4'-DDT	16/20	80	4.4 JN	82 JN	15	9.7 – 17	µg/kg ww
Total DDTs	20/20	100	2.2 JN	167 JN	42	nc	µg/kg ww
Aldrin	0/20	0	nd	nd	5.4	9.7 – 18	µg/kg ww
Dieldrin	1/20	5	2.8 JN	2.8 JN	5.3	9.7 – 18	µg/kg ww
Total aldrin/dieldrin	1/20	5	2.8 JN	2.8 JN	5.3	nc	µg/kg ww
alpha-BHC	1/20	5	21 JN	21 JN	6.2	9.7 – 18	µg/kg ww
beta-BHC	4/20	20	7.9 JN	13 JN	6.7	9.7 – 18	µg/kg ww
gamma-BHC	0/20	0	nd	nd	5.4	9.7 – 18	µg/kg ww
delta-BHC	0/20	0	nd	nd	5.4	9.7 – 18	µg/kg ww
alpha-Chlordane	1/20	5	12 JN	12 JN	5.7	9.7 – 18	µg/kg ww
gamma-Chlordane	10/20	50	1.4 JN	22 JN	6.2	9.8 – 18	µg/kg ww
alpha-Endosulfan	4/20	20	2.8 JN	30 JN	6.2	9.7 – 15	µg/kg ww
beta-Endosulfan	4/20	20	6.8 JN	16 JN	6.6	9.9 – 18	µg/kg ww
Endosulfan sulfate	0/20	0	nd	nd	14	9.7 – 190	µg/kg ww
Endrin	0/20	0	nd	nd	5.4	9.7 – 18	µg/kg ww
Endrin aldehyde	2/20	10	2.4 JN	11 JN	5.6	9.7 – 18	µg/kg ww
Endrin ketone	2/20	10	6.5 JN	8.4 JN	5.8	9.7 – 18	µg/kg ww
Heptachlor	1/20	5	8.6 JN	8.6 JN	5.6	9.7 – 18	µg/kg ww

Table E.6.3-2, cont. Summary statistics for benthic invertebrates, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Heptachlor epoxide	3/20	15	2.8 JN	6.6 JN	5.3	9.7 – 18	µg/kg ww
Methoxychlor	3/20	15	5.6 JN	42 JN	7.1	9.7 – 15	µg/kg ww
Mirex	0/20	0	nd	nd	5.4	9.7 – 18	µg/kg ww
Toxaphene	0/20	0	nd	nd	320	490 – 2,100	µg/kg ww
Total chlordane	10/20	50	1.4 JN	34 JN	6.8	nc	µg/kg ww
Conventional parameters							
Total solids	20/20	100	4.10	16.6	11.1	na	% ww
Lipid	20/20	100	0.35	1.4	0.89	na	% ww

Table E.6.3-3. Summary statistics for juvenile chinook salmon, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Mercury	6/6	100	0.022	0.031	0.026	na	mg/kg ww
Organometals							
Tributyltin as ion	9/18	50	1.8 J	14 J	4.1	1.5	µg/kg ww
Polychlorinated biphenyls							
Aroclor-1016	0/18	0	nd	nd	1.9	2.0 – 8.3	µg/kg ww
Aroclor-1016/1242	6/6	100	1.93	13.6	4.38	na	µg/kg ww
Aroclor-1221	0/24	0	nd	nd	2.3	0.281 – 13	µg/kg ww
Aroclor-1232	0/24	0	nd	nd	1.5	0.281 – 8.3	µg/kg ww
Aroclor-1242	0/18	0	nd	nd	3.4	3.5 – 15	µg/kg ww
Aroclor-1248	0/24	0	nd	nd	0.59	0.217 – 3.2	µg/kg ww
Aroclor-1254	24/24	100	6.9 J	1,200	120	na	µg/kg ww
Aroclor-1260	13/24	54	4.08	110 J	24	4.7 – 17	µg/kg ww
Total PCBs	24/24	100	6.9 J	1,200	140	na	µg/kg ww
Pesticides							
2,4'-DDD	8/18	44	0.49 J	5.1 J	1.6	0.18 – 14	µg/kg ww
2,4'-DDE	8/18	44	0.72 J	12 J	2.5	0.26 – 4.2	µg/kg ww
2,4'-DDT	13/18	72	1.8 J	83	14	0.22 – 2.0	µg/kg ww
4,4'-DDD	12/18	67	0.27 J	5.4	1.1	0.13 – 0.44	µg/kg ww
4,4'-DDE	13/18	72	1.8 J	14 J	4.8	1.5 – 7.3	µg/kg ww
4,4'-DDT	9/18	50	0.56 J	23	8.0	0.38 – 82	µg/kg ww
Total DDTs	18/18	100	1.4 J	87	25	nc	µg/kg ww
Aldrin	1/18	6	0.61 J	0.61 J	0.24	0.20 – 1.0	µg/kg ww
Dieldrin	4/18	22	0.76 J	5.7	1.1	0.11 – 3.5	µg/kg ww
Total aldrin/dieldrin	5/18	28	0.61 J	5.7	1.1	nc	µg/kg ww
alpha-BHC	1/18	6	1.3	1.3	0.31	0.16 – 2.0	µg/kg ww
beta-BHC	7/18	39	0.39 J	4.4	0.72	0.38 – 1.1	µg/kg ww
gamma-BHC	2/18	11	0.54 J	1.0 J	0.47	0.28 – 1.7	µg/kg ww
delta-BHC	0/18	0	nd	nd	0.44	0.34 – 2.0	µg/kg ww

Table E.6.3-3, cont. Summary statistics for juvenile chinook salmon, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
alpha-Chlordane	4/18	22	0.77 J	4.5 J	0.75	0.36 – 1.5	µg/kg ww
gamma-Chlordane	9/18	50	0.96 J	40	4.7	0.14 – 2.0	µg/kg ww
alpha-Endosulfan	5/18	28	0.21 J	1.5 J	0.52	0.13 – 3.5	µg/kg ww
beta-Endosulfan	1/18	6	0.94 J	0.94 J	0.45	0.35 – 2.9	µg/kg ww
Endosulfan sulfate	4/18	22	0.73 J	2.3	0.61	0.27 – 2.0	µg/kg ww
Endrin	7/18	39	0.39 J	6.5 J	0.92	0.099 – 2.0	µg/kg ww
Endrin aldehyde	5/18	28	0.86 J	9.7	1.5	0.17 – 3.1	µg/kg ww
Endrin ketone	1/18	6	0.80 J	0.80 J	0.60	0.29 – 3.5	µg/kg ww
Heptachlor	4/18	22	0.96 J	2.5 J	0.69	0.45 – 1.9	µg/kg ww
Heptachlor epoxide	12/18	67	0.72 J	3.6	1.7	0.15 – 7.4	µg/kg ww
Methoxychlor	1/18	6	0.49	0.49	0.30	0.27 – 1.2	µg/kg ww
Mirex	0/18	0	nd	nd	0.43	0.27 – 3.2	µg/kg ww
Cis-Nonachlor	0/18	0	nd	nd	0.46	0.12 – 2.3	µg/kg ww
Oxychlordane	6/18	33	0.23 J	1.5 J	0.36	0.12 – 1.0	µg/kg ww
Toxaphene	0/18	0	nd	nd	66	16 – 560	µg/kg ww
Trans-Nonachlor	6/18	33	0.70 J	3.2	0.74	0.14 – 1.5	µg/kg ww
Total chlordane	11/18	61	0.24 J	41 J	6.0	nc	µg/kg ww
Conventional parameters							
Total solids	24/24	100	20	22	21	na	% ww
Lipid	24/24	100	0.55	3.50	1.8	na	% ww

Table E.6.3-4. Summary statistics for Dungeness crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	7/9	78	0.0015 J	0.0037 J	0.0040	0.020	mg/kg ww
Arsenic	9/9	100	2.540	13	5.5	na	mg/kg ww
Arsenic (inorganic)	2/2	100	0.010	0.010	0.010	na	mg/kg ww
Cadmium	9/9	100	0.0055	0.0295	0.015	na	mg/kg ww
Chromium	2/9	22	0.13	0.16	0.07	0.08 – 0.11	mg/kg ww
Cobalt	7/7	100	0.0338 J	0.0736 J	0.0524	na	mg/kg ww
Copper	9/9	100	6.570 J	16	9.3	na	mg/kg ww
Lead	9/9	100	0.012	0.24 J	0.068	na	mg/kg ww
Mercury	10/10	100	0.034	0.11	0.063	na	mg/kg ww
Molybdenum	7/7	100	0.0108	0.0168	0.0126	na	mg/kg ww
Nickel	9/9	100	0.022 J	0.12	0.046	na	mg/kg ww
Selenium	7/7	100	0.11	0.175	0.14	na	mg/kg ww
Silver	9/9	100	0.0885 J	0.19	0.12	na	mg/kg ww
Thallium	0/7	0	nd	nd	0.002	0.0030 – 0.0042	mg/kg ww
Vanadium	0/7	0	nd	nd	0.1	0.2 – 0.21	mg/kg ww
Zinc	9/9	100	29.0	39	34	na	mg/kg ww
Organometals							
Monobutyltin as ion	0/7	0	nd	nd	0.75	1.5	µg/kg ww
Dibutyltin as ion	0/7	0	nd	nd	0.75	1.5	µg/kg ww
Tributyltin as ion	9/10	90	0.81 J	82	14	2.0	µg/kg ww
Tetrabutyltin as ion	0/7	0	nd	nd	0.75	1.5	µg/kg ww
PAHs							
2-Chloronaphthalene	0/9	0	nd	nd	220	16 – 570	µg/kg ww
2-Methylnaphthalene	1/9	11	1.3 J	1.3 J	5.2	0.57 – 43	µg/kg ww
Acenaphthene	7/9	78	0.30 J	0.89	1.7	11	µg/kg ww
Acenaphthylene	6/9	67	0.20 J	0.46 J	2.0	0.72 – 16	µg/kg ww
Anthracene	7/9	78	0.19 J	0.90	2.0	16	µg/kg ww
Benzo(a)anthracene	6/9	67	0.081 J	0.71 J	2.0	0.72 – 16	µg/kg ww
Benzo(a)pyrene	2/9	22	0.29 J	0.59 J	3.3	0.71 – 27	µg/kg ww
Benzo(b)fluoranthene	3/9	33	0.12 J	0.40 J	5.0	0.71 – 43	µg/kg ww
Benzo(g,h,i)perylene	2/9	22	0.27 J	0.45 J	3.3	0.71 – 27	µg/kg ww
Benzo(k)fluoranthene	2/9	22	0.25 J	0.44 J	5.1	0.71 – 43	µg/kg ww
Total benzofluoranthenes	3/9	33	0.12 J	0.84 J	5.1	nc	µg/kg ww
Chrysene	6/9	67	0.13 J	0.80	2.0	0.72 – 16	µg/kg ww

Table E.6.3-4, cont. Summary statistics for Dungeness crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Dibenzo(a,h)anthracene	1/9	11	0.13 J	0.13 J	5.0	0.71 – 43	µg/kg ww
Dibenzofuran	7/9	78	0.40 J	0.83	3.4	27	µg/kg ww
Fluoranthene	7/9	78	0.24 J	3.0	2.4	16	µg/kg ww
Fluorene	7/9	78	0.31 J	0.98	2.2	16	µg/kg ww
Indeno(1,2,3-cd)pyrene	2/9	22	0.21 J	0.37 J	3.3	0.71 – 27	µg/kg ww
Naphthalene	0/9	0	nd	nd	5.6	1.5 – 43	µg/kg ww
Phenanthrene	3/9	33	0.72	5.9	2.7	0.55 – 16	µg/kg ww
Pyrene	7/9	78	0.28 J	2.5	2.3	16	µg/kg ww
Total HPAH	7/9	78	0.53 J	9.4 J	6.8	nc	µg/kg ww
Total LPAH	7/9	78	0.97 J	9.0 J	6.9	nc	µg/kg ww
Carcinogenic PAHs – Mammal	6/9	67	0.54 J	0.84 J	3.7	0.65 – 29	µg/kg ww
Total PAH	7/9	78	1.88 J	18.4 J	8.9	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	0/9	0	nd	nd	31	16 – 130	µg/kg ww
Butyl benzyl phthalate	0/9	0	nd	nd	470	16 – 1,200	µg/kg ww
Diethyl phthalate	1/9	11	190 J	190 J	420	27 – 1,200	µg/kg ww
Dimethyl phthalate	0/9	0	nd	nd	220	11 – 570	µg/kg ww
Di-n-butyl phthalate	2/9	22	240	400 J	190	27 – 410	µg/kg ww
Di-n-octyl phthalate	0/9	0	nd	nd	1,100	16 – 2,900	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/9	0	nd	nd	220	16 – 570	µg/kg ww
1,2-Dichlorobenzene	0/9	0	nd	nd	220	16 – 570	µg/kg ww
1,2-Diphenylhydrazine	0/2	0	nd	nd	27	53	µg/kg ww
1,3-Dichlorobenzene	0/9	0	nd	nd	220	16 – 570	µg/kg ww
1,4-Dichlorobenzene	0/9	0	nd	nd	220	16 – 570	µg/kg ww
2,4,5-Trichlorophenol	0/9	0	nd	nd	1,100	110 – 2,900	µg/kg ww
2,4,6-Trichlorophenol	0/9	0	nd	nd	1,100	110 – 2,900	µg/kg ww
2,4-Dichlorophenol	0/9	0	nd	nd	470	27 – 1,200	µg/kg ww
2,4-Dimethylphenol	0/9	0	nd	nd	470	27 – 1,200	µg/kg ww
2,4-Dinitrophenol	0/9	0	nd	nd	4,700	53 – 12,000	µg/kg ww
2,4-Dinitrotoluene	0/9	0	nd	nd	560	11 – 2,900	µg/kg ww
2,6-Dinitrotoluene	0/9	0	nd	nd	560	11 – 2,900	µg/kg ww
2-Chlorophenol	0/9	0	nd	nd	470	53 – 1,200	µg/kg ww
2-Methylphenol	0/9	0	nd	nd	470	27 – 1,200	µg/kg ww
2-Nitroaniline	0/9	0	nd	nd	1,100	110 – 2,900	µg/kg ww
2-Nitrophenol	0/9	0	nd	nd	1,100	27 – 2,900	µg/kg ww
3,3'-Dichlorobenzidine	0/9	0	nd	nd	11,000	27 – 29,000	µg/kg ww

Table E.6.3-4, cont. Summary statistics for Dungeness crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
3-Nitroaniline	0/7	0	nd	nd	2,900	5,700	µg/kg ww
4,6-Dinitro-o-cresol	0/9	0	nd	nd	2,200	53 – 5,700	µg/kg ww
4-Bromophenyl phenyl ether	0/9	0	nd	nd	220	11 – 570	µg/kg ww
4-Chloro-3-methylphenol	0/9	0	nd	nd	1,100	53 – 2,900	µg/kg ww
4-Chloroaniline	0/7	0	nd	nd	1,500	2,900	µg/kg ww
4-Chlorophenyl phenyl ether	0/9	0	nd	nd	220	16 – 570	µg/kg ww
4-Methylphenol	0/9	0	nd	nd	470	27 – 1,200	µg/kg ww
4-Nitroaniline	0/7	0	nd	nd	1,700	2,900 – 5,700	µg/kg ww
4-Nitrophenol	0/9	0	nd	nd	2,200	53 – 5,700	µg/kg ww
Aniline	0/7	0	nd	nd	6,000	12,000	µg/kg ww
Benzidine	0/2	0	nd	nd	36,000	72,000	µg/kg ww
Benzoic acid	0/9	0	nd	nd	4,700	110 – 12,000	µg/kg ww
Benzyl alcohol	0/9	0	nd	nd	260	27 – 1,200	µg/kg ww
bis(2-chloroethoxy)methane	0/9	0	nd	nd	350	27 – 2,900	µg/kg ww
bis(2-chloroethyl)ether	0/9	0	nd	nd	260	16 – 1,200	µg/kg ww
bis(2-chloroisopropyl)ether	0/9	0	nd	nd	230	53 – 570	µg/kg ww
Caffeine	0/2	0	nd	nd	2.7	5.3	µg/kg ww
Carbazole	0/9	0	nd	nd	1,100	27 – 2,900	µg/kg ww
Coprostanol	0/2	0	nd	nd	55	110	µg/kg ww
Hexachlorobenzene	1/9	11	0.93 JN	0.93 JN	4.3	7.2 – 16	µg/kg ww
Hexachlorobutadiene	0/9	0	nd	nd	220	27 – 570	µg/kg ww
Hexachlorocyclopentadiene	0/9	0	nd	nd	28,000	27 – 72,000	µg/kg ww
Hexachloroethane	0/9	0	nd	nd	220	27 – 570	µg/kg ww
Isophorone	0/9	0	nd	nd	220	27 – 570	µg/kg ww
Nitrobenzene	0/9	0	nd	nd	220	27 – 570	µg/kg ww
N-Nitrosodimethylamine	0/9	0	nd	nd	1,600	110 – 12,000	µg/kg ww
N-Nitroso-di-n-propylamine	0/9	0	nd	nd	220	27 – 570	µg/kg ww
N-Nitrosodiphenylamine	0/9	0	nd	nd	220	27 – 570	µg/kg ww
Pentachlorophenol	0/9	0	nd	nd	4.7	3.3 – 27	µg/kg ww
Phenol	0/9	0	nd	nd	600	110 – 1,500	µg/kg ww
Polychlorinated biphenyls							
PCB-001	3/3	100	1.11 J	1.97 J	1.48	na	ng/kg ww
PCB-002	3/3	100	0.452 J	0.634 J	0.530	na	ng/kg ww
PCB-003	3/3	100	1.14 J	1.60 J	1.31	na	ng/kg ww
PCB-004	3/3	100	7.04	15.4	10.3	na	ng/kg ww
PCB-005	3/3	100	0.626 J	2.22 J	1.28	na	ng/kg ww
PCB-006	3/3	100	14.6	39.8	23.6	na	ng/kg ww

Table E.6.3-4, cont. Summary statistics for Dungeness crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-007	3/3	100	1.09 J	3.17 J	2.00	na	ng/kg ww
PCB-008	3/3	100	26.4	59.0	41.0	na	ng/kg ww
PCB-009	3/3	100	1.48 J	2.89 J	2.13	na	ng/kg ww
PCB-010	3/3	100	0.494 J	1.20 J	0.734	na	ng/kg ww
PCB-011	3/3	100	6.33	8.84	7.55	na	ng/kg ww
PCB-012	3/3	100	9.33 CJ	16.0 C	12.0	na	ng/kg ww
PCB-013	3/3	100	C12	C12	nc	na	ng/kg ww
PCB-014	0/3	0	nd	nd	0.181	0.292 – 0.407	ng/kg ww
PCB-015	3/3	100	193	322	247	na	ng/kg ww
PCB-016	3/3	100	22.4	68.0	44.3	na	ng/kg ww
PCB-017	3/3	100	40.8	110	73.1	na	ng/kg ww
PCB-018	3/3	100	114 C	289 C	201	na	ng/kg ww
PCB-019	3/3	100	3.14 J	5.36	4.31	na	ng/kg ww
PCB-020	3/3	100	1,710 C	3,210 C	2,480	na	ng/kg ww
PCB-021	3/3	100	184 C	391 C	291	na	ng/kg ww
PCB-022	3/3	100	233	452	349	na	ng/kg ww
PCB-023	0/3	0	nd	nd	0.585	0.797 – 1.40	ng/kg ww
PCB-024	3/3	100	2.40 J	6.73	4.10	na	ng/kg ww
PCB-025	3/3	100	57.2	231	129	na	ng/kg ww
PCB-026	3/3	100	129 C	523 C	282	na	ng/kg ww
PCB-027	3/3	100	25.5	78.6	43.5	na	ng/kg ww
PCB-028	3/3	100	C20	C20	nc	na	ng/kg ww
PCB-029	3/3	100	C26	C26	nc	na	ng/kg ww
PCB-030	3/3	100	C18	C18	nc	na	ng/kg ww
PCB-031	3/3	100	825	1,760	1,310	na	ng/kg ww
PCB-032	3/3	100	71.6	144	97.1	na	ng/kg ww
PCB-033	3/3	100	C21	C21	nc	na	ng/kg ww
PCB-034	3/3	100	2.77 J	6.01	3.86	na	ng/kg ww
PCB-035	3/3	100	3.69 J	7.03	5.36	na	ng/kg ww
PCB-036	0/3	0	nd	nd	0.636	0.868 – 1.53	ng/kg ww
PCB-037	3/3	100	448	784	652	na	ng/kg ww
PCB-038	0/3	0	nd	nd	0.621	0.846 – 1.49	ng/kg ww
PCB-039	3/3	100	2.38 J	8.37	5.12	na	ng/kg ww
PCB-040	3/3	100	249 C	549 C	381	na	ng/kg ww
PCB-041	3/3	100	C40	C40	nc	na	ng/kg ww
PCB-042	3/3	100	186	362	262	na	ng/kg ww
PCB-043	3/3	100	72.4	125	93.6	na	ng/kg ww

Table E.6.3-4, cont. Summary statistics for Dungeness crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-044	3/3	100	1,270 C	2,140 C	1,590	na	ng/kg ww
PCB-045	3/3	100	33.8 C	62.7 C	46.1	na	ng/kg ww
PCB-046	3/3	100	8.92	15.7	11.8	na	ng/kg ww
PCB-047	3/3	100	C44	C44	nc	na	ng/kg ww
PCB-048	3/3	100	87.6	215	154	na	ng/kg ww
PCB-049	3/3	100	781 C	1,860 C	1,230	na	ng/kg ww
PCB-050	3/3	100	42.4 C	87.0 C	60.2	na	ng/kg ww
PCB-051	3/3	100	C45	C45	nc	na	ng/kg ww
PCB-052	3/3	100	2,360	4,530	3,250	na	ng/kg ww
PCB-053	3/3	100	C50	C50	nc	na	ng/kg ww
PCB-054	0/3	0	nd	nd	0.0612	0.111 – 0.132	ng/kg ww
PCB-055	0/3	0	nd	nd	1.73	2.33 – 4.77	ng/kg ww
PCB-056	3/3	100	392	676	531	na	ng/kg ww
PCB-057	3/3	100	8.80	21.9	14.2	na	ng/kg ww
PCB-058	3/3	100	9.47	18.5	14.7	na	ng/kg ww
PCB-059	3/3	100	117 C	243 C	169	na	ng/kg ww
PCB-060	3/3	100	524	973	787	na	ng/kg ww
PCB-061	3/3	100	4,380 C	6,650 C	5,640	na	ng/kg ww
PCB-062	3/3	100	C59	C59	nc	na	ng/kg ww
PCB-063	3/3	100	99.6	175	139	na	ng/kg ww
PCB-064	3/3	100	507	927	722	na	ng/kg ww
PCB-065	3/3	100	C44	C44	nc	na	ng/kg ww
PCB-066	3/3	100	3,280	5,280	4,450	na	ng/kg ww
PCB-067	3/3	100	34.6	68.6	46.1	na	ng/kg ww
PCB-068	3/3	100	15.1	47.9	30.5	na	ng/kg ww
PCB-069	3/3	100	C49	C49	nc	na	ng/kg ww
PCB-070	3/3	100	C61	C61	nc	na	ng/kg ww
PCB-071	3/3	100	C40	C40	nc	na	ng/kg ww
PCB-072	3/3	100	35.1	93.9	61.6	na	ng/kg ww
PCB-073	0/3	0	nd	nd	0.0583	0.115 – 0.118	ng/kg ww
PCB-074	3/3	100	C61	C61	nc	na	ng/kg ww
PCB-075	3/3	100	C59	C59	nc	na	ng/kg ww
PCB-076	3/3	100	C61	C61	nc	na	ng/kg ww
PCB-077	3/3	100	148	218	194	na	ng/kg ww
PCB-078	0/3	0	nd	nd	1.71	2.31 – 4.72	ng/kg ww
PCB-079	3/3	100	64.7	88.9	77.9	na	ng/kg ww
PCB-080	0/3	0	nd	nd	1.58	2.12 – 4.35	ng/kg ww

Table E.6.3-4, cont. Summary statistics for Dungeness crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-081	1/3	33	9.49 J	9.49 J	6.86	10.8 – 11.4	ng/kg ww
PCB-082	3/3	100	227	309	266	na	ng/kg ww
PCB-083	3/3	100	3,980 C	5,490 C	4,590	na	ng/kg ww
PCB-084	3/3	100	403	746	595	na	ng/kg ww
PCB-085	3/3	100	824 C	1,120 C	937	na	ng/kg ww
PCB-086	3/3	100	2,530 C	3,510 C	3,020	na	ng/kg ww
PCB-087	3/3	100	C86	C86	nc	na	ng/kg ww
PCB-088	3/3	100	393 C	668 C	529	na	ng/kg ww
PCB-089	3/3	100	4.89	5.41	5.13	na	ng/kg ww
PCB-090	3/3	100	6,430 C	9,000 C	7,830	na	ng/kg ww
PCB-091	3/3	100	C88	C88	nc	na	ng/kg ww
PCB-092	3/3	100	962	1,590	1,320	na	ng/kg ww
PCB-093	3/3	100	1,840 C	3,460 C	2,840	na	ng/kg ww
PCB-094	3/3	100	5.35	13.4	9.48	na	ng/kg ww
PCB-095	3/3	100	C93	C93	nc	na	ng/kg ww
PCB-096	3/3	100	1.98 J	3.53 J	2.89	na	ng/kg ww
PCB-097	3/3	100	C86	C86	nc	na	ng/kg ww
PCB-098	3/3	100	C93	C93	nc	na	ng/kg ww
PCB-099	3/3	100	C83	C83	nc	na	ng/kg ww
PCB-100	3/3	100	C93	C93	nc	na	ng/kg ww
PCB-101	3/3	100	C90	C90	nc	na	ng/kg ww
PCB-102	3/3	100	C93	C93	nc	na	ng/kg ww
PCB-103	3/3	100	47.6	85.4	66.1	na	ng/kg ww
PCB-104	2/3	67	0.226 J	0.341 J	0.222	0.197	ng/kg ww
PCB-105	3/3	100	2,200	2,630	2,370	na	ng/kg ww
PCB-106	0/3	0	nd	nd	1.42	2.60 – 3.11	ng/kg ww
PCB-107	3/3	100	153 C	201 C	177	na	ng/kg ww
PCB-108	3/3	100	C86	C86	nc	na	ng/kg ww
PCB-109	3/3	100	404	569	479	na	ng/kg ww
PCB-110	3/3	100	3,910 C	6,240 C	5,440	na	ng/kg ww
PCB-111	3/3	100	4.01 J	7.19	5.72	na	ng/kg ww
PCB-112	0/3	0	nd	nd	1.20	1.65 – 3.75	ng/kg ww
PCB-113	3/3	100	C90	C90	nc	na	ng/kg ww
PCB-114	3/3	100	171	211	187	na	ng/kg ww
PCB-115	3/3	100	C110	C110	nc	na	ng/kg ww
PCB-116	3/3	100	C85	C85	nc	na	ng/kg ww
PCB-117	3/3	100	C85	C85	nc	na	ng/kg ww

Table E.6.3-4, cont. Summary statistics for Dungeness crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-118	3/3	100	6,330	8,040	7,050	na	ng/kg ww
PCB-119	3/3	100	C86	C86	nc	na	ng/kg ww
PCB-120	3/3	100	5.69	13.4	9.93	na	ng/kg ww
PCB-121	0/3	0	nd	nd	1.16	1.59 – 3.63	ng/kg ww
PCB-122	3/3	100	81.5	99.1	89.8	na	ng/kg ww
PCB-123	3/3	100	83.4	114	95.8	na	ng/kg ww
PCB-124	3/3	100	C107	C107	nc	na	ng/kg ww
PCB-125	3/3	100	C86	C86	nc	na	ng/kg ww
PCB-126	3/3	100	10.2	12.4	11.1	na	ng/kg ww
PCB-127	3/3	100	16.2	22.5	18.7	na	ng/kg ww
PCB-128	3/3	100	1,080 C	1,410 C	1,290	na	ng/kg ww
PCB-129	3/3	100	9,380 C	13,700 C	11,800	na	ng/kg ww
PCB-130	3/3	100	409	585	515	na	ng/kg ww
PCB-131	3/3	100	57.0	78.6	70.8	na	ng/kg ww
PCB-132	3/3	100	1,060	2,080	1,570	na	ng/kg ww
PCB-133	3/3	100	148	225	196	na	ng/kg ww
PCB-134	3/3	100	247 C	431 C	360	na	ng/kg ww
PCB-135	3/3	100	2,180 C	4,110 C	3,150	na	ng/kg ww
PCB-136	3/3	100	329	569	476	na	ng/kg ww
PCB-137	3/3	100	280	418	350	na	ng/kg ww
PCB-138	3/3	100	C129	C129	nc	na	ng/kg ww
PCB-139	3/3	100	94.7 C	148 C	117	na	ng/kg ww
PCB-140	3/3	100	C139	C139	nc	na	ng/kg ww
PCB-141	3/3	100	1,200	2,170	1,630	na	ng/kg ww
PCB-142	0/3	0	nd	nd	2.92	4.38 – 7.51	ng/kg ww
PCB-143	3/3	100	C134	C134	nc	na	ng/kg ww
PCB-144	3/3	100	240	374	318	na	ng/kg ww
PCB-145	0/3	0	nd	nd	0.0933	0.185 – 0.189	ng/kg ww
PCB-146	3/3	100	1,480	2,270	1,920	na	ng/kg ww
PCB-147	3/3	100	5,940 C	11,100 C	8,350	na	ng/kg ww
PCB-148	3/3	100	9.13	20.8	16.3	na	ng/kg ww
PCB-149	3/3	100	C147	C147	nc	na	ng/kg ww
PCB-150	3/3	100	9.05	14.9	12.3	na	ng/kg ww
PCB-151	3/3	100	C135	C135	nc	na	ng/kg ww
PCB-152	3/3	100	1.78 J	3.44 J	2.65	na	ng/kg ww
PCB-153	3/3	100	10,400 C	14,400 C	12,500	na	ng/kg ww
PCB-154	3/3	100	C135	C135	nc	na	ng/kg ww

Table E.6.3-4, cont. Summary statistics for Dungeness crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-155	3/3	100	0.760 J	1.17 J	0.904	na	ng/kg ww
PCB-156	3/3	100	866 C	1,110 C	987	na	ng/kg ww
PCB-157	3/3	100	C156	C156	nc	na	ng/kg ww
PCB-158	3/3	100	758	1,160	999	na	ng/kg ww
PCB-159	3/3	100	53.3	133	81.6	na	ng/kg ww
PCB-160	3/3	100	C129	C129	nc	na	ng/kg ww
PCB-161	0/3	0	nd	nd	2.12	3.18 – 5.45	ng/kg ww
PCB-162	3/3	100	21.7	31.1	24.8	na	ng/kg ww
PCB-163	3/3	100	C129	C129	nc	na	ng/kg ww
PCB-164	3/3	100	446	754	594	na	ng/kg ww
PCB-165	0/3	0	nd	nd	2.44	3.65 – 6.26	ng/kg ww
PCB-166	3/3	100	C128	C128	nc	na	ng/kg ww
PCB-167	3/3	100	352	425	389	na	ng/kg ww
PCB-168	3/3	100	C153	C153	nc	na	ng/kg ww
PCB-169	1/3	33	0.468	0.468	0.364	0.391 – 0.854	ng/kg ww
PCB-170	3/3	100	1,510	2,620	2,050	na	ng/kg ww
PCB-171	3/3	100	571 C	1,040 C	800	na	ng/kg ww
PCB-172	3/3	100	268	491	365	na	ng/kg ww
PCB-173	3/3	100	C171	C171	nc	na	ng/kg ww
PCB-174	3/3	100	1,060	2,540	1,630	na	ng/kg ww
PCB-175	3/3	100	59.4	126	90.3	na	ng/kg ww
PCB-176	3/3	100	189	363	264	na	ng/kg ww
PCB-177	3/3	100	901	2,060	1,440	na	ng/kg ww
PCB-178	3/3	100	479	904	675	na	ng/kg ww
PCB-179	3/3	100	639	1,310	952	na	ng/kg ww
PCB-180	3/3	100	4,100 C	7,740 C	5,780	na	ng/kg ww
PCB-181	3/3	100	9.66	15.6	12.9	na	ng/kg ww
PCB-182	0/3	0	nd	nd	0.228	0.230 – 0.762	ng/kg ww
PCB-183	3/3	100	1,450 C	2,680 C	2,000	na	ng/kg ww
PCB-184	3/3	100	1.27 J	2.04 J	1.54	na	ng/kg ww
PCB-185	3/3	100	C183	C183	nc	na	ng/kg ww
PCB-186	0/3	0	nd	nd	0.177	0.179 – 0.592	ng/kg ww
PCB-187	3/3	100	2,800	5,530	4,020	na	ng/kg ww
PCB-188	3/3	100	4.57 J	6.15	5.56	na	ng/kg ww
PCB-189	3/3	100	57.7	87.5	71.2	na	ng/kg ww
PCB-190	3/3	100	374	703	532	na	ng/kg ww
PCB-191	3/3	100	87.9	149	117	na	ng/kg ww

Table E.6.3-4, cont. Summary statistics for Dungeness crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-192	0/3	0	nd	nd	0.211	0.213 – 0.705	ng/kg ww
PCB-193	3/3	100	C180	C180	nc	na	ng/kg ww
PCB-194	3/3	100	502	875	657	na	ng/kg ww
PCB-195	3/3	100	169	368	263	na	ng/kg ww
PCB-196	3/3	100	335	653	468	na	ng/kg ww
PCB-197	3/3	100	84.9 C	167 C	116	na	ng/kg ww
PCB-198	3/3	100	594 C	1,060 C	757	na	ng/kg ww
PCB-199	3/3	100	C198	C198	nc	na	ng/kg ww
PCB-200	3/3	100	C197	C197	nc	na	ng/kg ww
PCB-201	3/3	100	132	229	172	na	ng/kg ww
PCB-202	3/3	100	248	375	301	na	ng/kg ww
PCB-203	3/3	100	439	765	572	na	ng/kg ww
PCB-204	3/3	100	0.236 J	0.374 J	0.306	na	ng/kg ww
PCB-205	3/3	100	25.5	44.3	34.2	na	ng/kg ww
PCB-206	3/3	100	119	177	148	na	ng/kg ww
PCB-207	3/3	100	17.1	26.9	21.2	na	ng/kg ww
PCB-208	3/3	100	32.2	49.2	42.5	na	ng/kg ww
PCB-209	3/3	100	11.8	28.5	20.7	na	ng/kg ww
Total PCB congeners	3/3	100	111,000 J	149,300 J	136,000	na	ng/kg ww
Aroclor-1016	0/12	0	nd	nd	7.3	5.3 – 20	µg/kg ww
Aroclor-1016/1242	1/1	100	5.6 J	5.6 J	5.6	na	µg/kg ww
Aroclor-1221	0/12	0	nd	nd	11	5.3 – 29	µg/kg ww
Aroclor-1232	0/12	0	nd	nd	7.3	5.3 – 20	µg/kg ww
Aroclor-1242	0/12	0	nd	nd	7.3	5.3 – 20	µg/kg ww
Aroclor-1248	7/13	54	9.0	67	31	0.21 – 20	µg/kg ww
Aroclor-1254	10/13	77	43 J	130	75	20	µg/kg ww
Aroclor-1260	10/13	77	31 J	120	61	20	µg/kg ww
Total PCBs	10/13	77	80 J	300	160	nc	µg/kg ww
PCB TEQ – Bird	3/3	100	9.37	13.30 J	11.9	na	ng/kg ww
PCB TEQ – Fish	3/3	100	0.1220	0.1500	0.134	na	ng/kg ww
PCB TEQ – Mammal	3/3	100	1.37	1.65	1.47	na	ng/kg ww
Pesticides							
2,4'-DDD	1/7	14	4.0 JN	4.0 JN	3.3	1.5 – 7.2	µg/kg ww
2,4'-DDE	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
2,4'-DDT	7/7	100	8.0 JN	13 JN	10	na	µg/kg ww
4,4'-DDD	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
4,4'-DDE	7/7	100	2.0 JN	2.8 JN	2.3	na	µg/kg ww

Table E.6.3-4, cont. Summary statistics for Dungeness crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
4,4'-DDT	7/7	100	6.5 JN	11 JN	8.2	na	µg/kg ww
Total DDTs	7/7	100	16.9 JN	27 JN	21	nc	µg/kg ww
Aldrin	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
Dieldrin	0/7	0	nd	nd	3.4	4.1 – 7.2	µg/kg ww
Total aldrin/dieldrin	0/7	0	nd	nd	3.4	nc	µg/kg ww
alpha-BHC	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
beta-BHC	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
gamma-BHC	1/7	14	4.0 JN	4.0 JN	3.7	7.2	µg/kg ww
delta-BHC	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
alpha-Chlordane	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
gamma-Chlordane	7/7	100	3.0 JN	5.4 JN	3.9	na	µg/kg ww
alpha-Endosulfan	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
beta-Endosulfan	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
Endosulfan sulfate	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
Endrin	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
Endrin aldehyde	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
Endrin ketone	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
Heptachlor	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
Heptachlor epoxide	6/7	86	1.2 JN	2.3 JN	2.0	7.2	µg/kg ww
Methoxychlor	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
Mirex	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
Toxaphene	0/7	0	nd	nd	160	120 – 360	µg/kg ww
Total chlordane	7/7	100	3.0 JN	5.4 JN	3.9	nc	µg/kg ww
Conventional parameters							
Total solids	12/12	100	15.1	22	18	na	% ww
Lipid	12/12	100	0.146 J	2.4	0.62	na	% ww

Table E.6.3-5. Summary statistics for Dungeness crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	3/4	75	0.0051 J	0.0087	0.0080	0.020	mg/kg ww
Arsenic	4/4	100	3.080	7.0	4.6	na	mg/kg ww
Arsenic (inorganic)	2/2	100	0.050	0.090	0.070	na	mg/kg ww
Cadmium	4/4	100	0.11	0.7880	0.48	na	mg/kg ww
Chromium	2/4	50	0.083	0.16	0.07	0.01 – 0.08	mg/kg ww
Cobalt	3/3	100	0.1680 J	0.3250 J	0.2253	na	mg/kg ww
Copper	4/4	100	17.5	43	29	na	mg/kg ww
Lead	4/4	100	0.037	0.18	0.093	na	mg/kg ww
Mercury	4/4	100	0.026	0.067	0.039	na	mg/kg ww
Molybdenum	3/3	100	0.0840	0.1310	0.106	na	mg/kg ww
Nickel	4/4	100	0.082	0.284 J	0.18	na	mg/kg ww
Selenium	3/3	100	0.23	0.249	0.24	na	mg/kg ww
Silver	4/4	100	0.2460 J	0.50	0.37	na	mg/kg ww
Thallium	2/3	67	0.0004 J	0.0005 J	0.0008	0.0032	mg/kg ww
Vanadium	1/3	33	0.2 J	0.2 J	0.1	0.2 – 0.24	mg/kg ww
Zinc	4/4	100	14.8	22.7	18	na	mg/kg ww
Organometals							
Monobutyltin as ion	2/3	67	1.3 J	1.6	1.2	1.5	µg/kg ww
Dibutyltin as ion	3/3	100	7.7	9.1	8.4	na	µg/kg ww
Tributyltin as ion	4/4	100	16	59	38	na	µg/kg ww
Tetrabutyltin as ion	0/3	0	nd	nd	0.75	1.5	µg/kg ww
PAHs							
2-Chloronaphthalene	0/4	0	nd	nd	220	24 – 580	µg/kg ww
2-Methylnaphthalene	3/4	75	2.1	3.4	10	64	µg/kg ww
Acenaphthene	3/4	75	6.5	12	8.3	16	µg/kg ww
Acenaphthylene	3/4	75	1.7	2.2	4.4	24	µg/kg ww
Anthracene	2/4	50	3.5	3.7	4.9	0.72 – 24	µg/kg ww
Benzo(a)anthracene	1/4	25	1.1	1.1	3.5	0.72 – 24	µg/kg ww
Benzo(a)pyrene	0/4	0	nd	nd	6.1	0.72 – 40	µg/kg ww
Benzo(b)fluoranthene	2/4	50	0.31 J	0.49 J	9.1	7.2 – 64	µg/kg ww
Benzo(g,h,i)perylene	2/4	50	0.28 J	0.90	6.2	7.2 – 40	µg/kg ww
Benzo(k)fluoranthene	2/4	50	0.54 J	0.60 J	9.2	7.2 – 64	µg/kg ww
Total benzofluoranthenes	2/4	50	0.85 J	1.09 J	9.4	nc	µg/kg ww
Chrysene	1/4	25	1.5	1.5	3.6	0.72 – 24	µg/kg ww

Table E.6.3-5, cont. Summary statistics for Dungeness crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Dibenzo(a,h)anthracene	0/4	0	nd	nd	9.1	0.72 – 64	µg/kg ww
Dibenzofuran	3/4	75	2.4	3.8	7.5	40	µg/kg ww
Fluoranthene	1/4	25	3.4	3.4	4.0	0.72 – 24	µg/kg ww
Fluorene	3/4	75	1.5	3.4	4.9	24	µg/kg ww
Indeno(1,2,3-cd)pyrene	2/4	50	0.14 J	0.74	6.1	7.2 – 40	µg/kg ww
Naphthalene	2/4	50	5.2	5.5	11	4.4 – 64	µg/kg ww
Phenanthrene	3/4	75	3.0	7.4	6.4	24	µg/kg ww
Pyrene	1/4	25	1.8	1.8	3.6	0.72 – 24	µg/kg ww
Total HPAH	2/4	50	2.73 J	9.1 J	12	nc	µg/kg ww
Total LPAH	3/4	75	18.7	30	26	nc	µg/kg ww
Carcinogenic PAHs – Mammal	2/4	50	0.73 J	0.73 J	6.5	6.2 – 43	µg/kg ww
Total PAH	3/4	75	18.7	32 J	28	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	0/4	0	nd	nd	36	24 – 130	µg/kg ww
Butyl benzyl phthalate	1/4	25	2,800	2,800	1,000	24 – 1,200	µg/kg ww
Diethyl phthalate	1/4	25	180 J	180 J	350	40 – 1,200	µg/kg ww
Dimethyl phthalate	0/4	0	nd	nd	220	16 – 580	µg/kg ww
Di-n-butyl phthalate	0/4	0	nd	nd	380	40 – 1,200	µg/kg ww
Di-n-octyl phthalate	0/4	0	nd	nd	1,100	24 – 2,900	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/4	0	nd	nd	220	24 – 580	µg/kg ww
1,2-Dichlorobenzene	0/4	0	nd	nd	220	24 – 580	µg/kg ww
1,2-Diphenylhydrazine	0/1	0	nd	nd	40	80	µg/kg ww
1,3-Dichlorobenzene	0/4	0	nd	nd	220	24 – 580	µg/kg ww
1,4-Dichlorobenzene	0/4	0	nd	nd	220	24 – 580	µg/kg ww
2,4,5-Trichlorophenol	0/4	0	nd	nd	1,100	160 – 2,900	µg/kg ww
2,4,6-Trichlorophenol	0/4	0	nd	nd	1,100	160 – 2,900	µg/kg ww
2,4-Dichlorophenol	0/4	0	nd	nd	460	40 – 1,200	µg/kg ww
2,4-Dimethylphenol	0/4	0	nd	nd	460	40 – 1,200	µg/kg ww
2,4-Dinitrophenol	0/4	0	nd	nd	4,500	80 – 12,000	µg/kg ww
2,4-Dinitrotoluene	0/4	0	nd	nd	660	16 – 2,900	µg/kg ww
2,6-Dinitrotoluene	0/4	0	nd	nd	660	16 – 2,900	µg/kg ww
2-Chlorophenol	0/4	0	nd	nd	460	80 – 1,200	µg/kg ww
2-Methylphenol	0/4	0	nd	nd	460	40 – 1,200	µg/kg ww
2-Nitroaniline	0/4	0	nd	nd	1,100	160 – 2,900	µg/kg ww
2-Nitrophenol	0/4	0	nd	nd	1,100	40 – 2,900	µg/kg ww
3,3'-Dichlorobenzidine	0/3	0	nd	nd	15,000	29,000	µg/kg ww

Table E.6.3-5, cont. Summary statistics for Dungeness crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
3-Nitroaniline	0/3	0	nd	nd	2,900	5,700 – 5,800	µg/kg ww
4,6-Dinitro-o-cresol	0/4	0	nd	nd	2,200	80 – 5,800	µg/kg ww
4-Bromophenyl phenyl ether	0/4	0	nd	nd	220	16 – 580	µg/kg ww
4-Chloro-3-methylphenol	0/4	0	nd	nd	1,100	80 – 2,900	µg/kg ww
4-Chloroaniline	0/3	0	nd	nd	1,500	2,900	µg/kg ww
4-Chlorophenyl phenyl ether	0/4	0	nd	nd	220	24 – 580	µg/kg ww
4-Methylphenol	0/4	0	nd	nd	460	40 – 1,200	µg/kg ww
4-Nitroaniline	0/4	0	nd	nd	1,500	160 – 5,700	µg/kg ww
4-Nitrophenol	0/4	0	nd	nd	2,200	80 – 5,800	µg/kg ww
Aniline	0/3	0	nd	nd	6,000	12,000	µg/kg ww
Benzidine	0/1	0	nd	nd	36,000	72,000	µg/kg ww
Benzoic acid	0/4	0	nd	nd	4,500	160 – 12,000	µg/kg ww
Benzyl alcohol	1/4	25	85	85	320	570 – 1,200	µg/kg ww
bis(2-chloroethoxy)methane	0/4	0	nd	nd	510	40 – 2,900	µg/kg ww
bis(2-chloroethyl)ether	0/4	0	nd	nd	300	24 – 1,200	µg/kg ww
bis(2-chloroisopropyl)ether	0/4	0	nd	nd	230	80 – 580	µg/kg ww
Caffeine	0/1	0	nd	nd	4.0	8.0	µg/kg ww
Carbazole	0/4	0	nd	nd	1,100	40 – 2,900	µg/kg ww
Coprostanol	0/1	0	nd	nd	80	160	µg/kg ww
Hexachlorobenzene	1/4	25	3.3 JN	3.3 JN	6.6	7.2 – 24	µg/kg ww
Hexachlorobutadiene	0/4	0	nd	nd	220	40 – 580	µg/kg ww
Hexachlorocyclopentadiene	0/4	0	nd	nd	27,000	40 – 72,000	µg/kg ww
Hexachloroethane	0/4	0	nd	nd	220	40 – 580	µg/kg ww
Isophorone	0/4	0	nd	nd	220	40 – 580	µg/kg ww
Nitrobenzene	0/4	0	nd	nd	220	40 – 580	µg/kg ww
N-Nitrosodimethylamine	0/4	0	nd	nd	2,200	160 – 12,000	µg/kg ww
N-Nitroso-di-n-propylamine	0/4	0	nd	nd	220	40 – 580	µg/kg ww
N-Nitrosodiphenylamine	0/4	0	nd	nd	220	40 – 580	µg/kg ww
Pentachlorophenol	0/4	0	nd	nd	6.4	3.3 – 40	µg/kg ww
Phenol	0/4	0	nd	nd	580	160 – 1,500	µg/kg ww
Polychlorinated biphenyls							
PCB-001	0/2	0	nd	nd	4.16	8.21 – 8.44	ng/kg ww
PCB-002	1/2	50	4.37 J	4.37 J	2.88	2.77	ng/kg ww
PCB-003	0/2	0	nd	nd	4.25	6.51 – 10.5	ng/kg ww
PCB-004	2/2	100	124	183	154	na	ng/kg ww
PCB-005	0/2	0	nd	nd	7.88	15.7 – 15.8	ng/kg ww
PCB-006	2/2	100	149	206	178	na	ng/kg ww

Table E.6.3-5, cont. Summary statistics for Dungeness crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-007	2/2	100	15.3 J	19.7 J	17.5	na	ng/kg ww
PCB-008	2/2	100	339	432	386	na	ng/kg ww
PCB-009	1/2	50	18.2 J	18.2 J	12.8	14.9	ng/kg ww
PCB-010	0/2	0	nd	nd	7.35	14.4 – 15.0	ng/kg ww
PCB-011	1/2	50	40.1	40.1	28.6	34.0	ng/kg ww
PCB-012	2/2	100	70.1 C	70.6 CJ	70.4	na	ng/kg ww
PCB-013	2/2	100	C12	C12	nc	na	ng/kg ww
PCB-014	0/2	0	nd	nd	7.70	15.3 – 15.5	ng/kg ww
PCB-015	2/2	100	679	1,220	950	na	ng/kg ww
PCB-016	2/2	100	357	676	517	na	ng/kg ww
PCB-017	2/2	100	850	1,660	1,260	na	ng/kg ww
PCB-018	2/2	100	2,360 C	4,150 C	3,260	na	ng/kg ww
PCB-019	2/2	100	82.2	93.6	87.9	na	ng/kg ww
PCB-020	2/2	100	12,600 C	22,600 C	17,600	na	ng/kg ww
PCB-021	2/2	100	1,250 C	2,070 C	1,660	na	ng/kg ww
PCB-022	2/2	100	2,190	3,140	2,670	na	ng/kg ww
PCB-023	0/2	0	nd	nd	4.09	8.10 – 8.24	ng/kg ww
PCB-024	2/2	100	16.9 J	27.9 J	22.4	na	ng/kg ww
PCB-025	2/2	100	1,540	2,340	1,940	na	ng/kg ww
PCB-026	2/2	100	4,070 C	6,880 C	5,480	na	ng/kg ww
PCB-027	2/2	100	590	960	775	na	ng/kg ww
PCB-028	2/2	100	C20	C20	nc	na	ng/kg ww
PCB-029	2/2	100	C26	C26	nc	na	ng/kg ww
PCB-030	2/2	100	C18	C18	nc	na	ng/kg ww
PCB-031	2/2	100	10,400	17,900	14,200	na	ng/kg ww
PCB-032	2/2	100	1,300	1,890	1,600	na	ng/kg ww
PCB-033	2/2	100	C21	C21	nc	na	ng/kg ww
PCB-034	2/2	100	40.2	55.8	48.0	na	ng/kg ww
PCB-035	2/2	100	13.3 J	23.2 J	18.3	na	ng/kg ww
PCB-036	0/2	0	nd	nd	3.96	7.81 – 8.01	ng/kg ww
PCB-037	2/2	100	2,160	3,650	2,910	na	ng/kg ww
PCB-038	2/2	100	13.9 J	24.2 J	19.1	na	ng/kg ww
PCB-039	2/2	100	60.7	120	90.4	na	ng/kg ww
PCB-040	2/2	100	4,660 C	8,070 C	6,370	na	ng/kg ww
PCB-041	2/2	100	C40	C40	nc	na	ng/kg ww
PCB-042	2/2	100	4,290	6,650	5,470	na	ng/kg ww
PCB-043	2/2	100	967	1,800	1,380	na	ng/kg ww

Table E.6.3-5, cont. Summary statistics for Dungeness crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-044	2/2	100	29,600 C	41,400 C	35,500	na	ng/kg ww
PCB-045	2/2	100	680 C	1,090 C	885	na	ng/kg ww
PCB-046	2/2	100	184	262	223	na	ng/kg ww
PCB-047	2/2	100	C44	C44	nc	na	ng/kg ww
PCB-048	2/2	100	1,310	3,100	2,210	na	ng/kg ww
PCB-049	2/2	100	20,700 C	37,700 C	29,200	na	ng/kg ww
PCB-050	2/2	100	1,220 C	1,620 C	1,420	na	ng/kg ww
PCB-051	2/2	100	C45	C45	nc	na	ng/kg ww
PCB-052	2/2	100	77,600	101,000	89,300	na	ng/kg ww
PCB-053	2/2	100	C50	C50	nc	na	ng/kg ww
PCB-054	1/2	50	4.97 J	4.97 J	3.03	2.16	ng/kg ww
PCB-055	0/2	0	nd	nd	1,640	96.8 – 6,460	ng/kg ww
PCB-056	2/2	100	5,990	8,280	7,140	na	ng/kg ww
PCB-057	1/2	50	247	247	1,730	6,420	ng/kg ww
PCB-058	1/2	50	329	329	1,710	6,180	ng/kg ww
PCB-059	2/2	100	2,160 C	3,610 C	2,890	na	ng/kg ww
PCB-060	2/2	100	5,640	9,120	7,380	na	ng/kg ww
PCB-061	2/2	100	59,400 C	83,300 C	71,400	na	ng/kg ww
PCB-062	2/2	100	C59	C59	nc	na	ng/kg ww
PCB-063	1/2	50	1,690	1,690	2,400	6,230	ng/kg ww
PCB-064	2/2	100	9,700	14,900	12,300	na	ng/kg ww
PCB-065	2/2	100	C44	C44	nc	na	ng/kg ww
PCB-066	2/2	100	31,200	54,500	42,900	na	ng/kg ww
PCB-067	1/2	50	545	545	1,720	5,790	ng/kg ww
PCB-068	1/2	50	695	695	1,900	6,190	ng/kg ww
PCB-069	2/2	100	C49	C49	nc	na	ng/kg ww
PCB-070	2/2	100	C61	C61	nc	na	ng/kg ww
PCB-071	2/2	100	C40	C40	nc	na	ng/kg ww
PCB-072	1/2	50	1,530	1,530	2,270	6,030	ng/kg ww
PCB-073	1/2	50	391	391	196	2.30	ng/kg ww
PCB-074	2/2	100	C61	C61	nc	na	ng/kg ww
PCB-075	2/2	100	C59	C59	nc	na	ng/kg ww
PCB-076	2/2	100	C61	C61	nc	na	ng/kg ww
PCB-077	2/2	100	2,070	3,060	2,570	na	ng/kg ww
PCB-078	0/2	0	nd	nd	1,670	98.9 – 6,600	ng/kg ww
PCB-079	1/2	50	1,770	1,770	2,210	5,280	ng/kg ww
PCB-080	0/2	0	nd	nd	1,490	88.9 – 5,890	ng/kg ww

Table E.6.3-5, cont. Summary statistics for Dungeness crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-081	2/2	100	91.2	148	120	na	ng/kg ww
PCB-082	2/2	100	5,020	5,050	5,040	na	ng/kg ww
PCB-083	2/2	100	111,000 C	128,000 C	120,000	na	ng/kg ww
PCB-084	2/2	100	14,600	15,300	15,000	na	ng/kg ww
PCB-085	2/2	100	21,500 C	24,100 C	22,800	na	ng/kg ww
PCB-086	2/2	100	67,300 C	70,800 C	69,100	na	ng/kg ww
PCB-087	2/2	100	C86	C86	nc	na	ng/kg ww
PCB-088	2/2	100	14,500 C	14,500 C	14,500	na	ng/kg ww
PCB-089	2/2	100	82.9	104	93.5	na	ng/kg ww
PCB-090	2/2	100	203,000 C	215,000 C	209,000	na	ng/kg ww
PCB-091	2/2	100	C88	C88	nc	na	ng/kg ww
PCB-092	2/2	100	41,800	42,200	42,000	na	ng/kg ww
PCB-093	2/2	100	80,700 C	86,100 C	83,400	na	ng/kg ww
PCB-094	2/2	100	239	241	240	na	ng/kg ww
PCB-095	2/2	100	C93	C93	nc	na	ng/kg ww
PCB-096	2/2	100	76.5	83.0	79.8	na	ng/kg ww
PCB-097	2/2	100	C86	C86	nc	na	ng/kg ww
PCB-098	2/2	100	C93	C93	nc	na	ng/kg ww
PCB-099	2/2	100	C83	C83	nc	na	ng/kg ww
PCB-100	2/2	100	C93	C93	nc	na	ng/kg ww
PCB-101	2/2	100	C90	C90	nc	na	ng/kg ww
PCB-102	2/2	100	C93	C93	nc	na	ng/kg ww
PCB-103	2/2	100	1,930	1,930	1,930	na	ng/kg ww
PCB-104	2/2	100	3.72 J	6.15 J	4.94	na	ng/kg ww
PCB-105	2/2	100	49,000	56,300	52,700	na	ng/kg ww
PCB-106	0/2	0	nd	nd	40.4	79.4 – 82.3	ng/kg ww
PCB-107	2/2	100	4,690 C	4,840 C	4,770	na	ng/kg ww
PCB-108	2/2	100	C86	C86	nc	na	ng/kg ww
PCB-109	2/2	100	12,200	14,800	13,500	na	ng/kg ww
PCB-110	2/2	100	148,000 C	158,000 C	153,000	na	ng/kg ww
PCB-111	2/2	100	118	167	143	na	ng/kg ww
PCB-112	0/2	0	nd	nd	6.12	8.86 – 15.6	ng/kg ww
PCB-113	2/2	100	C90	C90	nc	na	ng/kg ww
PCB-114	2/2	100	2,840	2,990	2,920	na	ng/kg ww
PCB-115	2/2	100	C110	C110	nc	na	ng/kg ww
PCB-116	2/2	100	C85	C85	nc	na	ng/kg ww
PCB-117	2/2	100	C85	C85	nc	na	ng/kg ww

Table E.6.3-5, cont. Summary statistics for Dungeness crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-118	2/2	100	167,000	188,000	178,000	na	ng/kg ww
PCB-119	2/2	100	C86	C86	nc	na	ng/kg ww
PCB-120	2/2	100	349	382	366	na	ng/kg ww
PCB-121	2/2	100	25.8 J	30.0 J	27.9	na	ng/kg ww
PCB-122	2/2	100	787	1,280	1,030	na	ng/kg ww
PCB-123	2/2	100	2,280	2,400	2,340	na	ng/kg ww
PCB-124	2/2	100	C107	C107	nc	na	ng/kg ww
PCB-125	2/2	100	C86	C86	nc	na	ng/kg ww
PCB-126	2/2	100	189	241	215	na	ng/kg ww
PCB-127	2/2	100	449	478	464	na	ng/kg ww
PCB-128	2/2	100	33,100 C	33,800 C	33,500	na	ng/kg ww
PCB-129	2/2	100	349,000 C	372,000 C	361,000	na	ng/kg ww
PCB-130	2/2	100	14,500	17,000	15,800	na	ng/kg ww
PCB-131	2/2	100	1,460	1,500	1,480	na	ng/kg ww
PCB-132	2/2	100	38,500	46,100	42,300	na	ng/kg ww
PCB-133	2/2	100	6,430	6,930	6,680	na	ng/kg ww
PCB-134	2/2	100	9,590 C	9,750 C	9,670	na	ng/kg ww
PCB-135	2/2	100	98,900 C	104,000 C	101,000	na	ng/kg ww
PCB-136	2/2	100	12,400	13,100	12,800	na	ng/kg ww
PCB-137	2/2	100	10,100	11,700	10,900	na	ng/kg ww
PCB-138	2/2	100	C129	C129	nc	na	ng/kg ww
PCB-139	2/2	100	2,510 C	3,430 C	2,970	na	ng/kg ww
PCB-140	2/2	100	C139	C139	nc	na	ng/kg ww
PCB-141	2/2	100	47,200	52,200	49,700	na	ng/kg ww
PCB-142	0/2	0	nd	nd	35.5	68.9 – 73.2	ng/kg ww
PCB-143	2/2	100	C134	C134	nc	na	ng/kg ww
PCB-144	2/2	100	9,380	9,450	9,420	na	ng/kg ww
PCB-145	0/2	0	nd	nd	0.149	0.251 – 0.346	ng/kg ww
PCB-146	2/2	100	57,500	68,900	63,200	na	ng/kg ww
PCB-147	2/2	100	183,000 C	228,000 C	206,000	na	ng/kg ww
PCB-148	2/2	100	547	638	593	na	ng/kg ww
PCB-149	2/2	100	C147	C147	nc	na	ng/kg ww
PCB-150	2/2	100	349	367	358	na	ng/kg ww
PCB-151	2/2	100	C135	C135	nc	na	ng/kg ww
PCB-152	2/2	100	61.9	66.4	64.2	na	ng/kg ww
PCB-153	2/2	100	364,000 C	401,000 C	383,000	na	ng/kg ww
PCB-154	2/2	100	C135	C135	nc	na	ng/kg ww

Table E.6.3-5, cont. Summary statistics for Dungeness crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-155	2/2	100	17.7 J	31.3 J	24.5	na	ng/kg ww
PCB-156	2/2	100	27,900 C	30,700 C	29,300	na	ng/kg ww
PCB-157	2/2	100	C156	C156	nc	na	ng/kg ww
PCB-158	2/2	100	27,600	28,800	28,200	na	ng/kg ww
PCB-159	2/2	100	1,500	3,130	2,320	na	ng/kg ww
PCB-160	2/2	100	C129	C129	nc	na	ng/kg ww
PCB-161	0/2	0	nd	nd	25.0	49.9	ng/kg ww
PCB-162	2/2	100	691	845	768	na	ng/kg ww
PCB-163	2/2	100	C129	C129	nc	na	ng/kg ww
PCB-164	2/2	100	15,100	18,200	16,700	na	ng/kg ww
PCB-165	2/2	100	171	190	181	na	ng/kg ww
PCB-166	2/2	100	C128	C128	nc	na	ng/kg ww
PCB-167	2/2	100	10,300	12,200	11,300	na	ng/kg ww
PCB-168	2/2	100	C153	C153	nc	na	ng/kg ww
PCB-169	1/2	50	8.56	8.56	5.91	6.53	ng/kg ww
PCB-170	2/2	100	71,000	77,400	74,200	na	ng/kg ww
PCB-171	2/2	100	22,200 C	24,700 C	23,500	na	ng/kg ww
PCB-172	2/2	100	12,900	15,800	14,400	na	ng/kg ww
PCB-173	2/2	100	C171	C171	nc	na	ng/kg ww
PCB-174	2/2	100	30,200	65,000	47,600	na	ng/kg ww
PCB-175	2/2	100	2,570	3,340	2,960	na	ng/kg ww
PCB-176	2/2	100	5,100	6,530	5,820	na	ng/kg ww
PCB-177	2/2	100	39,700	56,100	47,900	na	ng/kg ww
PCB-178	2/2	100	20,900	25,900	23,400	na	ng/kg ww
PCB-179	2/2	100	24,800	29,200	27,000	na	ng/kg ww
PCB-180	2/2	100	205,000 C	249,000 C	227,000	na	ng/kg ww
PCB-181	2/2	100	462	518	490	na	ng/kg ww
PCB-182	2/2	100	653	739	696	na	ng/kg ww
PCB-183	2/2	100	56,800 C	72,700 C	64,800	na	ng/kg ww
PCB-184	2/2	100	28.7 J	34.1 J	31.4	na	ng/kg ww
PCB-185	2/2	100	C183	C183	nc	na	ng/kg ww
PCB-186	0/2	0	nd	nd	1.14	1.77 – 2.78	ng/kg ww
PCB-187	2/2	100	130,000	159,000	145,000	na	ng/kg ww
PCB-188	2/2	100	148	170	159	na	ng/kg ww
PCB-189	2/2	100	2,240	2,520	2,380	na	ng/kg ww
PCB-190	2/2	100	17,300	20,300	18,800	na	ng/kg ww
PCB-191	2/2	100	3,680	4,000	3,840	na	ng/kg ww

Table E.6.3-5, cont. Summary statistics for Dungeness crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-192	0/2	0	nd	nd	1.32	1.96 – 3.32	ng/kg ww
PCB-193	2/2	100	C180	C180	nc	na	ng/kg ww
PCB-194	2/2	100	22,200	28,200	25,200	na	ng/kg ww
PCB-195	2/2	100	8,900	10,900	9,900	na	ng/kg ww
PCB-196	2/2	100	12,800	18,800	15,800	na	ng/kg ww
PCB-197	2/2	100	2,930 C	4,370 C	3,650	na	ng/kg ww
PCB-198	2/2	100	21,800 C	33,500 C	27,700	na	ng/kg ww
PCB-199	2/2	100	C198	C198	nc	na	ng/kg ww
PCB-200	2/2	100	C197	C197	nc	na	ng/kg ww
PCB-201	2/2	100	3,800	5,170	4,490	na	ng/kg ww
PCB-202	2/2	100	6,900	9,150	8,030	na	ng/kg ww
PCB-203	2/2	100	17,600	25,100	21,400	na	ng/kg ww
PCB-204	2/2	100	9.07 J	9.64 J	9.36	na	ng/kg ww
PCB-205	2/2	100	1,000	1,280	1,140	na	ng/kg ww
PCB-206	2/2	100	3,550	4,650	4,100	na	ng/kg ww
PCB-207	2/2	100	458	596	527	na	ng/kg ww
PCB-208	2/2	100	805	1,020	913	na	ng/kg ww
PCB-209	2/2	100	318	368	343	na	ng/kg ww
Total PCB congeners	2/2	100	3,618,000 J	3,622,000 J	3,620,000	nc	ng/kg ww
Aroclor-1016	0/7	0	nd	nd	56	40 – 150	µg/kg ww
Aroclor-1221	0/7	0	nd	nd	86	40 – 290	µg/kg ww
Aroclor-1232	0/7	0	nd	nd	56	40 – 150	µg/kg ww
Aroclor-1242	0/7	0	nd	nd	56	40 – 150	µg/kg ww
Aroclor-1248	4/7	57	120	620	300	100	µg/kg ww
Aroclor-1254	7/7	100	730	1,800	1,200	na	µg/kg ww
Aroclor-1260	7/7	100	450	3,100	1,300	na	µg/kg ww
Total PCBs	7/7	100	1,310	5,500	2,800	nc	µg/kg ww
PCB TEQ – Bird	2/2	100	141.0	203.0	172	na	ng/kg ww
PCB TEQ – Fish	2/2	100	2.510	3.060	2.79	na	ng/kg ww
PCB TEQ – Mammal	2/2	100	27.1	33.6	30.4	na	ng/kg ww
Pesticides							
2,4'-DDD	0/3	0	nd	nd	13	22 – 28	µg/kg ww
2,4'-DDE	0/3	0	nd	nd	12	15 – 32	µg/kg ww
2,4'-DDT	3/3	100	150 JN	210 JN	180	na	µg/kg ww
4,4'-DDD	2/3	67	6.1 JN	6.6 JN	6.7	15	µg/kg ww
4,4'-DDE	3/3	100	15 JN	46 JN	34	na	µg/kg ww

Table E.6.3-5, cont. Summary statistics for Dungeness crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
4,4'-DDT	3/3	100	120 JN	180 JN	150	na	µg/kg ww
Total DDTs	3/3	100	290 JN	440 JN	370	nc	µg/kg ww
Aldrin	0/3	0	nd	nd	4.9	7.2 – 15	µg/kg ww
Dieldrin	0/3	0	nd	nd	9.4	7.2 – 34	µg/kg ww
Total aldrin/dieldrin	0/3	0	nd	nd	9.4	nc	µg/kg ww
alpha-BHC	0/3	0	nd	nd	4.9	7.2 – 15	µg/kg ww
beta-BHC	0/3	0	nd	nd	4.9	7.2 – 15	µg/kg ww
gamma-BHC	0/3	0	nd	nd	4.9	7.2 – 15	µg/kg ww
delta-BHC	0/3	0	nd	nd	4.9	7.2 – 15	µg/kg ww
alpha-Chlordane	0/3	0	nd	nd	4.9	7.2 – 15	µg/kg ww
gamma-Chlordane	3/3	100	49 JN	73 JN	62	na	µg/kg ww
alpha-Endosulfan	0/3	0	nd	nd	4.9	7.2 – 15	µg/kg ww
beta-Endosulfan	0/3	0	nd	nd	5.8	8.7 – 15	µg/kg ww
Endosulfan sulfate	0/3	0	nd	nd	4.9	7.2 – 15	µg/kg ww
Endrin	0/3	0	nd	nd	6.1	9.4 – 15	µg/kg ww
Endrin aldehyde	0/3	0	nd	nd	5.0	7.2 – 15	µg/kg ww
Endrin ketone	0/3	0	nd	nd	7.0	13 – 15	µg/kg ww
Heptachlor	0/3	0	nd	nd	4.9	7.2 – 15	µg/kg ww
Heptachlor epoxide	1/3	33	12 JN	12 JN	8.3	11 – 15	µg/kg ww
Methoxychlor	0/3	0	nd	nd	5.7	7.2 – 15	µg/kg ww
Mirex	0/3	0	nd	nd	4.9	7.2 – 15	µg/kg ww
Toxaphene	0/3	0	nd	nd	1,000	1,900 – 2,200	µg/kg ww
Total chlordane	3/3	100	49 JN	73 JN	62	nc	µg/kg ww
Conventional parameters							
Total solids	7/7	100	14.20	25.53	20	na	% ww
Lipid	7/7	100	4.28 J	13	7.1	na	% ww

Table E.6.3-6. Summary statistics for Dungeness crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	7/9	78	0.0026 JM	0.0051 JM	0.0041	0.010	mg/kg ww
Arsenic	9/9	100	2.707 M	11.0 M	5.2	na	mg/kg ww
Arsenic (inorganic)	2/2	100	0.022 JM	0.035 M	0.029	na	mg/kg ww
Cadmium	9/9	100	0.04 M	0.2646 M	0.15	na	mg/kg ww
Chromium	3/9	33	0.120 M	0.140 M	0.06	0.03 – 0.04	mg/kg ww
Cobalt	7/7	100	0.0754 JM	0.1515 JM	0.09721	na	mg/kg ww
Copper	9/9	100	11.5 M	24 M	16	na	mg/kg ww
Lead	9/9	100	0.020 M	0.22 JM	0.075	na	mg/kg ww
Mercury	9/9	100	0.032 M	0.097 M	0.054	na	mg/kg ww
Molybdenum	7/7	100	0.0336 M	0.0522 M	0.0395	na	mg/kg ww
Nickel	9/9	100	0.041 JM	0.16 JM	0.077	na	mg/kg ww
Selenium	7/7	100	0.15 M	0.198 M	0.17	na	mg/kg ww
Silver	9/9	100	0.1442 JM	0.29 M	0.20	na	mg/kg ww
Thallium	4/7	57	0.0030 JM	0.0030 JM	0.002	0.0015 – 0.0018	mg/kg ww
Vanadium	3/7	43	0.2 JM	0.2 JM	0.1	0.1 – 0.11	mg/kg ww
Zinc	9/9	100	24.6 M	33 M	29	na	mg/kg ww
Organometals							
Monobutyltin as ion	6/7	86	1.4 JM	1.5 M	1.3	0.8	µg/kg ww
Dibutyltin as ion	7/7	100	3.4 M	3.9 M	3.6	na	µg/kg ww
Tributyltin as ion	9/9	100	6 JM	75 M	22	na	µg/kg ww
Tetrabutyltin as ion	0/7	0	nd	nd	0.38	0.8	µg/kg ww
PAHs							
2-Chloronaphthalene	0/9	0	nd	nd	110	9 – 290	µg/kg ww
2-Methylnaphthalene	7/9	78	1.0 M	1.8 M	4.0	25	µg/kg ww
Acenaphthene	7/9	78	2.2 JM	4 M	3.2	6	µg/kg ww
Acenaphthylene	7/9	78	0.7 JM	1.2 M	1.6	9	µg/kg ww

Table E.6.3-6, cont. Summary statistics for Dungeness crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Anthracene	7/9	78	0.41 JM	1.7 M	2.0	9	µg/kg ww
Benzo(a)anthracene	6/9	67	0.31 JM	0.8 JM	1.3	0.36 – 9	µg/kg ww
Benzo(a)pyrene	2/9	22	0.42 JM	0.63 JM	2.1	0.36 – 16	µg/kg ww
Benzo(b)fluoranthene	6/9	67	0.23 JM	0.65 JM	3.2	1.4 – 25	µg/kg ww
Benzo(g,h,i)perylene	6/9	67	0.40 JM	0.78 M	2.3	1.4 – 16	µg/kg ww
Benzo(k)fluoranthene	6/9	67	0.36 JM	0.68 JM	3.2	1.4 – 25	µg/kg ww
Total benzofluoranthenes	6/9	67	0.42 JM	0.84 JM	3.3	nc	µg/kg ww
Chrysene	6/9	67	0.33 JM	1.0 M	1.4	0.36 – 9	µg/kg ww
Dibenzo(a,h)anthracene	1/9	11	0.31 JM	0.31 JM	3.0	0.36 – 25	µg/kg ww
Dibenzofuran	7/9	78	1.0 JM	1.7 JM	2.9	16	µg/kg ww
Fluoranthene	7/9	78	0.39 JM	3.1 M	1.9	9	µg/kg ww
Fluorene	7/9	78	0.7 JM	1.6 M	1.9	9	µg/kg ww
Indeno(1,2,3-cd)pyrene	6/9	67	0.30 JM	0.73 M	2.2	1.4 – 16	µg/kg ww
Naphthalene	6/9	67	3.1 M	3.2 M	4.9	1.2 – 25	µg/kg ww
Phenanthrene	7/9	78	1.3 M	5.0 M	2.7	9	µg/kg ww
Pyrene	7/9	78	0.42 JM	2.3 M	1.7	9	µg/kg ww
Total HPAH	7/9	78	1.21 JM	9.3 JM	5.6	nc	µg/kg ww
Total LPAH	7/9	78	6.5 JM	12.9 JM	10	nc	µg/kg ww
Carcinogenic PAHs – Mammal	7/9	78	0.60 JM	2.4 JM	2.6	17	µg/kg ww
Total PAH	7/9	78	7.2 JM	22.2 JM	13	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	0/9	0	nd	nd	16	9 – 55	µg/kg ww
Butyl benzyl phthalate	1/9	11	1,700 M	1,700 M	390	9 – 600	µg/kg ww
Diethyl phthalate	1/9	11	190 JM	190 JM	220	16 – 600	µg/kg ww
Dimethyl phthalate	0/9	0	nd	nd	110	6 – 290	µg/kg ww
Di-n-butyl phthalate	2/9	22	340 M	700 JM	200	16 – 300	µg/kg ww
Di-n-octyl phthalate	0/9	0	nd	nd	580	9 – 1,500	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/9	0	nd	nd	110	9 – 290	µg/kg ww

Table E.6.3-6, cont. Summary statistics for Dungeness crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,2-Dichlorobenzene	0/9	0	nd	nd	110	9 – 290	µg/kg ww
1,2-Diphenylhydrazine	0/2	0	nd	nd	16	31	µg/kg ww
1,3-Dichlorobenzene	0/9	0	nd	nd	110	9 – 290	µg/kg ww
1,4-Dichlorobenzene	0/9	0	nd	nd	110	9 – 290	µg/kg ww
2,4,5-Trichlorophenol	0/9	0	nd	nd	590	60 – 1,500	µg/kg ww
2,4,6-Trichlorophenol	0/9	0	nd	nd	590	60 – 1,500	µg/kg ww
2,4-Dichlorophenol	0/9	0	nd	nd	240	16 – 600	µg/kg ww
2,4-Dimethylphenol	0/9	0	nd	nd	240	16 – 600	µg/kg ww
2,4-Dinitrophenol	0/9	0	nd	nd	2,300	31 – 6,000	µg/kg ww
2,4-Dinitrotoluene	0/9	0	nd	nd	280	6 – 1,500	µg/kg ww
2,6-Dinitrotoluene	0/9	0	nd	nd	280	6 – 1,500	µg/kg ww
2-Chlorophenol	0/9	0	nd	nd	240	31 – 600	µg/kg ww
2-Methylphenol	0/9	0	nd	nd	240	16 – 600	µg/kg ww
2-Nitroaniline	0/9	0	nd	nd	590	60 – 1,500	µg/kg ww
2-Nitrophenol	0/9	0	nd	nd	590	16 – 1,500	µg/kg ww
3,3'-Dichlorobenzidine	0/7	0	nd	nd	7,500	15,000	µg/kg ww
3-Nitroaniline	0/7	0	nd	nd	1,500	2,900	µg/kg ww
4,6-Dinitro-o-cresol	0/9	0	nd	nd	1,100	31 – 2,900	µg/kg ww
4-Bromophenyl phenyl ether	0/9	0	nd	nd	110	6 – 290	µg/kg ww
4-Chloro-3-methylphenol	0/9	0	nd	nd	590	31 – 1,500	µg/kg ww
4-Chloroaniline	0/7	0	nd	nd	750	1,500	µg/kg ww
4-Chlorophenyl phenyl ether	0/9	0	nd	nd	110	9 – 290	µg/kg ww
4-Methylphenol	0/9	0	nd	nd	240	16 – 600	µg/kg ww
4-Nitroaniline	0/7	0	nd	nd	850	1,500 – 2,900	µg/kg ww
4-Nitrophenol	0/9	0	nd	nd	1,100	31 – 2,900	µg/kg ww
Aniline	0/7	0	nd	nd	3,000	6,000	µg/kg ww
Benzidine	0/1	0	nd	nd	18,000	36,000	µg/kg ww
Benzoic acid	0/9	0	nd	nd	2,300	60 – 6,000	µg/kg ww
Benzyl alcohol	2/9	22	45 M	45 M	140	290 – 600	µg/kg ww

Table E.6.3-6, cont. Summary statistics for Dungeness crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
bis(2-chloroethoxy)methane	0/9	0	nd	nd	180	16 – 1,500	µg/kg ww
bis(2-chloroethyl)ether	0/9	0	nd	nd	130	9 – 600	µg/kg ww
bis(2-chloroisopropyl)ether	0/9	0	nd	nd	120	31 – 290	µg/kg ww
Caffeine	0/2	0	nd	nd	1.6	3.1	µg/kg ww
Carbazole	0/9	0	nd	nd	590	16 – 1,500	µg/kg ww
Coprostanol	0/2	0	nd	nd	32	60	µg/kg ww
Hexachlorobenzene	4/9	44	5 JNM	6.0 JNM	4.2	3.6 – 9	µg/kg ww
Hexachlorobutadiene	0/9	0	nd	nd	110	16 – 290	µg/kg ww
Hexachlorocyclopentadiene	0/9	0	nd	nd	14,000	16 – 36,000	µg/kg ww
Hexachloroethane	0/9	0	nd	nd	110	16 – 290	µg/kg ww
Isophorone	0/9	0	nd	nd	110	16 – 290	µg/kg ww
Nitrobenzene	0/9	0	nd	nd	110	16 – 290	µg/kg ww
N-Nitrosodimethylamine	0/9	0	nd	nd	840	60 – 6,000	µg/kg ww
N-Nitroso-di-n-propylamine	0/9	0	nd	nd	110	16 – 290	µg/kg ww
N-Nitrosodiphenylamine	0/9	0	nd	nd	110	16 – 290	µg/kg ww
Pentachlorophenol	0/9	0	nd	nd	2.6	1.7 – 16	µg/kg ww
Phenol	0/9	0	nd	nd	300	60 – 800	µg/kg ww
Polychlorinated biphenyls							
PCB-001	2/2	100	3.48 JM	3.98 JM	3.73	na	ng/kg ww
PCB-002	2/2	100	1.30 JM	1.70 JM	1.50	na	ng/kg ww
PCB-003	2/2	100	3.12 JM	4.0 JM	3.58	na	ng/kg ww
PCB-004	2/2	100	43 M	67 M	55.4	na	ng/kg ww
PCB-005	2/2	100	5.3 JM	6.4 JM	5.87	na	ng/kg ww
PCB-006	2/2	100	58 M	91 M	74.4	na	ng/kg ww
PCB-007	2/2	100	5.5 JM	8.3 JM	6.90	na	ng/kg ww
PCB-008	2/2	100	123 M	175 M	149	na	ng/kg ww
PCB-009	2/2	100	6.6 JM	6.7 JM	6.64	na	ng/kg ww
PCB-010	2/2	100	4.8 JM	5.5 JM	5.15	na	ng/kg ww
PCB-011	2/2	100	16.6 M	17.6 M	17.1	na	ng/kg ww

Table E.6.3-6, cont. Summary statistics for Dungeness crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-012	2/2	100	29.3 CJM	32.8 CM	31.1	na	ng/kg ww
PCB-013	2/2	100	C12	C12	nc	na	ng/kg ww
PCB-014	0/2	0	nd	nd	1.25	2.5	ng/kg ww
PCB-015	2/2	100	344 M	600 M	472	na	ng/kg ww
PCB-016	2/2	100	126 M	256 M	191	na	ng/kg ww
PCB-017	2/2	100	292 M	590 M	442	na	ng/kg ww
PCB-018	2/2	100	810 CM	1,490 CM	1,150	na	ng/kg ww
PCB-019	2/2	100	29.2 M	32.1 JM	30.7	na	ng/kg ww
PCB-020	2/2	100	5,100 CM	9,200 CM	7,160	na	ng/kg ww
PCB-021	2/2	100	510 CM	910 CM	713	na	ng/kg ww
PCB-022	2/2	100	840 M	1,290 M	1,070	na	ng/kg ww
PCB-023	0/2	0	nd	nd	0.815	1.55 – 1.71	ng/kg ww
PCB-024	2/2	100	6.9 JM	13.3 JM	10.1	na	ng/kg ww
PCB-025	2/2	100	550 M	890 M	715	na	ng/kg ww
PCB-026	2/2	100	1,400 CM	2,490 CM	1,950	na	ng/kg ww
PCB-027	2/2	100	201 M	352 M	277	na	ng/kg ww
PCB-028	2/2	100	C20	C20	nc	na	ng/kg ww
PCB-029	2/2	100	C26	C26	nc	na	ng/kg ww
PCB-030	2/2	100	C18	C18	nc	na	ng/kg ww
PCB-031	2/2	100	3,800 M	6,800 M	5,280	na	ng/kg ww
PCB-032	2/2	100	450 M	690 M	569	na	ng/kg ww
PCB-033	2/2	100	C21	C21	nc	na	ng/kg ww
PCB-034	2/2	100	14.4 JM	21.4 M	17.9	na	ng/kg ww
PCB-035	2/2	100	6.7 JM	12.0 JM	9.34	na	ng/kg ww
PCB-036	0/2	0	nd	nd	0.810	1.54 – 1.70	ng/kg ww
PCB-037	2/2	100	980 M	1,670 M	1,320	na	ng/kg ww
PCB-038	2/2	100	4.9 JM	8.5 JM	6.68	na	ng/kg ww
PCB-039	2/2	100	20.5 JM	43 M	31.8	na	ng/kg ww
PCB-040	2/2	100	1,620 CM	2,880 CM	2,250	na	ng/kg ww

Table E.6.3-6, cont. Summary statistics for Dungeness crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-041	2/2	100	C40	C40	nc	na	ng/kg ww
PCB-042	2/2	100	1,460 M	2,310 M	1,890	na	ng/kg ww
PCB-043	2/2	100	350 M	640 M	497	na	ng/kg ww
PCB-044	2/2	100	10,100 CM	14,300 CM	12,200	na	ng/kg ww
PCB-045	2/2	100	234 CM	380 CM	308	na	ng/kg ww
PCB-046	2/2	100	65 M	92 M	78.3	na	ng/kg ww
PCB-047	2/2	100	C44	C44	nc	na	ng/kg ww
PCB-048	2/2	100	470 M	1,110 M	789	na	ng/kg ww
PCB-049	2/2	100	7,000 CM	13,000 CM	9,980	na	ng/kg ww
PCB-050	2/2	100	410 CM	560 CM	488	na	ng/kg ww
PCB-051	2/2	100	C45	C45	nc	na	ng/kg ww
PCB-052	2/2	100	26,000 M	34,000 M	30,200	na	ng/kg ww
PCB-053	2/2	100	C50	C50	nc	na	ng/kg ww
PCB-054	1/2	50	1.63 JM	1.63 JM	0.908	0.37	ng/kg ww
PCB-055	0/2	0	nd	nd	254	15.8 – 1,000	ng/kg ww
PCB-056	2/2	100	2,130 M	3,030 M	2,580	na	ng/kg ww
PCB-057	2/2	100	85 M	2,010 M	1,050	na	ng/kg ww
PCB-058	2/2	100	113 M	1,930 M	1,020	na	ng/kg ww
PCB-059	2/2	100	750 CM	1,290 CM	1,020	na	ng/kg ww
PCB-060	2/2	100	2,110 M	3,420 M	2,770	na	ng/kg ww
PCB-061	2/2	100	21,400 CM	30,400 CM	25,900	na	ng/kg ww
PCB-062	2/2	100	C59	C59	nc	na	ng/kg ww
PCB-063	2/2	100	590 M	2,050 M	1,320	na	ng/kg ww
PCB-064	2/2	100	3,360 M	5,300 M	4,310	na	ng/kg ww
PCB-065	2/2	100	C44	C44	nc	na	ng/kg ww
PCB-066	2/2	100	11,900 M	20,500 M	16,200	na	ng/kg ww
PCB-067	2/2	100	193 M	1,840 M	1,020	na	ng/kg ww
PCB-068	2/2	100	235 M	1,950 M	1,090	na	ng/kg ww
PCB-069	2/2	100	C49	C49	nc	na	ng/kg ww

Table E.6.3-6, cont. Summary statistics for Dungeness crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-070	2/2	100	C61	C61	nc	na	ng/kg ww
PCB-071	2/2	100	C40	C40	nc	na	ng/kg ww
PCB-072	2/2	100	510 M	1,930 M	1,220	na	ng/kg ww
PCB-073	1/2	50	121 M	121 M	60.6	0.40	ng/kg ww
PCB-074	2/2	100	C61	C61	nc	na	ng/kg ww
PCB-075	2/2	100	C59	C59	nc	na	ng/kg ww
PCB-076	2/2	100	C61	C61	nc	na	ng/kg ww
PCB-077	2/2	100	740 M	1,100 M	922	na	ng/kg ww
PCB-078	0/2	0	nd	nd	259	16.1 – 1,020	ng/kg ww
PCB-079	2/2	100	600 M	1,700 M	1,150	na	ng/kg ww
PCB-080	0/2	0	nd	nd	232	14.5 – 910	ng/kg ww
PCB-081	2/2	100	35.7 M	54 M	44.7	na	ng/kg ww
PCB-082	2/2	100	1,750 M	1,770 M	1,760	na	ng/kg ww
PCB-083	2/2	100	37,000 CM	44,000 CM	40,500	na	ng/kg ww
PCB-084	2/2	100	5,000 M	5,200 M	5,110	na	ng/kg ww
PCB-085	2/2	100	7,200 CM	8,200 CM	7,740	na	ng/kg ww
PCB-086	2/2	100	22,900 CM	24,400 CM	23,700	na	ng/kg ww
PCB-087	2/2	100	C86	C86	nc	na	ng/kg ww
PCB-088	2/2	100	4,900 CM	5,000 CM	4,910	na	ng/kg ww
PCB-089	2/2	100	29.1 M	36 M	32.6	na	ng/kg ww
PCB-090	2/2	100	69,000 CM	73,000 CM	70,700	na	ng/kg ww
PCB-091	2/2	100	C88	C88	nc	na	ng/kg ww
PCB-092	2/2	100	13,900 M	14,200 M	14,100	na	ng/kg ww
PCB-093	2/2	100	27,400 CM	28,900 CM	28,200	na	ng/kg ww
PCB-094	2/2	100	81 M	84 M	82.4	na	ng/kg ww
PCB-095	2/2	100	C93	C93	nc	na	ng/kg ww
PCB-096	2/2	100	25.9 JM	28.2 JM	27.1	na	ng/kg ww
PCB-097	2/2	100	C86	C86	nc	na	ng/kg ww
PCB-098	2/2	100	C93	C93	nc	na	ng/kg ww

Table E.6.3-6, cont. Summary statistics for Dungeness crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-099	2/2	100	C83	C83	nc	na	ng/kg ww
PCB-100	2/2	100	C93	C93	nc	na	ng/kg ww
PCB-101	2/2	100	C90	C90	nc	na	ng/kg ww
PCB-102	2/2	100	C93	C93	nc	na	ng/kg ww
PCB-103	2/2	100	640 M	660 M	650	na	ng/kg ww
PCB-104	2/2	100	1.31 JM	2.14 JM	1.73	na	ng/kg ww
PCB-105	2/2	100	16,700 M	19,300 M	18,000	na	ng/kg ww
PCB-106	0/2	0	nd	nd	6.78	13.4 – 13.7	ng/kg ww
PCB-107	2/2	100	1,590 CM	1,620 CM	1,610	na	ng/kg ww
PCB-108	2/2	100	C86	C86	nc	na	ng/kg ww
PCB-109	2/2	100	4,100 M	5,000 M	4,540	na	ng/kg ww
PCB-110	2/2	100	50,000 CM	53,000 CM	51,700	na	ng/kg ww
PCB-111	2/2	100	42 M	56 M	48.7	na	ng/kg ww
PCB-112	0/2	0	nd	nd	1.41	1.94 – 3.7	ng/kg ww
PCB-113	2/2	100	C90	C90	nc	na	ng/kg ww
PCB-114	2/2	100	1,000 M	1,070 M	1,030	na	ng/kg ww
PCB-115	2/2	100	C110	C110	nc	na	ng/kg ww
PCB-116	2/2	100	C85	C85	nc	na	ng/kg ww
PCB-117	2/2	100	C85	C85	nc	na	ng/kg ww
PCB-118	2/2	100	57,000 M	64,000 M	60,200	na	ng/kg ww
PCB-119	2/2	100	C86	C86	nc	na	ng/kg ww
PCB-120	2/2	100	117 M	126 M	122	na	ng/kg ww
PCB-121	2/2	100	9.1 JM	11.8 JM	10.5	na	ng/kg ww
PCB-122	2/2	100	312 M	460 M	385	na	ng/kg ww
PCB-123	2/2	100	760 M	820 M	794	na	ng/kg ww
PCB-124	2/2	100	C107	C107	nc	na	ng/kg ww
PCB-125	2/2	100	C86	C86	nc	na	ng/kg ww
PCB-126	2/2	100	66 M	83 M	74.5	na	ng/kg ww
PCB-127	2/2	100	151 M	164 M	158	na	ng/kg ww

Table E.6.3-6, cont. Summary statistics for Dungeness crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-128	2/2	100	11,200 CM	11,400 CM	11,300	na	ng/kg ww
PCB-129	2/2	100	118,000 CM	124,000 CM	121,000	na	ng/kg ww
PCB-130	2/2	100	4,900 M	5,700 M	5,280	na	ng/kg ww
PCB-131	2/2	100	510 M	520 M	513	na	ng/kg ww
PCB-132	2/2	100	13,000 M	15,700 M	14,400	na	ng/kg ww
PCB-133	2/2	100	2,150 M	2,300 M	2,230	na	ng/kg ww
PCB-134	2/2	100	3,270 CM	3,300 CM	3,290	na	ng/kg ww
PCB-135	2/2	100	32,800 CM	35,000 CM	34,000	na	ng/kg ww
PCB-136	2/2	100	4,200 M	4,400 M	4,340	na	ng/kg ww
PCB-137	2/2	100	3,400 M	3,900 M	3,650	na	ng/kg ww
PCB-138	2/2	100	C129	C129	nc	na	ng/kg ww
PCB-139	2/2	100	850 CM	1,170 CM	1,010	na	ng/kg ww
PCB-140	2/2	100	C139	C139	nc	na	ng/kg ww
PCB-141	2/2	100	15,700 M	17,700 M	16,700	na	ng/kg ww
PCB-142	0/2	0	nd	nd	6.65	13.3	ng/kg ww
PCB-143	2/2	100	C134	C134	nc	na	ng/kg ww
PCB-144	2/2	100	3,140 M	3,190 M	3,170	na	ng/kg ww
PCB-145	0/2	0	nd	nd	0.0555	0.103 – 0.119	ng/kg ww
PCB-146	2/2	100	19,400 M	22,800 M	21,100	na	ng/kg ww
PCB-147	2/2	100	62,000 CM	78,000 CM	70,300	na	ng/kg ww
PCB-148	2/2	100	183 M	212 M	198	na	ng/kg ww
PCB-149	2/2	100	C147	C147	nc	na	ng/kg ww
PCB-150	2/2	100	117 M	124 M	121	na	ng/kg ww
PCB-151	2/2	100	C135	C135	nc	na	ng/kg ww
PCB-152	2/2	100	21.6 JM	22.5 JM	22.1	na	ng/kg ww
PCB-153	2/2	100	123,000 CM	133,000 CM	128,000	na	ng/kg ww
PCB-154	2/2	100	C135	C135	nc	na	ng/kg ww
PCB-155	2/2	100	6.0 JM	10.5 JM	8.27	na	ng/kg ww
PCB-156	2/2	100	9,300 CM	10,300 CM	9,820	na	ng/kg ww

Table E.6.3-6, cont. Summary statistics for Dungeness crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-157	2/2	100	C156	C156	nc	na	ng/kg ww
PCB-158	2/2	100	9,400 M	9,700 M	9,520	na	ng/kg ww
PCB-159	2/2	100	510 M	1,060 M	783	na	ng/kg ww
PCB-160	2/2	100	C129	C129	nc	na	ng/kg ww
PCB-161	0/2	0	nd	nd	4.69	9.2 – 9.6	ng/kg ww
PCB-162	2/2	100	236 M	277 M	257	na	ng/kg ww
PCB-163	2/2	100	C129	C129	nc	na	ng/kg ww
PCB-164	2/2	100	5,100 M	6,200 M	5,620	na	ng/kg ww
PCB-165	2/2	100	56 M	63 M	59.8	na	ng/kg ww
PCB-166	2/2	100	C128	C128	nc	na	ng/kg ww
PCB-167	2/2	100	3,500 M	4,100 M	3,770	na	ng/kg ww
PCB-168	2/2	100	C153	C153	nc	na	ng/kg ww
PCB-169	2/2	100	2.35 M	2.92 M	2.64	na	ng/kg ww
PCB-170	2/2	100	23,400 M	25,800 M	24,600	na	ng/kg ww
PCB-171	2/2	100	7,400 CM	8,400 CM	7,900	na	ng/kg ww
PCB-172	2/2	100	4,200 M	5,200 M	4,740	na	ng/kg ww
PCB-173	2/2	100	C171	C171	nc	na	ng/kg ww
PCB-174	2/2	100	10,200 M	21,900 M	16,100	na	ng/kg ww
PCB-175	2/2	100	860 M	1,120 M	988	na	ng/kg ww
PCB-176	2/2	100	1,750 M	2,270 M	2,010	na	ng/kg ww
PCB-177	2/2	100	13,200 M	18,800 M	16,000	na	ng/kg ww
PCB-178	2/2	100	6,900 M	8,700 M	7,790	na	ng/kg ww
PCB-179	2/2	100	8,300 M	10,000 M	9,140	na	ng/kg ww
PCB-180	2/2	100	67,000 CM	83,000 CM	75,000	na	ng/kg ww
PCB-181	2/2	100	154 M	170 M	162	na	ng/kg ww
PCB-182	2/2	100	203 M	230 M	217	na	ng/kg ww
PCB-183	2/2	100	18,900 CM	24,400 CM	21,700	na	ng/kg ww
PCB-184	2/2	100	9.8 JM	12.0 JM	10.9	na	ng/kg ww
PCB-185	2/2	100	C183	C183	nc	na	ng/kg ww

Table E.6.3-6, cont. Summary statistics for Dungeness crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-186	0/2	0	nd	nd	0.243	0.34 – 0.64	ng/kg ww
PCB-187	2/2	100	43,000 M	53,000 M	48,000	na	ng/kg ww
PCB-188	2/2	100	50 M	57 M	53.5	na	ng/kg ww
PCB-189	2/2	100	740 M	840 M	792	na	ng/kg ww
PCB-190	2/2	100	5,700 M	6,800 M	6,250	na	ng/kg ww
PCB-191	2/2	100	1,220 M	1,340 M	1,280	na	ng/kg ww
PCB-192	0/2	0	nd	nd	0.284	0.38 – 0.76	ng/kg ww
PCB-193	2/2	100	C180	C180	nc	na	ng/kg ww
PCB-194	2/2	100	7,300 M	9,400 M	8,320	na	ng/kg ww
PCB-195	2/2	100	2,930 M	3,600 M	3,280	na	ng/kg ww
PCB-196	2/2	100	4,300 M	6,300 M	5,270	na	ng/kg ww
PCB-197	2/2	100	970 CM	1,470 CM	1,220	na	ng/kg ww
PCB-198	2/2	100	7,200 CM	11,100 CM	9,140	na	ng/kg ww
PCB-199	2/2	100	C198	C198	nc	na	ng/kg ww
PCB-200	2/2	100	C197	C197	nc	na	ng/kg ww
PCB-201	2/2	100	1,280 M	1,760 M	1,520	na	ng/kg ww
PCB-202	2/2	100	2,330 M	3,100 M	2,720	na	ng/kg ww
PCB-203	2/2	100	5,800 M	8,300 M	7,060	na	ng/kg ww
PCB-204	2/2	100	2.97 JM	3.25 JM	3.11	na	ng/kg ww
PCB-205	2/2	100	330 M	430 M	380	na	ng/kg ww
PCB-206	2/2	100	1,180 M	1,560 M	1,370	na	ng/kg ww
PCB-207	2/2	100	154 M	203 M	179	na	ng/kg ww
PCB-208	2/2	100	272 M	350 M	310	na	ng/kg ww
PCB-209	2/2	100	107 M	129 M	118	na	ng/kg ww
Total PCB congeners	2/2	100	1,224,000 JM	1,226,000 JM	1,225,000	nc	ng/kg ww
Aroclor-1016	0/12	0	nd	nd	12	8 – 30	µg/kg ww
Aroclor-1221	0/12	0	nd	nd	19	8 – 60	µg/kg ww
Aroclor-1232	0/12	0	nd	nd	12	8 – 30	µg/kg ww
Aroclor-1242	0/12	0	nd	nd	12	8 – 30	µg/kg ww

Table E.6.3-6, cont. Summary statistics for Dungeness crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Aroclor-1248	9/12	75	40 M	240 M	140	20	µg/kg ww
Aroclor-1254	12/12	100	240 M	600 JM	480	na	µg/kg ww
Aroclor-1260	12/12	100	170 M	1,000 M	490	na	µg/kg ww
Total PCBs	12/12	100	420 M	1,900 JM	1,100	nc	µg/kg ww
PCB TEQ – Bird	2/2	100	50.3 M	72.0 M	61.2	na	ng/kg ww
PCB TEQ – Fish	2/2	100	0.861 M	1.050 M	0.956	na	ng/kg ww
PCB TEQ – Mammal	2/2	100	9.4 M	11.6 M	10.5	na	ng/kg ww
Pesticides							
2,4'-DDD	1/7	14	11 JNM	11 JNM	4.2	4 – 7	µg/kg ww
2,4'-DDE	0/7	0	nd	nd	3.2	3 – 7	µg/kg ww
2,4'-DDT	7/7	100	50 JNM	70 JNM	66	na	µg/kg ww
4,4'-DDD	6/7	86	6.9 JNM	7.0 JNM	6.2	3	µg/kg ww
4,4'-DDE	7/7	100	6 JNM	16 JNM	14	na	µg/kg ww
4,4'-DDT	7/7	100	40 JNM	60 JNM	56	na	µg/kg ww
Total DDTs	7/7	100	100 JNM	150 JNM	140	nc	µg/kg ww
Aldrin	0/7	0	nd	nd	1.7	3 – 3.6	µg/kg ww
Dieldrin	0/7	0	nd	nd	2.7	3.6 – 8	µg/kg ww
Total aldrin/dieldrin	0/7	0	nd	nd	2.7	nc	µg/kg ww
alpha-BHC	0/7	0	nd	nd	1.7	3 – 3.6	µg/kg ww
beta-BHC	0/7	0	nd	nd	1.7	3 – 3.6	µg/kg ww
gamma-BHC	1/7	14	7 JNM	7 JNM	2.6	3.6	µg/kg ww
delta-BHC	0/7	0	nd	nd	1.7	3 – 3.6	µg/kg ww
alpha-Chlordane	0/7	0	nd	nd	1.7	3 – 3.6	µg/kg ww
gamma-Chlordane	7/7	100	17 JNM	26 JNM	23	na	µg/kg ww
alpha-Endosulfan	0/7	0	nd	nd	1.7	3 – 3.6	µg/kg ww
beta-Endosulfan	0/7	0	nd	nd	1.9	3 – 4	µg/kg ww
Endosulfan sulfate	0/7	0	nd	nd	1.7	3 – 3.6	µg/kg ww
Endrin	0/7	0	nd	nd	2.0	3 – 4	µg/kg ww
Endrin aldehyde	0/7	0	nd	nd	1.8	3 – 3.7	µg/kg ww

Table E.6.3-6, cont. Summary statistics for Dungeness crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Endrin ketone	0/7	0	nd	nd	2.2	3 – 5	µg/kg ww
Heptachlor	0/7	0	nd	nd	1.7	3 – 3.6	µg/kg ww
Heptachlor epoxide	6/7	86	5 JNM	6 JNM	4.6	4	µg/kg ww
Methoxychlor	0/7	0	nd	nd	1.9	3 – 4	µg/kg ww
Mirex	0/7	0	nd	nd	1.7	3 – 3.6	µg/kg ww
Toxaphene	0/7	0	nd	nd	220	400 – 500	µg/kg ww
Total chlordane	7/7	100	17 JNM	26 JNM	23	nc	µg/kg ww
Conventional parameters							
Total solids	12/12	100	15.23 M	22.1 M	18	na	% ww
Lipid	12/12	100	1.43 JM	6 M	2.6	na	% ww

Note: Data from hepatopancreas composite samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Whole-body (i.e., edible meat plus hepatopancreas) crab concentrations were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weight of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

Table E.6.3-7. Summary statistics for English sole, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	2/7	29	0.0012 J	0.0015 J	0.0044	0.0104 – 0.0122	mg/kg ww
Arsenic	7/7	100	3.965	6.890	5.255	na	mg/kg ww
Arsenic (inorganic)	6/7	86	0.003	0.006 J	0.004	0.003	mg/kg ww
Cadmium	1/7	14	0.0013 J	0.0013 J	0.0021	0.0042 – 0.0049	mg/kg ww
Chromium	0/7	0	nd	nd	0.056	0.10 – 0.12	mg/kg ww
Cobalt	7/7	100	0.0037 J	0.0048	0.0042	na	mg/kg ww
Copper	7/7	100	0.386	1.390	1.12	na	mg/kg ww
Lead	7/7	100	0.0119	0.137	0.092	na	mg/kg ww
Mercury	7/7	100	0.013	0.025	0.017	na	mg/kg ww
Molybdenum	7/7	100	0.0046 J	0.0065 J	0.0052	na	mg/kg ww
Nickel	7/7	100	0.015 J	0.079 J	0.032	na	mg/kg ww
Selenium	7/7	100	0.15	0.210	0.2	na	mg/kg ww
Silver	0/7	0	nd	nd	0.0023	0.0042 – 0.0049	mg/kg ww
Thallium	0/7	0	nd	nd	0.0023	0.0042 – 0.0049	mg/kg ww
Vanadium	0/7	0	nd	nd	0.1	0.2 – 0.25	mg/kg ww
Zinc	7/7	100	7.35	8.89	7.77	na	mg/kg ww
Organometals							
Monobutyltin as ion	0/7	0	nd	nd	0.75	1.5	µg/kg ww
Dibutyltin as ion	3/7	43	0.55 J	0.70 J	0.69	1.5	µg/kg ww
Tributyltin as ion	6/7	86	1.2 J	2.2	1.5	1.5	µg/kg ww
Tetrabutyltin as ion	0/7	0	nd	nd	0.75	1.5	µg/kg ww
PAHs							
2-Chloronaphthalene	0/7	0	nd	nd	270	290 – 580	µg/kg ww
2-Methylnaphthalene	7/7	100	0.98 J	2.8	1.9	na	µg/kg ww
Acenaphthene	7/7	100	2.1	6.6	3.9	na	µg/kg ww
Acenaphthylene	7/7	100	0.27 J	1.0	0.68	na	µg/kg ww

Table E.6.3-7, cont. Summary statistics for English sole, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Anthracene	6/7	86	0.40 J	1.7	1.1	0.41	µg/kg ww
Benzo(a)anthracene	4/7	57	0.17 J	0.36 J	0.25	0.50	µg/kg ww
Benzo(a)pyrene	1/7	14	0.18 J	0.18 J	0.26	0.50 – 0.72	µg/kg ww
Benzo(b)fluoranthene	2/7	29	0.16	0.19 J	0.23	0.50	µg/kg ww
Benzo(g,h,i)perylene	2/7	29	0.20 J	0.21	0.24	0.50	µg/kg ww
Benzo(k)fluoranthene	2/7	29	0.18	0.22 J	0.24	0.50	µg/kg ww
Total benzofluoranthenes	2/7	29	0.34	0.41 J	0.29	nc	µg/kg ww
Chrysene	4/7	57	0.12 J	0.33 J	0.24	0.50	µg/kg ww
Dibenzo(a,h)anthracene	1/7	14	0.24	0.24	0.25	0.50	µg/kg ww
Dibenzofuran	7/7	100	0.96	2.9	1.8	na	µg/kg ww
Fluoranthene	3/7	43	0.82	1.7	0.94	0.87 – 1.4	µg/kg ww
Fluorene	7/7	100	0.72	2.1	1.3	na	µg/kg ww
Indeno(1,2,3-cd)pyrene	2/7	29	0.19 J	0.21	0.24	0.50	µg/kg ww
Naphthalene	7/7	100	1.7	4.1	3.1	na	µg/kg ww
Phenanthrene	3/7	43	0.82	2.4	1.1	0.89 – 1.6	µg/kg ww
Pyrene	2/7	29	0.33 J	0.64 J	0.35	0.36 – 0.91	µg/kg ww
Total HPAH	4/7	57	0.69 J	3.8 J	1.5	nc	µg/kg ww
Total LPAH	7/7	100	5.2 J	17.1	11	na	µg/kg ww
Carcinogenic PAHs – Mammal	4/7	57	0.37 J	0.53	0.35	0.45	µg/kg ww
Total PAH	7/7	100	5.2 J	19.0 J	12	na	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	2/7	29	1,100	1,300 J	370	67 – 130	µg/kg ww
Butyl benzyl phthalate	0/7	0	nd	nd	560	570 – 1,200	µg/kg ww
Diethyl phthalate	1/7	14	120 J	120 J	530	1,200	µg/kg ww
Dimethyl phthalate	0/7	0	nd	nd	270	290 – 580	µg/kg ww
Di-n-butyl phthalate	0/7	0	nd	nd	250	160 – 1,200	µg/kg ww
Di-n-octyl phthalate	0/7	0	nd	nd	1,400	1,500 – 2,900	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/7	0	nd	nd	270	290 – 580	µg/kg ww

Table E.6.3-7, cont. Summary statistics for English sole, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,2-Dichlorobenzene	0/7	0	nd	nd	270	290 – 580	µg/kg ww
1,3-Dichlorobenzene	0/7	0	nd	nd	270	290 – 580	µg/kg ww
1,4-Dichlorobenzene	0/7	0	nd	nd	270	290 – 580	µg/kg ww
2,4,5-Trichlorophenol	0/7	0	nd	nd	1,400	1,500 – 2,900	µg/kg ww
2,4,6-Trichlorophenol	0/7	0	nd	nd	1,400	1,500 – 2,900	µg/kg ww
2,4-Dichlorophenol	0/7	0	nd	nd	560	570 – 1,200	µg/kg ww
2,4-Dimethylphenol	0/7	0	nd	nd	560	570 – 1,200	µg/kg ww
2,4-Dinitrophenol	0/7	0	nd	nd	5,600	5,700 – 12,000	µg/kg ww
2,4-Dinitrotoluene	0/7	0	nd	nd	620	1,200 – 1,500	µg/kg ww
2,6-Dinitrotoluene	0/7	0	nd	nd	620	1,200 – 1,500	µg/kg ww
2-Chlorophenol	0/7	0	nd	nd	560	570 – 1,200	µg/kg ww
2-Methylphenol	0/7	0	nd	nd	560	570 – 1,200	µg/kg ww
2-Nitroaniline	0/7	0	nd	nd	1,400	1,500 – 2,900	µg/kg ww
2-Nitrophenol	0/7	0	nd	nd	1,400	1,500 – 2,900	µg/kg ww
3,3'-Dichlorobenzidine	0/7	0	nd	nd	14,000	15,000 – 29,000	µg/kg ww
3-Nitroaniline	0/7	0	nd	nd	2,700	2,900 – 5,800	µg/kg ww
4,6-Dinitro-o-cresol	0/7	0	nd	nd	2,700	2,900 – 5,800	µg/kg ww
4-Bromophenyl phenyl ether	0/7	0	nd	nd	270	290 – 580	µg/kg ww
4-Chloro-3-methylphenol	0/7	0	nd	nd	1,400	1,500 – 2,900	µg/kg ww
4-Chloroaniline	0/7	0	nd	nd	1,400	1,500 – 2,900	µg/kg ww
4-Chlorophenyl phenyl ether	0/7	0	nd	nd	270	290 – 580	µg/kg ww
4-Methylphenol	0/7	0	nd	nd	560	570 – 1,200	µg/kg ww
4-Nitroaniline	0/7	0	nd	nd	1,500	2,900	µg/kg ww
4-Nitrophenol	0/7	0	nd	nd	2,700	2,900 – 5,800	µg/kg ww
Aniline	0/7	0	nd	nd	5,600	5,700 – 12,000	µg/kg ww
Benzidine	0/1	0	nd	nd	25,000	50,000	µg/kg ww
Benzoic acid	6/7	86	5,300 J	6,500 J	5,600	5,700	µg/kg ww
Benzyl alcohol	0/7	0	nd	nd	290	570 – 580	µg/kg ww
bis(2-chloroethoxy)methane	0/7	0	nd	nd	350	570 – 1,500	µg/kg ww

Table E.6.3-7, cont. Summary statistics for English sole, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
bis(2-chloroethyl)ether	0/7	0	nd	nd	290	570 – 580	µg/kg ww
bis(2-chloroisopropyl)ether	0/7	0	nd	nd	270	290 – 580	µg/kg ww
Carbazole	0/7	0	nd	nd	1,400	1,500 – 2,900	µg/kg ww
Hexachlorobenzene	1/7	14	1.1 JN	1.1 JN	3.2	7.2	µg/kg ww
Hexachlorobutadiene	0/7	0	nd	nd	270	290 – 580	µg/kg ww
Hexachlorocyclopentadiene	0/7	0	nd	nd	34,000	50,000 – 72,000	µg/kg ww
Hexachloroethane	0/7	0	nd	nd	270	290 – 580	µg/kg ww
Isophorone	0/7	0	nd	nd	270	290 – 580	µg/kg ww
Nitrobenzene	0/7	0	nd	nd	270	290 – 580	µg/kg ww
N-Nitrosodimethylamine	0/7	0	nd	nd	1,700	2,900 – 5,700	µg/kg ww
N-Nitroso-di-n-propylamine	0/7	0	nd	nd	270	290 – 580	µg/kg ww
N-Nitrosodiphenylamine	0/7	0	nd	nd	270	290 – 580	µg/kg ww
Pentachlorophenol	0/7	0	nd	nd	620	3.3 – 5,800	µg/kg ww
Phenol	0/7	0	nd	nd	690	710 – 1,500	µg/kg ww
Polychlorinated biphenyls							
PCB-001	4/6	67	2.84	13.5 J	6.38	9.38 – 9.45	ng/kg ww
PCB-002	2/7	29	0.263 J	3.67 J	1.82	0.269 – 8.43	ng/kg ww
PCB-003	2/7	29	0.503 J	6.32 J	3.57	0.466 – 20.5	ng/kg ww
PCB-004	7/7	100	84.7	297	179	na	ng/kg ww
PCB-005	3/7	43	2.58	6.79 J	4.36	7.14 – 14.1	ng/kg ww
PCB-006	7/7	100	67.6	240	155	na	ng/kg ww
PCB-007	7/7	100	6.46	34.8 J	18.2	na	ng/kg ww
PCB-008	7/7	100	166	740	433	na	ng/kg ww
PCB-009	7/7	100	10.8	37.7	25.4	na	ng/kg ww
PCB-010	6/7	86	4.18	15.2 J	9.66	13.6	ng/kg ww
PCB-011	1/7	14	1.51 J	1.51 J	3.49	2.05 – 14.6	ng/kg ww
PCB-012	6/7	86	4.05 CJ	15.6 CJ	9.01	7.99	ng/kg ww
PCB-013	6/7	86	C12	C12	nc	0	ng/kg ww
PCB-014	0/7	0	nd	nd	2.98	0.0617 – 13.6	ng/kg ww

Table E.6.3-7, cont. Summary statistics for English sole, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-015	7/7	100	15.3 J	88.5	51.7	na	ng/kg ww
PCB-016	7/7	100	228	1,150	727	na	ng/kg ww
PCB-017	7/7	100	594	2,970	1,780	na	ng/kg ww
PCB-018	7/7	100	1,090 C	4,770 C	3,110	na	ng/kg ww
PCB-019	7/7	100	158	624	364	na	ng/kg ww
PCB-020	7/7	100	3,590 C	14,100 C	9,400	na	ng/kg ww
PCB-021	7/7	100	769 C	4,940 C	2,350	na	ng/kg ww
PCB-022	7/7	100	720	2,860	1,840	na	ng/kg ww
PCB-023	3/7	43	2.06	10.9 J	4.91	6.84 – 11.1	ng/kg ww
PCB-024	7/7	100	13.5	78.2	46.9	na	ng/kg ww
PCB-025	7/7	100	391	1,080	706	na	ng/kg ww
PCB-026	7/7	100	1,090 C	3,130 C	1,970	na	ng/kg ww
PCB-027	7/7	100	182	638	453	na	ng/kg ww
PCB-028	7/7	100	C20	C20	nc	na	ng/kg ww
PCB-029	7/7	100	C26	C26	nc	na	ng/kg ww
PCB-030	7/7	100	C18	C18	nc	na	ng/kg ww
PCB-031	7/7	100	2,090	7,710	5,080	na	ng/kg ww
PCB-032	6/7	86	527	2,660	1,280	8.66	ng/kg ww
PCB-033	7/7	100	C21	C21	nc	na	ng/kg ww
PCB-034	7/7	100	20.7	78.2	49.1	na	ng/kg ww
PCB-035	0/7	0	nd	nd	2.87	0.357 – 11.7	ng/kg ww
PCB-036	0/7	0	nd	nd	2.47	0.300 – 10.3	ng/kg ww
PCB-037	7/7	100	103	509	288	na	ng/kg ww
PCB-038	6/7	86	7.88	47.7	21.4	8.27	ng/kg ww
PCB-039	7/7	100	22.0	136	71.4	na	ng/kg ww
PCB-040	7/7	100	2,400 C	10,300 C	6,320	na	ng/kg ww
PCB-041	7/7	100	C40	C40	nc	na	ng/kg ww
PCB-042	7/7	100	1,430	7,020	4,350	na	ng/kg ww
PCB-043	7/7	100	224	1,520	848	na	ng/kg ww

Table E.6.3-7, cont. Summary statistics for English sole, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-044	7/7	100	6,940 C	22,100 C	15,200	na	ng/kg ww
PCB-045	7/7	100	716 C	3,320 C	2,110	na	ng/kg ww
PCB-046	7/7	100	134	613	397	na	ng/kg ww
PCB-047	7/7	100	C44	C44	nc	na	ng/kg ww
PCB-048	7/7	100	764	4,520	2,410	na	ng/kg ww
PCB-049	7/7	100	8,140 C	26,500 C	16,700	na	ng/kg ww
PCB-050	7/7	100	803 C	2,960 C	2,040	na	ng/kg ww
PCB-051	7/7	100	C45	C45	nc	na	ng/kg ww
PCB-052	7/7	100	13,300	38,700	27,100	na	ng/kg ww
PCB-053	7/7	100	C50	C50	nc	na	ng/kg ww
PCB-054	7/7	100	13.8	44.6	31.1	na	ng/kg ww
PCB-055	6/7	86	75.4	1,050	567	2.16	ng/kg ww
PCB-056	6/7	86	1,440	5,000	2,850	2.23	ng/kg ww
PCB-057	7/7	100	80.7	196	129	na	ng/kg ww
PCB-058	7/7	100	103	613	268	na	ng/kg ww
PCB-059	7/7	100	778 C	3,200 C	2,000	na	ng/kg ww
PCB-060	7/7	100	1,380	6,360	3,860	na	ng/kg ww
PCB-061	7/7	100	13,100 C	45,200 C	28,400	na	ng/kg ww
PCB-062	7/7	100	C59	C59	nc	na	ng/kg ww
PCB-063	7/7	100	382	1,490	890	na	ng/kg ww
PCB-064	7/7	100	2,930	11,900	7,430	na	ng/kg ww
PCB-065	7/7	100	C44	C44	nc	na	ng/kg ww
PCB-066	7/7	100	8,850	28,400	19,500	na	ng/kg ww
PCB-067	7/7	100	166	518	342	na	ng/kg ww
PCB-068	7/7	100	93.4	250	168	na	ng/kg ww
PCB-069	7/7	100	C49	C49	nc	na	ng/kg ww
PCB-070	7/7	100	C61	C61	nc	na	ng/kg ww
PCB-071	7/7	100	C40	C40	nc	na	ng/kg ww
PCB-072	7/7	100	205	548	361	na	ng/kg ww

Table E.6.3-7, cont. Summary statistics for English sole, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-073	5/7	71	197	375	199	0.0462 – 0.0472	ng/kg ww
PCB-074	7/7	100	C61	C61	nc	na	ng/kg ww
PCB-075	7/7	100	C59	C59	nc	na	ng/kg ww
PCB-076	7/7	100	C61	C61	nc	na	ng/kg ww
PCB-077	7/7	100	240	1,030	634	na	ng/kg ww
PCB-078	0/7	0	nd	nd	10.8	2.27 – 46.0	ng/kg ww
PCB-079	7/7	100	151	608	404	na	ng/kg ww
PCB-080	0/7	0	nd	nd	9.47	2.06 – 39.4	ng/kg ww
PCB-081	7/7	100	15.6 J	85.6	46.4	na	ng/kg ww
PCB-082	7/7	100	1,500	4,740	3,210	na	ng/kg ww
PCB-083	7/7	100	16,900 C	50,900 C	34,100	na	ng/kg ww
PCB-084	7/7	100	3,350	8,750	6,410	na	ng/kg ww
PCB-085	7/7	100	4,120 C	12,700 C	8,370	na	ng/kg ww
PCB-086	7/7	100	14,800 C	39,700 C	27,900	na	ng/kg ww
PCB-087	7/7	100	C86	C86	nc	na	ng/kg ww
PCB-088	7/7	100	3,510 C	9,110 C	6,480	na	ng/kg ww
PCB-089	7/7	100	130	416	281	na	ng/kg ww
PCB-090	7/7	100	31,000 C	88,700 C	59,400	na	ng/kg ww
PCB-091	7/7	100	C88	C88	nc	na	ng/kg ww
PCB-092	7/7	100	5,780	17,500	11,300	na	ng/kg ww
PCB-093	7/7	100	17,000 C	41,800 C	31,300	na	ng/kg ww
PCB-094	7/7	100	76.9	205	146	na	ng/kg ww
PCB-095	7/7	100	C93	C93	nc	na	ng/kg ww
PCB-096	7/7	100	85.0	265	189	na	ng/kg ww
PCB-097	7/7	100	C86	C86	nc	na	ng/kg ww
PCB-098	7/7	100	C93	C93	nc	na	ng/kg ww
PCB-099	7/7	100	C83	C83	nc	na	ng/kg ww
PCB-100	7/7	100	C93	C93	nc	na	ng/kg ww
PCB-101	7/7	100	C90	C90	nc	na	ng/kg ww

Table E.6.3-7, cont. Summary statistics for English sole, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-102	7/7	100	C93	C93	nc	na	ng/kg ww
PCB-103	7/7	100	453	1,010	766	na	ng/kg ww
PCB-104	7/7	100	4.44	11.4 J	8.85	na	ng/kg ww
PCB-105	7/7	100	6,890	19,200	14,200	na	ng/kg ww
PCB-106	0/7	0	nd	nd	6.62	2.30 – 28.8	ng/kg ww
PCB-107	7/7	100	723 C	2,220 C	1,450	na	ng/kg ww
PCB-108	7/7	100	C86	C86	nc	na	ng/kg ww
PCB-109	7/7	100	2,040	5,030	3,480	na	ng/kg ww
PCB-110	7/7	100	27,600 C	68,200 C	48,500	na	ng/kg ww
PCB-111	7/7	100	19.0 J	39.3	32.5	na	ng/kg ww
PCB-112	2/7	29	46.5	93.6	22.9	5.56 – 10.7	ng/kg ww
PCB-113	7/7	100	C90	C90	nc	na	ng/kg ww
PCB-114	7/7	100	450	1,260	932	na	ng/kg ww
PCB-115	7/7	100	C110	C110	nc	na	ng/kg ww
PCB-116	7/7	100	C85	C85	nc	na	ng/kg ww
PCB-117	7/7	100	C85	C85	nc	na	ng/kg ww
PCB-118	7/7	100	23,200	61,100	44,800	na	ng/kg ww
PCB-119	7/7	100	C86	C86	nc	na	ng/kg ww
PCB-120	7/7	100	165	325	245	na	ng/kg ww
PCB-121	6/7	86	12.8	31.0	18.0	5.85	ng/kg ww
PCB-122	7/7	100	93.9	435	250	na	ng/kg ww
PCB-123	7/7	100	270	1,130	742	na	ng/kg ww
PCB-124	7/7	100	C107	C107	nc	na	ng/kg ww
PCB-125	7/7	100	C86	C86	nc	na	ng/kg ww
PCB-126	7/7	100	29.2	110	73.7	na	ng/kg ww
PCB-127	7/7	100	34.8	213	117	na	ng/kg ww
PCB-128	7/7	100	4,010 C	10,800 C	7,740	na	ng/kg ww
PCB-129	7/7	100	41,700 C	109,000 C	77,100	na	ng/kg ww
PCB-130	7/7	100	2,090	4,560	3,670	na	ng/kg ww

Table E.6.3-7, cont. Summary statistics for English sole, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-131	7/7	100	270	778	547	na	ng/kg ww
PCB-132	7/7	100	9,170	20,900	16,100	na	ng/kg ww
PCB-133	7/7	100	750	1,470	1,210	na	ng/kg ww
PCB-134	7/7	100	1,440 C	4,010 C	2,830	na	ng/kg ww
PCB-135	7/7	100	12,900 C	31,300 C	23,400	na	ng/kg ww
PCB-136	7/7	100	3,010	9,490	6,410	na	ng/kg ww
PCB-137	7/7	100	1,450	4,270	2,750	na	ng/kg ww
PCB-138	7/7	100	C129	C129	nc	na	ng/kg ww
PCB-139	7/7	100	651 C	1,820 C	1,290	na	ng/kg ww
PCB-140	7/7	100	C139	C139	nc	na	ng/kg ww
PCB-141	7/7	100	5,810	13,900	10,800	na	ng/kg ww
PCB-142	0/7	0	nd	nd	19.8	2.41 – 84.3	ng/kg ww
PCB-143	7/7	100	C134	C134	nc	na	ng/kg ww
PCB-144	7/7	100	1,510	4,590	3,290	na	ng/kg ww
PCB-145	7/7	100	7.65 J	35.5	19.9	na	ng/kg ww
PCB-146	7/7	100	7,530	15,300	12,100	na	ng/kg ww
PCB-147	7/7	100	30,700 C	65,500 C	52,700	na	ng/kg ww
PCB-148	7/7	100	104	238	166	na	ng/kg ww
PCB-149	7/7	100	C147	C147	nc	na	ng/kg ww
PCB-150	7/7	100	64.4	175	129	na	ng/kg ww
PCB-151	7/7	100	C135	C135	nc	na	ng/kg ww
PCB-152	7/7	100	15.6	50.0	34.8	na	ng/kg ww
PCB-153	7/7	100	47,000 C	103,000 C	81,000	na	ng/kg ww
PCB-154	7/7	100	C135	C135	nc	na	ng/kg ww
PCB-155	7/7	100	4.49	12.3 J	9.03	na	ng/kg ww
PCB-156	7/7	100	3,130 C	8,750 C	6,350	na	ng/kg ww
PCB-157	7/7	100	C156	C156	nc	na	ng/kg ww
PCB-158	7/7	100	3,400	9,470	6,530	na	ng/kg ww
PCB-159	7/7	100	203	685	494	na	ng/kg ww

Table E.6.3-7, cont. Summary statistics for English sole, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-160	7/7	100	C129	C129	nc	na	ng/kg ww
PCB-161	0/7	0	nd	nd	14.1	1.80 – 64.8	ng/kg ww
PCB-162	7/7	100	80.8	248	160	na	ng/kg ww
PCB-163	7/7	100	C129	C129	nc	na	ng/kg ww
PCB-164	7/7	100	2,200	5,540	3,910	na	ng/kg ww
PCB-165	6/7	86	30.6	76.5	51.6	66.9	ng/kg ww
PCB-166	7/7	100	C128	C128	nc	na	ng/kg ww
PCB-167	7/7	100	1,250	3,600	2,610	na	ng/kg ww
PCB-168	7/7	100	C153	C153	nc	na	ng/kg ww
PCB-169	0/7	0	nd	nd	3.78	1.81 – 20.6	ng/kg ww
PCB-170	7/7	100	7,520	17,700	13,200	na	ng/kg ww
PCB-171	7/7	100	2,460 C	6,220 C	4,600	na	ng/kg ww
PCB-172	7/7	100	1,240	3,360	2,370	na	ng/kg ww
PCB-173	7/7	100	C171	C171	nc	na	ng/kg ww
PCB-174	7/7	100	6,350	13,700	10,400	na	ng/kg ww
PCB-175	7/7	100	343	765	596	na	ng/kg ww
PCB-176	7/7	100	938	2,540	1,850	na	ng/kg ww
PCB-177	7/7	100	5,580	11,800	9,090	na	ng/kg ww
PCB-178	7/7	100	2,070	4,600	3,480	na	ng/kg ww
PCB-179	7/7	100	3,390	8,030	6,100	na	ng/kg ww
PCB-180	7/7	100	21,400 C	47,300 C	34,600	na	ng/kg ww
PCB-181	7/7	100	63.9	178	124	na	ng/kg ww
PCB-182	7/7	100	75.3	196	142	na	ng/kg ww
PCB-183	7/7	100	7,210 C	16,000 C	12,200	na	ng/kg ww
PCB-184	7/7	100	5.62	22.0 J	12.1	na	ng/kg ww
PCB-185	7/7	100	C183	C183	nc	na	ng/kg ww
PCB-186	3/7	43	1.14 J	5.24 J	1.64	1.51 – 1.90	ng/kg ww
PCB-187	7/7	100	14,300	29,300	23,100	na	ng/kg ww
PCB-188	7/7	100	18.9	50.9	38.4	na	ng/kg ww

Table E.6.3-7, cont. Summary statistics for English sole, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-189	7/7	100	226	511	391	na	ng/kg ww
PCB-190	7/7	100	2,050	5,080	3,700	na	ng/kg ww
PCB-191	7/7	100	376	974	688	na	ng/kg ww
PCB-192	0/7	0	nd	nd	0.893	0.414 – 3.04	ng/kg ww
PCB-193	7/7	100	C180	C180	nc	na	ng/kg ww
PCB-194	7/7	100	2,550	5,820	4,520	na	ng/kg ww
PCB-195	7/7	100	1,090	2,520	1,940	na	ng/kg ww
PCB-196	7/7	100	1,590	3,810	2,850	na	ng/kg ww
PCB-197	7/7	100	340 C	1,080 C	768	na	ng/kg ww
PCB-198	7/7	100	3,100 C	7,730 C	5,760	na	ng/kg ww
PCB-199	7/7	100	C198	C198	nc	na	ng/kg ww
PCB-200	7/7	100	C197	C197	nc	na	ng/kg ww
PCB-201	7/7	100	370	980	754	na	ng/kg ww
PCB-202	7/7	100	774	1,920	1,440	na	ng/kg ww
PCB-203	7/7	100	2,480	5,460	4,180	na	ng/kg ww
PCB-204	7/7	100	0.647 J	3.73 J	2.13	na	ng/kg ww
PCB-205	7/7	100	156	351	276	na	ng/kg ww
PCB-206	7/7	100	554	1,680	1,130	na	ng/kg ww
PCB-207	7/7	100	67.9	212	145	na	ng/kg ww
PCB-208	7/7	100	147	447	312	na	ng/kg ww
PCB-209	7/7	100	96.1	257	168	na	ng/kg ww
Total PCB congeners	7/7	100	510,000 J	1,269,000 J	955,000	na	ng/kg ww
Aroclor-1016	0/17	0	nd	nd	32	10 – 100	µg/kg ww
Aroclor-1221	0/17	0	nd	nd	35	20 – 100	µg/kg ww
Aroclor-1232	0/17	0	nd	nd	32	10 – 100	µg/kg ww
Aroclor-1242	0/17	0	nd	nd	32	10 – 100	µg/kg ww
Aroclor-1248	7/17	41	140	380	140	100	µg/kg ww
Aroclor-1254	17/17	100	290	1,000	610	na	µg/kg ww
Aroclor-1260	17/17	100	150	810	410	na	µg/kg ww

Table E.6.3-7, cont. Summary statistics for English sole, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Total PCBs	17/17	100	450	2,010	1,100	nc	µg/kg ww
PCB TEQ – Bird	7/7	100	17.80 J	74.6	46.3	na	ng/kg ww
PCB TEQ – Fish	7/7	100	0.3550 J	1.170	0.805	na	ng/kg ww
PCB TEQ – Mammal	7/7	100	4.23 J	14.1	9.66	na	ng/kg ww
Pesticides							
2,4'-DDD	0/7	0	nd	nd	3.4	3.8 – 7.8	µg/kg ww
2,4'-DDE	0/7	0	nd	nd	3.2	1.0 – 7.2	µg/kg ww
2,4'-DDT	7/7	100	20 JN	50 JN	39	na	µg/kg ww
4,4'-DDD	7/7	100	2.3 JN	6.6 JN	4.5	na	µg/kg ww
4,4'-DDE	4/7	57	2.6 JN	12 JN	5.1	4.3 – 7.2	µg/kg ww
4,4'-DDT	7/7	100	12 JN	40 JN	28	na	µg/kg ww
Total DDTs	7/7	100	37 JN	103 JN	75	nc	µg/kg ww
Aldrin	0/7	0	nd	nd	3.2	1.0 – 7.2	µg/kg ww
Dieldrin	0/7	0	nd	nd	3.4	5.0 – 7.2	µg/kg ww
Total aldrin/dieldrin	0/7	0	nd	nd	3.4	nc	µg/kg ww
alpha-BHC	1/7	14	0.38 JN	0.38 JN	3.1	7.2	µg/kg ww
beta-BHC	2/7	29	1.6 JN	2.2 JN	3.1	7.2	µg/kg ww
gamma-BHC	0/7	0	nd	nd	3.2	1.0 – 7.2	µg/kg ww
delta-BHC	0/7	0	nd	nd	3.2	1.0 – 7.2	µg/kg ww
alpha-Chlordane	1/7	14	0.60 JN	0.60 JN	3.2	7.2	µg/kg ww
gamma-Chlordane	7/7	100	10 JN	28 JN	19	na	µg/kg ww
alpha-Endosulfan	4/7	57	1.7 JN	4.4 JN	3.1	7.2	µg/kg ww
beta-Endosulfan	1/7	14	6.9 JN	6.9 JN	4.1	7.2	µg/kg ww
Endosulfan sulfate	0/7	0	nd	nd	3.2	1.0 – 7.2	µg/kg ww
Endrin	0/7	0	nd	nd	3.2	1.0 – 7.2	µg/kg ww
Endrin aldehyde	1/7	14	8.1 JN	8.1 JN	3.8	1.6 – 7.2	µg/kg ww
Endrin ketone	0/7	0	nd	nd	3.2	1.5 – 7.2	µg/kg ww
Heptachlor	0/7	0	nd	nd	3.2	1.0 – 7.2	µg/kg ww
Heptachlor epoxide	0/7	0	nd	nd	3.3	2.9 – 7.2	µg/kg ww

Table E.6.3-7, cont. Summary statistics for English sole, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Methoxychlor	0/7	0	nd	nd	3.2	1.0 – 7.2	µg/kg ww
Mirex	0/7	0	nd	nd	3.2	1.0 – 7.2	µg/kg ww
Toxaphene	0/7	0	nd	nd	190	310 – 440	µg/kg ww
Total chlordane	7/7	100	10 JN	28 JN	19	nc	µg/kg ww
Conventional parameters							
Total solids	17/17	100	20.8	24.90	23.0	na	% ww
Lipid	17/17	100	1.6	5.09	3.3	na	% ww

Table E.6.3-8. Summary statistics for English sole, fillet without skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	0/3	0	nd	nd	0.010	0.020	mg/kg ww
Arsenic	9/9	100	9.0	15	11	na	mg/kg ww
Cadmium	0/3	0	nd	nd	0.0040	0.0079	mg/kg ww
Chromium	2/3	67	0.054	0.062	0.047	0.049	mg/kg ww
Copper	9/9	100	0.18	0.37	0.24	na	mg/kg ww
Lead	0/9	0	nd	nd	0.012	0.020 – 0.030	mg/kg ww
Mercury	15/15	100	0.020	0.083	0.052	na	mg/kg ww
Methylmercury	3/3	100	18	25	22	na	µg/kg ww
Nickel	0/3	0	nd	nd	0.010	0.020	mg/kg ww
Silver	0/3	0	nd	nd	0.0060	0.012	mg/kg ww
Zinc	3/3	100	3.8	4.6	4.1	na	mg/kg ww
Organometals							
Tributyltin as ion	3/9	33	3.9	5.7	2.1	0.74 – 2.0	µg/kg ww
PAHs							
2-Chloronaphthalene	0/6	0	nd	nd	6.8	11 – 16	µg/kg ww
2-Methylnaphthalene	0/6	0	nd	nd	12	3.6 – 43	µg/kg ww
Acenaphthene	0/6	0	nd	nd	3.7	3.6 – 11	µg/kg ww
Acenaphthylene	0/6	0	nd	nd	4.9	3.6 – 16	µg/kg ww
Anthracene	0/6	0	nd	nd	4.9	3.6 – 16	µg/kg ww
Benzo(a)anthracene	0/6	0	nd	nd	6.8	11 – 16	µg/kg ww
Benzo(a)pyrene	0/6	0	nd	nd	7.7	3.6 – 27	µg/kg ww
Benzo(b)fluoranthene	0/6	0	nd	nd	14	11 – 43	µg/kg ww
Benzo(g,h,i)perylene	0/6	0	nd	nd	9.5	11 – 27	µg/kg ww
Benzo(k)fluoranthene	0/6	0	nd	nd	13	7.1 – 43	µg/kg ww
Total benzofluoranthenes	0/6	0	nd	nd	14	nc	µg/kg ww
Chrysene	0/6	0	nd	nd	4.9	3.6 – 16	µg/kg ww
Dibenzo(a,h)anthracene	0/6	0	nd	nd	14	11 – 43	µg/kg ww
Dibenzofuran	0/6	0	nd	nd	9.5	11 – 27	µg/kg ww
Fluoranthene	0/6	0	nd	nd	4.9	3.6 – 16	µg/kg ww
Fluorene	0/6	0	nd	nd	4.9	3.6 – 16	µg/kg ww
Indeno(1,2,3-cd)pyrene	0/6	0	nd	nd	11	18 – 27	µg/kg ww
Naphthalene	0/6	0	nd	nd	12	3.6 – 43	µg/kg ww
Phenanthrene	0/6	0	nd	nd	4.9	3.6 – 16	µg/kg ww

Table E.6.3-8, cont. Summary statistics for English sole, fillet without skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Pyrene	0/6	0	nd	nd	4.9	3.6 – 16	µg/kg ww
Total HPAH	0/6	0	nd	nd	15	nc	µg/kg ww
Total LPAH	0/6	0	nd	nd	12	nc	µg/kg ww
Carcinogenic PAHs – Mammal	0/6	0	nd	nd	8.9	6.4 – 29	µg/kg ww
Total PAH	0/6	0	nd	nd	15	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	0/6	0	nd	nd	4.9	3.6 – 16	µg/kg ww
Butyl benzyl phthalate	0/6	0	nd	nd	6.8	11 – 16	µg/kg ww
Diethyl phthalate	0/6	0	nd	nd	7.7	3.6 – 27	µg/kg ww
Dimethyl phthalate	0/6	0	nd	nd	3.7	3.6 – 11	µg/kg ww
Di-n-butyl phthalate	0/6	0	nd	nd	7.7	3.6 – 27	µg/kg ww
Di-n-octyl phthalate	0/6	0	nd	nd	4.9	3.6 – 16	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/6	0	nd	nd	4.9	3.6 – 16	µg/kg ww
1,2-Dichlorobenzene	0/6	0	nd	nd	6.8	11 – 16	µg/kg ww
1,2-Diphenylhydrazine	0/6	0	nd	nd	14	3.6 – 53	µg/kg ww
1,3-Dichlorobenzene	0/6	0	nd	nd	6.8	11 – 16	µg/kg ww
1,4-Dichlorobenzene	0/6	0	nd	nd	6.8	11 – 16	µg/kg ww
2,4,5-Trichlorophenol	0/6	0	nd	nd	32	18 – 110	µg/kg ww
2,4,6-Trichlorophenol	0/6	0	nd	nd	32	18 – 110	µg/kg ww
2,4-Dichlorophenol	0/6	0	nd	nd	7.7	3.6 – 27	µg/kg ww
2,4-Dimethylphenol	0/6	0	nd	nd	7.7	3.6 – 27	µg/kg ww
2,4-Dinitrophenol	0/6	0	nd	nd	31	53 – 72	µg/kg ww
2,4-Dinitrotoluene	0/6	0	nd	nd	7.3	11 – 18	µg/kg ww
2,6-Dinitrotoluene	0/6	0	nd	nd	7.3	11 – 18	µg/kg ww
2-Chlorophenol	0/6	0	nd	nd	14	3.6 – 53	µg/kg ww
2-Methylphenol	0/6	0	nd	nd	7.7	3.6 – 27	µg/kg ww
2-Nitroaniline	0/6	0	nd	nd	29	7.1 – 110	µg/kg ww
2-Nitrophenol	0/6	0	nd	nd	7.7	3.6 – 27	µg/kg ww
3-Nitroaniline	0/6	0	nd	nd	28	3.6 – 110	µg/kg ww
4,6-Dinitro-o-cresol	0/6	0	nd	nd	27	53	µg/kg ww
4-Bromophenyl phenyl ether	0/6	0	nd	nd	7.3	11 – 18	µg/kg ww
4-Chloro-3-methylphenol	0/6	0	nd	nd	14	3.6 – 53	µg/kg ww
4-Chloroaniline	0/3	0	nd	nd	18	36	µg/kg ww
4-Chlorophenyl phenyl ether	0/6	0	nd	nd	4.9	3.6 – 16	µg/kg ww
4-Methylphenol	0/6	0	nd	nd	7.7	3.6 – 27	µg/kg ww
4-Nitroaniline	0/6	0	nd	nd	32	18 – 110	µg/kg ww

Table E.6.3-8, cont. Summary statistics for English sole, fillet without skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
4-Nitrophenol	0/6	0	nd	nd	22	36 – 53	µg/kg ww
Aniline	0/3	0	nd	nd	27	53	µg/kg ww
Benzoic acid	0/6	0	nd	nd	37	36 – 110	µg/kg ww
Benzyl alcohol	0/6	0	nd	nd	7.7	3.6 – 27	µg/kg ww
bis(2-chloroethoxy)methane	0/6	0	nd	nd	7.7	3.6 – 27	µg/kg ww
bis(2-chloroethyl)ether	0/6	0	nd	nd	4.9	3.6 – 16	µg/kg ww
bis(2-chloroisopropyl)ether	0/6	0	nd	nd	16	11 – 53	µg/kg ww
Caffeine	0/3	0	nd	nd	2.7	5.3	µg/kg ww
Carbazole	0/6	0	nd	nd	7.7	3.6 – 27	µg/kg ww
Coprostanol	0/6	0	nd	nd	73	110 – 180	µg/kg ww
Hexachlorobenzene	0/6	0	nd	nd	8.5	16 – 18	µg/kg ww
Hexachlorobutadiene	0/6	0	nd	nd	9.5	11 – 27	µg/kg ww
Hexachlorocyclopentadiene	0/3	0	nd	nd	18	36	µg/kg ww
Hexachloroethane	0/6	0	nd	nd	9.5	11 – 27	µg/kg ww
Isophorone	0/6	0	nd	nd	7.7	3.6 – 27	µg/kg ww
Nitrobenzene	0/6	0	nd	nd	9.5	11 – 27	µg/kg ww
N-Nitrosodimethylamine	0/6	0	nd	nd	28	3.6 – 110	µg/kg ww
N-Nitroso-di-n-propylamine	0/6	0	nd	nd	7.7	3.6 – 27	µg/kg ww
N-Nitrosodiphenylamine	0/6	0	nd	nd	7.7	3.6 – 27	µg/kg ww
Pentachlorophenol	0/6	0	nd	nd	16	27 – 36	µg/kg ww
Phenol	0/6	0	nd	nd	28	3.6 – 110	µg/kg ww
Polychlorinated biphenyls							
PCB-052	3/3	100	4,500	8,700	6,700	na	ng/kg ww
PCB-075	3/3	100	1,800	3,600	2,700	na	ng/kg ww
PCB-077	0/3	0	nd	nd	58	110 – 120	ng/kg ww
PCB-081	0/3	0	nd	nd	85	160 – 180	ng/kg ww
PCB-101	3/3	100	9,000	14,000	12,000	na	ng/kg ww
PCB-105	3/3	100	2,200	3,200	2,800	na	ng/kg ww
PCB-118	3/3	100	5,200	9,400	7,300	na	ng/kg ww
PCB-126	0/3	0	nd	nd	85	160 – 180	ng/kg ww
PCB-128	3/3	100	1,200	1,800	1,500	na	ng/kg ww
PCB-138	3/3	100	6,600	12,000	9,300	na	ng/kg ww
PCB-141	3/3	100	1,200	1,900	1,600	na	ng/kg ww
PCB-149	3/3	100	6,400	11,000	8,900	na	ng/kg ww
PCB-151	0/3	0	nd	nd	85	160 – 180	ng/kg ww
PCB-153	3/3	100	9,700	19,000	14,000	na	ng/kg ww
PCB-169	0/3	0	nd	nd	85	160 – 180	ng/kg ww

Table E.6.3-8, cont. Summary statistics for English sole, fillet without skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-170	3/3	100	1,500	2,600	2,100	na	ng/kg ww
PCB-174	3/3	100	1,100	2,000	1,600	na	ng/kg ww
PCB-177	3/3	100	1,000	1,700	1,400	na	ng/kg ww
PCB-180	3/3	100	2,700	4,800	3,900	na	ng/kg ww
PCB-183	3/3	100	1,300	2,200	1,700	na	ng/kg ww
PCB-187	3/3	100	2,200	4,200	3,200	na	ng/kg ww
PCB-195	3/3	100	470	570	530	na	ng/kg ww
PCB-206	3/3	100	340	440	400	na	ng/kg ww
Aroclor-1016	0/12	0	nd	nd	6.5	5.3 – 20	µg/kg ww
Aroclor-1016/1242	3/3	100	10 J	16 J	14	na	µg/kg ww
Aroclor-1221	0/12	0	nd	nd	6.5	5.3 – 20	µg/kg ww
Aroclor-1232	0/12	0	nd	nd	6.5	5.3 – 20	µg/kg ww
Aroclor-1242	0/12	0	nd	nd	4.0	5.3 – 10	µg/kg ww
Aroclor-1248	6/15	40	9.0	26	7.7	0.23 – 6.9	µg/kg ww
Aroclor-1254	15/15	100	22 J	300 J	130	na	µg/kg ww
Aroclor-1260	15/15	100	27	210 J	85	na	µg/kg ww
Total PCBs	15/15	100	79	530 J	230	nc	µg/kg ww
PCB TEQ – Bird	3/3	100	19	21	20	na	ng/kg ww
PCB TEQ – Fish	3/3	100	0.49	0.56	0.53	na	ng/kg ww
PCB TEQ – Mammal	3/3	100	11	12	11	na	ng/kg ww
Pesticides							
4,4'-DDD	6/9	67	1.1	5.0	2.1	1.3	µg/kg ww
4,4'-DDE	7/9	78	1.1	5.9	2.6	1.0	µg/kg ww
4,4'-DDT	0/9	0	nd	nd	1.0	2.0	µg/kg ww
Total DDTs	7/9	78	1.1	10.9	4.7	nc	µg/kg ww
Aldrin	0/9	0	nd	nd	0.25	0.50	µg/kg ww
Dieldrin	0/9	0	nd	nd	0.50	1.0	µg/kg ww
Total aldrin/dieldrin	0/9	0	nd	nd	0.50	nc	µg/kg ww
alpha-BHC	0/9	0	nd	nd	0.25	0.50	µg/kg ww
beta-BHC	0/9	0	nd	nd	0.25	0.50	µg/kg ww
gamma-BHC	0/9	0	nd	nd	0.25	0.50	µg/kg ww
delta-BHC	0/9	0	nd	nd	0.25	0.50	µg/kg ww
alpha-Chlordane	3/9	33	1.6 J	2.0 J	0.74	0.50	µg/kg ww
gamma-Chlordane	1/9	11	0.52 J	0.52 J	0.28	0.50	µg/kg ww
alpha-Endosulfan	0/9	0	nd	nd	0.25	0.50	µg/kg ww
beta-Endosulfan	0/9	0	nd	nd	0.50	1.0	µg/kg ww
Endosulfan sulfate	0/9	0	nd	nd	0.50	1.0	µg/kg ww

Table E.6.3-8, cont. Summary statistics for English sole, fillet without skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Endrin	0/9	0	nd	nd	0.50	1.0	µg/kg ww
Endrin aldehyde	0/9	0	nd	nd	0.50	1.0	µg/kg ww
Heptachlor	0/9	0	nd	nd	0.25	0.50	µg/kg ww
Heptachlor epoxide	0/9	0	nd	nd	0.25	0.50	µg/kg ww
Methoxychlor	0/9	0	nd	nd	5.0	10	µg/kg ww
Toxaphene	0/9	0	nd	nd	5.0	10	µg/kg ww
Total chlordane	3/9	33	1.6 J	2.5 J	0.80	nc	µg/kg ww
Conventional parameters							
Total solids	7/7	100	15	17	17	na	% ww
Lipid	12/12	100	0.24	12	3.0	na	% ww

Table E.6.3-9. Summary statistics for English sole, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	21/21	100	0.0025 J	0.0111 J	0.0060	na	mg/kg ww
Arsenic	21/21	100	2.230	4.330	3.274	na	mg/kg ww
Arsenic (inorganic)	7/7	100	0.020	0.090	0.051	na	mg/kg ww
Cadmium	21/21	100	0.0042 J	0.0151	0.0077	na	mg/kg ww
Chromium	18/21	86	0.08 J	0.39	0.2	0.13 – 0.14	mg/kg ww
Cobalt	21/21	100	0.0242	0.0949	0.0457	na	mg/kg ww
Copper	21/21	100	0.494	3.470	1.79	na	mg/kg ww
Lead	21/21	100	0.0977	0.946	0.373	na	mg/kg ww
Mercury	21/21	100	0.005	0.027	0.01	na	mg/kg ww
Molybdenum	21/21	100	0.0121 J	0.0430	0.0201	na	mg/kg ww
Nickel	21/21	100	0.120	0.378 J	0.208	na	mg/kg ww
Selenium	21/21	100	0.10	0.320	0.19	na	mg/kg ww
Silver	21/21	100	0.0013 J	0.0066	0.0034	na	mg/kg ww
Thallium	7/21	33	0.0005 J	0.0012 J	0.002	0.0043 – 0.0055	mg/kg ww
Vanadium	21/21	100	0.2 J	0.49	0.4	na	mg/kg ww
Zinc	21/21	100	11.2	14.4	12.6	na	mg/kg ww
Organometals							
Monobutyltin as ion	4/20	20	0.58 J	1.0 J	0.77	1.5	µg/kg ww
Dibutyltin as ion	18/20	90	0.53 J	4.0	1.7	1.5	µg/kg ww
Tributyltin as ion	15/20	75	3.1	9.9 J	4.7	1.5 – 2.1	µg/kg ww
Tetrabutyltin as ion	0/20	0	nd	nd	0.75	1.5	µg/kg ww
PAHs							
2-Chloronaphthalene	0/21	0	nd	nd	220	290 – 580	µg/kg ww
2-Methylnaphthalene	21/21	100	1.6	10	3.8	na	µg/kg ww
Acenaphthene	21/21	100	3.5	22	8.2	na	µg/kg ww
Acenaphthylene	21/21	100	0.56	2.8	1.7	na	µg/kg ww

Table E.6.3-9, cont. Summary statistics for English sole, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Anthracene	21/21	100	0.89	9.0	3.5	na	µg/kg ww
Benzo(a)anthracene	17/21	81	0.35 J	3.6	1.5	0.50	µg/kg ww
Benzo(a)pyrene	14/21	67	0.49 J	1.8	0.97	0.50 – 0.72	µg/kg ww
Benzo(b)fluoranthene	17/21	81	0.33 J	3.1	1.5	0.50 – 0.72	µg/kg ww
Benzo(g,h,i)perylene	17/21	81	0.21 J	1.2	0.63	0.50 – 0.72	µg/kg ww
Benzo(k)fluoranthene	17/21	81	0.25 J	2.7	1.3	0.50 – 0.72	µg/kg ww
Total benzofluoranthenes	17/21	81	0.58 J	5.2	2.7	nc	µg/kg ww
Chrysene	17/21	81	0.65 J	9.0	2.4	0.50	µg/kg ww
Dibenzo(a,h)anthracene	7/21	33	0.12 J	0.45 J	0.28	0.50 – 0.72	µg/kg ww
Dibenzofuran	21/21	100	1.6	9.5	3.8	na	µg/kg ww
Fluoranthene	21/21	100	2.3	11	4.9	na	µg/kg ww
Fluorene	21/21	100	1.2	6.3	2.9	na	µg/kg ww
Indeno(1,2,3-cd)pyrene	17/21	81	0.16 J	1.4	0.66	0.50 – 0.72	µg/kg ww
Naphthalene	17/21	81	2.6	12	5.2	4.8 – 7.8	µg/kg ww
Phenanthrene	21/21	100	1.9	13	4.2	na	µg/kg ww
Pyrene	21/21	100	1.2	7.7	3.1	na	µg/kg ww
Total HPAH	21/21	100	3.8	35 J	17	nc	µg/kg ww
Total LPAH	21/21	100	11.3	54	25	nc	µg/kg ww
Carcinogenic PAHs – Mammal	18/21	86	0.45 J	2.8	1.6	0.45	µg/kg ww
Total PAH	21/21	100	21.8 J	83	42	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	0/21	0	nd	nd	760	66 – 3,600	µg/kg ww
Butyl benzyl phthalate	3/21	14	560 J	650	460	290 – 1,200	µg/kg ww
Diethyl phthalate	4/21	19	100 J	110 J	420	570 – 1,200	µg/kg ww
Dimethyl phthalate	0/21	0	nd	nd	220	290 – 580	µg/kg ww
Di-n-butyl phthalate	0/21	0	nd	nd	380	290 – 1,200	µg/kg ww
Di-n-octyl phthalate	0/21	0	nd	nd	940	290 – 2,900	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/21	0	nd	nd	220	290 – 580	µg/kg ww

Table E.6.3-9, cont. Summary statistics for English sole, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
1,2-Dichlorobenzene	0/21	0	nd	nd	220	290 – 580	µg/kg ww
1,3-Dichlorobenzene	0/21	0	nd	nd	220	290 – 580	µg/kg ww
1,4-Dichlorobenzene	0/21	0	nd	nd	220	290 – 580	µg/kg ww
2,4,5-Trichlorophenol	0/21	0	nd	nd	980	570 – 2,900	µg/kg ww
2,4,6-Trichlorophenol	0/21	0	nd	nd	980	570 – 2,900	µg/kg ww
2,4-Dichlorophenol	0/21	0	nd	nd	450	570 – 1,200	µg/kg ww
2,4-Dimethylphenol	0/21	0	nd	nd	450	570 – 1,200	µg/kg ww
2,4-Dinitrophenol	0/21	0	nd	nd	4,500	5,700 – 12,000	µg/kg ww
2,4-Dinitrotoluene	0/21	0	nd	nd	540	570 – 1,500	µg/kg ww
2,6-Dinitrotoluene	0/21	0	nd	nd	500	290 – 1,500	µg/kg ww
2-Chlorophenol	0/21	0	nd	nd	450	570 – 1,200	µg/kg ww
2-Methylphenol	0/21	0	nd	nd	450	570 – 1,200	µg/kg ww
2-Nitroaniline	0/21	0	nd	nd	1,100	1,500 – 2,900	µg/kg ww
2-Nitrophenol	0/21	0	nd	nd	940	290 – 2,900	µg/kg ww
3,3'-Dichlorobenzidine	0/21	0	nd	nd	11,000	15,000 – 29,000	µg/kg ww
3-Nitroaniline	0/21	0	nd	nd	2,200	2,900 – 5,800	µg/kg ww
4,6-Dinitro-o-cresol	0/21	0	nd	nd	2,200	2,900 – 5,800	µg/kg ww
4-Bromophenyl phenyl ether	0/21	0	nd	nd	220	290 – 580	µg/kg ww
4-Chloro-3-methylphenol	0/21	0	nd	nd	1,100	1,500 – 2,900	µg/kg ww
4-Chloroaniline	0/21	0	nd	nd	1,100	1,500 – 2,900	µg/kg ww
4-Chlorophenyl phenyl ether	0/21	0	nd	nd	220	290 – 580	µg/kg ww
4-Methylphenol	0/21	0	nd	nd	450	570 – 1,200	µg/kg ww
4-Nitroaniline	0/21	0	nd	nd	1,300	1,500 – 2,900	µg/kg ww
4-Nitrophenol	0/21	0	nd	nd	2,200	2,900 – 5,800	µg/kg ww
Aniline	0/21	0	nd	nd	4,500	5,700 – 12,000	µg/kg ww
Benzidine	0/11	0	nd	nd	26,000	50,000 – 72,000	µg/kg ww
Benzoic acid	14/21	67	1,900 J	6,500 J	4,200	5,700 – 5,800	µg/kg ww
Benzyl alcohol	11/21	52	79 J	610	220	570 – 580	µg/kg ww
bis(2-chloroethoxy)methane	0/21	0	nd	nd	330	290 – 1,500	µg/kg ww

Table E.6.3-9, cont. Summary statistics for English sole, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
bis(2-chloroethyl)ether	0/21	0	nd	nd	250	290 – 580	µg/kg ww
bis(2-chloroisopropyl)ether	0/21	0	nd	nd	220	290 – 580	µg/kg ww
Carbazole	0/21	0	nd	nd	1,100	1,500 – 2,900	µg/kg ww
Hexachlorobenzene	4/21	19	4.4 JN	6.6 JN	4.6	7.2 – 10	µg/kg ww
Hexachlorobutadiene	0/21	0	nd	nd	220	290 – 580	µg/kg ww
Hexachlorocyclopentadiene	0/21	0	nd	nd	31,000	50,000 – 72,000	µg/kg ww
Hexachloroethane	0/21	0	nd	nd	220	290 – 580	µg/kg ww
Isophorone	0/21	0	nd	nd	220	290 – 580	µg/kg ww
Nitrobenzene	0/21	0	nd	nd	220	290 – 580	µg/kg ww
N-Nitrosodimethylamine	0/21	0	nd	nd	1,500	1,500 – 5,800	µg/kg ww
N-Nitroso-di-n-propylamine	1/21	5	270 JN	270 JN	220	290 – 580	µg/kg ww
N-Nitrosodiphenylamine	0/21	0	nd	nd	220	290 – 580	µg/kg ww
Pentachlorophenol	5/21	24	1.1 J	1,600 J	700	3.3 – 2,900	µg/kg ww
Phenol	0/21	0	nd	nd	560	710 – 1,500	µg/kg ww
Polychlorinated biphenyls							
PCB-001	3/10	30	12.4 J	27.8 J	11.0	9.65 – 23.1	ng/kg ww
PCB-002	4/10	40	2.35 J	4.12 J	2.02	2.42 – 3.58	ng/kg ww
PCB-003	3/10	30	3.81 J	6.90 J	2.93	2.83 – 5.63	ng/kg ww
PCB-004	10/10	100	150	1,020	419	na	ng/kg ww
PCB-005	8/10	80	6.69 J	34.1	13.6	7.00 – 11.6	ng/kg ww
PCB-006	10/10	100	158	719	379	na	ng/kg ww
PCB-007	10/10	100	19.7 J	80.6	36.1	na	ng/kg ww
PCB-008	10/10	100	488	2,570	1,010	na	ng/kg ww
PCB-009	10/10	100	28.8 J	167	64.8	na	ng/kg ww
PCB-010	9/10	90	12.6 J	56.5	23.5	10.4	ng/kg ww
PCB-011	2/10	20	10.1 J	263	30.8	4.03 – 11.9	ng/kg ww
PCB-012	4/10	40	11.7 CJ	24.0 CJ	12.5	11.6 – 28.8	ng/kg ww
PCB-013	4/10	40	C12	C12	nc	na	ng/kg ww
PCB-014	0/10	0	nd	nd	3.88	3.91 – 11.0	ng/kg ww

Table E.6.3-9, cont. Summary statistics for English sole, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-015	5/10	50	65.7	390	95.0	14.6 – 96.2	ng/kg ww
PCB-016	10/10	100	767	3,780	1,540	na	ng/kg ww
PCB-017	10/10	100	2,130	8,700	3,820	na	ng/kg ww
PCB-018	10/10	100	3,610 C	14,700 C	6,670	na	ng/kg ww
PCB-019	10/10	100	356	1,440	676	na	ng/kg ww
PCB-020	10/10	100	8,660 C	42,700 C	19,100	na	ng/kg ww
PCB-021	10/10	100	1,700 C	9,010 C	4,330	na	ng/kg ww
PCB-022	10/10	100	1,520	8,300	3,570	na	ng/kg ww
PCB-023	4/10	40	6.27 J	32.8	10.9	8.20 – 17.4	ng/kg ww
PCB-024	10/10	100	48.0	232	100	na	ng/kg ww
PCB-025	10/10	100	582	1,940	1,390	na	ng/kg ww
PCB-026	10/10	100	1,820 C	5,770 C	3,900	na	ng/kg ww
PCB-027	10/10	100	547	1,660	910	na	ng/kg ww
PCB-028	10/10	100	C20	C20	nc	na	ng/kg ww
PCB-029	10/10	100	C26	C26	nc	na	ng/kg ww
PCB-030	10/10	100	C18	C18	nc	na	ng/kg ww
PCB-031	10/10	100	4,620	24,500	10,400	na	ng/kg ww
PCB-032	10/10	100	1,470	7,210	3,190	na	ng/kg ww
PCB-033	10/10	100	C21	C21	nc	na	ng/kg ww
PCB-034	10/10	100	52.9	155	93.6	na	ng/kg ww
PCB-035	0/10	0	nd	nd	4.99	2.24 – 19.0	ng/kg ww
PCB-036	0/10	0	nd	nd	4.42	2.00 – 16.7	ng/kg ww
PCB-037	10/10	100	376	2,450	749	na	ng/kg ww
PCB-038	10/10	100	21.2 J	75.4	46.2	na	ng/kg ww
PCB-039	7/10	70	65.8	193	94.9	4.57 – 7.49	ng/kg ww
PCB-040	10/10	100	7,660 C	22,100 C	12,900	na	ng/kg ww
PCB-041	10/10	100	C40	C40	nc	na	ng/kg ww
PCB-042	10/10	100	4,760	15,300	8,920	na	ng/kg ww
PCB-043	10/10	100	840	2,540	1,590	na	ng/kg ww

Table E.6.3-9, cont. Summary statistics for English sole, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-044	10/10	100	18,100 C	48,500 C	30,500	na	ng/kg ww
PCB-045	10/10	100	2,530 C	7,710 C	4,330	na	ng/kg ww
PCB-046	10/10	100	393	1,330	722	na	ng/kg ww
PCB-047	10/10	100	C44	C44	nc	na	ng/kg ww
PCB-048	10/10	100	2,620	8,050	4,950	na	ng/kg ww
PCB-049	10/10	100	23,000 C	49,200 C	35,100	na	ng/kg ww
PCB-050	10/10	100	2,720 C	6,750 C	4,130	na	ng/kg ww
PCB-051	10/10	100	C45	C45	nc	na	ng/kg ww
PCB-052	10/10	100	37,000	75,200	56,500	na	ng/kg ww
PCB-053	10/10	100	C50	C50	nc	na	ng/kg ww
PCB-054	10/10	100	33.7	115	60.4	na	ng/kg ww
PCB-055	5/10	50	271	771	268	20.8 – 118	ng/kg ww
PCB-056	10/10	100	2,590	10,600	5,800	na	ng/kg ww
PCB-057	10/10	100	104	334	250	na	ng/kg ww
PCB-058	9/10	90	75.0	245	145	65.2	ng/kg ww
PCB-059	10/10	100	2,520 C	6,040 C	4,060	na	ng/kg ww
PCB-060	10/10	100	3,690	16,100	8,470	na	ng/kg ww
PCB-061	10/10	100	31,600 C	98,300 C	59,000	na	ng/kg ww
PCB-062	10/10	100	C59	C59	nc	na	ng/kg ww
PCB-063	10/10	100	1,030	2,940	1,870	na	ng/kg ww
PCB-064	10/10	100	8,440	27,100	16,100	na	ng/kg ww
PCB-065	10/10	100	C44	C44	nc	na	ng/kg ww
PCB-066	10/10	100	21,300	61,800	40,100	na	ng/kg ww
PCB-067	9/10	90	339	1,170	642	18.2	ng/kg ww
PCB-068	10/10	100	192	562	377	na	ng/kg ww
PCB-069	10/10	100	C49	C49	nc	na	ng/kg ww
PCB-070	10/10	100	C61	C61	nc	na	ng/kg ww
PCB-071	10/10	100	C40	C40	nc	na	ng/kg ww
PCB-072	10/10	100	402	1,100	768	na	ng/kg ww

Table E.6.3-9, cont. Summary statistics for English sole, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-073	2/10	20	454	496	96.2	0.396 – 4.99	ng/kg ww
PCB-074	10/10	100	C61	C61	nc	na	ng/kg ww
PCB-075	10/10	100	C59	C59	nc	na	ng/kg ww
PCB-076	10/10	100	C61	C61	nc	na	ng/kg ww
PCB-077	10/10	100	419	2,070	1,080	na	ng/kg ww
PCB-078	0/10	0	nd	nd	24.3	21.0 – 121	ng/kg ww
PCB-079	10/10	100	542	1,420	896	na	ng/kg ww
PCB-080	0/10	0	nd	nd	21.4	18.1 – 108	ng/kg ww
PCB-081	10/10	100	41.7	165	87.9	na	ng/kg ww
PCB-082	10/10	100	3,360	8,930	6,160	na	ng/kg ww
PCB-083	10/10	100	48,800 C	115,000 C	74,900	na	ng/kg ww
PCB-084	10/10	100	7,900	16,600	12,000	na	ng/kg ww
PCB-085	10/10	100	10,700 C	25,500 C	17,700	na	ng/kg ww
PCB-086	10/10	100	36,200 C	88,400 C	58,600	na	ng/kg ww
PCB-087	10/10	100	C86	C86	nc	na	ng/kg ww
PCB-088	10/10	100	9,540 C	22,000 C	14,400	na	ng/kg ww
PCB-089	10/10	100	323	771	518	na	ng/kg ww
PCB-090	10/10	100	81,100 C	199,000 C	132,000	na	ng/kg ww
PCB-091	10/10	100	C88	C88	nc	na	ng/kg ww
PCB-092	10/10	100	16,000	32,600	22,900	na	ng/kg ww
PCB-093	10/10	100	44,000 C	87,600 C	63,500	na	ng/kg ww
PCB-094	10/10	100	202	449	285	na	ng/kg ww
PCB-095	10/10	100	C93	C93	nc	na	ng/kg ww
PCB-096	10/10	100	262	514	373	na	ng/kg ww
PCB-097	10/10	100	C86	C86	nc	na	ng/kg ww
PCB-098	10/10	100	C93	C93	nc	na	ng/kg ww
PCB-099	10/10	100	C83	C83	nc	na	ng/kg ww
PCB-100	10/10	100	C93	C93	nc	na	ng/kg ww
PCB-101	10/10	100	C90	C90	nc	na	ng/kg ww

Table E.6.3-9, cont. Summary statistics for English sole, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-102	10/10	100	C93	C93	nc	na	ng/kg ww
PCB-103	10/10	100	1,260	3,240	1,920	na	ng/kg ww
PCB-104	10/10	100	11.6	32.6	19.2	na	ng/kg ww
PCB-105	10/10	100	17,000	49,200	31,900	na	ng/kg ww
PCB-106	0/10	0	nd	nd	26.1	11.9 – 157	ng/kg ww
PCB-107	10/10	100	1,710 C	4,330 C	2,680	na	ng/kg ww
PCB-108	10/10	100	C86	C86	nc	na	ng/kg ww
PCB-109	10/10	100	4,590	11,300	7,190	na	ng/kg ww
PCB-110	10/10	100	67,200 C	153,000 C	101,000	na	ng/kg ww
PCB-111	10/10	100	51.2	135	79.2	na	ng/kg ww
PCB-112	0/10	0	nd	nd	7.46	5.22 – 46.4	ng/kg ww
PCB-113	10/10	100	C90	C90	nc	na	ng/kg ww
PCB-114	10/10	100	1,200	3,620	2,130	na	ng/kg ww
PCB-115	10/10	100	C110	C110	nc	na	ng/kg ww
PCB-116	10/10	100	C85	C85	nc	na	ng/kg ww
PCB-117	10/10	100	C85	C85	nc	na	ng/kg ww
PCB-118	10/10	100	58,200	159,000 J	101,000	na	ng/kg ww
PCB-119	10/10	100	C86	C86	nc	na	ng/kg ww
PCB-120	10/10	100	363	958	571	na	ng/kg ww
PCB-121	9/10	90	28.0 J	97.8	45.3	47.4	ng/kg ww
PCB-122	8/10	80	274	744	347	45.1 – 159	ng/kg ww
PCB-123	10/10	100	934	2,430	1,690	na	ng/kg ww
PCB-124	10/10	100	C107	C107	nc	na	ng/kg ww
PCB-125	10/10	100	C86	C86	nc	na	ng/kg ww
PCB-126	10/10	100	59.5	192	133	na	ng/kg ww
PCB-127	7/10	70	148	296	162	55.0 – 175	ng/kg ww
PCB-128	10/10	100	10,100 C	26,500 C	17,700	na	ng/kg ww
PCB-129	10/10	100	103,000 C	284,000 C	180,000	na	ng/kg ww
PCB-130	10/10	100	4,990	13,500	8,600	na	ng/kg ww

Table E.6.3-9, cont. Summary statistics for English sole, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-131	10/10	100	722	1,840	1,170	na	ng/kg ww
PCB-132	10/10	100	23,000	51,300	33,200	na	ng/kg ww
PCB-133	10/10	100	1,840	4,760	2,900	na	ng/kg ww
PCB-134	10/10	100	3,890 C	9,970 C	6,120	na	ng/kg ww
PCB-135	10/10	100	33,600 C	80,600 C	54,400	na	ng/kg ww
PCB-136	10/10	100	9,600	22,900	14,300	na	ng/kg ww
PCB-137	10/10	100	3,530	9,130	5,770	na	ng/kg ww
PCB-138	10/10	100	C129	C129	nc	na	ng/kg ww
PCB-139	10/10	100	1,830 C	4,700 C	2,900	na	ng/kg ww
PCB-140	10/10	100	C139	C139	nc	na	ng/kg ww
PCB-141	10/10	100	15,000	45,700	26,500	na	ng/kg ww
PCB-142	0/10	0	nd	nd	28.8	16.6 – 127	ng/kg ww
PCB-143	10/10	100	C134	C134	nc	na	ng/kg ww
PCB-144	10/10	100	4,590	11,200	7,610	na	ng/kg ww
PCB-145	10/10	100	19.3 J	76.8	41.4	na	ng/kg ww
PCB-146	10/10	100	15,700	43,600	28,300	na	ng/kg ww
PCB-147	10/10	100	80,100 C	188,000 C	122,000	na	ng/kg ww
PCB-148	10/10	100	227	651	385	na	ng/kg ww
PCB-149	10/10	100	C147	C147	nc	na	ng/kg ww
PCB-150	10/10	100	218	603	341	na	ng/kg ww
PCB-151	10/10	100	C135	C135	nc	na	ng/kg ww
PCB-152	10/10	100	55.5	118	79.3	na	ng/kg ww
PCB-153	10/10	100	121,000 C	307,000 C	201,000	na	ng/kg ww
PCB-154	10/10	100	C135	C135	nc	na	ng/kg ww
PCB-155	10/10	100	12.9 J	57.4	24.6	na	ng/kg ww
PCB-156	10/10	100	8,850 C	24,300 C	14,800	na	ng/kg ww
PCB-157	10/10	100	C156	C156	nc	na	ng/kg ww
PCB-158	10/10	100	8,970	23,900	14,900	na	ng/kg ww
PCB-159	10/10	100	714	2,000	1,220	na	ng/kg ww

Table E.6.3-9, cont. Summary statistics for English sole, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-160	10/10	100	C129	C129	nc	na	ng/kg ww
PCB-161	0/10	0	nd	nd	19.6	11.7 – 88.0	ng/kg ww
PCB-162	10/10	100	247	555	391	na	ng/kg ww
PCB-163	10/10	100	C129	C129	nc	na	ng/kg ww
PCB-164	10/10	100	5,120	14,100	8,740	na	ng/kg ww
PCB-165	8/10	80	57.1	136	75.7	86.2 – 98.7	ng/kg ww
PCB-166	10/10	100	C128	C128	nc	na	ng/kg ww
PCB-167	10/10	100	3,600	9,910	6,090	na	ng/kg ww
PCB-168	10/10	100	C153	C153	nc	na	ng/kg ww
PCB-169	6/10	60	3.17 J	7.13	7.72	2.58 – 84.5	ng/kg ww
PCB-170	10/10	100	17,700	47,100	30,900	na	ng/kg ww
PCB-171	10/10	100	5,980 C	16,400 C	10,600	na	ng/kg ww
PCB-172	10/10	100	3,110	9,330	5,780	na	ng/kg ww
PCB-173	10/10	100	C171	C171	nc	na	ng/kg ww
PCB-174	10/10	100	14,100	39,800	24,600	na	ng/kg ww
PCB-175	10/10	100	833	2,190	1,460	na	ng/kg ww
PCB-176	10/10	100	2,520	6,340	4,240	na	ng/kg ww
PCB-177	10/10	100	10,800	29,600	20,200	na	ng/kg ww
PCB-178	10/10	100	4,810	12,700	8,340	na	ng/kg ww
PCB-179	10/10	100	8,460	21,900	13,900	na	ng/kg ww
PCB-180	10/10	100	51,900 C	139,000 C	84,600	na	ng/kg ww
PCB-181	10/10	100	151	488	274	na	ng/kg ww
PCB-182	10/10	100	185	904	392	na	ng/kg ww
PCB-183	10/10	100	17,500 C	50,300 C	30,900	na	ng/kg ww
PCB-184	10/10	100	16.7	46.8	26.3	na	ng/kg ww
PCB-185	10/10	100	C183	C183	nc	na	ng/kg ww
PCB-186	0/10	0	nd	nd	1.51	1.45 – 5.74	ng/kg ww
PCB-187	10/10	100	32,900	89,800	56,900	na	ng/kg ww
PCB-188	10/10	100	57.2	201	94.0	na	ng/kg ww

Table E.6.3-9, cont. Summary statistics for English sole, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-189	10/10	100	555	1,370	953	na	ng/kg ww
PCB-190	10/10	100	4,440	14,200	8,420	na	ng/kg ww
PCB-191	10/10	100	970	3,000	1,680	na	ng/kg ww
PCB-192	0/10	0	nd	nd	1.75	1.70 – 6.68	ng/kg ww
PCB-193	10/10	100	C180	C180	nc	na	ng/kg ww
PCB-194	10/10	100	6,310	19,900	11,300	na	ng/kg ww
PCB-195	10/10	100	2,580	7,300	4,680	na	ng/kg ww
PCB-196	10/10	100	4,140	11,900	7,270	na	ng/kg ww
PCB-197	10/10	100	1,050 C	3,410 C	1,890	na	ng/kg ww
PCB-198	10/10	100	7,980 C	25,900 C	14,500	na	ng/kg ww
PCB-199	10/10	100	C198	C198	nc	na	ng/kg ww
PCB-200	10/10	100	C197	C197	nc	na	ng/kg ww
PCB-201	10/10	100	1,020	3,640	1,850	na	ng/kg ww
PCB-202	10/10	100	1,850	7,330	3,430	na	ng/kg ww
PCB-203	10/10	100	5,810	18,600	10,600	na	ng/kg ww
PCB-204	9/10	90	2.64 J	8.27 J	4.21	0.257	ng/kg ww
PCB-205	10/10	100	383	1,150	671	na	ng/kg ww
PCB-206	10/10	100	1,200	7,680	2,900	na	ng/kg ww
PCB-207	10/10	100	172	979	364	na	ng/kg ww
PCB-208	10/10	100	330	2,150	784	na	ng/kg ww
PCB-209	10/10	100	149	1,050	398	na	ng/kg ww
Total PCB congeners	10/10	100	1,361,000 J	3,214,000 J	2,140,000	nc	ng/kg ww
Aroclor-1016	0/42	0	nd	nd	46	10 – 160	µg/kg ww
Aroclor-1221	0/42	0	nd	nd	68	20 – 290	µg/kg ww
Aroclor-1232	0/42	0	nd	nd	47	10 – 160	µg/kg ww
Aroclor-1242	0/42	0	nd	nd	46	10 – 160	µg/kg ww
Aroclor-1248	21/42	50	230	1,200	330	60 – 160	µg/kg ww
Aroclor-1254	42/42	100	380 M	1,900	1,100	na	µg/kg ww
Aroclor-1260	42/42	100	220 M	1,900	890	na	µg/kg ww

Table E.6.3-9, cont. Summary statistics for English sole, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Total PCBs [a]	42/42	100	610 M	4,700	2,300	nc	µg/kg ww
PCB TEQ – Bird	10/10	100	43.00	146.0	81.8	na	ng/kg ww
PCB TEQ – Fish	10/10	100	0.8730	2.420 J	1.61	na	ng/kg ww
PCB TEQ – Mammal	10/10	100	10.30	27.1 J	18.4	na	ng/kg ww
Pesticides							
2,4'-DDD	0/21	0	nd	nd	8.7	6.2 – 88	µg/kg ww
2,4'-DDE	0/21	0	nd	nd	4.4	2.9 – 18	µg/kg ww
2,4'-DDT	21/21	100	54 JN	130 JN	87	na	µg/kg ww
4,4'-DDD	21/21	100	6.7 JN	20 JN	11	na	µg/kg ww
4,4'-DDE	19/21	90	7.7 JN	20 JN	13	12 – 14	µg/kg ww
4,4'-DDT	21/21	100	42 JN	110 JN	73	na	µg/kg ww
Total DDTs	21/21	100	113 JN	280 JN	180	nc	µg/kg ww
Aldrin	1/21	5	6.2 JN	6.2 JN	4.3	7.2 – 10	µg/kg ww
Dieldrin	0/21	0	nd	nd	4.1	2.0 – 10	µg/kg ww
Total aldrin/dieldrin	1/21	5	6.2 JN	6.2 JN	4.3	nc	µg/kg ww
alpha-BHC	0/21	0	nd	nd	4.1	1.0 – 10	µg/kg ww
beta-BHC	8/21	38	4.0 JN	8.4 JN	4.7	7.2 – 10	µg/kg ww
gamma-BHC	2/21	10	2.3 JN	4.3 JN	4.2	7.2 – 10	µg/kg ww
delta-BHC	0/21	0	nd	nd	4.1	1.0 – 10	µg/kg ww
alpha-Chlordane	7/21	33	3.8 JN	6.6 JN	4.4	1.0 – 10	µg/kg ww
gamma-Chlordane	20/21	95	22 JN	53 JN	36	56	µg/kg ww
alpha-Endosulfan	13/21	62	2.1 JN	6.6 JN	4.0	7.2 – 10	µg/kg ww
beta-Endosulfan	4/21	19	6.5 JN	18 JN	5.7	7.2 – 10	µg/kg ww
Endosulfan sulfate	0/21	0	nd	nd	4.1	1.0 – 10	µg/kg ww
Endrin	2/21	10	2.8 JN	14 JN	4.6	1.7 – 12	µg/kg ww
Endrin aldehyde	1/21	5	5.5 JN	5.5 JN	4.2	1.3 – 10	µg/kg ww
Endrin ketone	0/21	0	nd	nd	4.1	1.9 – 10	µg/kg ww
Heptachlor	2/21	10	5.7 JN	6.8 JN	4.2	1.0 – 10	µg/kg ww
Heptachlor epoxide	12/21	57	12 JN	45 JN	18	7.2 – 10	µg/kg ww

Table E.6.3-9, cont. Summary statistics for English sole, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Methoxychlor	0/21	0	nd	nd	4.4	1.0 – 23	µg/kg ww
Mirex	0/21	0	nd	nd	4.1	1.0 – 10	µg/kg ww
Toxaphene	0/21	0	nd	nd	560	370 – 1,800	µg/kg ww
Total chlordane	21/21	100	6.6 JN	59 JN	37	nc	µg/kg ww
Conventional parameters							
Total solids[a]	42/42	100	20.99	28.96 M	25.1	na	% ww
Lipid[a]	42/42	100	2.6	8.7	5.5	na	% ww

[a] Samples include 32 whole-body samples and 10 calculated "whole-body" samples. Concentrations in "whole-body" samples were estimated using results from separate analyses of fillet and remainder composite samples (i.e., all remaining tissue and fluids after fillets were removed from the specimens). The estimated English sole "whole-body" concentrations were based on the relative weights and total PCB concentrations in skin-on fillet and remainder tissues collected in 2005.

Note: data for six English sole whole body composite samples collected by King County in 2006 are not included in this table.

Table E.6.3-10. Summary statistics for transplanted mussels, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	0/34	0	nd	nd	0.01	0.02	mg/kg ww
Arsenic	35/35	100	0.573	1.42	0.791	na	mg/kg ww
Cadmium	35/35	100	0.231	0.781	0.379	na	mg/kg ww
Chromium	33/35	94	0.059	0.305	0.1	0.05	mg/kg ww
Cobalt	15/15	100	0.030	0.0784	0.047	na	mg/kg ww
Copper	35/35	100	0.513	2.08	1.13	na	mg/kg ww
Lead	35/35	100	0.043	0.288	0.13	na	mg/kg ww
Mercury	35/35	100	0.0051	0.0088	0.0066	na	mg/kg ww
Molybdenum	15/15	100	0.057	0.116	0.082	na	mg/kg ww
Nickel	35/35	100	0.0820	0.289	0.158	na	mg/kg ww
Silver	7/35	20	0.013	0.032	0.009	0.01 – 0.012	mg/kg ww
Vanadium	10/10	100	0.119	0.281	0.195	na	mg/kg ww
Zinc	35/35	100	4.78	20.6	9.71	na	mg/kg ww
Organometals							
Monobutyltin as ion	6/14	43	1.75 J	4.71 J	1.82	1.74	µg/kg ww
Dibutyltin as ion	12/14	86	2.56	5.30	3.17	2.87 – 3.42	µg/kg ww
Tributyltin as ion	32/32	100	9.35	36.9	19.6	na	µg/kg ww
PAHs							
2-Chloronaphthalene	0/34	0	nd	nd	8.6	16 – 26	µg/kg ww
2-Methylnaphthalene	0/34	0	nd	nd	20	43 – 70	µg/kg ww
Acenaphthene	0/34	0	nd	nd	5.9	11 – 18	µg/kg ww
Acenaphthylene	0/34	0	nd	nd	8.6	16 – 26	µg/kg ww
Anthracene	0/34	0	nd	nd	8.6	16 – 26	µg/kg ww
Benzo(a)anthracene	13/34	38	20	39.3	17	16 – 26	µg/kg ww
Benzo(a)pyrene	0/34	0	nd	nd	10	27 – 44	µg/kg ww
Benzo(b)fluoranthene	8/34	24	43	62	30	43 – 70	µg/kg ww
Benzo(g,h,i)perylene	0/34	0	nd	nd	10	27 – 44	µg/kg ww

Table E.6.3-10, cont. Summary statistics for transplanted mussels, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Benzo(k)fluoranthene	0/34	0	nd	nd	20	43 – 70	µg/kg ww
Total benzofluoranthenes	8/34	24	43	62	30	nc	µg/kg ww
Chrysene	14/34	41	32.2	58.0	24	16 – 26	µg/kg ww
Dibenzo(a,h)anthracene	0/34	0	nd	nd	20	43 – 70	µg/kg ww
Dibenzofuran	0/34	0	nd	nd	10	27 – 44	µg/kg ww
Fluoranthene	23/34	68	16	123	45	16 – 26	µg/kg ww
Fluorene	0/34	0	nd	nd	8.6	16 – 26	µg/kg ww
Indeno(1,2,3-cd)pyrene	0/34	0	nd	nd	10	27 – 44	µg/kg ww
Naphthalene	0/34	0	nd	nd	20	43 – 70	µg/kg ww
Phenanthrene	10/34	29	16	24	12	16 – 26	µg/kg ww
Pyrene	15/34	44	30.0	122	40	16 – 26	µg/kg ww
Total HPAH	24/34	71	16	351	100	nc	µg/kg ww
Total LPAH	10/34	29	16	24	20	nc	µg/kg ww
Carcinogenic PAHs – Mammal	16/34	47	29	35	20	29 – 47	µg/kg ww
Total PAH	24/34	71	16	373	100	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	0/34	0	nd	nd	8.6	16 – 26	µg/kg ww
Butyl benzyl phthalate	0/34	0	nd	nd	8.6	16 – 26	µg/kg ww
Diethyl phthalate	0/34	0	nd	nd	10	27 – 44	µg/kg ww
Dimethyl phthalate	0/34	0	nd	nd	5.9	11 – 18	µg/kg ww
Di-n-butyl phthalate	1/34	3	59	59	20	27 – 44	µg/kg ww
Di-n-octyl phthalate	0/34	0	nd	nd	8.6	16 – 26	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/34	0	nd	nd	8.6	16 – 26	µg/kg ww
1,2-Dichlorobenzene	0/34	0	nd	nd	8.6	16 – 26	µg/kg ww
1,2-Diphenylhydrazine	0/34	0	nd	nd	28	53 – 88	µg/kg ww
1,3-Dichlorobenzene	0/34	0	nd	nd	8.6	16 – 26	µg/kg ww
1,4-Dichlorobenzene	0/34	0	nd	nd	8.6	16 – 26	µg/kg ww
2,4,5-Trichlorophenol	0/34	0	nd	nd	59	110 – 180	µg/kg ww

Table E.6.3-10, cont. Summary statistics for transplanted mussels, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
2,4,6-Trichlorophenol	0/34	0	nd	nd	59	110 – 180	µg/kg ww
2,4-Dichlorophenol	0/34	0	nd	nd	10	27 – 44	µg/kg ww
2,4-Dimethylphenol	0/34	0	nd	nd	10	27 – 44	µg/kg ww
2,4-Dinitrophenol	0/34	0	nd	nd	28	53 – 88	µg/kg ww
2,4-Dinitrotoluene	0/34	0	nd	nd	5.9	11 – 18	µg/kg ww
2,6-Dinitrotoluene	0/34	0	nd	nd	5.9	11 – 18	µg/kg ww
2-Chlorophenol	0/34	0	nd	nd	28	53 – 88	µg/kg ww
2-Methylphenol	29/34	85	29	178	80	27 – 41	µg/kg ww
2-Nitroaniline	0/34	0	nd	nd	59	110 – 180	µg/kg ww
2-Nitrophenol	0/34	0	nd	nd	10	27 – 44	µg/kg ww
3,3'-Dichlorobenzidine	0/1	0	nd	nd	20	30 – 30	µg/kg ww
3-Nitroaniline	0/10	0	nd	nd	56	110 – 120	µg/kg ww
4,6-Dinitro-o-cresol	0/34	0	nd	nd	28	53 – 88	µg/kg ww
4-Bromophenyl phenyl ether	0/34	0	nd	nd	5.9	11 – 18	µg/kg ww
4-Chloro-3-methylphenol	0/34	0	nd	nd	28	53 – 88	µg/kg ww
4-Chloroaniline	0/1	0	nd	nd	30	59 – 59	µg/kg ww
4-Chlorophenyl phenyl ether	0/34	0	nd	nd	8.6	16 – 26	µg/kg ww
4-Methylphenol	2/34	6	27	172	20	27 – 44	µg/kg ww
4-Nitroaniline	0/4	0	nd	nd	56	110 – 120	µg/kg ww
4-Nitrophenol	0/34	0	nd	nd	28	53 – 88	µg/kg ww
Aniline	0/16	0	nd	nd	27	53 – 59	µg/kg ww
Benzidine	0/1	0	nd	nd	360	710	µg/kg ww
Benzoic acid	34/34	100	659	11,900	3,080	na	µg/kg ww
Benzyl alcohol	5/34	15	85.8	3,450	200	27 – 44	µg/kg ww
bis(2-chloroethoxy)methane	0/34	0	nd	nd	10	27 – 44	µg/kg ww
bis(2-chloroethyl)ether	0/34	0	nd	nd	8.6	16 – 26	µg/kg ww
bis(2-chloroisopropyl)ether	0/34	0	nd	nd	28	53 – 88	µg/kg ww
Caffeine	0/34	0	nd	nd	2.8	5.3 – 8.8	µg/kg ww
Carbazole	0/34	0	nd	nd	10	27 – 44	µg/kg ww
Coprostanol	0/34	0	nd	nd	59	110 – 180	µg/kg ww

Table E.6.3-10, cont. Summary statistics for transplanted mussels, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Hexachlorobenzene	0/34	0	nd	nd	8.6	16 – 26	µg/kg ww
Hexachlorobutadiene	0/34	0	nd	nd	10	27 – 44	µg/kg ww
Hexachlorocyclopentadiene	0/34	0	nd	nd	10	27 – 44	µg/kg ww
Hexachloroethane	0/34	0	nd	nd	10	27 – 44	µg/kg ww
Isophorone	0/34	0	nd	nd	10	27 – 44	µg/kg ww
Nitrobenzene	0/34	0	nd	nd	10	27 – 44	µg/kg ww
N-Nitrosodimethylamine	0/34	0	nd	nd	59	110 – 180	µg/kg ww
N-Nitroso-di-n-propylamine	0/34	0	nd	nd	10	27 – 44	µg/kg ww
N-Nitrosodiphenylamine	0/34	0	nd	nd	10	27 – 44	µg/kg ww
Pentachlorophenol	0/34	0	nd	nd	10	27 – 44	µg/kg ww
Phenol	0/34	0	nd	nd	59	110 – 180	µg/kg ww
Polychlorinated biphenyls							
Aroclor-1016	0/32	0	nd	nd	6.5	13	µg/kg ww
Aroclor-1221	0/32	0	nd	nd	6.5	13	µg/kg ww
Aroclor-1232	0/32	0	nd	nd	6.5	13	µg/kg ww
Aroclor-1242	0/32	0	nd	nd	6.5	13	µg/kg ww
Aroclor-1248	0/32	0	nd	nd	6.5	13	µg/kg ww
Aroclor-1254	13/32	41	35.9	73.1	27	13	µg/kg ww
Aroclor-1260	0/32	0	nd	nd	6.5	13	µg/kg ww
Total PCBs	13/32	41	35.9	73.1	27	nc	µg/kg ww
Pesticides							
4,4'-DDD	0/13	0	nd	nd	0.65	1.3	µg/kg ww
4,4'-DDE	0/13	0	nd	nd	0.65	1.3	µg/kg ww
4,4'-DDT	0/13	0	nd	nd	0.65	1.3	µg/kg ww
Total DDTs	0/13	0	nd	nd	0.65	nc	µg/kg ww
Aldrin	0/13	0	nd	nd	0.65	1.3	µg/kg ww
Dieldrin	0/13	0	nd	nd	0.65	1.3	µg/kg ww
Total aldrin/dieldrin	0/13	0	nd	nd	0.65	nc	µg/kg ww
alpha-BHC	0/13	0	nd	nd	0.65	1.3	µg/kg ww
beta-BHC	0/13	0	nd	nd	0.65	1.3	µg/kg ww

Table E.6.3-10, cont. Summary statistics for transplanted mussels, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
gamma-BHC	0/13	0	nd	nd	0.65	1.3	µg/kg ww
delta-BHC	0/13	0	nd	nd	0.65	1.3	µg/kg ww
Chlordane	0/13	0	nd	nd	3.4	6.7	µg/kg ww
alpha-Endosulfan	0/13	0	nd	nd	0.65	1.3	µg/kg ww
beta-Endosulfan	0/13	0	nd	nd	0.65	1.3	µg/kg ww
Endosulfan sulfate	0/13	0	nd	nd	0.65	1.3	µg/kg ww
Endrin	0/13	0	nd	nd	0.65	1.3	µg/kg ww
Endrin aldehyde	0/13	0	nd	nd	0.65	1.3	µg/kg ww
Heptachlor	0/13	0	nd	nd	0.65	1.3	µg/kg ww
Heptachlor epoxide	0/13	0	nd	nd	0.65	1.3	µg/kg ww
Methoxychlor	0/13	0	nd	nd	3.4	6.7	µg/kg ww
Toxaphene	0/13	0	nd	nd	6.5	1.3	µg/kg ww
Conventional parameters							
Lipid	32/32	100	0.250	2.60	1.28	na	% ww

Table E.6.3-11. Summary statistics for wild mussels, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	0/22	0	nd	nd	0.0086	0.010 – 0.020	mg/kg ww
Arsenic	22/22	100	0.34	1.1 J	0.81	na	mg/kg ww
Cadmium	22/22	100	0.19	0.84	0.49	na	mg/kg ww
Chromium	21/22	95	0.10	0.35	0.16	0.050	mg/kg ww
Cobalt	11/11	100	0.030	0.070	0.055	na	mg/kg ww
Copper	22/22	100	0.58	1.7 J	1.2	na	mg/kg ww
Lead	22/22	100	0.13	0.72	0.41	na	mg/kg ww
Mercury	21/21	100	0.0088	0.023	0.013	na	mg/kg ww
Molybdenum	10/10	100	0.023	0.10	0.055	na	mg/kg ww
Nickel	22/22	100	0.051	0.42 J	0.15	na	mg/kg ww
Silver	0/22	0	nd	nd	0.0052	0.010 – 0.012	mg/kg ww
Vanadium	8/8	100	0.058	0.26	0.15	na	mg/kg ww
Zinc	22/22	100	17	44	30	na	mg/kg ww
Organometals							
Monobutyltin as ion	9/11	82	1.8 J	4.9 J	2.3	1.7	µg/kg ww
Dibutyltin as ion	11/11	100	4.0	11	7.3	na	µg/kg ww
Tributyltin as ion	22/22	100	12	37	23	na	µg/kg ww
PAHs							
2-Chloronaphthalene	0/22	0	nd	nd	8.0	16	µg/kg ww
2-Methylnaphthalene	0/22	0	nd	nd	22	43	µg/kg ww
Acenaphthene	0/22	0	nd	nd	5.5	11	µg/kg ww
Acenaphthylene	0/22	0	nd	nd	8.0	16	µg/kg ww
Anthracene	0/22	0	nd	nd	8.0	16	µg/kg ww
Benzo(a)anthracene	11/22	50	17	32	17	16	µg/kg ww
Benzo(a)pyrene	0/22	0	nd	nd	14	27	µg/kg ww
Benzo(b)fluoranthene	1/22	5	43	43	22	43	µg/kg ww
Benzo(g,h,i)perylene	0/22	0	nd	nd	14	27	µg/kg ww
Benzo(k)fluoranthene	0/22	0	nd	nd	22	43	µg/kg ww
Total benzofluoranthenes	1/22	5	43	43	22	nc	µg/kg ww

Table E.6.3-11, cont. Summary statistics for wild mussels, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Chrysene	11/22	50	19	46	21	16	µg/kg ww
Dibenzo(a,h)anthracene	0/22	0	nd	nd	22	43	µg/kg ww
Dibenzofuran	0/22	0	nd	nd	14	27	µg/kg ww
Fluoranthene	21/22	95	17	58	33	16	µg/kg ww
Fluorene	0/22	0	nd	nd	8.0	16	µg/kg ww
Indeno(1,2,3-cd)pyrene	0/22	0	nd	nd	14	27	µg/kg ww
Naphthalene	0/22	0	nd	nd	22	43	µg/kg ww
Phenanthrene	0/22	0	nd	nd	8.0	16	µg/kg ww
Pyrene	13/22	59	17	40	21	16	µg/kg ww
Total HPAH	21/22	95	17	208	82	nc	µg/kg ww
Total LPAH	0/22	0	nd	nd	22	nc	µg/kg ww
Carcinogenic PAHs – Mammal	11/22	50	30	33	23	29	µg/kg ww
Total PAH	21/22	95	17	208	82	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	2/22	9	28	190	17	16	µg/kg ww
Butyl benzyl phthalate	0/22	0	nd	nd	8.0	16	µg/kg ww
Diethyl phthalate	0/22	0	nd	nd	14	27	µg/kg ww
Dimethyl phthalate	0/22	0	nd	nd	5.5	11	µg/kg ww
Di-n-butyl phthalate	0/22	0	nd	nd	14	27	µg/kg ww
Di-n-octyl phthalate	0/22	0	nd	nd	8.0	16	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/22	0	nd	nd	8.0	16	µg/kg ww
1,2-Dichlorobenzene	0/22	0	nd	nd	8.0	16	µg/kg ww
1,2-Diphenylhydrazine	0/22	0	nd	nd	27	53	µg/kg ww
1,3-Dichlorobenzene	0/22	0	nd	nd	8.0	16	µg/kg ww
1,4-Dichlorobenzene	0/22	0	nd	nd	8.0	16	µg/kg ww
2,4,5-Trichlorophenol	0/22	0	nd	nd	55	110	µg/kg ww
2,4,6-Trichlorophenol	0/22	0	nd	nd	55	110	µg/kg ww
2,4-Dichlorophenol	0/22	0	nd	nd	14	27	µg/kg ww
2,4-Dimethylphenol	0/22	0	nd	nd	14	27	µg/kg ww
2,4-Dinitrophenol	0/22	0	nd	nd	27	53	µg/kg ww
2,4-Dinitrotoluene	0/22	0	nd	nd	5.5	11	µg/kg ww

Table E.6.3-11, cont. Summary statistics for wild mussels, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
2,6-Dinitrotoluene	0/22	0	nd	nd	5.5	11	µg/kg ww
2-Chlorophenol	0/22	0	nd	nd	27	53	µg/kg ww
2-Methylphenol	18/22	82	28	94	48	27	µg/kg ww
2-Nitroaniline	0/22	0	nd	nd	55	110	µg/kg ww
2-Nitrophenol	0/22	0	nd	nd	14	27	µg/kg ww
3-Nitroaniline	0/8	0	nd	nd	55	110	µg/kg ww
4,6-Dinitro-o-cresol	0/22	0	nd	nd	27	53	µg/kg ww
4-Bromophenyl phenyl ether	0/20	0	nd	nd	5.5	11	µg/kg ww
4-Chloro-3-methylphenol	0/22	0	nd	nd	27	53	µg/kg ww
4-Chlorophenyl phenyl ether	0/22	0	nd	nd	8.0	16	µg/kg ww
4-Methylphenol	0/22	0	nd	nd	14	27	µg/kg ww
4-Nitroaniline	0/14	0	nd	nd	55	110	µg/kg ww
4-Nitrophenol	0/22	0	nd	nd	27	53	µg/kg ww
Aniline	0/19	0	nd	nd	27	53	µg/kg ww
Benzoic acid	22/22	100	790 J	4,000 J	1,700	na	µg/kg ww
Benzyl alcohol	1/22	5	28	28	14	27	µg/kg ww
bis(2-chloroethoxy)methane	0/22	0	nd	nd	14	27	µg/kg ww
bis(2-chloroethyl)ether	0/22	0	nd	nd	8.0	16	µg/kg ww
bis(2-chloroisopropyl)ether	0/22	0	nd	nd	27	53	µg/kg ww
Caffeine	0/22	0	nd	nd	2.7	5.3	µg/kg ww
Carbazole	0/22	0	nd	nd	14	27	µg/kg ww
Coprostanol	0/22	0	nd	nd	55	110	µg/kg ww
Hexachlorobenzene	0/22	0	nd	nd	8.0	16	µg/kg ww
Hexachlorobutadiene	0/22	0	nd	nd	14	27	µg/kg ww
Hexachlorocyclopentadiene	0/22	0	nd	nd	14	27	µg/kg ww
Hexachloroethane	0/21	0	nd	nd	14	27	µg/kg ww
Isophorone	0/22	0	nd	nd	14	27	µg/kg ww
Nitrobenzene	0/22	0	nd	nd	14	27	µg/kg ww
N-Nitrosodimethylamine	0/22	0	nd	nd	55	110	µg/kg ww
N-Nitroso-di-n-propylamine	0/22	0	nd	nd	14	27	µg/kg ww
N-Nitrosodiphenylamine	0/22	0	nd	nd	14	27	µg/kg ww
Pentachlorophenol	0/22	0	nd	nd	14	27	µg/kg ww

Table E.6.3-11, cont. Summary statistics for wild mussels, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Phenol	0/22	0	nd	nd	55	110	µg/kg ww
Polychlorinated biphenyls							
Aroclor-1016	0/22	0	nd	nd	6.5	13	µg/kg ww
Aroclor-1221	0/22	0	nd	nd	6.5	13	µg/kg ww
Aroclor-1232	0/22	0	nd	nd	6.5	13	µg/kg ww
Aroclor-1242	0/22	0	nd	nd	6.5	13	µg/kg ww
Aroclor-1248	0/22	0	nd	nd	6.5	13	µg/kg ww
Aroclor-1254	18/22	82	16	60	34	13	µg/kg ww
Aroclor-1260	0/22	0	nd	nd	6.5	13	µg/kg ww
Total PCBs	18/22	82	16	60	34	nc	µg/kg ww
Pesticides							
4,4'-DDD	0/11	0	nd	nd	0.65	1.3	µg/kg ww
4,4'-DDE	0/11	0	nd	nd	0.65	1.3	µg/kg ww
4,4'-DDT	0/11	0	nd	nd	0.65	1.3	µg/kg ww
Total DDTs	0/11	0	nd	nd	0.65	nc	µg/kg ww
Aldrin	0/11	0	nd	nd	0.65	1.3	µg/kg ww
Dieldrin	0/11	0	nd	nd	0.65	1.3	µg/kg ww
Total aldrin/dieldrin	0/11	0	nd	nd	0.65	nc	µg/kg ww
alpha-BHC	0/11	0	nd	nd	0.65	1.3	µg/kg ww
beta-BHC	0/11	0	nd	nd	0.65	1.3	µg/kg ww
gamma-BHC	0/11	0	nd	nd	0.65	1.3	µg/kg ww
delta-BHC	0/11	0	nd	nd	0.65	1.3	µg/kg ww
Chlordane	0/11	0	nd	nd	3.4	6.7	µg/kg ww
alpha-Endosulfan	0/11	0	nd	nd	0.65	1.3	µg/kg ww
beta-Endosulfan	0/11	0	nd	nd	0.65	1.3	µg/kg ww
Endosulfan sulfate	0/11	0	nd	nd	0.65	1.3	µg/kg ww
Endrin	0/11	0	nd	nd	0.65	1.3	µg/kg ww
Endrin aldehyde	0/11	0	nd	nd	0.65	1.3	µg/kg ww
Heptachlor	0/11	0	nd	nd	0.65	1.3	µg/kg ww
Heptachlor epoxide	0/11	0	nd	nd	0.65	1.3	µg/kg ww
Methoxychlor	0/11	0	nd	nd	3.4	6.7	µg/kg ww
Toxaphene	0/11	0	nd	nd	6.5	13	µg/kg ww

Table E.6.3-11, cont. Summary statistics for wild mussels, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Conventional parameters							
Total solids (estimated)	22/22	100	14.9	14.9	14.9	na	% ww
Lipid	21/21	100	0.29	2.4	0.89	na	% ww

Table E.6.3-12. Summary statistics for Pacific staghorn sculpin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	19/24	79	0.001 J	0.007 J	0.003	0.010 – 0.011	mg/kg ww
Arsenic	24/24	100	0.364	1.430	0.738	na	mg/kg ww
Cadmium	24/24	100	0.002 J	0.011	0.005	na	mg/kg ww
Chromium	6/24	25	0.06 J	0.11	0.06	0.10 – 0.11	mg/kg ww
Cobalt	24/24	100	0.0182	0.0377	0.0250	na	mg/kg ww
Copper	24/24	100	0.67	1.22	0.93	na	mg/kg ww
Lead	24/24	100	0.012	0.114	0.054	na	mg/kg ww
Mercury	24/24	100	0.018	0.039	0.029	na	mg/kg ww
Molybdenum	24/24	100	0.0083 J	0.0162	0.012	na	mg/kg ww
Nickel	23/24	96	0.126	0.194	0.156	0.130	mg/kg ww
Selenium	24/24	100	0.14	0.23	0.18	na	mg/kg ww
Silver	24/24	100	0.0015 J	0.0077	0.0042	na	mg/kg ww
Thallium	17/24	71	0.0004 J	0.0007 J	0.001	0.0042 – 0.0043	mg/kg ww
Vanadium	10/24	42	0.1 J	0.2 J	0.1	0.2	mg/kg ww
Zinc	24/24	100	9.95	13.8	11.4	na	mg/kg ww
Organometals							
Monobutyltin as ion	3/24	12	0.44 J	27	1.6	1.0	µg/kg ww
Dibutyltin as ion	24/24	100	2.1	110	8.2	na	µg/kg ww
Tributyltin as ion	24/24	100	23	80	32	na	µg/kg ww
Tetrabutyltin as ion	1/24	4	66	66	3.2	1.0	µg/kg ww
PAHs							
2-Chloronaphthalene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
2-Methylnaphthalene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Acenaphthene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Acenaphthylene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Anthracene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Benzo(a)anthracene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Benzo(a)pyrene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Benzo(b)fluoranthene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Benzo(g,h,i)perylene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Benzo(k)fluoranthene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Total benzofluoranthenes	0/24	0	nd	nd	140	nc	µg/kg ww
Chrysene	1/24	4	9.0 J	9.0 J	140	40 – 400	µg/kg ww

Table E.6.3-12, cont. Summary statistics for Pacific staghorn sculpin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Dibenzo(a,h)anthracene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Dibenzofuran	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Fluoranthene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Fluorene	2/24	8	6.5 J	7.7 J	140	40 – 400	µg/kg ww
Indeno(1,2,3-cd)pyrene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Naphthalene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Phenanthrene	0/24	0	nd	nd	140	15 – 400	µg/kg ww
Pyrene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Total HPAH	1/24	4	9.0 J	9.0 J	140	nc	µg/kg ww
Total LPAH	2/24	8	6.5 J	7.7 J	140	nc	µg/kg ww
Carcinogenic PAHs – Mammal	1/24	4	36 J	36 J	130	36 – 360	µg/kg ww
Total PAH	3/24	12	6.5 J	9.0 J	140	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	0/24	0	nd	nd	1,700	490 – 5,000	µg/kg ww
Butyl benzyl phthalate	0/24	0	nd	nd	1,400	400 – 4,000	µg/kg ww
Diethyl phthalate	5/24	21	18 J	180	81	21 – 790	µg/kg ww
Dimethyl phthalate	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Di-n-butyl phthalate	1/24	4	1,300	1,300	490	200 – 1,300	µg/kg ww
Di-n-octyl phthalate	0/24	0	nd	nd	1,400	400 – 4,000	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
1,2-Dichlorobenzene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
1,3-Dichlorobenzene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
1,4-Dichlorobenzene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
2,4,5-Trichlorophenol	1/24	4	540 J	540 J	280	79 – 800	µg/kg ww
2,4,6-Trichlorophenol	1/24	4	270 J	270 J	270	79 – 800	µg/kg ww
2,4-Dichlorophenol	1/24	4	220 J	220 J	270	79 – 800	µg/kg ww
2,4-Dimethylphenol	1/24	4	210 J	210 J	270	79 – 800	µg/kg ww
2,4-Dinitrophenol	0/20	0	nd	nd	3,300	790 – 8,000	µg/kg ww
2,4-Dinitrotoluene	0/24	0	nd	nd	700	200 – 2,000	µg/kg ww
2,6-Dinitrotoluene	1/24	4	7.6 J	7.6 J	700	200 – 2,000	µg/kg ww
2-Chlorophenol	0/24	0	nd	nd	280	79 – 800	µg/kg ww
2-Methylphenol	0/24	0	nd	nd	280	79 – 800	µg/kg ww
2-Nitroaniline	0/24	0	nd	nd	700	200 – 2,000	µg/kg ww
2-Nitrophenol	0/24	0	nd	nd	140	40 – 400	µg/kg ww
3,3'-Dichlorobenzidine	0/24	0	nd	nd	7,000	2,000 – 20,000	µg/kg ww
3-Nitroaniline	0/24	0	nd	nd	1,400	400 – 4,000	µg/kg ww

Table E.6.3-12, cont. Summary statistics for Pacific staghorn sculpin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
4,6-Dinitro-o-cresol	0/24	0	nd	nd	2,800	790 – 8,000	µg/kg ww
4-Bromophenyl phenyl ether	0/24	0	nd	nd	140	40 – 400	µg/kg ww
4-Chloro-3-methylphenol	1/24	4	860 J	860 J	690	200 – 2,000	µg/kg ww
4-Chloroaniline	1/24	4	79 J	79 J	660	200 – 2,000	µg/kg ww
4-Chlorophenyl phenyl ether	1/24	4	5.1 J	5.1 J	140	40 – 400	µg/kg ww
4-Methylphenol	4/24	17	20 J	380 J	280	80 – 800	µg/kg ww
4-Nitroaniline	0/24	0	nd	nd	700	200 – 2,000	µg/kg ww
4-Nitrophenol	1/24	4	3,300 J	3,300 J	1,500	400 – 4,000	µg/kg ww
Aniline	0/24	0	nd	nd	2,800	790 – 8,000	µg/kg ww
Benzidine	0/24	0	nd	nd	18,000	5,000 – 50,000	µg/kg ww
Benzoic acid	23/24	96	890	6,800 J	4,600	800	µg/kg ww
Benzyl alcohol	7/24	29	24 J	2,100	240	40 – 400	µg/kg ww
bis(2-chloroethoxy)methane	0/24	0	nd	nd	140	40 – 400	µg/kg ww
bis(2-chloroethyl)ether	0/24	0	nd	nd	140	40 – 400	µg/kg ww
bis(2-chloroisopropyl)ether	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Carbazole	0/24	0	nd	nd	700	200 – 2,000	µg/kg ww
Hexachlorobenzene	2/24	8	1.2 JN	1.3 JN	0.58	1.0 – 1.4	µg/kg ww
Hexachlorobutadiene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Hexachlorocyclopentadiene	0/24	0	nd	nd	18,000	5,000 – 50,000	µg/kg ww
Hexachloroethane	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Isophorone	1/24	4	7.3 J	7.3 J	140	40 – 400	µg/kg ww
Nitrobenzene	0/24	0	nd	nd	140	40 – 400	µg/kg ww
N-Nitrosodimethylamine	0/24	0	nd	nd	280	79 – 800	µg/kg ww
N-Nitroso-di-n-propylamine	1/24	4	170 J	170 J	140	40 – 400	µg/kg ww
N-Nitrosodiphenylamine	0/24	0	nd	nd	140	40 – 400	µg/kg ww
Pentachlorophenol	3/24	12	43 J	2,600 J	1,400	400 – 4,000	µg/kg ww
Phenol	2/24	8	17 J	200 J	330	98 – 1,000	µg/kg ww
Polychlorinated biphenyls							
PCB-001	6/8	75	2.19 J	7.19	3.78	3.20 – 7.38	ng/kg ww
PCB-002	3/8	38	0.488 J	1.01 J	0.724	0.243 – 3.33	ng/kg ww
PCB-003	5/8	62	0.538 J	1.25 J	1.21	0.460 – 7.31	ng/kg ww
PCB-004	8/8	100	41.8	124	85.6	na	ng/kg ww
PCB-005	6/8	75	1.37 J	6.07	3.11	5.27 – 9.10	ng/kg ww
PCB-006	8/8	100	38.6	105	74.7	na	ng/kg ww
PCB-007	6/8	75	2.21 J	6.18	4.08	4.90 – 8.72	ng/kg ww
PCB-008	8/8	100	62.1	274	152	na	ng/kg ww
PCB-009	8/8	100	5.24	22.6	13.0	na	ng/kg ww

Table E.6.3-12, cont. Summary statistics for Pacific staghorn sculpin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-010	6/8	75	2.58 J	5.96	4.53	5.10 – 8.81	ng/kg ww
PCB-011	1/8	12	3.10	3.10	1.97	1.28 – 9.41	ng/kg ww
PCB-012	6/8	75	2.77 CJ	7.11 C	4.69	5.27 – 9.12	ng/kg ww
PCB-013	6/8	75	C12	C12	nc	0	ng/kg ww
PCB-014	0/8	0	nd	nd	1.02	0.0994 – 8.76	ng/kg ww
PCB-015	8/8	100	8.27	33.3 J	22.5	na	ng/kg ww
PCB-016	8/8	100	105	395	241	na	ng/kg ww
PCB-017	8/8	100	301	805	549	na	ng/kg ww
PCB-018	8/8	100	634 C	1,840 C	1,280	na	ng/kg ww
PCB-019	8/8	100	61.4	164	134	na	ng/kg ww
PCB-020	8/8	100	1,920 C	7,350 C	4,470	na	ng/kg ww
PCB-021	8/8	100	206 C	998 C	529	na	ng/kg ww
PCB-022	8/8	100	165	640	388	na	ng/kg ww
PCB-023	5/8	62	1.09 J	3.94	2.37	4.00 – 5.04	ng/kg ww
PCB-024	7/8	88	11.9	30.5	17.5	0.924	ng/kg ww
PCB-025	8/8	100	100	321	195	na	ng/kg ww
PCB-026	8/8	100	629 C	1,860 C	1,190	na	ng/kg ww
PCB-027	8/8	100	114	259	200	na	ng/kg ww
PCB-028	8/8	100	C20	C20	nc	na	ng/kg ww
PCB-029	8/8	100	C26	C26	nc	na	ng/kg ww
PCB-030	8/8	100	C18	C18	nc	na	ng/kg ww
PCB-031	8/8	100	635	3,090	1,830	na	ng/kg ww
PCB-032	8/8	100	264	749	528	na	ng/kg ww
PCB-033	8/8	100	C21	C21	nc	na	ng/kg ww
PCB-034	8/8	100	10.8	24.3 J	18.6	na	ng/kg ww
PCB-035	0/8	0	nd	nd	1.17	0.255 – 5.34	ng/kg ww
PCB-036	0/8	0	nd	nd	1.03	0.228 – 4.77	ng/kg ww
PCB-037	8/8	100	35.1	170	94.0	na	ng/kg ww
PCB-038	5/8	62	2.39 J	8.62	4.65	3.88 – 4.99	ng/kg ww
PCB-039	6/8	75	6.93	29.7	13.9	3.90 – 4.70	ng/kg ww
PCB-040	8/8	100	756 C	2,180 C	1,690	na	ng/kg ww
PCB-041	8/8	100	C40	C40	nc	na	ng/kg ww
PCB-042	8/8	100	547	2,160	1,280	na	ng/kg ww
PCB-043	8/8	100	174	421	249	na	ng/kg ww
PCB-044	8/8	100	4,020 C	14,100 C	8,320	na	ng/kg ww
PCB-045	8/8	100	222 C	571 C	473	na	ng/kg ww
PCB-046	8/8	100	76.7	224	174	na	ng/kg ww

Table E.6.3-12, cont. Summary statistics for Pacific staghorn sculpin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-047	8/8	100	C44	C44	nc	na	ng/kg ww
PCB-048	8/8	100	351	930	679	na	ng/kg ww
PCB-049	8/8	100	4,620 C	15,000 C	8,070	na	ng/kg ww
PCB-050	8/8	100	420 C	1,250 C	839	na	ng/kg ww
PCB-051	8/8	100	C45	C45	nc	na	ng/kg ww
PCB-052	8/8	100	9,040	30,100	16,900	na	ng/kg ww
PCB-053	8/8	100	C50	C50	nc	na	ng/kg ww
PCB-054	8/8	100	5.08	12.5 J	9.82	na	ng/kg ww
PCB-055	1/8	12	123	123	18.5	3.22 – 12.4	ng/kg ww
PCB-056	8/8	100	168	1,040	558	na	ng/kg ww
PCB-057	8/8	100	45.3	158	75.5	na	ng/kg ww
PCB-058	6/8	75	24.2	46.5	26.9	4.19 – 8.81	ng/kg ww
PCB-059	8/8	100	442 C	1,320 C	820	na	ng/kg ww
PCB-060	8/8	100	828	3,230	1,830	na	ng/kg ww
PCB-061	8/8	100	4,650 C	16,400 C	10,300	na	ng/kg ww
PCB-062	8/8	100	C59	C59	nc	na	ng/kg ww
PCB-063	8/8	100	299	793	592	na	ng/kg ww
PCB-064	8/8	100	1,440	4,610	2,960	na	ng/kg ww
PCB-065	8/8	100	C44	C44	nc	na	ng/kg ww
PCB-066	8/8	100	4,360	14,700	9,110	na	ng/kg ww
PCB-067	8/8	100	38.1	143	91.3	na	ng/kg ww
PCB-068	8/8	100	18.4 J	87.8	39.4	na	ng/kg ww
PCB-069	8/8	100	C49	C49	nc	na	ng/kg ww
PCB-070	8/8	100	C61	C61	nc	na	ng/kg ww
PCB-071	8/8	100	C40	C40	nc	na	ng/kg ww
PCB-072	8/8	100	175	659	304	na	ng/kg ww
PCB-073	1/8	12	130	130	16.5	0.0611 – 3.65	ng/kg ww
PCB-074	8/8	100	C61	C61	nc	na	ng/kg ww
PCB-075	8/8	100	C59	C59	nc	na	ng/kg ww
PCB-076	8/8	100	C61	C61	nc	na	ng/kg ww
PCB-077	8/8	100	54.2	490	231	na	ng/kg ww
PCB-078	0/8	0	nd	nd	4.55	3.41 – 21.7	ng/kg ww
PCB-079	8/8	100	84.6	495	265	na	ng/kg ww
PCB-080	0/8	0	nd	nd	4.10	3.14 – 18.6	ng/kg ww
PCB-081	8/8	100	9.12	23.9 J	15.8	na	ng/kg ww
PCB-082	8/8	100	505	2,220	1,110	na	ng/kg ww
PCB-083	8/8	100	14,600 C	53,900 C	23,600	na	ng/kg ww

Table E.6.3-12, cont. Summary statistics for Pacific staghorn sculpin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-084	8/8	100	1,180	7,300	2,920	na	ng/kg ww
PCB-085	8/8	100	2,390 C	9,150 C	4,450	na	ng/kg ww
PCB-086	8/8	100	8,110 C	30,300 C	14,000	na	ng/kg ww
PCB-087	8/8	100	C86	C86	nc	na	ng/kg ww
PCB-088	8/8	100	1,600 C	7,130 C	2,940	na	ng/kg ww
PCB-089	6/8	75	19.5	87.6	41.2	0.746 – 1.13	ng/kg ww
PCB-090	8/8	100	20,100 C	71,500 C	33,900	na	ng/kg ww
PCB-091	8/8	100	C88	C88	nc	na	ng/kg ww
PCB-092	8/8	100	4,390	18,000	8,120	na	ng/kg ww
PCB-093	8/8	100	8,140 C	40,900 C	17,600	na	ng/kg ww
PCB-094	8/8	100	20.7	112	49.3	na	ng/kg ww
PCB-095	8/8	100	C93	C93	nc	na	ng/kg ww
PCB-096	8/8	100	37.7	163	75.1	na	ng/kg ww
PCB-097	8/8	100	C86	C86	nc	na	ng/kg ww
PCB-098	8/8	100	C93	C93	nc	na	ng/kg ww
PCB-099	8/8	100	C83	C83	nc	na	ng/kg ww
PCB-100	8/8	100	C93	C93	nc	na	ng/kg ww
PCB-101	8/8	100	C90	C90	nc	na	ng/kg ww
PCB-102	8/8	100	C93	C93	nc	na	ng/kg ww
PCB-103	8/8	100	256	1,120	442	na	ng/kg ww
PCB-104	8/8	100	1.79 J	5.26 J	3.12	na	ng/kg ww
PCB-105	8/8	100	5,880	19,600	10,400	na	ng/kg ww
PCB-106	0/8	0	nd	nd	5.57	3.58 – 21.1	ng/kg ww
PCB-107	8/8	100	194 C	786 C	508	na	ng/kg ww
PCB-108	8/8	100	C86	C86	nc	na	ng/kg ww
PCB-109	8/8	100	1,700	5,940	2,920	na	ng/kg ww
PCB-110	8/8	100	13,600 C	56,200 C	24,200	na	ng/kg ww
PCB-111	8/8	100	30.1	129	50.0	na	ng/kg ww
PCB-112	0/8	0	nd	nd	1.77	0.501 – 8.97	ng/kg ww
PCB-113	8/8	100	C90	C90	nc	na	ng/kg ww
PCB-114	8/8	100	413	1,230	710	na	ng/kg ww
PCB-115	8/8	100	C110	C110	nc	na	ng/kg ww
PCB-116	8/8	100	C85	C85	nc	na	ng/kg ww
PCB-117	8/8	100	C85	C85	nc	na	ng/kg ww
PCB-118	8/8	100	19,800	70,400	34,100	na	ng/kg ww
PCB-119	8/8	100	C86	C86	nc	na	ng/kg ww
PCB-120	8/8	100	130	594	229	na	ng/kg ww

Table E.6.3-12, cont. Summary statistics for Pacific staghorn sculpin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-121	7/8	88	9.59	59.7	17.7	3.09	ng/kg ww
PCB-122	3/8	38	56.7	75.5	27.6	3.92 – 11.4	ng/kg ww
PCB-123	8/8	100	212 J	602	402	na	ng/kg ww
PCB-124	8/8	100	C107	C107	nc	na	ng/kg ww
PCB-125	8/8	100	C86	C86	nc	na	ng/kg ww
PCB-126	8/8	100	25.9	66.5	48.2	na	ng/kg ww
PCB-127	8/8	100	44.2	190	81.5	na	ng/kg ww
PCB-128	8/8	100	3,630 C	19,200 C	6,720	na	ng/kg ww
PCB-129	8/8	100	37,600 C	178,000 C	73,500	na	ng/kg ww
PCB-130	8/8	100	2,050	8,970	3,820	na	ng/kg ww
PCB-131	8/8	100	161	673	274	na	ng/kg ww
PCB-132	8/8	100	3,790	22,400	7,940	na	ng/kg ww
PCB-133	8/8	100	755	3,950	1,510	na	ng/kg ww
PCB-134	8/8	100	922 C	4,600 C	1,800	na	ng/kg ww
PCB-135	8/8	100	9,810 C	55,700 C	21,700	na	ng/kg ww
PCB-136	8/8	100	1,770	10,700	3,850	na	ng/kg ww
PCB-137	8/8	100	1,580	5,660	2,450	na	ng/kg ww
PCB-138	8/8	100	C129	C129	nc	na	ng/kg ww
PCB-139	8/8	100	496 C	2,210 C	849	na	ng/kg ww
PCB-140	8/8	100	C139	C139	nc	na	ng/kg ww
PCB-141	8/8	100	4,270	23,300	9,080	na	ng/kg ww
PCB-142	0/8	0	nd	nd	13.2	4.31 – 57.0	ng/kg ww
PCB-143	8/8	100	C134	C134	nc	na	ng/kg ww
PCB-144	8/8	100	1,160	5,770	2,270	na	ng/kg ww
PCB-145	8/8	100	3.08	15.3 J	6.26	na	ng/kg ww
PCB-146	8/8	100	7,340	36,500	15,100	na	ng/kg ww
PCB-147	8/8	100	13,500 C	89,900 C	33,300	na	ng/kg ww
PCB-148	8/8	100	64.7	558	160	na	ng/kg ww
PCB-149	8/8	100	C147	C147	nc	na	ng/kg ww
PCB-150	8/8	100	39.5	231	81.5	na	ng/kg ww
PCB-151	8/8	100	C135	C135	nc	na	ng/kg ww
PCB-152	8/8	100	8.33	37.9	14.9	na	ng/kg ww
PCB-153	8/8	100	41,800 C	206,000 C	82,800	na	ng/kg ww
PCB-154	8/8	100	C135	C135	nc	na	ng/kg ww
PCB-155	8/8	100	3.62 J	16.2 J	7.05	na	ng/kg ww
PCB-156	8/8	100	3,570 C	15,500 C	6,650	na	ng/kg ww
PCB-157	8/8	100	C156	C156	nc	na	ng/kg ww

Table E.6.3-12, cont. Summary statistics for Pacific staghorn sculpin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-158	8/8	100	3,270	14,900	5,790	na	ng/kg ww
PCB-159	8/8	100	79.6	1,270	350	na	ng/kg ww
PCB-160	8/8	100	C129	C129	nc	na	ng/kg ww
PCB-161	0/8	0	nd	nd	9.63	3.13 – 41.3	ng/kg ww
PCB-162	8/8	100	105	375	181	na	ng/kg ww
PCB-163	8/8	100	C129	C129	nc	na	ng/kg ww
PCB-164	8/8	100	1,130	6,920	2,520	na	ng/kg ww
PCB-165	6/8	75	24.1	142	47.7	37.5 – 46.4	ng/kg ww
PCB-166	8/8	100	C128	C128	nc	na	ng/kg ww
PCB-167	8/8	100	1,050	4,610	2,170	na	ng/kg ww
PCB-168	8/8	100	C153	C153	nc	na	ng/kg ww
PCB-169	4/8	50	1.43	4.84	4.79	3.62 – 25.3	ng/kg ww
PCB-170	8/8	100	6,980	58,500	18,600	na	ng/kg ww
PCB-171	8/8	100	1,970 C	16,700 C	5,280	na	ng/kg ww
PCB-172	8/8	100	1,210	10,700	3,350	na	ng/kg ww
PCB-173	8/8	100	C171	C171	nc	na	ng/kg ww
PCB-174	8/8	100	1,720	27,500	7,440	na	ng/kg ww
PCB-175	8/8	100	279	2,650	814	na	ng/kg ww
PCB-176	8/8	100	410	4,760	1,380	na	ng/kg ww
PCB-177	8/8	100	4,010	38,300	11,900	na	ng/kg ww
PCB-178	8/8	100	1,940	16,200	5,420	na	ng/kg ww
PCB-179	8/8	100	1,800	18,500	5,410	na	ng/kg ww
PCB-180	8/8	100	18,500 C	180,000 C	54,400	na	ng/kg ww
PCB-181	8/8	100	58.4	282 J	103	na	ng/kg ww
PCB-182	8/8	100	62.4	357	137	na	ng/kg ww
PCB-183	8/8	100	5,600 C	50,400 C	15,900	na	ng/kg ww
PCB-184	7/8	88	5.07	17.9 J	7.25	1.07	ng/kg ww
PCB-185	8/8	100	C183	C183	nc	na	ng/kg ww
PCB-186	0/8	0	nd	nd	0.390	0.222 – 2.90	ng/kg ww
PCB-187	8/8	100	11,600	104,000	33,400	na	ng/kg ww
PCB-188	8/8	100	15.2	80.7	31.5	na	ng/kg ww
PCB-189	8/8	100	249	1,750	583	na	ng/kg ww
PCB-190	8/8	100	1,520	14,100	4,290	na	ng/kg ww
PCB-191	8/8	100	332	2,650	858	na	ng/kg ww
PCB-192	0/8	0	nd	nd	0.461	0.248 – 3.61	ng/kg ww
PCB-193	8/8	100	C180	C180	nc	na	ng/kg ww
PCB-194	8/8	100	2,030	27,600	7,030	na	ng/kg ww

Table E.6.3-12, cont. Summary statistics for Pacific staghorn sculpin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-195	8/8	100	828	12,400	3,110	na	ng/kg ww
PCB-196	8/8	100	1,110	17,700	4,280	na	ng/kg ww
PCB-197	8/8	100	184 C	3,050 C	742	na	ng/kg ww
PCB-198	8/8	100	2,070 C	28,800 C	7,510	na	ng/kg ww
PCB-199	8/8	100	C198	C198	nc	na	ng/kg ww
PCB-200	8/8	100	C197	C197	nc	na	ng/kg ww
PCB-201	8/8	100	304	3,760	970	na	ng/kg ww
PCB-202	8/8	100	683	6,170	1,930	na	ng/kg ww
PCB-203	8/8	100	1,680	23,000	5,860	na	ng/kg ww
PCB-204	8/8	100	0.448 J	4.03 J	1.51	na	ng/kg ww
PCB-205	8/8	100	108	1,350	341	na	ng/kg ww
PCB-206	8/8	100	381	5,070	1,260	na	ng/kg ww
PCB-207	8/8	100	51.0	785	182	na	ng/kg ww
PCB-208	8/8	100	93.7	797	257	na	ng/kg ww
PCB-209	8/8	100	39.3	118	72.3	na	ng/kg ww
Total PCB congeners	8/8	100	349,600 J	1,907,000 J	749,000	nc	ng/kg ww
Aroclor-1016	0/28	0	nd	nd	18	10 – 100	µg/kg ww
Aroclor-1221	0/28	0	nd	nd	29	20 – 200	µg/kg ww
Aroclor-1232	0/28	0	nd	nd	18	10 – 100	µg/kg ww
Aroclor-1242	0/28	0	nd	nd	18	10 – 100	µg/kg ww
Aroclor-1248	22/28	79	68	270	120	100	µg/kg ww
Aroclor-1254	28/28	100	190	880	350	na	µg/kg ww
Aroclor-1260	28/28	100	150	1,600	440	na	µg/kg ww
Total PCBs	28/28	100	430	2,800	900	nc	µg/kg ww
PCB TEQ – Bird	8/8	100	7.60 J	34.60 J	20.1	na	ng/kg ww
PCB TEQ – Fish	8/8	100	0.2960 J	0.9320	0.548	na	ng/kg ww
PCB TEQ – Mammal	8/8	100	3.58 J	10.20	6.64	na	ng/kg ww
Pesticides							
2,4'-DDD	1/24	4	23 JN	23 JN	3.3	2.4 – 16	µg/kg ww
2,4'-DDE	0/24	0	nd	nd	0.97	1.0 – 12	µg/kg ww
2,4'-DDT	24/24	100	19 JN	120 JN	43	na	µg/kg ww
4,4'-DDD	23/24	96	1.1 JN	7.3 JN	2.7	2.8	µg/kg ww
4,4'-DDE	21/24	88	3.4 JN	29 JN	5.9	3.5 – 5.6	µg/kg ww
4,4'-DDT	23/24	96	11 JN	99 JN	32	20	µg/kg ww
Total DDTs	24/24	100	33 JN	220 JN	84	nc	µg/kg ww
Aldrin	0/24	0	nd	nd	0.50	1.0	µg/kg ww

Table E.6.3-12, cont. Summary statistics for Pacific staghorn sculpin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Dieldrin	1/24	4	0.82 JN	0.82 JN	0.58	1.0 – 2.0	µg/kg ww
Total aldrin/dieldrin	1/24	4	0.82 JN	0.82 JN	0.58	nc	µg/kg ww
alpha-BHC	3/24	12	0.20 JN	0.66 JN	0.50	1.0	µg/kg ww
beta-BHC	7/24	29	0.27 JN	1.0 JN	0.54	1.0 – 2.0	µg/kg ww
gamma-BHC	1/24	4	5.6 JN	5.6 JN	0.71	1.0	µg/kg ww
delta-BHC	0/24	0	nd	nd	0.50	1.0	µg/kg ww
alpha-Chlordane	8/24	33	1.1 JN	7.3 JN	1.1	1.0 – 2.7	µg/kg ww
gamma-Chlordane	24/24	100	5.5 JN	27 JN	11	na	µg/kg ww
alpha-Endosulfan	11/24	46	1.0 JN	3.6 JN	1.3	1.0 – 10	µg/kg ww
beta-Endosulfan	5/24	21	4.7 JN	6.4 JN	2.6	1.1 – 13	µg/kg ww
Endosulfan sulfate	0/24	0	nd	nd	0.50	1.0	µg/kg ww
Endrin	1/24	4	36 JN	36 JN	2.3	1.0 – 4.1	µg/kg ww
Endrin aldehyde	6/24	25	1.2 JN	4.8 JN	1.3	1.0 – 5.3	µg/kg ww
Endrin ketone	1/24	4	0.60 JN	0.60 JN	1.3	1.0 – 16	µg/kg ww
Heptachlor	2/24	8	2.1 JN	2.7 JN	0.76	1.0 – 1.9	µg/kg ww
Heptachlor epoxide	0/24	0	nd	nd	0.50	1.0	µg/kg ww
Methoxychlor	0/24	0	nd	nd	0.64	1.0 – 4.2	µg/kg ww
Mirex	0/24	0	nd	nd	0.50	1.0	µg/kg ww
Toxaphene	0/24	0	nd	nd	210	160 – 1,900	µg/kg ww
Total chlordane	24/24	100	5.5 JN	27 JN	12	nc	µg/kg ww
Conventional parameters							
Total solids	28/28	100	19.5	22.0	21.0	na	% ww
Lipid	28/28	100	1.18	2.7	2.1	na	% ww

Table E.6.3-13. Summary statistics for pile perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	1/1	100	0.0016 J	0.0016 J	0.0016	na	mg/kg ww
Arsenic	1/1	100	0.563	0.563	0.563	na	mg/kg ww
Arsenic (inorganic)	0/1	0	nd	nd	0.0050	0.010	mg/kg ww
Cadmium	0/1	0	nd	nd	0.0023	0.0046	mg/kg ww
Chromium	0/1	0	nd	nd	0.060	0.12	mg/kg ww
Cobalt	1/1	100	0.0054	0.0054	0.0054	na	mg/kg ww
Copper	1/1	100	1.100	1.100	1.100	na	mg/kg ww
Lead	1/1	100	0.022	0.022	0.022	na	mg/kg ww
Mercury	1/1	100	0.040	0.040	0.040	na	mg/kg ww
Molybdenum	1/1	100	0.0026 J	0.0026 J	0.0026	na	mg/kg ww
Nickel	1/1	100	0.052	0.052	0.052	na	mg/kg ww
Selenium	1/1	100	0.12	0.12	0.12	na	mg/kg ww
Silver	0/1	0	nd	nd	0.0023	0.0046	mg/kg ww
Thallium	0/1	0	nd	nd	0.0023	0.0046	mg/kg ww
Vanadium	0/1	0	nd	nd	0.1	0.2	mg/kg ww
Zinc	1/1	100	7.47	7.47	7.47	na	mg/kg ww
Organometals							
Monobutyltin as ion	0/1	0	nd	nd	0.75	1.5	µg/kg ww
Dibutyltin as ion	1/1	100	1.5 J	1.5 J	1.5	na	µg/kg ww
Tributyltin as ion	1/1	100	4.8	4.8	4.8	na	µg/kg ww
Tetrabutyltin as ion	0/1	0	nd	nd	0.75	1.5	µg/kg ww
PAHs							
2-Chloronaphthalene	0/1	0	nd	nd	290	580	µg/kg ww
2-Methylnaphthalene	1/1	100	2.0	2.0	2.0	na	µg/kg ww
Acenaphthene	1/1	100	5.3	5.3	5.3	na	µg/kg ww
Acenaphthylene	0/1	0	nd	nd	0.13	0.26	µg/kg ww
Anthracene	1/1	100	0.82	0.82	0.82	na	µg/kg ww
Benzo(a)anthracene	1/1	100	0.13 J	0.13 J	0.13	na	µg/kg ww
Benzo(a)pyrene	0/1	0	nd	nd	0.25	0.50	µg/kg ww
Benzo(b)fluoranthene	0/1	0	nd	nd	0.25	0.50	µg/kg ww
Benzo(g,h,i)perylene	1/1	100	0.16 J	0.16 J	0.16	na	µg/kg ww
Benzo(k)fluoranthene	0/1	0	nd	nd	0.25	0.50	µg/kg ww
Total benzofluoranthenes	0/1	0	nd	nd	0.25	nc	µg/kg ww

Table E.6.3-13, cont. Summary statistics for pile perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Chrysene	1/1	100	0.51	0.51	0.51	na	µg/kg ww
Dibenzo(a,h)anthracene	0/1	0	nd	nd	0.25	0.50	µg/kg ww
Dibenzofuran	1/1	100	3.1	3.1	3.1	na	µg/kg ww
Fluoranthene	1/1	100	3.1	3.1	3.1	na	µg/kg ww
Fluorene	1/1	100	3.3	3.3	3.3	na	µg/kg ww
Indeno(1,2,3-cd)pyrene	1/1	100	0.11 J	0.11 J	0.11	na	µg/kg ww
Naphthalene	1/1	100	1.6	1.6	1.6	na	µg/kg ww
Phenanthrene	1/1	100	7.3	7.3	7.3	na	µg/kg ww
Pyrene	1/1	100	1.2	1.2	1.2	na	µg/kg ww
Total HPAH	1/1	100	5.2 J	5.2 J	5.2	nc	µg/kg ww
Total LPAH	1/1	100	18.3	18.3	18	nc	µg/kg ww
Carcinogenic PAHs – Mammal	1/1	100	0.43 J	0.43 J	0.43	na	µg/kg ww
Total PAH	1/1	100	23.5 J	23.5 J	24	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	0/1	0	nd	nd	34	67	µg/kg ww
Butyl benzyl phthalate	0/1	0	nd	nd	600	1,200	µg/kg ww
Diethyl phthalate	0/1	0	nd	nd	600	1,200	µg/kg ww
Dimethyl phthalate	0/1	0	nd	nd	290	580	µg/kg ww
Di-n-butyl phthalate	0/1	0	nd	nd	600	1,200	µg/kg ww
Di-n-octyl phthalate	0/1	0	nd	nd	1,500	2,900	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/1	0	nd	nd	290	580	µg/kg ww
1,2-Dichlorobenzene	0/1	0	nd	nd	290	580	µg/kg ww
1,3-Dichlorobenzene	0/1	0	nd	nd	290	580	µg/kg ww
1,4-Dichlorobenzene	0/1	0	nd	nd	290	580	µg/kg ww
2,4,5-Trichlorophenol	0/1	0	nd	nd	1,500	2,900	µg/kg ww
2,4,6-Trichlorophenol	0/1	0	nd	nd	1,500	2,900	µg/kg ww
2,4-Dichlorophenol	0/1	0	nd	nd	600	1,200	µg/kg ww
2,4-Dimethylphenol	0/1	0	nd	nd	600	1,200	µg/kg ww
2,4-Dinitrophenol	0/1	0	nd	nd	6,000	12,000	µg/kg ww
2,4-Dinitrotoluene	0/1	0	nd	nd	600	1,200	µg/kg ww
2,6-Dinitrotoluene	0/1	0	nd	nd	600	1,200	µg/kg ww
2-Chlorophenol	0/1	0	nd	nd	600	1,200	µg/kg ww
2-Methylphenol	0/1	0	nd	nd	600	1,200	µg/kg ww
2-Nitroaniline	0/1	0	nd	nd	1,500	2,900	µg/kg ww
2-Nitrophenol	0/1	0	nd	nd	1,500	2,900	µg/kg ww
3,3'-Dichlorobenzidine	0/1	0	nd	nd	15,000	29,000	µg/kg ww

Table E.6.3-13, cont. Summary statistics for pile perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
3-Nitroaniline	0/1	0	nd	nd	2,900	5,800	µg/kg ww
4,6-Dinitro-o-cresol	0/1	0	nd	nd	2,900	5,800	µg/kg ww
4-Bromophenyl phenyl ether	0/1	0	nd	nd	290	580	µg/kg ww
4-Chloro-3-methylphenol	0/1	0	nd	nd	1,500	2,900	µg/kg ww
4-Chloroaniline	0/1	0	nd	nd	1,500	2,900	µg/kg ww
4-Chlorophenyl phenyl ether	0/1	0	nd	nd	290	580	µg/kg ww
4-Methylphenol	0/1	0	nd	nd	600	1,200	µg/kg ww
4-Nitroaniline	0/1	0	nd	nd	1,500	2,900	µg/kg ww
4-Nitrophenol	0/1	0	nd	nd	2,900	5,800	µg/kg ww
Aniline	0/1	0	nd	nd	6,000	12,000	µg/kg ww
Benzoic acid	1/1	100	5,700 J	5,700 J	5,700	na	µg/kg ww
Benzyl alcohol	1/1	100	180 J	180 J	180	na	µg/kg ww
bis(2-chloroethoxy)methane	0/1	0	nd	nd	290	580	µg/kg ww
bis(2-chloroethyl)ether	0/1	0	nd	nd	290	580	µg/kg ww
bis(2-chloroisopropyl)ether	0/1	0	nd	nd	290	580	µg/kg ww
Carbazole	0/1	0	nd	nd	1,500	2,900	µg/kg ww
Hexachlorobenzene	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Hexachlorobutadiene	0/1	0	nd	nd	290	580	µg/kg ww
Hexachlorocyclopentadiene	0/1	0	nd	nd	36,000	72,000	µg/kg ww
Hexachloroethane	0/1	0	nd	nd	290	580	µg/kg ww
Isophorone	0/1	0	nd	nd	290	580	µg/kg ww
Nitrobenzene	0/1	0	nd	nd	290	580	µg/kg ww
N-Nitrosodimethylamine	0/1	0	nd	nd	1,500	2,900	µg/kg ww
N-Nitroso-di-n-propylamine	0/1	0	nd	nd	290	580	µg/kg ww
N-Nitrosodiphenylamine	0/1	0	nd	nd	290	580	µg/kg ww
Pentachlorophenol	0/1	0	nd	nd	3.4	6.7	µg/kg ww
Phenol	0/1	0	nd	nd	750	1,500	µg/kg ww
Polychlorinated biphenyls							
PCB-001	1/1	100	1.84 J	1.84 J	1.84	na	ng/kg ww
PCB-002	1/1	100	0.454 J	0.454 J	0.454	na	ng/kg ww
PCB-003	1/1	100	0.767 J	0.767 J	0.767	na	ng/kg ww
PCB-004	1/1	100	12.9	12.9	12.9	na	ng/kg ww
PCB-005	1/1	100	0.402 J	0.402 J	0.402	na	ng/kg ww
PCB-006	1/1	100	14.6	14.6	14.6	na	ng/kg ww
PCB-007	1/1	100	2.25 J	2.25 J	2.25	na	ng/kg ww
PCB-008	1/1	100	21.8	21.8	21.8	na	ng/kg ww
PCB-009	1/1	100	13.9	13.9	13.9	na	ng/kg ww

Table E.6.3-13, cont. Summary statistics for pile perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-010	1/1	100	1.72 J	1.72 J	1.72	na	ng/kg ww
PCB-011	1/1	100	2.98 J	2.98 J	2.98	na	ng/kg ww
PCB-012	1/1	100	2.93 CJ	2.93 CJ	2.93	na	ng/kg ww
PCB-013	1/1	100	C12	C12	nc	na	ng/kg ww
PCB-014	0/1	0	nd	nd	0.136	0.271	ng/kg ww
PCB-015	1/1	100	13.6	13.6	13.6	na	ng/kg ww
PCB-016	1/1	100	14.9	14.9	14.9	na	ng/kg ww
PCB-017	1/1	100	63.5	63.5	63.5	na	ng/kg ww
PCB-018	1/1	100	443 C	443 C	443	na	ng/kg ww
PCB-019	1/1	100	20.6	20.6	20.6	na	ng/kg ww
PCB-020	1/1	100	2,150 C	2,150 C	2,150	na	ng/kg ww
PCB-021	1/1	100	120 C	120 C	120	na	ng/kg ww
PCB-022	1/1	100	123	123	123	na	ng/kg ww
PCB-023	1/1	100	1.44 J	1.44 J	1.44	na	ng/kg ww
PCB-024	1/1	100	10.3	10.3	10.3	na	ng/kg ww
PCB-025	1/1	100	295	295	295	na	ng/kg ww
PCB-026	1/1	100	1,050 C	1,050 C	1,050	na	ng/kg ww
PCB-027	1/1	100	41.2	41.2	41.2	na	ng/kg ww
PCB-028	1/1	100	C20	C20	nc	na	ng/kg ww
PCB-029	1/1	100	C26	C26	nc	na	ng/kg ww
PCB-030	1/1	100	C18	C18	nc	na	ng/kg ww
PCB-031	1/1	100	1,570	1,570	1,570	na	ng/kg ww
PCB-032	1/1	100	235	235	235	na	ng/kg ww
PCB-033	1/1	100	C21	C21	nc	na	ng/kg ww
PCB-034	1/1	100	9.77	9.77	9.77	na	ng/kg ww
PCB-035	0/1	0	nd	nd	0.565	1.13	ng/kg ww
PCB-036	0/1	0	nd	nd	0.525	1.05	ng/kg ww
PCB-037	1/1	100	60.6	60.6	60.6	na	ng/kg ww
PCB-038	0/1	0	nd	nd	0.530	1.06	ng/kg ww
PCB-039	1/1	100	1.95 J	1.95 J	1.95	na	ng/kg ww
PCB-040	1/1	100	329 C	329 C	329	na	ng/kg ww
PCB-041	1/1	100	C40	C40	nc	na	ng/kg ww
PCB-042	1/1	100	201	201	201	na	ng/kg ww
PCB-043	0/1	0	nd	nd	0.0975	0.195	ng/kg ww
PCB-044	1/1	100	2,670 C	2,670 C	2,670	na	ng/kg ww
PCB-045	1/1	100	122 C	122 C	122	na	ng/kg ww
PCB-046	1/1	100	38.9	38.9	38.9	na	ng/kg ww

Table E.6.3-13, cont. Summary statistics for pile perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-047	1/1	100	C44	C44	nc	na	ng/kg ww
PCB-048	1/1	100	182	182	182	na	ng/kg ww
PCB-049	1/1	100	3,560 C	3,560 C	3,560	na	ng/kg ww
PCB-050	1/1	100	294 C	294 C	294	na	ng/kg ww
PCB-051	1/1	100	C45	C45	nc	na	ng/kg ww
PCB-052	1/1	100	9,050	9,050	9,050	na	ng/kg ww
PCB-053	1/1	100	C50	C50	nc	na	ng/kg ww
PCB-054	1/1	100	3.43 J	3.43 J	3.43	na	ng/kg ww
PCB-055	0/1	0	nd	nd	3.42	6.84	ng/kg ww
PCB-056	1/1	100	153	153	153	na	ng/kg ww
PCB-057	1/1	100	59.3	59.3	59.3	na	ng/kg ww
PCB-058	1/1	100	30.0	30.0	30.0	na	ng/kg ww
PCB-059	1/1	100	374 C	374 C	374	na	ng/kg ww
PCB-060	1/1	100	549	549	549	na	ng/kg ww
PCB-061	1/1	100	6,030 C	6,030 C	6,030	na	ng/kg ww
PCB-062	1/1	100	C59	C59	nc	na	ng/kg ww
PCB-063	1/1	100	257	257	257	na	ng/kg ww
PCB-064	1/1	100	1,050	1,050	1,050	na	ng/kg ww
PCB-065	1/1	100	C44	C44	nc	na	ng/kg ww
PCB-066	1/1	100	2,830	2,830	2,830	na	ng/kg ww
PCB-067	1/1	100	111	111	111	na	ng/kg ww
PCB-068	1/1	100	65.5	65.5	65.5	na	ng/kg ww
PCB-069	1/1	100	C49	C49	nc	na	ng/kg ww
PCB-070	1/1	100	C61	C61	nc	na	ng/kg ww
PCB-071	1/1	100	C40	C40	nc	na	ng/kg ww
PCB-072	1/1	100	165	165	165	na	ng/kg ww
PCB-073	0/1	0	nd	nd	0.0660	0.132	ng/kg ww
PCB-074	1/1	100	C61	C61	nc	na	ng/kg ww
PCB-075	1/1	100	C59	C59	nc	na	ng/kg ww
PCB-076	1/1	100	C61	C61	nc	na	ng/kg ww
PCB-077	1/1	100	142	142	142	na	ng/kg ww
PCB-078	0/1	0	nd	nd	3.53	7.05	ng/kg ww
PCB-079	1/1	100	68.1	68.1	68.1	na	ng/kg ww
PCB-080	0/1	0	nd	nd	3.29	6.58	ng/kg ww
PCB-081	1/1	100	11.2 J	11.2 J	11.2	na	ng/kg ww
PCB-082	1/1	100	134	134	134	na	ng/kg ww
PCB-083	1/1	100	8,870 C	8,870 C	8,870	na	ng/kg ww

Table E.6.3-13, cont. Summary statistics for pile perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-084	1/1	100	870	870	870	na	ng/kg ww
PCB-085	1/1	100	809 C	809 C	809	na	ng/kg ww
PCB-086	1/1	100	4,860 C	4,860 C	4,860	na	ng/kg ww
PCB-087	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-088	1/1	100	720 C	720 C	720	na	ng/kg ww
PCB-089	1/1	100	14.4	14.4	14.4	na	ng/kg ww
PCB-090	1/1	100	13,400 C	13,400 C	13,400	na	ng/kg ww
PCB-091	1/1	100	C88	C88	nc	na	ng/kg ww
PCB-092	1/1	100	2,570	2,570	2,570	na	ng/kg ww
PCB-093	1/1	100	5,180 C	5,180 C	5,180	na	ng/kg ww
PCB-094	1/1	100	11.2	11.2	11.2	na	ng/kg ww
PCB-095	1/1	100	C93	C93	nc	na	ng/kg ww
PCB-096	1/1	100	24.0	24.0	24.0	na	ng/kg ww
PCB-097	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-098	1/1	100	C93	C93	nc	na	ng/kg ww
PCB-099	1/1	100	C83	C83	nc	na	ng/kg ww
PCB-100	1/1	100	C93	C93	nc	na	ng/kg ww
PCB-101	1/1	100	C90	C90	nc	na	ng/kg ww
PCB-102	1/1	100	C93	C93	nc	na	ng/kg ww
PCB-103	1/1	100	120	120	120	na	ng/kg ww
PCB-104	1/1	100	0.927 J	0.927 J	0.927	na	ng/kg ww
PCB-105	1/1	100	3,920	3,920	3,920	na	ng/kg ww
PCB-106	0/1	0	nd	nd	1.74	3.48	ng/kg ww
PCB-107	1/1	100	373 C	373 C	373	na	ng/kg ww
PCB-108	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-109	1/1	100	1,070	1,070	1,070	na	ng/kg ww
PCB-110	1/1	100	6,690 C	6,690 C	6,690	na	ng/kg ww
PCB-111	1/1	100	13.5	13.5	13.5	na	ng/kg ww
PCB-112	0/1	0	nd	nd	1.02	2.03	ng/kg ww
PCB-113	1/1	100	C90	C90	nc	na	ng/kg ww
PCB-114	1/1	100	261	261	261	na	ng/kg ww
PCB-115	1/1	100	C110	C110	nc	na	ng/kg ww
PCB-116	1/1	100	C85	C85	nc	na	ng/kg ww
PCB-117	1/1	100	C85	C85	nc	na	ng/kg ww
PCB-118	1/1	100	12,800	12,800	12,800	na	ng/kg ww
PCB-119	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-120	1/1	100	80.5	80.5	80.5	na	ng/kg ww

Table E.6.3-13, cont. Summary statistics for pile perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-121	1/1	100	6.09	6.09	6.09	na	ng/kg ww
PCB-122	1/1	100	92.7	92.7	92.7	na	ng/kg ww
PCB-123	1/1	100	209 J	209 J	209	na	ng/kg ww
PCB-124	1/1	100	C107	C107	nc	na	ng/kg ww
PCB-125	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-126	1/1	100	20.6	20.6	20.6	na	ng/kg ww
PCB-127	1/1	100	28.0	28.0	28.0	na	ng/kg ww
PCB-128	1/1	100	1,530 C	1,530 C	1,530	na	ng/kg ww
PCB-129	1/1	100	18,100 C	18,100 C	18,100	na	ng/kg ww
PCB-130	1/1	100	1,060	1,060	1,060	na	ng/kg ww
PCB-131	1/1	100	62.4	62.4	62.4	na	ng/kg ww
PCB-132	1/1	100	1,500	1,500	1,500	na	ng/kg ww
PCB-133	1/1	100	335	335	335	na	ng/kg ww
PCB-134	1/1	100	473 C	473 C	473	na	ng/kg ww
PCB-135	1/1	100	4,370 C	4,370 C	4,370	na	ng/kg ww
PCB-136	1/1	100	747	747	747	na	ng/kg ww
PCB-137	1/1	100	819	819	819	na	ng/kg ww
PCB-138	1/1	100	C129	C129	nc	na	ng/kg ww
PCB-139	1/1	100	231 C	231 C	231	na	ng/kg ww
PCB-140	1/1	100	C139	C139	nc	na	ng/kg ww
PCB-141	1/1	100	1,880	1,880	1,880	na	ng/kg ww
PCB-142	0/1	0	nd	nd	4.71	9.41	ng/kg ww
PCB-143	1/1	100	C134	C134	nc	na	ng/kg ww
PCB-144	1/1	100	484	484	484	na	ng/kg ww
PCB-145	1/1	100	4.11 J	4.11 J	4.11	na	ng/kg ww
PCB-146	1/1	100	3,500	3,500	3,500	na	ng/kg ww
PCB-147	1/1	100	5,850 C	5,850 C	5,850	na	ng/kg ww
PCB-148	1/1	100	36.7	36.7	36.7	na	ng/kg ww
PCB-149	1/1	100	C147	C147	nc	na	ng/kg ww
PCB-150	1/1	100	13.9	13.9	13.9	na	ng/kg ww
PCB-151	1/1	100	C135	C135	nc	na	ng/kg ww
PCB-152	1/1	100	5.83	5.83	5.83	na	ng/kg ww
PCB-153	1/1	100	19,100 C	19,100 C	19,100	na	ng/kg ww
PCB-154	1/1	100	C135	C135	nc	na	ng/kg ww
PCB-155	1/1	100	1.70 J	1.70 J	1.70	na	ng/kg ww
PCB-156	1/1	100	1,750 C	1,750 C	1,750	na	ng/kg ww
PCB-157	1/1	100	C156	C156	nc	na	ng/kg ww

Table E.6.3-13, cont. Summary statistics for pile perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-158	1/1	100	1,550	1,550	1,550	na	ng/kg ww
PCB-159	1/1	100	31.6	31.6	31.6	na	ng/kg ww
PCB-160	1/1	100	C129	C129	nc	na	ng/kg ww
PCB-161	0/1	0	nd	nd	3.42	6.83	ng/kg ww
PCB-162	1/1	100	53.3	53.3	53.3	na	ng/kg ww
PCB-163	1/1	100	C129	C129	nc	na	ng/kg ww
PCB-164	1/1	100	532	532	532	na	ng/kg ww
PCB-165	1/1	100	11.4	11.4	11.4	na	ng/kg ww
PCB-166	1/1	100	C128	C128	nc	na	ng/kg ww
PCB-167	1/1	100	694	694	694	na	ng/kg ww
PCB-168	1/1	100	C153	C153	nc	na	ng/kg ww
PCB-169	0/1	0	nd	nd	4.20	8.39	ng/kg ww
PCB-170	1/1	100	3,000	3,000	3,000	na	ng/kg ww
PCB-171	1/1	100	925 C	925 C	925	na	ng/kg ww
PCB-172	1/1	100	456	456	456	na	ng/kg ww
PCB-173	1/1	100	C171	C171	nc	na	ng/kg ww
PCB-174	1/1	100	610	610	610	na	ng/kg ww
PCB-175	1/1	100	142	142	142	na	ng/kg ww
PCB-176	1/1	100	125	125	125	na	ng/kg ww
PCB-177	1/1	100	1,610	1,610	1,610	na	ng/kg ww
PCB-178	1/1	100	804	804	804	na	ng/kg ww
PCB-179	1/1	100	645	645	645	na	ng/kg ww
PCB-180	1/1	100	7,850 C	7,850 C	7,850	na	ng/kg ww
PCB-181	1/1	100	21.6	21.6	21.6	na	ng/kg ww
PCB-182	1/1	100	42.7	42.7	42.7	na	ng/kg ww
PCB-183	1/1	100	2,670 C	2,670 C	2,670	na	ng/kg ww
PCB-184	1/1	100	2.63 J	2.63 J	2.63	na	ng/kg ww
PCB-185	1/1	100	C183	C183	nc	na	ng/kg ww
PCB-186	0/1	0	nd	nd	0.0995	0.199	ng/kg ww
PCB-187	1/1	100	5,150	5,150	5,150	na	ng/kg ww
PCB-188	1/1	100	7.40	7.40	7.40	na	ng/kg ww
PCB-189	1/1	100	102	102	102	na	ng/kg ww
PCB-190	1/1	100	615	615	615	na	ng/kg ww
PCB-191	1/1	100	162	162	162	na	ng/kg ww
PCB-192	0/1	0	nd	nd	0.112	0.223	ng/kg ww
PCB-193	1/1	100	C180	C180	nc	na	ng/kg ww
PCB-194	1/1	100	925	925	925	na	ng/kg ww

Table E.6.3-13, cont. Summary statistics for pile perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-195	1/1	100	341	341	341	na	ng/kg ww
PCB-196	1/1	100	553	553	553	na	ng/kg ww
PCB-197	1/1	100	74.9 C	74.9 C	74.9	na	ng/kg ww
PCB-198	1/1	100	980 C	980 C	980	na	ng/kg ww
PCB-199	1/1	100	C198	C198	nc	na	ng/kg ww
PCB-200	1/1	100	C197	C197	nc	na	ng/kg ww
PCB-201	1/1	100	167	167	167	na	ng/kg ww
PCB-202	1/1	100	349	349	349	na	ng/kg ww
PCB-203	1/1	100	816	816	816	na	ng/kg ww
PCB-204	1/1	100	0.402 J	0.402 J	0.402	na	ng/kg ww
PCB-205	1/1	100	44.4	44.4	44.4	na	ng/kg ww
PCB-206	1/1	100	359	359	359	na	ng/kg ww
PCB-207	1/1	100	44.0	44.0	44.0	na	ng/kg ww
PCB-208	1/1	100	81.8	81.8	81.8	na	ng/kg ww
PCB-209	1/1	100	41.5	41.5	41.5	na	ng/kg ww
Total PCB congeners	1/1	100	192,200 J	192,200 J	192,000	nc	ng/kg ww
Aroclor-1016	0/1	0	nd	nd	7.5	15	µg/kg ww
Aroclor-1221	0/1	0	nd	nd	15	29	µg/kg ww
Aroclor-1232	0/1	0	nd	nd	7.5	15	µg/kg ww
Aroclor-1242	0/1	0	nd	nd	7.5	15	µg/kg ww
Aroclor-1248	1/1	100	59	59	59	na	µg/kg ww
Aroclor-1254	1/1	100	120	120	120	na	µg/kg ww
Aroclor-1260	1/1	100	120	120	120	na	µg/kg ww
Total PCBs	1/1	100	300	300	300	nc	µg/kg ww
PCB TEQ – Bird	1/1	100	11.00 J	11.00 J	11.0	na	ng/kg ww
PCB TEQ – Fish	1/1	100	0.2220 J	0.2220 J	0.222	na	ng/kg ww
PCB TEQ – Mammal	1/1	100	2.80 J	2.80 J	2.80	na	ng/kg ww
Pesticides							
2,4'-DDD	0/1	0	nd	nd	3.6	7.2	µg/kg ww
2,4'-DDE	0/1	0	nd	nd	3.6	7.2	µg/kg ww
2,4'-DDT	1/1	100	6.0 JN	6.0 JN	6.0	na	µg/kg ww
4,4'-DDD	0/1	0	nd	nd	3.6	7.2	µg/kg ww
4,4'-DDE	1/1	100	1.0 JN	1.0 JN	1.0	na	µg/kg ww
4,4'-DDT	1/1	100	3.2 JN	3.2 JN	3.2	na	µg/kg ww
Total DDTs	1/1	100	10.2 JN	10.2 JN	10	nc	µg/kg ww
Aldrin	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Dieldrin	0/1	0	nd	nd	3.6	7.2	µg/kg ww

Table E.6.3-13, cont. Summary statistics for pile perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Total aldrin/dieldrin	0/1	0	nd	nd	3.6	nc	µg/kg ww
alpha-BHC	0/1	0	nd	nd	3.6	7.2	µg/kg ww
beta-BHC	0/1	0	nd	nd	3.6	7.2	µg/kg ww
gamma-BHC	0/1	0	nd	nd	3.6	7.2	µg/kg ww
delta-BHC	0/1	0	nd	nd	3.6	7.2	µg/kg ww
alpha-Chlordane	0/1	0	nd	nd	3.6	7.2	µg/kg ww
gamma-Chlordane	1/1	100	3.9 JN	3.9 JN	3.9	na	µg/kg ww
alpha-Endosulfan	0/1	0	nd	nd	3.6	7.2	µg/kg ww
beta-Endosulfan	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Endosulfan sulfate	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Endrin	1/1	100	0.89 JN	0.89 JN	0.89	na	µg/kg ww
Endrin aldehyde	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Endrin ketone	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Heptachlor	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Heptachlor epoxide	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Methoxychlor	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Mirex	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Toxaphene	0/1	0	nd	nd	180	360	µg/kg ww
Total chlordane	1/1	100	3.9 JN	3.9 JN	3.9	nc	µg/kg ww
Conventional parameters							
Total solids	1/1	100	23.3	23.3	23.3	na	% ww
Lipid	1/1	100	1.1	1.1	1.1	na	% ww

Table E.6.3-14. Summary statistics for red rock crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Mercury	2/2	100	0.050 J	0.11 J	0.080	na	mg/kg ww
Organometals							
Tributyltin as ion	0/2	0	nd	nd	1.0	2.0	µg/kg ww
Polychlorinated biphenyls							
Aroclor-1016/1242	2/2	100	10 J	16 J	13	na	µg/kg ww
Aroclor-1248	0/2	0	nd	nd	0.43	0.83 – 0.87	µg/kg ww
Aroclor-1254	2/2	100	42	81	62	na	µg/kg ww
Aroclor-1260	2/2	100	33	67	50	na	µg/kg ww
Total PCBs	2/2	100	85 J	164 J	120	nc	µg/kg ww

Table E.6.3-15. Summary statistics for red rock/Dungeness crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Mercury	1/1	100	0.070 J	0.070 J	0.070	na	mg/kg ww
Organometals							
Tributyltin as ion	0/1	0	nd	nd	1.0	2.0	µg/kg ww
Polychlorinated biphenyls							
Aroclor-1016/1242	1/1	100	10 J	10 J	10	na	µg/kg ww
Aroclor-1248	0/1	0	nd	nd	0.24	0.48	µg/kg ww
Aroclor-1254	1/1	100	28	28	28	na	µg/kg ww
Aroclor-1260	1/1	100	22	22	22	na	µg/kg ww
Total PCBs	1/1	100	60 J	60 J	60	nc	µg/kg ww

Table E.6.3-16. Summary statistics for shiner surfperch, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	24/27	89	0.0017 J	0.0079 J	0.0042	0.020	mg/kg ww
Arsenic	27/27	100	0.715	1.4	0.99	na	mg/kg ww
Arsenic (inorganic)	8/8	100	0.020	0.160	0.070	na	mg/kg ww
Cadmium	27/27	100	0.0099	0.0240	0.015	na	mg/kg ww
Chromium	26/27	96	0.08 J	0.45	0.2	0.13	mg/kg ww
Cobalt	24/24	100	0.0279	0.0606	0.0417	na	mg/kg ww
Copper	27/27	100	0.582	2.2	1.6	na	mg/kg ww
Lead	27/27	100	0.0453	0.2610	0.12	na	mg/kg ww
Mercury	27/27	100	0.018	0.088	0.033	na	mg/kg ww
Molybdenum	24/24	100	0.0138	0.0435	0.0207	na	mg/kg ww
Nickel	27/27	100	0.17 J	0.545 J	0.39	na	mg/kg ww
Selenium	24/24	100	0.111	0.219	0.177	na	mg/kg ww
Silver	24/27	89	0.0022 J	0.0108	0.0047	0.012	mg/kg ww
Thallium	22/24	92	0.0005 J	0.0017 J	0.0008	0.0047 – 0.0052	mg/kg ww
Vanadium	22/24	92	0.21 J	1.23	0.40	0.25	mg/kg ww
Zinc	27/27	100	17	28.0	21	na	mg/kg ww
Organometals							
Monobutyltin as ion	24/24	100	0.75 J	4.0	2.3	na	µg/kg ww
Dibutyltin as ion	24/24	100	6.8	17	10	na	µg/kg ww
Tributyltin as ion	27/27	100	33	180	58	na	µg/kg ww
Tetrabutyltin as ion	0/24	0	nd	nd	0.75	1.5	µg/kg ww
PAHs							
2-Chloronaphthalene	0/27	0	nd	nd	170	24 – 2,900	µg/kg ww
2-Methylnaphthalene	24/27	89	2.1	8.8	7.2	64	µg/kg ww
Acenaphthene	25/27	93	4.8	22	9.9	16	µg/kg ww
Acenaphthylene	24/27	89	0.55 J	1.4	2.1	24	µg/kg ww
Anthracene	24/27	89	0.61 J	2.1	2.4	24	µg/kg ww
Benzo(a)anthracene	23/27	85	0.15 J	1.7	1.8	0.72 – 24	µg/kg ww
Benzo(a)pyrene	19/27	70	0.13 J	1.5	2.6	0.72 – 40	µg/kg ww
Benzo(b)fluoranthene	24/27	89	0.19 J	2.3	4.2	64	µg/kg ww

Table E.6.3-16, cont. Summary statistics for shiner surfperch, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Benzo(g,h,i)perylene	8/27	30	0.16 J	0.99	2.5	0.16 – 40	µg/kg ww
Benzo(k)fluoranthene	23/27	85	0.18 J	2.2	4.1	0.72 – 64	µg/kg ww
Total benzofluoranthenes	24/27	89	0.21 J	4.5	4.7	nc	µg/kg ww
Chrysene	24/27	89	0.53 J	5.2	2.6	24	µg/kg ww
Dibenzo(a,h)anthracene	1/27	4	0.24	0.24	3.8	0.18 – 64	µg/kg ww
Dibenzofuran	24/27	89	2.7	7.4	6.6	40	µg/kg ww
Fluoranthene	24/27	89	3.0	9.4	6.0	24	µg/kg ww
Fluorene	24/27	89	2.4	7.1	5.4	24	µg/kg ww
Indeno(1,2,3-cd)pyrene	8/27	30	0.12 J	1.1	2.4	0.13 – 40	µg/kg ww
Naphthalene	5/27	19	5.8	8.7	6.4	3.0 – 64	µg/kg ww
Phenanthrene	24/27	89	3.8	13	7.4	24	µg/kg ww
Pyrene	24/27	89	1.3	5.7	3.6	24	µg/kg ww
Total HPAH	24/27	89	5.6 J	25.8	14	nc	µg/kg ww
Total LPAH	25/27	93	12.6 J	37	25	nc	µg/kg ww
Carcinogenic PAHs – Mammal	24/27	89	0.37 J	2.2	3.1	43	µg/kg ww
Total PAH	25/27	93	18.8 J	58	35	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	5/27	19	280 J	2,100 J	800	24 – 3,600	µg/kg ww
Butyl benzyl phthalate	7/24	29	300	1,400	490	57 – 1,200	µg/kg ww
Diethyl phthalate	13/27	48	19 J	900 J	210	40 – 1,200	µg/kg ww
Dimethyl phthalate	0/27	0	nd	nd	170	9.9 – 2,900	µg/kg ww
Di-n-butyl phthalate	1/27	4	2,300	2,300	220	40 – 580	µg/kg ww
Di-n-octyl phthalate	0/27	0	nd	nd	590	24 – 2,900	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/27	0	nd	nd	110	24 – 580	µg/kg ww
1,2-Dichlorobenzene	0/27	0	nd	nd	110	24 – 580	µg/kg ww
1,2-Diphenylhydrazine	0/3	0	nd	nd	40	80	µg/kg ww
1,3-Dichlorobenzene	0/27	0	nd	nd	110	24 – 580	µg/kg ww
1,4-Dichlorobenzene	0/27	0	nd	nd	110	24 – 580	µg/kg ww
2,4,5-Trichlorophenol	0/27	0	nd	nd	740	120 – 15,000	µg/kg ww
2,4,6-Trichlorophenol	0/27	0	nd	nd	740	120 – 15,000	µg/kg ww
2,4-Dichlorophenol	0/27	0	nd	nd	220	40 – 1,200	µg/kg ww

Table E.6.3-16, cont. Summary statistics for shiner surfperch, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
2,4-Dimethylphenol	0/27	0	nd	nd	230	40 – 1,200	µg/kg ww
2,4-Dinitrophenol	0/12	0	nd	nd	3,400	80 – 29,000	µg/kg ww
2,4-Dinitrotoluene	0/27	0	nd	nd	880	16 – 15,000	µg/kg ww
2,6-Dinitrotoluene	0/27	0	nd	nd	740	16 – 15,000	µg/kg ww
2-Chlorophenol	0/27	0	nd	nd	220	80 – 1,200	µg/kg ww
2-Methylphenol	1/27	4	1,100 J	1,100 J	240	40 – 1,200	µg/kg ww
2-Nitroaniline	0/27	0	nd	nd	890	160 – 15,000	µg/kg ww
2-Nitrophenol	0/27	0	nd	nd	550	40 – 5,200	µg/kg ww
3,3'-Dichlorobenzidine	0/24	0	nd	nd	6,200	2,900 – 29,000	µg/kg ww
3-Nitroaniline	0/24	0	nd	nd	1,900	570 – 29,000	µg/kg ww
4,6-Dinitro-o-cresol	0/27	0	nd	nd	2,000	80 – 29,000	µg/kg ww
4-Bromophenyl phenyl ether	0/27	0	nd	nd	110	16 – 580	µg/kg ww
4-Chloro-3-methylphenol	0/27	0	nd	nd	550	80 – 2,900	µg/kg ww
4-Chloroaniline	0/24	0	nd	nd	620	290 – 2,900	µg/kg ww
4-Chlorophenyl phenyl ether	0/27	0	nd	nd	170	24 – 2,900	µg/kg ww
4-Methylphenol	1/27	4	1,500	1,500	260	40 – 1,200	µg/kg ww
4-Nitroaniline	0/27	0	nd	nd	1,500	160 – 29,000	µg/kg ww
4-Nitrophenol	2/27	7	530 J	530 J	1,800	80 – 29,000	µg/kg ww
Aniline	0/24	0	nd	nd	2,500	1,200 – 12,000	µg/kg ww
Benzidine	0/24	0	nd	nd	17,000	7,200 – 72,000	µg/kg ww
Benzoic acid	17/27	63	740	54,000	4,800	2,900 – 5,800	µg/kg ww
Benzyl alcohol	6/27	22	48	200 J	150	57 – 580	µg/kg ww
bis(2-chloroethoxy)methane	1/27	4	240 J	240 J	270	40 – 1,500	µg/kg ww
bis(2-chloroethyl)ether	0/27	0	nd	nd	150	24 – 580	µg/kg ww
bis(2-chloroisopropyl)ether	0/27	0	nd	nd	120	57 – 580	µg/kg ww
Caffeine	0/3	0	nd	nd	4.0	8.0	µg/kg ww
Carbazole	2/27	7	6,000	14,000	1,200	40 – 2,900	µg/kg ww
Coprostanol	0/3	0	nd	nd	80	160	µg/kg ww
Hexachlorobenzene	1/27	4	4.1 JN	4.1 JN	2.4	1.5 – 24	µg/kg ww
Hexachlorobutadiene	0/27	0	nd	nd	110	40 – 580	µg/kg ww
Hexachlorocyclopentadiene	0/27	0	nd	nd	25,000	40 – 360,000	µg/kg ww
Hexachloroethane	0/27	0	nd	nd	110	40 – 580	µg/kg ww

Table E.6.3-16, cont. Summary statistics for shiner surfperch, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Isophorone	0/27	0	nd	nd	110	40 – 580	µg/kg ww
Nitrobenzene	0/27	0	nd	nd	110	40 – 580	µg/kg ww
N-Nitrosodimethylamine	0/27	0	nd	nd	860	120 – 5,800	µg/kg ww
N-Nitroso-di-n-propylamine	0/27	0	nd	nd	110	40 – 580	µg/kg ww
N-Nitrosodiphenylamine	0/27	0	nd	nd	180	40 – 2,900	µg/kg ww
Pentachlorophenol	2/27	7	2.8 J	2,400 J	670	4.5 – 2,900	µg/kg ww
Phenol	13/27	48	52 J	670 J	280	150 – 1,500	µg/kg ww
Polychlorinated biphenyls							
PCB-001	7/12	58	3.29	16.6 J	7.27	6.58 – 23.7	ng/kg ww
PCB-002	5/12	42	0.530 J	4.17 J	2.18	2.62 – 13.2	ng/kg ww
PCB-003	7/12	58	1.14 J	39.3 J	6.01	5.15 – 6.45	ng/kg ww
PCB-004	12/12	100	46.6	1,700	215	na	ng/kg ww
PCB-005	4/12	33	0.953 J	20.3 J	5.05	1.85 – 16.2	ng/kg ww
PCB-006	12/12	100	24.8	3,240	319	na	ng/kg ww
PCB-007	7/12	58	2.63	698	68.1	6.48 – 13.3	ng/kg ww
PCB-008	12/12	100	44.0	2,520	274	na	ng/kg ww
PCB-009	12/12	100	13.0	222	35.9	na	ng/kg ww
PCB-010	7/12	58	4.92	80.7	13.0	6.55 – 15.7	ng/kg ww
PCB-011	5/12	42	5.71	57.2 J	11.6	6.99 – 31.7	ng/kg ww
PCB-012	8/12	67	5.32 C	89.0 C	15.9	8.85 – 13.9	ng/kg ww
PCB-013	8/12	67	C12	C12	nc	0	ng/kg ww
PCB-014	0/12	0	nd	nd	3.67	0.136 – 16.7	ng/kg ww
PCB-015	12/12	100	119	1,320	245	na	ng/kg ww
PCB-016	12/12	100	26.9 J	389	74.6	na	ng/kg ww
PCB-017	12/12	100	180	7,640	903	na	ng/kg ww
PCB-018	12/12	100	913 C	24,900 C	3,310	na	ng/kg ww
PCB-019	12/12	100	115	2,330	338	na	ng/kg ww
PCB-020	12/12	100	3,950 C	75,100 C	12,200	na	ng/kg ww
PCB-021	12/12	100	144 C	1,910 C	343	na	ng/kg ww
PCB-022	12/12	100	232	4,730	708	na	ng/kg ww
PCB-023	4/12	33	1.27 J	3.98 J	2.75	1.64 – 16.4	ng/kg ww
PCB-024	10/12	83	13.3 J	155	28.3	0.858 – 1.53	ng/kg ww

Table E.6.3-16, cont. Summary statistics for shiner surfperch, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-025	12/12	100	384	55,000	5,190	na	ng/kg ww
PCB-026	12/12	100	1,270 C	151,000 C	14,500	na	ng/kg ww
PCB-027	12/12	100	159	3,390	483	na	ng/kg ww
PCB-028	12/12	100	C20	C20	nc	na	ng/kg ww
PCB-029	12/12	100	C26	C26	nc	na	ng/kg ww
PCB-030	12/12	100	C18	C18	nc	na	ng/kg ww
PCB-031	12/12	100	2,120	55,100	7,540	na	ng/kg ww
PCB-032	12/12	100	550	9,340	1,470	na	ng/kg ww
PCB-033	12/12	100	C21	C21	nc	na	ng/kg ww
PCB-034	12/12	100	17.3	681	81.9	na	ng/kg ww
PCB-035	0/12	0	nd	nd	2.33	0.765 – 17.4	ng/kg ww
PCB-036	0/12	0	nd	nd	2.02	0.682 – 15.6	ng/kg ww
PCB-037	12/12	100	515	6,560	1,400	na	ng/kg ww
PCB-038	8/12	67	4.06 J	223 J	26.8	3.24 – 4.59	ng/kg ww
PCB-039	8/12	67	6.32	183	25.1	3.26 – 4.62	ng/kg ww
PCB-040	12/12	100	781 C	32,600 C	4,190	na	ng/kg ww
PCB-041	12/12	100	C40	C40	nc	na	ng/kg ww
PCB-042	12/12	100	252	27,900	2,870	na	ng/kg ww
PCB-043	10/12	83	102	1,890	312	0.138 – 0.469	ng/kg ww
PCB-044	12/12	100	4,460 C	328,000 C	36,600	na	ng/kg ww
PCB-045	12/12	100	346 C	8,600 C	1,280	na	ng/kg ww
PCB-046	12/12	100	95.5	3,830	496	na	ng/kg ww
PCB-047	12/12	100	C44	C44	nc	na	ng/kg ww
PCB-048	12/12	100	303	4,650	866	na	ng/kg ww
PCB-049	12/12	100	6,490 C	396,000 C	45,100	na	ng/kg ww
PCB-050	12/12	100	897 C	23,000 C	3,320	na	ng/kg ww
PCB-051	12/12	100	C45	C45	nc	na	ng/kg ww
PCB-052	12/12	100	13,900	770,000	89,900	na	ng/kg ww
PCB-053	12/12	100	C50	C50	nc	na	ng/kg ww
PCB-054	12/12	100	9.23 J	151	25.0	na	ng/kg ww
PCB-055	4/12	33	104 J	431	102	2.90 – 54.9	ng/kg ww
PCB-056	12/12	100	421	15,800	2,020	na	ng/kg ww

Table E.6.3-16, cont. Summary statistics for shiner surfperch, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-057	12/12	100	70.5	11,500	1,100	na	ng/kg ww
PCB-058	11/12	92	32.1	2,700	287	5.40	ng/kg ww
PCB-059	12/12	100	670 C	20,500 C	2,900	na	ng/kg ww
PCB-060	12/12	100	1,100	10,300	2,770	na	ng/kg ww
PCB-061	12/12	100	11,100 C	335,000 C	47,400	na	ng/kg ww
PCB-062	12/12	100	C59	C59	nc	na	ng/kg ww
PCB-063	12/12	100	536	13,500	1,870	na	ng/kg ww
PCB-064	12/12	100	2,050	65,900	9,230	na	ng/kg ww
PCB-065	12/12	100	C44	C44	nc	na	ng/kg ww
PCB-066	12/12	100	6,190	217,000	29,500	na	ng/kg ww
PCB-067	12/12	100	210	9,160	1,140	na	ng/kg ww
PCB-068	12/12	100	121	12,700	1,350	na	ng/kg ww
PCB-069	12/12	100	C49	C49	nc	na	ng/kg ww
PCB-070	12/12	100	C61	C61	nc	na	ng/kg ww
PCB-071	12/12	100	C40	C40	nc	na	ng/kg ww
PCB-072	12/12	100	224	21,100	2,220	na	ng/kg ww
PCB-073	6/12	50	51.6	1,010	128	0.0497 – 2.19	ng/kg ww
PCB-074	12/12	100	C61	C61	nc	na	ng/kg ww
PCB-075	12/12	100	C59	C59	nc	na	ng/kg ww
PCB-076	12/12	100	C61	C61	nc	na	ng/kg ww
PCB-077	12/12	100	568	5,940	1,470	na	ng/kg ww
PCB-078	0/12	0	nd	nd	11.4	3.07 – 55.7	ng/kg ww
PCB-079	12/12	100	143	9,580	1,120	na	ng/kg ww
PCB-080	1/12	8	321	321	35.8	2.83 – 49.4	ng/kg ww
PCB-081	12/12	100	45.8	234	90.9	na	ng/kg ww
PCB-082	12/12	100	179	14,700	1,770	na	ng/kg ww
PCB-083	12/12	100	23,500 C	686,000 C	102,000	na	ng/kg ww
PCB-084	12/12	100	1,260	155,000	16,600	na	ng/kg ww
PCB-085	12/12	100	1,800 C	80,800 C	10,200	na	ng/kg ww
PCB-086	12/12	100	9,240 C	423,000 C	58,900	na	ng/kg ww
PCB-087	12/12	100	C86	C86	nc	na	ng/kg ww
PCB-088	12/12	100	1,860 C	105,000 C	13,200	na	ng/kg ww

Table E.6.3-16, cont. Summary statistics for shiner surfperch, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-089	11/12	92	20.6	1,680	198	2.45	ng/kg ww
PCB-090	12/12	100	30,300 C	886,000 C	155,000	na	ng/kg ww
PCB-091	12/12	100	C88	C88	nc	na	ng/kg ww
PCB-092	12/12	100	4,410	241,000	33,100	na	ng/kg ww
PCB-093	12/12	100	9,670 C	705,000 C	93,000	na	ng/kg ww
PCB-094	11/12	92	18.4	2,090	219	29.6	ng/kg ww
PCB-095	12/12	100	C93	C93	nc	na	ng/kg ww
PCB-096	11/12	92	59.0	2,510	324	0.695	ng/kg ww
PCB-097	12/12	100	C86	C86	nc	na	ng/kg ww
PCB-098	12/12	100	C93	C93	nc	na	ng/kg ww
PCB-099	12/12	100	C83	C83	nc	na	ng/kg ww
PCB-100	12/12	100	C93	C93	nc	na	ng/kg ww
PCB-101	12/12	100	C90	C90	nc	na	ng/kg ww
PCB-102	12/12	100	C93	C93	nc	na	ng/kg ww
PCB-103	12/12	100	320	13,500	2,130	na	ng/kg ww
PCB-104	11/12	92	3.30 J	73.3	11.8	4.66	ng/kg ww
PCB-105	12/12	100	10,800	195,000	35,400	na	ng/kg ww
PCB-106	0/12	0	nd	nd	19.0	13.6 – 102	ng/kg ww
PCB-107	12/12	100	574 C	19,000 C	2,870	na	ng/kg ww
PCB-108	12/12	100	C86	C86	nc	na	ng/kg ww
PCB-109	12/12	100	2,550	80,300	11,300	na	ng/kg ww
PCB-110	12/12	100	15,400 C	906,000 C	114,000	na	ng/kg ww
PCB-111	12/12	100	30.4 J	1,310	194	na	ng/kg ww
PCB-112	0/12	0	nd	nd	4.47	1.65 – 22.4	ng/kg ww
PCB-113	12/12	100	C90	C90	nc	na	ng/kg ww
PCB-114	12/12	100	741	11,400	2,100	na	ng/kg ww
PCB-115	12/12	100	C110	C110	nc	na	ng/kg ww
PCB-116	12/12	100	C85	C85	nc	na	ng/kg ww
PCB-117	12/12	100	C85	C85	nc	na	ng/kg ww
PCB-118	12/12	100	33,800	812,000	129,000	na	ng/kg ww
PCB-119	12/12	100	C86	C86	nc	na	ng/kg ww
PCB-120	12/12	100	218	8,790	1,250	na	ng/kg ww

Table E.6.3-16, cont. Summary statistics for shiner surfperch, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-121	9/12	75	11.9	275	56.9	6.19 – 6.63	ng/kg ww
PCB-122	11/12	92	108	3,650	533	15.5	ng/kg ww
PCB-123	12/12	100	600	7,750	1,670	na	ng/kg ww
PCB-124	12/12	100	C107	C107	nc	na	ng/kg ww
PCB-125	12/12	100	C86	C86	nc	na	ng/kg ww
PCB-126	12/12	100	55.3	370 J	140	na	ng/kg ww
PCB-127	9/12	75	64.0	1,550	265	45.4 – 113	ng/kg ww
PCB-128	12/12	100	5,040 C	124,000 C	25,900	na	ng/kg ww
PCB-129	12/12	100	63,200 C	854,000 C	249,000	na	ng/kg ww
PCB-130	12/12	100	3,140	56,100	12,300	na	ng/kg ww
PCB-131	12/12	100	116	6,270	980	na	ng/kg ww
PCB-132	12/12	100	2,980	209,000	32,600	na	ng/kg ww
PCB-133	12/12	100	1,040	15,000	4,300	na	ng/kg ww
PCB-134	12/12	100	994 C	44,500 C	7,810	na	ng/kg ww
PCB-135	12/12	100	12,000 C	334,000 C	70,800	na	ng/kg ww
PCB-136	12/12	100	2,270	73,800	17,400	na	ng/kg ww
PCB-137	12/12	100	2,030	47,800	8,320	na	ng/kg ww
PCB-138	12/12	100	C129	C129	nc	na	ng/kg ww
PCB-139	12/12	100	691 C	17,600 C	3,060	na	ng/kg ww
PCB-140	12/12	100	C139	C139	nc	na	ng/kg ww
PCB-141	12/12	100	3,960	183,000	32,800	na	ng/kg ww
PCB-142	0/12	0	nd	nd	22.0	5.19 – 119	ng/kg ww
PCB-143	12/12	100	C134	C134	nc	na	ng/kg ww
PCB-144	12/12	100	1,410	41,700	8,120	na	ng/kg ww
PCB-145	7/12	58	4.45	224	25.4	0.117 – 4.52	ng/kg ww
PCB-146	12/12	100	10,400	158,000	44,800	na	ng/kg ww
PCB-147	12/12	100	11,400 C	515,000 C	115,000	na	ng/kg ww
PCB-148	12/12	100	78.9	1,380	418	na	ng/kg ww
PCB-149	12/12	100	C147	C147	nc	na	ng/kg ww
PCB-150	12/12	100	50.7	988	268	na	ng/kg ww
PCB-151	12/12	100	C135	C135	nc	na	ng/kg ww
PCB-152	12/12	100	11.4	639	81.1	na	ng/kg ww

Table E.6.3-16, cont. Summary statistics for shiner surfperch, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-153	12/12	100	72,500 C	1,070,000 C	269,000	na	ng/kg ww
PCB-154	12/12	100	C135	C135	nc	na	ng/kg ww
PCB-155	12/12	100	8.10	60.4	20.5	na	ng/kg ww
PCB-156	12/12	100	5,710 C	108,000 C	21,500	na	ng/kg ww
PCB-157	12/12	100	C156	C156	nc	na	ng/kg ww
PCB-158	12/12	100	4,830	81,200	22,200	na	ng/kg ww
PCB-159	12/12	100	50.7	3,970	699	na	ng/kg ww
PCB-160	12/12	100	C129	C129	nc	na	ng/kg ww
PCB-161	0/12	0	nd	nd	15.3	3.88 – 82.3	ng/kg ww
PCB-162	12/12	100	146	2,670	582	na	ng/kg ww
PCB-163	12/12	100	C129	C129	nc	na	ng/kg ww
PCB-164	12/12	100	775	46,300	8,990	na	ng/kg ww
PCB-165	11/12	92	35.7	370	110	50.7	ng/kg ww
PCB-166	12/12	100	C128	C128	nc	na	ng/kg ww
PCB-167	12/12	100	2,320	34,900	8,600	na	ng/kg ww
PCB-168	12/12	100	C153	C153	nc	na	ng/kg ww
PCB-169	4/12	33	3.45	22.4	8.62	1.76 – 46.7	ng/kg ww
PCB-170	12/12	100	11,400	366,000	63,400	na	ng/kg ww
PCB-171	12/12	100	3,350 C	109,000 C	18,500	na	ng/kg ww
PCB-172	12/12	100	1,660	59,700	10,100	na	ng/kg ww
PCB-173	12/12	100	C171	C171	nc	na	ng/kg ww
PCB-174	12/12	100	1,150	90,000	14,900	na	ng/kg ww
PCB-175	12/12	100	439	14,700	2,440	na	ng/kg ww
PCB-176	12/12	100	367	27,200	4,080	na	ng/kg ww
PCB-177	12/12	100	5,080	223,000	35,700	na	ng/kg ww
PCB-178	12/12	100	2,700	78,800	13,900	na	ng/kg ww
PCB-179	12/12	100	2,160	119,000	18,000	na	ng/kg ww
PCB-180	12/12	100	33,300 C	1,080,000 C	181,000	na	ng/kg ww
PCB-181	12/12	100	81.3	2,070	425	na	ng/kg ww
PCB-182	12/12	100	108	927	375	na	ng/kg ww
PCB-183	12/12	100	10,000 C	310,000 C	51,100	na	ng/kg ww
PCB-184	11/12	92	8.66	86.9	24.6	2.42	ng/kg ww

Table E.6.3-16, cont. Summary statistics for shiner surfperch, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-185	12/12	100	C183	C183	nc	na	ng/kg ww
PCB-186	0/12	0	nd	nd	1.09	0.366 – 9.39	ng/kg ww
PCB-187	12/12	100	18,300	549,000	95,900	na	ng/kg ww
PCB-188	12/12	100	34.5	273	87.5	na	ng/kg ww
PCB-189	12/12	100	388	9,590	1,860	na	ng/kg ww
PCB-190	12/12	100	2,470	76,800	13,800	na	ng/kg ww
PCB-191	12/12	100	513	15,000	2,690	na	ng/kg ww
PCB-192	0/12	0	nd	nd	1.28	0.409 – 10.7	ng/kg ww
PCB-193	12/12	100	C180	C180	nc	na	ng/kg ww
PCB-194	12/12	100	3,410	97,600	19,200	na	ng/kg ww
PCB-195	12/12	100	1,500	50,700	8,960	na	ng/kg ww
PCB-196	12/12	100	2,000	63,600	11,600	na	ng/kg ww
PCB-197	12/12	100	259 C	9,590 C	1,640	na	ng/kg ww
PCB-198	12/12	100	2,360 C	98,800 C	17,600	na	ng/kg ww
PCB-199	12/12	100	C198	C198	nc	na	ng/kg ww
PCB-200	12/12	100	C197	C197	nc	na	ng/kg ww
PCB-201	12/12	100	570	15,300	2,860	na	ng/kg ww
PCB-202	12/12	100	1,120	21,500	4,690	na	ng/kg ww
PCB-203	12/12	100	3,000	77,100	15,400	na	ng/kg ww
PCB-204	11/12	92	1.18 J	15.2 J	5.20	0.457	ng/kg ww
PCB-205	12/12	100	180	4,700	957	na	ng/kg ww
PCB-206	12/12	100	693	9,710	2,820	na	ng/kg ww
PCB-207	12/12	100	100	1,680	420	na	ng/kg ww
PCB-208	12/12	100	125	1,640	503	na	ng/kg ww
PCB-209	12/12	100	77.1	299	168	na	ng/kg ww
Total PCB congeners	9/9	100	532,400 J	12,228,000 J	3,190,000	nc	ng/kg ww
Aroclor-1016	0/49	0	nd	nd	32	8.0 – 200	µg/kg ww
Aroclor-1221	0/49	0	nd	nd	42	8.0 – 290	µg/kg ww
Aroclor-1232	0/49	0	nd	nd	33	8.0 – 200	µg/kg ww
Aroclor-1242	0/49	0	nd	nd	32	8.0 – 200	µg/kg ww
Aroclor-1248	25/49	51	100	4,400	220	8.0 – 200	µg/kg ww
Aroclor-1254	49/49	100	200	7,600	730	na	µg/kg ww

Table E.6.3-16, cont. Summary statistics for shiner surfperch, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Aroclor-1260	49/49	100	150	7,100	850	na	µg/kg ww
Total PCBs	49/49	100	350	18,400 J	1,800	nc	µg/kg ww
PCB TEQ – Bird	9/9	100	41.40 J	393.0 J	113	na	ng/kg ww
PCB TEQ – Fish	9/9	100	0.6330 J	8.400 J	2.16	na	ng/kg ww
PCB TEQ – Mammal	9/9	100	7.55 J	73.0 J	23.2	na	ng/kg ww
Pesticides							
2,4'-DDD	1/24	4	57 JN	57 JN	5.4	1.5 – 41	µg/kg ww
2,4'-DDE	2/24	8	3.2 JN	110 JN	6.8	1.5 – 16	µg/kg ww
2,4'-DDT	24/24	100	18 JN	440 JN	78	na	µg/kg ww
4,4'-DDD	22/24	92	1.3 JN	8.5 JN	4.6	3.5 – 4.7	µg/kg ww
4,4'-DDE	17/24	71	4.4 JN	15 JN	7.3	3.7 – 8.1	µg/kg ww
4,4'-DDT	24/24	100	14 JN	470 JN	90	na	µg/kg ww
Total DDTs	24/24	100	35 JN	1,020 JN	190	nc	µg/kg ww
Aldrin	1/24	4	1.4 JN	1.4 JN	0.82	1.5 – 3.7	µg/kg ww
Dieldrin	0/24	0	nd	nd	1.3	1.5 – 7.2	µg/kg ww
Total aldrin/dieldrin	1/24	4	1.4 JN	1.4 JN	1.3	nc	µg/kg ww
alpha-BHC	2/24	8	0.45 JN	0.46 JN	0.96	1.5 – 7.2	µg/kg ww
beta-BHC	16/24	67	2.5 JN	15 JN	5.9	1.5 – 5.1	µg/kg ww
gamma-BHC	7/24	29	0.59 JN	5.1 JN	1.2	1.5 – 2.8	µg/kg ww
delta-BHC	0/24	0	nd	nd	0.75	1.5	µg/kg ww
alpha-Chlordane	16/24	67	0.60 JN	3.6 JN	1.6	1.5 – 7.2	µg/kg ww
gamma-Chlordane	24/24	100	4.1 JN	330 JN	32	na	µg/kg ww
alpha-Endosulfan	11/24	46	2.0 JN	6.3 JN	2.4	1.5 – 9.9	µg/kg ww
beta-Endosulfan	14/24	58	2.0 JN	44 JN	7.6	2.4 – 11	µg/kg ww
Endosulfan sulfate	0/24	0	nd	nd	0.75	1.5	µg/kg ww
Endrin	8/24	33	2.2 JN	40 JN	5.3	1.5 – 72	µg/kg ww
Endrin aldehyde	3/24	12	5.3 JN	78 JN	4.9	1.5 – 6.5	µg/kg ww
Endrin ketone	0/24	0	nd	nd	1.4	1.5 – 15	µg/kg ww
Heptachlor	1/24	4	9.7 JN	9.7 JN	1.6	1.5 – 6.8	µg/kg ww
Heptachlor epoxide	5/24	21	3.4 JN	10 JN	2.5	1.5 – 6.0	µg/kg ww
Methoxychlor	0/24	0	nd	nd	1.5	1.5 – 7.2	µg/kg ww
Mirex	0/24	0	nd	nd	0.75	1.5	µg/kg ww

Table E.6.3-16, cont. Summary statistics for shiner surfperch, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Toxaphene	0/24	0	nd	nd	390	190 – 4,800	µg/kg ww
Total chlordane	24/24	100	4.9 JN	330 JN	33	nc	µg/kg ww
Conventional parameters							
Total solids	46/46	100	22.8	30.42	26.1	na	% ww
Total solids (estimated)	3/3	100	26.1	26.1	26.1	na	% ww
Lipid	49/49	100	1.6	6.93	4.6	na	% ww

Note: data for seven shiner surfperch whole body composite samples collected by King County in 2006 are not included in this table

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Table E.6.3-17. Summary statistics for slender crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	10/12	83	0.0009 J	0.0025 J	0.002	0.0079 – 0.0087	mg/kg ww
Arsenic	12/12	100	1.670	3.570	2.612	na	mg/kg ww
Arsenic (inorganic)	4/4	100	0.030	0.030	0.030	na	mg/kg ww
Cadmium	12/12	100	0.0169	0.0444	0.0290	na	mg/kg ww
Chromium	0/12	0	nd	nd	0.04	0.07 – 0.10	mg/kg ww
Cobalt	12/12	100	0.0107	0.0169 J	0.0132	na	mg/kg ww
Copper	12/12	100	4.430	7.320	6.238	na	mg/kg ww
Lead	12/12	100	0.0131	0.0503	0.0270	na	mg/kg ww
Mercury	12/12	100	0.023	0.060	0.047	na	mg/kg ww
Molybdenum	12/12	100	0.0131	0.0171	0.0150	na	mg/kg ww
Nickel	12/12	100	0.035 J	0.065	0.050	na	mg/kg ww
Selenium	12/12	100	0.160	0.262	0.209	na	mg/kg ww
Silver	12/12	100	0.0431	0.0702	0.0563	na	mg/kg ww
Thallium	0/12	0	nd	nd	0.0018	0.0027 – 0.0039	mg/kg ww
Vanadium	0/12	0	nd	nd	0.088	0.14 – 0.20	mg/kg ww
Zinc	12/12	100	26.1	39.3	34.4	na	mg/kg ww
Organometals							
Monobutyltin as ion	0/12	0	nd	nd	0.75	1.5	µg/kg ww
Dibutyltin as ion	0/12	0	nd	nd	0.75	1.5	µg/kg ww
Tributyltin as ion	0/12	0	nd	nd	0.75	1.5	µg/kg ww
Tetrabutyltin as ion	0/12	0	nd	nd	0.75	1.5	µg/kg ww
PAHs							
2-Chloronaphthalene	0/12	0	nd	nd	220	57 – 580	µg/kg ww
2-Methylnaphthalene	1/12	8	0.45	0.45	0.24	0.34 – 0.52	µg/kg ww
Acenaphthene	5/12	42	0.13 J	0.18 J	0.27	0.72	µg/kg ww
Acenaphthylene	1/12	8	0.13 J	0.13 J	0.34	0.72	µg/kg ww
Anthracene	8/12	67	0.090 J	0.18 J	0.21	0.72	µg/kg ww
Benzo(a)anthracene	2/12	17	0.12 J	0.16	0.32	0.72	µg/kg ww
Benzo(a)pyrene	1/12	8	0.18	0.18	0.35	0.72	µg/kg ww
Benzo(b)fluoranthene	1/12	8	0.17	0.17	0.34	0.72	µg/kg ww
Benzo(g,h,i)perylene	1/12	8	0.22	0.22	0.35	0.72	µg/kg ww
Benzo(k)fluoranthene	1/12	8	0.16	0.16	0.34	0.72	µg/kg ww
Total benzofluoranthenes	1/12	8	0.33	0.33	0.36	nc	µg/kg ww
Chrysene	2/12	17	0.14 J	0.17	0.33	0.72	µg/kg ww

Table E.6.3-17, cont. Summary statistics for slender crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Dibenzo(a,h)anthracene	1/12	8	0.20	0.20	0.35	0.72	µg/kg ww
Dibenzofuran	8/12	67	0.097 J	0.19 J	0.12	0.11 – 0.23	µg/kg ww
Fluoranthene	12/12	100	0.18 J	0.80	0.51	na	µg/kg ww
Fluorene	12/12	100	0.094 J	0.25 J	0.15	na	µg/kg ww
Indeno(1,2,3-cd)pyrene	1/12	8	0.23	0.23	0.35	0.72	µg/kg ww
Naphthalene	1/12	8	1.5	1.5	0.92	1.4 – 2.2	µg/kg ww
Phenanthrene	2/12	17	0.49	0.67 J	0.27	0.31 – 0.51	µg/kg ww
Pyrene	12/12	100	0.16 J	0.43 J	0.25	na	µg/kg ww
Total HPAH	12/12	100	0.34 J	2.09 J	0.91	nc	µg/kg ww
Total LPAH	12/12	100	0.094 J	2.4 J	0.52	nc	µg/kg ww
Carcinogenic PAHs – Mammal	2/12	17	0.33	0.63 J	0.35	0.65	µg/kg ww
Total PAH	12/12	100	0.43 J	4.5 J	1.4	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	0/12	0	nd	nd	60	66 – 260	µg/kg ww
Butyl benzyl phthalate	0/12	0	nd	nd	390	120 – 1,200	µg/kg ww
Diethyl phthalate	5/12	42	21 J	180 J	320	120 – 1,200	µg/kg ww
Dimethyl phthalate	1/12	8	7.6 J	7.6 J	220	57 – 580	µg/kg ww
Di-n-butyl phthalate	0/12	0	nd	nd	200	31 – 580	µg/kg ww
Di-n-octyl phthalate	0/12	0	nd	nd	830	290 – 2,900	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/12	0	nd	nd	220	57 – 580	µg/kg ww
1,2-Dichlorobenzene	0/12	0	nd	nd	220	57 – 580	µg/kg ww
1,3-Dichlorobenzene	0/12	0	nd	nd	220	57 – 580	µg/kg ww
1,4-Dichlorobenzene	0/12	0	nd	nd	220	57 – 580	µg/kg ww
2,4,5-Trichlorophenol	0/12	0	nd	nd	910	290 – 2,900	µg/kg ww
2,4,6-Trichlorophenol	0/12	0	nd	nd	910	290 – 2,900	µg/kg ww
2,4-Dichlorophenol	0/12	0	nd	nd	470	120 – 1,200	µg/kg ww
2,4-Dimethylphenol	0/12	0	nd	nd	470	120 – 1,200	µg/kg ww
2,4-Dinitrophenol	0/12	0	nd	nd	4,700	1,200 – 12,000	µg/kg ww
2,4-Dinitrotoluene	0/12	0	nd	nd	840	290 – 2,900	µg/kg ww
2,6-Dinitrotoluene	0/12	0	nd	nd	760	290 – 2,900	µg/kg ww
2-Chlorophenol	0/12	0	nd	nd	470	120 – 1,200	µg/kg ww
2-Methylphenol	0/12	0	nd	nd	470	120 – 1,200	µg/kg ww
2-Nitroaniline	0/12	0	nd	nd	1,100	290 – 2,900	µg/kg ww
2-Nitrophenol	0/12	0	nd	nd	830	290 – 2,900	µg/kg ww
3,3'-Dichlorobenzidine	0/12	0	nd	nd	11,000	2,900 – 29,000	µg/kg ww
3-Nitroaniline	0/12	0	nd	nd	2,200	570 – 5,800	µg/kg ww

Table E.6.3-17, cont. Summary statistics for slender crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
4,6-Dinitro-o-cresol	0/12	0	nd	nd	2,200	570 – 5,800	µg/kg ww
4-Bromophenyl phenyl ether	0/12	0	nd	nd	220	57 – 580	µg/kg ww
4-Chloro-3-methylphenol	0/12	0	nd	nd	1,100	290 – 2,900	µg/kg ww
4-Chloroaniline	0/12	0	nd	nd	1,100	290 – 2,900	µg/kg ww
4-Chlorophenyl phenyl ether	0/12	0	nd	nd	220	57 – 580	µg/kg ww
4-Methylphenol	0/12	0	nd	nd	470	120 – 1,200	µg/kg ww
4-Nitroaniline	0/12	0	nd	nd	1,800	570 – 5,800	µg/kg ww
4-Nitrophenol	0/12	0	nd	nd	2,200	570 – 5,800	µg/kg ww
Aniline	0/12	0	nd	nd	4,700	1,200 – 12,000	µg/kg ww
Benzidine	0/12	0	nd	nd	28,000	7,200 – 72,000	µg/kg ww
Benzoic acid	0/12	0	nd	nd	4,700	1,200 – 12,000	µg/kg ww
Benzyl alcohol	1/12	8	12 J	12 J	360	120 – 1,200	µg/kg ww
bis(2-chloroethoxy)methane	0/12	0	nd	nd	740	290 – 2,900	µg/kg ww
bis(2-chloroethyl)ether	0/12	0	nd	nd	360	120 – 1,200	µg/kg ww
bis(2-chloroisopropyl)ether	0/12	0	nd	nd	220	57 – 580	µg/kg ww
Carbazole	0/12	0	nd	nd	1,100	290 – 2,900	µg/kg ww
Hexachlorobenzene	0/12	0	nd	nd	0.75	1.5	µg/kg ww
Hexachlorobutadiene	0/12	0	nd	nd	220	57 – 580	µg/kg ww
Hexachlorocyclopentadiene	0/12	0	nd	nd	28,000	7,200 – 72,000	µg/kg ww
Hexachloroethane	0/12	0	nd	nd	220	57 – 580	µg/kg ww
Isophorone	0/12	0	nd	nd	220	57 – 580	µg/kg ww
Nitrobenzene	0/12	0	nd	nd	220	57 – 580	µg/kg ww
N-Nitrosodimethylamine	0/12	0	nd	nd	3,100	1,200 – 12,000	µg/kg ww
N-Nitroso-di-n-propylamine	0/12	0	nd	nd	220	57 – 580	µg/kg ww
N-Nitrosodiphenylamine	0/12	0	nd	nd	220	57 – 580	µg/kg ww
Pentachlorophenol	0/12	0	nd	nd	74	3.3 – 580	µg/kg ww
Phenol	1/12	8	43 J	43 J	580	150 – 1,500	µg/kg ww
Polychlorinated biphenyls							
PCB-001	2/5	40	1.04 J	3.45 J	1.11	0.686 – 0.780	ng/kg ww
PCB-002	5/5	100	0.340 J	2.90	0.874	na	ng/kg ww
PCB-003	5/5	100	0.401 J	15.4 J	3.46	na	ng/kg ww
PCB-004	5/5	100	4.68	13.5	7.35	na	ng/kg ww
PCB-005	1/5	20	0.222 J	0.222 J	0.185	0.257 – 0.508	ng/kg ww
PCB-006	5/5	100	1.25 J	2.92 J	1.90	na	ng/kg ww
PCB-007	5/5	100	0.391 J	33.3	7.01	na	ng/kg ww
PCB-008	5/5	100	1.69 J	4.21 J	2.75	na	ng/kg ww
PCB-009	5/5	100	0.490 J	0.897 J	0.695	na	ng/kg ww

Table E.6.3-17, cont. Summary statistics for slender crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-010	1/5	20	0.165 J	0.165 J	0.163	0.238 – 0.473	ng/kg ww
PCB-011	1/5	20	35.6 J	35.6 J	8.17	2.07 – 3.43	ng/kg ww
PCB-012	5/5	100	1.49 CJ	2.53 CJ	1.84	na	ng/kg ww
PCB-013	5/5	100	C12	C12	nc	na	ng/kg ww
PCB-014	0/5	0	nd	nd	0.152	0.148 – 0.483	ng/kg ww
PCB-015	5/5	100	132	314	192	na	ng/kg ww
PCB-016	5/5	100	8.90	38.3	20.3	na	ng/kg ww
PCB-017	5/5	100	19.2	99.5	53.1	na	ng/kg ww
PCB-018	5/5	100	229 C	412 C	309	na	ng/kg ww
PCB-019	5/5	100	2.01 J	9.16	3.98	na	ng/kg ww
PCB-020	5/5	100	1,850 C	3,820 C	2,430	na	ng/kg ww
PCB-021	2/5	40	22.0 C	121 C	28.8	0.658 – 0.854	ng/kg ww
PCB-022	5/5	100	131	331	211	na	ng/kg ww
PCB-023	1/5	20	1.39	1.39	0.590	0.649 – 0.843	ng/kg ww
PCB-024	5/5	100	0.237 J	1.91 J	1.20	na	ng/kg ww
PCB-025	5/5	100	7.62	54.8	32.9	na	ng/kg ww
PCB-026	5/5	100	132 C	340 C	234	na	ng/kg ww
PCB-027	5/5	100	0.0855 J	19.5	7.37	na	ng/kg ww
PCB-028	5/5	100	C20	C20	nc	na	ng/kg ww
PCB-029	5/5	100	C26	C26	nc	na	ng/kg ww
PCB-030	5/5	100	C18	C18	nc	na	ng/kg ww
PCB-031	5/5	100	391	723	588	na	ng/kg ww
PCB-032	5/5	100	14.1	99.3	41.4	na	ng/kg ww
PCB-033	2/5	40	C21	C21	nc	0	ng/kg ww
PCB-034	2/5	40	1.02 J	1.89 J	0.849	0.747 – 0.970	ng/kg ww
PCB-035	1/5	20	0.350 J	0.350 J	0.446	0.783 – 1.02	ng/kg ww
PCB-036	0/5	0	nd	nd	0.359	0.197 – 0.918	ng/kg ww
PCB-037	5/5	100	415	981	612	na	ng/kg ww
PCB-038	0/5	0	nd	nd	0.352	0.206 – 0.895	ng/kg ww
PCB-039	5/5	100	3.82	11.3	6.94	na	ng/kg ww
PCB-040	5/5	100	172 C	402 C	276	na	ng/kg ww
PCB-041	5/5	100	C40	C40	nc	na	ng/kg ww
PCB-042	5/5	100	274	528	395	na	ng/kg ww
PCB-043	4/5	80	59.2	163	95.7	0.147	ng/kg ww
PCB-044	5/5	100	1,850 C	2,980 C	2,470	na	ng/kg ww
PCB-045	5/5	100	18.5 CJ	72.2 C	38.9	na	ng/kg ww
PCB-046	5/5	100	2.89	20.1	9.79	na	ng/kg ww

Table E.6.3-17, cont. Summary statistics for slender crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-047	5/5	100	C44	C44	nc	na	ng/kg ww
PCB-048	5/5	100	115	338	208	na	ng/kg ww
PCB-049	5/5	100	1,990 C	2,800 C	2,580	na	ng/kg ww
PCB-050	5/5	100	13.8 C	86.9 C	46.8	na	ng/kg ww
PCB-051	5/5	100	C45	C45	nc	na	ng/kg ww
PCB-052	5/5	100	4,440	6,250	5,510	na	ng/kg ww
PCB-053	5/5	100	C50	C50	nc	na	ng/kg ww
PCB-054	1/5	20	1.32	1.32	0.305	0.0799 – 0.118	ng/kg ww
PCB-055	0/5	0	nd	nd	1.93	0.496 – 5.36	ng/kg ww
PCB-056	5/5	100	549	900	714	na	ng/kg ww
PCB-057	5/5	100	5.07	18.0	13.0	na	ng/kg ww
PCB-058	5/5	100	5.77	18.6	14.5	na	ng/kg ww
PCB-059	5/5	100	106 C	187 C	153	na	ng/kg ww
PCB-060	5/5	100	792	1,650	1,200	na	ng/kg ww
PCB-061	5/5	100	3,620 C	5,200 C	4,440	na	ng/kg ww
PCB-062	5/5	100	C59	C59	nc	na	ng/kg ww
PCB-063	5/5	100	168	248	210	na	ng/kg ww
PCB-064	5/5	100	583	899	745	na	ng/kg ww
PCB-065	5/5	100	C44	C44	nc	na	ng/kg ww
PCB-066	5/5	100	3,400	5,730	4,500	na	ng/kg ww
PCB-067	5/5	100	31.5	55.2	47.5	na	ng/kg ww
PCB-068	5/5	100	20.0	46.1	29.9	na	ng/kg ww
PCB-069	5/5	100	C49	C49	nc	na	ng/kg ww
PCB-070	5/5	100	C61	C61	nc	na	ng/kg ww
PCB-071	5/5	100	C40	C40	nc	na	ng/kg ww
PCB-072	5/5	100	56.9	107	75.6	na	ng/kg ww
PCB-073	0/5	0	nd	nd	0.0483	0.0782 – 0.120	ng/kg ww
PCB-074	5/5	100	C61	C61	nc	na	ng/kg ww
PCB-075	5/5	100	C59	C59	nc	na	ng/kg ww
PCB-076	5/5	100	C61	C61	nc	na	ng/kg ww
PCB-077	5/5	100	232	456	329	na	ng/kg ww
PCB-078	0/5	0	nd	nd	1.91	0.509 – 5.30	ng/kg ww
PCB-079	5/5	100	67.8	101	84.8	na	ng/kg ww
PCB-080	0/5	0	nd	nd	1.76	0.464 – 4.88	ng/kg ww
PCB-081	5/5	100	12.8 J	25.4	19.7	na	ng/kg ww
PCB-082	5/5	100	302	522	393	na	ng/kg ww
PCB-083	5/5	100	5,120 C	7,400 C	6,470	na	ng/kg ww

Table E.6.3-17, cont. Summary statistics for slender crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-084	5/5	100	315	589	447	na	ng/kg ww
PCB-085	5/5	100	1,060 C	1,770 C	1,500	na	ng/kg ww
PCB-086	5/5	100	3,470 C	5,430 C	4,420	na	ng/kg ww
PCB-087	5/5	100	C86	C86	nc	na	ng/kg ww
PCB-088	5/5	100	570 C	906 C	758	na	ng/kg ww
PCB-089	2/5	40	4.35 J	9.99	3.59	0.256 – 3.88	ng/kg ww
PCB-090	5/5	100	10,200 C	14,200 C	12,300	na	ng/kg ww
PCB-091	5/5	100	C88	C88	nc	na	ng/kg ww
PCB-092	5/5	100	1,870	2,520	2,220	na	ng/kg ww
PCB-093	5/5	100	2,940 C	4,730 C	3,640	na	ng/kg ww
PCB-094	4/5	80	4.58 J	8.84	6.17	0.256	ng/kg ww
PCB-095	5/5	100	C93	C93	nc	na	ng/kg ww
PCB-096	5/5	100	1.04	6.03	3.56	na	ng/kg ww
PCB-097	5/5	100	C86	C86	nc	na	ng/kg ww
PCB-098	5/5	100	C93	C93	nc	na	ng/kg ww
PCB-099	5/5	100	C83	C83	nc	na	ng/kg ww
PCB-100	5/5	100	C93	C93	nc	na	ng/kg ww
PCB-101	5/5	100	C90	C90	nc	na	ng/kg ww
PCB-102	5/5	100	C93	C93	nc	na	ng/kg ww
PCB-103	5/5	100	68.0	113	93.6	na	ng/kg ww
PCB-104	5/5	100	0.222 J	2.06	0.646	na	ng/kg ww
PCB-105	5/5	100	2,900	4,380	3,640	na	ng/kg ww
PCB-106	0/5	0	nd	nd	1.14	0.420 – 3.07	ng/kg ww
PCB-107	5/5	100	214 C	335 C	288	na	ng/kg ww
PCB-108	5/5	100	C86	C86	nc	na	ng/kg ww
PCB-109	5/5	100	460	666	586	na	ng/kg ww
PCB-110	5/5	100	2,770 C	4,520 C	3,500	na	ng/kg ww
PCB-111	5/5	100	4.21 J	11.1	7.12	na	ng/kg ww
PCB-112	0/5	0	nd	nd	0.873	0.183 – 2.87	ng/kg ww
PCB-113	5/5	100	C90	C90	nc	na	ng/kg ww
PCB-114	5/5	100	238	324	286	na	ng/kg ww
PCB-115	5/5	100	C110	C110	nc	na	ng/kg ww
PCB-116	5/5	100	C85	C85	nc	na	ng/kg ww
PCB-117	5/5	100	C85	C85	nc	na	ng/kg ww
PCB-118	5/5	100	7,980	11,400	9,990	na	ng/kg ww
PCB-119	5/5	100	C86	C86	nc	na	ng/kg ww
PCB-120	5/5	100	16.5	23.9	19.9	na	ng/kg ww

Table E.6.3-17, cont. Summary statistics for slender crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-121	0/5	0	nd	nd	0.846	0.179 – 2.78	ng/kg ww
PCB-122	5/5	100	53.9	151	107	na	ng/kg ww
PCB-123	5/5	100	146	248	190	na	ng/kg ww
PCB-124	5/5	100	C107	C107	nc	na	ng/kg ww
PCB-125	5/5	100	C86	C86	nc	na	ng/kg ww
PCB-126	5/5	100	12.6	23.1	17.6	na	ng/kg ww
PCB-127	5/5	100	12.8	23.8	19.8	na	ng/kg ww
PCB-128	5/5	100	1,330 C	2,040 C	1,670	na	ng/kg ww
PCB-129	5/5	100	11,400 C	19,400 C	14,900	na	ng/kg ww
PCB-130	5/5	100	553	834	724	na	ng/kg ww
PCB-131	5/5	100	67.4	109	86.6	na	ng/kg ww
PCB-132	5/5	100	1,220	1,690	1,440	na	ng/kg ww
PCB-133	5/5	100	240	413	302	na	ng/kg ww
PCB-134	5/5	100	322 C	500 C	371	na	ng/kg ww
PCB-135	5/5	100	2,870 C	4,700 C	3,740	na	ng/kg ww
PCB-136	5/5	100	323	510	396	na	ng/kg ww
PCB-137	5/5	100	362	607	476	na	ng/kg ww
PCB-138	5/5	100	C129	C129	nc	na	ng/kg ww
PCB-139	5/5	100	155 C	232 C	194	na	ng/kg ww
PCB-140	5/5	100	C139	C139	nc	na	ng/kg ww
PCB-141	5/5	100	1,280	2,390	1,880	na	ng/kg ww
PCB-142	0/5	0	nd	nd	1.88	0.507 – 6.21	ng/kg ww
PCB-143	5/5	100	C134	C134	nc	na	ng/kg ww
PCB-144	5/5	100	303	462	389	na	ng/kg ww
PCB-145	0/5	0	nd	nd	0.0751	0.0821 – 0.200	ng/kg ww
PCB-146	5/5	100	2,230	3,690	2,810	na	ng/kg ww
PCB-147	5/5	100	8,010 C	12,800 C	10,200	na	ng/kg ww
PCB-148	5/5	100	15.4	23.1	19.2	na	ng/kg ww
PCB-149	5/5	100	C147	C147	nc	na	ng/kg ww
PCB-150	5/5	100	14.9	28.3	20.3	na	ng/kg ww
PCB-151	5/5	100	C135	C135	nc	na	ng/kg ww
PCB-152	5/5	100	0.996	3.01 J	2.10	na	ng/kg ww
PCB-153	5/5	100	10,700 C	19,700 C	14,600	na	ng/kg ww
PCB-154	5/5	100	C135	C135	nc	na	ng/kg ww
PCB-155	5/5	100	1.33 J	2.99 J	2.02	na	ng/kg ww
PCB-156	5/5	100	1,170 C	1,980 C	1,520	na	ng/kg ww
PCB-157	5/5	100	C156	C156	nc	na	ng/kg ww

Table E.6.3-17, cont. Summary statistics for slender crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-158	5/5	100	713	1,180	938	na	ng/kg ww
PCB-159	5/5	100	41.7	70.7	55.5	na	ng/kg ww
PCB-160	5/5	100	C129	C129	nc	na	ng/kg ww
PCB-161	0/5	0	nd	nd	1.36	0.350 – 4.50	ng/kg ww
PCB-162	5/5	100	20.5	36.3	29.7	na	ng/kg ww
PCB-163	5/5	100	C129	C129	nc	na	ng/kg ww
PCB-164	5/5	100	527	788	686	na	ng/kg ww
PCB-165	2/5	40	8.86	11.4	5.25	2.71 – 5.17	ng/kg ww
PCB-166	5/5	100	C128	C128	nc	na	ng/kg ww
PCB-167	5/5	100	432	807	595	na	ng/kg ww
PCB-168	5/5	100	C153	C153	nc	na	ng/kg ww
PCB-169	2/5	40	0.626	0.707	0.811	0.378 – 4.22	ng/kg ww
PCB-170	5/5	100	1,170	2,260	1,590	na	ng/kg ww
PCB-171	5/5	100	548 C	974 C	764	na	ng/kg ww
PCB-172	5/5	100	235	455	324	na	ng/kg ww
PCB-173	5/5	100	C171	C171	nc	na	ng/kg ww
PCB-174	5/5	100	845	1,630	1,240	na	ng/kg ww
PCB-175	5/5	100	72.7	107	91.9	na	ng/kg ww
PCB-176	5/5	100	225	358	300	na	ng/kg ww
PCB-177	5/5	100	1,240	2,320	1,790	na	ng/kg ww
PCB-178	5/5	100	617	1,160	859	na	ng/kg ww
PCB-179	5/5	100	636	1,000	847	na	ng/kg ww
PCB-180	5/5	100	4,100 C	7,590 C	5,380	na	ng/kg ww
PCB-181	5/5	100	12.1	21.2	17.0	na	ng/kg ww
PCB-182	1/5	20	37.5	37.5	7.64	0.221 – 0.455	ng/kg ww
PCB-183	5/5	100	1,430 C	2,400 C	1,930	na	ng/kg ww
PCB-184	5/5	100	1.88 J	2.64 J	2.29	na	ng/kg ww
PCB-185	5/5	100	C183	C183	nc	na	ng/kg ww
PCB-186	0/5	0	nd	nd	0.123	0.117 – 0.353	ng/kg ww
PCB-187	5/5	100	3,430	6,490	4,810	na	ng/kg ww
PCB-188	5/5	100	5.80	10.5	7.99	na	ng/kg ww
PCB-189	5/5	100	54.4	132	84.6	na	ng/kg ww
PCB-190	5/5	100	456	730	579	na	ng/kg ww
PCB-191	5/5	100	89.2	136	114	na	ng/kg ww
PCB-192	0/5	0	nd	nd	0.145	0.125 – 0.421	ng/kg ww
PCB-193	5/5	100	C180	C180	nc	na	ng/kg ww
PCB-194	5/5	100	266	571	386	na	ng/kg ww

Table E.6.3-17, cont. Summary statistics for slender crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-195	5/5	100	128	239	171	na	ng/kg ww
PCB-196	5/5	100	206	359	257	na	ng/kg ww
PCB-197	5/5	100	61.8 C	123 C	87.6	na	ng/kg ww
PCB-198	5/5	100	408 C	817 C	556	na	ng/kg ww
PCB-199	5/5	100	C198	C198	nc	na	ng/kg ww
PCB-200	5/5	100	C197	C197	nc	na	ng/kg ww
PCB-201	5/5	100	78.5	164	124	na	ng/kg ww
PCB-202	5/5	100	190	346	284	na	ng/kg ww
PCB-203	5/5	100	307	534	400	na	ng/kg ww
PCB-204	5/5	100	0.177 J	0.311 J	0.238	na	ng/kg ww
PCB-205	5/5	100	17.7	30.0	22.6	na	ng/kg ww
PCB-206	5/5	100	41.6	91.5	62.3	na	ng/kg ww
PCB-207	5/5	100	5.64	12.5	8.58	na	ng/kg ww
PCB-208	5/5	100	15.2	41.3	26.5	na	ng/kg ww
PCB-209	5/5	100	4.40 J	17.5	10.3	na	ng/kg ww
Total PCB congeners	5/5	100	129,700 J	186,500 J	161,000	nc	ng/kg ww
Aroclor-1016	0/13	0	nd	nd	7.7	15 – 20	µg/kg ww
Aroclor-1221	0/13	0	nd	nd	14	20 – 29	µg/kg ww
Aroclor-1232	0/13	0	nd	nd	7.7	15 – 20	µg/kg ww
Aroclor-1242	0/13	0	nd	nd	7.7	15 – 20	µg/kg ww
Aroclor-1248	1/13	8	84	84	14	15 – 20	µg/kg ww
Aroclor-1254	13/13	100	38	160 J	100	na	µg/kg ww
Aroclor-1260	13/13	100	26	150	88	na	µg/kg ww
Total PCBs	13/13	100	64	390 J	200	nc	µg/kg ww
PCB TEQ – Bird	5/5	100	14.70 J	28.40	20.8	na	ng/kg ww
PCB TEQ – Fish	5/5	100	0.1630 J	0.2640	0.212	na	ng/kg ww
PCB TEQ – Mammal	5/5	100	1.73 J	2.93	2.31	na	ng/kg ww
Pesticides							
2,4'-DDD	9/12	75	1.6 JN	5.2 JN	2.2	1.5	µg/kg ww
2,4'-DDE	0/12	0	nd	nd	0.87	1.5 – 2.4	µg/kg ww
2,4'-DDT	12/12	100	3.7 JN	14 JN	8.6	na	µg/kg ww
4,4'-DDD	0/12	0	nd	nd	0.81	1.5 – 2.2	µg/kg ww
4,4'-DDE	12/12	100	1.2 JN	4.7 JN	2.6	na	µg/kg ww
4,4'-DDT	12/12	100	3.7 JN	12 JN	7.3	na	µg/kg ww
Total DDTs	12/12	100	10.5 JN	32 JN	21	nc	µg/kg ww
Aldrin	0/12	0	nd	nd	0.75	1.5	µg/kg ww
Dieldrin	1/12	8	1.3 JN	1.3 JN	1.0	1.5 – 3.3	µg/kg ww

Table E.6.3-17, cont. Summary statistics for slender crab, edible meat

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Total aldrin/dieldrin	1/12	8	1.3 JN	1.3 JN	1.0	nc	µg/kg ww
alpha-BHC	0/12	0	nd	nd	0.75	1.5	µg/kg ww
beta-BHC	0/12	0	nd	nd	1.5	1.5 – 8.2	µg/kg ww
gamma-BHC	0/12	0	nd	nd	0.75	1.5	µg/kg ww
delta-BHC	0/12	0	nd	nd	0.75	1.5	µg/kg ww
alpha-Chlordane	2/12	17	1.5 JN	1.8 JN	0.90	1.5	µg/kg ww
gamma-Chlordane	12/12	100	2.0 JN	6.3 JN	3.8	na	µg/kg ww
alpha-Endosulfan	1/12	8	0.34 JN	0.34 JN	0.72	1.5	µg/kg ww
beta-Endosulfan	0/12	0	nd	nd	0.75	1.5	µg/kg ww
Endosulfan sulfate	0/12	0	nd	nd	0.75	1.5	µg/kg ww
Endrin	0/12	0	nd	nd	0.90	1.5 – 5.0	µg/kg ww
Endrin aldehyde	5/12	42	0.83 JN	2.8 JN	1.2	1.5	µg/kg ww
Endrin ketone	0/12	0	nd	nd	0.75	1.5	µg/kg ww
Heptachlor	0/12	0	nd	nd	0.75	1.5	µg/kg ww
Heptachlor epoxide	9/12	75	0.93 JN	3.0 JN	1.8	1.5	µg/kg ww
Methoxychlor	3/12	25	7.7 JN	130 JN	14	1.5	µg/kg ww
Mirex	0/12	0	nd	nd	0.75	1.5	µg/kg ww
Toxaphene	0/12	0	nd	nd	50	72 – 160	µg/kg ww
Total chlordane	12/12	100	2.0 JN	6.3 JN	4.1	nc	µg/kg ww
Conventional parameters							
Total solids	13/13	100	13.5	19.7	17.7	na	% ww
Lipid	13/13	100	0.23	0.74	0.43	na	% ww

Table E.6.3-18. Summary statistics for slender crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	4/4	100	0.0025 J	0.0048 J	0.0031	na	mg/kg ww
Arsenic	4/4	100	2.230	3.310	2.645	na	mg/kg ww
Arsenic (inorganic)	4/4	100	0.080	0.330	0.24	na	mg/kg ww
Cadmium	4/4	100	0.2700	0.8530	0.4835	na	mg/kg ww
Chromium	1/4	25	0.04 J	0.04 J	0.03	0.06 – 0.07	mg/kg ww
Cobalt	4/4	100	0.0531 J	0.0836 J	0.0681	na	mg/kg ww
Copper	4/4	100	12.4	49.9	26.8	na	mg/kg ww
Lead	4/4	100	0.0718	0.2690	0.136	na	mg/kg ww
Mercury	4/4	100	0.020	0.025	0.022	na	mg/kg ww
Molybdenum	4/4	100	0.0599	0.0936	0.0727	na	mg/kg ww
Nickel	4/4	100	0.075 J	0.110	0.088	na	mg/kg ww
Selenium	4/4	100	0.133	0.206	0.172	na	mg/kg ww
Silver	4/4	100	0.1120	0.4060	0.2268	na	mg/kg ww
Thallium	4/4	100	0.0004 J	0.0008 J	0.0006	na	mg/kg ww
Vanadium	3/4	75	0.11 J	0.14	0.11	0.13	mg/kg ww
Zinc	4/4	100	24.4	33.6	27.9	na	mg/kg ww
Organometals							
Monobutyltin as ion	4/4	100	1.3 J	1.5	1.4	na	µg/kg ww
Dibutyltin as ion	4/4	100	0.85 J	1.4 J	1.2	na	µg/kg ww
Tributyltin as ion	2/4	50	0.50 J	0.55 J	0.64	1.5	µg/kg ww
Tetrabutyltin as ion	0/4	0	nd	nd	0.75	1.5	µg/kg ww
PAHs							
2-Chloronaphthalene	0/4	0	nd	nd	290	570 – 580	µg/kg ww
2-Methylnaphthalene	2/4	50	0.94 J	0.97 J	0.68	0.81	µg/kg ww
Acenaphthene	4/4	100	0.44 J	0.67 J	0.54	na	µg/kg ww
Acenaphthylene	1/4	25	0.61 J	0.61 J	0.42	0.72	µg/kg ww
Anthracene	4/4	100	0.53 J	1.2	0.77	na	µg/kg ww
Benzo(a)anthracene	4/4	100	0.63 J	0.85	0.76	na	µg/kg ww
Benzo(a)pyrene	0/4	0	nd	nd	0.36	0.72	µg/kg ww
Benzo(b)fluoranthene	0/4	0	nd	nd	0.36	0.72	µg/kg ww
Benzo(g,h,i)perylene	0/4	0	nd	nd	0.36	0.72	µg/kg ww
Benzo(k)fluoranthene	0/4	0	nd	nd	0.36	0.72	µg/kg ww
Total benzofluoranthenes	0/4	0	nd	nd	0.36	nc	µg/kg ww
Chrysene	4/4	100	0.64 J	1.0	0.77	na	µg/kg ww

Table E.6.3-18, cont. Summary statistics for slender crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Dibenzo(a,h)anthracene	0/4	0	nd	nd	0.36	0.72	µg/kg ww
Dibenzofuran	4/4	100	0.32 J	0.51 J	0.43	na	µg/kg ww
Fluoranthene	4/4	100	1.4	1.9	1.7	na	µg/kg ww
Fluorene	4/4	100	0.37 J	0.49 J	0.45	na	µg/kg ww
Indeno(1,2,3-cd)pyrene	0/4	0	nd	nd	0.36	0.72	µg/kg ww
Naphthalene	0/4	0	nd	nd	1.4	2.2 – 3.5	µg/kg ww
Phenanthrene	4/4	100	1.4	1.6	1.5	na	µg/kg ww
Pyrene	4/4	100	0.69 J	1.1	0.86	na	µg/kg ww
Total HPAH	4/4	100	3.5 J	4.8	4.1	nc	µg/kg ww
Total LPAH	4/4	100	2.7 J	4.4 J	3.4	nc	µg/kg ww
Carcinogenic PAHs – Mammal	4/4	100	0.68 J	0.71	0.70	na	µg/kg ww
Total PAH	4/4	100	6.3 J	9.2 J	7.5	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	1/4	25	100 J	100 J	70	66 – 230	µg/kg ww
Butyl benzyl phthalate	3/4	75	1,700	1,800	1,400	570	µg/kg ww
Diethyl phthalate	3/4	75	160 J	200 J	290	1,200	µg/kg ww
Dimethyl phthalate	1/4	25	76 J	76 J	230	570 – 580	µg/kg ww
Di-n-butyl phthalate	0/4	0	nd	nd	290	570 – 580	µg/kg ww
Di-n-octyl phthalate	0/4	0	nd	nd	1,200	570 – 2,900	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/4	0	nd	nd	290	570 – 580	µg/kg ww
1,2-Dichlorobenzene	0/4	0	nd	nd	290	570 – 580	µg/kg ww
1,3-Dichlorobenzene	0/4	0	nd	nd	290	570 – 580	µg/kg ww
1,4-Dichlorobenzene	0/4	0	nd	nd	290	570 – 580	µg/kg ww
2,4,5-Trichlorophenol	0/4	0	nd	nd	1,200	1,200 – 2,900	µg/kg ww
2,4,6-Trichlorophenol	0/4	0	nd	nd	1,200	1,200 – 2,900	µg/kg ww
2,4-Dichlorophenol	0/4	0	nd	nd	600	1,200	µg/kg ww
2,4-Dimethylphenol	0/4	0	nd	nd	600	1,200	µg/kg ww
2,4-Dinitrophenol	0/4	0	nd	nd	6,000	12,000	µg/kg ww
2,4-Dinitrotoluene	0/4	0	nd	nd	1,200	1,200 – 2,900	µg/kg ww
2,6-Dinitrotoluene	0/4	0	nd	nd	1,200	570 – 2,900	µg/kg ww
2-Chlorophenol	0/4	0	nd	nd	600	1,200	µg/kg ww
2-Methylphenol	0/4	0	nd	nd	600	1,200	µg/kg ww
2-Nitroaniline	0/4	0	nd	nd	1,500	2,900	µg/kg ww
2-Nitrophenol	0/4	0	nd	nd	1,200	570 – 2,900	µg/kg ww
3,3'-Dichlorobenzidine	0/4	0	nd	nd	15,000	29,000	µg/kg ww
3-Nitroaniline	0/4	0	nd	nd	2,900	5,700 – 5,800	µg/kg ww

Table E.6.3-18, cont. Summary statistics for slender crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
4,6-Dinitro-o-cresol	0/4	0	nd	nd	2,900	5,700 – 5,800	µg/kg ww
4-Bromophenyl phenyl ether	0/4	0	nd	nd	290	570 – 580	µg/kg ww
4-Chloro-3-methylphenol	0/4	0	nd	nd	1,500	2,900	µg/kg ww
4-Chloroaniline	0/4	0	nd	nd	1,500	2,900	µg/kg ww
4-Chlorophenyl phenyl ether	0/4	0	nd	nd	290	570 – 580	µg/kg ww
4-Methylphenol	0/4	0	nd	nd	600	1,200	µg/kg ww
4-Nitroaniline	0/4	0	nd	nd	2,500	2,900 – 5,800	µg/kg ww
4-Nitrophenol	0/4	0	nd	nd	2,900	5,700 – 5,800	µg/kg ww
Aniline	0/4	0	nd	nd	6,000	12,000	µg/kg ww
Benzidine	0/4	0	nd	nd	36,000	72,000	µg/kg ww
Benzoic acid	0/4	0	nd	nd	6,000	12,000	µg/kg ww
Benzyl alcohol	0/4	0	nd	nd	520	570 – 1,200	µg/kg ww
bis(2-chloroethoxy)methane	0/4	0	nd	nd	1,200	570 – 2,900	µg/kg ww
bis(2-chloroethyl)ether	0/4	0	nd	nd	520	570 – 1,200	µg/kg ww
bis(2-chloroisopropyl)ether	0/4	0	nd	nd	290	570 – 580	µg/kg ww
Carbazole	0/4	0	nd	nd	1,500	2,900	µg/kg ww
Hexachlorobenzene	0/4	0	nd	nd	0.75	1.5	µg/kg ww
Hexachlorobutadiene	0/4	0	nd	nd	290	570 – 580	µg/kg ww
Hexachlorocyclopentadiene	0/4	0	nd	nd	36,000	72,000	µg/kg ww
Hexachloroethane	0/4	0	nd	nd	290	570 – 580	µg/kg ww
Isophorone	0/4	0	nd	nd	290	570 – 580	µg/kg ww
Nitrobenzene	0/4	0	nd	nd	290	570 – 580	µg/kg ww
N-Nitrosodimethylamine	0/4	0	nd	nd	4,900	2,900 – 12,000	µg/kg ww
N-Nitroso-di-n-propylamine	0/4	0	nd	nd	290	570 – 580	µg/kg ww
N-Nitrosodiphenylamine	0/4	0	nd	nd	290	570 – 580	µg/kg ww
Pentachlorophenol	0/4	0	nd	nd	2.8	3.3 – 11	µg/kg ww
Phenol	0/4	0	nd	nd	750	1,500	µg/kg ww
Polychlorinated biphenyls							
PCB-001	0/2	0	nd	nd	2.59	4.58 – 5.76	ng/kg ww
PCB-002	0/2	0	nd	nd	1.88	3.24 – 4.29	ng/kg ww
PCB-003	0/2	0	nd	nd	3.69	7.36 – 7.38	ng/kg ww
PCB-004	2/2	100	29.3 J	65.2	47.3	na	ng/kg ww
PCB-005	0/2	0	nd	nd	3.43	5.72 – 8.01	ng/kg ww
PCB-006	1/2	50	13.9 J	13.9 J	8.96	8.05	ng/kg ww
PCB-007	0/2	0	nd	nd	3.41	5.69 – 7.96	ng/kg ww
PCB-008	2/2	100	8.47 J	14.7 J	11.6	na	ng/kg ww

Table E.6.3-18, cont. Summary statistics for slender crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-009	0/2	0	nd	nd	3.38	5.63 – 7.87	ng/kg ww
PCB-010	0/2	0	nd	nd	3.51	5.84 – 8.18	ng/kg ww
PCB-011	2/2	100	9.74 J	10.8 J	10.3	na	ng/kg ww
PCB-012	0/2	0	nd	nd	3.61	6.02 – 8.42	ng/kg ww
PCB-013	0/2	0	nd	nd	C12	0	ng/kg ww
PCB-014	0/2	0	nd	nd	3.45	5.75 – 8.04	ng/kg ww
PCB-015	2/2	100	880	913	897	na	ng/kg ww
PCB-016	2/2	100	62.3	236	149	na	ng/kg ww
PCB-017	2/2	100	165	568	367	na	ng/kg ww
PCB-018	2/2	100	1,080 C	2,670 C	1,880	na	ng/kg ww
PCB-019	2/2	100	9.78 J	44.7	27.2	na	ng/kg ww
PCB-020	2/2	100	10,500 C	12,700 C	11,600	na	ng/kg ww
PCB-021	0/2	0	nd	nd	2.06	3.07 – 5.16	ng/kg ww
PCB-022	2/2	100	698	1,390	1,040	na	ng/kg ww
PCB-023	0/2	0	nd	nd	2.07	3.09 – 5.19	ng/kg ww
PCB-024	0/2	0	nd	nd	0.388	0.685 – 0.866	ng/kg ww
PCB-025	2/2	100	86.0	289	188	na	ng/kg ww
PCB-026	2/2	100	716 C	1,900 C	1,310	na	ng/kg ww
PCB-027	2/2	100	17.1 J	80.2	48.7	na	ng/kg ww
PCB-028	2/2	100	C20	C20	nc	na	ng/kg ww
PCB-029	2/2	100	C26	C26	nc	na	ng/kg ww
PCB-030	2/2	100	C18	C18	nc	na	ng/kg ww
PCB-031	2/2	100	2,130	5,290	3,710	na	ng/kg ww
PCB-032	2/2	100	117	490	304	na	ng/kg ww
PCB-033	0/2	0	nd	nd	C21	0	ng/kg ww
PCB-034	2/2	100	3.14 J	10.6 J	6.87	na	ng/kg ww
PCB-035	0/2	0	nd	nd	2.35	3.50 – 5.89	ng/kg ww
PCB-036	0/2	0	nd	nd	2.22	3.31 – 5.56	ng/kg ww
PCB-037	2/2	100	3,260	3,530	3,400	na	ng/kg ww
PCB-038	0/2	0	nd	nd	1.99	2.97 – 4.99	ng/kg ww
PCB-039	2/2	100	11.3 J	15.0 J	13.2	na	ng/kg ww
PCB-040	2/2	100	879 C	2,520 C	1,700	na	ng/kg ww
PCB-041	2/2	100	C40	C40	nc	na	ng/kg ww
PCB-042	2/2	100	1,570	3,150	2,360	na	ng/kg ww
PCB-043	2/2	100	543	873	708	na	ng/kg ww
PCB-044	2/2	100	9,300 C	15,300 C	12,300	na	ng/kg ww
PCB-045	2/2	100	85.2 C	456 C	271	na	ng/kg ww

Table E.6.3-18, cont. Summary statistics for slender crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-046	2/2	100	31.9 J	122	77.0	na	ng/kg ww
PCB-047	2/2	100	C44	C44	nc	na	ng/kg ww
PCB-048	2/2	100	556	1,700	1,130	na	ng/kg ww
PCB-049	2/2	100	10,300 C	17,400 C	13,900	na	ng/kg ww
PCB-050	2/2	100	150 C	656 C	403	na	ng/kg ww
PCB-051	2/2	100	C45	C45	nc	na	ng/kg ww
PCB-052	2/2	100	22,100	33,900	28,000	na	ng/kg ww
PCB-053	2/2	100	C50	C50	nc	na	ng/kg ww
PCB-054	1/2	50	1.87 J	1.87 J	1.49	2.21	ng/kg ww
PCB-055	0/2	0	nd	nd	19.4	5.63 – 71.9	ng/kg ww
PCB-056	2/2	100	2,680	4,430	3,560	na	ng/kg ww
PCB-057	2/2	100	55.9	111	83.5	na	ng/kg ww
PCB-058	2/2	100	89.0	106	97.5	na	ng/kg ww
PCB-059	2/2	100	549 C	1,180 C	865	na	ng/kg ww
PCB-060	2/2	100	5,010	5,530	5,270	na	ng/kg ww
PCB-061	2/2	100	17,900 C	27,300 C	22,600	na	ng/kg ww
PCB-062	2/2	100	C59	C59	nc	na	ng/kg ww
PCB-063	2/2	100	832	1,170	1,000	na	ng/kg ww
PCB-064	2/2	100	3,440	5,450	4,450	na	ng/kg ww
PCB-065	2/2	100	C44	C44	nc	na	ng/kg ww
PCB-066	2/2	100	21,600	25,400	23,500	na	ng/kg ww
PCB-067	2/2	100	148	322	235	na	ng/kg ww
PCB-068	2/2	100	128	235	182	na	ng/kg ww
PCB-069	2/2	100	C49	C49	nc	na	ng/kg ww
PCB-070	2/2	100	C61	C61	nc	na	ng/kg ww
PCB-071	2/2	100	C40	C40	nc	na	ng/kg ww
PCB-072	2/2	100	256	525	391	na	ng/kg ww
PCB-073	2/2	100	293	373	333	na	ng/kg ww
PCB-074	2/2	100	C61	C61	nc	na	ng/kg ww
PCB-075	2/2	100	C59	C59	nc	na	ng/kg ww
PCB-076	2/2	100	C61	C61	nc	na	ng/kg ww
PCB-077	2/2	100	1,840	2,250	2,050	na	ng/kg ww
PCB-078	0/2	0	nd	nd	19.6	5.69 – 72.7	ng/kg ww
PCB-079	2/2	100	365	500	433	na	ng/kg ww
PCB-080	0/2	0	nd	nd	18.1	5.24 – 67.0	ng/kg ww
PCB-081	2/2	100	94.4	123	109	na	ng/kg ww
PCB-082	2/2	100	1,620	2,500	2,060	na	ng/kg ww

Table E.6.3-18, cont. Summary statistics for slender crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-083	2/2	100	24,600 C	35,700 C	30,200	na	ng/kg ww
PCB-084	2/2	100	2,070	4,080	3,080	na	ng/kg ww
PCB-085	2/2	100	6,870 C	9,070 C	7,970	na	ng/kg ww
PCB-086	2/2	100	18,900 C	27,400 C	23,200	na	ng/kg ww
PCB-087	2/2	100	C86	C86	nc	na	ng/kg ww
PCB-088	2/2	100	3,200 C	5,150 C	4,180	na	ng/kg ww
PCB-089	1/2	50	52.3	52.3	32.7	26.0	ng/kg ww
PCB-090	2/2	100	55,900 C	83,600 C	69,800	na	ng/kg ww
PCB-091	2/2	100	C88	C88	nc	na	ng/kg ww
PCB-092	2/2	100	10,800	14,900	12,900	na	ng/kg ww
PCB-093	2/2	100	18,200 C	29,700 C	24,000	na	ng/kg ww
PCB-094	2/2	100	31.3 J	99.2	65.3	na	ng/kg ww
PCB-095	2/2	100	C93	C93	nc	na	ng/kg ww
PCB-096	1/2	50	59.1	59.1	33.1	14.0	ng/kg ww
PCB-097	2/2	100	C86	C86	nc	na	ng/kg ww
PCB-098	2/2	100	C93	C93	nc	na	ng/kg ww
PCB-099	2/2	100	C83	C83	nc	na	ng/kg ww
PCB-100	2/2	100	C93	C93	nc	na	ng/kg ww
PCB-101	2/2	100	C90	C90	nc	na	ng/kg ww
PCB-102	2/2	100	C93	C93	nc	na	ng/kg ww
PCB-103	2/2	100	410	679	545	na	ng/kg ww
PCB-104	0/2	0	nd	nd	4.72	3.88 – 15.0	ng/kg ww
PCB-105	2/2	100	18,900	21,300	20,100	na	ng/kg ww
PCB-106	0/2	0	nd	nd	16.7	29.8 – 37.0	ng/kg ww
PCB-107	2/2	100	1,430 C	2,510 C	1,970	na	ng/kg ww
PCB-108	2/2	100	C86	C86	nc	na	ng/kg ww
PCB-109	2/2	100	2,650	4,030	3,340	na	ng/kg ww
PCB-110	2/2	100	15,000 C	26,700 C	20,900	na	ng/kg ww
PCB-111	2/2	100	24.1 J	25.9 J	25.0	na	ng/kg ww
PCB-112	0/2	0	nd	nd	7.48	12.3 – 17.6	ng/kg ww
PCB-113	2/2	100	C90	C90	nc	na	ng/kg ww
PCB-114	2/2	100	1,110	1,250	1,180	na	ng/kg ww
PCB-115	2/2	100	C110	C110	nc	na	ng/kg ww
PCB-116	2/2	100	C85	C85	nc	na	ng/kg ww
PCB-117	2/2	100	C85	C85	nc	na	ng/kg ww
PCB-118	2/2	100	50,700	62,100	56,400	na	ng/kg ww
PCB-119	2/2	100	C86	C86	nc	na	ng/kg ww

Table E.6.3-18, cont. Summary statistics for slender crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-120	2/2	100	81.0	152	117	na	ng/kg ww
PCB-121	0/2	0	nd	nd	7.85	12.9 – 18.5	ng/kg ww
PCB-122	2/2	100	409	474	442	na	ng/kg ww
PCB-123	2/2	100	964	1,110	1,040	na	ng/kg ww
PCB-124	2/2	100	C107	C107	nc	na	ng/kg ww
PCB-125	2/2	100	C86	C86	nc	na	ng/kg ww
PCB-126	2/2	100	94.0	142	118	na	ng/kg ww
PCB-127	2/2	100	152	197	175	na	ng/kg ww
PCB-128	2/2	100	10,400 C	11,700 C	11,100	na	ng/kg ww
PCB-129	2/2	100	79,800 C	94,600 C	87,200	na	ng/kg ww
PCB-130	2/2	100	3,760	4,680	4,220	na	ng/kg ww
PCB-131	2/2	100	331	539	435	na	ng/kg ww
PCB-132	2/2	100	7,230	10,200	8,720	na	ng/kg ww
PCB-133	2/2	100	1,500	1,900	1,700	na	ng/kg ww
PCB-134	2/2	100	1,640 C	2,540 C	2,090	na	ng/kg ww
PCB-135	2/2	100	18,200 C	26,400 C	22,300	na	ng/kg ww
PCB-136	2/2	100	1,650	3,340	2,500	na	ng/kg ww
PCB-137	2/2	100	2,690	3,190	2,940	na	ng/kg ww
PCB-138	2/2	100	C129	C129	nc	na	ng/kg ww
PCB-139	2/2	100	792 C	1,350 C	1,070	na	ng/kg ww
PCB-140	2/2	100	C139	C139	nc	na	ng/kg ww
PCB-141	2/2	100	10,500	11,700	11,100	na	ng/kg ww
PCB-142	0/2	0	nd	nd	29.0	27.9 – 88.2	ng/kg ww
PCB-143	2/2	100	C134	C134	nc	na	ng/kg ww
PCB-144	2/2	100	1,820	2,780	2,300	na	ng/kg ww
PCB-145	2/2	100	3.40 J	11.4 J	7.40	na	ng/kg ww
PCB-146	2/2	100	12,600	16,400	14,500	na	ng/kg ww
PCB-147	2/2	100	47,600 C	64,300 C	56,000	na	ng/kg ww
PCB-148	2/2	100	69.8	153	111	na	ng/kg ww
PCB-149	2/2	100	C147	C147	nc	na	ng/kg ww
PCB-150	2/2	100	94.4	150	122	na	ng/kg ww
PCB-151	2/2	100	C135	C135	nc	na	ng/kg ww
PCB-152	2/2	100	8.58 J	23.1 J	15.8	na	ng/kg ww
PCB-153	2/2	100	77,500 C	99,200 C	88,400	na	ng/kg ww
PCB-154	2/2	100	C135	C135	nc	na	ng/kg ww
PCB-155	2/2	100	11.6 J	13.0 J	12.3	na	ng/kg ww
PCB-156	2/2	100	8,330 C	9,880 C	9,110	na	ng/kg ww

Table E.6.3-18, cont. Summary statistics for slender crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-157	2/2	100	C156	C156	nc	na	ng/kg ww
PCB-158	2/2	100	4,380	6,680	5,530	na	ng/kg ww
PCB-159	2/2	100	392	399	396	na	ng/kg ww
PCB-160	2/2	100	C129	C129	nc	na	ng/kg ww
PCB-161	0/2	0	nd	nd	19.2	18.5 – 58.3	ng/kg ww
PCB-162	2/2	100	173	232	203	na	ng/kg ww
PCB-163	2/2	100	C129	C129	nc	na	ng/kg ww
PCB-164	2/2	100	3,160	4,060	3,610	na	ng/kg ww
PCB-165	1/2	50	59.4	59.4	44.3	58.3	ng/kg ww
PCB-166	2/2	100	C128	C128	nc	na	ng/kg ww
PCB-167	2/2	100	3,500	4,000	3,750	na	ng/kg ww
PCB-168	2/2	100	C153	C153	nc	na	ng/kg ww
PCB-169	1/2	50	4.29	4.29	3.05	3.60	ng/kg ww
PCB-170	2/2	100	9,870	10,300	10,100	na	ng/kg ww
PCB-171	2/2	100	4,220 C	4,820 C	4,520	na	ng/kg ww
PCB-172	2/2	100	2,020	2,120	2,070	na	ng/kg ww
PCB-173	2/2	100	C171	C171	nc	na	ng/kg ww
PCB-174	2/2	100	7,230	7,710	7,470	na	ng/kg ww
PCB-175	2/2	100	433	602	518	na	ng/kg ww
PCB-176	2/2	100	1,300	1,790	1,550	na	ng/kg ww
PCB-177	2/2	100	10,200	10,700	10,500	na	ng/kg ww
PCB-178	2/2	100	4,140	5,130	4,640	na	ng/kg ww
PCB-179	2/2	100	4,700	5,860	5,280	na	ng/kg ww
PCB-180	2/2	100	33,700 C	38,200 C	36,000	na	ng/kg ww
PCB-181	2/2	100	103	116	110	na	ng/kg ww
PCB-182	2/2	100	165	186	176	na	ng/kg ww
PCB-183	2/2	100	10,600 C	13,900 C	12,300	na	ng/kg ww
PCB-184	2/2	100	10.8 J	13.2 J	12.0	na	ng/kg ww
PCB-185	2/2	100	C183	C183	nc	na	ng/kg ww
PCB-186	0/2	0	nd	nd	0.794	0.994 – 2.18	ng/kg ww
PCB-187	2/2	100	26,000	32,000	29,000	na	ng/kg ww
PCB-188	2/2	100	44.6	45.7	45.2	na	ng/kg ww
PCB-189	2/2	100	499	508	504	na	ng/kg ww
PCB-190	2/2	100	3,330	3,890	3,610	na	ng/kg ww
PCB-191	2/2	100	612	760	686	na	ng/kg ww
PCB-192	0/2	0	nd	nd	1.02	1.28 – 2.81	ng/kg ww
PCB-193	2/2	100	C180	C180	nc	na	ng/kg ww

Table E.6.3-18, cont. Summary statistics for slender crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-194	2/2	100	2,760	3,230	3,000	na	ng/kg ww
PCB-195	2/2	100	1,050	1,160	1,110	na	ng/kg ww
PCB-196	2/2	100	1,510	1,640	1,580	na	ng/kg ww
PCB-197	2/2	100	491 C	530 C	511	na	ng/kg ww
PCB-198	2/2	100	3,290 C	3,560 C	3,430	na	ng/kg ww
PCB-199	2/2	100	C198	C198	nc	na	ng/kg ww
PCB-200	2/2	100	C197	C197	nc	na	ng/kg ww
PCB-201	2/2	100	589	712	651	na	ng/kg ww
PCB-202	2/2	100	1,680	1,740	1,710	na	ng/kg ww
PCB-203	2/2	100	2,720	3,050	2,890	na	ng/kg ww
PCB-204	1/2	50	1.89 J	1.89 J	1.16	0.855	ng/kg ww
PCB-205	2/2	100	137	189	163	na	ng/kg ww
PCB-206	2/2	100	395	571	483	na	ng/kg ww
PCB-207	2/2	100	53.9	69.2	61.6	na	ng/kg ww
PCB-208	2/2	100	128	251	190	na	ng/kg ww
PCB-209	2/2	100	48.9	118	83.5	na	ng/kg ww
Total PCB congeners	2/2	100	790,100 J	1,047,000 J	919,000	nc	ng/kg ww
Aroclor-1016	0/5	0	nd	nd	16	15 – 100	µg/kg ww
Aroclor-1221	0/5	0	nd	nd	22	29 – 100	µg/kg ww
Aroclor-1232	0/5	0	nd	nd	16	15 – 100	µg/kg ww
Aroclor-1242	0/5	0	nd	nd	16	15 – 100	µg/kg ww
Aroclor-1248	4/5	80	270	420 J	270	100	µg/kg ww
Aroclor-1254	5/5	100	410	950 J	700	na	µg/kg ww
Aroclor-1260	5/5	100	250	820	620	na	µg/kg ww
Total PCBs	5/5	100	660	2,190 J	1,600	nc	µg/kg ww
PCB TEQ – Bird	2/2	100	115.0	142.0	129	na	ng/kg ww
PCB TEQ – Fish	2/2	100	1.200	1.420	1.31	na	ng/kg ww
PCB TEQ – Mammal	2/2	100	12.70	17.1	14.9	na	ng/kg ww
Pesticides							
2,4'-DDD	1/4	25	15 JN	15 JN	6.4	4.6 – 8.9	µg/kg ww
2,4'-DDE	0/4	0	nd	nd	1.7	1.5 – 7.2	µg/kg ww
2,4'-DDT	4/4	100	53 JN	89 JN	71	na	µg/kg ww
4,4'-DDD	1/4	25	1.6 JN	1.6 JN	1.2	1.5 – 3.3	µg/kg ww
4,4'-DDE	4/4	100	16 JN	24 JN	21	na	µg/kg ww
4,4'-DDT	4/4	100	45 JN	68 JN	58	na	µg/kg ww
Total DDTs	4/4	100	119 JN	181 JN	154	nc	µg/kg ww

Table E.6.3-18, cont. Summary statistics for slender crab, hepatopancreas

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Aldrin	0/4	0	nd	nd	0.75	1.5	µg/kg ww
Dieldrin	0/4	0	nd	nd	3.9	7.2 – 9.1	µg/kg ww
Total aldrin/dieldrin	0/4	0	nd	nd	3.9	nc	µg/kg ww
alpha-BHC	1/4	25	0.41 JN	0.41 JN	0.67	1.5	µg/kg ww
beta-BHC	0/4	0	nd	nd	0.83	1.5 – 2.1	µg/kg ww
gamma-BHC	0/4	0	nd	nd	0.75	1.5	µg/kg ww
delta-BHC	0/4	0	nd	nd	0.79	1.5 – 1.8	µg/kg ww
alpha-Chlordane	0/4	0	nd	nd	0.75	1.5	µg/kg ww
gamma-Chlordane	4/4	100	23 JN	36 JN	30	na	µg/kg ww
alpha-Endosulfan	1/4	25	3.4 JN	3.4 JN	1.4	1.5	µg/kg ww
beta-Endosulfan	0/4	0	nd	nd	1.3	2.0 – 3.6	µg/kg ww
Endosulfan sulfate	0/4	0	nd	nd	1.5	1.5 – 7.2	µg/kg ww
Endrin	0/4	0	nd	nd	1.5	1.5 – 7.2	µg/kg ww
Endrin aldehyde	0/4	0	nd	nd	2.4	1.9 – 8.4	µg/kg ww
Endrin ketone	0/4	0	nd	nd	1.3	2.5 – 2.8	µg/kg ww
Heptachlor	0/4	0	nd	nd	0.75	1.5	µg/kg ww
Heptachlor epoxide	0/4	0	nd	nd	2.3	3.1 – 6.1	µg/kg ww
Methoxychlor	0/4	0	nd	nd	0.85	1.5 – 2.1	µg/kg ww
Mirex	0/4	0	nd	nd	0.75	1.5	µg/kg ww
Toxaphene	0/4	0	nd	nd	170	290 – 360	µg/kg ww
Total chlordane	4/4	100	23 JN	36 JN	30	nc	µg/kg ww
Conventional parameters							
Total solids	5/5	100	11.4	14.76	13.1	na	% ww
Lipid	5/5	100	1.9	3.6	2.6	na	% ww

Table E.6.3-19. Summary statistics for slender crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	12/12	100	0.0014 JM	0.0068 JM	0.0027	na	mg/kg ww
Arsenic	12/12	100	1.844 M	3.489 M	2.622	na	mg/kg ww
Arsenic (inorganic)	4/4	100	0.046 M	0.123 M	0.098	na	mg/kg ww
Cadmium	12/12	100	0.0954 M	0.2951 M	0.1699	na	mg/kg ww
Chromium	3/12	25	0.07 JM	0.08 JM	0.03	0.03 – 0.05	mg/kg ww
Cobalt	12/12	100	0.0241 JM	0.0376 JM	0.0302	na	mg/kg ww
Copper	12/12	100	6.9 M	20.5 M	12.6	na	mg/kg ww
Lead	12/12	100	0.0313 M	0.1181 M	0.0610	na	mg/kg ww
Mercury	12/12	100	0.022 M	0.049 M	0.039	na	mg/kg ww
Molybdenum	12/12	100	0.0276 M	0.0399 M	0.0329	na	mg/kg ww
Nickel	12/12	100	0.052 JM	0.079 M	0.062	na	mg/kg ww
Selenium	12/12	100	0.152 M	0.245 M	0.198	na	mg/kg ww
Silver	12/12	100	0.0706 M	0.1743 M	0.1091	na	mg/kg ww
Thallium	12/12	100	0.0020 JM	0.0030 JM	0.003	na	mg/kg ww
Vanadium	9/12	75	0.13 M	0.17 M	0.13	0.08 – 0.09	mg/kg ww
Zinc	12/12	100	25.6 M	37.3 M	32.4	na	mg/kg ww
Organometals							
Monobutyltin as ion	12/12	100	1.4 JM	1.5 JM	1.5	na	µg/kg ww
Dibutyltin as ion	12/12	100	1.30 JM	1.5 JM	1.4	na	µg/kg ww
Tributyltin as ion	6/12	50	1.20 JM	1.20 JM	0.79	0.8	µg/kg ww
Tetrabutyltin as ion	0/12	0	nd	nd	0.38	0.8	µg/kg ww
PAHs							
2-Chloronaphthalene	0/12	0	nd	nd	120	110 – 290	µg/kg ww
2-Methylnaphthalene	6/12	50	0.55 JM	0.65 JM	0.37	0.24 – 0.30	µg/kg ww
Acenaphthene	12/12	100	0.23 JM	0.70 JM	0.50	na	µg/kg ww
Acenaphthylene	4/12	33	0.31 JM	0.69 JM	0.32	0.36	µg/kg ww
Anthracene	12/12	100	0.25 JM	0.9 M	0.46	na	µg/kg ww
Benzo(a)anthracene	12/12	100	0.28 JM	0.76 M	0.66	na	µg/kg ww
Benzo(a)pyrene	1/12	8	0.35 M	0.35 M	0.19	0.36	µg/kg ww
Benzo(b)fluoranthene	1/12	8	0.34 M	0.34 M	0.19	0.36	µg/kg ww
Benzo(g,h,i)perylene	1/12	8	0.38 M	0.38 M	0.20	0.36	µg/kg ww
Benzo(k)fluoranthene	1/12	8	0.33 M	0.33 M	0.19	0.36	µg/kg ww
Total benzofluoranthenes	1/12	8	0.45 M	0.45 M	0.20	nc	µg/kg ww
Chrysene	12/12	100	0.34 JM	0.8 M	0.67	na	µg/kg ww

Table E.6.3-19, cont. Summary statistics for slender crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Dibenzo(a,h)anthracene	1/12	8	0.36 M	0.36 M	0.20	0.36	µg/kg ww
Dibenzofuran	12/12	100	0.18 JM	0.30 JM	0.23	na	µg/kg ww
Fluoranthene	12/12	100	0.7 JM	1.0 JM	0.88	na	µg/kg ww
Fluorene	12/12	100	0.19 JM	0.32 JM	0.24	na	µg/kg ww
Indeno(1,2,3-cd)pyrene	1/12	8	0.38 M	0.38 M	0.20	0.36	µg/kg ww
Naphthalene	1/12	8	1.9 M	1.9 M	0.63	0.8 – 1.3	µg/kg ww
Phenanthrene	12/12	100	0.7 M	0.9 JM	0.76	na	µg/kg ww
Pyrene	12/12	100	0.36 JM	0.51 JM	0.44	na	µg/kg ww
Total HPAH	12/12	100	1.6 JM	2.9 JM	1.9	nc	µg/kg ww
Total LPAH	12/12	100	0.9 JM	3.0 JM	1.4	nc	µg/kg ww
Carcinogenic PAHs – Mammal	12/12	100	0.45 M	0.67 M	0.65	na	µg/kg ww
Total PAH	12/12	100	2.5 JM	6.0 JM	3.3	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	3/12	25	100 JM	100 JM	40	33 – 100	µg/kg ww
Butyl benzyl phthalate	9/12	75	900 M	1,400 M	950	130	µg/kg ww
Diethyl phthalate	10/12	83	150 JM	890 JM	480	200	µg/kg ww
Dimethyl phthalate	4/12	33	180 JM	420 JM	200	110 – 290	µg/kg ww
Di-n-butyl phthalate	0/12	0	nd	nd	110	100 – 290	µg/kg ww
Di-n-octyl phthalate	0/12	0	nd	nd	480	190 – 1,500	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/12	0	nd	nd	120	110 – 290	µg/kg ww
1,2-Dichlorobenzene	0/12	0	nd	nd	120	110 – 290	µg/kg ww
1,3-Dichlorobenzene	0/12	0	nd	nd	120	110 – 290	µg/kg ww
1,4-Dichlorobenzene	0/12	0	nd	nd	120	110 – 290	µg/kg ww
2,4,5-Trichlorophenol	0/12	0	nd	nd	520	300 – 1,500	µg/kg ww
2,4,6-Trichlorophenol	0/12	0	nd	nd	520	300 – 1,500	µg/kg ww
2,4-Dichlorophenol	0/12	0	nd	nd	250	200 – 600	µg/kg ww
2,4-Dimethylphenol	0/12	0	nd	nd	250	200 – 600	µg/kg ww
2,4-Dinitrophenol	0/12	0	nd	nd	2,500	2,000 – 6,000	µg/kg ww
2,4-Dinitrotoluene	0/12	0	nd	nd	490	300 – 1,500	µg/kg ww
2,6-Dinitrotoluene	0/12	0	nd	nd	450	190 – 1,500	µg/kg ww
2-Chlorophenol	0/12	0	nd	nd	250	200 – 600	µg/kg ww
2-Methylphenol	0/12	0	nd	nd	250	200 – 600	µg/kg ww
2-Nitroaniline	0/12	0	nd	nd	630	600 – 1,500	µg/kg ww
2-Nitrophenol	0/12	0	nd	nd	480	190 – 1,500	µg/kg ww
3,3'-Dichlorobenzidine	0/12	0	nd	nd	6,300	6,000 – 15,000	µg/kg ww
3-Nitroaniline	0/12	0	nd	nd	1,200	1,100 – 2,900	µg/kg ww

Table E.6.3-19, cont. Summary statistics for slender crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
4,6-Dinitro-o-cresol	0/12	0	nd	nd	1,200	1,100 – 2,900	µg/kg ww
4-Bromophenyl phenyl ether	0/12	0	nd	nd	120	110 – 290	µg/kg ww
4-Chloro-3-methylphenol	0/12	0	nd	nd	630	600 – 1,500	µg/kg ww
4-Chloroaniline	0/12	0	nd	nd	630	600 – 1,500	µg/kg ww
4-Chlorophenyl phenyl ether	0/12	0	nd	nd	120	110 – 290	µg/kg ww
4-Methylphenol	0/12	0	nd	nd	250	200 – 600	µg/kg ww
4-Nitroaniline	0/12	0	nd	nd	1,000	700 – 2,900	µg/kg ww
4-Nitrophenol	0/12	0	nd	nd	1,200	1,100 – 2,900	µg/kg ww
Aniline	0/12	0	nd	nd	2,500	2,000 – 6,000	µg/kg ww
Benzidine	0/12	0	nd	nd	15,000	14,000 – 36,000	µg/kg ww
Benzoic acid	0/12	0	nd	nd	2,500	2,000 – 6,000	µg/kg ww
Benzyl alcohol	1/12	8	180 JM	180 JM	220	130 – 600	µg/kg ww
bis(2-chloroethoxy)methane	0/12	0	nd	nd	440	190 – 1,500	µg/kg ww
bis(2-chloroethyl)ether	0/12	0	nd	nd	210	130 – 600	µg/kg ww
bis(2-chloroisopropyl)ether	0/12	0	nd	nd	120	110 – 290	µg/kg ww
Carbazole	0/12	0	nd	nd	630	600 – 1,500	µg/kg ww
Hexachlorobenzene	0/12	0	nd	nd	0.38	0.8	µg/kg ww
Hexachlorobutadiene	0/12	0	nd	nd	120	110 – 290	µg/kg ww
Hexachlorocyclopentadiene	0/12	0	nd	nd	15,000	14,000 – 36,000	µg/kg ww
Hexachloroethane	0/12	0	nd	nd	120	110 – 290	µg/kg ww
Isophorone	0/12	0	nd	nd	120	110 – 290	µg/kg ww
Nitrobenzene	0/12	0	nd	nd	120	110 – 290	µg/kg ww
N-Nitrosodimethylamine	0/12	0	nd	nd	1,800	900 – 6,000	µg/kg ww
N-Nitroso-di-n-propylamine	0/12	0	nd	nd	120	110 – 290	µg/kg ww
N-Nitrosodiphenylamine	0/12	0	nd	nd	120	110 – 290	µg/kg ww
Pentachlorophenol	0/12	0	nd	nd	26	1.7 – 200	µg/kg ww
Phenol	1/12	8	500 JM	500 JM	350	300 – 800	µg/kg ww
Polychlorinated biphenyls							
PCB-001	2/4	50	2.50 JM	3.80 JM	1.84	0.95 – 1.16	ng/kg ww
PCB-002	4/4	100	1.24 JM	3.01 M	1.86	na	ng/kg ww
PCB-003	4/4	100	2.60 JM	12.90 JM	5.20	na	ng/kg ww
PCB-004	4/4	100	12.3 JM	29.5 M	20.1	na	ng/kg ww
PCB-005	1/4	25	2.64 JM	2.64 JM	1.08	0.98 – 1.42	ng/kg ww
PCB-006	4/4	100	3.36 JM	6.3 JM	4.74	na	ng/kg ww
PCB-007	4/4	100	2.07 JM	25.40 M	8.09	na	ng/kg ww

Table E.6.3-19, cont. Summary statistics for slender crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-008	4/4	100	4.31 JM	7.5 JM	5.58	na	ng/kg ww
PCB-009	4/4	100	2.08 JM	3.06 JM	2.60	na	ng/kg ww
PCB-010	1/4	25	2.65 JM	2.65 JM	1.09	0.99 – 1.43	ng/kg ww
PCB-011	4/4	100	4.45 JM	27.9 JM	10.5	na	ng/kg ww
PCB-012	4/4	100	2.89 CJM	4.36 CJM	3.54	na	ng/kg ww
PCB-013	4/4	100	C12	C12	nc	na	ng/kg ww
PCB-014	0/4	0	nd	nd	0.585	0.98 – 1.41	ng/kg ww
PCB-015	4/4	100	384 M	500 M	421	na	ng/kg ww
PCB-016	4/4	100	25.5 M	100 M	61.1	na	ng/kg ww
PCB-017	4/4	100	64 M	245 M	151	na	ng/kg ww
PCB-018	4/4	100	510 CM	1,110 CM	808	na	ng/kg ww
PCB-019	4/4	100	4.42 JM	20.2 M	11.3	na	ng/kg ww
PCB-020	4/4	100	4,800 CM	5,900 CM	5,370	na	ng/kg ww
PCB-021	2/4	50	16.10 CM	85.10 CM	25.5	0.70 – 1.09	ng/kg ww
PCB-022	4/4	100	307 M	570 M	475	na	ng/kg ww
PCB-023	1/4	25	1.92 M	1.92 M	0.839	0.70 – 1.09	ng/kg ww
PCB-024	4/4	100	0.376 JM	1.590 JM	1.05	na	ng/kg ww
PCB-025	4/4	100	31.9 M	120 M	77.0	na	ng/kg ww
PCB-026	4/4	100	313 CM	750 CM	549	na	ng/kg ww
PCB-027	4/4	100	5.4 JM	38.3 M	20.2	na	ng/kg ww
PCB-028	4/4	100	C20	C20	nc	na	ng/kg ww
PCB-029	4/4	100	C26	C26	nc	na	ng/kg ww
PCB-030	4/4	100	C18	C18	nc	na	ng/kg ww
PCB-031	4/4	100	930 M	2,070 M	1,550	na	ng/kg ww
PCB-032	4/4	100	46 M	220 M	123	na	ng/kg ww
PCB-033	2/4	50	C21	C21	nc	0	ng/kg ww
PCB-034	4/4	100	1.49 JM	4.6 JM	2.93	na	ng/kg ww
PCB-035	1/4	25	1.33 JM	1.33 JM	0.748	0.81 – 1.26	ng/kg ww
PCB-036	0/4	0	nd	nd	0.459	0.58 – 1.17	ng/kg ww
PCB-037	4/4	100	1,330 M	1,770 M	1,510	na	ng/kg ww
PCB-038	0/4	0	nd	nd	0.422	0.53 – 1.08	ng/kg ww
PCB-039	4/4	100	7.3 JM	11.3 JM	9.02	na	ng/kg ww
PCB-040	4/4	100	391 CM	1,060 CM	725	na	ng/kg ww
PCB-041	4/4	100	C40	C40	nc	na	ng/kg ww
PCB-042	4/4	100	740 M	1,340 M	1,020	na	ng/kg ww
PCB-043	4/4	100	209 M	383 M	302	na	ng/kg ww
PCB-044	4/4	100	4,680 CM	6,800 CM	5,610	na	ng/kg ww

Table E.6.3-19, cont. Summary statistics for slender crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-045	4/4	100	39.2 CJM	191 CM	111	na	ng/kg ww
PCB-046	4/4	100	11.9 JM	52 M	30.4	na	ng/kg ww
PCB-047	4/4	100	C44	C44	nc	na	ng/kg ww
PCB-048	4/4	100	252 M	760 M	499	na	ng/kg ww
PCB-049	4/4	100	5,000 CM	7,300 CM	6,060	na	ng/kg ww
PCB-050	4/4	100	56 CM	263 CM	156	na	ng/kg ww
PCB-051	4/4	100	C45	C45	nc	na	ng/kg ww
PCB-052	4/4	100	10,600 M	14,800 M	12,600	na	ng/kg ww
PCB-053	4/4	100	C50	C50	nc	na	ng/kg ww
PCB-054	3/4	75	0.65 JM	1.60 M	0.773	0.37	ng/kg ww
PCB-055	0/4	0	nd	nd	3.61	1.04 – 13.0	ng/kg ww
PCB-056	4/4	100	1,280 M	1,990 M	1,620	na	ng/kg ww
PCB-057	4/4	100	20.8 M	44 M	33.9	na	ng/kg ww
PCB-058	4/4	100	31.6 M	46 M	40.0	na	ng/kg ww
PCB-059	4/4	100	243 CM	500 CM	375	na	ng/kg ww
PCB-060	4/4	100	2,300 M	2,690 M	2,530	na	ng/kg ww
PCB-061	4/4	100	8,600 CM	12,000 CM	10,200	na	ng/kg ww
PCB-062	4/4	100	C59	C59	nc	na	ng/kg ww
PCB-063	4/4	100	415 M	530 M	463	na	ng/kg ww
PCB-064	4/4	100	1,630 M	2,310 M	1,920	na	ng/kg ww
PCB-065	4/4	100	C44	C44	nc	na	ng/kg ww
PCB-066	4/4	100	9,800 M	11,500 M	10,600	na	ng/kg ww
PCB-067	4/4	100	68 M	137 M	105	na	ng/kg ww
PCB-068	4/4	100	54 M	95 M	74.1	na	ng/kg ww
PCB-069	4/4	100	C49	C49	nc	na	ng/kg ww
PCB-070	4/4	100	C61	C61	nc	na	ng/kg ww
PCB-071	4/4	100	C40	C40	nc	na	ng/kg ww
PCB-072	4/4	100	119 M	220 M	168	na	ng/kg ww
PCB-073	4/4	100	91 M	116 M	103	na	ng/kg ww
PCB-074	4/4	100	C61	C61	nc	na	ng/kg ww
PCB-075	4/4	100	C59	C59	nc	na	ng/kg ww
PCB-076	4/4	100	C61	C61	nc	na	ng/kg ww
PCB-077	4/4	100	740 M	1,010 M	877	na	ng/kg ww
PCB-078	0/4	0	nd	nd	3.63	1.06 – 13.1	ng/kg ww
PCB-079	4/4	100	174 M	222 M	195	na	ng/kg ww
PCB-080	0/4	0	nd	nd	3.36	0.97 – 12.1	ng/kg ww
PCB-081	4/4	100	39.3 JM	56 M	48.5	na	ng/kg ww

Table E.6.3-19, cont. Summary statistics for slender crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-082	4/4	100	760 M	1,140 M	921	na	ng/kg ww
PCB-083	4/4	100	12,400 CM	16,100 CM	14,000	na	ng/kg ww
PCB-084	4/4	100	860 M	1,670 M	1,260	na	ng/kg ww
PCB-085	4/4	100	3,290 CM	4,030 CM	3,540	na	ng/kg ww
PCB-086	4/4	100	9,000 CM	12,200 CM	10,300	na	ng/kg ww
PCB-087	4/4	100	C86	C86	nc	na	ng/kg ww
PCB-088	4/4	100	1,520 CM	2,220 CM	1,820	na	ng/kg ww
PCB-089	2/4	50	18.9 M	23.1 M	11.7	4.1 – 5.1	ng/kg ww
PCB-090	4/4	100	26,100 CM	35,700 CM	30,300	na	ng/kg ww
PCB-091	4/4	100	C88	C88	nc	na	ng/kg ww
PCB-092	4/4	100	4,800 M	6,400 M	5,520	na	ng/kg ww
PCB-093	4/4	100	8,000 CM	12,500 CM	9,950	na	ng/kg ww
PCB-094	4/4	100	9.9 JM	36.9 M	24.1	na	ng/kg ww
PCB-095	4/4	100	C93	C93	nc	na	ng/kg ww
PCB-096	4/4	100	5.1 M	22.5 M	13.5	na	ng/kg ww
PCB-097	4/4	100	C86	C86	nc	na	ng/kg ww
PCB-098	4/4	100	C93	C93	nc	na	ng/kg ww
PCB-099	4/4	100	C83	C83	nc	na	ng/kg ww
PCB-100	4/4	100	C93	C93	nc	na	ng/kg ww
PCB-101	4/4	100	C90	C90	nc	na	ng/kg ww
PCB-102	4/4	100	C93	C93	nc	na	ng/kg ww
PCB-103	4/4	100	193 M	288 M	234	na	ng/kg ww
PCB-104	4/4	100	1.41 JM	6.1 M	3.43	na	ng/kg ww
PCB-105	4/4	100	8,600 M	9,400 M	8,850	na	ng/kg ww
PCB-106	0/4	0	nd	nd	2.95	5.3 – 6.8	ng/kg ww
PCB-107	4/4	100	650 CM	1,010 CM	814	na	ng/kg ww
PCB-108	4/4	100	C86	C86	nc	na	ng/kg ww
PCB-109	4/4	100	1,220 M	1,710 M	1,440	na	ng/kg ww
PCB-110	4/4	100	6,600 CM	11,400 CM	8,850	na	ng/kg ww
PCB-111	4/4	100	10.9 JM	15.1 JM	12.6	na	ng/kg ww
PCB-112	0/4	0	nd	nd	1.46	2.5 – 3.5	ng/kg ww
PCB-113	4/4	100	C90	C90	nc	na	ng/kg ww
PCB-114	4/4	100	550 M	600 M	570	na	ng/kg ww
PCB-115	4/4	100	C110	C110	nc	na	ng/kg ww
PCB-116	4/4	100	C85	C85	nc	na	ng/kg ww
PCB-117	4/4	100	C85	C85	nc	na	ng/kg ww
PCB-118	4/4	100	23,000 M	27,100 M	24,500	na	ng/kg ww

Table E.6.3-19, cont. Summary statistics for slender crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-119	4/4	100	C86	C86	nc	na	ng/kg ww
PCB-120	4/4	100	36.5 M	64 M	49.3	na	ng/kg ww
PCB-121	0/4	0	nd	nd	1.51	2.6 – 3.6	ng/kg ww
PCB-122	4/4	100	184 M	233 M	209	na	ng/kg ww
PCB-123	4/4	100	430 M	490 M	459	na	ng/kg ww
PCB-124	4/4	100	C107	C107	nc	na	ng/kg ww
PCB-125	4/4	100	C86	C86	nc	na	ng/kg ww
PCB-126	4/4	100	38.2 M	60 M	49.6	na	ng/kg ww
PCB-127	4/4	100	56 M	78 M	67.4	na	ng/kg ww
PCB-128	4/4	100	4,500 CM	4,900 CM	4,640	na	ng/kg ww
PCB-129	4/4	100	35,700 CM	40,700 CM	38,000	na	ng/kg ww
PCB-130	4/4	100	1,720 M	2,020 M	1,830	na	ng/kg ww
PCB-131	4/4	100	167 M	242 M	198	na	ng/kg ww
PCB-132	4/4	100	3,210 M	4,300 M	3,690	na	ng/kg ww
PCB-133	4/4	100	670 M	800 M	744	na	ng/kg ww
PCB-134	4/4	100	740 CM	1,130 CM	908	na	ng/kg ww
PCB-135	4/4	100	8,200 CM	11,200 CM	9,620	na	ng/kg ww
PCB-136	4/4	100	730 M	1,390 M	1,040	na	ng/kg ww
PCB-137	4/4	100	1,170 M	1,350 M	1,250	na	ng/kg ww
PCB-138	4/4	100	C129	C129	nc	na	ng/kg ww
PCB-139	4/4	100	381 CM	580 CM	472	na	ng/kg ww
PCB-140	4/4	100	C139	C139	nc	na	ng/kg ww
PCB-141	4/4	100	4,500 M	5,000 M	4,750	na	ng/kg ww
PCB-142	0/4	0	nd	nd	5.09	5.5 – 15.8	ng/kg ww
PCB-143	4/4	100	C134	C134	nc	na	ng/kg ww
PCB-144	4/4	100	850 M	1,180 M	995	na	ng/kg ww
PCB-145	4/4	100	1.11 JM	3.7 JM	2.39	na	ng/kg ww
PCB-146	4/4	100	5,900 M	7,100 M	6,530	na	ng/kg ww
PCB-147	4/4	100	21,900 CM	27,900 CM	24,800	na	ng/kg ww
PCB-148	4/4	100	33.5 M	63 M	47.2	na	ng/kg ww
PCB-149	4/4	100	C147	C147	nc	na	ng/kg ww
PCB-150	4/4	100	43.7 M	62 M	52.8	na	ng/kg ww
PCB-151	4/4	100	C135	C135	nc	na	ng/kg ww
PCB-152	4/4	100	3.35 JM	9.2 JM	6.20	na	ng/kg ww
PCB-153	4/4	100	34,900 CM	41,200 CM	38,200	na	ng/kg ww
PCB-154	4/4	100	C135	C135	nc	na	ng/kg ww
PCB-155	4/4	100	4.5 JM	6.1 JM	5.33	na	ng/kg ww

Table E.6.3-19, cont. Summary statistics for slender crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-156	4/4	100	3,720 CM	4,180 CM	3,930	na	ng/kg ww
PCB-157	4/4	100	C156	C156	nc	na	ng/kg ww
PCB-158	4/4	100	2,000 M	2,890 M	2,360	na	ng/kg ww
PCB-159	4/4	100	152 M	170 M	162	na	ng/kg ww
PCB-160	4/4	100	C129	C129	nc	na	ng/kg ww
PCB-161	0/4	0	nd	nd	3.41	3.7 – 10.6	ng/kg ww
PCB-162	4/4	100	78 M	94 M	84.9	na	ng/kg ww
PCB-163	4/4	100	C129	C129	nc	na	ng/kg ww
PCB-164	4/4	100	1,480 M	1,770 M	1,600	na	ng/kg ww
PCB-165	3/4	75	20.3 M	25.9 M	19.0	10.8	ng/kg ww
PCB-166	4/4	100	C128	C128	nc	na	ng/kg ww
PCB-167	4/4	100	1,520 M	1,690 M	1,600	na	ng/kg ww
PCB-168	4/4	100	C153	C153	nc	na	ng/kg ww
PCB-169	3/4	75	1.55 M	4.24 M	1.99	0.69	ng/kg ww
PCB-170	4/4	100	3,890 M	4,800 M	4,300	na	ng/kg ww
PCB-171	4/4	100	1,880 CM	2,080 CM	1,970	na	ng/kg ww
PCB-172	4/4	100	790 M	970 M	876	na	ng/kg ww
PCB-173	4/4	100	C171	C171	nc	na	ng/kg ww
PCB-174	4/4	100	2,820 M	3,510 M	3,190	na	ng/kg ww
PCB-175	4/4	100	202 M	259 M	227	na	ng/kg ww
PCB-176	4/4	100	630 M	780 M	699	na	ng/kg ww
PCB-177	4/4	100	4,300 M	4,800 M	4,570	na	ng/kg ww
PCB-178	4/4	100	1,900 M	2,220 M	2,070	na	ng/kg ww
PCB-179	4/4	100	2,100 M	2,510 M	2,260	na	ng/kg ww
PCB-180	4/4	100	14,100 CM	15,700 CM	15,100	na	ng/kg ww
PCB-181	4/4	100	44 M	49 M	46.1	na	ng/kg ww
PCB-182	4/4	100	51 M	77 M	61.1	na	ng/kg ww
PCB-183	4/4	100	4,700 CM	5,800 CM	5,220	na	ng/kg ww
PCB-184	4/4	100	5.0 JM	5.9 JM	5.37	na	ng/kg ww
PCB-185	4/4	100	C183	C183	nc	na	ng/kg ww
PCB-186	0/4	0	nd	nd	0.164	0.213 – 0.44	ng/kg ww
PCB-187	4/4	100	11,500 M	13,500 M	12,600	na	ng/kg ww
PCB-188	4/4	100	18.7 M	21.1 M	19.9	na	ng/kg ww
PCB-189	4/4	100	197 M	249 M	220	na	ng/kg ww
PCB-190	4/4	100	1,440 M	1,660 M	1,540	na	ng/kg ww
PCB-191	4/4	100	268 M	327 M	294	na	ng/kg ww
PCB-192	0/4	0	nd	nd	0.207	0.27 – 0.56	ng/kg ww

Table E.6.3-19, cont. Summary statistics for slender crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-193	4/4	100	C180	C180	nc	na	ng/kg ww
PCB-194	4/4	100	1,060 M	1,400 M	1,220	na	ng/kg ww
PCB-195	4/4	100	420 M	530 M	468	na	ng/kg ww
PCB-196	4/4	100	650 M	720 M	675	na	ng/kg ww
PCB-197	4/4	100	201 CM	249 CM	223	na	ng/kg ww
PCB-198	4/4	100	1,300 CM	1,670 CM	1,470	na	ng/kg ww
PCB-199	4/4	100	C198	C198	nc	na	ng/kg ww
PCB-200	4/4	100	C197	C197	nc	na	ng/kg ww
PCB-201	4/4	100	281 M	305 M	295	na	ng/kg ww
PCB-202	4/4	100	690 M	780 M	742	na	ng/kg ww
PCB-203	4/4	100	1,150 M	1,220 M	1,190	na	ng/kg ww
PCB-204	4/4	100	0.466 JM	0.74 JM	0.599	na	ng/kg ww
PCB-205	4/4	100	60 M	74 M	66.9	na	ng/kg ww
PCB-206	4/4	100	153 M	240 M	196	na	ng/kg ww
PCB-207	4/4	100	21.2 M	30.1 M	25.5	na	ng/kg ww
PCB-208	4/4	100	51 M	106 M	78.9	na	ng/kg ww
PCB-209	4/4	100	19.0 M	49 M	34.0	na	ng/kg ww
Total PCB congeners	4/4	100	365,500 JM	449,200 JM	400,600	nc	ng/kg ww
Aroclor-1016	0/13	0	nd	nd	4.3	8 – 20	µg/kg ww
Aroclor-1221	0/13	0	nd	nd	7.8	15 – 20	µg/kg ww
Aroclor-1232	0/13	0	nd	nd	4.3	8 – 20	µg/kg ww
Aroclor-1242	0/13	0	nd	nd	4.3	8 – 20	µg/kg ww
Aroclor-1248	12/13	92	90 M	140 JM	110	20	µg/kg ww
Aroclor-1254	13/13	100	150 M	380 JM	300	na	µg/kg ww
Aroclor-1260	13/13	100	100 M	320 M	270	na	µg/kg ww
Total PCBs	13/13	100	250 M	840 JM	670	nc	µg/kg ww
PCB TEQ – Bird	4/4	100	46.5 JM	63.7 M	55.3	na	ng/kg ww
PCB TEQ – Fish	4/4	100	0.485 JM	0.622 M	0.561	na	ng/kg ww
PCB TEQ – Mammal	4/4	100	5.13 JM	7.3 M	6.31	na	ng/kg ww
Pesticides							
2,4'-DDD	9/12	75	3.2 JNM	6 JNM	3.9	1.2 – 1.9	µg/kg ww
2,4'-DDE	0/12	0	nd	nd	0.57	0.8 – 1.8	µg/kg ww
2,4'-DDT	12/12	100	21 JNM	33 JNM	28	na	µg/kg ww
4,4'-DDD	3/12	25	1.5 JNM	1.5 JNM	0.71	0.8 – 1.0	µg/kg ww
4,4'-DDE	12/12	100	7 JNM	9 JNM	8.1	na	µg/kg ww
4,4'-DDT	12/12	100	17 JNM	27 JNM	23	na	µg/kg ww
Total DDTs	12/12	100	48 JNM	71 JNM	61.8	nc	µg/kg ww

Table E.6.3-19, cont. Summary statistics for slender crab, whole body (calculated)

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Aldrin	0/12	0	nd	nd	0.38	0.8	µg/kg ww
Dieldrin	1/12	8	3.2 JNM	3.2 JNM	1.1	1.6 – 2.3	µg/kg ww
Total aldrin/dieldrin	1/12	8	3.2 JNM	3.2 JNM	1.1	nc	µg/kg ww
alpha-BHC	3/12	25	1.20 JNM	1.20 JNM	0.58	0.8	µg/kg ww
beta-BHC	0/12	0	nd	nd	0.64	0.8 – 3.2	µg/kg ww
gamma-BHC	0/12	0	nd	nd	0.38	0.8	µg/kg ww
delta-BHC	0/12	0	nd	nd	0.38	0.8	µg/kg ww
alpha-Chlordane	2/12	17	1.5 JNM	1.7 JNM	0.58	0.8	µg/kg ww
gamma-Chlordane	12/12	100	9 JNM	14 JNM	12	na	µg/kg ww
alpha-Endosulfan	3/12	25	1.3 JNM	2.1 JNM	0.74	0.8	µg/kg ww
beta-Endosulfan	0/12	0	nd	nd	0.47	0.8 – 1.1	µg/kg ww
Endosulfan sulfate	0/12	0	nd	nd	0.48	0.8 – 1.6	µg/kg ww
Endrin	0/12	0	nd	nd	0.53	0.8 – 2.0	µg/kg ww
Endrin aldehyde	5/12	42	1.9 JNM	3.3 JNM	1.5	0.8 – 1.8	µg/kg ww
Endrin ketone	0/12	0	nd	nd	0.47	0.9 – 1.0	µg/kg ww
Heptachlor	0/12	0	nd	nd	0.38	0.8	µg/kg ww
Heptachlor epoxide	9/12	75	2.5 JNM	3.7 JNM	2.4	1.0 – 1.3	µg/kg ww
Methoxychlor	3/12	25	5.8 JNM	90.0 JNM	9.9	0.8	µg/kg ww
Mirex	0/12	0	nd	nd	0.38	0.8	µg/kg ww
Toxaphene	0/12	0	nd	nd	43	70 – 110	µg/kg ww
Total chlordane	12/12	100	9 JNM	15 JNM	12	nc	µg/kg ww
Conventional parameters							
Total solids	13/13	100	12.8 M	17.7 M	16.2	na	% ww
Lipid	13/13	100	0.9 M	1.4 M	1.1	na	% ww

Note: Data from hepatopancreas composite samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Whole-body (i.e., edible meat plus hepatopancreas) crab concentrations were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weight of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

Table E.6.3-20. Summary statistics for softshell clam, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	14/14	100	0.007 J	0.252	0.05	na	mg/kg ww
Arsenic	14/14	100	1.300 J	5.870 J	3.073	na	mg/kg ww
Arsenic (inorganic)	8/8	100	0.132	3.27	1.24	na	mg/kg ww
Cadmium	14/14	100	0.064	0.148	0.10	na	mg/kg ww
Chromium	14/14	100	0.36	1.32	0.67	na	mg/kg ww
Cobalt	14/14	100	0.1470	0.7110	0.3349	na	mg/kg ww
Copper	14/14	100	3.50	7.30	5.34	na	mg/kg ww
Lead	14/14	100	0.368	6.370	1.96	na	mg/kg ww
Mercury	14/14	100	0.009	0.022	0.02	na	mg/kg ww
Molybdenum	14/14	100	0.1750	0.3610	0.2473	na	mg/kg ww
Nickel	14/14	100	0.313	1.090	0.597	na	mg/kg ww
Selenium	14/14	100	0.215	0.373	0.279	na	mg/kg ww
Silver	14/14	100	0.012	0.093	0.035	na	mg/kg ww
Thallium	14/14	100	0.0009 J	0.0042	0.002	na	mg/kg ww
Vanadium	14/14	100	0.68	2.65	1.3	na	mg/kg ww
Zinc	14/14	100	16.1	32.3	23.7	na	mg/kg ww
Organometals							
Monobutyltin as ion	14/14	100	0.57 J	2.5	1.2	na	µg/kg ww
Dibutyltin as ion	13/14	93	1.8	10 J	3.9	3.9	µg/kg ww
Tributyltin as ion	14/14	100	150	660	320	na	µg/kg ww
Tetrabutyltin as ion	0/14	0	nd	nd	0.49	0.97 – 1.0	µg/kg ww
PAHs							
2-Chloronaphthalene	0/14	0	nd	nd	20	39 – 40	µg/kg ww
2-Methylnaphthalene	14/14	100	0.41 J	1.9	0.86	na	µg/kg ww
Acenaphthene	14/14	100	0.82	7.6	2.1	na	µg/kg ww
Acenaphthylene	14/14	100	0.56	1.9	1.1	na	µg/kg ww
Anthracene	14/14	100	1.8	8.0	4.0	na	µg/kg ww
Benzo(a)anthracene	14/14	100	12	42	23	na	µg/kg ww
Benzo(a)pyrene	14/14	100	3.0	26	8.2	na	µg/kg ww
Benzo(b)fluoranthene	14/14	100	7.3	44	16	na	µg/kg ww
Benzo(g,h,i)perylene	14/14	100	3.3	32	9.8	na	µg/kg ww
Benzo(k)fluoranthene	14/14	100	6.2	38	13	na	µg/kg ww
Total benzofluoranthenes	14/14	100	13.5	82	29	nc	µg/kg ww
Chrysene	14/14	100	20	85	42	na	µg/kg ww

Table E.6.3-20, cont. Summary statistics for softshell clam, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Dibenzo(a,h)anthracene	14/14	100	0.63	5.1	1.4	na	µg/kg ww
Dibenzofuran	14/14	100	0.61	2.8	1.4	na	µg/kg ww
Fluoranthene	14/14	100	34	120	70	na	µg/kg ww
Fluorene	14/14	100	0.81	4.6	2.1	na	µg/kg ww
Indeno(1,2,3-cd)pyrene	14/14	100	2.1	28	6.0	na	µg/kg ww
Naphthalene	1/14	7	0.80 J	0.80 J	0.46	0.57 – 1.6	µg/kg ww
Phenanthrene	14/14	100	4.0	26	11	na	µg/kg ww
Pyrene	14/14	100	34	130	64	na	µg/kg ww
Total HPAH	14/14	100	132	550	250	nc	µg/kg ww
Total LPAH	14/14	100	8.2	48	20	nc	µg/kg ww
Carcinogenic PAHs – Mammal	14/14	100	6.8	44	15	na	µg/kg ww
Total PAH	14/14	100	140	600	270	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	10/14	71	56 J	220 J	140	490 – 500	µg/kg ww
Butyl benzyl phthalate	0/14	0	nd	nd	20	39 – 40	µg/kg ww
Diethyl phthalate	2/14	14	9.5 J	14 J	35	77 – 80	µg/kg ww
Dimethyl phthalate	0/14	0	nd	nd	20	39 – 40	µg/kg ww
Di-n-butyl phthalate	4/14	29	19 J	34 J	23	39 – 40	µg/kg ww
Di-n-octyl phthalate	0/14	0	nd	nd	20	39 – 40	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/14	0	nd	nd	20	39 – 40	µg/kg ww
1,2-Dichlorobenzene	0/14	0	nd	nd	20	39 – 40	µg/kg ww
1,3-Dichlorobenzene	0/14	0	nd	nd	20	39 – 40	µg/kg ww
1,4-Dichlorobenzene	0/14	0	nd	nd	20	39 – 40	µg/kg ww
2,4,5-Trichlorophenol	0/14	0	nd	nd	39	77 – 80	µg/kg ww
2,4,6-Trichlorophenol	0/14	0	nd	nd	39	77 – 80	µg/kg ww
2,4-Dichlorophenol	0/14	0	nd	nd	39	77 – 80	µg/kg ww
2,4-Dimethylphenol	0/14	0	nd	nd	39	77 – 80	µg/kg ww
2,4-Dinitrophenol	0/14	0	nd	nd	390	770 – 800	µg/kg ww
2,4-Dinitrotoluene	0/14	0	nd	nd	39	77 – 80	µg/kg ww
2,6-Dinitrotoluene	0/14	0	nd	nd	20	39 – 40	µg/kg ww
2-Chlorophenol	0/14	0	nd	nd	39	77 – 80	µg/kg ww
2-Methylphenol	0/14	0	nd	nd	39	77 – 80	µg/kg ww
2-Nitroaniline	0/14	0	nd	nd	100	200	µg/kg ww
2-Nitrophenol	0/14	0	nd	nd	20	39 – 40	µg/kg ww
3,3'-Dichlorobenzidine	0/14	0	nd	nd	1,000	2,000	µg/kg ww
3-Nitroaniline	0/14	0	nd	nd	200	390 – 400	µg/kg ww

Table E.6.3-20, cont. Summary statistics for softshell clam, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
4,6-Dinitro-o-cresol	0/14	0	nd	nd	200	390 – 400	µg/kg ww
4-Bromophenyl phenyl ether	0/14	0	nd	nd	20	39 – 40	µg/kg ww
4-Chloro-3-methylphenol	0/14	0	nd	nd	100	200	µg/kg ww
4-Chloroaniline	0/14	0	nd	nd	100	200	µg/kg ww
4-Chlorophenyl phenyl ether	0/14	0	nd	nd	20	39 – 40	µg/kg ww
4-Methylphenol	7/14	50	15 J	41 J	32	77 – 80	µg/kg ww
4-Nitroaniline	0/14	0	nd	nd	100	200	µg/kg ww
4-Nitrophenol	0/14	0	nd	nd	200	390 – 400	µg/kg ww
Aniline	0/14	0	nd	nd	390	770 – 800	µg/kg ww
Benzidine	0/14	0	nd	nd	2,500	5,000	µg/kg ww
Benzoic acid	14/14	100	340 J	640 J	470	na	µg/kg ww
Benzyl alcohol	0/14	0	nd	nd	20	39 – 40	µg/kg ww
bis(2-chloroethoxy)methane	0/14	0	nd	nd	20	39 – 40	µg/kg ww
bis(2-chloroethyl)ether	0/14	0	nd	nd	20	39 – 40	µg/kg ww
bis(2-chloroisopropyl)ether	0/14	0	nd	nd	20	39 – 40	µg/kg ww
Carbazole	0/14	0	nd	nd	100	200	µg/kg ww
Hexachlorobenzene	9/14	64	0.38 JN	1.0 JN	0.66	1.0	µg/kg ww
Hexachlorobutadiene	0/14	0	nd	nd	20	39 – 40	µg/kg ww
Hexachlorocyclopentadiene	0/14	0	nd	nd	2,500	5,000	µg/kg ww
Hexachloroethane	0/14	0	nd	nd	20	39 – 40	µg/kg ww
Isophorone	0/14	0	nd	nd	20	39 – 40	µg/kg ww
Nitrobenzene	0/14	0	nd	nd	20	39 – 40	µg/kg ww
N-Nitrosodimethylamine	0/14	0	nd	nd	20	39 – 40	µg/kg ww
N-Nitroso-di-n-propylamine	0/14	0	nd	nd	20	39 – 40	µg/kg ww
N-Nitrosodiphenylamine	0/14	0	nd	nd	20	39 – 40	µg/kg ww
Pentachlorophenol	0/14	0	nd	nd	200	390 – 400	µg/kg ww
Phenol	12/14	86	18 J	50 J	30	97 – 100	µg/kg ww
Polychlorinated biphenyls							
PCB-001	6/8	75	1.23 J	74.8	11.1	0.971 – 1.00	ng/kg ww
PCB-002	2/8	25	1.07 J	13.3	1.97	0.293 – 0.847	ng/kg ww
PCB-003	2/8	25	2.58	29.0	4.29	0.711 – 1.24	ng/kg ww
PCB-004	8/8	100	21.8	1,300	196	na	ng/kg ww
PCB-005	8/8	100	0.558 J	12.6	2.37	na	ng/kg ww
PCB-006	8/8	100	16.6	2,470	350	na	ng/kg ww
PCB-007	8/8	100	2.01	76.8	12.4	na	ng/kg ww
PCB-008	8/8	100	42.1	1,790	280	na	ng/kg ww
PCB-009	8/8	100	2.97	125	19.8	na	ng/kg ww

Table E.6.3-20, cont. Summary statistics for softshell clam, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-010	8/8	100	1.31 J	38.0	6.63	na	ng/kg ww
PCB-011	8/8	100	12.5	183	38.6	na	ng/kg ww
PCB-012	8/8	100	7.98 C	532 C	82.3	na	ng/kg ww
PCB-013	8/8	100	C12	C12	nc	na	ng/kg ww
PCB-014	4/8	50	0.0980 J	2.05	0.353	0.0570 – 0.105	ng/kg ww
PCB-015	8/8	100	53.8	653	142	na	ng/kg ww
PCB-016	8/8	100	78.3	685	179	na	ng/kg ww
PCB-017	8/8	100	135	4,090	742	na	ng/kg ww
PCB-018	8/8	100	237 C	10,700 C	1,810	na	ng/kg ww
PCB-019	8/8	100	34.6	1,980	324	na	ng/kg ww
PCB-020	8/8	100	630 C	8,680 C	1,960	na	ng/kg ww
PCB-021	8/8	100	164 C	1,110 C	334	na	ng/kg ww
PCB-022	8/8	100	164	981	313	na	ng/kg ww
PCB-023	8/8	100	0.371 J	2.63	0.779	na	ng/kg ww
PCB-024	8/8	100	3.29	41.5	9.67	na	ng/kg ww
PCB-025	8/8	100	99.7	14,300	2,240	na	ng/kg ww
PCB-026	8/8	100	220 C	38,300 C	5,960	na	ng/kg ww
PCB-027	8/8	100	49.5	7,670	1,200	na	ng/kg ww
PCB-028	8/8	100	C20	C20	nc	na	ng/kg ww
PCB-029	8/8	100	C26	C26	nc	na	ng/kg ww
PCB-030	8/8	100	C18	C18	nc	na	ng/kg ww
PCB-031	8/8	100	438	10,700	2,040	na	ng/kg ww
PCB-032	8/8	100	116	3,530	649	na	ng/kg ww
PCB-033	8/8	100	C21	C21	nc	na	ng/kg ww
PCB-034	8/8	100	2.82	166	28.4	na	ng/kg ww
PCB-035	8/8	100	8.07	49.6	15.7	na	ng/kg ww
PCB-036	8/8	100	0.646 J	63.7	10.1	na	ng/kg ww
PCB-037	8/8	100	147	640	246	na	ng/kg ww
PCB-038	8/8	100	0.839 J	61.2	11.9	na	ng/kg ww
PCB-039	8/8	100	4.15	64.1	15.2	na	ng/kg ww
PCB-040	8/8	100	455 C	14,700 C	2,710	na	ng/kg ww
PCB-041	8/8	100	C40	C40	nc	na	ng/kg ww
PCB-042	8/8	100	245	6,420	1,250	na	ng/kg ww
PCB-043	8/8	100	34.0	266	79.1	na	ng/kg ww
PCB-044	8/8	100	994 C	38,800 C	7,290	na	ng/kg ww
PCB-045	8/8	100	124 C	5,410 C	951	na	ng/kg ww
PCB-046	8/8	100	42.3	1,970	332	na	ng/kg ww

Table E.6.3-20, cont. Summary statistics for softshell clam, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-047	8/8	100	C44	C44	nc	na	ng/kg ww
PCB-048	8/8	100	142	793	277	na	ng/kg ww
PCB-049	8/8	100	796 C	60,200 C	10,400	na	ng/kg ww
PCB-050	8/8	100	138 C	13,000 C	2,110	na	ng/kg ww
PCB-051	8/8	100	C45	C45	nc	na	ng/kg ww
PCB-052	8/8	100	1,680	110,000	19,400	na	ng/kg ww
PCB-053	8/8	100	C50	C50	nc	na	ng/kg ww
PCB-054	8/8	100	2.88	255	41.5	na	ng/kg ww
PCB-055	8/8	100	18.1	191	49.6	na	ng/kg ww
PCB-056	8/8	100	383	2,140	756	na	ng/kg ww
PCB-057	8/8	100	13.8	1,040	174	na	ng/kg ww
PCB-058	8/8	100	7.35	353	64.0	na	ng/kg ww
PCB-059	8/8	100	126 C	6,630 C	1,180	na	ng/kg ww
PCB-060	8/8	100	197	607	294	na	ng/kg ww
PCB-061	8/8	100	1,480 C	17,300 C	4,370	na	ng/kg ww
PCB-062	8/8	100	C59	C59	nc	na	ng/kg ww
PCB-063	8/8	100	36.5	716	149	na	ng/kg ww
PCB-064	8/8	100	346	5,180	1,150	na	ng/kg ww
PCB-065	8/8	100	C44	C44	nc	na	ng/kg ww
PCB-066	8/8	100	1,040	13,300	3,240	na	ng/kg ww
PCB-067	8/8	100	37.5	1,740	303	na	ng/kg ww
PCB-068	8/8	100	16.0	1,680	284	na	ng/kg ww
PCB-069	8/8	100	C49	C49	nc	na	ng/kg ww
PCB-070	8/8	100	C61	C61	nc	na	ng/kg ww
PCB-071	8/8	100	C40	C40	nc	na	ng/kg ww
PCB-072	8/8	100	33.2	3,060	527	na	ng/kg ww
PCB-073	1/8	12	462	462	57.8	0.0251 – 0.0768	ng/kg ww
PCB-074	8/8	100	C61	C61	nc	na	ng/kg ww
PCB-075	8/8	100	C59	C59	nc	na	ng/kg ww
PCB-076	8/8	100	C61	C61	nc	na	ng/kg ww
PCB-077	8/8	100	71.5	454	146	na	ng/kg ww
PCB-078	0/8	0	nd	nd	0.267	0.436 – 0.592	ng/kg ww
PCB-079	8/8	100	17.9 J	504	109	na	ng/kg ww
PCB-080	0/8	0	nd	nd	0.224	0.362 – 0.492	ng/kg ww
PCB-081	8/8	100	3.04	26.7 J	7.90	na	ng/kg ww
PCB-082	8/8	100	176	2,020	549	na	ng/kg ww

Table E.6.3-20, cont. Summary statistics for softshell clam, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-083	8/8	100	1,390 C	37,200 C	7,840	na	ng/kg ww
PCB-084	8/8	100	361	14,000	2,720	na	ng/kg ww
PCB-085	8/8	100	313 C	5,100 C	1,230	na	ng/kg ww
PCB-086	8/8	100	1,050 C	22,500 C	5,120	na	ng/kg ww
PCB-087	8/8	100	C86	C86	nc	na	ng/kg ww
PCB-088	8/8	100	286 C	13,100 C	2,450	na	ng/kg ww
PCB-089	8/8	100	15.5	182	47.0	na	ng/kg ww
PCB-090	8/8	100	2,240 C	46,300 C	11,000	na	ng/kg ww
PCB-091	8/8	100	C88	C88	nc	na	ng/kg ww
PCB-092	8/8	100	631	16,200	3,610	na	ng/kg ww
PCB-093	8/8	100	1,820 C	58,500 C	12,500	na	ng/kg ww
PCB-094	8/8	100	10.8	338	64.7	na	ng/kg ww
PCB-095	8/8	100	C93	C93	nc	na	ng/kg ww
PCB-096	8/8	100	9.93	424	77.0	na	ng/kg ww
PCB-097	8/8	100	C86	C86	nc	na	ng/kg ww
PCB-098	8/8	100	C93	C93	nc	na	ng/kg ww
PCB-099	8/8	100	C83	C83	nc	na	ng/kg ww
PCB-100	8/8	100	C93	C93	nc	na	ng/kg ww
PCB-101	8/8	100	C90	C90	nc	na	ng/kg ww
PCB-102	8/8	100	C93	C93	nc	na	ng/kg ww
PCB-103	8/8	100	36.8	1,350	258	na	ng/kg ww
PCB-104	8/8	100	0.516 J	35.9	6.20	na	ng/kg ww
PCB-105	8/8	100	478	6,680	1,700	na	ng/kg ww
PCB-106	0/8	0	nd	nd	0.186	0.246 – 0.446	ng/kg ww
PCB-107	8/8	100	64.3 C	925 C	241	na	ng/kg ww
PCB-108	8/8	100	C86	C86	nc	na	ng/kg ww
PCB-109	8/8	100	116	2,810	603	na	ng/kg ww
PCB-110	8/8	100	1,980 C	59,800 C	12,500	na	ng/kg ww
PCB-111	8/8	100	3.36	81.3	17.6	na	ng/kg ww
PCB-112	0/8	0	nd	nd	0.127	0.0879 – 0.512	ng/kg ww
PCB-113	8/8	100	C90	C90	nc	na	ng/kg ww
PCB-114	8/8	100	29.8	359	95.2	na	ng/kg ww
PCB-115	8/8	100	C110	C110	nc	na	ng/kg ww
PCB-116	8/8	100	C85	C85	nc	na	ng/kg ww
PCB-117	8/8	100	C85	C85	nc	na	ng/kg ww
PCB-118	8/8	100	1,290	33,100	7,150	na	ng/kg ww
PCB-119	8/8	100	C86	C86	nc	na	ng/kg ww

Table E.6.3-20, cont. Summary statistics for softshell clam, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-120	8/8	100	15.2	417	85.7	na	ng/kg ww
PCB-121	8/8	100	1.20 J	40.2	8.06	na	ng/kg ww
PCB-122	8/8	100	23.9	290	79.3	na	ng/kg ww
PCB-123	8/8	100	32.6	453	116	na	ng/kg ww
PCB-124	8/8	100	C107	C107	nc	na	ng/kg ww
PCB-125	8/8	100	C86	C86	nc	na	ng/kg ww
PCB-126	8/8	100	3.31	41.0	10.6	na	ng/kg ww
PCB-127	8/8	100	2.42	62.2	14.8	na	ng/kg ww
PCB-128	8/8	100	295 C	5,480 C	1,390	na	ng/kg ww
PCB-129	8/8	100	2,350 C	30,600 C	10,200	na	ng/kg ww
PCB-130	8/8	100	189	2,490	733	na	ng/kg ww
PCB-131	8/8	100	22.6	343	91.9	na	ng/kg ww
PCB-132	8/8	100	652	11,900	3,260	na	ng/kg ww
PCB-133	8/8	100	87.4	900	285	na	ng/kg ww
PCB-134	8/8	100	141 C	2,490 C	666	na	ng/kg ww
PCB-135	8/8	100	1,200 C	13,600 C	5,030	na	ng/kg ww
PCB-136	8/8	100	309	5,250	1,480	na	ng/kg ww
PCB-137	8/8	100	100	2,000	479	na	ng/kg ww
PCB-138	8/8	100	C129	C129	nc	na	ng/kg ww
PCB-139	8/8	100	48.7 C	768 C	191	na	ng/kg ww
PCB-140	8/8	100	C139	C139	nc	na	ng/kg ww
PCB-141	8/8	100	257	4,210	1,320	na	ng/kg ww
PCB-142	0/8	0	nd	nd	0.243	0.383 – 0.674	ng/kg ww
PCB-143	8/8	100	C134	C134	nc	na	ng/kg ww
PCB-144	8/8	100	112	1,220	410	na	ng/kg ww
PCB-145	8/8	100	0.732 J	14.8	3.25	na	ng/kg ww
PCB-146	8/8	100	627	6,130	2,150	na	ng/kg ww
PCB-147	8/8	100	2,260 C	33,100 C	10,500	na	ng/kg ww
PCB-148	8/8	100	10.4	110	30.7	na	ng/kg ww
PCB-149	8/8	100	C147	C147	nc	na	ng/kg ww
PCB-150	8/8	100	5.78	118	25.6	na	ng/kg ww
PCB-151	8/8	100	C135	C135	nc	na	ng/kg ww
PCB-152	8/8	100	1.68 J	49.4	10.4	na	ng/kg ww
PCB-153	8/8	100	2,590 C	28,800 C	10,700	na	ng/kg ww
PCB-154	8/8	100	C135	C135	nc	na	ng/kg ww
PCB-155	8/8	100	0.475 J	3.98	1.16	na	ng/kg ww
PCB-156	8/8	100	163 C	2,980 C	777	na	ng/kg ww

Table E.6.3-20, cont. Summary statistics for softshell clam, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-157	8/8	100	C156	C156	nc	na	ng/kg ww
PCB-158	8/8	100	207	3,140	972	na	ng/kg ww
PCB-159	0/8	0	nd	nd	0.197	0.299 – 0.548	ng/kg ww
PCB-160	8/8	100	C129	C129	nc	na	ng/kg ww
PCB-161	0/8	0	nd	nd	0.177	0.282 – 0.491	ng/kg ww
PCB-162	8/8	100	7.25	108	29.6	na	ng/kg ww
PCB-163	8/8	100	C129	C129	nc	na	ng/kg ww
PCB-164	8/8	100	214	2,700	895	na	ng/kg ww
PCB-165	8/8	100	2.31	41.2	10.0	na	ng/kg ww
PCB-166	8/8	100	C128	C128	nc	na	ng/kg ww
PCB-167	8/8	100	85.8	1,310	375	na	ng/kg ww
PCB-168	8/8	100	C153	C153	nc	na	ng/kg ww
PCB-169	0/8	0	nd	nd	3.10	1.21 – 20.0	ng/kg ww
PCB-170	8/8	100	232	5,390	1,310	na	ng/kg ww
PCB-171	8/8	100	184 C	2,890 C	761	na	ng/kg ww
PCB-172	8/8	100	43.1	996	235	na	ng/kg ww
PCB-173	8/8	100	C171	C171	nc	na	ng/kg ww
PCB-174	8/8	100	296	7,440	1,670	na	ng/kg ww
PCB-175	8/8	100	37.8	537	136	na	ng/kg ww
PCB-176	8/8	100	86.7	1,250	325	na	ng/kg ww
PCB-177	8/8	100	547	8,130	2,050	na	ng/kg ww
PCB-178	8/8	100	276	3,700	930	na	ng/kg ww
PCB-179	8/8	100	318	5,160	1,220	na	ng/kg ww
PCB-180	8/8	100	1,040 C	20,200 C	4,640	na	ng/kg ww
PCB-181	8/8	100	3.45	71.4	18.6	na	ng/kg ww
PCB-182	8/8	100	7.47	58.4	20.8	na	ng/kg ww
PCB-183	8/8	100	476 C	7,830 C	1,890	na	ng/kg ww
PCB-184	8/8	100	0.638 J	5.70	1.69	na	ng/kg ww
PCB-185	8/8	100	C183	C183	nc	na	ng/kg ww
PCB-186	0/8	0	nd	nd	0.0516	0.0681 – 0.175	ng/kg ww
PCB-187	8/8	100	1,110	16,500	3,960	na	ng/kg ww
PCB-188	8/8	100	1.98	14.9	4.83	na	ng/kg ww
PCB-189	8/8	100	7.52	159	41.3	na	ng/kg ww
PCB-190	8/8	100	82.5	1,670	395	na	ng/kg ww
PCB-191	8/8	100	25.8	444	110	na	ng/kg ww
PCB-192	0/8	0	nd	nd	0.0652	0.0864 – 0.222	ng/kg ww
PCB-193	8/8	100	C180	C180	nc	na	ng/kg ww

Table E.6.3-20, cont. Summary statistics for softshell clam, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-194	8/8	100	43.8	1,710	350	na	ng/kg ww
PCB-195	8/8	100	21.9	897	178	na	ng/kg ww
PCB-196	8/8	100	94.9	1,890	430	na	ng/kg ww
PCB-197	8/8	100	17.5 C	365 C	82.7	na	ng/kg ww
PCB-198	8/8	100	221 C	4,430 C	974	na	ng/kg ww
PCB-199	8/8	100	C198	C198	nc	na	ng/kg ww
PCB-200	8/8	100	C197	C197	nc	na	ng/kg ww
PCB-201	8/8	100	52.6	648	162	na	ng/kg ww
PCB-202	8/8	100	116	1,360	342	na	ng/kg ww
PCB-203	8/8	100	68.5	1,520	344	na	ng/kg ww
PCB-204	6/8	75	0.0540 J	0.302 J	0.112	0.0210 – 0.0490	ng/kg ww
PCB-205	8/8	100	3.88	107	23.4	na	ng/kg ww
PCB-206	8/8	100	10.3	252	69.1	na	ng/kg ww
PCB-207	8/8	100	1.15 J	36.0	9.08	na	ng/kg ww
PCB-208	8/8	100	2.88	48.5	15.2	na	ng/kg ww
PCB-209	8/8	100	2.23	18.3	5.60	na	ng/kg ww
Total PCB congeners	8/8	100	41,050 J	930,000 J	222,000	nc	ng/kg ww
Aroclor-1016	0/14	0	nd	nd	5.0	10	µg/kg ww
Aroclor-1221	0/14	0	nd	nd	10	20	µg/kg ww
Aroclor-1232	0/14	0	nd	nd	5.0	10	µg/kg ww
Aroclor-1242	0/14	0	nd	nd	5.0	10	µg/kg ww
Aroclor-1248	3/14	21	64 J	190 J	27	10	µg/kg ww
Aroclor-1254	14/14	100	24	390	84	na	µg/kg ww
Aroclor-1260	2/14	14	240	250	39	10	µg/kg ww
Total PCBs	14/14	100	24	580 J	140	nc	µg/kg ww
PCB TEQ – Bird	8/8	100	4.310	30.80 J	9.48	na	ng/kg ww
PCB TEQ – Fish	8/8	100	0.03670	0.4890 J	0.123	na	ng/kg ww
PCB TEQ – Mammal	8/8	100	0.440	5.65 J	1.48	na	ng/kg ww
Pesticides							
2,4'-DDD	9/14	64	2.0 JN	4.8 JN	2.3	1.0 – 4.4	µg/kg ww
2,4'-DDE	0/14	0	nd	nd	0.56	1.0 – 1.5	µg/kg ww
2,4'-DDT	12/14	86	2.1 JN	21 JN	4.5	3.2 – 3.5	µg/kg ww
4,4'-DDD	13/14	93	0.23 JN	1.4 JN	0.67	1.0	µg/kg ww
4,4'-DDE	9/14	64	0.70 JN	3.5 JN	1.1	1.0	µg/kg ww
4,4'-DDT	14/14	100	0.84 JN	12 JN	3.8	na	µg/kg ww
Total DDTs	14/14	100	3.8 JN	33 JN	12	nc	µg/kg ww

Table E.6.3-20, cont. Summary statistics for softshell clam, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Aldrin	3/14	21	0.77 JN	1.0 JN	0.59	1.0	µg/kg ww
Dieldrin	4/14	29	3.8 JN	5.0 JN	2.4	1.0 – 24	µg/kg ww
Total aldrin/dieldrin	6/14	43	0.95 JN	5.4 JN	2.5	nc	µg/kg ww
alpha-BHC	1/14	7	0.35 JN	0.35 JN	0.49	1.0	µg/kg ww
beta-BHC	10/14	71	0.41 JN	1.9 JN	0.90	1.0 – 1.1	µg/kg ww
gamma-BHC	3/14	21	0.51 JN	2.5 JN	0.68	1.0	µg/kg ww
delta-BHC	3/14	21	0.51 JN	2.2 JN	0.66	1.0	µg/kg ww
alpha-Chlordane	0/14	0	nd	nd	0.50	1.0	µg/kg ww
gamma-Chlordane	14/14	100	0.86 JN	9.3 JN	2.1	na	µg/kg ww
alpha-Endosulfan	2/14	14	0.53 JN	2.8 JN	0.81	1.0 – 4.3	µg/kg ww
beta-Endosulfan	4/14	29	3.8 JN	4.8 JN	1.7	1.0 – 1.2	µg/kg ww
Endosulfan sulfate	0/14	0	nd	nd	0.50	1.0	µg/kg ww
Endrin	11/14	79	0.10 JN	1.6 JN	0.41	1.0	µg/kg ww
Endrin aldehyde	2/14	14	0.42 JN	0.49 JN	0.59	1.0 – 3.6	µg/kg ww
Endrin ketone	0/14	0	nd	nd	0.61	1.0 – 2.6	µg/kg ww
Heptachlor	0/14	0	nd	nd	0.50	1.0	µg/kg ww
Heptachlor epoxide	5/14	36	1.1 JN	1.5 JN	0.81	1.0	µg/kg ww
Methoxychlor	1/14	7	0.63 JN	0.63 JN	0.51	1.0	µg/kg ww
Mirex	0/14	0	nd	nd	0.50	1.0	µg/kg ww
Toxaphene	0/14	0	nd	nd	41	50 – 250	µg/kg ww
Total chlordane	14/14	100	0.86 JN	9.3 JN	2.1	nc	µg/kg ww
Conventional parameters							
Total solids	14/14	100	12.8	17.3	14.9	na	% ww
Lipid	14/14	100	0.55	0.83	0.71	na	% ww

Table E.6.3-21. Summary statistics for starry flounder, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	1/1	100	0.0036 J	0.0036 J	0.0036	na	mg/kg ww
Arsenic	1/1	100	0.899	0.899	0.899	na	mg/kg ww
Arsenic (inorganic)	0/1	0	nd	nd	0.002	0.003	mg/kg ww
Cadmium	0/1	0	nd	nd	0.0022	0.0043	mg/kg ww
Chromium	0/1	0	nd	nd	0.055	0.11	mg/kg ww
Cobalt	1/1	100	0.0086 J	0.0086 J	0.0086	na	mg/kg ww
Copper	1/1	100	0.272 J	0.272 J	0.272	na	mg/kg ww
Lead	1/1	100	0.006	0.006	0.006	na	mg/kg ww
Mercury	1/1	100	0.046	0.046	0.046	na	mg/kg ww
Molybdenum	1/1	100	0.0036 J	0.0036 J	0.0036	na	mg/kg ww
Nickel	1/1	100	0.034 J	0.034 J	0.034	na	mg/kg ww
Selenium	1/1	100	0.13	0.13	0.13	na	mg/kg ww
Silver	0/1	0	nd	nd	0.0022	0.0043	mg/kg ww
Thallium	0/1	0	nd	nd	0.0022	0.0043	mg/kg ww
Vanadium	0/1	0	nd	nd	0.1	0.2	mg/kg ww
Zinc	1/1	100	7.93	7.93	7.93	na	mg/kg ww
Organometals							
Monobutyltin as ion	0/1	0	nd	nd	0.75	1.5	µg/kg ww
Dibutyltin as ion	1/1	100	1.2 J	1.2 J	1.2	na	µg/kg ww
Tributyltin as ion	1/1	100	4.4	4.4	4.4	na	µg/kg ww
Tetrabutyltin as ion	0/1	0	nd	nd	0.75	1.5	µg/kg ww
PAHs							
2-Chloronaphthalene	0/1	0	nd	nd	290	570	µg/kg ww
2-Methylnaphthalene	1/1	100	2.0	2.0	2.0	na	µg/kg ww
Acenaphthene	1/1	100	5.0	5.0	5.0	na	µg/kg ww
Acenaphthylene	1/1	100	0.44 J	0.44 J	0.44	na	µg/kg ww
Anthracene	1/1	100	0.51 J	0.51 J	0.51	na	µg/kg ww
Benzo(a)anthracene	1/1	100	0.34 J	0.34 J	0.34	na	µg/kg ww
Benzo(a)pyrene	1/1	100	0.37 J	0.37 J	0.37	na	µg/kg ww
Benzo(b)fluoranthene	1/1	100	0.27 J	0.27 J	0.27	na	µg/kg ww
Benzo(g,h,i)perylene	1/1	100	0.36 J	0.36 J	0.36	na	µg/kg ww
Benzo(k)fluoranthene	1/1	100	0.31 J	0.31 J	0.31	na	µg/kg ww
Total benzofluoranthenes	1/1	100	0.58 J	0.58 J	0.58	na	µg/kg ww
Chrysene	1/1	100	0.53 J	0.53 J	0.53	na	µg/kg ww

Table E.6.3-21, cont. Summary statistics for starry flounder, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Dibenzo(a,h)anthracene	0/1	0	nd	nd	0.36	0.71	µg/kg ww
Dibenzofuran	1/1	100	2.3	2.3	2.3	na	µg/kg ww
Fluoranthene	1/1	100	1.8	1.8	1.8	na	µg/kg ww
Fluorene	1/1	100	1.6	1.6	1.6	na	µg/kg ww
Indeno(1,2,3-cd)pyrene	1/1	100	0.32 J	0.32 J	0.32	na	µg/kg ww
Naphthalene	0/1	0	nd	nd	1.9	3.7	µg/kg ww
Phenanthrene	1/1	100	1.7	1.7	1.7	na	µg/kg ww
Pyrene	1/1	100	1.0	1.0	1.0	na	µg/kg ww
Total HPAH	1/1	100	5.3 J	5.3 J	5.3	nc	µg/kg ww
Total LPAH	1/1	100	9.3 J	9.3 J	9.3	nc	µg/kg ww
Carcinogenic PAHs – Mammal	1/1	100	0.64 J	0.64 J	0.64	na	µg/kg ww
Total PAH	1/1	100	14.6 J	14.6 J	15	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	0/1	0	nd	nd	34	67	µg/kg ww
Butyl benzyl phthalate	0/1	0	nd	nd	600	1,200	µg/kg ww
Diethyl phthalate	0/1	0	nd	nd	600	1,200	µg/kg ww
Dimethyl phthalate	0/1	0	nd	nd	290	570	µg/kg ww
Di-n-butyl phthalate	0/1	0	nd	nd	600	1,200	µg/kg ww
Di-n-octyl phthalate	0/1	0	nd	nd	1,500	2,900	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/1	0	nd	nd	290	570	µg/kg ww
1,2-Dichlorobenzene	0/1	0	nd	nd	290	570	µg/kg ww
1,3-Dichlorobenzene	0/1	0	nd	nd	290	570	µg/kg ww
1,4-Dichlorobenzene	0/1	0	nd	nd	290	570	µg/kg ww
2,4,5-Trichlorophenol	0/1	0	nd	nd	1,500	2,900	µg/kg ww
2,4,6-Trichlorophenol	0/1	0	nd	nd	1,500	2,900	µg/kg ww
2,4-Dichlorophenol	0/1	0	nd	nd	600	1,200	µg/kg ww
2,4-Dimethylphenol	0/1	0	nd	nd	600	1,200	µg/kg ww
2,4-Dinitrophenol	0/1	0	nd	nd	6,000	12,000	µg/kg ww
2,4-Dinitrotoluene	0/1	0	nd	nd	600	1,200	µg/kg ww
2,6-Dinitrotoluene	0/1	0	nd	nd	600	1,200	µg/kg ww
2-Chlorophenol	0/1	0	nd	nd	600	1,200	µg/kg ww
2-Methylphenol	0/1	0	nd	nd	600	1,200	µg/kg ww
2-Nitroaniline	0/1	0	nd	nd	1,500	2,900	µg/kg ww
2-Nitrophenol	0/1	0	nd	nd	1,500	2,900	µg/kg ww
3,3'-Dichlorobenzidine	0/1	0	nd	nd	15,000	29,000	µg/kg ww
3-Nitroaniline	0/1	0	nd	nd	2,900	5,700	µg/kg ww

Table E.6.3-21, cont. Summary statistics for starry flounder, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
4,6-Dinitro-o-cresol	0/1	0	nd	nd	2,900	5,700	µg/kg ww
4-Bromophenyl phenyl ether	0/1	0	nd	nd	290	570	µg/kg ww
4-Chloro-3-methylphenol	0/1	0	nd	nd	1,500	2,900	µg/kg ww
4-Chloroaniline	0/1	0	nd	nd	1,500	2,900	µg/kg ww
4-Chlorophenyl phenyl ether	0/1	0	nd	nd	290	570	µg/kg ww
4-Methylphenol	0/1	0	nd	nd	600	1,200	µg/kg ww
4-Nitroaniline	0/1	0	nd	nd	1,500	2,900	µg/kg ww
4-Nitrophenol	0/1	0	nd	nd	2,900	5,700	µg/kg ww
Aniline	0/1	0	nd	nd	6,000	12,000	µg/kg ww
Benzoic acid	1/1	100	4,700 J	4,700 J	4,700	na	µg/kg ww
Benzyl alcohol	0/1	0	nd	nd	290	570	µg/kg ww
bis(2-chloroethoxy)methane	0/1	0	nd	nd	290	570	µg/kg ww
bis(2-chloroethyl)ether	0/1	0	nd	nd	290	570	µg/kg ww
bis(2-chloroisopropyl)ether	0/1	0	nd	nd	290	570	µg/kg ww
Carbazole	0/1	0	nd	nd	1,500	2,900	µg/kg ww
Hexachlorobenzene	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Hexachlorobutadiene	0/1	0	nd	nd	290	570	µg/kg ww
Hexachlorocyclopentadiene	0/1	0	nd	nd	36,000	72,000	µg/kg ww
Hexachloroethane	0/1	0	nd	nd	290	570	µg/kg ww
Isophorone	0/1	0	nd	nd	290	570	µg/kg ww
Nitrobenzene	0/1	0	nd	nd	290	570	µg/kg ww
N-Nitrosodimethylamine	0/1	0	nd	nd	1,500	2,900	µg/kg ww
N-Nitroso-di-n-propylamine	0/1	0	nd	nd	290	570	µg/kg ww
N-Nitrosodiphenylamine	0/1	0	nd	nd	290	570	µg/kg ww
Pentachlorophenol	0/1	0	nd	nd	1.7	3.3	µg/kg ww
Phenol	0/1	0	nd	nd	750	1,500	µg/kg ww
Polychlorinated biphenyls							
PCB-001	1/1	100	4.34 J	4.34 J	4.34	na	ng/kg ww
PCB-002	1/1	100	0.424 J	0.424 J	0.424	na	ng/kg ww
PCB-003	1/1	100	0.738 J	0.738 J	0.738	na	ng/kg ww
PCB-004	1/1	100	154	154	154	na	ng/kg ww
PCB-005	1/1	100	2.93 J	2.93 J	2.93	na	ng/kg ww
PCB-006	1/1	100	99.9	99.9	99.9	na	ng/kg ww
PCB-007	1/1	100	7.63	7.63	7.63	na	ng/kg ww
PCB-008	1/1	100	151	151	151	na	ng/kg ww
PCB-009	1/1	100	17.5	17.5	17.5	na	ng/kg ww
PCB-010	1/1	100	8.21	8.21	8.21	na	ng/kg ww

Table E.6.3-21, cont. Summary statistics for starry flounder, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-011	1/1	100	4.69 J	4.69 J	4.69	na	ng/kg ww
PCB-012	1/1	100	5.02 CJ	5.02 CJ	5.02	na	ng/kg ww
PCB-013	1/1	100	C12	C12	nc	na	ng/kg ww
PCB-014	0/1	0	nd	nd	0.345	0.689	ng/kg ww
PCB-015	1/1	100	29.8	29.8	29.8	na	ng/kg ww
PCB-016	1/1	100	167	167	167	na	ng/kg ww
PCB-017	1/1	100	410	410	410	na	ng/kg ww
PCB-018	1/1	100	1,240 C	1,240 C	1,240	na	ng/kg ww
PCB-019	1/1	100	153	153	153	na	ng/kg ww
PCB-020	1/1	100	5,030 C	5,030 C	5,030	na	ng/kg ww
PCB-021	1/1	100	426 C	426 C	426	na	ng/kg ww
PCB-022	1/1	100	666	666	666	na	ng/kg ww
PCB-023	0/1	0	nd	nd	1.06	2.12	ng/kg ww
PCB-024	1/1	100	22.6	22.6	22.6	na	ng/kg ww
PCB-025	1/1	100	525	525	525	na	ng/kg ww
PCB-026	1/1	100	1,610 C	1,610 C	1,610	na	ng/kg ww
PCB-027	1/1	100	264	264	264	na	ng/kg ww
PCB-028	1/1	100	C20	C20	nc	na	ng/kg ww
PCB-029	1/1	100	C26	C26	nc	na	ng/kg ww
PCB-030	1/1	100	C18	C18	nc	na	ng/kg ww
PCB-031	1/1	100	3,190	3,190	3,190	na	ng/kg ww
PCB-032	1/1	100	700	700	700	na	ng/kg ww
PCB-033	1/1	100	C21	C21	nc	na	ng/kg ww
PCB-034	1/1	100	11.9	11.9	11.9	na	ng/kg ww
PCB-035	0/1	0	nd	nd	1.17	2.34	ng/kg ww
PCB-036	0/1	0	nd	nd	1.09	2.18	ng/kg ww
PCB-037	1/1	100	126	126	126	na	ng/kg ww
PCB-038	1/1	100	3.77 J	3.77 J	3.77	na	ng/kg ww
PCB-039	1/1	100	3.17 J	3.17 J	3.17	na	ng/kg ww
PCB-040	1/1	100	1,170 C	1,170 C	1,170	na	ng/kg ww
PCB-041	1/1	100	C40	C40	nc	na	ng/kg ww
PCB-042	1/1	100	456	456	456	na	ng/kg ww
PCB-043	0/1	0	nd	nd	0.194	0.388	ng/kg ww
PCB-044	1/1	100	5,640 C	5,640 C	5,640	na	ng/kg ww
PCB-045	1/1	100	544 C	544 C	544	na	ng/kg ww
PCB-046	1/1	100	76.0	76.0	76.0	na	ng/kg ww
PCB-047	1/1	100	C44	C44	nc	na	ng/kg ww

Table E.6.3-21, cont. Summary statistics for starry flounder, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-048	1/1	100	300	300	300	na	ng/kg ww
PCB-049	1/1	100	5,960 C	5,960 C	5,960	na	ng/kg ww
PCB-050	1/1	100	547 C	547 C	547	na	ng/kg ww
PCB-051	1/1	100	C45	C45	nc	na	ng/kg ww
PCB-052	1/1	100	13,000	13,000	13,000	na	ng/kg ww
PCB-053	1/1	100	C50	C50	nc	na	ng/kg ww
PCB-054	1/1	100	15.6	15.6	15.6	na	ng/kg ww
PCB-055	0/1	0	nd	nd	1.35	2.70	ng/kg ww
PCB-056	1/1	100	945	945	945	na	ng/kg ww
PCB-057	1/1	100	49.8	49.8	49.8	na	ng/kg ww
PCB-058	1/1	100	28.8	28.8	28.8	na	ng/kg ww
PCB-059	1/1	100	772 C	772 C	772	na	ng/kg ww
PCB-060	1/1	100	1,520	1,520	1,520	na	ng/kg ww
PCB-061	1/1	100	10,900 C	10,900 C	10,900	na	ng/kg ww
PCB-062	1/1	100	C59	C59	nc	na	ng/kg ww
PCB-063	1/1	100	208	208	208	na	ng/kg ww
PCB-064	1/1	100	2,640	2,640	2,640	na	ng/kg ww
PCB-065	1/1	100	C44	C44	nc	na	ng/kg ww
PCB-066	1/1	100	7,250	7,250	7,250	na	ng/kg ww
PCB-067	1/1	100	108	108	108	na	ng/kg ww
PCB-068	1/1	100	99.4	99.4	99.4	na	ng/kg ww
PCB-069	1/1	100	C49	C49	nc	na	ng/kg ww
PCB-070	1/1	100	C61	C61	nc	na	ng/kg ww
PCB-071	1/1	100	C40	C40	nc	na	ng/kg ww
PCB-072	1/1	100	203	203	203	na	ng/kg ww
PCB-073	0/1	0	nd	nd	0.132	0.264	ng/kg ww
PCB-074	1/1	100	C61	C61	nc	na	ng/kg ww
PCB-075	1/1	100	C59	C59	nc	na	ng/kg ww
PCB-076	1/1	100	C61	C61	nc	na	ng/kg ww
PCB-077	1/1	100	221	221	221	na	ng/kg ww
PCB-078	0/1	0	nd	nd	1.39	2.78	ng/kg ww
PCB-079	1/1	100	59.7	59.7	59.7	na	ng/kg ww
PCB-080	0/1	0	nd	nd	1.30	2.60	ng/kg ww
PCB-081	1/1	100	16.2 J	16.2 J	16.2	na	ng/kg ww
PCB-082	1/1	100	274	274	274	na	ng/kg ww
PCB-083	1/1	100	12,900 C	12,900 C	12,900	na	ng/kg ww
PCB-084	1/1	100	1,100	1,100	1,100	na	ng/kg ww

Table E.6.3-21, cont. Summary statistics for starry flounder, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-085	1/1	100	2,860 C	2,860 C	2,860	na	ng/kg ww
PCB-086	1/1	100	5,470 C	5,470 C	5,470	na	ng/kg ww
PCB-087	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-088	1/1	100	1,360 C	1,360 C	1,360	na	ng/kg ww
PCB-089	1/1	100	22.7	22.7	22.7	na	ng/kg ww
PCB-090	1/1	100	13,800 C	13,800 C	13,800	na	ng/kg ww
PCB-091	1/1	100	C88	C88	nc	na	ng/kg ww
PCB-092	1/1	100	3,810	3,810	3,810	na	ng/kg ww
PCB-093	1/1	100	7,940 C	7,940 C	7,940	na	ng/kg ww
PCB-094	1/1	100	20.1	20.1	20.1	na	ng/kg ww
PCB-095	1/1	100	C93	C93	nc	na	ng/kg ww
PCB-096	1/1	100	55.0	55.0	55.0	na	ng/kg ww
PCB-097	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-098	1/1	100	C93	C93	nc	na	ng/kg ww
PCB-099	1/1	100	C83	C83	nc	na	ng/kg ww
PCB-100	1/1	100	C93	C93	nc	na	ng/kg ww
PCB-101	1/1	100	C90	C90	nc	na	ng/kg ww
PCB-102	1/1	100	C93	C93	nc	na	ng/kg ww
PCB-103	1/1	100	272	272	272	na	ng/kg ww
PCB-104	1/1	100	2.90 J	2.90 J	2.90	na	ng/kg ww
PCB-105	1/1	100	4,650	4,650	4,650	na	ng/kg ww
PCB-106	0/1	0	nd	nd	1.82	3.63	ng/kg ww
PCB-107	1/1	100	380 C	380 C	380	na	ng/kg ww
PCB-108	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-109	1/1	100	987	987	987	na	ng/kg ww
PCB-110	1/1	100	13,000 C	13,000 C	13,000	na	ng/kg ww
PCB-111	1/1	100	19.3	19.3	19.3	na	ng/kg ww
PCB-112	0/1	0	nd	nd	1.67	3.34	ng/kg ww
PCB-113	1/1	100	C90	C90	nc	na	ng/kg ww
PCB-114	1/1	100	370	370	370	na	ng/kg ww
PCB-115	1/1	100	C110	C110	nc	na	ng/kg ww
PCB-116	1/1	100	C85	C85	nc	na	ng/kg ww
PCB-117	1/1	100	C85	C85	nc	na	ng/kg ww
PCB-118	1/1	100	15,300	15,300	15,300	na	ng/kg ww
PCB-119	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-120	1/1	100	104	104	104	na	ng/kg ww
PCB-121	1/1	100	9.08	9.08	9.08	na	ng/kg ww

Table E.6.3-21, cont. Summary statistics for starry flounder, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-122	0/1	0	nd	nd	1.99	3.98	ng/kg ww
PCB-123	1/1	100	240	240	240	na	ng/kg ww
PCB-124	1/1	100	C107	C107	nc	na	ng/kg ww
PCB-125	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-126	1/1	100	21.4	21.4	21.4	na	ng/kg ww
PCB-127	1/1	100	39.8	39.8	39.8	na	ng/kg ww
PCB-128	1/1	100	2,740 C	2,740 C	2,740	na	ng/kg ww
PCB-129	1/1	100	25,500 C	25,500 C	25,500	na	ng/kg ww
PCB-130	1/1	100	732	732	732	na	ng/kg ww
PCB-131	1/1	100	84.4	84.4	84.4	na	ng/kg ww
PCB-132	1/1	100	2,250	2,250	2,250	na	ng/kg ww
PCB-133	1/1	100	523	523	523	na	ng/kg ww
PCB-134	1/1	100	519 C	519 C	519	na	ng/kg ww
PCB-135	1/1	100	7,300 C	7,300 C	7,300	na	ng/kg ww
PCB-136	1/1	100	1,490	1,490	1,490	na	ng/kg ww
PCB-137	1/1	100	1,150	1,150	1,150	na	ng/kg ww
PCB-138	1/1	100	C129	C129	nc	na	ng/kg ww
PCB-139	1/1	100	497 C	497 C	497	na	ng/kg ww
PCB-140	1/1	100	C139	C139	nc	na	ng/kg ww
PCB-141	1/1	100	2,780	2,780	2,780	na	ng/kg ww
PCB-142	0/1	0	nd	nd	2.75	5.49	ng/kg ww
PCB-143	1/1	100	C134	C134	nc	na	ng/kg ww
PCB-144	1/1	100	943	943	943	na	ng/kg ww
PCB-145	1/1	100	5.24	5.24	5.24	na	ng/kg ww
PCB-146	1/1	100	4,430	4,430	4,430	na	ng/kg ww
PCB-147	1/1	100	10,000 C	10,000 C	10,000	na	ng/kg ww
PCB-148	1/1	100	56.1	56.1	56.1	na	ng/kg ww
PCB-149	1/1	100	C147	C147	nc	na	ng/kg ww
PCB-150	1/1	100	36.2	36.2	36.2	na	ng/kg ww
PCB-151	1/1	100	C135	C135	nc	na	ng/kg ww
PCB-152	1/1	100	6.56	6.56	6.56	na	ng/kg ww
PCB-153	1/1	100	31,200 C	31,200 C	31,200	na	ng/kg ww
PCB-154	1/1	100	C135	C135	nc	na	ng/kg ww
PCB-155	1/1	100	3.03 J	3.03 J	3.03	na	ng/kg ww
PCB-156	1/1	100	2,000 C	2,000 C	2,000	na	ng/kg ww
PCB-157	1/1	100	C156	C156	nc	na	ng/kg ww
PCB-158	1/1	100	2,430	2,430	2,430	na	ng/kg ww

Table E.6.3-21, cont. Summary statistics for starry flounder, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-159	1/1	100	67.0	67.0	67.0	na	ng/kg ww
PCB-160	1/1	100	C129	C129	nc	na	ng/kg ww
PCB-161	0/1	0	nd	nd	2.00	3.99	ng/kg ww
PCB-162	1/1	100	64.6	64.6	64.6	na	ng/kg ww
PCB-163	1/1	100	C129	C129	nc	na	ng/kg ww
PCB-164	1/1	100	744	744	744	na	ng/kg ww
PCB-165	1/1	100	16.7	16.7	16.7	na	ng/kg ww
PCB-166	1/1	100	C128	C128	nc	na	ng/kg ww
PCB-167	1/1	100	859	859	859	na	ng/kg ww
PCB-168	1/1	100	C153	C153	nc	na	ng/kg ww
PCB-169	1/1	100	0.916	0.916	0.916	na	ng/kg ww
PCB-170	1/1	100	3,900	3,900	3,900	na	ng/kg ww
PCB-171	1/1	100	1,550 C	1,550 C	1,550	na	ng/kg ww
PCB-172	1/1	100	667	667	667	na	ng/kg ww
PCB-173	1/1	100	C171	C171	nc	na	ng/kg ww
PCB-174	1/1	100	1,420	1,420	1,420	na	ng/kg ww
PCB-175	1/1	100	209	209	209	na	ng/kg ww
PCB-176	1/1	100	327	327	327	na	ng/kg ww
PCB-177	1/1	100	1,630	1,630	1,630	na	ng/kg ww
PCB-178	1/1	100	1,320	1,320	1,320	na	ng/kg ww
PCB-179	1/1	100	1,550	1,550	1,550	na	ng/kg ww
PCB-180	1/1	100	11,500 C	11,500 C	11,500	na	ng/kg ww
PCB-181	1/1	100	37.2	37.2	37.2	na	ng/kg ww
PCB-182	1/1	100	62.0	62.0	62.0	na	ng/kg ww
PCB-183	1/1	100	4,720 C	4,720 C	4,720	na	ng/kg ww
PCB-184	1/1	100	5.11	5.11	5.11	na	ng/kg ww
PCB-185	1/1	100	C183	C183	nc	na	ng/kg ww
PCB-186	0/1	0	nd	nd	0.143	0.285	ng/kg ww
PCB-187	1/1	100	7,190	7,190	7,190	na	ng/kg ww
PCB-188	1/1	100	13.2	13.2	13.2	na	ng/kg ww
PCB-189	1/1	100	115	115	115	na	ng/kg ww
PCB-190	1/1	100	935	935	935	na	ng/kg ww
PCB-191	1/1	100	224	224	224	na	ng/kg ww
PCB-192	0/1	0	nd	nd	0.160	0.320	ng/kg ww
PCB-193	1/1	100	C180	C180	nc	na	ng/kg ww
PCB-194	1/1	100	1,100	1,100	1,100	na	ng/kg ww
PCB-195	1/1	100	512	512	512	na	ng/kg ww

Table E.6.3-21, cont. Summary statistics for starry flounder, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-196	1/1	100	860	860	860	na	ng/kg ww
PCB-197	1/1	100	171 C	171 C	171	na	ng/kg ww
PCB-198	1/1	100	1,430 C	1,430 C	1,430	na	ng/kg ww
PCB-199	1/1	100	C198	C198	nc	na	ng/kg ww
PCB-200	1/1	100	C197	C197	nc	na	ng/kg ww
PCB-201	1/1	100	243	243	243	na	ng/kg ww
PCB-202	1/1	100	450	450	450	na	ng/kg ww
PCB-203	1/1	100	1,250	1,250	1,250	na	ng/kg ww
PCB-204	1/1	100	0.613 J	0.613 J	0.613	na	ng/kg ww
PCB-205	1/1	100	65.7	65.7	65.7	na	ng/kg ww
PCB-206	1/1	100	339	339	339	na	ng/kg ww
PCB-207	1/1	100	49.3	49.3	49.3	na	ng/kg ww
PCB-208	1/1	100	86.4	86.4	86.4	na	ng/kg ww
PCB-209	1/1	100	53.3	53.3	53.3	na	ng/kg ww
Total PCB congeners	1/1	100	295,200 J	295,200 J	295,000	nc	ng/kg ww
Aroclor-1016	0/1	0	nd	nd	7.5	15	µg/kg ww
Aroclor-1221	0/1	0	nd	nd	15	29	µg/kg ww
Aroclor-1232	0/1	0	nd	nd	7.5	15	µg/kg ww
Aroclor-1242	0/1	0	nd	nd	7.5	15	µg/kg ww
Aroclor-1248	1/1	100	98	98	98	na	µg/kg ww
Aroclor-1254	1/1	100	170	170	170	na	µg/kg ww
Aroclor-1260	1/1	100	180	180	180	na	µg/kg ww
Total PCBs	1/1	100	450	450	450	nc	µg/kg ww
PCB TEQ – Bird	1/1	100	15.70 J	15.70 J	15.7	na	ng/kg ww
PCB TEQ – Fish	1/1	100	0.2550 J	0.2550 J	0.255	na	ng/kg ww
PCB TEQ – Mammal	1/1	100	2.90 J	2.90 J	2.90	na	ng/kg ww
Pesticides							
2,4'-DDD	0/1	0	nd	nd	3.6	7.2	µg/kg ww
2,4'-DDE	0/1	0	nd	nd	3.6	7.2	µg/kg ww
2,4'-DDT	1/1	100	31 JN	31 JN	31	na	µg/kg ww
4,4'-DDD	1/1	100	3.0 JN	3.0 JN	3.0	na	µg/kg ww
4,4'-DDE	1/1	100	5.9 JN	5.9 JN	5.9	na	µg/kg ww
4,4'-DDT	1/1	100	18 JN	18 JN	18	na	µg/kg ww
Total DDTs	1/1	100	58 JN	58 JN	58	nc	µg/kg ww
Aldrin	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Dieldrin	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Total aldrin/dieldrin	0/1	0	nd	nd	3.6	nc	µg/kg ww

Table E.6.3-21, cont. Summary statistics for starry flounder, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
alpha-BHC	0/1	0	nd	nd	3.6	7.2	µg/kg ww
beta-BHC	0/1	0	nd	nd	3.6	7.2	µg/kg ww
gamma-BHC	0/1	0	nd	nd	3.6	7.2	µg/kg ww
delta-BHC	0/1	0	nd	nd	3.6	7.2	µg/kg ww
alpha-Chlordane	0/1	0	nd	nd	3.6	7.2	µg/kg ww
gamma-Chlordane	1/1	100	6.2 JN	6.2 JN	6.2	na	µg/kg ww
alpha-Endosulfan	0/1	0	nd	nd	3.6	7.2	µg/kg ww
beta-Endosulfan	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Endosulfan sulfate	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Endrin	1/1	100	1.0 JN	1.0 JN	1.0	na	µg/kg ww
Endrin aldehyde	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Endrin ketone	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Heptachlor	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Heptachlor epoxide	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Methoxychlor	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Mirex	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Toxaphene	0/1	0	nd	nd	180	360	µg/kg ww
Total chlordane	1/1	100	6.2 JN	6.2 JN	6.2	nc	µg/kg ww
Conventional parameters							
Total solids	1/1	100	21.8	21.8	21.8	na	% ww
Lipid	1/1	100	2.6	2.6	2.6	na	% ww

Table E.6.3-22. Summary statistics for starry flounder, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	3/3	100	0.0028 J	0.0070 J	0.0044	na	mg/kg ww
Arsenic	3/3	100	0.793	0.973	0.887	na	mg/kg ww
Arsenic (inorganic)	1/1	100	0.090	0.090	0.090	na	mg/kg ww
Cadmium	3/3	100	0.0044 J	0.0079	0.0062	na	mg/kg ww
Chromium	3/3	100	0.14	3.74	1.5	na	mg/kg ww
Cobalt	3/3	100	0.0496	0.2290 J	0.141	na	mg/kg ww
Copper	3/3	100	0.550 J	2.770	1.35	na	mg/kg ww
Lead	3/3	100	0.035	0.403	0.17	na	mg/kg ww
Mercury	3/3	100	0.021	0.025	0.023	na	mg/kg ww
Molybdenum	3/3	100	0.0143	0.4100	0.157	na	mg/kg ww
Nickel	3/3	100	0.202	2.060	0.864	na	mg/kg ww
Selenium	3/3	100	0.13	0.16	0.14	na	mg/kg ww
Silver	3/3	100	0.0013 J	0.0076 J	0.0040	na	mg/kg ww
Thallium	1/3	33	0.0006 J	0.0006 J	0.002	0.0044 – 0.0045	mg/kg ww
Vanadium	3/3	100	0.2 J	0.5	0.3	na	mg/kg ww
Zinc	3/3	100	15.1	16.1	15.6	na	mg/kg ww
Organometals							
Monobutyltin as ion	3/3	100	0.64 J	1.9 J	1.2	na	µg/kg ww
Dibutyltin as ion	3/3	100	2.6	5.8	3.8	na	µg/kg ww
Tributyltin as ion	3/3	100	11	15	12	na	µg/kg ww
Tetrabutyltin as ion	0/3	0	nd	nd	0.75	1.5	µg/kg ww
PAHs							
2-Chloronaphthalene	0/3	0	nd	nd	290	570 – 580	µg/kg ww
2-Methylnaphthalene	3/3	100	1.7	2.8	2.2	na	µg/kg ww
Acenaphthene	3/3	100	4.6	9.0	6.4	na	µg/kg ww
Acenaphthylene	3/3	100	0.38 J	0.56 J	0.47	na	µg/kg ww
Anthracene	2/3	67	0.59 J	0.77	0.56	0.66	µg/kg ww
Benzo(a)anthracene	3/3	100	0.26 J	0.32 J	0.29	na	µg/kg ww
Benzo(a)pyrene	3/3	100	0.30 J	0.36 J	0.34	na	µg/kg ww
Benzo(b)fluoranthene	3/3	100	0.30 J	0.57	0.44	na	µg/kg ww
Benzo(g,h,i)perylene	3/3	100	0.25 J	0.36 J	0.32	na	µg/kg ww
Benzo(k)fluoranthene	3/3	100	0.30 J	0.57	0.41	na	µg/kg ww
Total benzofluoranthenes	3/3	100	0.60 J	1.14	0.85	nc	µg/kg ww
Chrysene	3/3	100	0.50 J	0.88	0.70	na	µg/kg ww

Table E.6.3-22, cont. Summary statistics for starry flounder, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Dibenzo(a,h)anthracene	1/3	33	0.14 J	0.14 J	0.25	0.50 – 0.72	µg/kg ww
Dibenzofuran	3/3	100	2.2	4.6	3.2	na	µg/kg ww
Fluoranthene	3/3	100	2.3	2.4	2.4	na	µg/kg ww
Fluorene	3/3	100	1.6	3.8	2.5	na	µg/kg ww
Indeno(1,2,3-cd)pyrene	2/3	67	0.20 J	0.35 J	0.30	0.72	µg/kg ww
Naphthalene	2/3	67	2.4	4.1	2.7	3.1	µg/kg ww
Phenanthrene	3/3	100	1.9	3.8	2.7	na	µg/kg ww
Pyrene	3/3	100	1.1	1.5	1.3	na	µg/kg ww
Total HPAH	3/3	100	5.8 J	7.3 J	6.4	nc	µg/kg ww
Total LPAH	3/3	100	11.0 J	22.0 J	15	nc	µg/kg ww
Carcinogenic PAHs – Mammal	3/3	100	0.47 J	0.66 J	0.59	na	µg/kg ww
Total PAH	3/3	100	17.3 J	27.8 J	21	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	0/3	0	nd	nd	33	66 – 67	µg/kg ww
Butyl benzyl phthalate	0/3	0	nd	nd	600	1,200	µg/kg ww
Diethyl phthalate	0/3	0	nd	nd	600	1,200	µg/kg ww
Dimethyl phthalate	0/3	0	nd	nd	290	570 – 580	µg/kg ww
Di-n-butyl phthalate	0/3	0	nd	nd	600	1,200	µg/kg ww
Di-n-octyl phthalate	0/3	0	nd	nd	1,500	2,900	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/3	0	nd	nd	290	570 – 580	µg/kg ww
1,2-Dichlorobenzene	0/3	0	nd	nd	290	570 – 580	µg/kg ww
1,3-Dichlorobenzene	0/3	0	nd	nd	290	570 – 580	µg/kg ww
1,4-Dichlorobenzene	0/3	0	nd	nd	290	570 – 580	µg/kg ww
2,4,5-Trichlorophenol	0/3	0	nd	nd	1,500	2,900	µg/kg ww
2,4,6-Trichlorophenol	0/3	0	nd	nd	1,500	2,900	µg/kg ww
2,4-Dichlorophenol	0/3	0	nd	nd	600	1,200	µg/kg ww
2,4-Dimethylphenol	0/3	0	nd	nd	600	1,200	µg/kg ww
2,4-Dinitrophenol	0/3	0	nd	nd	6,000	12,000	µg/kg ww
2,4-Dinitrotoluene	0/3	0	nd	nd	600	1,200	µg/kg ww
2,6-Dinitrotoluene	0/3	0	nd	nd	600	1,200	µg/kg ww
2-Chlorophenol	0/3	0	nd	nd	600	1,200	µg/kg ww
2-Methylphenol	0/3	0	nd	nd	600	1,200	µg/kg ww
2-Nitroaniline	0/3	0	nd	nd	1,500	2,900	µg/kg ww
2-Nitrophenol	0/3	0	nd	nd	1,500	2,900	µg/kg ww
3,3'-Dichlorobenzidine	0/3	0	nd	nd	15,000	29,000	µg/kg ww
3-Nitroaniline	0/3	0	nd	nd	2,900	5,700 – 5,800	µg/kg ww

Table E.6.3-22, cont. Summary statistics for starry flounder, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
4,6-Dinitro-o-cresol	0/3	0	nd	nd	2,900	5,700 – 5,800	µg/kg ww
4-Bromophenyl phenyl ether	0/3	0	nd	nd	290	570 – 580	µg/kg ww
4-Chloro-3-methylphenol	0/3	0	nd	nd	1,500	2,900	µg/kg ww
4-Chloroaniline	0/3	0	nd	nd	1,500	2,900	µg/kg ww
4-Chlorophenyl phenyl ether	0/3	0	nd	nd	290	570 – 580	µg/kg ww
4-Methylphenol	0/3	0	nd	nd	600	1,200	µg/kg ww
4-Nitroaniline	0/3	0	nd	nd	1,500	2,900	µg/kg ww
4-Nitrophenol	0/3	0	nd	nd	2,900	5,700 – 5,800	µg/kg ww
Aniline	0/3	0	nd	nd	6,000	12,000	µg/kg ww
Benzoic acid	3/3	100	5,000 J	5,800 J	5,500	na	µg/kg ww
Benzyl alcohol	0/3	0	nd	nd	290	570 – 580	µg/kg ww
bis(2-chloroethoxy)methane	0/3	0	nd	nd	290	570 – 580	µg/kg ww
bis(2-chloroethyl)ether	0/3	0	nd	nd	290	570 – 580	µg/kg ww
bis(2-chloroisopropyl)ether	0/3	0	nd	nd	290	570 – 580	µg/kg ww
Carbazole	0/3	0	nd	nd	1,500	2,900	µg/kg ww
Hexachlorobenzene	0/3	0	nd	nd	3.6	7.2	µg/kg ww
Hexachlorobutadiene	0/3	0	nd	nd	290	570 – 580	µg/kg ww
Hexachlorocyclopentadiene	0/3	0	nd	nd	36,000	72,000	µg/kg ww
Hexachloroethane	0/3	0	nd	nd	290	570 – 580	µg/kg ww
Isophorone	0/3	0	nd	nd	290	570 – 580	µg/kg ww
Nitrobenzene	0/3	0	nd	nd	290	570 – 580	µg/kg ww
N-Nitrosodimethylamine	0/3	0	nd	nd	1,500	2,900	µg/kg ww
N-Nitroso-di-n-propylamine	0/3	0	nd	nd	290	570 – 580	µg/kg ww
N-Nitrosodiphenylamine	0/3	0	nd	nd	290	570 – 580	µg/kg ww
Pentachlorophenol	1/3	33	1.3 J	1.3 J	2.1	3.3 – 6.7	µg/kg ww
Phenol	0/3	0	nd	nd	750	1,500	µg/kg ww
Polychlorinated biphenyls							
PCB-001	1/1	100	5.92	5.92	5.92	na	ng/kg ww
PCB-002	1/1	100	0.736 J	0.736 J	0.736	na	ng/kg ww
PCB-003	1/1	100	1.19 J	1.19 J	1.19	na	ng/kg ww
PCB-004	1/1	100	176	176	176	na	ng/kg ww
PCB-005	1/1	100	5.42	5.42	5.42	na	ng/kg ww
PCB-006	1/1	100	165	165	165	na	ng/kg ww
PCB-007	1/1	100	10.5	10.5	10.5	na	ng/kg ww
PCB-008	1/1	100	229	229	229	na	ng/kg ww
PCB-009	1/1	100	22.0	22.0	22.0	na	ng/kg ww
PCB-010	1/1	100	9.38	9.38	9.38	na	ng/kg ww

Table E.6.3-22, cont. Summary statistics for starry flounder, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-011	1/1	100	5.48	5.48	5.48	na	ng/kg ww
PCB-012	1/1	100	8.57 CJ	8.57 CJ	8.57	na	ng/kg ww
PCB-013	1/1	100	C12	C12	nc	na	ng/kg ww
PCB-014	0/1	0	nd	nd	0.369	0.737	ng/kg ww
PCB-015	1/1	100	30.8	30.8	30.8	na	ng/kg ww
PCB-016	1/1	100	206	206	206	na	ng/kg ww
PCB-017	1/1	100	667	667	667	na	ng/kg ww
PCB-018	1/1	100	1,710 C	1,710 C	1,710	na	ng/kg ww
PCB-019	1/1	100	199	199	199	na	ng/kg ww
PCB-020	1/1	100	5,470 C	5,470 C	5,470	na	ng/kg ww
PCB-021	1/1	100	586 C	586 C	586	na	ng/kg ww
PCB-022	1/1	100	889	889	889	na	ng/kg ww
PCB-023	0/1	0	nd	nd	1.62	3.24	ng/kg ww
PCB-024	1/1	100	28.1	28.1	28.1	na	ng/kg ww
PCB-025	1/1	100	648	648	648	na	ng/kg ww
PCB-026	1/1	100	1,920 C	1,920 C	1,920	na	ng/kg ww
PCB-027	1/1	100	304	304	304	na	ng/kg ww
PCB-028	1/1	100	C20	C20	nc	na	ng/kg ww
PCB-029	1/1	100	C26	C26	nc	na	ng/kg ww
PCB-030	1/1	100	C18	C18	nc	na	ng/kg ww
PCB-031	1/1	100	3,470	3,470	3,470	na	ng/kg ww
PCB-032	1/1	100	941	941	941	na	ng/kg ww
PCB-033	1/1	100	C21	C21	nc	na	ng/kg ww
PCB-034	1/1	100	18.4	18.4	18.4	na	ng/kg ww
PCB-035	0/1	0	nd	nd	1.79	3.58	ng/kg ww
PCB-036	0/1	0	nd	nd	1.66	3.32	ng/kg ww
PCB-037	1/1	100	129	129	129	na	ng/kg ww
PCB-038	1/1	100	4.04 J	4.04 J	4.04	na	ng/kg ww
PCB-039	1/1	100	7.88	7.88	7.88	na	ng/kg ww
PCB-040	1/1	100	1,620 C	1,620 C	1,620	na	ng/kg ww
PCB-041	1/1	100	C40	C40	nc	na	ng/kg ww
PCB-042	1/1	100	677	677	677	na	ng/kg ww
PCB-043	1/1	100	261	261	261	na	ng/kg ww
PCB-044	1/1	100	6,550 C	6,550 C	6,550	na	ng/kg ww
PCB-045	1/1	100	718 C	718 C	718	na	ng/kg ww
PCB-046	1/1	100	91.5	91.5	91.5	na	ng/kg ww
PCB-047	1/1	100	C44	C44	nc	na	ng/kg ww

Table E.6.3-22, cont. Summary statistics for starry flounder, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-048	1/1	100	478	478	478	na	ng/kg ww
PCB-049	1/1	100	7,850 C	7,850 C	7,850	na	ng/kg ww
PCB-050	1/1	100	643 C	643 C	643	na	ng/kg ww
PCB-051	1/1	100	C45	C45	nc	na	ng/kg ww
PCB-052	1/1	100	17,000	17,000	17,000	na	ng/kg ww
PCB-053	1/1	100	C50	C50	nc	na	ng/kg ww
PCB-054	1/1	100	17.3	17.3	17.3	na	ng/kg ww
PCB-055	0/1	0	nd	nd	2.89	5.78	ng/kg ww
PCB-056	1/1	100	1,170	1,170	1,170	na	ng/kg ww
PCB-057	1/1	100	70.7	70.7	70.7	na	ng/kg ww
PCB-058	1/1	100	37.3	37.3	37.3	na	ng/kg ww
PCB-059	1/1	100	944 C	944 C	944	na	ng/kg ww
PCB-060	1/1	100	1,690	1,690	1,690	na	ng/kg ww
PCB-061	1/1	100	12,800 C	12,800 C	12,800	na	ng/kg ww
PCB-062	1/1	100	C59	C59	nc	na	ng/kg ww
PCB-063	1/1	100	302	302	302	na	ng/kg ww
PCB-064	1/1	100	3,140	3,140	3,140	na	ng/kg ww
PCB-065	1/1	100	C44	C44	nc	na	ng/kg ww
PCB-066	1/1	100	8,290	8,290	8,290	na	ng/kg ww
PCB-067	1/1	100	160	160	160	na	ng/kg ww
PCB-068	1/1	100	116	116	116	na	ng/kg ww
PCB-069	1/1	100	C49	C49	nc	na	ng/kg ww
PCB-070	1/1	100	C61	C61	nc	na	ng/kg ww
PCB-071	1/1	100	C40	C40	nc	na	ng/kg ww
PCB-072	1/1	100	285	285	285	na	ng/kg ww
PCB-073	0/1	0	nd	nd	0.137	0.273	ng/kg ww
PCB-074	1/1	100	C61	C61	nc	na	ng/kg ww
PCB-075	1/1	100	C59	C59	nc	na	ng/kg ww
PCB-076	1/1	100	C61	C61	nc	na	ng/kg ww
PCB-077	1/1	100	242	242	242	na	ng/kg ww
PCB-078	0/1	0	nd	nd	2.98	5.96	ng/kg ww
PCB-079	1/1	100	86.6	86.6	86.6	na	ng/kg ww
PCB-080	0/1	0	nd	nd	2.78	5.56	ng/kg ww
PCB-081	1/1	100	21.8 J	21.8 J	21.8	na	ng/kg ww
PCB-082	1/1	100	356	356	356	na	ng/kg ww
PCB-083	1/1	100	19,100 C	19,100 C	19,100	na	ng/kg ww
PCB-084	1/1	100	1,500	1,500	1,500	na	ng/kg ww

Table E.6.3-22, cont. Summary statistics for starry flounder, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-085	1/1	100	3,730 C	3,730 C	3,730	na	ng/kg ww
PCB-086	1/1	100	8,230 C	8,230 C	8,230	na	ng/kg ww
PCB-087	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-088	1/1	100	1,980 C	1,980 C	1,980	na	ng/kg ww
PCB-089	1/1	100	34.2	34.2	34.2	na	ng/kg ww
PCB-090	1/1	100	23,600 C	23,600 C	23,600	na	ng/kg ww
PCB-091	1/1	100	C88	C88	nc	na	ng/kg ww
PCB-092	1/1	100	5,830	5,830	5,830	na	ng/kg ww
PCB-093	1/1	100	11,300 C	11,300 C	11,300	na	ng/kg ww
PCB-094	1/1	100	26.7	26.7	26.7	na	ng/kg ww
PCB-095	1/1	100	C93	C93	nc	na	ng/kg ww
PCB-096	1/1	100	60.9	60.9	60.9	na	ng/kg ww
PCB-097	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-098	1/1	100	C93	C93	nc	na	ng/kg ww
PCB-099	1/1	100	C83	C83	nc	na	ng/kg ww
PCB-100	1/1	100	C93	C93	nc	na	ng/kg ww
PCB-101	1/1	100	C90	C90	nc	na	ng/kg ww
PCB-102	1/1	100	C93	C93	nc	na	ng/kg ww
PCB-103	1/1	100	436	436	436	na	ng/kg ww
PCB-104	1/1	100	3.12 J	3.12 J	3.12	na	ng/kg ww
PCB-105	1/1	100	6,450	6,450	6,450	na	ng/kg ww
PCB-106	0/1	0	nd	nd	2.48	4.95	ng/kg ww
PCB-107	1/1	100	528 C	528 C	528	na	ng/kg ww
PCB-108	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-109	1/1	100	1,400	1,400	1,400	na	ng/kg ww
PCB-110	1/1	100	20,600 C	20,600 C	20,600	na	ng/kg ww
PCB-111	1/1	100	35.3	35.3	35.3	na	ng/kg ww
PCB-112	0/1	0	nd	nd	1.66	3.31	ng/kg ww
PCB-113	1/1	100	C90	C90	nc	na	ng/kg ww
PCB-114	1/1	100	509	509	509	na	ng/kg ww
PCB-115	1/1	100	C110	C110	nc	na	ng/kg ww
PCB-116	1/1	100	C85	C85	nc	na	ng/kg ww
PCB-117	1/1	100	C85	C85	nc	na	ng/kg ww
PCB-118	1/1	100	22,700	22,700	22,700	na	ng/kg ww
PCB-119	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-120	1/1	100	194	194	194	na	ng/kg ww
PCB-121	1/1	100	14.6	14.6	14.6	na	ng/kg ww

Table E.6.3-22, cont. Summary statistics for starry flounder, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-122	0/1	0	nd	nd	2.72	5.43	ng/kg ww
PCB-123	1/1	100	310	310	310	na	ng/kg ww
PCB-124	1/1	100	C107	C107	nc	na	ng/kg ww
PCB-125	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-126	1/1	100	30.2	30.2	30.2	na	ng/kg ww
PCB-127	1/1	100	54.6	54.6	54.6	na	ng/kg ww
PCB-128	1/1	100	4,230 C	4,230 C	4,230	na	ng/kg ww
PCB-129	1/1	100	40,700 C	40,700 C	40,700	na	ng/kg ww
PCB-130	1/1	100	1,110	1,110	1,110	na	ng/kg ww
PCB-131	1/1	100	115	115	115	na	ng/kg ww
PCB-132	1/1	100	3,920	3,920	3,920	na	ng/kg ww
PCB-133	1/1	100	857	857	857	na	ng/kg ww
PCB-134	1/1	100	736 C	736 C	736	na	ng/kg ww
PCB-135	1/1	100	12,000 C	12,000 C	12,000	na	ng/kg ww
PCB-136	1/1	100	2,150	2,150	2,150	na	ng/kg ww
PCB-137	1/1	100	1,520	1,520	1,520	na	ng/kg ww
PCB-138	1/1	100	C129	C129	nc	na	ng/kg ww
PCB-139	1/1	100	791 C	791 C	791	na	ng/kg ww
PCB-140	1/1	100	C139	C139	nc	na	ng/kg ww
PCB-141	1/1	100	5,660	5,660	5,660	na	ng/kg ww
PCB-142	0/1	0	nd	nd	5.45	10.9	ng/kg ww
PCB-143	1/1	100	C134	C134	nc	na	ng/kg ww
PCB-144	1/1	100	1,330	1,330	1,330	na	ng/kg ww
PCB-145	1/1	100	5.76	5.76	5.76	na	ng/kg ww
PCB-146	1/1	100	6,820	6,820	6,820	na	ng/kg ww
PCB-147	1/1	100	16,700 C	16,700 C	16,700	na	ng/kg ww
PCB-148	1/1	100	85.7	85.7	85.7	na	ng/kg ww
PCB-149	1/1	100	C147	C147	nc	na	ng/kg ww
PCB-150	1/1	100	53.7	53.7	53.7	na	ng/kg ww
PCB-151	1/1	100	C135	C135	nc	na	ng/kg ww
PCB-152	1/1	100	8.96	8.96	8.96	na	ng/kg ww
PCB-153	1/1	100	54,000 C	54,000 C	54,000	na	ng/kg ww
PCB-154	1/1	100	C135	C135	nc	na	ng/kg ww
PCB-155	1/1	100	5.87	5.87	5.87	na	ng/kg ww
PCB-156	1/1	100	3,280 C	3,280 C	3,280	na	ng/kg ww
PCB-157	1/1	100	C156	C156	nc	na	ng/kg ww
PCB-158	1/1	100	3,850	3,850	3,850	na	ng/kg ww

Table E.6.3-22, cont. Summary statistics for starry flounder, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-159	1/1	100	147	147	147	na	ng/kg ww
PCB-160	1/1	100	C129	C129	nc	na	ng/kg ww
PCB-161	0/1	0	nd	nd	3.95	7.89	ng/kg ww
PCB-162	1/1	100	101	101	101	na	ng/kg ww
PCB-163	1/1	100	C129	C129	nc	na	ng/kg ww
PCB-164	1/1	100	1,610	1,610	1,610	na	ng/kg ww
PCB-165	1/1	100	29.8	29.8	29.8	na	ng/kg ww
PCB-166	1/1	100	C128	C128	nc	na	ng/kg ww
PCB-167	1/1	100	1,460	1,460	1,460	na	ng/kg ww
PCB-168	1/1	100	C153	C153	nc	na	ng/kg ww
PCB-169	1/1	100	1.24	1.24	1.24	na	ng/kg ww
PCB-170	1/1	100	8,100	8,100	8,100	na	ng/kg ww
PCB-171	1/1	100	2,750 C	2,750 C	2,750	na	ng/kg ww
PCB-172	1/1	100	1,300	1,300	1,300	na	ng/kg ww
PCB-173	1/1	100	C171	C171	nc	na	ng/kg ww
PCB-174	1/1	100	3,070	3,070	3,070	na	ng/kg ww
PCB-175	1/1	100	322	322	322	na	ng/kg ww
PCB-176	1/1	100	568	568	568	na	ng/kg ww
PCB-177	1/1	100	2,490	2,490	2,490	na	ng/kg ww
PCB-178	1/1	100	2,250	2,250	2,250	na	ng/kg ww
PCB-179	1/1	100	2,730	2,730	2,730	na	ng/kg ww
PCB-180	1/1	100	22,300 C	22,300 C	22,300	na	ng/kg ww
PCB-181	1/1	100	65.3	65.3	65.3	na	ng/kg ww
PCB-182	1/1	100	112	112	112	na	ng/kg ww
PCB-183	1/1	100	8,200 C	8,200 C	8,200	na	ng/kg ww
PCB-184	1/1	100	6.51	6.51	6.51	na	ng/kg ww
PCB-185	1/1	100	C183	C183	nc	na	ng/kg ww
PCB-186	0/1	0	nd	nd	0.315	0.629	ng/kg ww
PCB-187	1/1	100	11,700	11,700	11,700	na	ng/kg ww
PCB-188	1/1	100	22.0	22.0	22.0	na	ng/kg ww
PCB-189	1/1	100	252	252	252	na	ng/kg ww
PCB-190	1/1	100	2,010	2,010	2,010	na	ng/kg ww
PCB-191	1/1	100	444	444	444	na	ng/kg ww
PCB-192	0/1	0	nd	nd	0.353	0.705	ng/kg ww
PCB-193	1/1	100	C180	C180	nc	na	ng/kg ww
PCB-194	1/1	100	2,680	2,680	2,680	na	ng/kg ww
PCB-195	1/1	100	1,210	1,210	1,210	na	ng/kg ww

Table E.6.3-22, cont. Summary statistics for starry flounder, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-196	1/1	100	1,760	1,760	1,760	na	ng/kg ww
PCB-197	1/1	100	365 C	365 C	365	na	ng/kg ww
PCB-198	1/1	100	2,910 C	2,910 C	2,910	na	ng/kg ww
PCB-199	1/1	100	C198	C198	nc	na	ng/kg ww
PCB-200	1/1	100	C197	C197	nc	na	ng/kg ww
PCB-201	1/1	100	432	432	432	na	ng/kg ww
PCB-202	1/1	100	845	845	845	na	ng/kg ww
PCB-203	1/1	100	2,570	2,570	2,570	na	ng/kg ww
PCB-204	1/1	100	1.27 J	1.27 J	1.27	na	ng/kg ww
PCB-205	1/1	100	159	159	159	na	ng/kg ww
PCB-206	1/1	100	632	632	632	na	ng/kg ww
PCB-207	1/1	100	89.9	89.9	89.9	na	ng/kg ww
PCB-208	1/1	100	163	163	163	na	ng/kg ww
PCB-209	1/1	100	109	109	109	na	ng/kg ww
Total PCB congeners	1/1	100	458,000 J	458,000 J	458,000	nc	ng/kg ww
Aroclor-1016	0/3	0	nd	nd	7.5	15	µg/kg ww
Aroclor-1221	0/3	0	nd	nd	15	29	µg/kg ww
Aroclor-1232	0/3	0	nd	nd	7.5	15	µg/kg ww
Aroclor-1242	0/3	0	nd	nd	7.5	15	µg/kg ww
Aroclor-1248	3/3	100	96	120	110	na	µg/kg ww
Aroclor-1254	3/3	100	170	250	220	na	µg/kg ww
Aroclor-1260	3/3	100	180	290	240	na	µg/kg ww
Total PCBs	3/3	100	450	660	570	nc	µg/kg ww
PCB TEQ – Bird	1/1	100	18.60 J	18.60 J	18.6	na	ng/kg ww
PCB TEQ – Fish	1/1	100	0.3610 J	0.3610 J	0.361	na	ng/kg ww
PCB TEQ – Mammal	1/1	100	4.14 J	4.14 J	4.14	na	ng/kg ww
Pesticides							
2,4'-DDD	0/3	0	nd	nd	3.6	7.2	µg/kg ww
2,4'-DDE	1/3	33	5.1 JN	5.1 JN	4.1	7.2	µg/kg ww
2,4'-DDT	3/3	100	23 JN	40 JN	31	na	µg/kg ww
4,4'-DDD	3/3	100	3.4 JN	4.4 JN	4.0	na	µg/kg ww
4,4'-DDE	3/3	100	6.7 JN	8.6 JN	7.9	na	µg/kg ww
4,4'-DDT	3/3	100	18 JN	27 JN	23	na	µg/kg ww
Total DDTs	3/3	100	51 JN	80 JN	68	nc	µg/kg ww
Aldrin	0/3	0	nd	nd	3.6	7.2	µg/kg ww
Dieldrin	0/3	0	nd	nd	3.6	7.2	µg/kg ww
Total aldrin/dieldrin	0/3	0	nd	nd	3.6	nc	µg/kg ww

Table E.6.3-22, cont. Summary statistics for starry flounder, whole body

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
alpha-BHC	0/3	0	nd	nd	3.6	7.2	µg/kg ww
beta-BHC	1/3	33	4.0 JN	4.0 JN	3.7	7.2	µg/kg ww
gamma-BHC	0/3	0	nd	nd	3.6	7.2	µg/kg ww
delta-BHC	0/3	0	nd	nd	3.6	7.2	µg/kg ww
alpha-Chlordane	0/3	0	nd	nd	3.6	7.2	µg/kg ww
gamma-Chlordane	3/3	100	6.3 JN	11 JN	8.3	na	µg/kg ww
alpha-Endosulfan	0/3	0	nd	nd	3.6	7.2	µg/kg ww
beta-Endosulfan	0/3	0	nd	nd	3.6	7.2	µg/kg ww
Endosulfan sulfate	0/3	0	nd	nd	3.6	7.2	µg/kg ww
Endrin	2/3	67	0.86 JN	2.8 JN	2.4	7.2	µg/kg ww
Endrin aldehyde	1/3	33	7.1 JN	7.1 JN	4.8	7.2	µg/kg ww
Endrin ketone	0/3	0	nd	nd	3.6	7.2	µg/kg ww
Heptachlor	0/3	0	nd	nd	3.6	7.2	µg/kg ww
Heptachlor epoxide	1/3	33	7.9 JN	7.9 JN	5.0	7.2	µg/kg ww
Methoxychlor	0/3	0	nd	nd	3.6	7.2	µg/kg ww
Mirex	0/3	0	nd	nd	3.6	7.2	µg/kg ww
Toxaphene	0/3	0	nd	nd	180	360	µg/kg ww
Total chlordane	3/3	100	6.3 JN	11 JN	8.3	nc	µg/kg ww
Conventional parameters							
Total solids	3/3	100	22.2	22.9	22.6	na	% ww
Lipid	3/3	100	2.1	2.5	2.2	na	% ww

Table E.6.3-23. Summary statistics for striped perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Metals and trace elements							
Antimony	0/1	0	nd	nd	0.00570	0.0114	mg/kg ww
Arsenic	1/1	100	0.274	0.274	0.274	na	mg/kg ww
Arsenic (inorganic)	0/1	0	nd	nd	0.0050	0.010	mg/kg ww
Cadmium	0/1	0	nd	nd	0.0023	0.0046	mg/kg ww
Chromium	0/1	0	nd	nd	0.055	0.11	mg/kg ww
Cobalt	1/1	100	0.0071	0.0071	0.0071	na	mg/kg ww
Copper	1/1	100	1.250	1.250	1.250	na	mg/kg ww
Lead	1/1	100	0.023	0.023	0.023	na	mg/kg ww
Mercury	3/3	100	0.020 J	0.053	0.034	na	mg/kg ww
Molybdenum	1/1	100	0.0025 J	0.0025 J	0.0025	na	mg/kg ww
Nickel	1/1	100	0.064	0.064	0.064	na	mg/kg ww
Selenium	1/1	100	0.10	0.10	0.10	na	mg/kg ww
Silver	0/1	0	nd	nd	0.0023	0.0046	mg/kg ww
Thallium	0/1	0	nd	nd	0.0023	0.0046	mg/kg ww
Vanadium	0/1	0	nd	nd	0.1	0.2	mg/kg ww
Zinc	1/1	100	9.33	9.33	9.33	na	mg/kg ww
Organometals							
Monobutyltin as ion	0/1	0	nd	nd	0.75	1.5	µg/kg ww
Dibutyltin as ion	1/1	100	1.3 J	1.3 J	1.3	na	µg/kg ww
Tributyltin as ion	3/3	100	7.0	16 J	11	na	µg/kg ww
Tetrabutyltin as ion	0/1	0	nd	nd	0.75	1.5	µg/kg ww
PAHs							
2-Chloronaphthalene	0/1	0	nd	nd	290	580	µg/kg ww
2-Methylnaphthalene	1/1	100	0.94 J	0.94 J	0.94	na	µg/kg ww
Acenaphthene	1/1	100	2.8	2.8	2.8	na	µg/kg ww
Acenaphthylene	0/1	0	nd	nd	0.13	0.26	µg/kg ww
Anthracene	0/1	0	nd	nd	0.21	0.41	µg/kg ww
Benzo(a)anthracene	1/1	100	0.069 J	0.069 J	0.069	na	µg/kg ww

Table E.6.3-23, cont. Summary statistics for striped perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Benzo(a)pyrene	0/1	0	nd	nd	0.25	0.50	µg/kg ww
Benzo(b)fluoranthene	0/1	0	nd	nd	0.25	0.50	µg/kg ww
Benzo(g,h,i)perylene	0/1	0	nd	nd	0.25	0.50	µg/kg ww
Benzo(k)fluoranthene	0/1	0	nd	nd	0.25	0.50	µg/kg ww
Total benzofluoranthenes	0/1	0	nd	nd	0.25	nc	µg/kg ww
Chrysene	1/1	100	0.14 J	0.14 J	0.14	na	µg/kg ww
Dibenzo(a,h)anthracene	0/1	0	nd	nd	0.25	0.50	µg/kg ww
Dibenzofuran	1/1	100	1.6	1.6	1.6	na	µg/kg ww
Fluoranthene	0/1	0	nd	nd	0.70	1.4	µg/kg ww
Fluorene	1/1	100	1.4	1.4	1.4	na	µg/kg ww
Indeno(1,2,3-cd)pyrene	0/1	0	nd	nd	0.25	0.50	µg/kg ww
Naphthalene	0/1	0	nd	nd	0.65	1.3	µg/kg ww
Phenanthrene	1/1	100	1.9	1.9	1.9	na	µg/kg ww
Pyrene	0/1	0	nd	nd	0.24	0.48	µg/kg ww
Total HPAH	1/1	100	0.21 J	0.21 J	0.21	nc	µg/kg ww
Total LPAH	1/1	100	6.1	6.1	6.1	nc	µg/kg ww
Carcinogenic PAHs – Mammal	1/1	100	0.43 J	0.43 J	0.43	na	µg/kg ww
Total PAH	1/1	100	6.3 J	6.3 J	6.3	nc	µg/kg ww
Phthalates							
Bis(2-ethylhexyl)phthalate	0/1	0	nd	nd	34	67	µg/kg ww
Butyl benzyl phthalate	0/1	0	nd	nd	600	1,200	µg/kg ww
Diethyl phthalate	0/1	0	nd	nd	600	1,200	µg/kg ww
Dimethyl phthalate	0/1	0	nd	nd	290	580	µg/kg ww
Di-n-butyl phthalate	0/1	0	nd	nd	210	410	µg/kg ww
Di-n-octyl phthalate	0/1	0	nd	nd	1,500	2,900	µg/kg ww
Other SVOCs							
1,2,4-Trichlorobenzene	0/1	0	nd	nd	290	580	µg/kg ww
1,2-Dichlorobenzene	0/1	0	nd	nd	290	580	µg/kg ww
1,3-Dichlorobenzene	0/1	0	nd	nd	290	580	µg/kg ww
1,4-Dichlorobenzene	0/1	0	nd	nd	290	580	µg/kg ww
2,4,5-Trichlorophenol	0/1	0	nd	nd	1,500	2,900	µg/kg ww

Table E.6.3-23, cont. Summary statistics for striped perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
2,4,6-Trichlorophenol	0/1	0	nd	nd	1,500	2,900	µg/kg ww
2,4-Dichlorophenol	0/1	0	nd	nd	600	1,200	µg/kg ww
2,4-Dimethylphenol	0/1	0	nd	nd	600	1,200	µg/kg ww
2,4-Dinitrophenol	0/1	0	nd	nd	6,000	12,000	µg/kg ww
2,4-Dinitrotoluene	0/1	0	nd	nd	600	1,200	µg/kg ww
2,6-Dinitrotoluene	0/1	0	nd	nd	600	1,200	µg/kg ww
2-Chlorophenol	0/1	0	nd	nd	600	1,200	µg/kg ww
2-Methylphenol	0/1	0	nd	nd	600	1,200	µg/kg ww
2-Nitroaniline	0/1	0	nd	nd	1,500	2,900	µg/kg ww
2-Nitrophenol	0/1	0	nd	nd	1,500	2,900	µg/kg ww
3,3'-Dichlorobenzidine	0/1	0	nd	nd	15,000	29,000	µg/kg ww
3-Nitroaniline	0/1	0	nd	nd	2,900	5,800	µg/kg ww
4,6-Dinitro-o-cresol	0/1	0	nd	nd	2,900	5,800	µg/kg ww
4-Bromophenyl phenyl ether	0/1	0	nd	nd	290	580	µg/kg ww
4-Chloro-3-methylphenol	0/1	0	nd	nd	1,500	2,900	µg/kg ww
4-Chloroaniline	0/1	0	nd	nd	1,500	2,900	µg/kg ww
4-Chlorophenyl phenyl ether	0/1	0	nd	nd	290	580	µg/kg ww
4-Methylphenol	0/1	0	nd	nd	600	1,200	µg/kg ww
4-Nitroaniline	0/1	0	nd	nd	1,500	2,900	µg/kg ww
4-Nitrophenol	0/1	0	nd	nd	2,900	5,800	µg/kg ww
Aniline	0/1	0	nd	nd	6,000	12,000	µg/kg ww
Benzoic acid	0/1	0	nd	nd	6,000	12,000	µg/kg ww
Benzyl alcohol	0/1	0	nd	nd	290	580	µg/kg ww
bis(2-chloroethoxy)methane	0/1	0	nd	nd	290	580	µg/kg ww
bis(2-chloroethyl)ether	0/1	0	nd	nd	290	580	µg/kg ww
bis(2-chloroisopropyl)ether	0/1	0	nd	nd	290	580	µg/kg ww
Carbazole	0/1	0	nd	nd	1,500	2,900	µg/kg ww
Hexachlorobenzene	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Hexachlorobutadiene	0/1	0	nd	nd	290	580	µg/kg ww
Hexachlorocyclopentadiene	0/1	0	nd	nd	36,000	72,000	µg/kg ww
Hexachloroethane	0/1	0	nd	nd	290	580	µg/kg ww

Table E.6.3-23, cont. Summary statistics for striped perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Isophorone	0/1	0	nd	nd	290	580	µg/kg ww
Nitrobenzene	0/1	0	nd	nd	290	580	µg/kg ww
N-Nitrosodimethylamine	0/1	0	nd	nd	1,500	2,900	µg/kg ww
N-Nitroso-di-n-propylamine	0/1	0	nd	nd	290	580	µg/kg ww
N-Nitrosodiphenylamine	0/1	0	nd	nd	290	580	µg/kg ww
Pentachlorophenol	0/1	0	nd	nd	3.4	6.7	µg/kg ww
Phenol	0/1	0	nd	nd	750	1,500	µg/kg ww
Polychlorinated biphenyls							
PCB-001	1/1	100	1.94 J	1.94 J	1.94	na	ng/kg ww
PCB-002	1/1	100	0.525 J	0.525 J	0.525	na	ng/kg ww
PCB-003	1/1	100	0.787 J	0.787 J	0.787	na	ng/kg ww
PCB-004	1/1	100	17.9	17.9	17.9	na	ng/kg ww
PCB-005	1/1	100	0.691 J	0.691 J	0.691	na	ng/kg ww
PCB-006	1/1	100	19.1	19.1	19.1	na	ng/kg ww
PCB-007	1/1	100	2.01 J	2.01 J	2.01	na	ng/kg ww
PCB-008	1/1	100	22.7	22.7	22.7	na	ng/kg ww
PCB-009	1/1	100	7.78	7.78	7.78	na	ng/kg ww
PCB-010	1/1	100	2.51 J	2.51 J	2.51	na	ng/kg ww
PCB-011	1/1	100	4.20 J	4.20 J	4.20	na	ng/kg ww
PCB-012	1/1	100	4.50 CJ	4.50 CJ	4.50	na	ng/kg ww
PCB-013	1/1	100	C12	C12	nc	na	ng/kg ww
PCB-014	0/1	0	nd	nd	0.140	0.280	ng/kg ww
PCB-015	1/1	100	16.9	16.9	16.9	na	ng/kg ww
PCB-016	1/1	100	18.4	18.4	18.4	na	ng/kg ww
PCB-017	1/1	100	95.0	95.0	95.0	na	ng/kg ww
PCB-018	1/1	100	406 C	406 C	406	na	ng/kg ww
PCB-019	1/1	100	30.0	30.0	30.0	na	ng/kg ww
PCB-020	1/1	100	2,850 C	2,850 C	2,850	na	ng/kg ww
PCB-021	1/1	100	131 C	131 C	131	na	ng/kg ww
PCB-022	1/1	100	186	186	186	na	ng/kg ww
PCB-023	1/1	100	1.44 J	1.44 J	1.44	na	ng/kg ww

Table E.6.3-23, cont. Summary statistics for striped perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-024	1/1	100	9.26	9.26	9.26	na	ng/kg ww
PCB-025	1/1	100	405	405	405	na	ng/kg ww
PCB-026	1/1	100	1,120 C	1,120 C	1,120	na	ng/kg ww
PCB-027	1/1	100	46.7	46.7	46.7	na	ng/kg ww
PCB-028	1/1	100	C20	C20	nc	na	ng/kg ww
PCB-029	1/1	100	C26	C26	nc	na	ng/kg ww
PCB-030	1/1	100	C18	C18	nc	na	ng/kg ww
PCB-031	1/1	100	1,820	1,820	1,820	na	ng/kg ww
PCB-032	1/1	100	296	296	296	na	ng/kg ww
PCB-033	1/1	100	C21	C21	nc	na	ng/kg ww
PCB-034	1/1	100	12.1	12.1	12.1	na	ng/kg ww
PCB-035	0/1	0	nd	nd	0.422	0.844	ng/kg ww
PCB-036	0/1	0	nd	nd	0.392	0.784	ng/kg ww
PCB-037	1/1	100	129	129	129	na	ng/kg ww
PCB-038	1/1	100	1.64 J	1.64 J	1.64	na	ng/kg ww
PCB-039	1/1	100	4.49 J	4.49 J	4.49	na	ng/kg ww
PCB-040	1/1	100	517 C	517 C	517	na	ng/kg ww
PCB-041	1/1	100	C40	C40	nc	na	ng/kg ww
PCB-042	1/1	100	293	293	293	na	ng/kg ww
PCB-043	0/1	0	nd	nd	0.105	0.209	ng/kg ww
PCB-044	1/1	100	3,390 C	3,390 C	3,390	na	ng/kg ww
PCB-045	1/1	100	203 C	203 C	203	na	ng/kg ww
PCB-046	1/1	100	32.6	32.6	32.6	na	ng/kg ww
PCB-047	1/1	100	C44	C44	nc	na	ng/kg ww
PCB-048	1/1	100	247	247	247	na	ng/kg ww
PCB-049	1/1	100	5,410 C	5,410 C	5,410	na	ng/kg ww
PCB-050	1/1	100	325 C	325 C	325	na	ng/kg ww
PCB-051	1/1	100	C45	C45	nc	na	ng/kg ww
PCB-052	1/1	100	13,600	13,600	13,600	na	ng/kg ww
PCB-053	1/1	100	C50	C50	nc	na	ng/kg ww
PCB-054	1/1	100	5.25	5.25	5.25	na	ng/kg ww

Table E.6.3-23, cont. Summary statistics for striped perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-055	0/1	0	nd	nd	2.48	4.95	ng/kg ww
PCB-056	1/1	100	332	332	332	na	ng/kg ww
PCB-057	1/1	100	111	111	111	na	ng/kg ww
PCB-058	1/1	100	50.7	50.7	50.7	na	ng/kg ww
PCB-059	1/1	100	511 C	511 C	511	na	ng/kg ww
PCB-060	1/1	100	932	932	932	na	ng/kg ww
PCB-061	1/1	100	9,710 C	9,710 C	9,710	na	ng/kg ww
PCB-062	1/1	100	C59	C59	nc	na	ng/kg ww
PCB-063	1/1	100	400	400	400	na	ng/kg ww
PCB-064	1/1	100	1,820	1,820	1,820	na	ng/kg ww
PCB-065	1/1	100	C44	C44	nc	na	ng/kg ww
PCB-066	1/1	100	6,150	6,150	6,150	na	ng/kg ww
PCB-067	1/1	100	148	148	148	na	ng/kg ww
PCB-068	1/1	100	215	215	215	na	ng/kg ww
PCB-069	1/1	100	C49	C49	nc	na	ng/kg ww
PCB-070	1/1	100	C61	C61	nc	na	ng/kg ww
PCB-071	1/1	100	C40	C40	nc	na	ng/kg ww
PCB-072	1/1	100	367	367	367	na	ng/kg ww
PCB-073	0/1	0	nd	nd	0.0710	0.142	ng/kg ww
PCB-074	1/1	100	C61	C61	nc	na	ng/kg ww
PCB-075	1/1	100	C59	C59	nc	na	ng/kg ww
PCB-076	1/1	100	C61	C61	nc	na	ng/kg ww
PCB-077	1/1	100	193	193	193	na	ng/kg ww
PCB-078	0/1	0	nd	nd	2.55	5.10	ng/kg ww
PCB-079	1/1	100	139	139	139	na	ng/kg ww
PCB-080	0/1	0	nd	nd	2.38	4.76	ng/kg ww
PCB-081	1/1	100	25.3 J	25.3 J	25.3	na	ng/kg ww
PCB-082	1/1	100	193	193	193	na	ng/kg ww
PCB-083	1/1	100	21,400 C	21,400 C	21,400	na	ng/kg ww
PCB-084	1/1	100	921	921	921	na	ng/kg ww
PCB-085	1/1	100	1,850 C	1,850 C	1,850	na	ng/kg ww

Table E.6.3-23, cont. Summary statistics for striped perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-086	1/1	100	7,510 C	7,510 C	7,510	na	ng/kg ww
PCB-087	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-088	1/1	100	2,070 C	2,070 C	2,070	na	ng/kg ww
PCB-089	1/1	100	13.7	13.7	13.7	na	ng/kg ww
PCB-090	1/1	100	23,600 C	23,600 C	23,600	na	ng/kg ww
PCB-091	1/1	100	C88	C88	nc	na	ng/kg ww
PCB-092	1/1	100	5,420	5,420	5,420	na	ng/kg ww
PCB-093	1/1	100	8,300 C	8,300 C	8,300	na	ng/kg ww
PCB-094	1/1	100	11.6	11.6	11.6	na	ng/kg ww
PCB-095	1/1	100	C93	C93	nc	na	ng/kg ww
PCB-096	1/1	100	26.7	26.7	26.7	na	ng/kg ww
PCB-097	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-098	1/1	100	C93	C93	nc	na	ng/kg ww
PCB-099	1/1	100	C83	C83	nc	na	ng/kg ww
PCB-100	1/1	100	C93	C93	nc	na	ng/kg ww
PCB-101	1/1	100	C90	C90	nc	na	ng/kg ww
PCB-102	1/1	100	C93	C93	nc	na	ng/kg ww
PCB-103	1/1	100	121	121	121	na	ng/kg ww
PCB-104	1/1	100	2.00 J	2.00 J	2.00	na	ng/kg ww
PCB-105	1/1	100	8,730	8,730	8,730	na	ng/kg ww
PCB-106	0/1	0	nd	nd	3.18	6.35	ng/kg ww
PCB-107	1/1	100	605 C	605 C	605	na	ng/kg ww
PCB-108	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-109	1/1	100	2,220	2,220	2,220	na	ng/kg ww
PCB-110	1/1	100	15,700 C	15,700 C	15,700	na	ng/kg ww
PCB-111	1/1	100	37.6	37.6	37.6	na	ng/kg ww
PCB-112	0/1	0	nd	nd	1.64	3.27	ng/kg ww
PCB-113	1/1	100	C90	C90	nc	na	ng/kg ww
PCB-114	1/1	100	545	545	545	na	ng/kg ww
PCB-115	1/1	100	C110	C110	nc	na	ng/kg ww
PCB-116	1/1	100	C85	C85	nc	na	ng/kg ww

Table E.6.3-23, cont. Summary statistics for striped perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-117	1/1	100	C85	C85	nc	na	ng/kg ww
PCB-118	1/1	100	28,300	28,300	28,300	na	ng/kg ww
PCB-119	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-120	1/1	100	209	209	209	na	ng/kg ww
PCB-121	1/1	100	16.8	16.8	16.8	na	ng/kg ww
PCB-122	1/1	100	127	127	127	na	ng/kg ww
PCB-123	1/1	100	489	489	489	na	ng/kg ww
PCB-124	1/1	100	C107	C107	nc	na	ng/kg ww
PCB-125	1/1	100	C86	C86	nc	na	ng/kg ww
PCB-126	1/1	100	50.4	50.4	50.4	na	ng/kg ww
PCB-127	1/1	100	57.8	57.8	57.8	na	ng/kg ww
PCB-128	1/1	100	4,330 C	4,330 C	4,330	na	ng/kg ww
PCB-129	1/1	100	50,800 C	50,800 C	50,800	na	ng/kg ww
PCB-130	1/1	100	2,370	2,370	2,370	na	ng/kg ww
PCB-131	1/1	100	77.8	77.8	77.8	na	ng/kg ww
PCB-132	1/1	100	3,630	3,630	3,630	na	ng/kg ww
PCB-133	1/1	100	904	904	904	na	ng/kg ww
PCB-134	1/1	100	834 C	834 C	834	na	ng/kg ww
PCB-135	1/1	100	10,700 C	10,700 C	10,700	na	ng/kg ww
PCB-136	1/1	100	1,420	1,420	1,420	na	ng/kg ww
PCB-137	1/1	100	1,880	1,880	1,880	na	ng/kg ww
PCB-138	1/1	100	C129	C129	nc	na	ng/kg ww
PCB-139	1/1	100	660 C	660 C	660	na	ng/kg ww
PCB-140	1/1	100	C139	C139	nc	na	ng/kg ww
PCB-141	1/1	100	4,830	4,830	4,830	na	ng/kg ww
PCB-142	0/1	0	nd	nd	6.55	13.1	ng/kg ww
PCB-143	1/1	100	C134	C134	nc	na	ng/kg ww
PCB-144	1/1	100	691	691	691	na	ng/kg ww
PCB-145	1/1	100	5.80	5.80	5.80	na	ng/kg ww
PCB-146	1/1	100	8,770	8,770	8,770	na	ng/kg ww
PCB-147	1/1	100	17,100 C	17,100 C	17,100	na	ng/kg ww

Table E.6.3-23, cont. Summary statistics for striped perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-148	1/1	100	136	136	136	na	ng/kg ww
PCB-149	1/1	100	C147	C147	nc	na	ng/kg ww
PCB-150	1/1	100	36.4	36.4	36.4	na	ng/kg ww
PCB-151	1/1	100	C135	C135	nc	na	ng/kg ww
PCB-152	1/1	100	10.3	10.3	10.3	na	ng/kg ww
PCB-153	1/1	100	47,800 C	47,800 C	47,800	na	ng/kg ww
PCB-154	1/1	100	C135	C135	nc	na	ng/kg ww
PCB-155	1/1	100	5.20	5.20	5.20	na	ng/kg ww
PCB-156	1/1	100	3,990 C	3,990 C	3,990	na	ng/kg ww
PCB-157	1/1	100	C156	C156	nc	na	ng/kg ww
PCB-158	1/1	100	4,810	4,810	4,810	na	ng/kg ww
PCB-159	1/1	100	114	114	114	na	ng/kg ww
PCB-160	1/1	100	C129	C129	nc	na	ng/kg ww
PCB-161	0/1	0	nd	nd	4.75	9.50	ng/kg ww
PCB-162	1/1	100	116	116	116	na	ng/kg ww
PCB-163	1/1	100	C129	C129	nc	na	ng/kg ww
PCB-164	1/1	100	1,950	1,950	1,950	na	ng/kg ww
PCB-165	1/1	100	31.0	31.0	31.0	na	ng/kg ww
PCB-166	1/1	100	C128	C128	nc	na	ng/kg ww
PCB-167	1/1	100	1,500	1,500	1,500	na	ng/kg ww
PCB-168	1/1	100	C153	C153	nc	na	ng/kg ww
PCB-169	0/1	0	nd	nd	14.0	28.0	ng/kg ww
PCB-170	1/1	100	9,650	9,650	9,650	na	ng/kg ww
PCB-171	1/1	100	3,000 C	3,000 C	3,000	na	ng/kg ww
PCB-172	1/1	100	1,430	1,430	1,430	na	ng/kg ww
PCB-173	1/1	100	C171	C171	nc	na	ng/kg ww
PCB-174	1/1	100	2,650	2,650	2,650	na	ng/kg ww
PCB-175	1/1	100	443	443	443	na	ng/kg ww
PCB-176	1/1	100	379	379	379	na	ng/kg ww
PCB-177	1/1	100	5,380	5,380	5,380	na	ng/kg ww
PCB-178	1/1	100	2,350	2,350	2,350	na	ng/kg ww

Table E.6.3-23, cont. Summary statistics for striped perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-179	1/1	100	2,260	2,260	2,260	na	ng/kg ww
PCB-180	1/1	100	24,400 C	24,400 C	24,400	na	ng/kg ww
PCB-181	1/1	100	61.2	61.2	61.2	na	ng/kg ww
PCB-182	1/1	100	111	111	111	na	ng/kg ww
PCB-183	1/1	100	7,930 C	7,930 C	7,930	na	ng/kg ww
PCB-184	1/1	100	6.55	6.55	6.55	na	ng/kg ww
PCB-185	1/1	100	C183	C183	nc	na	ng/kg ww
PCB-186	0/1	0	nd	nd	0.207	0.413	ng/kg ww
PCB-187	1/1	100	15,800	15,800	15,800	na	ng/kg ww
PCB-188	1/1	100	21.6	21.6	21.6	na	ng/kg ww
PCB-189	1/1	100	291	291	291	na	ng/kg ww
PCB-190	1/1	100	2,150	2,150	2,150	na	ng/kg ww
PCB-191	1/1	100	491	491	491	na	ng/kg ww
PCB-192	0/1	0	nd	nd	0.232	0.463	ng/kg ww
PCB-193	1/1	100	C180	C180	nc	na	ng/kg ww
PCB-194	1/1	100	2,670	2,670	2,670	na	ng/kg ww
PCB-195	1/1	100	1,280	1,280	1,280	na	ng/kg ww
PCB-196	1/1	100	1,780	1,780	1,780	na	ng/kg ww
PCB-197	1/1	100	270 C	270 C	270	na	ng/kg ww
PCB-198	1/1	100	2,490 C	2,490 C	2,490	na	ng/kg ww
PCB-199	1/1	100	C198	C198	nc	na	ng/kg ww
PCB-200	1/1	100	C197	C197	nc	na	ng/kg ww
PCB-201	1/1	100	493	493	493	na	ng/kg ww
PCB-202	1/1	100	681	681	681	na	ng/kg ww
PCB-203	1/1	100	2,230	2,230	2,230	na	ng/kg ww
PCB-204	1/1	100	0.842 J	0.842 J	0.842	na	ng/kg ww
PCB-205	1/1	100	131	131	131	na	ng/kg ww
PCB-206	1/1	100	462	462	462	na	ng/kg ww
PCB-207	1/1	100	79.2	79.2	79.2	na	ng/kg ww
PCB-208	1/1	100	72.5	72.5	72.5	na	ng/kg ww
PCB-209	1/1	100	38.1	38.1	38.1	na	ng/kg ww

Table E.6.3-23, cont. Summary statistics for striped perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
Total PCB congeners	1/1	100	442,300 J	442,300 J	442,000	nc	ng/kg ww
Aroclor-1016	0/1	0	nd	nd	7.5	15	µg/kg ww
Aroclor-1016/1242	2/2	100	7.4 J	9.4 J	8.4	na	µg/kg ww
Aroclor-1221	0/1	0	nd	nd	15	29	µg/kg ww
Aroclor-1232	0/1	0	nd	nd	7.5	15	µg/kg ww
Aroclor-1242	0/1	0	nd	nd	7.5	15	µg/kg ww
Aroclor-1248	1/3	33	98	98	33	0.34 – 0.46	µg/kg ww
Aroclor-1254	3/3	100	76 J	220	130	na	µg/kg ww
Aroclor-1260	3/3	100	80 J	310	160	na	µg/kg ww
Total PCBs	3/3	100	164 J	630	320	nc	µg/kg ww
PCB TEQ – Bird	1/1	100	18.90 J	18.90 J	18.9	na	ng/kg ww
PCB TEQ – Fish	1/1	100	0.5040 J	0.5040 J	0.504	na	ng/kg ww
PCB TEQ – Mammal	1/1	100	6.80 J	6.80 J	6.80	na	ng/kg ww
Pesticides							
2,4'-DDD	0/1	0	nd	nd	3.6	7.2	µg/kg ww
2,4'-DDE	0/1	0	nd	nd	3.6	7.2	µg/kg ww
2,4'-DDT	1/1	100	13 JN	13 JN	13	na	µg/kg ww
4,4'-DDD	0/1	0	nd	nd	3.6	7.2	µg/kg ww
4,4'-DDE	1/1	100	1.5 JN	1.5 JN	1.5	na	µg/kg ww
4,4'-DDT	1/1	100	11 JN	11 JN	11	na	µg/kg ww
Total DDTs	1/1	100	26 JN	26 JN	26	nc	µg/kg ww
Aldrin	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Dieldrin	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Total aldrin/dieldrin	0/1	0	nd	nd	3.6	nc	µg/kg ww
alpha-BHC	0/1	0	nd	nd	3.6	7.2	µg/kg ww
beta-BHC	0/1	0	nd	nd	3.6	7.2	µg/kg ww
gamma-BHC	0/1	0	nd	nd	3.6	7.2	µg/kg ww
delta-BHC	0/1	0	nd	nd	3.6	7.2	µg/kg ww
alpha-Chlordane	0/1	0	nd	nd	3.6	7.2	µg/kg ww
gamma-Chlordane	1/1	100	5.9 JN	5.9 JN	5.9	na	µg/kg ww
alpha-Endosulfan	0/1	0	nd	nd	3.6	7.2	µg/kg ww

Table E.6.3-23, cont. Summary statistics for striped perch, fillet with skin

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
beta-Endosulfan	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Endosulfan sulfate	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Endrin	1/1	100	2.4 JN	2.4 JN	2.4	na	µg/kg ww
Endrin aldehyde	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Endrin ketone	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Heptachlor	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Heptachlor epoxide	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Methoxychlor	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Mirex	0/1	0	nd	nd	3.6	7.2	µg/kg ww
Toxaphene	0/1	0	nd	nd	180	360	µg/kg ww
Total chlordane	1/1	100	5.9 JN	5.9 JN	5.9	nc	µg/kg ww
Conventional parameters							
Total solids	1/1	100	22.9	22.9	22.9	na	% ww
Lipid	1/1	100	1.4	1.4	1.4	na	% ww

E.6.4 SURFACE WATER

Table E.6.4-1. Summary statistics for surface water

Location ID and Chemical	Detection Frequency		Concentration					Criteria		Comparison to WQS			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	Chronic WQS	Acute WQS	Detect > Chronic and ≤Acute	Detect > Acute	Nondetect > Chronic and ≤ Acute	Nondetect > Acute
Brandon													
Metals and trace elements													
Antimony (dissolved)	71/71	100	0.013	0.116	0.051	na	µg/L	na	na	na	na	na	na
Antimony (total)	150/166	90	0.011	0.131	0.039	0.0097 – 0.011	µg/L	na	na	na	na	na	na
Arsenic (dissolved)	72/72	100	0.237	1.46	0.855	na	µg/L	36	69	0	0	0	0
Arsenic (total)	167/167	100	0.292	1.53	0.931	na	µg/L	na	na	na	na	na	na
Beryllium (dissolved)	0/66	0	nd	nd	0.0074	0.013 – 0.016	µg/L	na	na	na	na	na	na
Beryllium (total)	14/161	9	0.016	0.027	0.0087	0.013 – 0.016	µg/L	na	na	na	na	na	na
Cadmium (dissolved)	72/72	100	0.011	0.0755	0.047	na	µg/L	9.3	42	0	0	0	0
Cadmium (total)	173/173	100	0.0088	0.0780	0.047	na	µg/L	na	na	na	na	na	na
Chromium (dissolved)	68/68	100	0.11 J	0.576 J	0.28	na	µg/L	50	1,100	0	0	0	0
Chromium (total)	165/165	100	0.240 J	1.74 J	0.571	na	µg/L	na	na	na	na	na	na
Cobalt (dissolved)	72/72	100	0.021	0.141	0.052	na	µg/L	na	na	na	na	na	na
Cobalt (total)	155/155	100	0.0334	0.575	0.178	na	µg/L	na	na	na	na	na	na
Copper (dissolved)	65/65	100	0.384 J	1.54 J	0.661	na	µg/L	3.1	4.8	0	0	0	0
Copper (total)	166/166	100	0.536 J	5.83 J	1.42	na	µg/L	na	na	na	na	na	na
Lead (dissolved)	70/70	100	0.010 J	0.553 J	0.042	na	µg/L	8.1	210	0	0	0	0
Lead (total)	171/171	100	0.0459 J	1.45 J	0.345	na	µg/L	na	na	na	na	na	na
Mercury (dissolved)	8/9	89	0.00013	0.00051	0.0003	0.0001	µg/L	0.025	1.8	0	0	0	0
Mercury (total)	9/15	60	0.00056	0.00336	0.041	0.20	µg/L	na	na	na	na	na	na
Nickel (dissolved)	61/65	94	0.274 J	0.910 J	0.386	0.154 – 0.387	µg/L	8.2	74	0	0	0	0
Nickel (total)	145/147	99	0.394 J	2.11 J	0.672	0.348 – 0.386	µg/L	na	na	na	na	na	na
Selenium (dissolved)	1/66	2	0.16	0.16	0.075	0.13 – 0.16	µg/L	na	na	na	na	na	na
Selenium (total)	3/151	2	0.15	0.27	0.077	0.13 – 0.16	µg/L	na	na	na	na	na	na
Silver (dissolved)	0/72	0	nd	nd	0.060	0.11 – 0.13	µg/L	nv	1.9	na	0	na	0
Silver (total)	0/173	0	nd	nd	0.060	0.10 – 0.13	µg/L	nv	1.9	na	0	na	0
Thallium (dissolved)	40/72	56	0.0050	0.011	0.0064	0.0046 – 0.0053	µg/L	na	na	na	na	na	na
Thallium (total)	121/173	70	0.0049	0.013	0.0069	0.0044 – 0.0053	µg/L	na	na	na	na	na	na
Vanadium (dissolved)	50/50	100	0.193	1.57	0.978	na	µg/L	na	na	na	na	na	na
Vanadium (Total)	133/133	100	0.267	2.96	1.36	na	µg/L	na	na	na	na	na	na

Table E.6.4-1, cont. Summary statistics for surface water

Location ID and Chemical	Detection Frequency		Concentration					Criteria		Comparison to WQS			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	Chronic WQS	Acute WQS	Detect > Chronic and ≤Acute	Detect > Acute	Nondetect > Chronic and ≤ Acute	Nondetect > Acute
Zinc (dissolved)	72/72	100	0.750 J	5.39 J	2.16	na	µg/L	81	90	0	0	0	0
Zinc (total)	173/173	100	0.70 J	8.34 J	2.8	na	µg/L	na	na	na	na	na	na
PAHs													
2-Chloronaphthalene	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
2-Methylnaphthalene	0/39	0	nd	nd	0.19	0.38 – 0.39	µg/L	na	na	na	na	na	na
Acenaphthene	0/39	0	nd	nd	0.047	0.094 – 0.097	µg/L	na	na	na	na	na	na
Acenaphthylene	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Anthracene	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Benzo(a)anthracene	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Benzo(a)pyrene	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Benzo(b)fluoranthene	0/39	0	nd	nd	0.19	0.38 – 0.39	µg/L	na	na	na	na	na	na
Benzo(g,h,i)perylene	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Benzo(k)fluoranthene	0/39	0	nd	nd	0.19	0.38 – 0.39	µg/L	na	na	na	na	na	na
Benzofluoranthenes (total-calc'd)	0/39	0	nd	nd	0.19	nc	µg/L	na	na	na	na	na	na
Chrysene	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Dibenzo(a,h)anthracene	0/39	0	nd	nd	0.19	0.38 – 0.39	µg/L	na	na	na	na	na	na
Dibenzofuran	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Fluoranthene	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Fluorene	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Indeno(1,2,3-cd)pyrene	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Naphthalene	0/39	0	nd	nd	0.19	0.38 – 0.39	µg/L	na	na	na	na	na	na
Phenanthrene	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Pyrene	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Total HPAH	0/39	0	nd	nd	0.19	nc	µg/L	na	na	na	na	na	na
Total LPAH	0/39	0	nd	nd	0.19	nc	µg/L	na	na	na	na	na	na
Carcinogenic PAHs - Mammal	0/39	0	nd	nd	0.13	0.25 – 0.26	µg/L	na	na	na	na	na	na
Total PAH	0/39	0	nd	nd	0.19	nc	µg/L	na	na	na	na	na	na
Phthalates													
Bis(2-ethylhexyl)phthalate	7/39	18	0.21	3.51	0.43	0.14 – 1.31	µg/L	na	na	na	na	na	na
Butyl benzyl phthalate	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Diethyl phthalate	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Dimethyl phthalate	0/39	0	nd	nd	0.047	0.094 – 0.097	µg/L	na	na	na	na	na	na
Di-n-butyl phthalate	2/39	5	0.25	0.26	0.13	0.24	µg/L	na	na	na	na	na	na
Di-n-octyl phthalate	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na

Table E.6.4-1, cont. Summary statistics for surface water

Location ID and Chemical	Detection Frequency		Concentration					Criteria		Comparison to WQS			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	Chronic WQS	Acute WQS	Detect > Chronic and ≤Acute	Detect > Acute	Nondetect > Chronic and ≤ Acute	Nondetect > Acute
Other SVOCs													
1,2,4-Trichlorobenzene	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
1,2-Dichlorobenzene	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
1,2-Diphenylhydrazine	0/39	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
1,3-Dichlorobenzene	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
1,4-Dichlorobenzene	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
2,4,5-Trichlorophenol	0/39	0	nd	nd	0.47	0.94 – 0.97	µg/L	na	na	na	na	na	na
2,4,6-Trichlorophenol	0/39	0	nd	nd	0.47	0.94 – 0.97	µg/L	na	na	na	na	na	na
2,4-Dichlorophenol	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
2,4-Dimethylphenol	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
2,4-Dinitrophenol	0/39	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
2,4-Dinitrotoluene	0/39	0	nd	nd	0.047	0.094 – 0.097	µg/L	na	na	na	na	na	na
2,6-Dinitrotoluene	0/39	0	nd	nd	0.047	0.094 – 0.097	µg/L	na	na	na	na	na	na
2-Chlorophenol	0/39	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
2-Methylphenol	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
2-Nitroaniline	0/39	0	nd	nd	0.47	0.94 – 0.97	µg/L	na	na	na	na	na	na
2-Nitrophenol	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
3,3'-Dichlorobenzidine	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
3-Nitroaniline	0/39	0	nd	nd	0.47	0.94 – 0.97	µg/L	na	na	na	na	na	na
4,6-Dinitro-o-cresol	0/39	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
4-Bromophenyl phenyl ether	0/39	0	nd	nd	0.047	0.094 – 0.097	µg/L	na	na	na	na	na	na
4-Chloro-3-methylphenol	0/39	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
4-Chloroaniline	0/39	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
4-Chlorophenyl phenyl ether	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
4-Methylphenol	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
4-Nitroaniline	0/39	0	nd	nd	0.47	0.94 – 0.97	µg/L	na	na	na	na	na	na
4-Nitrophenol	0/39	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
Aniline	0/39	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
Benzidine	0/39	0	nd	nd	2.9	5.7 – 5.8	µg/L	na	na	na	na	na	na
Benzoic acid	5/39	13	0.98	1.4	0.56	0.94 – 0.97	µg/L	na	na	na	na	na	na
Benzyl alcohol	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
bis(2-chloroethoxy)methane	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
bis(2-chloroethyl)ether	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
bis(2-chloroisopropyl)ether	0/39	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
Caffeine	3/39	8	0.052	0.083	0.027	0.047 – 0.049	µg/L	na	na	na	na	na	na

Table E.6.4-1, cont. Summary statistics for surface water

Location ID and Chemical	Detection Frequency		Concentration					Criteria		Comparison to WQS			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	Chronic WQS	Acute WQS	Detect > Chronic and ≤Acute	Detect > Acute	Nondetect > Chronic and ≤ Acute	Nondetect > Acute
Carbazole	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Coprostanol	0/39	0	nd	nd	0.47	0.94 – 0.97	µg/L	na	na	na	na	na	na
Hexachlorobenzene	0/39	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Hexachlorobutadiene	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Hexachlorocyclopentadiene	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Hexachloroethane	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Isophorone	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Nitrobenzene	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
N-Nitrosodimethylamine	0/39	0	nd	nd	0.47	0.94 – 0.97	µg/L	na	na	na	na	na	na
N-Nitroso-di-n-propylamine	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
N-Nitrosodiphenylamine	0/39	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Pentachlorophenol	0/39	0	nd	nd	0.12	0.24	µg/L	7.9	13	0	0	0	0
Phenol	0/39	0	nd	nd	0.47	0.94 – 0.97	µg/L	na	na	na	na	na	na
Conventional parameters													
Total suspended solids	192/192	100	2.1	69.0	13	na	mg/L	na	na	na	na	na	na
Volatile suspended solids	131/132	99	0.62	5.5	2.1	0.50	mg/L	na	na	na	na	na	na
Total dissolved solids	192/192	100	1.2	69.5	19	na	mg/L	na	na	na	na	na	na
Ammonia (total as nitrogen)	148/192	77	0.02	0.553	0.05	0.02	mg/L	na	na	na	na	na	na
Chemical oxygen demand	6/6	100	50	690	240	na	mg/L	na	na	na	na	na	na
Dissolved oxygen-field	120/120	100	7.5	11.9	9.0	na	mg/L	na	na	na	na	na	na
Hardness	6/6	100	656	5,770	3,210	na	mg/L CaCO3	na	na	na	na	na	na
Nitrite + nitrate (total as nitrogen)	132/132	100	0.118	0.616	0.334	na	mg/L	na	na	na	na	na	na
pH	192/192	100	6.92	8.20	7.6	na	pH	na	na	na	na	na	na
Specific Conductance	191/191	100	9.90	57,700	25,800	na	umhos/cm	na	na	na	na	na	na
Temperature	196/196	100	5.5	16	9.2	na	°C	na	na	na	na	na	na
LTKE03													
Conventional parameters													
Total Organic Carbon (TOC)	24/24	100	1.49	3.49	2	na	mg/L	na	na	na	na	na	na
Total suspended solids	24/24	100	1.3 J	7.2	3	na	mg/L	na	na	na	na	na	na
Total Suspended Solids (0.45um)	22/22	100	1.8 J	12.6	4	na	mg/L	na	na	na	na	na	na
Total dissolved solids	22/22	100	12,800	32,100	26,000	na	mg/L	na	na	na	na	na	na
Dissolved Organic Carbon	24/24	100	1.33	3.78	2.1	na	mg/L	na	na	na	na	na	na
Dissolved oxygen-field	22/22	100	4.4 J	9.7 J	7	na	mg/L	na	na	na	na	na	na
Dissolved oxygen	34/34	100	5.8	9.6	8	na	mg/L	na	na	na	na	na	na

Table E.6.4-1, cont. Summary statistics for surface water

Location ID and Chemical	Detection Frequency		Concentration					Criteria		Comparison to WQS			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	Chronic WQS	Acute WQS	Detect > Chronic and ≤Acute	Detect > Acute	Nondetect > Chronic and ≤ Acute	Nondetect > Acute
Salinity-field	22/22	100	12.855 J	30.574 J	25.780	na	PSS	na	na	na	na	na	na
Salinity	17/17	100	13.388	30.437	26.9	na	PSS	na	na	na	na	na	na
Temperature	24/24	100	8.2	15.8	10	na	°C	na	na	na	na	na	na
LTUM03													
Conventional parameters													
Total Organic Carbon (TOC)	24/24	100	1.79	6.2	2.8	na	mg/L	na	na	na	na	na	na
Total suspended solids	24/24	100	1.6 J	13.7	6	na	mg/L	na	na	na	na	na	na
Total Suspended Solids (0.45um)	22/22	100	2.4	16.7	7	na	mg/L	na	na	na	na	na	na
Total dissolved solids	22/22	100	1,100	31,300	10,000	na	mg/L	na	na	na	na	na	na
Dissolved Organic Carbon	24/24	100	1.67	7.72	3	na	mg/L	na	na	na	na	na	na
Dissolved oxygen-field	22/22	100	4.5 J	10.1 J	6	na	mg/L	na	na	na	na	na	na
Dissolved oxygen	34/34	100	5.4	10.4	8	na	mg/L	na	na	na	na	na	na
Salinity-field	22/22	100	1.8042 J	29.915 J	17.6	na	PSS	na	na	na	na	na	na
Salinity	13/13	100	5.8878	29.749	19.14	na	PSS	na	na	na	na	na	na
Temperature	24/24	100	4.9	15.5	11	na	°C	na	na	na	na	na	na
Norfolk													
Metals and trace elements													
Antimony (dissolved)	21/22	95	0.0095	0.025	0.017	0.010	µg/L	na	na	na	na	na	na
Antimony (total)	35/56	62	0.010	0.030	0.011	0.0096 – 0.011	µg/L	na	na	na	na	na	na
Arsenic (dissolved)	24/24	100	0.175	0.456	0.319	na	µg/L	36	69	0	0	0	0
Arsenic (total)	56/56	100	0.183	0.868	0.493	na	µg/L	na	na	na	na	na	na
Beryllium (dissolved)	0/24	0	nd	nd	0.0074	0.013 – 0.016	µg/L	na	na	na	na	na	na
Beryllium (total)	30/58	52	0.015	0.053	0.017	0.014 – 0.016	µg/L	na	na	na	na	na	na
Cadmium (dissolved)	12/22	55	0.0072	0.021	0.0086	0.0067 – 0.0073	µg/L	9.3	42	0	0	0	0
Cadmium (total)	49/56	88	0.0071	0.032	0.015	0.0068 – 0.0073	µg/L	na	na	na	na	na	na
Chromium (dissolved)	24/24	100	0.14 J	0.423 J	0.27	na	µg/L	50	1,100	0	0	0	0
Chromium (total)	58/58	100	0.256 J	2.37 J	0.978	na	µg/L	na	na	na	na	na	na
Cobalt (dissolved)	21/21	100	0.0330	0.130	0.0594	na	µg/L	na	na	na	na	na	na
Cobalt (total)	49/49	100	0.123	1.33	0.399	na	µg/L	na	na	na	na	na	na
Copper (dissolved)	23/24	96	0.496 J	1.34 J	0.805	0.628	µg/L	3.1	4.8	0	0	0	0
Copper (total)	58/58	100	0.728 J	4.24 J	2.09	na	µg/L	na	na	na	na	na	na
Lead (dissolved)	24/24	100	0.0611 J	0.343 J	0.149	na	µg/L	8.1	210	0	0	0	0
Lead (total)	58/58	100	0.143 J	2.81 J	0.778	na	µg/L	na	na	na	na	na	na
Mercury (dissolved)	6/6	100	0.00046	0.00071	0.00061	na	µg/L	0.025	1.8	0	0	0	0
Mercury (total)	6/8	75	0.00104	0.00689	0.027	0.20	µg/L	na	na	na	na	na	na

Table E.6.4-1, cont. Summary statistics for surface water

Location ID and Chemical	Detection Frequency		Concentration					Criteria		Comparison to WQS			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	Chronic WQS	Acute WQS	Detect > Chronic and ≤Acute	Detect > Acute	Nondetect > Chronic and ≤ Acute	Nondetect > Acute
Nickel (dissolved)	21/21	100	0.190 J	0.472 J	0.308	na	µg/L	8.2	74	0	0	0	0
Nickel (total)	55/55	100	0.434 J	2.91 J	1.12	na	µg/L	na	na	na	na	na	na
Selenium (dissolved)	0/22	0	nd	nd	0.074	0.13 – 0.16	µg/L	na	na	na	na	na	na
Selenium (total)	0/54	0	nd	nd	0.075	0.14 – 0.16	µg/L	na	na	na	na	na	na
Silver (dissolved)	0/24	0	nd	nd	0.059	0.10 – 0.13	µg/L	nv	1.9	na	0	na	0
Silver (total)	0/58	0	nd	nd	0.060	0.11 – 0.13	µg/L	nv	1.9	na	0	na	0
Thallium (dissolved)	0/24	0	nd	nd	0.0025	0.0043 – 0.0052	µg/L	na	na	na	na	na	na
Thallium (total)	17/58	29	0.0049	0.012 J	0.0040	0.0046 – 0.0053	µg/L	na	na	na	na	na	na
Vanadium (dissolved)	18/18	100	0.141	0.400	0.282	na	µg/L	na	na	na	na	na	na
Vanadium (Total)	46/46	100	0.315	3.57	1.51	na	µg/L	na	na	na	na	na	na
Zinc (dissolved)	22/22	100	0.881 J	5.24 J	2.39	na	µg/L	81	90	0	0	0	0
Zinc (total)	56/56	100	0.979 J	9.04 J	4.18	na	µg/L	na	na	na	na	na	na
PAHs													
2-Chloronaphthalene	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
2-Methylnaphthalene	0/13	0	nd	nd	0.20	0.38 – 0.45	µg/L	na	na	na	na	na	na
Acenaphthene	0/13	0	nd	nd	0.049	0.094 – 0.11	µg/L	na	na	na	na	na	na
Acenaphthylene	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
Anthracene	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
Benzo(a)anthracene	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
Benzo(a)pyrene	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
Benzo(b)fluoranthene	0/13	0	nd	nd	0.20	0.38 – 0.45	µg/L	na	na	na	na	na	na
Benzo(g,h,i)perylene	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
Benzo(k)fluoranthene	0/13	0	nd	nd	0.20	0.38 – 0.45	µg/L	na	na	na	na	na	na
Benzofluoranthenes (total-calc'd)	0/13	0	nd	nd	0.20	nc	µg/L	na	na	na	na	na	na
Chrysene	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
Dibenzo(a,h)anthracene	0/13	0	nd	nd	0.20	0.38 – 0.45	µg/L	na	na	na	na	na	na
Dibenzofuran	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
Fluoranthene	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
Fluorene	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
Indeno(1,2,3-cd)pyrene	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
Naphthalene	0/13	0	nd	nd	0.20	0.38 – 0.45	µg/L	na	na	na	na	na	na
Phenanthrene	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
Pyrene	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
Total HPAH	0/13	0	nd	nd	0.20	nc	µg/L	na	na	na	na	na	na
Total LPAH	0/13	0	nd	nd	0.20	nc	µg/L	na	na	na	na	na	na

Table E.6.4-1, cont. Summary statistics for surface water

Location ID and Chemical	Detection Frequency		Concentration					Criteria		Comparison to WQS			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	Chronic WQS	Acute WQS	Detect > Chronic and ≤Acute	Detect > Acute	Nondetect > Chronic and ≤ Acute	Nondetect > Acute
Carcinogenic PAHs - Mammal	0/13	0	nd	nd	0.13	0.25 – 0.30	µg/L	na	na	na	na	na	na
Total PAH	0/13	0	nd	nd	0.20	nc	µg/L	na	na	na	na	na	na
Phthalates													
Bis(2-ethylhexyl)phthalate	4/13	31	0.14	0.253	0.18	0.15 – 0.859	µg/L	na	na	na	na	na	na
Butyl benzyl phthalate	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
Diethyl phthalate	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
Dimethyl phthalate	0/13	0	nd	nd	0.049	0.094 – 0.11	µg/L	na	na	na	na	na	na
Di-n-butyl phthalate	5/13	38	0.39	1.2	0.41	0.24 – 0.46	µg/L	na	na	na	na	na	na
Di-n-octyl phthalate	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
Other SVOCs													
1,2,4-Trichlorobenzene	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
1,2-Dichlorobenzene	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
1,2-Diphenylhydrazine	0/13	0	nd	nd	0.25	0.47 – 0.56	µg/L	na	na	na	na	na	na
1,3-Dichlorobenzene	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
1,4-Dichlorobenzene	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
2,4,5-Trichlorophenol	0/13	0	nd	nd	0.49	0.94 – 1.1	µg/L	na	na	na	na	na	na
2,4,6-Trichlorophenol	0/13	0	nd	nd	0.49	0.94 – 1.1	µg/L	na	na	na	na	na	na
2,4-Dichlorophenol	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
2,4-Dimethylphenol	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
2,4-Dinitrophenol	0/13	0	nd	nd	0.25	0.47 – 0.56	µg/L	na	na	na	na	na	na
2,4-Dinitrotoluene	0/13	0	nd	nd	0.049	0.094 – 0.11	µg/L	na	na	na	na	na	na
2,6-Dinitrotoluene	0/13	0	nd	nd	0.049	0.094 – 0.11	µg/L	na	na	na	na	na	na
2-Chlorophenol	0/13	0	nd	nd	0.25	0.47 – 0.56	µg/L	na	na	na	na	na	na
2-Methylphenol	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
2-Nitroaniline	0/13	0	nd	nd	0.49	0.94 – 1.1	µg/L	na	na	na	na	na	na
2-Nitrophenol	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
3,3'-Dichlorobenzidine	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
3-Nitroaniline	0/13	0	nd	nd	0.49	0.94 – 1.1	µg/L	na	na	na	na	na	na
4,6-Dinitro-o-cresol	0/13	0	nd	nd	0.25	0.47 – 0.56	µg/L	na	na	na	na	na	na
4-Bromophenyl phenyl ether	0/13	0	nd	nd	0.049	0.094 – 0.11	µg/L	na	na	na	na	na	na
4-Chloro-3-methylphenol	0/13	0	nd	nd	0.25	0.47 – 0.56	µg/L	na	na	na	na	na	na
4-Chloroaniline	0/13	0	nd	nd	0.25	0.47 – 0.56	µg/L	na	na	na	na	na	na
4-Chlorophenyl phenyl ether	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
4-Methylphenol	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
4-Nitroaniline	0/13	0	nd	nd	0.49	0.94 – 1.1	µg/L	na	na	na	na	na	na

Table E.6.4-1, cont. Summary statistics for surface water

Location ID and Chemical	Detection Frequency		Concentration					Criteria		Comparison to WQS			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	Chronic WQS	Acute WQS	Detect > Chronic and ≤Acute	Detect > Acute	Nondetect > Chronic and ≤ Acute	Nondetect > Acute
4-Nitrophenol	0/13	0	nd	nd	0.25	0.47 – 0.56	µg/L	na	na	na	na	na	na
Aniline	0/13	0	nd	nd	0.25	0.47 – 0.56	µg/L	na	na	na	na	na	na
Benzidine	0/13	0	nd	nd	2.9	5.7 – 6.7	µg/L	na	na	na	na	na	na
Benzoic acid	0/13	0	nd	nd	0.49	0.94 – 1.1	µg/L	na	na	na	na	na	na
Benzyl alcohol	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
bis(2-chloroethoxy)methane	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
bis(2-chloroethyl)ether	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
bis(2-chloroisopropyl)ether	0/13	0	nd	nd	0.25	0.47 – 0.56	µg/L	na	na	na	na	na	na
Caffeine	0/13	0	nd	nd	0.025	0.047 – 0.056	µg/L	na	na	na	na	na	na
Carbazole	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
Coprostanol	0/13	0	nd	nd	0.49	0.94 – 1.1	µg/L	na	na	na	na	na	na
Hexachlorobenzene	0/13	0	nd	nd	0.073	0.14 – 0.17	µg/L	na	na	na	na	na	na
Hexachlorobutadiene	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
Hexachlorocyclopentadiene	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
Hexachloroethane	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
Isophorone	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
Nitrobenzene	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
N-Nitrosodimethylamine	0/13	0	nd	nd	0.49	0.94 – 1.1	µg/L	na	na	na	na	na	na
N-Nitroso-di-n-propylamine	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
N-Nitrosodiphenylamine	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	na	na	na	na	na	na
Pentachlorophenol	0/13	0	nd	nd	0.12	0.24 – 0.28	µg/L	7.9	13	0	0	0	0
Phenol	0/13	0	nd	nd	0.49	0.94 – 1.1	µg/L	na	na	na	na	na	na
Conventional parameters													
Total suspended solids	66/66	100	3.5	70.2	24	na	mg/L	na	na	na	na	na	na
Volatile suspended solids	45/46	98	0.63	6.2	2.7	0.50	mg/L	na	na	na	na	na	na
Total dissolved solids	66/66	100	3.4	70.0	25	na	mg/L	na	na	na	na	na	na
Ammonia (total as nitrogen)	62/66	94	0.024	0.160	0.06	0.02	mg/L	na	na	na	na	na	na
Chemical oxygen demand	32/66	48	3.0	48	5.8	3.0	mg/L	na	na	na	na	na	na
Dissolved oxygen	46/46	100	9.0	12.2	11	na	mg/L	na	na	na	na	na	na
Hardness	66/66	100	19.0	316	56.4	na	mg/L $CaCO_3$	na	na	na	na	na	na
Nitrite + nitrate (total as nitrogen)	46/46	100	0.129	0.634	0.344	na	mg/L	na	na	na	na	na	na
pH	66/66	100	6.36	7.70	7.1	na	pH	na	na	na	na	na	na
Specific Conductance	68/68	100	27.5	3,200	344	na	umhos/cm	na	na	na	na	na	na
Temperature	70/70	100	4.3	17	8.8	na	°C	na	na	na	na	na	na

Table E.6.4-1, cont. Summary statistics for surface water

Location ID and Chemical	Detection Frequency		Concentration					Criteria		Comparison to WQS			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	Chronic WQS	Acute WQS	Detect > Chronic and ≤Acute	Detect > Acute	Nondetect > Chronic and ≤ Acute	Nondetect > Acute
Southwest Michigan													
Metals and trace elements													
Antimony (dissolved)	65/66	98	0.010	0.103	0.048	0.010	µg/L	na	na	na	na	na	na
Antimony (total)	138/161	86	0.0098	0.113	0.032	0.0095 – 0.010	µg/L	na	na	na	na	na	na
Arsenic (dissolved)	72/72	100	0.224	1.42	0.806	na	µg/L	36	69	0	0	0	0
Arsenic (total)	167/167	100	0.282	1.57	0.880	na	µg/L	na	na	na	na	na	na
Beryllium (dissolved)	0/63	0	nd	nd	0.0075	0.012 – 0.016	µg/L	na	na	na	na	na	na
Beryllium (total)	35/158	22	0.015	0.037	0.011	0.013 – 0.016	µg/L	na	na	na	na	na	na
Cadmium (dissolved)	72/72	100	0.0079	0.0795	0.043	na	µg/L	9.3	42	0	0	0	0
Cadmium (total)	171/173	99	0.0076	0.391	0.043	0.0067 – 0.0068	µg/L	na	na	na	na	na	na
Chromium (dissolved)	56/56	100	0.10 J	0.453 J	0.30	na	µg/L	50	1,100	0	0	0	0
Chromium (total)	157/157	100	0.277 J	2.32 J	0.679	na	µg/L	na	na	na	na	na	na
Cobalt (dissolved)	72/72	100	0.019	0.163	0.060	na	µg/L	na	na	na	na	na	na
Cobalt (total)	155/155	100	0.0311	0.772	0.232	na	µg/L	na	na	na	na	na	na
Copper (dissolved)	64/66	97	0.370 J	1.89 J	0.663	0.354 – 0.368	µg/L	3.1	4.8	0	0	0	0
Copper (total)	166/167	99	0.474 J	4.03 J	1.48	0.643	µg/L	na	na	na	na	na	na
Lead (dissolved)	66/66	100	0.0077 J	0.198 J	0.043	na	µg/L	8.1	210	0	0	0	0
Lead (total)	167/167	100	0.0570 J	1.57 J	0.398	na	µg/L	na	na	na	na	na	na
Mercury (total)	0/6	0	nd	nd	0.10	0.20	µg/L	na	na	na	na	na	na
Nickel (dissolved)	54/60	90	0.259 J	1.50 J	0.385	0.118 – 0.306	µg/L	8.2	74	0	0	0	0
Nickel (total)	137/143	96	0.328 J	2.88 J	0.764	0.291 – 0.575	µg/L	na	na	na	na	na	na
Selenium (dissolved)	0/66	0	nd	nd	0.074	0.12 – 0.16	µg/L	na	na	na	na	na	na
Selenium (total)	0/155	0	nd	nd	0.074	0.13 – 0.16	µg/L	na	na	na	na	na	na
Silver (dissolved)	0/72	0	nd	nd	0.059	0.097 – 0.13	µg/L	nv	1.9	na	0	na	0
Silver (total)	0/173	0	nd	nd	0.060	0.10 – 0.13	µg/L	nv	1.9	na	0	na	0
Thallium (dissolved)	38/72	53	0.0079	0.011	0.0064	0.0046 – 0.0052	µg/L	na	na	na	na	na	na
Thallium (total)	102/173	59	0.0050	0.015	0.0065	0.0043 – 0.0052	µg/L	na	na	na	na	na	na
Vanadium (dissolved)	42/42	100	0.370	1.56	0.944	na	µg/L	na	na	na	na	na	na
Vanadium (Total)	125/125	100	0.220	3.99	1.35	na	µg/L	na	na	na	na	na	na
Zinc (dissolved)	72/72	100	0.825 J	4.09 J	1.88	na	µg/L	81	90	0	0	0	0
Zinc (total)	173/173	100	1.08 J	6.62 J	2.84	na	µg/L	na	na	na	na	na	na
PAHs													
2-Chloronaphthalene	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
2-Methylnaphthalene	0/42	0	nd	nd	0.19	0.38 – 0.39	µg/L	na	na	na	na	na	na
Acenaphthene	0/42	0	nd	nd	0.047	0.094 – 0.097	µg/L	na	na	na	na	na	na

Table E.6.4-1, cont. Summary statistics for surface water

Location ID and Chemical	Detection Frequency		Concentration					Criteria		Comparison to WQS			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	Chronic WQS	Acute WQS	Detect > Chronic and ≤Acute	Detect > Acute	Nondetect > Chronic and ≤ Acute	Nondetect > Acute
Acenaphthylene	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Anthracene	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Benzo(a)anthracene	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Benzo(a)pyrene	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Benzo(b)fluoranthene	0/42	0	nd	nd	0.19	0.38 – 0.39	µg/L	na	na	na	na	na	na
Benzo(g,h,i)perylene	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Benzo(k)fluoranthene	0/42	0	nd	nd	0.19	0.38 – 0.39	µg/L	na	na	na	na	na	na
Benzofluoranthenes (total-calc'd)	0/42	0	nd	nd	0.19	nc	µg/L	na	na	na	na	na	na
Chrysene	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Dibenzo(a,h)anthracene	0/42	0	nd	nd	0.19	0.38 – 0.39	µg/L	na	na	na	na	na	na
Dibenzofuran	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Fluoranthene	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Fluorene	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Indeno(1,2,3-cd)pyrene	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Naphthalene	0/42	0	nd	nd	0.19	0.38 – 0.39	µg/L	na	na	na	na	na	na
Phenanthrene	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Pyrene	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Total HPAH	0/42	0	nd	nd	0.19	nc	µg/L	na	na	na	na	na	na
Total LPAH	0/42	0	nd	nd	0.19	nc	µg/L	na	na	na	na	na	na
Carcinogenic PAHs - Mammal	0/42	0	nd	nd	0.13	0.25 – 0.26	µg/L	na	na	na	na	na	na
Total PAH	0/42	0	nd	nd	0.19	nc	µg/L	na	na	na	na	na	na
Phthalates													
Bis(2-ethylhexyl)phthalate	8/42	19	0.302	23.8	0.86	0.14 – 0.667	µg/L	na	na	na	na	na	na
Butyl benzyl phthalate	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Diethyl phthalate	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Dimethyl phthalate	0/42	0	nd	nd	0.047	0.094 – 0.097	µg/L	na	na	na	na	na	na
Di-n-butyl phthalate	2/42	5	0.27	0.483	0.13	0.24	µg/L	na	na	na	na	na	na
Di-n-octyl phthalate	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Other SVOCs													
1,2,4-Trichlorobenzene	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
1,2-Dichlorobenzene	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
1,2-Diphenylhydrazine	0/42	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
1,3-Dichlorobenzene	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
1,4-Dichlorobenzene	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
2,4,5-Trichlorophenol	0/42	0	nd	nd	0.47	0.94 – 0.97	µg/L	na	na	na	na	na	na

Table E.6.4-1, cont. Summary statistics for surface water

Location ID and Chemical	Detection Frequency		Concentration					Criteria		Comparison to WQS			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	Chronic WQS	Acute WQS	Detect > Chronic and ≤Acute	Detect > Acute	Nondetect > Chronic and ≤ Acute	Nondetect > Acute
2,4,6-Trichlorophenol	0/42	0	nd	nd	0.47	0.94 – 0.97	µg/L	na	na	na	na	na	na
2,4-Dichlorophenol	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
2,4-Dimethylphenol	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
2,4-Dinitrophenol	0/42	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
2,4-Dinitrotoluene	0/42	0	nd	nd	0.047	0.094 – 0.097	µg/L	na	na	na	na	na	na
2,6-Dinitrotoluene	0/42	0	nd	nd	0.047	0.094 – 0.097	µg/L	na	na	na	na	na	na
2-Chlorophenol	0/42	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
2-Methylphenol	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
2-Nitroaniline	0/42	0	nd	nd	0.47	0.94 – 0.97	µg/L	na	na	na	na	na	na
2-Nitrophenol	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
3,3'-Dichlorobenzidine	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
3-Nitroaniline	0/42	0	nd	nd	0.47	0.94 – 0.97	µg/L	na	na	na	na	na	na
4,6-Dinitro-o-cresol	0/42	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
4-Bromophenyl phenyl ether	0/42	0	nd	nd	0.047	0.094 – 0.097	µg/L	na	na	na	na	na	na
4-Chloro-3-methylphenol	0/42	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
4-Chloroaniline	0/42	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
4-Chlorophenyl phenyl ether	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
4-Methylphenol	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
4-Nitroaniline	0/42	0	nd	nd	0.47	0.94 – 0.97	µg/L	na	na	na	na	na	na
4-Nitrophenol	0/42	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
Aniline	0/42	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
Benzidine	0/42	0	nd	nd	2.9	5.7 – 5.8	µg/L	na	na	na	na	na	na
Benzoic acid	3/42	7	1.1	1.5	0.53	0.94 – 0.97	µg/L	na	na	na	na	na	na
Benzyl alcohol	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
bis(2-chloroethoxy)methane	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
bis(2-chloroethyl)ether	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
bis(2-chloroisopropyl)ether	0/42	0	nd	nd	0.24	0.47 – 0.49	µg/L	na	na	na	na	na	na
Caffeine	0/42	0	nd	nd	0.024	0.047 – 0.049	µg/L	na	na	na	na	na	na
Carbazole	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Coprostanol	0/42	0	nd	nd	0.47	0.94 – 0.97	µg/L	na	na	na	na	na	na
Hexachlorobenzene	0/42	0	nd	nd	0.070	0.14 – 0.15	µg/L	na	na	na	na	na	na
Hexachlorobutadiene	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Hexachlorocyclopentadiene	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Hexachloroethane	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Isophorone	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na

Table E.6.4-1, cont. Summary statistics for surface water

Location ID and Chemical	Detection Frequency		Concentration					Criteria		Comparison to WQS			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	Chronic WQS	Acute WQS	Detect > Chronic and ≤Acute	Detect > Acute	Nondetect > Chronic and ≤ Acute	Nondetect > Acute
Nitrobenzene	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
N-Nitrosodimethylamine	0/42	0	nd	nd	0.47	0.94 – 0.97	µg/L	na	na	na	na	na	na
N-Nitroso-di-n-propylamine	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
N-Nitrosodiphenylamine	0/42	0	nd	nd	0.12	0.24	µg/L	na	na	na	na	na	na
Pentachlorophenol	0/42	0	nd	nd	0.12	0.24	µg/L	7.9	13	0	0	0	0
Phenol	1/42	2	2.01	2.01	0.51	0.94 – 0.97	µg/L	na	na	na	na	na	na
Conventional parameters													
Total suspended solids	192/192	100	2.2	59.8	15	na	mg/L	na	na	na	na	na	na
Volatile suspended solids	132/132	100	0.54	7.3	2.3	na	mg/L	na	na	na	na	na	na
Total dissolved solids	192/192	100	3.0	64.0	20	na	mg/L	na	na	na	na	na	na
Ammonia (total as nitrogen)	165/192	86	0.02	0.136	0.05	0.02	mg/L	na	na	na	na	na	na
Chemical oxygen demand	6/6	100	76	790	330	na	mg/L	na	na	na	na	na	na
Dissolved oxygen-field	120/120	100	7.2	12.0	9.0	na	mg/L	na	na	na	na	na	na
Hardness	6/6	100	292	5,190	3,280	na	mg/L $CaCO_3$	na	na	na	na	na	na
Nitrite + nitrate (total as nitrogen)	132/132	100	0.127	0.625	0.329	na	mg/L	na	na	na	na	na	na
pH	192/192	100	7.08	8.10	7.6	na	pH	na	na	na	na	na	na
Specific Conductance	186/186	100	5.27	56,700	20,800	na	µmhos/cm	na	na	na	na	na	na
Temperature	192/192	100	5.2	13	8.9	na	°C	na	na	na	na	na	na

Table E.6.4-2. Summary statistics for PCB congeners in surface water collected from RM 0.0 and 3.3

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-001	4/16	25	1.03	2.05	1.07	1.37 – 2.86	pg/L
PCB-002	2/16	13	1.10	1.47	0.785	0.728 – 2.47	pg/L
PCB-003	1/16	6	2.66	2.66	1.25	0.930 – 3.71	pg/L
PCB-004	6/16	38	3.13	28.7	7.39	2.88 – 21.2	pg/L
PCB-005	0/16	0	nd	nd	nd	1.11 – 4.21	pg/L
PCB-006	1/16	6	1.22	1.22	1.31	1.13 – 4.70	pg/L
PCB-007	1/16	6	4.82	4.82	2.18	2.49 – 9.51	pg/L
PCB-008	1/16	6	6.51	6.51	3.33	2.35 – 16.2	pg/L
PCB-009	0/16	0	nd	nd	nd	0.983 – 3.80	pg/L
PCB-010	0/16	0	nd	nd	nd	1.01 – 3.80	pg/L
PCB-011	1/16	6	9.32	9.32	3.19	1.65 – 14.4	pg/L
PCB-012	0/16	0	nd	nd	nd	1.12 – 4.12	pg/L
PCB-013	0/16	0	C12	C12	nc	na	pg/L
PCB-014	0/16	0	nd	nd	nd	1.07 – 3.90	pg/L
PCB-015	1/16	6	9.81	9.81	3.66	1.93 – 15.9	pg/L
PCB-016	7/16	44	2.82	16.2	6.26	1.18 – 11.9	pg/L
PCB-017	8/16	50	3.03	24.6	8.85	1.22 – 13.7	pg/L
PCB-018	8/16	50	27.3 C	48.6 C	19.6	3.32 – 16.8	pg/L
PCB-019	14/16	88	1.04	16.7	7.20	0.666 – 2.72	pg/L
PCB-020	8/16	50	31.5 C	74.0 C	26.8	3.94 – 21.2	pg/L
PCB-021	2/16	13	17.2 C	22.0 C	5.09	2.01 – 13.9	pg/L
PCB-022	5/16	31	11.3	18.5	6.21	1.43 – 10.4	pg/L
PCB-023	0/16	0	nd	nd	nd	0.464 – 1.05	pg/L
PCB-024	3/16	19	0.493	0.844	0.328	0.466 – 0.729	pg/L
PCB-025	13/16	81	1.17	17.4	5.18	0.495 – 1.34	pg/L

Table E.6.4-2, cont. Summary statistics for PCB congeners in surface water collected from RM 0.0 and 3.3

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-026	12/16	75	0.747 C	39.4 C	11.0	1.75 – 6.0	pg/L
PCB-027	11/16	69	1.23	10.3	4.53	0.495 – 5.22	pg/L
PCB-028	8/16	50	C20	C20	nc	na	pg/L
PCB-029	12/16	75	C26	C26	nc	na	pg/L
PCB-030	8/16	50	C18	C18	nc	na	pg/L
PCB-031	8/16	50	25.2	55.3	19.9	3.37 – 12.8	pg/L
PCB-032	8/16	50	10.2	20.0	7.71	0.624 – 5.90	pg/L
PCB-033	2/16	13	C21	C21	nc	na	pg/L
PCB-034	2/16	13	0.548	0.841	0.349	0.464 – 1.04	pg/L
PCB-035	1/16	6	1.29	1.29	0.392	0.464 – 1.15	pg/L
PCB-036	0/16	0	nd	nd	nd	0.464 – 1.03	pg/L
PCB-037	4/16	25	8.38	14.4	4.71	1.69 – 8.17	pg/L
PCB-038	0/16	0	nd	nd	nd	0.464 – 1.04	pg/L
PCB-039	1/16	6	0.554	0.554	0.305	0.464 – 0.999	pg/L
PCB-040	11/16	69	1.76 C	44.9 C	17.3	8.08 – 14.0	pg/L
PCB-041	11/16	69	C40	C40	nc	na	pg/L
PCB-042	13/16	81	0.994	24.2	8.80	3.10 – 8.15	pg/L
PCB-043	3/16	19	0.726	2.53	0.741	0.469 – 3.07	pg/L
PCB-044	8/16	50	40.0 C	93.4 C	33.6	4.23 – 22.1	pg/L
PCB-045	9/16	56	3.43 C	18.1 C	7.61	0.807 – 8.21	pg/L
PCB-046	9/16	56	2.80	6.48	2.65	0.489 – 4.03	pg/L
PCB-047	8/16	50	C44	C44	nc	na	pg/L
PCB-048	10/16	63	1.34	11.7	4.71	0.737 – 6.49	pg/L
PCB-049	9/16	56	17.3 C	82.4 C	26.7	2.81 – 16.5	pg/L
PCB-050	8/16	50	9.29 C	19.9 C	8.18	0.807 – 10.5	pg/L
PCB-051	9/16	56	C45	C45	nc	na	pg/L
PCB-052	8/16	50	55.9	166	51.7	7.96 – 39.2	pg/L

Table E.6.4-2, cont. Summary statistics for PCB congeners in surface water collected from RM 0.0 and 3.3

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-053	8/16	50	C50	C50	nc	na	pg/L
PCB-054	2/16	13	0.596	0.989	0.333	0.441 – 1.25	pg/L
PCB-055	4/16	25	1.04	3.05	0.724	0.469 – 1.72	pg/L
PCB-056	9/16	56	7.16	32.9	11.8	2.13 – 9.51	pg/L
PCB-057	2/16	13	0.533	0.811	0.397	0.464 – 1.49	pg/L
PCB-058	0/16	0	nd	nd	nd	0.464 – 1.56	pg/L
PCB-059	8/16	50	1.85 C	9.76 C	3.03	0.495 – 5.99	pg/L
PCB-060	13/16	81	0.864	12.5	4.77	1.72 – 4.53	pg/L
PCB-061	8/16	50	39.3 C	109 C	38.2	9.19 – 22.7	pg/L
PCB-062	8/16	50	C59	C59	nc	na	pg/L
PCB-063	6/16	38	0.743	2.53	0.888	0.469 – 1.82	pg/L
PCB-064	8/16	50	12.7	29.2	10.9	1.66 – 9.72	pg/L
PCB-065	8/16	50	C44	C44	nc	na	pg/L
PCB-066	11/16	69	13.2	71.8	25.2	3.60 – 13.4	pg/L
PCB-067	5/16	31	1.14	1.88	0.774	0.489 – 2.46	pg/L
PCB-068	7/16	44	0.750	2.68	1.07	0.491 – 1.39	pg/L
PCB-069	9/16	56	C49	C49	nc	na	pg/L
PCB-070	8/16	50	C61	C61	nc	na	pg/L
PCB-071	11/16	69	C40	C40	nc	na	pg/L
PCB-072	5/16	31	0.583	2.89	0.713	0.469 – 1.44	pg/L
PCB-073	2/16	13	0.683	0.823	0.317	0.464 – 0.896	pg/L
PCB-074	8/16	50	C61	C61	nc	na	pg/L
PCB-075	8/16	50	C59	C59	nc	na	pg/L
PCB-076	8/16	50	C61	C61	nc	na	pg/L
PCB-077	9/16	56	2.19	5.30	2.40	0.912 – 3.09	pg/L
PCB-078	0/16	0	nd	nd	nd	0.464 – 1.67	pg/L
PCB-079	5/16	31	0.510	1.80	0.575	0.489 – 1.38	pg/L

Table E.6.4-2, cont. Summary statistics for PCB congeners in surface water collected from RM 0.0 and 3.3

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-080	0/16	0	nd	nd	nd	0.464 – 1.45	pg/L
PCB-081	1/16	6	0.884	0.884	0.393	0.464 – 1.67	pg/L
PCB-082	11/15	73	2.09	14.9	5.70	0.495 – 6.79	pg/L
PCB-083	15/15	100	5.96 C	84.2 C	35.0	na	pg/L
PCB-084	14/15	93	3.51	43.3	17.6	2.40	pg/L
PCB-085	8/15	53	6.78 C	20.9 C	7.27	1.84 – 9.49	pg/L
PCB-086	11/15	73	20.4 C	85.1 C	34.1	9.15 – 17.0	pg/L
PCB-087	11/15	73	C86	C86	nc	na	pg/L
PCB-088	12/15	80	2.10 C	25.5 C	9.48	1.34 – 13.7	pg/L
PCB-089	5/15	33	0.529	1.27	0.570	0.466 – 3.13	pg/L
PCB-090	14/15	93	13.9 C	147 C	55.3	11.8	pg/L
PCB-091	12/15	80	C88	C88	nc	na	pg/L
PCB-092	12/15	80	2.16	33.0	11.6	4.91 – 10.7	pg/L
PCB-093	14/15	93	13.6 C	149 C	62.3	8.25	pg/L
PCB-094	0/15	0	nd	nd	nd	0.467 – 3.09	pg/L
PCB-095	14/15	93	C93	C93	nc	na	pg/L
PCB-096	4/15	27	0.515	0.788	0.386	0.466 – 1.36	pg/L
PCB-097	11/15	73	C86	C86	nc	na	pg/L
PCB-098	14/15	93	C93	C93	nc	na	pg/L
PCB-099	15/15	100	C83	C83	nc	na	pg/L
PCB-100	14/15	93	C93	C93	nc	na	pg/L
PCB-101	14/15	93	C90	C90	nc	na	pg/L
PCB-102	14/15	93	C93	C93	nc	na	pg/L
PCB-103	5/15	33	1.16	2.75	0.850	0.466 – 1.47	pg/L
PCB-104	0/15	0	nd	nd	nd	0.450 – 2.36	pg/L
PCB-105	8/15	53	13.3	33.4	12.9	3.74 – 14.0	pg/L
PCB-106	0/15	0	nd	nd	nd	0.466 – 3.77	pg/L

Table E.6.4-2, cont. Summary statistics for PCB congeners in surface water collected from RM 0.0 and 3.3

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-107	9/15	60	0.682 C	4.71 C	1.40	0.489 – 2.50	pg/L
PCB-108	11/15	73	C86	C86	nc	na	pg/L
PCB-109	7/15	47	1.14	10.3	2.75	0.489 – 5.11	pg/L
PCB-110	13/15	87	26.4 C	166 C	64.4	13.3 – 14.9	pg/L
PCB-111	0/15	0	nd	nd	nd	0.464 – 2.08	pg/L
PCB-112	1/15	7	0.856	0.856	0.353	0.464 – 2.11	pg/L
PCB-113	14/15	93	C90	C90	nc	na	pg/L
PCB-114	5/15	33	0.614	4.10	0.832	0.466 – 1.22	pg/L
PCB-115	13/15	87	C110	C110	nc	na	pg/L
PCB-116	8/15	53	C85	C85	nc	na	pg/L
PCB-117	8/15	53	C85	C85	nc	na	pg/L
PCB-118	13/15	87	17.6	96.4	40.6	9.92 – 10.2	pg/L
PCB-119	11/15	73	C86	C86	nc	na	pg/L
PCB-120	0/15	0	nd	nd	nd	0.464 – 2.04	pg/L
PCB-121	0/15	0	nd	nd	nd	0.464 – 2.09	pg/L
PCB-122	2/15	13	0.658	0.972	0.513	0.466 – 4.15	pg/L
PCB-123	2/15	13	0.978	1.51	0.611	0.473 – 3.94	pg/L
PCB-124	9/15	60	C107	C107	nc	na	pg/L
PCB-125	11/15	73	C86	C86	nc	na	pg/L
PCB-126	0/15	0	nd	nd	nd	0.466 – 3.94	pg/L
PCB-127	0/15	0	nd	nd	nd	0.466 – 3.71	pg/L
PCB-128	14/15	93	1.95 C	20.9 C	8.76	9.56	pg/L
PCB-129	15/15	100	13.8 C	156 C	67.0	na	pg/L
PCB-130	10/15	67	1.27	10.1	3.58	1.06 – 4.98	pg/L
PCB-131	3/15	20	0.888	1.80	0.507	0.466 – 1.26	pg/L
PCB-132	15/15	100	4.38	49.3	22.3	na	pg/L
PCB-133	4/15	27	1.05	3.37	0.859	0.467 – 1.72	pg/L

Table E.6.4-2, cont. Summary statistics for PCB congeners in surface water collected from RM 0.0 and 3.3

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-134	11/15	73	1.18 C	8.97 C	3.38	0.773 – 3.95	pg/L
PCB-135	14/15	93	7.16 C	58.2 C	25.2	4.28	pg/L
PCB-136	14/15	93	2.37	20.2	9.09	1.52	pg/L
PCB-137	9/15	60	1.30	5.67	2.29	0.549 – 3.13	pg/L
PCB-138	15/15	100	C129	C129	nc	na	pg/L
PCB-139	6/15	40	0.769 C	2.15 C	0.874	0.489 – 1.71	pg/L
PCB-140	6/15	40	C139	C139	nc	na	pg/L
PCB-141	13/15	87	2.74	26.5	10.8	2.65 – 5.88	pg/L
PCB-142	0/15	0	nd	nd	nd	0.464 – 0.700	pg/L
PCB-143	11/15	73	C134	C134	nc	na	pg/L
PCB-144	8/15	53	0.723	6.60	2.42	0.751 – 5.03	pg/L
PCB-145	0/15	0	nd	nd	nd	0.164 – 0.499	pg/L
PCB-146	13/15	87	1.80	27.3	9.58	7.75 – 14.7	pg/L
PCB-147	15/15	100	9.43 C	126 C	58.0	na	pg/L
PCB-148	0/15	0	nd	nd	nd	0.212 – 0.499	pg/L
PCB-149	15/15	100	C147	C147	nc	na	pg/L
PCB-150	1/15	7	0.556	0.556	0.251	0.168 – 0.499	pg/L
PCB-151	14/15	93	C135	C135	nc	na	pg/L
PCB-152	0/15	0	nd	nd	nd	0.116 – 0.499	pg/L
PCB-153	15/15	100	10.6 C	135 C	57.8	na	pg/L
PCB-154	14/15	93	C135	C135	nc	na	pg/L
PCB-155	0/15	0	nd	nd	nd	0.343 – 0.499	pg/L
PCB-156	4/15	27	7.68 C	14.5 C	4.32	1.79 – 7.19	pg/L
PCB-157	4/15	27	C156	C156	nc	na	pg/L
PCB-158	12/15	80	2.03	15.0	5.48	1.19 – 6.71	pg/L
PCB-159	3/15	20	1.89	2.43	0.703	0.466 – 1.19	pg/L
PCB-160	15/15	100	C129	C129	nc	na	pg/L

Table E.6.4-2, cont. Summary statistics for PCB congeners in surface water collected from RM 0.0 and 3.3

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-161	0/15	0	nd	nd	nd	0.463 – 0.533	pg/L
PCB-162	0/15	0	nd	nd	nd	0.464 – 0.516	pg/L
PCB-163	15/15	100	C129	C129	nc	na	pg/L
PCB-164	11/15	73	1.47	11.5	4.35	1.07 – 6.08	pg/L
PCB-165	0/15	0	nd	nd	nd	0.464 – 0.519	pg/L
PCB-166	14/15	93	C128	C128	nc	na	pg/L
PCB-167	8/15	53	2.33	5.11	1.96	0.639 – 2.18	pg/L
PCB-168	15/15	100	C153	C153	nc	na	pg/L
PCB-169	0/15	0	nd	nd	nd	0.460 – 0.516	pg/L
PCB-170	11/15	73	11.1	33.7	14.2	3.28 – 7.35	pg/L
PCB-171	10/15	67	2.10 C	11.8 C	4.44	1.13 – 5.42	pg/L
PCB-172	10/15	67	1.22	7.21	2.42	0.495 – 3.84	pg/L
PCB-173	10/15	67	C171	C171	nc	na	pg/L
PCB-174	14/15	93	4.59	37.8	16.9	2.84	pg/L
PCB-175	2/15	13	0.508	0.758	0.422	0.489 – 1.80	pg/L
PCB-176	9/15	60	0.694	4.55	1.77	0.495 – 3.14	pg/L
PCB-177	12/15	80	3.22	27.9	9.90	1.71 – 9.30	pg/L
PCB-178	13/15	87	0.944	8.71	3.46	0.824 – 1.42	pg/L
PCB-179	13/15	87	2.35	16.6	7.16	1.23 – 2.68	pg/L
PCB-180	12/15	80	6.15 C	75.3 C	29.5	0.467 – 12.8	pg/L
PCB-181	0/15	0	nd	nd	nd	0.165 – 0.516	pg/L
PCB-182	1/15	7	0.517	0.517	0.259	0.445 – 0.516	pg/L
PCB-183	15/15	100	1.51 C	26.3 C	11.6	na	pg/L
PCB-184	0/15	0	nd	nd	nd	0.109 – 0.499	pg/L
PCB-185	15/15	100	C183	C183	nc	na	pg/L
PCB-186	0/15	0	nd	nd	nd	0.117 – 0.499	pg/L
PCB-187	14/15	93	4.19	50.2	21.3	8.19	pg/L

Table E.6.4-2, cont. Summary statistics for PCB congeners in surface water collected from RM 0.0 and 3.3

Chemical	Detection Frequency		Concentration				
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit
PCB-188	0/15	0	nd	nd	nd	0.248 – 0.499	pg/L
PCB-189	4/15	27	0.701	1.35	0.478	0.466 – 0.838	pg/L
PCB-190	12/15	80	1.10	6.79	2.86	0.592 – 3.24	pg/L
PCB-191	5/15	33	0.554	1.43	0.476	0.480 – 0.679	pg/L
PCB-192	0/15	0	nd	nd	nd	0.135 – 0.499	pg/L
PCB-193	12/15	80	C180	C180	nc	na	pg/L
PCB-194	11/16	69	2.44	14.7	6.22	1.42 – 6.99	pg/L
PCB-195	9/16	56	1.20	10.0	2.90	0.495 – 3.09	pg/L
PCB-196	11/16	69	0.994	7.54	3.03	0.785 – 4.38	pg/L
PCB-197	9/16	56	0.638 C	5.37 C	1.30	0.489 – 1.35	pg/L
PCB-198	9/16	56	5.49 C	18.2 C	7.13	1.61 – 7.73	pg/L
PCB-199	9/16	56	C198	C198	nc	na	pg/L
PCB-200	9/16	56	C197	C197	nc	na	pg/L
PCB-201	8/16	50	0.696	3.51	0.942	0.489 – 1.17	pg/L
PCB-202	5/16	31	1.59	5.51	1.43	0.590 – 4.01	pg/L
PCB-203	15/16	94	1.51	10.6	4.43	2.16	pg/L
PCB-204	0/16	0	nd	nd	nd	0.190 – 0.499	pg/L
PCB-205	4/16	25	0.612	0.971	0.382	0.429 – 0.821	pg/L
PCB-206	5/15	33	2.73	6.57	2.30	0.874 – 4.59	pg/L
PCB-207	1/15	7	0.666	0.666	0.519	0.467 – 1.76	pg/L
PCB-208	2/15	13	2.24	2.29	0.844	0.495 – 2.14	pg/L
PCB-209	0/15	0	nd	nd	nd	1.12 – 7.49	pg/L
PCB congeners (total calc'd)	15/15	100	69.6	3,144	1,170	na	pg/L
PCB TEQ - Bird	13/15	87	0.0836	0.557	0.205	0.0723 – 0.0831	pg/L
PCB TEQ - Fish	13/15	87	0.00157	0.0116	0.00275	0.00145 – 0.00148	pg/L
PCB TEQ - Mammal	13/15	87	0.0321	0.210	0.0487	0.0322 – 0.0326	pg/L

E.6.5 SEEPS

Table E.6.5-1. Summary statistics for Boeing Plant 2 seep data

Analyte	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Metals and trace elements											
Aluminum (dissolved)	0/10	0	nd	nd	30	20 – 100	µg/L	na	na	na	na
Aluminum (total)	17/17	100	140	18,900	4,000	na	µg/L	SE-31003	na	na	na
Antimony (dissolved)	0/10	0	nd	nd	10	20	µg/L	na	na	na	na
Antimony (total)	1/17	6	6	6	6	2 – 20	µg/L	SE-SWY02	na	na	na
Arsenic (dissolved)	10/10	100	6	10	9	na	µg/L	SE-61006 SE-11001 SE-31003	69	0	0
Arsenic (total)	16/17	94	2	20	9	5	µg/L	SE-31003 SE-SWY01	na	na	na
Barium (dissolved)	1/10	10	71	71	20	10 – 37	µg/L	SE-31003	na	na	na
Barium (total)	17/17	100	6	132	30	na	µg/L	SE-31003	na	na	na
Beryllium (dissolved)	0/10	0	nd	nd	2	1 – 5	µg/L	na	na	na	na
Beryllium (total)	0/17	0	nd	nd	1	1 – 5	µg/L	na	na	na	na
Cadmium (dissolved)	0/10	0	nd	nd	3	2 – 10	µg/L	na	42	0	0
Cadmium (total)	0/17	0	nd	nd	3	2 – 10	µg/L	na	na	na	na
Calcium (dissolved)	10/10	100	129,000	257,000	200,000	na	µg/L	SE-21002	na	na	na
Calcium (total)	17/17	100	23,900	263,000	100,000	na	µg/L	SE-21002	na	na	na
Chromium (dissolved)	0/10	0	nd	nd	7	5 – 20	µg/L	na	1,100	0	0
Chromium (total)	6/17	35	6	49	10	5 – 20	µg/L	SE-SWY03	na	na	na
Cobalt (dissolved)	0/10	0	nd	nd	6	3 – 20	µg/L	na	na	na	na
Cobalt (total)	3/17	18	3	4	5	3 – 20	µg/L	SE-SWY03 SE-SWY01	na	na	na
Copper (dissolved)	1/10	10	8	8	4	2 – 10	µg/L	SE-94105	4.8	1	5
Copper (total)	11/17	65	2	60	20	2 – 10	µg/L	SE-SWY03	na	na	na
Iron (dissolved)	2/10	20	1,630	2,360	400	10 – 50	µg/L	SE-31003	na	na	na
Iron (total)	17/17	100	480	26,400	6	na	µg/L	SE-31003	na	na	na
Lead (dissolved)	0/10	0	nd	nd	5	1 – 20	µg/L	na	210	0	0
Lead (total)	14/17	82	1	104	20	20	µg/L	SE-SWY02	na	na	na
Magnesium (dissolved)	10/10	100	390,000	783,000	500,000	na	µg/L	SE-21002	na	na	na

Table E.6.5-1, cont. Summary statistics for Boeing Plant 2 seep data

Analyte	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Magnesium (total)	17/17	100	19,500	805,000	400,000	na	µg/L	SE-21002	na	na	na
Manganese (dissolved)	10/10	100	12	262	160	na	µg/L	SE-31003	na	na	na
Manganese (total)	17/17	100	14	639	230	na	µg/L	SE-SWY07	na	na	na
Mercury (dissolved)	0/10	0	nd	nd	0.050	0.100	µg/L	na	1.8	0	0
Mercury (total)	3/17	18	0.20	0.20	0.076	0.1	µg/L	SE-31003 SE-SWY03 SE-SWY01	na	na	na
Nickel (dissolved)	0/10	0	nd	nd	20	10 – 50	µg/L	na	74	0	0
Nickel (total)	4/17	24	10	50	20	10 – 50	µg/L	SE-SWY04	na	na	na
Potassium (dissolved)	10/10	100	140,000	238,000	180,000	na	µg/L	SE-21002	na	na	na
Potassium (total)	17/17	100	8,200	246,000	130,000	na	µg/L	SE-21002	na	na	na
Selenium (dissolved)	4/10	40	50	120	90	50 – 200	µg/L	SE-11001	na	na	na
Selenium (total)	8/17	47	60	300	90	50 – 200	µg/L	SE-31003 SE-11001	na	na	na
Silver (dissolved)	0/10	0	nd	nd	6	3 – 20	µg/L	na	1.9	0	10
Silver (total)	0/17	0	nd	nd	5	3 – 20	µg/L	na	1.9	0	17
Sodium (dissolved)	10/10	100	3,260,000	6,280,000	4,500,000	na	µg/L	SE-21002	na	na	na
Sodium (total)	17/17	100	152,000	6,440,000	3,400,000	na	µg/L	SE-21002	na	na	na
Thallium (dissolved)	2/10	20	50	70	70	50 – 20	µg/L	SE-94105	na	na	na
Thallium (total)	5/17	29	50	300	70	50 – 20	µg/L	SE-11001	na	na	na
Vanadium (dissolved)	2/10	20	2	4	3	2 – 10	µg/L	SE-11001	na	na	na
Vanadium (total)	15/17	88	2	50	20	2 – 10	µg/L	SE-31003	na	na	na
Zinc (dissolved)	3/10	30	30	90	20	4 – 20	µg/L	SE-SWY04	90	0	0
Zinc (total)	14/17	82	6	200	50	20	µg/L	SE-SWY04	na	na	na
PAHs											
2-Chloronaphthalene	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
2-Methylnaphthalene	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
Acenaphthene	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Acenaphthylene	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Anthracene	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Benzo(a)anthracene	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Benzo(a)pyrene	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Benzo(b)fluoranthene	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Benzo(g,h,i)perylene	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Benzo(k)fluoranthene	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na

Table E.6.5-1, cont. Summary statistics for Boeing Plant 2 seep data

Analyte	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Total benzofluoranthenes	0/17	0	nd	nd	0.50	nc	µg/L	na	na	na	na
Chrysene	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Dibenzo(a,h)anthracene	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Dibenzofuran	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Fluoranthene	1/17	6	1.3	1.3	0.55	1	µg/L	SE-84102	na	na	na
Fluorene	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Indeno(1,2,3-cd)pyrene	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Naphthalene	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Phenanthrene	1/17	6	1.0	1.0	0.53	1	µg/L	SE-84102	na	na	na
Pyrene	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Total HPAH	1/17	6	1.3	1.3	0.55	nc	µg/L	SE-84102	na	na	na
Total LPAH	1/17	6	1.0	1.0	0.53	nc	µg/L	SE-84102	na	na	na
Carcinogenic PAHs - Mammal	0/17	0	nd	nd	0.46	0.91	µg/L	na	na	na	na
Total PAH	1/17	6	2.3	2.3	0.61	nc	µg/L	SE-84102	na	na	na
Phthalates											
Bis(2-ethylhexyl)phthalate	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
Butyl benzyl phthalate	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
Diethyl phthalate	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
Dimethyl phthalate	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
Di-n-butyl phthalate	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
Di-n-octyl phthalate	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
Other SVOCs											
1,2,4-Trichlorobenzene	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
1,2-Dichlorobenzene	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
1,3-Dichlorobenzene	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
1,4-Dichlorobenzene	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
2,4,5-Trichlorophenol	0/9	0	nd	nd	2.5	5	µg/L	na	na	na	na
2,4,6-Trichlorophenol	0/9	0	nd	nd	2.5	5	µg/L	na	na	na	na
2,4-Dichlorophenol	0/9	0	nd	nd	1.5	3	µg/L	na	na	na	na
2,4-Dimethylphenol	0/9	0	nd	nd	1.5	3	µg/L	na	na	na	na
2,4-Dinitrophenol	0/9	0	nd	nd	5.0	10	µg/L	na	na	na	na
2,4-Dinitrotoluene	0/9	0	nd	nd	2.5	5	µg/L	na	na	na	na
2,6-Dinitrotoluene	0/9	0	nd	nd	2.5	5	µg/L	na	na	na	na
2-Chlorophenol	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
2-Methylphenol	0/9	0	nd	nd	1.0	2	µg/L	na	na	na	na

Table E.6.5-1, cont. Summary statistics for Boeing Plant 2 seep data

Analyte	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
2-Nitroaniline	0/9	0	nd	nd	2.5	5	µg/L	na	na	na	na
2-Nitrophenol	0/9	0	nd	nd	2.5	5	µg/L	na	na	na	na
3,3'-Dichlorobenzidine	0/9	0	nd	nd	2.5	5	µg/L	na	na	na	na
3-Nitroaniline	0/9	0	nd	nd	3.0	6	µg/L	na	na	na	na
4,6-Dinitro-o-cresol	0/9	0	nd	nd	5.0	10	µg/L	na	na	na	na
4-Bromophenyl phenyl ether	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
4-Chloro-3-methylphenol	0/9	0	nd	nd	1.0	2	µg/L	na	na	na	na
4-Chloroaniline	0/9	0	nd	nd	1.5	3	µg/L	na	na	na	na
4-Chlorophenyl phenyl ether	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
4-Methylphenol	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
4-Nitroaniline	0/9	0	nd	nd	2.5	5	µg/L	na	na	na	na
4-Nitrophenol	0/9	0	nd	nd	2.5	5	µg/L	na	na	na	na
Benzoic acid	0/9	0	nd	nd	5.0	10	µg/L	na	na	na	na
Benzyl alcohol	0/9	0	nd	nd	2.5	5	µg/L	na	na	na	na
bis(2-chloroethoxy)methane	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
bis(2-chloroethyl)ether	0/9	0	nd	nd	1.0	2	µg/L	na	na	na	na
bis(2-chloroisopropyl)ether	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
Carbazole	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
Hexachlorobenzene	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
Hexachlorobutadiene	0/9	0	nd	nd	1.0	2	µg/L	na	na	na	na
Hexachlorocyclopentadiene	0/9	0	nd	nd	2.5	5	µg/L	na	na	na	na
Hexachloroethane	0/9	0	nd	nd	1.0	2	µg/L	na	na	na	na
Isophorone	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
Methyl isobutyl ketone	0/18	0	nd	nd	2.5	5	µg/L	na	na	na	na
Nitrobenzene	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
N-Nitroso-di-n-propylamine	0/9	0	nd	nd	1.0	2	µg/L	na	na	na	na
N-Nitrosodiphenylamine	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na
Pentachlorophenol	0/9	0	nd	nd	2.5	5	µg/L	na	13	0	0
Phenol	0/9	0	nd	nd	1.0	2	µg/L	na	na	na	na
Polychlorinated biphenyls											
Aroclor-1016	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Aroclor-1242	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Aroclor-1248	0/17	0	nd	nd	0.50	1	µg/L	na	na	na	na
Aroclor-1254	1/17	6	0.93 J	0.93 J	0.54	1 – 1.5	µg/L	SW-SWY01	na	na	na
Aroclor-1260	3/17	18	1.7 J	4.6	0.89	1	µg/L	SE-SWY03	na	na	na

Table E.6.5-1, cont. Summary statistics for Boeing Plant 2 seep data

Analyte	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Aroclor-1262	0/1	0	nd	nd	0.60	1.2	µg/L	na	na	na	na
PCBs (total calc'd)	4/17	24	0.93 J	4.6	0.91	nc	µg/L	SE-SWY03	10	0	0
Conventional parameters											
Total suspended solids	17/17	100	15	190	80	na	mg/L	SE-31003	na	na	na
Total dissolved solids	17/17	100	590	20,000	10,000	na	mg/L	SE-21002	na	na	na
Alkalinity	17/17	100	67	180	120	na	mg/L $CaCO_3$	SE-SWY07	na	na	na
Bicarbonate	8/8	100	62	200	110	na	mg/L $CaCO_3$	SE-SWY01	na	na	na
Carbonate	0/8	0	nd	nd	0.5	1	mg/L $CaCO_3$	na	na	na	na
Hardness	17/17	100	140	4,000	2,000	na	mg/L $CaCO_3$	SE-21002	na	na	na
Volatile organic compounds											
1,1,1-Trichloroethane	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
1,1,2,2-Tetrachloroethane	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
1,1,2-Trichloroethane	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
1,1,2-Trichlorotrifluoroethane	0/18	0	nd	nd	1.0	2	µg/L	na	na	na	na
1,1-Dichloroethane	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
1,1-Dichloroethene	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
1,2-Dichloroethane	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
1,2-Dichloropropane	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
2-Chloroethyl vinyl ether	0/18	0	nd	nd	2.5	5	µg/L	na	na	na	na
2-Hexanone	0/18	0	nd	nd	2.5	5	µg/L	na	na	na	na
Acetone	0/18	0	nd	nd	2.5	5	µg/L	na	na	na	na
Benzene	1/18	6	2.2	2.2	0.59	1	µg/L	SE-SWY07	na	na	na
Bromodichloromethane	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
Bromoform	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
Bromomethane	0/18	0	nd	nd	1.0	2	µg/L	na	na	na	na
Carbon disulfide	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
Carbon tetrachloride	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
Chlorobenzene	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
Chloroethane	0/18	0	nd	nd	1.0	2	µg/L	na	na	na	na
Chloroform	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
Chloromethane	0/18	0	nd	nd	1.0	2	µg/L	na	na	na	na
cis-1,2-Dichloroethene	6/18	33	1.2	40	5.6	1	µg/L	SE-11001	na	na	na
cis-1,3-Dichloropropene	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na

Table E.6.5-1, cont. Summary statistics for Boeing Plant 2 seep data

Analyte	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Dibromochloromethane	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
Dichloromethane	0/18	0	nd	nd	1.0	2	µg/L	na	na	na	na
Ethylbenzene	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
Methyl ethyl ketone	0/18	0	nd	nd	2.5	5	µg/L	na	na	na	na
Styrene	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
Tetrachloroethene	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
Toluene	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
trans-1,2-Dichloroethene	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
trans-1,3-Dichloropropene	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
Trichloroethene	3/18	17	1.9	13	1.4	1	µg/L	SE-SWY02	na	na	na
Trichlorofluoromethane	0/18	0	nd	nd	1.0	2	µg/L	na	na	na	na
Vinyl acetate	0/18	0	nd	nd	2.5	5	µg/L	na	na	na	na
Vinyl chloride	4/18	22	3.1	36	5	0.01 – 2	µg/L	SE-11001	na	na	na
Xylene (ortho)	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
Xylene (meta & para)	0/18	0	nd	nd	0.50	1	µg/L	na	na	na	na
Total xylenes	0/18	0	nd	nd	0.50	nc	µg/L	na	na	na	na
Petroleum groups											
TPH	0/2	0	nd	nd	0.5	1	mg/L	na	na	na	na

[a] Comparisons were not made to chronic water quality standards because chronic standards are based on 4-day average concentrations not to be exceeded more than once every three years. Because of the tidal cycle, comparison of intertidal seep samples to acute standards is more appropriate. Acute standards represent 1-hour average concentrations not to be exceeded more than once every three years on average.

Table E.6.5-2. Summary of Rhône-Poulenc RFI-3 seep data for detected chemicals

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Metals and trace elements											
Aluminum (total)	7/7	100	361	59,600	nc	na	µg/L	02-SP	na	na	na
Arsenic (total)	1/7	14	31.0	31.0	nc	nr	µg/L	02-SP	na	na	na
Barium (total)	7/7	100	4.5448	174	nc	na	µg/L	01-SP	na	na	na
Beryllium (total)	1/7	14	0.89	0.89	nc	nr	µg/L	02-SP	na	na	na
Cadmium (total)	2/7	29	2.1	11.6	nc	nr	µg/L	02-SP	na	na	na
Calcium (total)[a]	5/5	100	15,012	168,000	nc	na	µg/L	04-SP	na	na	na
Chromium (total)	1/7	14	202	202	nc	nr	µg/L	02-SP	na	na	na
Cobalt (total)	2/7	29	2.9	55.5	nc	nr	µg/L	02-SP	na	na	na
Copper (total)	1/7	14	203	203	nc	nr	µg/L	02-SP	na	na	na
Lead (total)	1/7	14	44.1	44.1	nc	nr	µg/L	02-SP	na	na	na
Magnesium (total) [a]	5/5	100	45,585	541,000	nc	na	µg/L	04-SP	na	na	na
Mercury (total)	1/7	14	0.65	0.65	nc	nr	µg/L	05-SP	na	na	na
Nickel (total)	1/7	14	70.0	70.0	nc	nr	µg/L	02-SP	na	na	na
Phosphorus	5/7	71	210	1,600	nc	nr	µg/L	02-SP	na	na	na
Potassium (total) [a]	5/5	100	30,611.5	211,000	nc	na	µg/L	04-SP	na	na	na
Sodium (total) [a]	5/5	100	69,3176	5,190,000	nc	na	µg/L	04-SP	na	na	na
Vanadium (Total)	7/7	100	2.8	400	nc	na	µg/L	02-SP	na	na	na
Zinc (total)	1/7	14	223	223	nc	nr	µg/L	02-SP	na	na	na
Phthalates											
Bis(2-ethylhexyl)phthalate	2/7	29	13.8	27.0	nc	nr	µg/L	02-SP	na	na	na
Conventional parameters											
Total Organic Carbon (TOC)	7/7	100	1.6	160	nc	na	mg/L	02-SP	na	na	na
Total dissolved solids	7/7	100	1,900	17,000	nc	na	mg/L	04-SP	na	na	na
Sulfate	7/7	100	130	1,200	nc	na	mg/L	04-SP	na	na	na
Alkalinity	7/7	100	68	1,000	nc	na	mg/L $CaCO_3$	02-SP	na	na	na
Bicarbonate	7/7	100	68	1,000	nc	na	mg/L $CaCO_3$	02-SP	na	na	na
Chloride	7/7	100	2,900	9,100	nc	na	mg/L	07-SP	na	na	na
Dissolved oxygen	7/7	100	2.6	9.9	nc	na	mg/L	05-SP	na	na	na
Nitrate	7/7	100	0.10	0.47	nc	nr	mg/L	06-SP 04-SP 03-SP	na	na	na

Table E.6.5-2, cont. Summary of Rhône-Poulenc RFI-3 seep data for detected chemicals

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Nitrite	1/7	14	0.080	0.080	nc	nr	mg/L	02-SP	na	na	na
pH	7/7	100	6.37	7.79	nc	na	pH	04-SP	na	na	na
Salinity	5/7	71	2.5	12.3	nc	nr	ppt	04-SP	na	na	na
Specific Conductance	7/7	100	2,450	14,200	nc	na	µmhos/cm	01-SP	na	na	na
Temperature	7/7	100	10.8	13.8	nc	na	°C	07-SP	na	na	na
Total Kjeldahl Nitrogen (TKN)	6/7	86	0.14	2.2	nc	nr	mg/L	01-SP	na	na	na
Volatile organic compounds											
Formaldehyde	1/7	14	24 J	24 J	nc	nr	µg/L	06-SP	na	na	na

Note: Only detected chemicals were reported in the data report; RLs for nondetected results are not available.

Seven seep locations were analyzed for conventional parameters, hexavalent chromium, metals, SVOCs, VOCs, formaldehyde, and guaiacol/resin acids. Additionally, locations 1, 2, and 3 were analyzed for PCBs, pesticides and herbicides.

[a] Comparisons were not made to chronic water quality standards because chronic standards are based on 4-day average concentrations not to be exceeded more than once every three years. Because of the tidal cycle, comparison of intertidal seep samples to acute standards is more appropriate. Acute standards represent 1-hour average concentrations not to be exceeded more than once every three years on average.

[b] Seep locations 1 and 3 were not anaylyzed for calcium, magnesium, potassium, and sodium.

Table E.6.5-3. Summary statistics for T117 seep data

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Metals and trace elements											
Arsenic (dissolved)	0/3	0	nd	nd	25	50	µg/L	na	69	0	0
Arsenic (total)	0/1	0	nd	nd	25	50	µg/L	na	na	na	na
Cadmium (dissolved)	0/3	0	nd	nd	1.0	2.00	µg/L	na	42	0	0
Cadmium (total)	0/3	0	nd	nd	1.0	2.0	µg/L	na	na	na	na
Chromium (dissolved)	2/3	67	8.00 J	9.00 J	6.50	5.00	µg/L	SEEP_2	1,100	0	0
Chromium (total)	2/3	67	6.00	7.00	5.17	5.00	µg/L	SEEP_3	na	na	na
Copper (dissolved)	3/3	100	4 J	5.00 J	4.67	na	µg/L	SEEP_2 SEEP_1	4.8	2	0
Copper (total)	3/3	100	2.50	4.00	3.17	na	µg/L	SEEP_3	na	na	na
Lead (dissolved)	0/3	0	nd	nd	10	20	µg/L	na	210	0	0
Lead (total)	0/3	0	nd	nd	10	20	µg/L	na	na	na	na
Mercury (total)	0/3	0	nd	nd	0.050	0.10	µg/L	na	na	na	na
Silver (dissolved)	0/3	0	nd	nd	1.50	3.00	µg/L	na	1.9	0	3
Silver (total)	0/3	0	nd	nd	1.50	3.00	µg/L	na	1.9	0	3
Zinc (dissolved)	0/3	0	nd	nd	3.00	6.00	µg/L	na	90	0	0
Zinc (total)	1/3	33	7.00 J	7.00 J	4.33	6.00	µg/L	SEEP_1	na	na	na
PAHs											
2-Methylnaphthalene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Acenaphthene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Acenaphthylene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Anthracene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Benzo(a)anthracene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Benzo(a)pyrene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Benzo(b)fluoranthene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Benzo(g,h,i)perylene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Benzo(k)fluoranthene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Benzofluoranthenes (total-calc'd)	0/3	0	nd	nd	0.50	nc	µg/L	na	nv	0	0
Chrysene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Dibenzo(a,h)anthracene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Dibenzofuran	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0

Table E.6.5-3, cont. Summary statistics for T117 seep data

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Fluoranthene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Fluorene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Indeno(1,2,3-cd)pyrene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Naphthalene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Phenanthrene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Pyrene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Total HPAH	0/3	0	nd	nd	0.50	nc	µg/L	na	nv	0	0
Total LPAH	0/3	0	nd	nd	0.50	nc	µg/L	na	nv	0	0
Carcinogenic PAHs - Mammal	0/3	0	nd	nd	0.46	0.91	µg/L	na	nv	0	0
Total PAH	0/3	0	nd	nd	0.50	nc	µg/L	na	nv	0	0
Phthalates											
Bis(2-ethylhexyl)phthalate	1/3	33	8.9 J	8.9 J	3.3	1.0	µg/L	SEEP_2	nv	0	0
Butyl benzyl phthalate	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Diethyl phthalate	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Dimethyl phthalate	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Di-n-butyl phthalate	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Di-n-octyl phthalate	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Other SVOCs											
1,2,4-Trichlorobenzene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
1,2-Dichlorobenzene	0/1	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
1,3-Dichlorobenzene	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
1,4-Dichlorobenzene	0/1	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
2,4-Dimethylphenol	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
2-Methylphenol	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
4-Methylphenol	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Benzoic acid	0/3	0	nd	nd	5.0	10	µg/L	na	nv	0	0
Benzyl alcohol	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Hexachlorobenzene	0/3	0	nd	nd	0.025	0.050	µg/L	na	nv	0	0
Hexachlorobutadiene	0/3	0	nd	nd	0.025	0.050	µg/L	na	nv	0	0
N-Nitrosodiphenylamine	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Pentachlorophenol	0/3	0	nd	nd	2.5	5.0	µg/L	na	13	0	0
Phenol	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Polychlorinated biphenyls											
Aroclor-1016	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Aroclor-1221	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0

Table E.6.5-3, cont. Summary statistics for T117 seep data

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Aroclor-1232	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Aroclor-1242	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Aroclor-1248	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Aroclor-1254	0/3	0	nd	nd	0.50	1.0	µg/L	na	nv	0	0
Aroclor-1260	1/3	33	0.94 J	0.94 J	0.65	1.0	µg/L	SEEP_3	nv	0	0
PCBs (total calc'd)[a]	1/3	33	0.94 J	0.94 J	0.65	nc	µg/L	SEEP_3	10	0	0
Conventional parameters											
Total Organic Carbon (TOC)	2/3	67	2.1	2.5	1.8	1.5	mg/L	SEEP_1	nv	0	0
Total suspended solids	3/3	100	2.2	27	11	na	mg/L	SEEP_3	nv	0	0

[a] Comparisons were not made to chronic water quality standards because chronic standards are based on 4-day average concentrations not to be exceeded more than once every three years. Because of the tidal cycle, comparison of intertidal seep samples to acute standards is more appropriate. Acute standards represent 1-hour average concentrations not to be exceeded more than once every three years on average.

[b] The seep water sample at Location SEEP 3 was re-sampled because it was suspected that the detected PCB concentration of 0.94 J may have been an artifact of suspended solids in the water sample. The sample was centrifuged and then analyzed, and PCBs were not detected at a reporting limit of 0.033 µg/L.

Table E.6.5-4. Summary statistics for LDWG Phase 2 RI seep data

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Unfiltered											
Metals and trace elements											
Arsenic	13/13	100	0.058	287	28	na	µg/L	SP-76	na	na	na
Cadmium	13/13	100	0.022	0.710	0.20	na	µg/L	SP-54	na	na	na
Chromium	1/13	8	74.9	74.9	8.1	0.07 – 11.4	µg/L	SP-54	na	na	na
Copper	10/13	77	8.06 J	50.9	13.2	4.75 – 6.47	µg/L	SP-76	na	na	na
Lead	13/13	100	0.080	296	29	na	µg/L	SP-54	na	na	na
Mercury	13/13	100	0.00061	0.582	0.056	na	µg/L	SP-54	na	na	na
Nickel	12/13	92	2.80	8.83	4.6	0.040 – 0.04	µg/L	SP-20	na	na	na
Silver	11/13	85	0.025	0.11	0.050	0.015	µg/L	SP-82	na	na	na
Zinc	13/13	100	3.49	322	75.8	na	µg/L	SP-54	na	na	na
PAHs											
2-Chloronaphthalene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
2-Methylnaphthalene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Acenaphthene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Acenaphthylene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Anthracene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Benzo(a)anthracene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Benzo(a)pyrene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Benzo(b)fluoranthene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Benzo(g,h,i)perylene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Benzo(k)fluoranthene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Benzofluoranthenes (total-calc'd)	0/14	0	nd	nd	0.50	nc	µg/L	nd	nv	na	na
Chrysene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Dibenzo(a,h)anthracene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Dibenzofuran	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Fluoranthene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Fluorene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Indeno(1,2,3-cd)pyrene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Naphthalene	0/16	0	nd	nd	0.75	1.0 – 5.0	µg/L	nd	nv	na	na
Phenanthrene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Pyrene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na

Table E.6.5-4, cont. Summary statistics for LDWG Phase 2 RI seep data

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Total HPAH	0/14	0	nd	nd	0.50	nc	µg/L	nd	nv	na	na
Total LPAH	0/14	0	nd	nd	0.50	nc	µg/L	nd	nv	na	na
Carcinogenic PAHs - Mammal	0/14	0	nd	nd	0.46	0.91	µg/L	nd	nv	na	na
Total PAH	0/14	0	nd	nd	0.50	nc	µg/L	nd	nv	na	na
Phthalates											
Bis(2-ethylhexyl)phthalate	0/14	0	nd	nd	0.81	1.0 – 3.9	µg/L	nd	nv	na	na
Butyl benzyl phthalate	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Diethyl phthalate	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Dimethyl phthalate	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Di-n-butyl phthalate	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Di-n-octyl phthalate	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Other SVOCs											
1,2,4-Trichlorobenzene	0/16	0	nd	nd	0.75	1.0 – 5.0	µg/L	nd	nv	na	na
1,2-Dichlorobenzene	1/16	6	2.9	2.9	0.65	1.0	µg/L	SP-54	nv	na	na
1,3-Dichlorobenzene	1/16	6	58.3	58.3	4.1	1.0	µg/L	SP-54	nv	na	na
1,4-Dichlorobenzene	1/16	6	40.2	40.2	3.0	1.0	µg/L	SP-54	nv	na	na
1,4-Dioxane	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
2,4,5-Trichlorophenol	0/14	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
2,4,6-Trichlorophenol	0/14	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
2,4-Dichlorophenol	0/14	0	nd	nd	1.5	3.0	µg/L	nd	nv	na	na
2,4-Dimethylphenol	0/14	0	nd	nd	1.5	3.0	µg/L	nd	nv	na	na
2,4-Dinitrophenol	0/14	0	nd	nd	13	25	µg/L	nd	nv	na	na
2,4-Dinitrotoluene	0/14	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
2,6-Dinitrotoluene	0/14	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
2-Chlorophenol	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
2-Methylphenol	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
2-Nitroaniline	0/14	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
2-Nitrophenol	0/14	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
3,3'-Dichlorobenzidine	0/14	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
3-Nitroaniline	0/14	0	nd	nd	3.0	6.0	µg/L	nd	nv	na	na
4,6-Dinitro-o-cresol	0/14	0	nd	nd	7.5	15	µg/L	nd	nv	na	na
4-Bromophenyl phenyl ether	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
4-Chloro-3-methylphenol	0/14	0	nd	nd	1.0	2.0	µg/L	nd	nv	na	na
4-Chloroaniline	0/14	0	nd	nd	1.5	3.0	µg/L	nd	nv	na	na
4-Chlorophenyl phenyl ether	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na

Table E.6.5-4, cont. Summary statistics for LDWG Phase 2 RI seep data

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
4-Methylphenol	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
4-Nitroaniline	0/14	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
4-Nitrophenol	0/14	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
Benzoic acid	0/14	0	nd	nd	5.0	10	µg/L	nd	nv	na	na
Benzyl alcohol	0/14	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
bis(2-chloroethoxy)methane	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
bis(2-chloroethyl)ether	0/14	0	nd	nd	1.0	2.0	µg/L	nd	nv	na	na
bis(2-chloroisopropyl)ether	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Carbazole	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Hexachlorobenzene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Hexachlorobutadiene	0/16	0	nd	nd	1.2	2.0 – 5.0	µg/L	nd	nv	na	na
Hexachlorocyclopentadiene	0/14	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
Hexachloroethane	0/14	0	nd	nd	1.0	2.0	µg/L	nd	nv	na	na
Isophorone	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Methyl isobutyl ketone	0/16	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
Nitrobenzene	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
N-Nitroso-di-n-propylamine	0/14	0	nd	nd	1.0	2.0	µg/L	nd	nv	na	na
N-Nitrosodiphenylamine	0/14	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Pentachlorophenol	0/14	0	nd	nd	2.5	5.0	µg/L	nd	na	na	na
Phenol	0/14	0	nd	nd	1.0	2.0	µg/L	nd	nv	na	na
Polychlorinated biphenyls											
Aroclor-1016	0/14	0	nd	nd	0.015	0.017 – 0.17	µg/L	nd	nv	na	na
Aroclor-1221	0/14	0	nd	nd	0.015	0.017 – 0.17	µg/L	nd	nv	na	na
Aroclor-1232	0/14	0	nd	nd	0.015	0.017 – 0.17	µg/L	nd	nv	na	na
Aroclor-1242	0/14	0	nd	nd	0.015	0.017 – 0.17	µg/L	nd	nv	na	na
Aroclor-1248	2/14	14	0.092	4.7	0.35	0.017 – 0.02	µg/L	SP-54	nv	na	na
Aroclor-1254	3/14	21	0.020 J	2.3 J	0.19	0.017 – 0.02	µg/L	SP-54	nv	na	na
Aroclor-1260	2/14	14	0.16	1.9 J	0.15	0.017 – 0.02	µg/L	SP-54	nv	na	na
PCBs (total calc'd)	3/14	21	0.020 J	8.9 J	0.68	nc	µg/L	SP-54	na	na	na
Pesticides											
4,4'-DDD	0/13	0	nd	nd	0.0077	0.0017 – 0.18	µg/L	nd	na	na	na
4,4'-DDE	0/13	0	nd	nd	0.0087	0.0017 – 0.17	µg/L	nd	na	na	na
4,4'-DDT	0/13	0	nd	nd	0.0015	0.0017 – 0.017	µg/L	nd	na	na	na
DDTs (total-calc'd)	0/13	0	nd	nd	0.0091	0.0017 – 0.18	µg/L	nd	na	na	na
Aldrin	0/13	0	nd	nd	0.00070	0.0008 – 0.0083	µg/L	nd	na	na	na

Table E.6.5-4, cont. Summary statistics for LDWG Phase 2 RI seep data

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Dieldrin	0/13	0	nd	nd	0.0060	0.0017 – 0.11	µg/L	nd	na	na	na
Total aldrin/dieldrin	0/13	0	nd	nd	0.0060	nc	µg/L	nd	na	na	na
alpha-BHC	0/13	0	nd	nd	0.00082	0.0008 – 0.0083	µg/L	nd	nv	na	na
beta-BHC	0/13	0	nd	nd	0.00081	0.0008 – 0.0083	µg/L	nd	nv	na	na
gamma-BHC	0/13	0	nd	nd	0.00070	0.0008 – 0.0083	µg/L	nd	na	na	na
delta-BHC	0/13	0	nd	nd	0.0012	0.0008 – 0.0083	µg/L	nd	nv	na	na
alpha-Chlordane	0/13	0	nd	nd	0.00070	0.0008 – 0.0083	µg/L	nd	nv	na	na
gamma-Chlordane	0/13	0	nd	nd	0.00079	0.0008 – 0.0083	µg/L	nd	nv	na	na
alpha-Endosulfan	0/13	0	nd	nd	0.00070	0.0008 – 0.0083	µg/L	nd	na	na	na
beta-Endosulfan	0/13	0	nd	nd	0.011	0.0017 – 0.26	µg/L	nd	na	na	na
Endosulfan sulfate	0/13	0	nd	nd	0.0015	0.0017 – 0.017	µg/L	nd	na	na	na
Endrin	0/13	0	nd	nd	0.0030	0.0017 – 0.057	µg/L	nd	na	na	na
Endrin aldehyde	0/13	0	nd	nd	0.0031	0.0017 – 0.061	µg/L	nd	nv	na	na
Endrin ketone	0/13	0	nd	nd	0.0015	0.0017 – 0.017	µg/L	nd	nv	na	na
Heptachlor	0/13	0	nd	nd	0.00070	0.0008 – 0.0083	µg/L	nd	na	na	na
Heptachlor epoxide	1/13	8	0.0076	0.0076	0.0013	0.0008 – 0.0083	µg/L	SP-39	nv	na	na
Methoxychlor	0/13	0	nd	nd	0.0071	0.0083 – 0.083	µg/L	nd	nv	na	na
Toxaphene	0/13	0	nd	nd	0.071	0.083 – 0.83	µg/L	nd	na	na	na
Total chlordane	0/13	0	nd	nd	0.00079	nc	µg/L	nd	nv	na	na
Conventional parameters											
Total Organic Carbon (TOC)	8/13	62	2.08	13.4	3.8	1.5	mg/L	SP-80	nv	na	na
Total suspended solids	13/13	100	4.3 J	33.3	14	na	mg/L	SP-80	nv	na	na
Volatile organic compounds											
1,1,1,2-Tetrachloroethane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
1,1,1-Trichloroethane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
1,1,2,2-Tetrachloroethane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
1,1,2-Trichloroethane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
1,1,2-Trichlorotrifluoroethane	0/16	0	nd	nd	1.0	2.0	µg/L	nd	nv	na	na
1,1-Dichloroethane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
1,1-Dichloroethene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
1,1-Dichloropropene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
1,2,3-Trichlorobenzene	0/16	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
1,2,3-Trichloropropane	0/16	0	nd	nd	1.5	3.0	µg/L	nd	nv	na	na
1,2,4-Trimethylbenzene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
1,2-Dibromo-3-chloropropane	0/16	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na

Table E.6.5-4, cont. Summary statistics for LDWG Phase 2 RI seep data

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
1,2-Dibromoethane (EDB)	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
1,2-Dichloroethane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
1,2-Dichloropropane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
1,3,5-Trimethylbenzene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
1,3-Dichloropropane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
2,2-Dichloropropane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
2-Chlorotoluene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
2-Hexanone	0/16	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
4-Chlorotoluene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Acetone	0/16	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
Acrolein	0/16	0	nd	nd	25	50	µg/L	nd	nv	na	na
Acrylonitrile	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Benzene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Bromobenzene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Bromochloromethane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Bromodichloromethane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Bromoethane	0/16	0	nd	nd	1.0	2.0	µg/L	nd	nv	na	na
Bromoform	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Bromomethane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Carbon disulfide	2/16	12	1.1	2.4	0.66	1.0	µg/L	SP-54	nv	na	na
Carbon tetrachloride	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Chlorobenzene	1/16	6	6.5	6.5	0.88	1.0	µg/L	SP-54	nv	na	na
Chloroethane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Chloroform	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Chloromethane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
cis-1,2-Dichloroethene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
cis-1,3-Dichloropropene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
p-Cymene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Dibromochloromethane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Dibromomethane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Dichloromethane	0/16	0	nd	nd	1.0	2.0	µg/L	nd	nv	na	na
Ethylbenzene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Iodomethane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Isopropylbenzene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Methyl ethyl ketone	0/16	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na

Table E.6.5-4, cont. Summary statistics for LDWG Phase 2 RI seep data

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
n-Butylbenzene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
n-Propylbenzene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
sec-Butylbenzene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Styrene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
tert-Butylbenzene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Tetrachloroethene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Toluene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
trans-1,2-Dichloroethene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
trans-1,3-Dichloropropene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
trans-1,4-Dichloro-2-butene	0/16	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
Trichloroethene	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Trichlorofluoromethane	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Vinyl acetate	0/16	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
Vinyl chloride	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Xylene (ortho)	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Xylene (meta & para)	0/16	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Total xylenes	0/16	0	nd	nd	0.50	nc	µg/L	nd	nv	na	na
Petroleum groups											
Gasoline	1/8	12	0.29	0.29	0.15	0.25	mg/L	SP-54	nv	na	na
TPH - Diesel Range	2/8	25	0.54	2.2	0.44	0.25	mg/L	SP-54	nv	na	na
TPH - Motor Oil Range	1/8	12	1.9	1.9	0.46	0.5	mg/L	SP-54	nv	na	na
Filtered											
Metals and trace elements											
Arsenic	16/16	100	0.054	253	22	na	µg/L	SP-76	69	2	0
Cadmium	16/16	100	0.009	0.508	0.099	na	µg/L	SP-82	42	0	0
Chromium	0/16	0	nd	nd	2.75	1.51 – 9.74	µg/L	na	1100	0	0
Copper	7/16	44	8.16 J	22.8	6.6	3.28 – 7.77	µg/L	SP-80	4.8	7	5
Lead	16/16	100	0.036	3	0.34	na	µg/L	SP-76	210	0	0
Mercury	16/16	100	0.00062	0.0153	0.0035	na	µg/L	SP-76	1.8	0	0
Nickel	12/16	75	0.84	5.25	1.9	0.04	µg/L	SP-20	74	0	0
Silver	14/16	88	0.012	0.112	0.047	0.015	µg/L	SP-20	1.9	0	0
Zinc	16/16	100	3.29	161	26.5	na	µg/L	SP-82	90	2	0
PAHs											
2-Chloronaphthalene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
2-Methylnaphthalene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na

Table E.6.5-4, cont. Summary statistics for LDWG Phase 2 RI seep data

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Acenaphthene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Acenaphthylene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Anthracene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Benzo(a)anthracene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Benzo(a)pyrene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Benzo(b)fluoranthene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Benzo(g,h,i)perylene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Benzo(k)fluoranthene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Benzofluoranthenes (total-calc'd)	0/15	0	nd	nd	0.50	nc	µg/L	nd	nv	na	na
Chrysene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Dibenzo(a,h)anthracene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Dibenzofuran	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Fluoranthene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Fluorene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Indeno(1,2,3-cd)pyrene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Naphthalene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Phenanthrene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Pyrene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Total HPAH	0/15	0	nd	nd	0.50	nc	µg/L	nd	nv	na	na
Total LPAH	0/15	0	nd	nd	0.50	nc	µg/L	nd	nv	na	na
Carcinogenic PAHs - Mammal	0/15	0	nd	nd	0.46	0.91	µg/L	nd	nv	na	na
Total PAH	0/15	0	nd	nd	0.50	nc	µg/L	nd	nv	na	na
Phthalates											
Bis(2-ethylhexyl)phthalate	0/14	0	nd	nd	0.67	1.0 – 3.8	µg/L	nd	nv	na	na
Butyl benzyl phthalate	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Diethyl phthalate	0/15	0	nd	nd	0.67	1.0 – 5.5	µg/L	nd	nv	na	na
Dimethyl phthalate	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Di-n-butyl phthalate	0/15	0	nd	nd	0.59	1.0 – 3.8	µg/L	nd	nv	na	na
Di-n-octyl phthalate	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Other SVOCs											
1,2,4-Trichlorobenzene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
1,2-Dichlorobenzene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
1,3-Dichlorobenzene	1/15	7	3.6	3.6	0.71	1.0	µg/L	SP-54	nv	na	na
1,4-Dichlorobenzene	1/15	7	3.9	3.9	0.73	1.0	µg/L	SP-54	nv	na	na

Table E.6.5-4, cont. Summary statistics for LDWG Phase 2 RI seep data

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
1,4-Dioxane	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
2,4,5-Trichlorophenol	0/15	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
2,4,6-Trichlorophenol	0/15	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
2,4-Dichlorophenol	0/15	0	nd	nd	1.5	3.0	µg/L	nd	nv	na	na
2,4-Dimethylphenol	0/15	0	nd	nd	1.5	3.0	µg/L	nd	nv	na	na
2,4-Dinitrophenol	0/15	0	nd	nd	13	25	µg/L	nd	nv	na	na
2,4-Dinitrotoluene	0/15	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
2,6-Dinitrotoluene	0/15	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
2-Chlorophenol	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
2-Methylphenol	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
2-Nitroaniline	0/15	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
2-Nitrophenol	0/15	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
3,3'-Dichlorobenzidine	0/15	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
3-Nitroaniline	0/15	0	nd	nd	3.0	6.0	µg/L	nd	nv	na	na
4,6-Dinitro-o-cresol	0/15	0	nd	nd	7.5	15	µg/L	nd	nv	na	na
4-Bromophenyl phenyl ether	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
4-Chloro-3-methylphenol	0/15	0	nd	nd	1.0	2.0	µg/L	nd	nv	na	na
4-Chloroaniline	0/15	0	nd	nd	1.5	3.0	µg/L	nd	nv	na	na
4-Chlorophenyl phenyl ether	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
4-Methylphenol	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
4-Nitroaniline	0/15	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
4-Nitrophenol	0/15	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
Benzoic acid	0/15	0	nd	nd	5.0	10	µg/L	nd	nv	na	na
Benzyl alcohol	0/15	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
bis(2-chloroethoxy)methane	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
bis(2-chloroethyl)ether	0/15	0	nd	nd	1.0	2.0	µg/L	nd	nv	na	na
bis(2-chloroisopropyl)ether	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Carbazole	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Hexachlorobenzene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Hexachlorobutadiene	0/15	0	nd	nd	1.0	2.0	µg/L	nd	nv	na	na
Hexachlorocyclopentadiene	0/15	0	nd	nd	2.5	5.0	µg/L	nd	nv	na	na
Hexachloroethane	0/15	0	nd	nd	1.0	2.0	µg/L	nd	nv	na	na
Isophorone	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Nitrobenzene	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
N-Nitroso-di-n-propylamine	0/15	0	nd	nd	1.0	2.0	µg/L	nd	nv	na	na

Table E.6.5-4, cont. Summary statistics for LDWG Phase 2 RI seep data

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
N-Nitrosodiphenylamine	0/15	0	nd	nd	0.50	1.0	µg/L	nd	nv	na	na
Pentachlorophenol	0/15	0	nd	nd	2.5	5.0	µg/L	nd	13	0	0
Phenol	0/15	0	nd	nd	1.0	2.0	µg/L	nd	nv	na	na
Polychlorinated biphenyls											
Aroclor-1016	0/16	0	nd	nd	0.0085	0.017	µg/L	nd	nv	na	na
Aroclor-1221	0/16	0	nd	nd	0.0085	0.017	µg/L	nd	nv	na	na
Aroclor-1232	0/16	0	nd	nd	0.0085	0.017	µg/L	nd	nv	na	na
Aroclor-1242	0/16	0	nd	nd	0.0085	0.017	µg/L	nd	nv	na	na
Aroclor-1248	1/16	6	0.21	0.21	0.021	0.017	µg/L	SP-54	nv	na	na
Aroclor-1254	0/16	0	nd	nd	0.013	0.017 – 0.15	µg/L	nd	nv	na	na
Aroclor-1260	1/16	6	0.047	0.047	0.011	0.017	µg/L	SP-54	nv	na	na
PCBs (total calc'd)	1/16	6	0.26	0.26	0.024	nc	µg/L	SP-54	10	0	0
Pesticides											
4,4'-DDD	0/16	0	nd	nd	0.0016	0.0017 – 0.021	µg/L	nd	0.13	0	0
4,4'-DDE	0/16	0	nd	nd	0.0026	0.0017 – 0.058	µg/L	nd	0.13	0	0
4,4'-DDT	0/16	0	nd	nd	0.00085	0.0017	µg/L	nd	0.13	0	0
DDTs (total-calc'd)	0/16	0	nd	nd	0.0032	0.0017 – 0.058	µg/L	nd	0.13	0	0
Aldrin	0/16	0	nd	nd	0.00040	0.0008	µg/L	nd	0.71	0	0
Dieldrin	0/16	0	nd	nd	0.0011	0.0017 – 0.0095	µg/L	nd	0.71	0	0
Total aldrin/dieldrin	0/16	0	nd	nd	0.0011	nc	µg/L	nd	nv	na	na
alpha-BHC	0/16	0	nd	nd	0.00059	0.0008 – 0.007	µg/L	nd	nv	na	na
beta-BHC	0/16	0	nd	nd	0.00066	0.0008 – 0.009	µg/L	nd	nv	na	na
gamma-BHC	0/16	0	nd	nd	0.00040	0.0008	µg/L	nd	0.16	0	na
delta-BHC	0/16	0	nd	nd	0.0018	0.0008 – 0.013	µg/L	nd	nv	na	na
alpha-Chlordane	0/16	0	nd	nd	0.0016	0.0008 – 0.038	µg/L	nd	nv	na	na
gamma-Chlordane	0/16	0	nd	nd	0.00067	0.0008 – 0.0054	µg/L	nd	nv	na	na
alpha-Endosulfan	0/16	0	nd	nd	0.00040	0.0008	µg/L	nd	0.034	0	0
beta-Endosulfan	0/16	0	nd	nd	0.0011	0.0017 – 0.011	µg/L	nd	0.034	0	0
Endosulfan sulfate	0/16	0	nd	nd	0.00085	0.0017	µg/L	nd	0.034	0	0
Endrin	0/16	0	nd	nd	0.00085	0.0017	µg/L	nd	0.037	0	0
Endrin aldehyde	0/16	0	nd	nd	0.00085	0.0017	µg/L	nd	nv	na	na
Endrin ketone	0/16	0	nd	nd	0.00085	0.0017	µg/L	nd	nv	na	na
Heptachlor	0/16	0	nd	nd	0.00040	0.0008	µg/L	nd	0.053	0	0
Heptachlor epoxide	1/16	6	0.0090	0.0090	0.0014	0.0008 – 0.016	µg/L	SP-39	nv	na	na
Methoxychlor	0/16	0	nd	nd	0.0042	0.0083	µg/L	nd	nv	na	na

Table E.6.5-4, cont. Summary statistics for LDWG Phase 2 RI seep data

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Toxaphene	0/16	0	nd	nd	0.042	0.083	µg/L	nd	0.21	0	0
Total chlordane	0/16	0	nd	nd	0.0019	nc	µg/L	nd	nv	na	na
Conventional parameters											
Dissolved Organic Carbon	6/16	38	1.75 J	14.8 J	2.7	1.5	mg/L	SP-80	nv	na	na
Petroleum groups											
TPH - Diesel Range	2/8	25	0.50	1.4	0.33	0.25	mg/L	SP-54	nv	na	na
TPH - Motor Oil Range	0/8	0	nd	nd	0.25	0.5	mg/L	nd	nv	na	na

[a] Comparisons were not made to chronic water quality standards because chronic standards are based on 4-day average concentrations not to be exceeded more than once every three years. Because of the tidal cycle, comparison of intertidal seep samples to acute standards is more appropriate. Acute standards represent 1-hour average concentrations not to be exceeded more than once every three years on average.

Table E.6.5-5. Summary statistics for Great Western seep data by sampling event

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
GreatWestern Apr-94											
Other SVOCs											
Methyl isobutyl ketone	0/6	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Conventional parameters											
Salinity	6/6	100	2.57	12.03	7.4	na	ppt	S-1 S-6	nv	na	na
Volatile organic compounds											
1,1,1-Trichloroethane	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1,2,2-Tetrachloroethane	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1,2-Trichloroethane	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1-Dichloroethane	3/6	50	1.0	2.0	1.1	1.0	µg/L	S-4 S-1	nv	na	na
1,1-Dichloroethene	1/6	17	1.0	1.0	0.58	1.0	µg/L	S-4	nv	na	na
1,2-Dichloroethane	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,2-Dichloroethene (total)	3/6	50	7.0	110	23	1.0	µg/L	S-2	nv	na	na
1,2-Dichloropropane	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
2-Hexanone	0/6	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Acetone	0/6	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Benzene	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Bromodichloromethane	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Bromoform	0/6	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Bromomethane	0/6	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Carbon disulfide	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Carbon tetrachloride	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chlorobenzene	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloroethane	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloroform	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloromethane	0/6	0	nd	nd	5.0	10	µg/L	na	nv	na	na
cis-1,3-Dichloropropene	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dibromochloromethane	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dichloromethane	0/6	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Ethylbenzene	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na

Table E.6.5-5, cont. Summary statistics for Great Western seep data by sampling event

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Methyl ethyl ketone	0/6	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Styrene	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Tetrachloroethene	2/6	33	3.0	760	130	1.0	µg/L	S-2	nv	na	na
Toluene	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
trans-1,3-Dichloropropene	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Trichloroethene	3/6	50	1.0	370	62	1.0	µg/L	S-2	nv	na	na
Vinyl acetate	0/6	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Vinyl chloride	1/6	17	1.0	1.0	0.58	1.0	µg/L	S-4	nv	na	na
Xylene (total)	0/6	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
GreatWestern Jul-94											
Other SVOCs											
Methyl isobutyl ketone	0/2	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Conventional parameters											
Salinity	2/2	100	17.8	20.55	19.2	na	ppt	S-1	nv	na	na
Volatile organic compounds											
1,1,1-Trichloroethane	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1,2,2-Tetrachloroethane	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1,2-Trichloroethane	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1-Dichloroethane	1/2	50	1.0	1.0	0.75	1.0	µg/L	S-1	nv	na	na
1,1-Dichloroethene	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,2-Dichloroethane	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,2-Dichloroethene (total)	2/2	100	3.0	40	22	na	µg/L	S-2	nv	na	na
1,2-Dichloropropane	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
2-Hexanone	0/2	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Acetone	0/2	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Benzene	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Bromodichloromethane	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Bromoform	0/2	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Bromomethane	0/2	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Carbon disulfide	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Carbon tetrachloride	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chlorobenzene	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloroethane	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloroform	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloromethane	0/2	0	nd	nd	5.0	10	µg/L	na	nv	na	na

Table E.6.5-5, cont. Summary statistics for Great Western seep data by sampling event

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
cis-1,3-Dichloropropene	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dibromochloromethane	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dichloromethane	0/2	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Ethylbenzene	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Methyl ethyl ketone	0/2	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Styrene	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Tetrachloroethene	2/2	100	2.0	220	110	na	µg/L	S-2	nv	na	na
Toluene	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
trans-1,3-Dichloropropene	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Trichloroethene	1/2	50	94	94	47	1.0	µg/L	S-2	nv	na	na
Vinyl acetate	0/2	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Vinyl chloride	1/2	50	3.0	3.0	1.8	1.0	µg/L	S-2	nv	na	na
Xylene (total)	0/2	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
GreatWestern May-95											
Other SVOCs											
Methyl isobutyl ketone	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Volatile organic compounds											
1,1,1-Trichloroethane	1/7	14	1.0	1.0	0.57	1.0	µg/L	S-1	nv	na	na
1,1,2,2-Tetrachloroethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1,2-Trichloroethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1-Dichloroethane	2/7	29	1.0	2.0	0.79	1.0	µg/L	S-1	nv	na	na
1,1-Dichloroethene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,2-Dichloroethane	1/7	14	1.0	1.0	0.57	1.0	µg/L	S-2	nv	na	na
1,2-Dichloroethene (total)	3/7	43	3.0	150	26	1.0	µg/L	S-2	nv	na	na
1,2-Dichloropropane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
2-Hexanone	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Acetone	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Benzene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Bromodichloromethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Bromoform	0/7	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Bromomethane	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Carbon disulfide	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Carbon tetrachloride	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chlorobenzene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloroethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na

Table E.6.5-5, cont. Summary statistics for Great Western seep data by sampling event

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Chloroform	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloromethane	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
cis-1,3-Dichloropropene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dibromochloromethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dichloromethane	0/7	0	nd	nd	3.1	5.0 – 10	µg/L	na	nv	na	na
Ethylbenzene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Methyl ethyl ketone	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Styrene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Tetrachloroethene	2/7	29	6.0	710	100	1.0	µg/L	S-2	nv	na	na
Toluene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
trans-1,3-Dichloropropene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Trichloroethene	2/7	29	8.0	480	70	1.0	µg/L	S-2	nv	na	na
Vinyl acetate	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Vinyl chloride	2/7	29	2.0	2.0	0.93	1.0	µg/L	S-4 S-2	nv	na	na
Xylene (total)	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
GreatWestern Nov-94											
Other SVOCs											
Methyl isobutyl ketone	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Volatile organic compounds											
1,1,1-Trichloroethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1,2,2-Tetrachloroethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1,2-Trichloroethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1-Dichloroethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1-Dichloroethene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,2-Dichloroethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,2-Dichloroethene (total)	2/7	29	1.0	50	7.6	1.0	µg/L	S-2	nv	na	na
1,2-Dichloropropane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
2-Hexanone	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Acetone	0/7	0	nd	nd	16	10 – 100	µg/L	na	nv	na	na
Benzene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Bromodichloromethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Bromoform	0/7	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Bromomethane	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Carbon disulfide	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na

Table E.6.5-5, cont. Summary statistics for Great Western seep data by sampling event

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Carbon tetrachloride	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chlorobenzene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloroethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloroform	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloromethane	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
cis-1,3-Dichloropropene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dibromochloromethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dichloromethane	0/7	0	nd	nd	2.9	5.0 – 10	µg/L	na	nv	na	na
Ethylbenzene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Methyl ethyl ketone	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Styrene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Tetrachloroethene	2/7	29	1.0	440	63	1.0	µg/L	S-2	nv	na	na
Toluene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
trans-1,3-Dichloropropene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Trichloroethene	1/7	14	130	130	19	1.0	µg/L	S-2	nv	na	na
Vinyl acetate	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Vinyl chloride	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Xylene (total)	0/7	0	nd	nd	0.50	nc	µg/L	na	nv	na	na
GreatWestern-1995annual											
Other SVOCs											
Methyl isobutyl ketone	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Volatile organic compounds											
1,1,1-Trichloroethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1,2,2-Tetrachloroethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1,2-Trichloroethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1-Dichloroethane	2/7	29	1.0	1.0	0.64	1.0	µg/L	S-1 S-2	nv	na	na
1,1-Dichloroethene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,2-Dichloroethane	1/7	14	1.0	1.0	0.57	1.0	µg/L	S-2	nv	na	na
1,2-Dichloroethene (total)	4/7	57	1.0	160	27	1.0	µg/L	S-2	nv	na	na
1,2-Dichloropropane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
2-Hexanone	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Acetone	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Benzene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Bromodichloromethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na

Table E.6.5-5, cont. Summary statistics for Great Western seep data by sampling event

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Bromoform	0/7	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Bromomethane	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Carbon disulfide	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Carbon tetrachloride	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chlorobenzene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloroethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloroform	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloromethane	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
cis-1,3-Dichloropropene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dibromochloromethane	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dichloromethane	0/7	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Ethylbenzene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Methyl ethyl ketone	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Styrene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Tetrachloroethene	2/7	29	4.0	610	88	1.0	µg/L	S-2	nv	na	na
Toluene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
trans-1,3-Dichloropropene	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Trichloroethene	2/7	29	4.0	360	52	1.0	µg/L	S-2	nv	na	na
Vinyl acetate	0/7	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Vinyl chloride	2/7	29	1.0	1.0	0.64	1.0	µg/L	S-2 S-11	nv	na	na
Xylene (total)	0/7	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
GreatWestern-1996annual											
Other SVOCs											
Methyl isobutyl ketone	0/5	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Volatile organic compounds											
1,1,1-Trichloroethane	0/5	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1,2,2-Tetrachloroethane	0/5	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1,2-Trichloroethane	0/5	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1-Dichloroethane	1/5	20	1.0	1.0	0.60	1.0	µg/L	S-2	nv	na	na
1,1-Dichloroethene	0/5	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,2-Dichloroethane	1/5	20	8.0	8.0	2.0	1.0	µg/L	S-2	nv	na	na
1,2-Dichloroethene (total)	3/5	60	8.0	310	69	1.0	µg/L	S-2	nv	na	na
1,2-Dichloropropane	1/5	20	1.0	1.0	0.60	1.0	µg/L	S-2	nv	na	na
2-Hexanone	0/5	0	nd	nd	5.0	10	µg/L	na	nv	na	na

Table E.6.5-5, cont. Summary statistics for Great Western seep data by sampling event

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Acetone	0/5	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Benzene	0/5	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Bromodichloromethane	0/5	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Bromoform	0/5	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Bromomethane	0/5	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Carbon disulfide	0/5	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Carbon tetrachloride	0/5	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chlorobenzene	0/5	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloroethane	0/5	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloroform	0/5	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloromethane	0/5	0	nd	nd	5.0	10	µg/L	na	nv	na	na
cis-1,3-Dichloropropene	0/5	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dibromochloromethane	0/5	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dichloromethane	0/5	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Ethylbenzene	0/5	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Methyl ethyl ketone	0/5	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Styrene	0/5	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Tetrachloroethene	2/5	40	13	79	19	1.0	µg/L	S-2	nv	na	na
Toluene	1/5	20	2.0	2.0	0.80	1.0	µg/L	S-4	nv	na	na
trans-1,3-Dichloropropene	0/5	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Trichloroethene	2/5	40	7.0	58	13	1.0	µg/L	S-2	nv	na	na
Vinyl acetate	0/5	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Vinyl chloride	1/5	20	3.0 J	3.0 J	1.0	1.0	µg/L	S-2	nv	na	na
Xylene (total)	1/5	20	1.0	1.0	0.60	nc	µg/L	S-4	nv	na	na
GreatWestern-1997annual											
Other SVOCs											
Methyl isobutyl ketone	0/4	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Conventional parameters											
Chloride	1/1	100	5,600	5,600	5,600	na	mg/L	S-2	nv	na	na
Salinity	4/4	100	3.6	12	7.8	na	g/L	S-12	nv	na	na
Volatile organic compounds											
1,1,1-Trichloroethane	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1,2,2-Tetrachloroethane	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1,2-Trichloroethane	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1-Dichloroethane	1/4	25	1.0	1.0	0.60	1.0	µg/L	S-1	nv	na	na

Table E.6.5-5, cont. Summary statistics for Great Western seep data by sampling event

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
1,1-Dichloroethene	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,2-Dichloroethane	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,2-Dichloroethene (total)	2/4	50	37	470	100	1.0	µg/L	S-2	nv	na	na
1,2-Dichloropropane	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
2-Hexanone	0/4	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Acetone	0/4	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Benzene	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Bromodichloromethane	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Bromoform	0/4	0	nd	nd	3.0	5.0	µg/L	na	nv	na	na
Bromomethane	0/4	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Carbon disulfide	0/4	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Carbon tetrachloride	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chlorobenzene	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloroethane	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloroform	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloromethane	0/4	0	nd	nd	5.0	10	µg/L	na	nv	na	na
cis-1,3-Dichloropropene	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dibromochloromethane	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dichloromethane	0/4	0	nd	nd	3.0	5.0	µg/L	na	nv	na	na
Ethylbenzene	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Methyl ethyl ketone	0/4	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Styrene	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Tetrachloroethene	2/4	50	19	150	40	1.0	µg/L	S-2	nv	na	na
Toluene	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
trans-1,3-Dichloropropene	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Trichloroethene	2/4	50	7.0	200	50	1.0	µg/L	S-2	nv	na	na
Vinyl acetate	0/4	0	nd	nd	5.0	10	µg/L	na	nv	na	na
Vinyl chloride	0/4	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Xylene (total)	0/4	0	nd	nd	0.50	nc	µg/L	na	nv	na	na
GreatWestern-1998annual											
PAHs											
Naphthalene	0/9	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Other SVOCs											
1,2,4-Trichlorobenzene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,2-Dichlorobenzene	1/9	11	1.3	1.3	0.59	1.0	µg/L	S-13	nv	na	na

Table E.6.5-5, cont. Summary statistics for Great Western seep data by sampling event

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
1,3-Dichlorobenzene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,4-Dichlorobenzene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Hexachlorobutadiene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Conventional parameters											
Salinity	8/8	100	16	25	19	na	s/cm	S-11	nv	na	na
Volatile organic compounds											
1,1,1,2-Tetrachloroethane	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1,1-Trichloroethane	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1,2,2-Tetrachloroethane	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1,2-Trichloroethane	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,1-Dichloroethane	2/9	22	4.1	53	6.7	1.0	µg/L	S-13	nv	na	na
1,1-Dichloroethene	1/9	11	18	18	2.4	1.0	µg/L	S-13	nv	na	na
1,1-Dichloropropene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,2,3-Trichlorobenzene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,2,3-Trichloropropane	0/9	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
1,2,4-Trimethylbenzene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,2-Dibromo-3-chloropropane	0/9	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
1,2-Dibromoethane (EDB)	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,2-Dichloroethane	1/9	11	8.5	8.5	1.4	1.0	µg/L	S-13	nv	na	na
1,2-Dichloropropane	1/9	11	2.7	2.7	0.74	1.0	µg/L	S-13	nv	na	na
1,3,5-Trimethylbenzene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
1,3-Dichloropropane	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
2,2-Dichloropropane	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
2-Chlorotoluene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
4-Chlorotoluene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Benzene	1/9	11	28	28	3.6	1.0	µg/L	S-13	nv	na	na
Bromobenzene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Bromodichloromethane	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Bromoform	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Bromomethane	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Carbon tetrachloride	0/9	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Chlorobenzene	1/9	11	4.1	4.1	0.90	1.0	µg/L	S-13	nv	na	na
Chloroethane	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloroform	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Chloromethane	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na

Table E.6.5-5, cont. Summary statistics for Great Western seep data by sampling event

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
cis-1,2-Dichloroethene	3/9	33	41	3,300	380	1.0	µg/L	S-13	nv	na	na
cis-1,3-Dichloropropene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dibromochloromethane	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dibromomethane	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dichlorodifluoromethane	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Dichloromethane	0/9	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Ethylbenzene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Isopropylbenzene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
iso-Propyltoluene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
n-Butylbenzene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
n-Propylbenzene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
sec-Butylbenzene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Styrene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
tert-Butylbenzene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Tetrachloroethene	4/9	44	1.3	290	34	1.0	µg/L	S-2	nv	na	na
Toluene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
trans-1,2-Dichloroethene	2/9	22	3.5	46	5.9	1.0	µg/L	S-13	nv	na	na
trans-1,3-Dichloropropene	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Trichloroethene	3/9	33	4.0	170	20	1.0	µg/L	S-2	nv	na	na
Trichlorofluoromethane	0/9	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Vinyl chloride	2/9	22	1.0	760	85	1.0	µg/L	S-13	nv	na	na
Xylene (ortho)	1/9	11	1.4	1.4	0.60	1.0	µg/L	S-13	nv	na	na
Xylene (meta & para)	0/9	0	nd	nd	1.0	2.0	µg/L	na	nv	na	na
Total xylenes	1/9	11	1.4	1.4	1.0	nc	µg/L	S-13	nv	na	na
GreatWestern-1999annual											
PAHs											
2-Chloronaphthalene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
2-Methylnaphthalene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Acenaphthene	1/5	20	1.3	1.3	0.46	0.50	µg/L	S-13	nv	na	na
Acenaphthylene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Anthracene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Benzo(a)anthracene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Benzo(a)pyrene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Benzo(b)fluoranthene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Benzo(g,h,i)perylene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na

Table E.6.5-5, cont. Summary statistics for Great Western seep data by sampling event

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Benzo(k)fluoranthene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Benzofluoranthenes (total-calc'd)	0/5	0	nd	nd	0.25	nc	µg/L	na	nv	na	na
Chrysene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Dibenzo(a,h)anthracene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Dibenzofuran	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Fluoranthene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Fluorene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Indeno(1,2,3-cd)pyrene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Naphthalene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Phenanthrene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Pyrene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Total HPAH	0/5	0	nd	nd	0.25	nc	µg/L	na	nv	na	na
Total LPAH	1/5	20	1.3	1.3	0.46	nc	µg/L	S-13	nv	na	na
Carcinogenic PAHs - Mammal	0/5	0	nd	nd	0.23	0.45	µg/L	na	nv	na	na
Total PAH	1/5	20	1.3	1.3	0.46	nc	µg/L	S-13	nv	na	na
Phthalates											
Bis(2-ethylhexyl)phthalate	0/5	0	nd	nd	0.64	0.50 – 4.4	µg/L	na	nv	na	na
Butyl benzyl phthalate	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Diethyl phthalate	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Dimethyl phthalate	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Di-n-butyl phthalate	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Di-n-octyl phthalate	0/5	0	nd	nd	2.1	0.50 – 5.0	µg/L	na	nv	na	na
Other SVOCs											
1,2,4-Trichlorobenzene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
1,2-Dichlorobenzene	1/5	20	1.0	1.0	0.40	0.50	µg/L	S-13	nv	na	na
1,3-Dichlorobenzene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
1,4-Dichlorobenzene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
2,4,5-Trichlorophenol	0/5	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
2,4,6-Trichlorophenol	0/5	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
2,4-Dichlorophenol	0/5	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
2,4-Dimethylphenol	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
2,4-Dinitrophenol	0/5	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
2,4-Dinitrotoluene	0/5	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
2,6-Dinitrotoluene	0/5	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na

Table E.6.5-5, cont. Summary statistics for Great Western seep data by sampling event

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
2-Chlorophenol	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
2-Methylphenol	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
2-Nitroaniline	0/5	0	nd	nd	2.1	0.50 – 5.0	µg/L	na	nv	na	na
2-Nitrophenol	0/5	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
3,3'-Dichlorobenzidine	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
3-Nitroaniline	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
4,6-Dinitro-o-cresol	0/5	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
4-Bromophenyl phenyl ether	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
4-Chloro-3-methylphenol	0/5	0	nd	nd	0.70	0.50 – 5.0	µg/L	na	nv	na	na
4-Chloroaniline	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
4-Chlorophenyl phenyl ether	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
4-Methylphenol	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
4-Nitroaniline	0/5	0	nd	nd	2.1	0.50 – 5.0	µg/L	na	nv	na	na
4-Nitrophenol	0/5	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Aniline	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Benzidine	0/5	0	nd	nd	6.5	13	µg/L	na	nv	na	na
Benzoic acid	0/5	0	nd	nd	6.5	13	µg/L	na	nv	na	na
Benzyl alcohol	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
bis(2-chloroethoxy)methane	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
bis(2-chloroethyl)ether	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
bis(2-chloroisopropyl)ether	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Carbazole	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Hexachlorobenzene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Hexachlorobutadiene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Hexachlorocyclopentadiene	0/5	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Hexachloroethane	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Isophorone	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Methyl isobutyl ketone	0/5	0	nd	nd	13	5.0 – 100	µg/L	na	nv	na	na
Nitrobenzene	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
N-Nitroso-di-n-propylamine	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
N-Nitrosodiphenylamine	0/5	0	nd	nd	0.70	0.50 – 5.0	µg/L	na	nv	na	na
Pentachlorophenol	0/5	0	nd	nd	0.25	0.50	µg/L	na	13	0	0
Phenol	0/5	0	nd	nd	0.25	0.50	µg/L	na	nv	na	na
Conventional parameters											
Salinity	1/1	100	6.8	6.8	6.8	na	s/cm	S-13	nv	na	na

Table E.6.5-5, cont. Summary statistics for Great Western seep data by sampling event

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Volatile organic compounds											
1,1,1,2-Tetrachloroethane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
1,1,1-Trichloroethane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
1,1,2,2-Tetrachloroethane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
1,1,2-Trichloroethane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
1,1-Dichloroethane	1/5	20	58	58	12	1.0 – 2.0	µg/L	S-13	nv	na	na
1,1-Dichloroethene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
1,1-Dichloropropene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
1,2,3-Trichlorobenzene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
1,2,3-Trichloropropane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
1,2,4-Trimethylbenzene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
1,2-Dibromo-3-chloropropane	0/5	0	nd	nd	13	5.0 – 100	µg/L	na	nv	na	na
1,2-Dibromoethane (EDB)	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
1,2-Dichloroethane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
1,2-Dichloropropane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
1,3,5-Trimethylbenzene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
1,3-Dichloropropane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
2,2-Dichloropropane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
2-Chloroethyl vinyl ether	0/5	0	nd	nd	13	5.0 – 100	µg/L	na	nv	na	na
2-Chlorotoluene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
4-Chlorotoluene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Acetone	0/5	0	nd	nd	13	5.0 – 100	µg/L	na	nv	na	na
Benzene	1/5	20	28	28	6.1	1.0 – 2.0	µg/L	S-13	nv	na	na
Bromobenzene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Bromodichloromethane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Bromoform	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Bromomethane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Carbon disulfide	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Carbon tetrachloride	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Chlorobenzene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Chloroethane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Chloroform	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Chloromethane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
cis-1,2-Dichloroethene	3/5	60	5.6	3,200	660	1.0	µg/L	S-13	nv	na	na
cis-1,3-Dichloropropene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na

Table E.6.5-5, cont. Summary statistics for Great Western seep data by sampling event

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Dibromochloromethane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Dibromomethane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Dichlorodifluoromethane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Dichloromethane	0/5	0	nd	nd	13	5.0 – 100	µg/L	na	nv	na	na
Ethylbenzene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Isopropylbenzene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
iso-Propyltoluene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Methyl ethyl ketone	0/5	0	nd	nd	50	20 – 400	µg/L	na	nv	na	na
n-Butylbenzene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
n-Propylbenzene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
sec-Butylbenzene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Styrene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
tert-Butylbenzene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Tetrachloroethene	2/5	40	3.7	190	41	1.0 – 20	µg/L	S-2	nv	na	na
Toluene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
trans-1,2-Dichloroethene	2/5	40	12	27	8.1	1.0	µg/L	S-13	nv	na	na
trans-1,3-Dichloropropene	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Trichloroethene	2/5	40	2.1	270	57	1.0 – 20	µg/L	S-2	nv	na	na
Trichlorofluoromethane	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Vinyl acetate	0/5	0	nd	nd	13	5.0 – 100	µg/L	na	nv	na	na
Vinyl chloride	1/5	20	3,500	3,500	700	1.0 – 2.0	µg/L	S-13	nv	na	na
Xylene (ortho)	0/5	0	nd	nd	2.5	1.0 – 20	µg/L	na	nv	na	na
Xylene (meta & para)	0/5	0	nd	nd	5.0	2.0 – 40	µg/L	na	nv	na	na
Total xylenes	0/5	0	nd	nd	5.0	nc	µg/L	na	nv	na	na
GreatWestern-Embayment Study											
PAHs											
Naphthalene	0/4	0	nd	nd	19	5.0 – 50	µg/L	na	nv	na	na
Other SVOCs											
1,2,4-Trichlorobenzene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
1,2-Dichlorobenzene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
1,3-Dichlorobenzene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
1,4-Dichlorobenzene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
Hexachlorobutadiene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
Methyl isobutyl ketone	0/8	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na

Table E.6.5-5, cont. Summary statistics for Great Western seep data by sampling event

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Conventional parameters											
Salinity	6/6	100	7.5	14	10	na	g/L	S-1	nv	na	na
Salinity	4/4	100	3.1	7.2	5.0	na	s/cm	S-1	nv	na	na
Volatile organic compounds											
1,1,1,2-Tetrachloroethane	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
1,1,1-Trichloroethane	0/10	0	nd	nd	1.4	1.0 – 10	µg/L	na	nv	na	na
1,1,2,2-Tetrachloroethane	0/10	0	nd	nd	1.4	1.0 – 10	µg/L	na	nv	na	na
1,1,2-Trichloroethane	0/10	0	nd	nd	2.8	1.0 – 10	µg/L	na	nv	na	na
1,1-Dichloroethane	5/10	50	1.5	62	13	1.0	µg/L	S-13	nv	na	na
1,1-Dichloroethene	3/10	30	1.0	27	4.7	1.0 – 10	µg/L	S-13	nv	na	na
1,1-Dichloropropene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
1,2,3-Trichlorobenzene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
1,2,3-Trichloropropane	0/10	0	nd	nd	5.4	1.0 – 50	µg/L	na	nv	na	na
1,2,4-Trimethylbenzene	1/4	25	4.1	4.1	4.8	10	µg/L	S-1	nv	na	na
1,2-Dibromo-3-chloropropane	0/4	0	nd	nd	19	5.0 – 50	µg/L	na	nv	na	na
1,2-Dibromoethane (EDB)	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
1,2-Dichloroethane	2/10	20	6.6	27	4.2	1.0 – 10	µg/L	S-14	nv	na	na
1,2-Dichloropropane	1/10	10	16	16	3.9	1.0 – 10	µg/L	S-14	nv	na	na
1,3,5-Trimethylbenzene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
1,3-Dichloropropane	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
2,2-Dichloropropane	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
2-Chlorotoluene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
2-Hexanone	0/8	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
4-Chlorotoluene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
Acetone	3/8	38	1.0	6.4	3.6	5.0 – 11	µg/L	S-6	nv	na	na
Benzene	2/10	20	21	36	6.6	1.0 – 10	µg/L	S-13	nv	na	na
Bromobenzene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
Bromodichloromethane	0/10	0	nd	nd	1.4	1.0 – 10	µg/L	na	nv	na	na
Bromoform	0/10	0	nd	nd	1.4	1.0 – 10	µg/L	na	nv	na	na
Bromomethane	0/10	0	nd	nd	1.4	1.0 – 10	µg/L	na	nv	na	na
Carbon disulfide	0/8	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Carbon tetrachloride	0/10	0	nd	nd	7.0	5.0 – 50	µg/L	na	nv	na	na
Chlorobenzene	1/10	10	8.8	8.8	2.2	1.0 – 10	µg/L	S-2	nv	na	na
Chloroethane	0/10	0	nd	nd	1.4	1.0 – 10	µg/L	na	nv	na	na
Chloroform	0/10	0	nd	nd	1.4	1.0 – 10	µg/L	na	nv	na	na

Table E.6.5-5, cont. Summary statistics for Great Western seep data by sampling event

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Acute WQS	Comparison to Acute WQS [a]	
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit			Detect > Acute	Nondetect > Acute
Chloromethane	0/10	0	nd	nd	1.4	1.0 – 10	µg/L	na	nv	na	na
cis-1,2-Dichloroethene	4/4	100	29	5,400	1,900	na	µg/L	S-13	nv	na	na
cis-1,3-Dichloropropene	0/10	0	nd	nd	1.4	1.0 – 10	µg/L	na	nv	na	na
Dibromochloromethane	0/10	0	nd	nd	1.4	1.0 – 10	µg/L	na	nv	na	na
Dibromomethane	0/10	0	nd	nd	1.4	1.0 – 10	µg/L	na	nv	na	na
Dichlorodifluoromethane	0/10	0	nd	nd	1.4	1.0 – 10	µg/L	na	nv	na	na
Dichloromethane	0/10	0	nd	nd	5.4	1.0 – 50	µg/L	na	nv	na	na
Ethylbenzene	0/10	0	nd	nd	1.4	1.0 – 10	µg/L	na	nv	na	na
Iodomethane	0/8	0	nd	nd	0.50	1.0	µg/L	na	nv	na	na
Isopropylbenzene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
iso-Propyltoluene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
Methyl ethyl ketone	0/8	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
n-Butylbenzene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
n-Propylbenzene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
sec-Butylbenzene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
Styrene	0/10	0	nd	nd	1.4	1.0 – 10	µg/L	na	nv	na	na
tert-Butylbenzene	0/4	0	nd	nd	3.9	1.0 – 10	µg/L	na	nv	na	na
Tetrachloroethene	4/10	40	2.6	180	22	1.0 – 10	µg/L	S-2	nv	na	na
Toluene	1/10	10	2.7	2.7	1.6	1.0 – 10	µg/L	S-2	nv	na	na
trans-1,2-Dichloroethene	3/10	30	16	110	20	1.0	µg/L	S-14	nv	na	na
trans-1,3-Dichloropropene	0/10	0	nd	nd	1.4	1.0 – 10	µg/L	na	nv	na	na
trans-1,4-Dichloro-2-butene	0/8	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Trichloroethene	3/10	30	6.0	110	14	1.0 – 10	µg/L	S-2	nv	na	na
Trichlorofluoromethane	0/10	0	nd	nd	1.4	1.0 – 10	µg/L	na	nv	na	na
Vinyl acetate	0/8	0	nd	nd	2.5	5.0	µg/L	na	nv	na	na
Vinyl chloride	4/10	40	3.8	1,600	340	1.0	µg/L	S-13	nv	na	na
Xylene (ortho)	1/10	10	2.8	2.8	1.6	1.0 – 10	µg/L	S-2	nv	na	na
Xylene (meta & para)	0/10	0	nd	nd	2.8	2.0 – 20	µg/L	na	nv	na	na
Total xylenes	1/10	10	2.8	2.8	3.0	nc	µg/L	S-2	nv	na	na

[a] Comparisons were not made to chronic water quality standards because chronic standards are based on 4-day average concentrations not to be exceeded more than once every three years. Because of the tidal cycle, comparison of intertidal seep samples to acute standards is more appropriate. Acute standards represent 1-hour average concentrations not to be exceeded more than once every three years on average.

E.6.6 POREWATER

Table E.6.6-1. Summary statistics for Boeing Plant 2/Jorgensen porewater

Chemical	Detection Frequency		Concentration					Location of Maximum Detect
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	
LDWRI-Peeper								
1,1,1,2-Tetrachloroethane	0/10	0	nd	nd	0.1	0.2	µg/L	na
1,1,1-Trichloroethane	0/10	0	nd	nd	0.1	0.2	µg/L	na
1,1,2,2-Tetrachloroethane	0/10	0	nd	nd	0.1	0.2	µg/L	na
1,1,2-Trichloroethane	0/10	0	nd	nd	0.1	0.2	µg/L	na
1,1,2-Trichlorotrifluoroethane	0/10	0	nd	nd	0.1	0.2	µg/L	na
1,1-Dichloroethane	1/10	10	0.3	0.3	0.1	0.2	µg/L	LDW-PW-B-PE-14
1,1-Dichloroethene	0/10	0	nd	nd	0.1	0.2	µg/L	na
1,1-Dichloropropene	0/10	0	nd	nd	0.1	0.2	µg/L	na
1,2,3-Trichlorobenzene	0/10	0	nd	nd	0.3	0.5	µg/L	na
1,2,3-Trichloropropane	0/10	0	nd	nd	0.3	0.5	µg/L	na
1,2,4-Trichlorobenzene	0/10	0	nd	nd	0.3	0.5	µg/L	na
1,2,4-Trimethylbenzene	0/10	0	nd	nd	0.1	0.2 – 0.3	µg/L	na
1,2-Dibromo-3-chloropropane	0/10	0	nd	nd	1.0	2.0	µg/L	na
1,2-Dibromoethane (EDB)	0/10	0	nd	nd	0.1	0.2	µg/L	na
1,2-Dichlorobenzene	0/10	0	nd	nd	0.1	0.2	µg/L	na
1,2-Dichloroethane	0/10	0	nd	nd	0.1	0.2	µg/L	na
1,2-Dichloropropane	0/10	0	nd	nd	0.1	0.2	µg/L	na
1,3,5-Trimethylbenzene	0/10	0	nd	nd	0.1	0.2	µg/L	na
1,3-Dichlorobenzene	0/10	0	nd	nd	0.1	0.2	µg/L	na
1,3-Dichloropropane	0/10	0	nd	nd	0.1	0.2	µg/L	na
1,4-Dichlorobenzene	0/10	0	nd	nd	0.1	0.2	µg/L	na
2,2-Dichloropropane	0/10	0	nd	nd	0.1	0.2	µg/L	na
2-Chloroethyl vinyl ether	0/10	0	nd	nd	0.3	0.5	µg/L	na

Table E.6.6-1, cont. Summary statistics for Boeing Plant 2/Jorgensen porewater

Chemical	Detection Frequency		Concentration					Location of Maximum Detect
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	
2-Chlorotoluene	0/10	0	nd	nd	0.1	0.2	µg/L	na
2-Hexanone	0/10	0	nd	nd	0.5	1.0	µg/L	na
4-Chlorotoluene	0/10	0	nd	nd	0.1	0.2	µg/L	na
Acetone	0/10	0	nd	nd	9.3	3.7 – 60	µg/L	na
Acrolein	0/10	0	nd	nd	2.5	5.0	µg/L	na
Acrylonitrile	0/10	0	nd	nd	0.5	1.0	µg/L	na
Benzene	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Bromobenzene	0/10	0	nd	nd	0.1	0.2	µg/L	na
Bromochloromethane	0/10	0	nd	nd	0.1	0.2	µg/L	na
Bromodichloromethane	0/10	0	nd	nd	0.1	0.2	µg/L	na
Bromoethane	0/10	0	nd	nd	0.1	0.2	µg/L	na
Bromoform	0/10	0	nd	nd	0.1	0.2	µg/L	na
Bromomethane	0/10	0	nd	nd	0.1	0.2	µg/L	na
Carbon disulfide	0/10	0	nd	nd	0.1	0.2	µg/L	na
Carbon tetrachloride	0/10	0	nd	nd	0.1	0.2	µg/L	na
Chlorobenzene	0/10	0	nd	nd	0.1	0.2	µg/L	na
Chloroethane	0/10	0	nd	nd	0.1	0.2	µg/L	na
Chloroform	0/10	0	nd	nd	0.1	0.2	µg/L	na
Chloromethane	0/10	0	nd	nd	0.1	0.2	µg/L	na
cis-1,2-Dichloroethene	7/10	70	0.2	1.7	0.5	0.2	µg/L	LDW-PW-B-PE-11
cis-1,3-Dichloropropene	0/10	0	nd	nd	0.1	0.2	µg/L	na
Dibromochloromethane	0/10	0	nd	nd	0.1	0.2	µg/L	na
Dibromomethane	0/10	0	nd	nd	0.1	0.2	µg/L	na
Dichloromethane	0/10	0	nd	nd	0.2	0.3	µg/L	na
Ethylbenzene	0/10	0	nd	nd	0.1	0.2	µg/L	na
Hexachlorobutadiene	0/10	0	nd	nd	0.3	0.5	µg/L	na
Iodomethane	0/10	0	nd	nd	0.1	0.2	µg/L	na
Isopropylbenzene	0/10	0	nd	nd	0.1	0.2	µg/L	na
Methyl ethyl ketone	0/10	0	nd	nd	0.5	1.0	µg/L	na

Table E.6.6-1, cont. Summary statistics for Boeing Plant 2/Jorgensen porewater

Chemical	Detection Frequency		Concentration					Location of Maximum Detect
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	
Methyl isobutyl ketone	0/10	0	nd	nd	0.5	1.0	µg/L	na
Naphthalene	0/10	0	nd	nd	0.3	0.5	µg/L	na
n-Butylbenzene	0/10	0	nd	nd	0.1	0.2	µg/L	na
n-Propylbenzene	0/10	0	nd	nd	0.1	0.2	µg/L	na
p-Cymene	0/10	0	nd	nd	0.1	0.2	µg/L	na
sec-Butylbenzene	0/10	0	nd	nd	0.1	0.2	µg/L	na
Styrene	0/10	0	nd	nd	0.1	0.2	µg/L	na
tert-Butylbenzene	0/10	0	nd	nd	0.1	0.2	µg/L	na
Tetrachloroethene	0/10	0	nd	nd	0.1	0.2	µg/L	na
Toluene	0/10	0	nd	nd	0.1	0.2	µg/L	na
Total xylenes	0/10	0	nd	nd	0.2	nc	µg/L	na
trans-1,2-Dichloroethene	0/10	0	nd	nd	0.1	0.2	µg/L	na
trans-1,3-Dichloropropene	0/10	0	nd	nd	0.1	0.2	µg/L	na
trans-1,4-Dichloro-2-butene	0/10	0	nd	nd	0.5	1.0	µg/L	na
Trichloroethene	2/10	20	0.2	0.2	0.1	0.2	µg/L	LDW-PW-B-PE-10 LDW-PW-B-PE-11
Trichlorofluoromethane	0/10	0	nd	nd	0.1	0.2	µg/L	na
Vinyl acetate	0/10	0	nd	nd	0.1	0.2	µg/L	na
Vinyl chloride	2/10	20	1.1	13	1.5	0.2	µg/L	LDW-PW-B-PE-11
Xylene (meta & para)	0/10	0	nd	nd	0.2	0.4	µg/L	na
Xylene (ortho)	0/10	0	nd	nd	0.1	0.2	µg/L	na
LDWRI-Porewater								
1,1,1,2-Tetrachloroethane	0/6	0	nd	nd	0.1	0.2	µg/L	na
1,1,1-Trichloroethane	0/6	0	nd	nd	0.1	0.2	µg/L	na
1,1,2,2-Tetrachloroethane	0/6	0	nd	nd	0.1	0.2	µg/L	na
1,1,2-Trichloroethane	0/6	0	nd	nd	0.1	0.2	µg/L	na
1,1,2-Trichlorotrifluoroethane	0/6	0	nd	nd	0.1	0.2	µg/L	na
1,1-Dichloroethane	0/6	0	nd	nd	0.1	0.2	µg/L	na
1,1-Dichloroethene	0/6	0	nd	nd	0.1	0.2	µg/L	na

Table E.6.6-1, cont. Summary statistics for Boeing Plant 2/Jorgensen porewater

Chemical	Detection Frequency		Concentration					Location of Maximum Detect
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	
1,1-Dichloropropene	0/6	0	nd	nd	0.1	0.2	µg/L	na
1,2,3-Trichlorobenzene	0/6	0	nd	nd	0.3	0.5	µg/L	na
1,2,3-Trichloropropane	0/6	0	nd	nd	0.3	0.5	µg/L	na
1,2,4-Trichlorobenzene	0/6	0	nd	nd	0.3	0.5	µg/L	na
1,2,4-Trimethylbenzene	0/6	0	nd	nd	0.1	0.2	µg/L	na
1,2-Dibromo-3-chloropropane	0/6	0	nd	nd	1.0	2.0	µg/L	na
1,2-Dibromoethane (EDB)	0/6	0	nd	nd	0.1	0.2	µg/L	na
1,2-Dichlorobenzene	0/6	0	nd	nd	0.1	0.2	µg/L	na
1,2-Dichloroethane	0/6	0	nd	nd	0.1	0.2	µg/L	na
1,2-Dichloropropane	0/6	0	nd	nd	0.1	0.2	µg/L	na
1,3,5-Trimethylbenzene	0/6	0	nd	nd	0.1	0.2	µg/L	na
1,3-Dichlorobenzene	0/6	0	nd	nd	0.1	0.2	µg/L	na
1,3-Dichloropropane	0/6	0	nd	nd	0.1	0.2	µg/L	na
1,4-Dichlorobenzene	0/6	0	nd	nd	0.1	0.2	µg/L	na
2,2-Dichloropropane	0/6	0	nd	nd	0.1	0.2	µg/L	na
2-Chloroethyl vinyl ether	0/6	0	nd	nd	0.3	0.5	µg/L	na
2-Chlorotoluene	0/6	0	nd	nd	0.1	0.2	µg/L	na
2-Hexanone	0/6	0	nd	nd	0.5	1.0	µg/L	na
4-Chlorotoluene	0/6	0	nd	nd	0.1	0.2	µg/L	na
Acetone	0/6	0	nd	nd	0.7	1.0 – 2.2	µg/L	na
Acrolein	0/6	0	nd	nd	2.5	5.0	µg/L	na
Acrylonitrile	0/6	0	nd	nd	0.5	1.0	µg/L	na
Benzene	0/6	0	nd	nd	0.1	0.2	µg/L	na
Bromobenzene	0/6	0	nd	nd	0.1	0.2	µg/L	na
Bromochloromethane	0/6	0	nd	nd	0.1	0.2	µg/L	na
Bromodichloromethane	0/6	0	nd	nd	0.1	0.2	µg/L	na
Bromoethane	0/6	0	nd	nd	0.1	0.2	µg/L	na
Bromoform	0/6	0	nd	nd	0.1	0.2	µg/L	na
Bromomethane	0/6	0	nd	nd	0.1	0.2	µg/L	na

Table E.6.6-1, cont. Summary statistics for Boeing Plant 2/Jorgensen porewater

Chemical	Detection Frequency		Concentration					Location of Maximum Detect
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	
Carbon disulfide	0/6	0	nd	nd	0.1	0.2	µg/L	na
Carbon tetrachloride	0/6	0	nd	nd	0.1	0.2	µg/L	na
Chlorobenzene	0/6	0	nd	nd	0.1	0.2	µg/L	na
Chloroethane	0/6	0	nd	nd	0.1	0.2	µg/L	na
Chloroform	0/6	0	nd	nd	0.1	0.2	µg/L	na
Chloromethane	0/6	0	nd	nd	0.1	0.2	µg/L	na
cis-1,2-Dichloroethene	0/6	0	nd	nd	0.1	0.2	µg/L	na
cis-1,3-Dichloropropene	0/6	0	nd	nd	0.1	0.2	µg/L	na
Dibromochloromethane	0/6	0	nd	nd	0.1	0.2	µg/L	na
Dibromomethane	0/6	0	nd	nd	0.1	0.2	µg/L	na
Dichloromethane	0/6	0	nd	nd	0.2	0.3	µg/L	na
Ethylbenzene	0/6	0	nd	nd	0.1	0.2	µg/L	na
Hexachlorobutadiene	0/6	0	nd	nd	0.3	0.5	µg/L	na
Iodomethane	0/6	0	nd	nd	0.1	0.2	µg/L	na
Isopropylbenzene	0/6	0	nd	nd	0.1	0.2	µg/L	na
Methyl ethyl ketone	0/6	0	nd	nd	0.5	1.0	µg/L	na
Methyl isobutyl ketone	0/6	0	nd	nd	0.5	1.0	µg/L	na
Naphthalene	0/6	0	nd	nd	0.3	0.5	µg/L	na
n-Butylbenzene	0/6	0	nd	nd	0.1	0.2	µg/L	na
n-Propylbenzene	0/6	0	nd	nd	0.1	0.2	µg/L	na
p-Cymene	0/6	0	nd	nd	0.1	0.2	µg/L	na
sec-Butylbenzene	0/6	0	nd	nd	0.1	0.2	µg/L	na
Styrene	0/6	0	nd	nd	0.1	0.2	µg/L	na
tert-Butylbenzene	0/6	0	nd	nd	0.1	0.2	µg/L	na
Tetrachloroethene	0/6	0	nd	nd	0.1	0.2	µg/L	na
Toluene	0/6	0	nd	nd	0.1	0.2	µg/L	na
Total xylenes	0/6	0	nd	nd	0.2	nc	µg/L	na
trans-1,2-Dichloroethene	0/6	0	nd	nd	0.1	0.2	µg/L	na
trans-1,3-Dichloropropene	0/6	0	nd	nd	0.1	0.2	µg/L	na

Table E.6.6-1, cont. Summary statistics for Boeing Plant 2/Jorgensen porewater

Chemical	Detection Frequency		Concentration					Location of Maximum Detect
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	
trans-1,4-Dichloro-2-butene	0/6	0	nd	nd	0.5	1.0	µg/L	na
Trichloroethene	0/6	0	nd	nd	0.1	0.2	µg/L	na
Trichlorofluoromethane	0/6	0	nd	nd	0.1	0.2	µg/L	na
Vinyl acetate	0/6	0	nd	nd	0.1	0.2	µg/L	na
Vinyl chloride	0/6	0	nd	nd	0.1	0.2	µg/L	na
Xylene (meta & para)	0/6	0	nd	nd	0.2	0.4	µg/L	na
Xylene (ortho)	0/6	0	nd	nd	0.1	0.2	µg/L	na

Table E.6.6-2. Summary statistics for Great Western porewater

Chemical	Detection Frequency		Concentration					Location of Maximum Detect
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	
LDWRI-Peeper								
1,1,1,2-Tetrachloroethane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
1,1,1-Trichloroethane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
1,1,2,2-Tetrachloroethane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
1,1,2-Trichloroethane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
1,1,2-Trichlorotrifluoroethane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
1,1-Dichloroethane	8/10	80	0.4	16	5.0	0.2	µg/L	LDW-PW-G-PE-06
1,1-Dichloroethene	3/10	30	0.3	4.9	0.7	0.2 – 0.4	µg/L	LDW-PW-G-PE-06
1,1-Dichloropropene	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
1,2,3-Trichlorobenzene	0/10	0	nd	nd	0.3	0.5 – 1.0	µg/L	na
1,2,3-Trichloropropane	0/10	0	nd	nd	0.3	0.5 – 1.0	µg/L	na
1,2,4-Trichlorobenzene	0/10	0	nd	nd	0.3	0.5 – 1.0	µg/L	na
1,2,4-Trimethylbenzene	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
1,2-Dibromo-3-chloropropane	0/10	0	nd	nd	1.2	2.0 – 4.0	µg/L	na
1,2-Dibromoethane (EDB)	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
1,2-Dichlorobenzene	3/10	30	0.5	1.2	0.3	0.2 – 0.4	µg/L	LDW-PW-G-PE-08
1,2-Dichloroethane	2/10	20	7.4	15	2.0	0.2 – 0.4	µg/L	LDW-PW-G-PE-05
1,2-Dichloropropane	2/10	20	1.7	2.5	0.5	0.2 – 0.4	µg/L	LDW-PW-G-PE-05
1,3,5-Trimethylbenzene	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
1,3-Dichlorobenzene	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
1,3-Dichloropropane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
1,4-Dichlorobenzene	2/10	20	0.3	0.3	0.2	0.2 – 0.4	µg/L	LDW-PW-G-PE-08 LDW-PW-G-PE-06
2,2-Dichloropropane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
2-Chloroethyl vinyl ether	0/10	0	nd	nd	0.3	0.5 – 1.0	µg/L	na
2-Chlorotoluene	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
2-Hexanone	0/10	0	nd	nd	0.6	1.0 – 2.0	µg/L	na

Table E.6.6-2, cont. Summary statistics for Great Western porewater

Chemical	Detection Frequency		Concentration					Location of Maximum Detect
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	
4-Chlorotoluene	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Acetone	0/10	0	nd	nd	13	2.6 – 71	µg/L	na
Acrolein	0/10	0	nd	nd	3.0	5.0 – 10	µg/L	na
Acrylonitrile	0/10	0	nd	nd	0.60	1.0 – 2.0	µg/L	na
Benzene	1/10	10	9.4	9.4	2.0	0.2 – 4.7	µg/L	LDW-PW-G-PE-06
Bromobenzene	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Bromochloromethane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Bromodichloromethane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Bromoethane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Bromoform	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Bromomethane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Carbon disulfide	5/10	50	0.2	0.7	0.2	0.2 – 0.4	µg/L	LDW-PW-G-PE-06
Carbon tetrachloride	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Chlorobenzene	4/10	40	0.3	1.4	0.3	0.2 – 0.4	µg/L	LDW-PW-G-PE-06
Chloroethane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Chloroform	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Chloromethane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
cis-1,2-Dichloroethene	10/10	100	0.5	2,900	400	na	µg/L	LDW-PW-G-PE-06
cis-1,3-Dichloropropene	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Dibromochloromethane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Dibromomethane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Dichloromethane	0/10	0	nd	nd	0.2	0.3 – 0.6	µg/L	na
Ethylbenzene	0/10	0	nd	nd	0.2	0.2 – 1.3	µg/L	na
Hexachlorobutadiene	0/10	0	nd	nd	0.3	0.5 – 1.0	µg/L	na
Iodomethane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Isopropylbenzene	2/10	20	0.2	0.3	0.2	0.2 – 0.4	µg/L	LDW-PW-G-PE-08
Methyl ethyl ketone	0/10	0	nd	nd	0.7	1.0 – 2.4	µg/L	na
Methyl isobutyl ketone	0/10	0	nd	nd	0.6	1.0 – 2.0	µg/L	na
Naphthalene	0/10	0	nd	nd	0.3	0.5 – 1.0	µg/L	na

Table E.6.6-2, cont. Summary statistics for Great Western porewater

Chemical	Detection Frequency		Concentration					Location of Maximum Detect
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	
n-Butylbenzene	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
n-Propylbenzene	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
p-Cymene	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
sec-Butylbenzene	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Styrene	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
tert-Butylbenzene	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Tetrachloroethene	2/10	20	0.4	1.1	0.3	0.2 – 0.4	µg/L	LDW-PW-G-PE-05
Toluene	5/10	50	0.3	3.5	0.6	0.2 – 0.4	µg/L	LDW-PW-G-PE-06
Total xylenes	0/10	0	nd	nd	0.3	nc	µg/L	na
trans-1,2-Dichloroethene	7/10	70	0.3	21 J	4.0	0.2 – 0.4	µg/L	LDW-PW-G-PE-06
trans-1,3-Dichloropropene	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
trans-1,4-Dichloro-2-butene	0/10	0	nd	nd	0.6	1.0 – 2.0	µg/L	na
Trichloroethene	4/10	40	0.4	2.5	0.5	0.2 – 0.4	µg/L	LDW-PW-G-PE-02
Trichlorofluoromethane	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Vinyl acetate	0/10	0	nd	nd	0.1	0.2 – 0.4	µg/L	na
Vinyl chloride	10/10	100	0.4	2,500	300	na	µg/L	LDW-PW-G-PE-06
Xylene (meta & para)	0/10	0	nd	nd	0.3	0.4 – 0.8	µg/L	na
Xylene (ortho)	0/10	0	nd	nd	0.2	0.2 – 1.3	µg/L	na
LDWRI-Porewater								
1,1,1,2-Tetrachloroethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
1,1,1-Trichloroethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
1,1,2,2-Tetrachloroethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
1,1,2-Trichloroethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
1,1,2-Trichlorotrifluoroethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
1,1-Dichloroethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
1,1-Dichloroethene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
1,1-Dichloropropene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
1,2,3-Trichlorobenzene	0/6	0	nd	nd	0.6	0.5 – 2.5	µg/L	na
1,2,3-Trichloropropane	0/6	0	nd	nd	0.6	0.5 – 2.5	µg/L	na

Table E.6.6-2, cont. Summary statistics for Great Western porewater

Chemical	Detection Frequency		Concentration					Location of Maximum Detect
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	
1,2,4-Trichlorobenzene	0/6	0	nd	nd	0.6	0.5 – 2.5	µg/L	na
1,2,4-Trimethylbenzene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
1,2-Dibromo-3-chloropropane	0/6	0	nd	nd	2.0	2.0 – 10	µg/L	na
1,2-Dibromoethane (EDB)	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
1,2-Dichlorobenzene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
1,2-Dichloroethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
1,2-Dichloropropane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
1,3,5-Trimethylbenzene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
1,3-Dichlorobenzene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
1,3-Dichloropropane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
1,4-Dichlorobenzene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
2,2-Dichloropropane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
2-Chloroethyl vinyl ether	0/6	0	nd	nd	0.6	0.5 – 2.5	µg/L	na
2-Chlorotoluene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
2-Hexanone	0/6	0	nd	nd	1.2	1.0 – 5.0	µg/L	na
4-Chlorotoluene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Acetone	0/6	0	nd	nd	1.8	1.4 – 6.2	µg/L	na
Acrolein	0/6	0	nd	nd	5.8	5.0 – 25	µg/L	na
Acrylonitrile	0/6	0	nd	nd	1.2	1.0 – 5.0	µg/L	na
Benzene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Bromobenzene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Bromochloromethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Bromodichloromethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Bromoethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Bromoform	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Bromomethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Carbon disulfide	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Carbon tetrachloride	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Chlorobenzene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na

Table E.6.6-2, cont. Summary statistics for Great Western porewater

Chemical	Detection Frequency		Concentration					Location of Maximum Detect
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	
Chloroethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Chloroform	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Chloromethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
cis-1,2-Dichloroethene	0/6	0	nd	nd	0.4	0.2 – 2.0	µg/L	na
cis-1,3-Dichloropropene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Dibromochloromethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Dibromomethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Dichloromethane	0/6	0	nd	nd	0.4	0.3 – 1.5	µg/L	na
Ethylbenzene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Hexachlorobutadiene	0/6	0	nd	nd	0.6	0.5 – 2.5	µg/L	na
Iodomethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Isopropylbenzene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Methyl ethyl ketone	0/6	0	nd	nd	1.2	1.0 – 5.0	µg/L	na
Methyl isobutyl ketone	0/6	0	nd	nd	1.2	1.0 – 5.0	µg/L	na
Naphthalene	0/6	0	nd	nd	0.6	0.5 – 2.5	µg/L	na
n-Butylbenzene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
n-Propylbenzene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
p-Cymene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
sec-Butylbenzene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Styrene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
tert-Butylbenzene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Tetrachloroethene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Toluene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Total xylenes	0/6	0	nd	nd	0.5	nc	µg/L	na
trans-1,2-Dichloroethene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
trans-1,3-Dichloropropene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
trans-1,4-Dichloro-2-butene	0/6	0	nd	nd	1.2	1.0 – 5.0	µg/L	na
Trichloroethene	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Trichlorofluoromethane	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na

Table E.6.6-2, cont. Summary statistics for Great Western porewater

Chemical	Detection Frequency		Concentration					Location of Maximum Detect
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit	
Vinyl acetate	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na
Vinyl chloride	0/6	0	nd	nd	0.4	0.2 – 1.6	µg/L	na
Xylene (meta & para)	0/6	0	nd	nd	0.5	0.4 – 2.0	µg/L	na
Xylene (ortho)	0/6	0	nd	nd	0.2	0.2 – 1.0	µg/L	na

Table E.6.6-3. Summary statistics for Rhône-Poulenc porewater

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Criteria		Comparison to WQS			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit		Chronic WQS	Acute WQS	Detect > Chronic and ≤Acute	Detect > Acute	Nondetect > Chronic and ≤ Acute	Nondetect > Acute
Metals and trace elements														
Aluminum	6/15	40	790	10,500	1,000	300	µg/L	SB-18	na	na	na	na	na	na
Arsenic	0/15	0	nd	nd	230	450	µg/L	na	36	69	0	0	0	15
Barium	15/15	100	14 J	217 J	70	na	µg/L	SH-05	na	na	na	na	na	na
Beryllium	0/15	0	nd	nd	5	10	µg/L	na	na	na	na	na	na	na
Cadmium	0/15	0	nd	nd	20	30	µg/L	na	9.3	42	0	0	15	0
Calcium	15/15	100	40,900	323,000	212,000	na	µg/L	SB-18	na	na	na	na	na	na
Chromium	0/15	0	nd	nd	50	100	µg/L	na	50	1,100	0	0	15	0
Cobalt	0/15	0	nd	nd	30	50	µg/L	na	na	na	na	na	na	na
Copper	4/15	27	5.4	264	30	5	µg/L	SHB-5	3.1	4.8	0	4	0	11
Iron	12/15	80	560	41,700	8,000	200	µg/L	SB-18	na	na	na	na	na	na
Lead	0/15	0	nd	nd	130	250	µg/L	na	8.1	210	0	0	0	15
Magnesium	15/15	100	127,000	1,030,000	650,000	na	µg/L	SB-18	na	na	na	na	na	na
Manganese	12/15	80	25	1,890	600	20	µg/L	SH-01	na	na	na	na	na	na
Mercury	10/15	67	0.0016	0.408	0.069	0.2	µg/L	SB-18	0.025	1.8	4	0	5	0
Nickel	0/15	0	nd	nd	50	100	µg/L	na	8.2	74	0	0	0	15
Potassium	15/15	100	47,200	292,000	180,000	na	µg/L	SB-18	na	na	na	na	na	na
Sodium	15/15	100	1,290,000	8,310,000	5,120,000	na	µg/L	SB-18	na	na	na	na	na	na
Vanadium	0/15	0	nd	nd	50	100	µg/L	na	na	na	na	na	na	na
Zinc	3/15	20	263	1,560	200	50	µg/L	SB-18	81	90	0	3	0	0
PAHs														
Benzo(a)pyrene	1/9	11	0.0320 J	0.0320 J	0.17	0.37	µg/L	SH-02	na	na	na	na	na	na
Benzo(b)fluoranthene	1/9	11	0.0390 J	0.0390 J	0.17	0.37	µg/L	SH-02	na	na	na	na	na	na
Benzo(k)fluoranthene	1/9	11	0.0390 J	0.0390 J	0.17	0.37	µg/L	SH-02	na	na	na	na	na	na
Total benzofluoranthenes	1/9	11	0.0780 J	0.0780 J	0.17	nc	µg/L	SH-02	na	na	na	na	na	na
Fluoranthene	1/9	11	0.26 J	0.26 J	0.19	0.37	µg/L	SH-02	na	na	na	na	na	na
Pyrene	1/9	11	0.32 J	0.32 J	0.20	0.37	µg/L	SH-02	na	na	na	na	na	na
Total HPAH	1/9	11	0.69 J	0.69 J	0.24	nc	µg/L	SH-02	na	na	na	na	na	na
Carcinogenic PAHs - Mammal	1/9	11	0.0398 J	0.0398 J	0.10	0.22	µg/L	SH-02	na	na	na	na	na	na
Total PAH	1/9	11	0.69 J	0.69 J	0.24	nc	µg/L	SH-02	na	na	na	na	na	na

Table E.6.6-3, cont. Summary statistics for Rhône-Poulenc porewater

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Criteria		Comparison to WQS			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit		Chronic WQS	Acute WQS	Detect > Chronic and ≤Acute	Detect > Acute	Nondetect > Chronic and ≤ Acute	Nondetect > Acute
Phthalates														
Bis(2-ethylhexyl)phthalate	5/9	56	2.0	390	45	1.9	µg/L	SH-02	na	na	na	na	na	na
Diethyl phthalate	0/9	0	nd	nd	0.40	0.37 – 3.7	µg/L	na	na	na	na	na	na	na
Other SVOCs														
Biphenyl	2/9	22	0.0260 J	0.0320 J	0.34	0.37 – 3.7	µg/L	SH-04	na	na	na	na	na	na
Caprolactam	8/9	89	1.5 J	7.5 J	3.7	1.9	µg/L	SH-01	na	na	na	na	na	na
Volatile organic compounds														
Benzene	0/9	0	nd	nd	0.50	1	µg/L	na	na	na	na	na	na	na
Ethylbenzene	0/9	0	nd	nd	1.0	2	µg/L	na	na	na	na	na	na	na
Toluene	0/9	0	nd	nd	1.0	2	µg/L	na	na	na	na	na	na	na
Xylene (ortho)	0/9	0	nd	nd	1.0	2	µg/L	na	na	na	na	na	na	na
Xylene (meta & para)	0/9	0	nd	nd	2.0	4	µg/L	na	na	na	na	na	na	na
Total xylenes	0/9	0	nd	nd	2.0	nc	µg/L	na	na	na	na	na	na	na

Table E.6.6-4. Summary statistics for EPA SI porewater

Chemical	Detection Frequency		Concentration					Location of Maximum Detect	Criteria		Comparison to WQS			
	Ratio	%	Minimum Detect	Maximum Detect	Calculated Mean	RL or Range of RLs	Unit		Chronic WQS	Acute WQS	Detect > Chronic and ≤Acute	Detect > Acute	Nondetect > Chronic and ≤ Acute	Nondetect > Acute
Metals and trace elements														
Aluminum	8/15	53	77	378	100	50 – 77	µg/L	DR055	na	na	na	na	na	na
Antimony	1/15	7	30 J	30 J	20	5 – 50	µg/L	DR244	na	na	na	na	na	na
Arsenic	12/15	80	26	114	50	10 – 30	µg/L	DR244	36	69	4	4	0	0
Barium	15/15	100	4 J	214	60	na – na	µg/L	DR262	na	na	na	na	na	na
Beryllium	0/15	0	nd	nd	3	5 – 5	µg/L	na	na	na	na	na	na	na
Cadmium	4/15	27	4 J	4 J	3	5	µg/L	DR181 DR147 DR109 DR244	9.3	42	0	0	0	0
Calcium	15/15	100	15,300	347,000	300,000	na	µg/L	DR018	na	na	na	na	na	na
Chromium	0/15	0	nd	nd	5	10	µg/L	na	50	1,100	0	0	0	0
Cobalt	0/15	0	nd	nd	5	10	µg/L	na	na	na	na	na	na	na
Copper	4/15	27	1	5	2	4	µg/L	DR262 DR109	3.1	4.8	0	2	11	0
Iron	15/15	100	186	18,300	9,000	na	µg/L	DR244	na	na	na	na	na	na
Lead	13/15	87	0.6 J	4	1	1	µg/L	DR109	8.1	210	0	0	0	0
Magnesium	15/15	100	51,000	1,100,000	890,000	na	µg/L	DR018 DR055	na	na	na	na	na	na
Manganese	15/15	100	13	5,440	2,000	na	µg/L	DR244	na	na	na	na	na	na
Mercury	0/15	0	nd	nd	0.05	0.1	µg/L	na	0.025	1.8	0	0	15	0
Nickel	0/15	0	nd	nd	10	20 – 30	µg/L	na	8.2	74	0	0	15	0
Potassium	15/15	100	41,600	373,000	290,000	na	µg/L	DR055	na	na	na	na	na	na
Selenium	0/15	0	nd	nd	10	20 – 30	µg/L	na	na	na	na	na	na	na
Silver	6/15	40	0.3 J	0.5 J	0.4	1	µg/L	DR301	na	1.9	na	0	na	0
Sodium	15/15	100	1,160,000	9,730,000	7,800,000	na	µg/L	DR038	na	na	na	na	na	na
Thallium	0/15	0	nd	nd	0.5	1	µg/L	na	na	na	na	na	na	na
Tin	0/15	0	nd	nd	8	10	µg/L	na	na	na	na	na	na	na
Vanadium	15/15	100	3 J	22	10	na	µg/L	DR244	na	na	na	na	na	na
Zinc	3/15	20	4 J	6 J	5	10	µg/L	DR140	81	90	0	0	0	0
Organometals														
Monobutyltin as ion	0/15	0	nd	nd	0.025	0.05	µg/L	na	na	na	na	na	na	na
Dibutyltin as ion	4/15	27	0.0070 J	0.010 J	0.021	0.05	µg/L	DR038 DR018 DR055	na	na	na	na	na	na
Tributyltin as ion	8/15	53	0.0080 J	0.080 J	0.026	0.05	µg/L	DR055	na	na	na	na	na	na
Tetrabutyltin as ion	0/15	0	nd	nd	0.025	0.05	µg/L	na	na	na	na	na	na	na

E.7 Concentrations of Arsenic and cPAHs in Sediment Corresponding to Tissue RBTCs

This section of Appendix E presents details of the back-calculation of arsenic and carcinogenic polycyclic aromatic hydrocarbons (cPAHs) concentrations in sediment corresponding to tissue risk-based threshold concentrations (RBTCs).

As discussed in detail in Sections 8.3.2 and 8.3.3 of the main body of the remedial investigation (RI), the clam tissue-to-sediment relationships for arsenic and cPAHs are too uncertain to develop RBTCs for sediment. This result is not surprising given the feeding behavior of Eastern soft-shell clam (*Mya arenaria*), which is the primary clam species of sufficient size and abundance within the LDW to be consumed by humans. *M. arenaria* are filter feeders and can process large quantities of water (4 to 6 L/hr) while feeding on suspended particulates in the water column (Brown et al. 1994). Thus, water and suspended material in the water are likely to be important sources of bioaccumulated chemicals (Abraham and Dillon 1986). This conclusion is supported by Foster et al. (1987), who conducted an experiment using sediment from Chesapeake Bay to evaluate the bioaccumulation of sediment-sorbed chemicals in a filter-feeding clam (*M. arenaria*) and a deposit-feeding clam (*Macoma balthica*). The *M. baltica* clams bioaccumulated the chemicals (naphthalene, diphenyl ether, di-n-octyl phthalate, 4,4'-1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane [DDT], and chrysene) at measurable rates over the 12-day exposure period, whereas *M. arenaria* did not show bioaccumulation of any of the sediment chemicals (Foster et al. 1987). Thus, in this study, contaminated sediment did not influence chemical concentrations in the tissues of filter-feeding clams.

As discussed in the human health risk assessment (HHRA) (Windward 2007), greater than 93% of the arsenic and cPAH risk associated with seafood consumption for all scenarios evaluated in the baseline HHRA is from the consumption of clams. Thus, if sediment RBTCs were to be developed for arsenic and cPAHs for the seafood consumption pathway, there would have to be significant regressions between the concentrations of these chemicals in sediment and clam tissue.

To evaluate such relationships, tissue samples of *M. arenaria* were collected from the LDW along with co-located sediment samples in 2004 (Windward 2005); the tissue samples were analyzed for a number of analytes, including inorganic arsenic and cPAHs, and the sediment samples were analyzed for a number of analytes, including total arsenic, cPAHs, grain size, and total organic carbon (TOC). Co-located clam tissue and sediment samples were also collected and analyzed for total and inorganic arsenic in clam tissue and total arsenic in sediment in 2007. Inorganic arsenic is the form of arsenic of concern in tissue samples because it is the form associated with human toxicity (both carcinogenic and non-carcinogenic).

The relationships between inorganic arsenic in clams and total arsenic in sediment and between cPAHs in clams and cPAHs in sediment were evaluated using a regression model. Because *M. arenaria* are filter feeders, the appropriate areal extent of the source of suspended particulates is uncertain and may be greater than the co-located composite sediment sample collected with each composite clam tissue sample. Thus, the regression relationships between the concentrations of arsenic and cPAHs in clam tissue and in sediment were evaluated at three spatial scales. The regression statistics for the larger intertidal areas were similar to those for the co-located samples using 2004 data (see Tables 8-15 and 8-19 in the main body of the RI), and, therefore, the regressions using sediment data for larger areas were not investigated further. Figure E.7-1 and Table E.7-1 and Figure E.7-2 and Table E.7-2 present the regressions and the untransformed data for arsenic (2004 and 2007 data) and cPAHs (2004 data), respectively. The regressions were discussed in detail in Sections 8.3.2 and 8.3.3 (in the main body of the RI) and were found to be too uncertain to calculate sediment RBTCs.

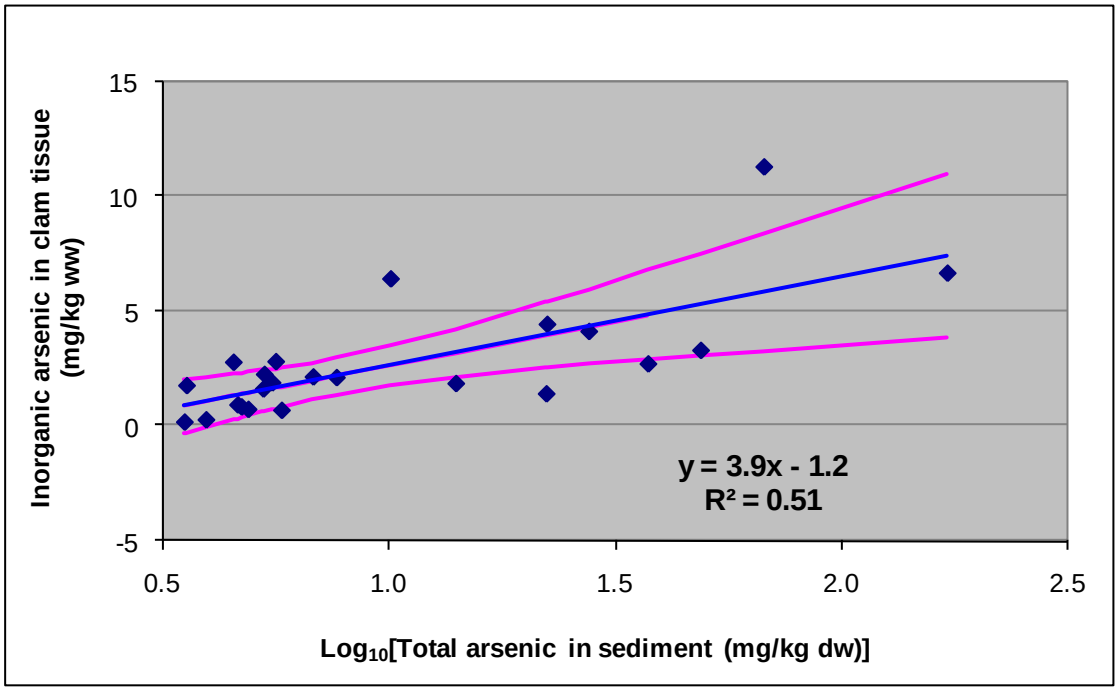


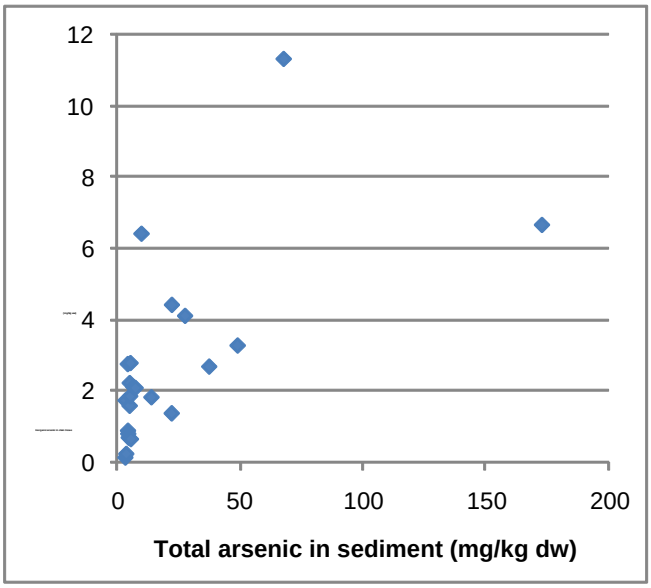
Figure E.7-1. Regression relationship for inorganic arsenic in clam tissue and total arsenic in sediment

Table E.7-1. Arsenic data and regression equation

Year	Total Arsenic Concentration in Sediment (mg/kg dw)	Inorganic Arsenic Concentration in Tissue (mg/kg ww)
2004	3.53	0.132
2007	3.57	1.73
2004	3.94	0.23
2007	4.53	2.75
2004	4.63	0.885
2004	4.72	0.795
2007	4.88	0.690
2007	5.27	1.58
2007	5.30	2.22
2004	5.52	1.85
2007	5.62	2.78
2004	5.79	0.648
2004	6.80	2.11
2007	7.66	2.08
2007	10.1	6.48
2007	14.1	1.82
2007	22.3	1.37
2007	22.4	4.41
2007	27.7	4.10
2007	37.5	2.68
2004	49.0	3.27
2007	67.6	11.3
2007	172	6.65

$$[As]_{tissue} = 3.9(Log_{10}([As]_{sediment}))-1.2$$

$$10^{Log_{10}}([As]_{sediment}) = ([As]_{tissue} + 1.2)/3.9$$



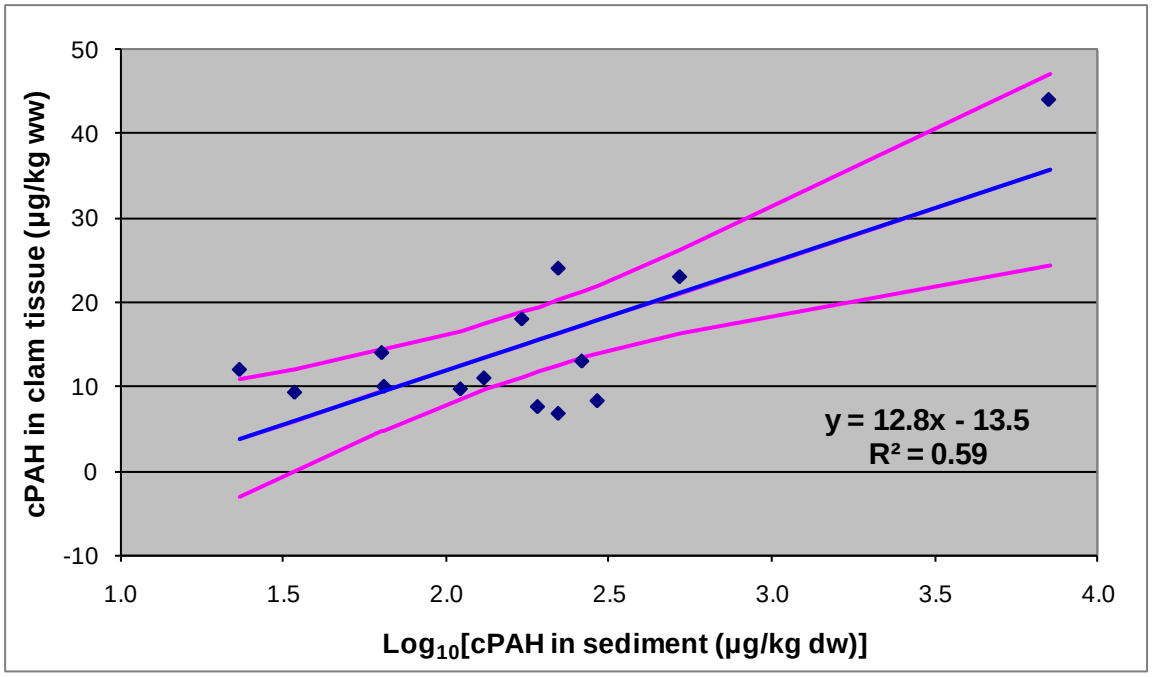


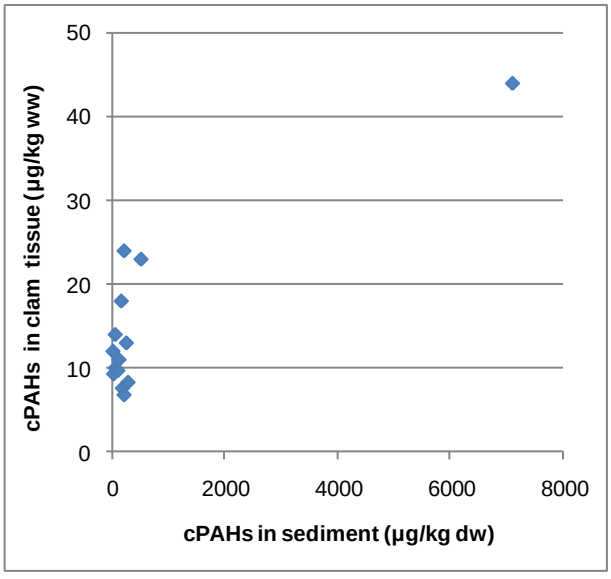
Figure E.7-2. Regression relationship for cPAHs in clam tissue and sediment

Table E.7-2. cPAH data and regression equation

Year	cPAH TEQ in Sediment (µg/kg dw)	cPAH TEQ in Tissue (µg/kg dw)
2004	23	12
2004	34	9.3
2004	63	14
2004	64	10
2004	110	9.7
2004	130	11
2004	170	18
2004	190	7.6
2004	220	6.8
2004	220	24
2004	260	13
2004	290	8.3
2004	520	23
2004	7,100	44

$$[cPAH]_{tissue} = 12.8(\log([cPAH]_{sediment}))-13.5$$

$$10^{\wedge}\log([cPAH]_{sediment}) = ([cPAH]_{tissue} + 13.5)/12.8$$



Nevertheless, at the request of EPA, the regression relationships were used to "back-calculate" the sediment concentrations that corresponded to the tissue RBTCs presented in Table E.7-3. Because the regressions are not expected to be predictive given the feeding behavior of *M. arenaria*, the development of these sediment concentrations may falsely raise expectations regarding the potential success of sediment cleanup in reducing seafood consumption risks for arsenic and cPAHs. Therefore, this exercise should be viewed as only informational.

Table E.7-3. Tissue RBTCs estimated from HHRA RME seafood consumption scenarios

Chemical	Seafood Consumption Scenario	Unit (ww)	Tissue RBTC[a]			
			Excess Cancer Risk			Non-Cancer Hazard
			1×10^{-6}	1×10^{-5}	1×10^{-4}	HQ = 1
Arsenic (inorganic)	adult tribal RME (Tulalip data)	mg/kg	0.00056	0.0056	0.056	0.25
	child tribal RME (Tulalip data)	mg/kg	0.0030	0.030	0.30	0.12
	adult API RME	mg/kg	0.0019	0.019	0.19	0.37
cPAHs[b]	adult tribal RME (Tulalip data)	µg/kg	0.11	1.1	11	na
	child tribal RME (Tulalip data)[c]	µg/kg	0.12	1.2	12	na
	adult API RME	µg/kg	0.39	3.9	39	na

[a] Tissue RBTCs represent ingestion-weighted average concentrations across different seafood categories. Tissue concentrations in individual seafood categories may be higher or lower than the tissue RBTC, but the average concentration in all resident seafood consumed must equal the tissue RBTC in order to result in the specified risk threshold.

[b] cPAH concentrations are expressed in terms of benzo(a)pyrene equivalents.

[c] Because of the potential for increased susceptibility of children to carcinogens with mutagenic activity, as described in EPA guidance (2005), the risk estimate for children for cPAHs is based on dose adjustments across the 0-to-6-year age range of children (see Section B.5.1 of the HHRA (Windward 2007) for more information).

API – Asian and Pacific Islander
cPAH – carcinogenic polycyclic aromatic hydrocarbon
EPA – US Environmental Protection Agency
HHRA – human health risk assessment
HQ – hazard quotient
na – not applicable
RBTC – risk-based threshold concentration
RME – reasonable maximum exposure
ww – wet weight

Sediment concentrations of total arsenic that corresponded to tissue RBTCs for the reasonable maximum exposure (RME) seafood consumption scenarios (for carcinogenic risks between 1×10^{-6} and 1×10^{-4}, and a non-cancer hazard quotient [HQ] < 1) all fall between 2.1 and 2.6 mg/kg dw, even though the tissue RBTCs spanned 3 orders of magnitude (Table E.7-4). Inverse prediction confidence intervals around these estimated sediment concentrations can also be calculated (Zar 1984); these confidence intervals spanned an order of magnitude. All of the estimated sediment arsenic concentrations (and even the upper confidence limits) are below the range of upstream sediment concentrations (see Section 7.2 in the main body of the RI).

Table E.7-4. Concentrations of arsenic in sediment that corresponded to tissue RBTCs

Risk Level	Scenario	Inorganic Arsenic Tissue RBTC (mg/kg ww)	Corresponding Sediment Total Arsenic Concentration (mg/kg dw)	Sediment LCL	Sediment UCL
1×10^{-6}	adult tribal RME (Tulalip data)	0.00056	2.1	0.52	5.19
1×10^{-6}	child tribal RME (Tulalip data)	0.003	2.1	0.52	5.19
1×10^{-6}	adult API RME	0.0019	2.1	0.52	5.19
1×10^{-5}	adult tribal RME (Tulalip data)	0.0056	2.1	0.52	5.20
1×10^{-5}	child tribal RME (Tulalip data)	0.03	2.1	0.54	5.23
1×10^{-5}	adult API RME	0.019	2.1	0.53	5.22
1×10^{-4}	adult tribal RME (Tulalip data)	0.056	2.1	0.56	5.28
1×10^{-4}	child tribal RME (Tulalip data)	0.3	2.5	0.74	5.70
1×10^{-4}	adult API RME	0.19	2.3	0.65	5.50
HQ = 1	adult tribal RME (Tulalip data)	0.25	2.4	0.70	5.61
HQ = 1	child tribal RME (Tulalip data)	0.12	2.2	0.60	5.38
HQ = 1	adult API RME	0.37	2.6	0.80	5.83

Note: None of the corresponding sediment concentrations were within the range of sediment concentrations used in the regression.

API – Asian and Pacific Islander
dw – dry weight
HQ – hazard quotient
LCL – lower confidence limit on the mean
RBTC – risk-based threshold concentration
RME – reasonable maximum exposure
UCL – upper confidence limit on the mean
ww – wet weight

cPAH toxic equivalents (TEQs) in sediment that corresponded to clam tissue RBTCs for the RME seafood consumption scenarios (for carcinogenic risks between 1×10^{-6} and 1×10^{-5}) ranged from 12 to 23 µg/kg dw and the corresponding confidence limits spanned 2 orders of magnitude (Table E.7-5). Sediment TEQs that corresponded to 1×10^{-4} tissue RBTCs for the adult and child tribal RME scenarios were 83 and 100 µg/kg dw, respectively, with corresponding confidence limits that spanned 1 order of magnitude. All of these sediment TEQs are less than the lower end of the range of upstream sediment concentrations (see Section 7.2 in the main body of the RI). The sediment TEQ for the 1×10^{-4} adult Asian and Pacific Islander (API) RME seafood consumption scenario (13,000 µg/kg dw) was much higher than the range of upstream sediment concentrations and the baseline LDW-wide spatially weighted average concentration (SWAC) for cPAHs (380 µg/kg dw).

Table E.7-5. cPAH TEQs in sediment that corresponded to tissue RBTCs

Risk Level	Scenario	Tissue RBTC (µg/kg ww)	Corresponding Sediment TEQ (µg/kg dw)	Sediment LCL	Sediment UCL
1×10^{-6}	adult tribal RME (Tulalip data)	0.11	12	0.54	34
1×10^{-6}	child tribal RME (Tulalip data)	0.12	12	0.54	35
1×10^{-6}	adult API RME	0.39	12	0.60	36
1×10^{-5}	adult tribal RME (Tulalip data)	1.1	14	0.77	39
1×10^{-5}	child tribal RME (Tulalip data)	1.2	14	0.80	40
1×10^{-5}	adult API RME	3.9	**23**	2.1	57
1×10^{-4}	adult tribal RME (Tulalip data)	11	**83**	24	165
1×10^{-4}	child tribal RME (Tulalip data)	12	**100**	33	199
1×10^{-4}	adult API RME	39	13,000	2,640	1,500,000

API – Asian and Pacific Islander
cPAH – carcinogenic polycyclic aromatic hydrocarbon
dw – dry weight
LCL – lower confidence limit on the mean
RBTC – risk-based threshold concentration
RME – reasonable maximum exposure
TEQ – toxic equivalent
UCL – upper confidence limit on the mean
ww – wet weight

Bold identifies corresponding sediment concentrations that were within the range of sediment concentrations used in the regression.

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Appendix F. Subsurface Core Analysis

Table F-1.	*Subsurface core analysis results for Reach 1 (RM 0.0 to RM 2.2)*	*1*
Table F-2.	*Subsurface core analysis results for Reach 2 (RM 2.2 to RM 4.0)*	*6*
Table F-3.	*Subsurface core analysis results for Reach 3 (RM 4.0 to RM 4.8)*	*12*
Table F-4.	*Cores not included in subsurface core analysis*	*13*

Table F-1. Subsurface core analysis results for Reach 1 (RM 0.0 to RM 2.2)

RM	Event	Location Name	Early Action Area	Total Core Depth (ft)	No. of Sampled Intervals	Input Parameters for Equation 4-2 [a]			Depth (D) of Peak Total PCB Concentration Predicted from Equation 4-2			Analyzed Interval with Expected Peak Concentration (i.e., interval within which D falls) and its Actual Total PCB Concentration		Analyzed Interval with Actual Peak Total PCB Concentration		Consistent with STM?
						Collec-tion Year (T_c)	Sed Rate from STM [b] (cm/yr)	Sed Rate (S) (ft/yr)	Sed Accum Since 1960 (ft)	Sed Accum Since 1965 (ft)	Sed Accum Since 1974 (ft)	Interval (ft)	Concen-tration (µg/kg dw)	Interval (ft)	Concen-tration (µg/kg dw)	
0	LDW Subsurface Sediment 2006	LDW-SC1		6	7	2006	1.3	0.042	1.9	1.7	1.3	0-2	3,400	1-1.5	6,700	Yes
												1-1.5	6,700			
												1.5-2	4,300			
0.1	LDW Subsurface Sediment 2006	LDW-SC2		12	4	2006	0.56	0.018	0.85	0.75	0.59	0-2	1,380	2-4	2,900	Yes
0.2	LDW Subsurface Sediment 2006	LDW-SC4		6	4	2006	0.76	0.025	1.1	1	0.8	0-1	143	2-4	600	Yes
												1-2	490			
0.2	LDW Subsurface Sediment 2006	LDW-SC5		4	3	2006	1.3	0.044	2	1.8	1.4	1-2.2	66	0-1	510	No
0.3	LDW Subsurface Sediment 2006	LDW-SC6		8	12	2006	1.1	0.037	1.7	1.5	1.2	0-2	172	4-4.5	2,600	Yes
												1-1.5	101			
												1.5-2	94			
0.4	Duw/Diag-2	DUD251[c]	EAA 1	9	3	1996	1.1	0.036	1.3	1.1	0.79	0-3	2,090 J	0-3	2,090 J	Yes
0.4	Duw/Diag-2	DUD252[c]	EAA 1	9	3	1996	2.1	0.068	2.5	2.1	1.5	0-3	80	0-3	80	Yes
0.4	LDW Subsurface Sediment 2006	LDW-SC7		4	3	2006	1.1	0.037	1.7	1.5	1.2	1-1.7	1,270 J	0-1	1,300	No
												1.7-4	5.5 U			
0.4	LDW Subsurface Sediment 2006	LDW-SC8		10	6	2006	1.1	0.037	1.7	1.5	1.2	1-2	1,030	4-6	5,500	Yes
0.5	EPA SI	DR008	EAA 1	4	2	1998	1.7	0.055	2.1	1.8	1.3	0-2	750	2-4	1,610	Yes
												2-4	1,610			
0.5	Duw/Diag-1	DUD006	EAA 1	4.9	7	1994	4	0.13	4.4	3.8	2.6	2.5-3	1,152	4.4-4.9	1,770	Yes
												3.5-4.4	1,250			
												4.4-4.9	1,770			
0.5	Duw/Diag-1	DUD020	EAA 1	3	5	1994	1.7	0.055	1.9	1.6	1.1	1-1.5	158 J	2.5-3	4,450	Yes
												1.5-2	441			

Table F-1, cont. Subsurface core analysis results for Reach 1 (RM 0.0 to RM 2.2)

RM	Event	Location Name	Early Action Area	Total Core Depth (ft)	No. of Sampled Intervals	Input Parameters for Equation 4-2 [a]			Depth (D) of Peak Total PCB Concentration Predicted from Equation 4-2			Analyzed Interval with Expected Peak Concentration (i.e., interval within which D falls) and its Actual Total PCB Concentration		Analyzed Interval with Actual Peak Total PCB Concentration		Consistent with STM?
						Collection Year (T_c)	Sed Rate from STM [b] (cm/yr)	Sed Rate (S) (ft/yr)	Sed Accum Since 1960 (ft)	Sed Accum Since 1965 (ft)	Sed Accum Since 1974 (ft)	Interval (ft)	Concentration (µg/kg dw)	Interval (ft)	Concentration (µg/kg dw)	
0.5	Duw/Diag-2	DUD253[c]	EAA 1	9	3	1996	1.1	0.037	1.3	1.1	0.81	0-3	500 J	6-9	7,000 J	Yes
0.5	Duw/Diag-2	DUD254[c]	EAA 1	9	3	1996	4	0.13	4.7	4	2.9	0-3	790 J	3-6	5,600 J	Yes
												3-6	5,600 J			
0.5	Duw/Diag-2	DUD255[c]	EAA 1	9	3	1996	1.2	0.039	1.4	1.2	0.85	0-3	1,050 J	0-3	7,700 J	Yes
												0-3	7,700 J			
0.5	Duw/Diag-2	DUD256[c]	EAA 1	9	3	1996	1.7	0.055	2	1.7	1.2	0-3	890 J	3-6	1,670 J	Yes
0.5	Duw/Diag-2	DUD257[c]	EAA 1	9	3	1996	1.2	0.04	1.4	1.2	0.87	0-3	163 J	0-3	163 J	Yes
0.5	Duw/Diag-2	DUD258[c]		9	3	1996	1.5	0.048	1.7	1.5	1	0-3	690 J	0-3	690 J	Yes
0.5	LDW Subsurface Sediment 2006	LDW-SC9		4	3	2006	1.2	0.039	1.8	1.6	1.2	1-2.6	2,700	0-1	3,600	No
0.5	LDW Subsurface Sediment 2006	LDW-SC10		8	5	2006	1.5	0.048	2.2	2	1.5	1-2	290	2-4	1,120	Yes
												2-4	1,120			
0.5	LDW Subsurface Sediment 2006	LDW-SC11		4.1	4	2006	1.3	0.044	2	1.8	1.4	0.8-2	3.9 U	0-0.8	3,000	No
												2-3.4	3.9 U			
0.6	EPA SI	DR044		4	2	1998	1.7	0.056	2.1	1.8	1.3	0-2	230	2-4	1,900	Yes
												2-4	1,900			
0.6	Duw/Diag-2	DUD027[c]	EAA 1	9	3	1996	1.3	0.043	1.6	1.3	0.95	0-3	1,800 J	0-3	1,800 J	Yes
0.6	Duw/Diag-2	DUD260		6	2	1996	1.5	0.048	1.7	1.5	1.1	0-3	1,340 J	0-3	1,340 J	Yes
0.6	Duw/Diag-2	DUD261[c]	EAA 1	6	2	1996	1.3	0.042	1.5	1.3	0.93	0-3	13,200 J	3-6	21,000 J	Yes
0.6	Duw/Diag-2	DUD262[c]	EAA 1	6	2	1996	1.5	0.051	1.8	1.6	1.1	0-3	3,520 J	0-3	3,520 J	Yes
0.6	LDW Subsurface Sediment 2006	LDW-SC12		8.7	12	2006	1.7	0.056	2.6	2.3	1.8	0-2	350	2-2.5	2,000 J	Yes
												1.5-2	320			
												2-2.5	2,000 J			
												2-4	2,500			
												2.5-3	630			
0.9	EPA SI	DR021		4	2	1998	1.7	0.055	2.1	1.8	1.3	0-2	520	2-4	4,000	Yes

Table F-1, cont. Subsurface core analysis results for Reach 1 (RM 0.0 to RM 2.2)

RM	Event	Location Name	Early Action Area	Total Core Depth (ft)	No. of Sampled Intervals	Input Parameters for Equation 4-2 [a]			Depth (D) of Peak Total PCB Concentration Predicted from Equation 4-2			Analyzed Interval with Expected Peak Concentration (i.e., interval within which D falls) and its Actual Total PCB Concentration		Analyzed Interval with Actual Peak Total PCB Concentration		Consistent with STM?
						Collection Year (T_c)	Sed Rate from STM [b] (cm/yr)	Sed Rate (S) (ft/yr)	Sed Accum Since 1960 (ft)	Sed Accum Since 1965 (ft)	Sed Accum Since 1974 (ft)	Interval (ft)	Concentration (µg/kg dw)	Interval (ft)	Concentration (µg/kg dw)	
												2-4	4,000			
0.9	LDW Subsurface Sediment 2006	LDW-SC13		4	9	2006	1.6	0.053	2.4	2.2	1.7	0-2	480	0.5-1	470	No
												1.5-2	360			
												2-2.5	120			
												2-4	53			
0.9	LDW Subsurface Sediment 2006	LDW-SC14		11	6	2006	0	0	0	0	0	0-1.4	4,500	0-1.4	4,500	Yes
0.9	LDW Subsurface Sediment 2006	LDW-SC15		10	5	2006	1.7	0.055	2.5	2.3	1.8	1-2	340 J	4-6	1,950	Yes
												2-4	510			
1	LDW Subsurface Sediment 2006	LDW-SC16		10	4	2006	1.9	0.062	2.9	2.6	2	2-4	5,400	2-4	5,400	Yes
1	LDW Subsurface Sediment 2006	LDW-SC17		8.6	4	2006	1.9	0.062	2.9	2.5	2	2-4	9,800	2-4	9,800	Yes
1	LDW Subsurface Sediment 2006	LDW-SC19		11.9	6	2006	1.5	0.049	2.3	2	1.6	1-2	233	6-7	2,400	Yes
												2-4	250			
1	LDW Subsurface Sediment 2006	LDW-SC20		10	4	2006	1.4	0.046	2.1	1.9	1.5	0-2	3,200	0-2	3,200	Yes
												2-4	600			
1	LDW Subsurface Sediment 2006	LDW-SC21		11.3	5	2006	1.5	0.051	2.3	2.1	1.6	1-2	145	4-6.2	1,680	Yes
												2-4	380 J			
1.1	LDW Subsurface Sediment 2006	LDW-SC22		4	3	2006	2.3	0.074	3.4	3.1	2.4	2-4	7.8 J	0-1.1	56	No
1.2	EPA SI	DR025		4	2	1998	2.5	0.08	3.1	2.7	1.9	0-2	290	2-4	1,150	Yes
												2-4	1,150			
1.2	LDW Subsurface Sediment 2006	LDW-SC23		10.2	5	2006	2.5	0.08	3.7	3.3	2.6	2-4	219	4-6	880	Yes
1.2	LDW Subsurface Sediment 2006	LDW-SC24		4	3	2006	1.8	0.059	2.7	2.4	1.9	1-2	36	0-1	280	No

Table F-1, cont. Subsurface core analysis results for Reach 1 (RM 0.0 to RM 2.2)

RM	Event	Location Name	Early Action Area	Total Core Depth (ft)	No. of Sampled Intervals	Input Parameters for Equation 4-2 [a]			Depth (D) of Peak Total PCB Concentration Predicted from Equation 4-2			Analyzed Interval with Expected Peak Concentration (i.e., interval within which D falls) and its Actual Total PCB Concentration		Analyzed Interval with Actual Peak Total PCB Concentration		Consistent with STM?
						Collection Year (T_c)	Sed Rate from STM [b] (cm/yr)	Sed Rate (S) (ft/yr)	Sed Accum Since 1960 (ft)	Sed Accum Since 1965 (ft)	Sed Accum Since 1974 (ft)	Interval (ft)	Concentration (µg/kg dw)	Interval (ft)	Concentration (µg/kg dw)	
												2-4	3.9 U			
1.3	EPA SI	DR054		4	2	1998	2	0.065	2.5	2.1	1.6	0-2	250	2-4	750	Yes
												2-4	750			
1.3	LDW Subsurface Sediment 2006	LDW-SC25		9.1	5	2006	2	0.065	3	2.7	2.1	2-4	430	4-6	800 J	Yes
1.4	LDW Subsurface Sediment 2006	LDW-SC26		12.1	5	2006	2	0.065	3	2.7	2.1	2-4	310	6-8	2,300	Yes
1.4	LDW Subsurface Sediment 2006	LDW-SC27		4.5	11	2006	2.6	0.084	3.9	3.5	2.7	2-4.5	250 J	1-1.5	3,200	No
												2.5-3	290			
												3.5-4	3.9 U			
1.4	LDW Subsurface Sediment 2006	LDW-SC28		12.6	5	2006	1.9	0.063	2.9	2.6	2	2-4	290	5.5-7.5	3,200	Yes
1.4	LDW Subsurface Sediment 2006	LDW-SC29		3.6	3	2006	2.5	0.083	3.8	3.4	2.7	2-3.6	3.9 U	0-1	33 J	No
1.6	Lone Star-Hardie Gypsum	c-4[c]		12	2	1995	2.4	0.077	2.7	2.3	1.6	0-4	71	0-4	71	Yes
1.7	LDW Subsurface Sediment 2006	LDW-SC32		8	4	2006	2.5	0.081	3.7	3.3	2.6	2-4	2,450	2-4	2,450	Yes
1.9	LDW Subsurface Sediment 2006	LDW-SC33		10	10	2006	2.7	0.09	4.1	3.7	2.9	2-4	420	1-1.5	4,700	No
												2.5-3	940			
												4-6	280			
1.9	LDW Subsurface Sediment 2006	LDW-SC34		4	3	2006	0.26	0.0085	0.39	0.35	0.27	0-1	210	1-2	280	Yes
1.9	LDW Subsurface Sediment 2006	LDW-SC35		4	2	2006	3.1	0.1	4.7	4.2	3.3	2-4	150 J	0-2	370 J	No
1.9	LDW Subsurface Sediment 2006	LDW-SC201[d]		10	4	2006	2.6	0.085	3.9	3.5	2.7	1.5-4	530 J	0-1.5	1,450	No
1.9	LDW Subsurface Sediment 2006	LDW-SC203[e]		6	4	2006	0.26	0.0085	0.39	0.35	0.27	0-1	250	0-1	250	Yes
2.1	EPA SI	DR106		4	2	1998	2.3	0.075	2.9	2.5	1.8	0-2	61	0-2	61	Yes
												2-4	0.1 U			

Table F-1, cont. Subsurface core analysis results for Reach 1 (RM 0.0 to RM 2.2)

RM	Event	Location Name	Early Action Area	Total Core Depth (ft)	No. of Sampled Intervals	Input Parameters for Equation 4-2 [a]			Depth (D) of Peak Total PCB Concentration Predicted from Equation 4-2			Analyzed Interval with Expected Peak Concentration (i.e., interval within which D falls) and its Actual Total PCB Concentration		Analyzed Interval with Actual Peak Total PCB Concentration		Consistent with STM?
						Collection Year (T_c)	Sed Rate from STM [b] (cm/yr)	Sed Rate (S) (ft/yr)	Sed Accum Since 1960 (ft)	Sed Accum Since 1965 (ft)	Sed Accum Since 1974 (ft)	Interval (ft)	Concentration (µg/kg dw)	Interval (ft)	Concentration (µg/kg dw)	
2.1	EPA SI	DR112		4	2	1998	3.9	0.13	4.9	4.2	3.1	2-4	330	2-4	330	Yes
2.1	LDW Subsurface Sediment 2006	LDW-SC36		4	3	2006	2.3	0.075	3.5	3.1	2.4	2-4	3.8 U	0-1	75	No
2.1	LDW Subsurface Sediment 2006	LDW-SC37		6.9	4	2006	1.8	0.059	2.7	2.4	1.9	1-2	950 J	1-2	950 J	Yes
												2-4	550			
2.1	LDW Subsurface Sediment 2006	LDW-SC202[f]		4	3	2006	2.3	0.075	3.5	3.1	2.4	2-4	3.9 UJ	0-1	30	No
2.2	LDW Subsurface Sediment 2006	LDW-SC39		6	4	2006	3.3	0.11	5	4.4	3.5	2-4	220	1-2	440	No
												4-6	150			

[a] Equation 4-2: D = (Tc-Tm) x S, where D = predicted depth (ft), Tc = collection year, Tm = assumed year of peak use, S = sedimentation rate (ft/yr); D was calculated using three assumptions of peak use: 1960, 1965, and 1974. The predicted depth (D) may be located in more than one interval because it is calculated using three different dates.

[b] If samples were out of the model domain, the sedimentation rate of the nearest model cell was used.

[c] These cores had ≥ 3 ft sampling intervals in the portion of the core near the estimated and actual peak depths. They were excluded in the uncertainty analysis conducted in Section 4.3 (see Table 4-95). These cores were consistent with the STM; however, because of the larger intervals, their interpretation is more uncertain. [d] Field replicate of LDW-SC33.

[e] Field replicate of LDW-SC34.

[f] Field replicate of LDW-SC36.

Table F-2. Subsurface core analysis results for Reach 2 (RM 2.2 to RM 4.0)

RM	Event	Location Name	Early Action Area	Total Core Depth (ft)	No. of Sampled Intervals	Input Parameters for Equation 4-2 [a]			Depth (D) of Peak Total PCB Concentration Predicted from Equation 4-2			Analyzed Interval with Expected Peak Concentration (i.e., Interval within which D falls) and its Actual Total PCB Concentration		Analyzed Interval with Actual Peak Total PCB Concentration		Consistent with STM?
						Collection Year (T_c)	Sed Rate from STM [b] (cm/yr)	Sed Rate (S) (ft/yr)	Sed Accum Since 1960 (ft)	Sed Accum Since 1965 (ft)	Sed Accum Since 1974 (ft)	Interval (ft)	Concentration (µg/kg dw)	Interval (ft)	Concentration (µg/kg dw)	
2.2	EPA SI	DR137		4	2	1998	3.3	0.11	4.1	3.6	2.6	2-4	730 J	2-4	730 J	Yes
2.3	LDW Subsurface Sediment 2006	LDW-SC40	EAA 2	4	3	2006	2.8	0.091	4.2	3.7	2.9	2-4	3.9 UJ	0-1.3	160 J	No
2.4	LDW Subsurface Sediment 2006	LDW-SC41		7.9	5	2006	2	0.067	3.1	2.7	2.1	2-4	270	4-6	510	Yes
2.5	EPA SI	DR171		4	2	1998	4.9	0.16	6.1	5.3	3.9	2-4	270	2-4	270	Yes
2.7	LDW Subsurface Sediment 2006	LDW-SC44		4	10	2006	0.21	0.0069	0.32	0.28	0.22	0-0.5	260	0.5-1	880 J	Yes
												0-2	510			
2.8	LDW Subsurface Sediment 2006	LDW-SC45		6	4	2006	4.8	0.16	7.3	6.5	5.1	5-6	122	2-4	570	No
2.8	Slip4-EarlyAction	SC01	EAA 3	6	3	2004	1.9	0.062	2.7	2.4	1.9	0-2	35,000	0-2	35,000	Yes
												2-4	780			
2.8	Slip4-EarlyAction	SC02	EAA 3	6	3	2004	1.9	0.062	2.7	2.4	1.9	0-2	1,200 J	4-6	10,900	Yes
												2-4	8,200 N			
2.8	Slip4-EarlyAction	SC03	EAA 3	6	3	2004	1.9	0.062	2.7	2.4	1.9	0-2	560 N	4-6	15,000	Yes
												2-4	4,800 N			
2.8	Slip4-EarlyAction	SC04	EAA 3	6	3	2004	1.9	0.062	2.7	2.4	1.9	0-2	14,000 J	0-2	14,000 J	Yes
												2-4	9,700			
2.8	Slip4-EarlyAction	SC05	EAA 3	6	3	2004	1.9	0.062	2.7	2.4	1.9	0-2	1,300	0-2	1300	Yes
												2-4	27			
2.9	DSOAvertchar	DUW108	EAA 4	6.6	3	2001	2.1	0.069	2.8	2.5	1.9	2-2.8	132	2-2.8	132	Yes
2.9	Slip4-EarlyAction	SC07	EAA 3	6	3	2004	1.9	0.062	2.7	2.4	1.9	0-2	6,900 J	2-4	7,300	Yes
												2-4	7,300			
3	DSOAvertchar	DUW111	EAA 4	4.7	3	2001	2.3	0.075	3.1	2.7	2	2-3	840	2-3	840	Yes
												3-3.7	320			
3	DSOAvertchar2	DUW140	EAA 4	3.5	2	2003	2.3	0.075	3.2	2.9	2.2	2-3	450	2-3	450	Yes
												3-3.5	14 J			
3	LDW Subsurface Sediment 2006	LDW-SC47		4	4	2006	0.02	0.00066	0.03	0.027	0.021	0-1	72 J	1-2	2,000	Yes
3.1	DSOAvertchar	DUW113	EAA 4	5	3	2001	1.7	0.054	2.2	2	1.5	2-2.8	840	2-2.8	840	Yes
3.1	DSOAvertchar2	DUW142	EAA 4	3.3	2	2003	2.3	0.075	3.2	2.9	2.2	2-2.7	670	2-2.7	670	Yes

Table F-2, cont. Subsurface core analysis results for Reach 2 (RM 2.2 to RM 4.0)

RM	Event	Location Name	Early Action Area	Total Core Depth (ft)	No. of Sampled Intervals	Input Parameters for Equation 4-2 [a]			Depth (D) of Peak Total PCB Concentration Predicted from Equation 4-2			Analyzed Interval with Expected Peak Concentration (i.e., Interval within which D falls) and its Actual Total PCB Concentration		Analyzed Interval with Actual Peak Total PCB Concentration		Consistent with STM?
						Collection Year (T_c)	Sed Rate from STM [b] (cm/yr)	Sed Rate (S) (ft/yr)	Sed Accum Since 1960 (ft)	Sed Accum Since 1965 (ft)	Sed Accum Since 1974 (ft)	Interval (ft)	Concentration (µg/kg dw)	Interval (ft)	Concentration (µg/kg dw)	
												3-3.3	128			
3.1	DSOAvertchar2	DUW144	EAA 4	4.8	3	2003	1.7	0.054	2.3	2.1	1.6	2-2.8	1,300	2-2.8	1,300	Yes
3.1	DSOAvertchar2	DUW145	EAA 4	4.6	3	2003	1.7	0.054	2.3	2.1	1.6	2-2.6	760	2-2.6	760	Yes
3.1	Plant 2 RFI-2b	SD-01001[c]	EAA 4	5.6	2	1996	0.18	0.0059	0.21	0.18	0.13	0-4	2,300	0-4	2,300	Yes
3.1	Plant 2 RFI-2b	SD-DUW04[c]	EAA 4	5	2	1996	1.7	0.054	2	1.7	1.2	0-4	1,790	0-4	1,790	Yes
3.2	DSOAvertchar	DUW115	EAA 4	7	4	2001	1.7	0.054	2.2	2	1.5	2-3	3,400	2-3	3,400	Yes
3.2	DSOAvertchar	DUW117	EAA 4	7	4	2001	2.6	0.085	3.5	3	2.3	2-3	14,400	2-3	14,400	Yes
3.2	DSOAvertchar2	DUW146	EAA 4	4.6	3	2003	1.7	0.054	2.3	2.1	1.6	2-3	1,430 J	2-3	1,430 J	Yes
3.2	DSOAvertchar2	DUW147	EAA 4	4.1	3	2003	1.7	0.054	2.3	2.1	1.6	2-3	2,300	2-3	2,300	Yes
3.2	DSOAvertchar2	DUW149	EAA 4	4	2	2003	2.6	0.085	3.6	3.2	2.5	2-3	350	2-3	350	Yes
												3-4	38 U			
3.2	Plant 2 RFI-2b	SD-DUW06[c]	EAA 4	12	3	1996	2.6	0.085	3	2.6	1.9	0-4	2,100 J	0-4	2,100 J	Yes
3.3	DSOAvertchar3	DUW168	EAA 4	5	3	2004	2.6	0.085	3.7	3.3	2.5	2-3	2,300	2-3	2,300	Yes
												3-3.8	112			
3.3	LDW Subsurface Sediment 2006	LDW-SC48		4	3	2006	2.1	0.067	3.1	2.8	2.2	2-4	3.9 U	0-1	77	No
3.3	South Park Bridge	SB-5		7.5	3	2003	3.2	0.1	4.5	4	3	2.5-5	1,720	2.5-5	1,720	Yes
3.3	Plant 2 RFI-2b	SD-DUW07[c]	EAA 4	9.7	3	1996	2.6	0.085	3	2.6	1.9	0-1.9	4,400	0-1.9	4,400	Yes
												1.9-7.1	510			
3.3	Plant 2 RFI-2b	SD-DUW34[c]	EAA 4	5.9	2	1996	0.09	0.003	0.11	0.092	0.065	0-1.9	11,300	0-1.9	11,300	Yes
3.4	DSOAvertchar	DUW122	EAA 4	5	3	2001	2.5	0.08	3.3	2.9	2.2	2-3	260	2-3	260	Yes
												3-4	65			
3.4	DSOAvertchar	DUW124	EAA 4	7	4	2001	2.5	0.08	3.3	2.9	2.2	2-2.5	30,000	2-2.5	30,000	Yes
3.4	Plant 2 RFI-2b	SD-DUW26[c]	EAA 4	7.2	2	1996	2.9	0.096	3.5	3	2.1	0-4	9,600	0-4	9,600	Yes
3.4	Plant 2 RFI-2b	SD-DUW39[c]	EAA 4	8	2	1996	0.09	0.003	0.11	0.092	0.065	0-4	5,700	0-4	5,700	Yes
3.5	Plant 2 RFI-1	SD-04901	EAA 4	3	2	1995	3.1	0.1	3.5	3	2.1	1.5-3	66 J	0.3-1.5	350	No
3.5	Plant 2 RFI-1	SD-04902	EAA 4	3	2	1995	3.1	0.1	3.5	3	2.1	1.5-3	250	0.3-1.5	370	No
3.5	Plant 2 RFI-1	SD-04903	EAA 4	3	2	1995	3.1	0.1	3.5	3	2.1	1.5-3	2,500	0.3-1.5	3,000	No

Table F-2, cont. Subsurface core analysis results for Reach 2 (RM 2.2 to RM 4.0)

RM	Event	Location Name	Early Action Area	Total Core Depth (ft)	No. of Sampled Intervals	Input Parameters for Equation 4-2 [a]			Depth (D) of Peak Total PCB Concentration Predicted from Equation 4-2			Analyzed Interval with Expected Peak Concentration (i.e., Interval within which D falls) and its Actual Total PCB Concentration		Analyzed Interval with Actual Peak Total PCB Concentration		Consistent with STM?
						Collection Year (T_c)	Sed Rate from STM [b] (cm/yr)	Sed Rate (S) (ft/yr)	Sed Accum Since 1960 (ft)	Sed Accum Since 1965 (ft)	Sed Accum Since 1974 (ft)	Interval (ft)	Concentration (µg/kg dw)	Interval (ft)	Concentration (µg/kg dw)	
3.5	Plant 2 RFI-1	SD-04904	EAA 4	3	2	1995	3.1	0.1	3.5	3	2.1	1.5-3	10,000 J	1.5-3	10,000 J	Yes
3.5	Plant 2 RFI-2b	SD-DUW13[c]	EAA 4	7.6	2	1996	2.9	0.096	3.5	3	2.1	0-4	1,800	4-7.6	1,900	Yes
3.5	Plant 2 RFI-2b	SD-DUW13D[c]	EAA 4	12.8	3	1996	2.9	0.096	3.5	3	2.1	0-4	14,000 J	0-4	14,000 J	Yes
3.5	Plant 2 RFI-2b	SD-DUW28[c]	EAA 4	6.9	2	1996	2.9	0.096	3.5	3	2.1	1.9-6.9	78 J	0-1.9	13,000	No
3.5	Plant 2 RFI-2b	SD-DUW47[c]	EAA 4	8.4	2	1996	2.9	0.096	3.5	3	2.1	0-4.4	42 U	0-4.4	110	Yes
												0-4.4	110			
3.5	Plant 2 RFI-2b	SD-DUW51[c]	EAA 4	6.6	2	1996	3.5	0.11	4.1	3.5	2.5	0-2.6	3,400	0-2.6	3,500	Yes
												0-2.6	3,500			
												2.6-6.6	41 U			
												2.6-6.6	42 U			
3.5	Plant 2 RFI-2b	SD-DUW52[c]	EAA 4	14.5	4	1996	3.5	0.11	4.1	3.5	2.5	0-4	18,000	0-4	18,000	Yes
												4-8	540			
3.5	DSOAvertchar	DUW94	EAA 4	6	2	2001	3.1	0.1	4.1	3.6	2.7	4-5	5,500	4-5	5,500	Yes
3.5	DSOAvertchar	DUW96	EAA 4	8.6	3	2001	3.1	0.1	4.1	3.6	2.7	4-5	6,400	4-5	6,400	Yes
3.5	DSOAvertchar	DUW98	EAA 4	8.5	4	2001	3.1	0.1	4.1	3.6	2.7	2-3	36	2-3	36	Yes
												4-5	40 U			
3.5	DSOAvertchar	DUW99	EAA 4	2.8	2	2001	3.1	0.1	4.1	3.6	2.7	1-2.8	25,000 JN	0-0.9	51,000	No
3.5	DSOAvertchar	DUW102	EAA 4	3.3	3	2001	3.1	0.1	4.1	3.6	2.7	2-3.3	37	0-0.6	1,080	No
3.5	DSOAvertchar	DUW128	EAA 4	9.4	6	2001	2.9	0.096	3.9	3.5	2.6	3-3.8	370	2-2.6	810	Yes
3.5	DSOAvertchar	DUW132	EAA 4	9	5	2001	3.1	0.1	4.1	3.6	2.7	2-3	1,180	2-3	1,180	Yes
												3-4	670			
												4-5	48 J			
3.5	LDW Subsurface Sediment 2006	LDW-SC49a		10	6	2006	2.3	0.074	3.4	3	2.4	2-4	420	6-8	810	Yes
3.6	Plant 2 RFI-2b	SD-DUW15[c]	EAA 4	9.1	3	1996	3.5	0.11	4.1	3.5	2.5	0-4	8,500	0-4	8,500	Yes
												4-8	1,190			
3.6	Plant 2 RFI-2b	SD-DUW16	EAA 4	7.6	2	1996	2.3	0.074	2.7	2.3	1.6	0-3.6	7,600	0-3.6	7,600	Yes
3.6	Plant 2 RFI-2b	SD-DUW53[c]	EAA 4	15.9	4	1996	3.5	0.11	4.1	3.5	2.5	0-4	3,900	0-4	3,900	Yes
												4-8	2,300			

Table F-2, cont. Subsurface core analysis results for Reach 2 (RM 2.2 to RM 4.0)

RM	Event	Location Name	Early Action Area	Total Core Depth (ft)	No. of Sampled Intervals	Input Parameters for Equation 4-2 [a]			Depth (D) of Peak Total PCB Concentration Predicted from Equation 4-2			Analyzed Interval with Expected Peak Concentration (i.e., Interval within which D falls) and its Actual Total PCB Concentration		Analyzed Interval with Actual Peak Total PCB Concentration		Consistent with STM?
						Collec-tion Year (T_c)	Sed Rate from STM [b] (cm/yr)	Sed Rate (S) (ft/yr)	Sed Accum Since 1960 (ft)	Sed Accum Since 1965 (ft)	Sed Accum Since 1974 (ft)	Interval (ft)	Concen-tration (µg/kg dw)	Interval (ft)	Concen-tration (µg/kg dw)	
3.6	T117BoundaryDefinition	T117-SE-16-SC	EAA 5	10	7	2003	8.7	0.28	12	11	8.3	8-10	69	0-0.9	3,400	No
3.6	T117BoundaryDefinition	T117-SE-17-SC	EAA 5	10	6	2003	8.7	0.28	12	11	8.3	8-10	20 U	0-1	3,700	No
3.6	T117BoundaryDefinition	T117-SE-20-SC	EAA 5	10	6	2003	6.9	0.23	9.7	8.6	6.5	6-8	18 J	0-1	2,800	No
												8-10	118			
3.6	T117BoundaryDefinition	T117-SE-21-SC	EAA 5	10	6	2003	6.9	0.23	9.7	8.6	6.5	6-8	20 U	0-1	16,000	No
												8-10	20 U			
3.6	T117BoundaryDefinition	T117-SE-24-SC	EAA 5	10	6	2003	6.9	0.23	9.7	8.6	6.5	6-8	68 J	0-1	1,310	No
												8-10	45 J			
3.6	T117BoundaryDefinition	T117-SE-25-SC	EAA 5	10	6	2003	0.14	0.0046	0.2	0.17	0.13	0-1	2,000	0-1	2,000	Yes
3.6	T117BoundaryDefinition	T117-SE-30-SC	EAA 5	10	6	2003	4.6	0.15	6.5	5.8	4.4	4-6	19 U	0-1	990	No
												6-8	19 U			
3.6	T117BoundaryDefinition	T117-SE-31-SC	EAA 5	10	6	2003	0.01	0.00033	0.014	0.012	0.0095	0-1	51,000	0-1	51,000	Yes
3.6	T117BoundaryDefinition	T117-SE-36-SC	EAA 5	10	6	2003	4.6	0.15	6.5	5.8	4.4	4-6	19 U	0-1	168 J	No
												6-8	19 U			
3.6	T117BoundaryDefinition	T117-SE-37-SC	EAA 5	10	6	2003	0.01	0.00033	0.014	0.012	0.0095	0-1	3,100	0-1	3,100	Yes
3.6	DSOAvertchar	DUW133	EAA 4	5.7	3	2001	3.5	0.11	4.7	4.1	3.1	4-4.9	310	2-2.7	16,000	No
3.6	DSOAvertchar	DUW134	EAA 4	7	4	2001	2.3	0.074	3.1	2.7	2	2-3	29,000 J	2-3	29,000 J	Yes
												3-4	9,100			
3.6	DSOAvertchar	DUW135	EAA 4	6.8	4	2001	3.5	0.11	4.7	4.1	3.1	4-5	1,700	4-5	1,700	Yes
3.6	Plant 2-TransformerPhase1	SD-DUW153	EAA 4	5.8	4	2003	3.5	0.11	4.9	4.4	3.3	2-4	6,200	0-1	108,000	No
												4-5	1,740			
3.6	Plant 2-TransformerPhase1	SD-DUW154	EAA 4	7.8	5	2003	2.3	0.074	3.2	2.8	2.2	2-4	1,390	2-4	1,390	Yes
3.6	Plant 2-TransformerPhase1	SD-DUW155	EAA 4	7.9	5	2003	2.3	0.074	3.2	2.8	2.2	2-3.7	3,100	2-3.7	3,100	Yes
3.6	Plant 2-TransformerPhase1	SD-DUW156	EAA 4	5.8	4	2003	2.3	0.074	3.2	2.8	2.2	2-3	370 J	4-4.8	1,230	Yes
3.6	Plant 2-TransformerPhase1	SD-DUW157	EAA 4	6	4	2003	2.3	0.074	3.2	2.8	2.2	2-3	130 UJ	0-1	30,000	No
												3-4	510 U			
3.6	Plant 2-TransformerPhase1	SD-DUW158	EAA 4	4.9	3	2003	2.3	0.074	3.2	2.8	2.2	2-2.9	180	0-1	5,000	No
3.6	Plant 2-TransformerPhase1	SD-DUW159	EAA 4	5	3	2003	2.3	0.074	3.2	2.8	2.2	2-2.8	380	0-1	2,300	No

Table F-2, cont. Subsurface core analysis results for Reach 2 (RM 2.2 to RM 4.0)

RM	Event	Location Name	Early Action Area	Total Core Depth (ft)	No. of Sampled Intervals	Input Parameters for Equation 4-2 [a]			Depth (D) of Peak Total PCB Concentration Predicted from Equation 4-2			Analyzed Interval with Expected Peak Concentration (i.e., Interval within which D falls) and its Actual Total PCB Concentration		Analyzed Interval with Actual Peak Total PCB Concentration		Consistent with STM?
						Collection Year (T_c)	Sed Rate from STM [b] (cm/yr)	Sed Rate (S) (ft/yr)	Sed Accum Since 1960 (ft)	Sed Accum Since 1965 (ft)	Sed Accum Since 1974 (ft)	Interval (ft)	Concentration (µg/kg dw)	Interval (ft)	Concentration (µg/kg dw)	
3.6	Plant 2-TransformerPhase1	SD-DUW160	EAA 4	4.6	3	2003	2.3	0.074	3.2	2.8	2.2	2-3	390	0-0.9	3,100	No
3.6	Plant 2-TransformerPhase1	SD-DUW161	EAA 4	5	2	2003	2.3	0.074	3.2	2.8	2.2	2-3	32	2-3	32	Yes
3.6	Plant 2-TransformerPhase1	SD-DUW162	EAA 4	4.6	3	2003	2.3	0.074	3.2	2.8	2.2	2-3	13,500	2-3	13,500	Yes
3.6	Plant 2-TransformerPhase1	SD-DUW163	EAA 4	5.1	3	2003	2.3	0.074	3.2	2.8	2.2	2-2.6	40 U	0-0.7	1,080	No
3.6	JorgensenApril2004	SD-201	EAA 4	5.7	6	2004	3.5	0.11	5	4.5	3.4	3-4	320	2-3	3,400	No
												4-5	220			
												5-5.7	50			
3.6	JorgensenApril2004	SD-204	EAA 4	8.7	9	2004	3.7	0.12	5.4	4.8	3.7	3-4	7,600	3-4	7,600	Yes
												4-5	4,800			
												5-6	4,700			
3.6	JorgensenAugust2004	SD-319-C	EAA 4	4	3	2004	3.7	0.12	5.4	4.8	3.7	3-4	13 U	2-3	132.9	No
3.7	T117BoundaryDefinition	T117-SE-42-SC	EAA 5	10	6	2003	4.6	0.15	6.5	5.8	4.4	4-6	19 U	0-1	470	No
												6-8	20 U			
3.7	JorgensenApril2004	SD-211	EAA 4	7	7	2004	2.9	0.094	4.1	3.7	2.8	2-3	1,540 J	3-4	1,660	Yes
												3-4	1,660			
												4-4.8	650			
3.7	JorgensenApril2004	SD-216	EAA 4	7.7	8	2004	4.8	0.16	6.9	6.1	4.7	4-5	480	6-7	1,290	Yes
												6-7	1,290			
3.7	JorgensenApril2004	SD-217	EAA 4	5.6	6	2004	2.9	0.094	4.1	3.7	2.8	2-2.9	280	1-1.9	690	No
												3-3.7	460			
												4-4.5	34			
3.7	JorgensenAugust2004	SD-313-C	EAA 4	4	3	2004	2.9	0.094	4.1	3.7	2.8	2-3	12 U	1-2	64.2	No
												3-4	120 U			
3.7	JorgensenAugust2004	SD-314-C	EAA 4	3.3	3	2004	2.9	0.094	4.1	3.7	2.8	2-3	580 U	3-3.3	220 J	Yes
												3-3.3	220 J			
3.7	JorgensenAugust2004	SD-320-C	EAA 4	4	3	2004	3.7	0.12	5.4	4.8	3.7	3-4	240	1-2	1,480	No
3.7	JorgensenAugust2004	SD-323-C	EAA 4	4	3	2004	3.7	0.12	5.4	4.8	3.7	3-4	1.2 J	1-2	792	No
3.8	EPA SI	DR220		4	2	1998	2.2	0.072	2.7	2.4	1.7	0-2	830	0-2	830	Yes

Table F-2, cont. Subsurface core analysis results for Reach 2 (RM 2.2 to RM 4.0)

RM	Event	Location Name	Early Action Area	Total Core Depth (ft)	No. of Sampled Intervals	Input Parameters for Equation 4-2 [a]			Depth (D) of Peak Total PCB Concentration Predicted from Equation 4-2			Analyzed Interval with Expected Peak Concentration (i.e., Interval within which D falls) and its Actual Total PCB Concentration		Analyzed Interval with Actual Peak Total PCB Concentration		Consistent with STM?
						Collec-tion Year (T_c)	Sed Rate from STM [b] (cm/yr)	Sed Rate (S) (ft/yr)	Sed Accum Since 1960 (ft)	Sed Accum Since 1965 (ft)	Sed Accum Since 1974 (ft)	Interval (ft)	Concen-tration (µg/kg dw)	Interval (ft)	Concen-tration (µg/kg dw)	
												2-4	230			
3.8	LDW Subsurface Sediment 2006	LDW-SC50a		4	4	2006	0.06	0.002	0.091	0.081	0.063	0-1	510	1-2	780	Yes
3.8	LDW Subsurface Sediment 2006	LDW-SC51	EAA 6	5.8	3	2006	2.3	0.075	3.4	3.1	2.4	2-3.8	700	0-2	1,290	No
3.9	LDW Subsurface Sediment 2006	LDW-SC52		4	3	2006	1.7	0.054	2.5	2.2	1.7	1-2	65	0-1	3,000 J	No
												2-4	4 U			

[a] Equation 4-2: D = (Tc-Tm) x S, where D = predicted depth (ft), Tc = collection year, Tm = assumed year of peak use, S = sedimentation rate (ft/yr); D was calculated using three assumptions of peak use: 1960, 1965, and 1974. The predicted depth (D) may be located in more than one interval because it is calculated using three different dates.

[b] If samples were out of the model domain, the sedimentation rate of the nearest model cell was used.

[c] These cores had ≥ 3 ft sampling intervals in the portion of the core near the estimated and actual peak depths. They were excluded in the uncertainty analysis conducted in Section 4.3 (see Table 4-95). These cores were consistent with the STM; however, because of the larger intervals, their interpretation is more uncertain.

Table F-3. Subsurface core analysis results for Reach 3 (RM 4.0 to RM 4.8)

RM	Event	Location Name	Total Core Depth (ft)	No. of Sampled Intervals	Input Parameters for Equation 4-2 [a]			Depth (D) of Peak Total PCB Concentration Predicted from Equation 4-2			Analyzed Interval with Expected Peak Concentration (i.e., Interval within which D falls) and its Actual Total PCB Concentration		Analyzed Interval with Actual Peak Total PCB Concentration		Consistent with STM?
					Collection Year (Tc)	Sed Rate from STM (cm/yr)	Sed Rate (S) (ft/yr)	Sed Accum Since 1960 (ft)	Sed Accum Since 1965 (ft)	Sed Accum Since 1974 (ft)	Interval (ft)	Concen-tration (µg/kg dw)	Interval (ft)	Concen-tration (µg/kg dw)	
4.2	LDW Subsurface Sediment 2006	LDW-SC53	4	2	2006	2.2	0.071	3.3	2.9	2.3	2-4	77	2-4	77	Yes

[a] Equation 4-2: D = (Tc-Tm) x S, where D = predicted depth (ft), Tc = collection year, Tm = assumed year of peak use, S = sedimentation rate (ft/yr); D calculated using three assumptions of peak use: 1960, 1965, and 1974.

Table F-4. Cores not included in subsurface core analysis

RM	Event	Location Name	Early Action Area	Reason		
				Disrupted by Dredging Prior to Sampling	Insufficient Depth Interval[a]	No PCBs Detected in Core
Reach 1						
0.2	LDW Subsurface Sediment 2006	LDW-SC3				X
0.3	EPA SI	DR068			X	
0.4	Duw/Diag-2	DUD250			X	
0.6	Duw/Diag-2	DUD206			X	X
1	LDW Subsurface Sediment 2006	LDW-SC18		X		
1.6	LDW Subsurface Sediment 2006	LDW-SC30		X		
1.7	LDW Subsurface Sediment 2006	LDW-SC31		X		
1	Lehigh NW	C2			X	
1	Lehigh NW	C3			X	
1.1	Lehigh NW	A1			X	
1.4	Glacier NW	SCDMMU3			X	
1.5	Lone Star 92	C-1			X	
1.5	Glacier NW	SCDMMU1			X	
1.5	Glacier NW	SCDMMU2			X	
1.5	Glacier NW	SCDMMU2R			X	X
1.6	Hardie Gypsum-1	1		X	X	
1.6	Hardie Gypsum-1	2		X	X	
1.6	Hardie Gypsum-2	A		X	X	
1.6	Hardie Gypsum-2	B		X	X	
1.6	Hardie Gypsum-2	2b		X	X	
1.6	Lone Star-Hardie Gypsum	c-3			X	
1.7	EPA SI	DR101				X
1.7	Hardie Gypsum-1	3		X	X	
1.7	Hardie Gypsum-1	4		X	X	
1.7	Hardie Gypsum-1	5		X	X	

Table F-4, cont. Cores not included in subsurface core analysis

RM	Event	Location Name	Early Action Area	Reason		
				Disrupted by Dredging Prior to Sampling	Insufficient Depth Interval[a]	No PCBs Detected in Core
1.7	Hardie Gypsum-2	C			X	
1.7	Hardie Gypsum-2	D		X	X	
1.7	Hardie Gypsum-2	E		X	X	
1.7	Hardie Gypsum-2	3		X	X	
1.7	Hardie Gypsum-2	4		X	X	
1.7	Hardie Gypsum-2	5.2		X	X	
1.7	Lone Star-Hardie Gypsum	c-1			X	
1.7	Lone Star-Hardie Gypsum	c-2			X	
1.8	PSDDA99	S1			X	
1.8	PSDDA99	S2			X	
1.8	PSDDA99	S3			X	
1.8	PSDDA99	S4			X	
1.8	PSDDA99	S5			X	
1.9	PSDDA99	S6			X	
1.9	PSDDA99	S7			X	
1.9	PSDDA99	S8			X	
1.9	PSDDA99	S9			X	
1.9	PSDDA99	S10			X	
1.9	PSDDA99	B1			X	
2	PSDDA99	S11			X	
2	PSDDA99	S12			X	
2.1	PSDDA99	B2			X	
2.1	LDW Subsurface Sediment 2006	LDW-SC38a			X	
2.1	LDW Subsurface Sediment 2006	LDW-SC38b			X	
Reach 2						
2.2	PSDDA99	S13			X	
2.4	Hurlen-Boyer	C5		X	X	

Table F-4, cont. Cores not included in subsurface core analysis

RM	Event	Location Name	Early Action Area	Reason		
				Disrupted by Dredging Prior to Sampling	Insufficient Depth Interval[a]	No PCBs Detected in Core
2.4	PSDDA99	S14			X	
2.5	Hurlen-Boyer	C6		X	X	
2.5	PSDDA99	S15			X	
2.5	BoyerTowing	WRC-SS-B1		X	X	X
2.5	BoyerTowing	WRC-SS-B2		X	X	X
2.5	BoyerTowing	WRC-SS-B3		X	X	X
2.5	LDW Subsurface Sediment 2006	LDW-SC42			X	
2.6	PSDDA99	S16			X	
2.6	LDW Subsurface Sediment 2006	LDW-SC43			X	X
2.7	LDW Subsurface Sediment 2006	LDW-SC46		X		
2.7	Hurlen-Boyer	C1		X	X	
2.7	Hurlen-Boyer	C2		X	X	
2.7	Hurlen-Boyer	C3		X	X	
2.8	Slip4-Crowley	DMMU 1			X	
2.8	Slip4-Crowley	DMMU 2			X	
2.8	Slip4-Crowley	DMMU 3			X	
2.8	Slip4-Crowley	DMMU 4			X	
2.8	Slip4-EarlyAction	SC06		X		
2.8	Hurlen-Boyer	C4		X	X	
2.9	DSOAvertchar	DUW106	EAA 4			X
2.9	DSOAvertchar	DUW107	EAA 4		X	
2.9	DSOAvertchar2	DUW137	EAA 4		X	
2.9	DSOAvertchar2	DUW138	EAA 4		X	X
3	EPA SI	DR224				X
3	DSOAvertchar	DUW109	EAA 4		X	X
3	DSOAvertchar	DUW110	EAA 4		X	
3	PSDDA99	S17			X	
3	DSOAvertchar2	DUW139	EAA 4		X	

Table F-4, cont. Cores not included in subsurface core analysis

RM	Event	Location Name	Early Action Area	Reason		
				Disrupted by Dredging Prior to Sampling	Insufficient Depth Interval[a]	No PCBs Detected in Core
3	DSOAvertchar2	DUW141	EAA 4		X	X
3.1	DSOAvertchar	DUW112	EAA 4		X	
3.1	DSOAvertchar	DUW114	EAA 4		X	X
3.1	DSOAvertchar	DUW136	EAA 4		X	X
3.1	DSOAvertchar2	DUW143	EAA 4		X	
3.1	DSOAvertchar3	DUW166	EAA 4		X	X
3.1	DSOAvertchar3	DUW167	EAA 4		X	
3.2	DSOAvertchar	DUW116	EAA 4		X	
3.2	PSDDA99	S18			X	
3.2	DSOAvertchar2	DUW148	EAA 4		X	X
3.2	DSOAvertchar2	DUW150	EAA 4		X	X
3.2	DSOAvertchar2	DUW152	EAA 4		X	X
3.2	DSOAvertchar3	DUW147R	EAA 4		X	X
3.3	Plant 2 RFI-1	SD-04107	EAA 4		X	
3.3	DSOAvertchar	DUW118	EAA 4		X	
3.3	DSOAvertchar	DUW119	EAA 4			X
3.3	DSOAvertchar	DUW120	EAA 4		X	X
3.3	DSOAvertchar	DUW121	EAA 4		X	X
3.3	DSOAvertchar3	DUW169	EAA 4		X	X
3.3	South Park Bridge	SB-4	EAA 4		X	
3.4	SouthParkMarina	1 & 2		X	X	
3.4	SouthParkMarina	3 & 4		X	X	
3.4	DSOAvertchar	DUW123	EAA 4		X	
3.4	DSOAvertchar	DUW125	EAA 4		X	X
3.4	DSOAvertchar	DUW126	EAA 4		X	
3.5	Plant 2 RFI-1	SD-04402	EAA 4		X	
3.5	Plant 2 RFI-1	SD-04405	EAA 4		X	
3.5	Plant 2 RFI-1	SD-04905	EAA 4		X	

Table F-4, cont. Cores not included in subsurface core analysis

RM	Event	Location Name	Early Action Area	Reason		
				Disrupted by Dredging Prior to Sampling	Insufficient Depth Interval[a]	No PCBs Detected in Core
3.5	Plant 2 RFI-1	SD-04920	EAA 4		X	
3.5	EPA SI	DR206	EAA 5		X	
3.5	T117BoundaryDefinition	T117-SE-70-SC	EAA 5		X	
3.5	T117BoundaryDefinition	T117-SE-71-SC	EAA 5		X	
3.5	T117BoundaryDefinition	T117-SE-72-SC	EAA 5		X	
3.5	DSOAvertchar	DUW103	EAA 4		X	
3.5	DSOAvertchar	DUW127	EAA 4			X
3.5	DSOAvertchar	DUW129	EAA 4		X	
3.5	DSOAvertchar	DUW130	EAA 4			X
3.5	DSOAvertchar	DUW131	EAA 4			X
3.5	PSDDA98	1		X	X	
3.5	T117BoundaryDefinition	T117-SE-91-SC			X	
3.5	T117BoundaryDefinition	T117-SE-93-SC			X	
3.5	T117BoundaryDefinition	T117-SE-COMP1-SC			X	
3.5	T117BoundaryDefinition	T117-SE-COMP2and3-SC	EAA 5		X	
3.5	T117BoundaryDefinition	T117-SE-COMP4-SC			X	
3.6	Plant 2-TransformerPhase1	SD-DUW164	EAA 4		X	
3.6	Plant 2-TransformerPhase1	SD-DUW165	EAA 4		X	
3.6	JorgensenApril2004	SD-202	EAA 4		X	
3.6	JorgensenApril2004	SD-203	EAA 4		X	
3.6	JorgensenApril2004	SD-205	EAA 4		X	
3.6	JorgensenApril2004	SD-205D	EAA 4		X	
3.6	JorgensenApril2004	SD-206	EAA 4		X	
3.6	JorgensenApril2004	SD-207	EAA 4		X	
3.6	JorgensenApril2004	SD-208	EAA 4		X	
3.6	JorgensenApril2004	SD-213	EAA 4		X	
3.6	JorgensenApril2004	SD-215	EAA 4		X	
3.6	JorgensenApril2004	SD-301	EAA 4		X	

Table F-4, cont. Cores not included in subsurface core analysis

RM	Event	Location Name	Early Action Area	Reason		
				Disrupted by Dredging Prior to Sampling	Insufficient Depth Interval[a]	No PCBs Detected in Core
3.6	JorgensenApril2004	SD-302	EAA 4		X	
3.6	JorgensenApril2004	SD-303	EAA 4		X	
3.6	JorgensenAugust2004	SD-307-C	EAA 4		X	
3.6	JorgensenAugust2004	SD-309-C	EAA 4		X	
3.6	JorgensenAugust2004	SD-310-C	EAA 4		X	
3.6	JorgensenAugust2004	SD-311-C	EAA 4		X	
3.6	JorgensenAugust2004	SD-316-C	EAA 4		X	
3.6	JorgensenAugust2004	SD-317-C	EAA 4		X	
3.6	JorgensenAugust2004	SD-318-C	EAA 4		X	X
3.6	JorgensenAugust2004	SD-321-C			X	
3.6	T117BoundaryDefinition	T117-SE-15-SC	EAA 5		X	
3.6	T117BoundaryDefinition	T117-SE-23-SC	EAA 5	X		
3.6	T117BoundaryDefinition	T117-SE-35-SC	EAA 5	X		
3.7	T117BoundaryDefinition	T117-SE-43-SC	EAA 5		X	X
3.7	PSDDA98	2		X	X	
3.7	JorgensenApril2004	SD-209	EAA 4		X	
3.7	JorgensenApril2004	SD-210	EAA 4		X	
3.7	JorgensenApril2004	SD-210D	EAA 4		X	
3.7	JorgensenApril2004	SD-212	EAA 4		X	
3.7	JorgensenApril2004	SD-214	EAA 4		X	
3.7	JorgensenAugust2004	SD-312-C	EAA 4		X	
3.7	JorgensenAugust2004	SD-315-C	EAA 4			X
3.7	JorgensenAugust2004	SD-322-C		X		
3.9	PSDDA98	3		X	X	
4	DuwamYachtClub	C1			X	X
4	PSDDA98	4		X	X	
4	RhônePoulenc2004	SH-01			X	
4	RhônePoulenc2004	SH-02			X	

Table F-4, cont. Cores not included in subsurface core analysis

RM	Event	Location Name	Early Action Area	Reason		
				Disrupted by Dredging Prior to Sampling	Insufficient Depth Interval[a]	No PCBs Detected in Core
4	RhônePoulenc2004	SB-13			X	
Reach 3						
4.1	EPA SI	DR284			X	
4.1	DuwamYachtClub	C2			X	X
4.1	DuwamYachtClub	C3			X	X
4.1	DuwamYachtClub	C4			X	X
4.1	DuwamYachtClub	C5			X	X
4.1	DuwamYachtClub	C6			X	X
4.1	PSDDA98	5		X	X	
4.1	RhônePoulenc2004	SH-03			X	X
4.1	RhônePoulenc2004	SH-04			X	
4.1	RhônePoulenc2004	SH-06			X	
4.1	RhônePoulenc2004	SB-12			X	
4.2	EPA SI	DR246			X	
4.2	PSDDA96	6		X	X	
4.2	PSDDA98	6		X	X	
4.2	PSDDA98	7		X	X	
4.2	RhônePoulenc2004	SH-07			X	
4.2	RhônePoulenc2004	SH-08			X	
4.2	RhônePoulenc2004	SH-09			X	
4.2	RhônePoulenc2004	SB-1			X	
4.2	RhônePoulenc2004	SB-2			X	
4.2	RhônePoulenc2004	SB-3			X	
4.2	RhônePoulenc2004	SB-4			X	
4.2	RhônePoulenc2004	SB-5			X	
4.2	RhônePoulenc2004	SB-6			X	
4.2	RhônePoulenc2004	SB-7			X	

Table F-4, cont. Cores not included in subsurface core analysis

RM	Event	Location Name	Early Action Area	Reason		
				Disrupted by Dredging Prior to Sampling	Insufficient Depth Interval[a]	No PCBs Detected in Core
4.2	RhônePoulenc2004	SB-8			X	
4.2	RhônePoulenc2004	SB-11			X	
4.2	RhônePoulenc2004	SB-17			X	
4.3	PSDDA96	4		X	X	
4.3	PSDDA96	5		X	X	
4.3	LDW Subsurface Sediment 2006	LDW-SC54			X	
4.4	Turning-basin	DTB-01SD		X	X	
4.4	PSDDA98	Average Of 8-9		X	X	
4.5	Turning-basin	DTB-02SD		X	X	
4.6	EPA SI	DR269			X	X
4.6	PSDDA96	C1		X	X	
4.6	Turning-basin	DTB-03SD		X	X	
4.6	Turning-basin	DTB-04SD		X	X	
4.6	PSDDA98	Average Of 10-12		X	X	X
4.7	Turning-basin	DTB-05SD		X	X	
4.7	LDW Subsurface Sediment 2006	LDW-SC56			X	
4.9	Norfolk-cleanup2	NFK008	EAA 7		X	
4.9	Norfolk-cleanup2	NFK009	EAA 7		X	
4.9	Norfolk-cleanup2	NFK207	EAA 7		X	
4.9	LDW Subsurface Sediment 2006	LDW-SC55			X	

[a] Only one interval was analyzed for PCBs or no interval was analyzed within the depth range of the expected peak.

Appendix G. Listed Properties and Source Control Documentation

Introduction **1**

Table G-1. NPDES permit holders within the LDW drainage basin *2*

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Introduction

The tables included in this appendix were derived using information from regulatory databases maintained by the US Environmental Protection Agency (EPA), Washington State Department of Ecology (Ecology), King County, the City of Seattle, and the Puget Sound Clean Air Agency (PSCAA). Much of the information was provided by a Environmental Data Resources, Inc. (EDR) database search prepared in 2006 for the LDW study area. Some of the documents and databases reviewed are known to contain errors and to have data that has been omitted. None of the resource information has been independently verified beyond the citations noted. In addition, this information does not reflect changes in database listings since the original 2006 database review effort, unless specific information was provided by members of the Lower Duwamish Waterway Group (LDWG) or the agencies.

Furthermore, much of the primary data themselves have had varying levels of quality control and data validation, which have not generally been documented in the resource materials reviewed. Therefore, information included in this section should not be relied upon as complete and factual. Additional evaluations of the data would be required to use the data quantitatively or as an inference to identify potential sources.

The information presented is only as accurate as the source information provided by the agencies at this time. Misspellings and name abbreviations listed on the tables is as provided in the resource materials reviewed. Because of inaccuracies in the source data, there are likely duplicate listings (under multiple names) for a single facility within a table; often when facility ownership or usage changes the former and new names are often retained in the source data. Also, some facility names provided in these tables likely reflect former use or ownership rather than current ownership and operation. Addresses listed in the tables often reflect corporate and/or administrative locations and not the facility addresses which is governed under the requirements noted in the table. The presence or absence of a facility in these databases does not imply that the facility is or is not a potential source of contamination to the LDW.

When possible, attempts have been made to reconcile inaccuracies in the information. In many cases, the most recent database information available for a facility is dated, and likely does not represent the current status or condition of the site. Much of the information included in the appendices has been summarized from available online resources. Because website addresses associated with these databases often change, hyperlinks to their current locations have not been included as part of this summation.

Table G-1. NPDES permit holders within the LDW drainage basin

Permit ID No.	Drainage Basin Name	Facility Name	Facility Address/Location[a]
Sand and Gravel General Permits			
WAG503337B	Duwamish River	Cadman Seattle	5225 E Marginal Way S
WAG503191C	Duwamish River	Glacier Northwest Inc.	5975 E Marginal Way S
WAG503282C	Duwamish River	ICON Materials Seattle Asphalt	1115 S 96th Street
WAG503082C	Duwamish River	J.A. Jack & Sons Inc.	5427 Ohio Avenue S
WAG503170C	Duwamish River	Meyers Way Sand Pit	9400 Meyers Way
WAG503300C	Duwamish River	Stoneway Concrete	3083 E Marginal Way
Industrial General Stormwater Permits			
SO3004602B	Duwamish River	ABX Air, Inc. – Seattle	8075 Perimeter Road S
SO3000154D	Duwamish River	Ace Galvanizing Inc 96th	429 S 96th Street
SO3001219D WA-002902-5	Duwamish River	AIRCO Gases Division of BOC Seattle	7700 14th Avenue S
SO3001365D	Duwamish River	Alaska Marine Lines Seattle Terminal	5502 + 5658 W Marginal Way SW
SO3004605B	Duwamish River	Alaska Street Reload & Recycling	70 South Alaska Street
SO3002830C	Duwamish River	Ameriflight Inc Hangar 5	7585 Perimeter Road S
SO3000146D	Duwamish River	Boeing Developmental Center	9725 E Marginal Way S
SO3000150D	Duwamish River	Boeing Military Flight Center	10002 E Marginal Way S
SO3000482D WA 0002917	Duwamish River	Boeing Plant II	7755 E Marginal Way S
SO3001009D WA-002987-4(I)	Duwamish River	Boeing South Park Facility (Aircraft Res & Flight Training Center)	1420 S Trenton Street
SO3000148D	Duwamish River	Boeing Thompson Site	8770 East Marginal Way S
SO3005598A	Duwamish River	Boyer Logistics Inc	7318 Fourth Avenue S
SO3002274D	Duwamish River	CB Finishing	9585 8th Avenue S
SO3002285D	Duwamish River-Hamm Creek	Charles A Lasater Co. Seattle	515 S 96th Street
SO3005621A	Duwamish River	DR Concrete Recycle	149 SW Kenyon
SO3002641C	Duwamish River	Emerald Services	7343 E Marginal Way S

Table G-1, cont. NPDES permit holders within the LDW drainage basin

PERMIT ID NO.	DRAINAGE BASIN NAME	FACILITY NAME	FACILITY ADDRESS/LOCATION[a]
SO3002966C	Duwamish River	Evergreen Trails Inc.	4500 W Marginal Way SW
SO3003598C	Duwamish River	Fibres International Inc. 4th Avenue	9208 4th Avenue S
SO3002329D	Duwamish River	First Student Inc. Steilacoom	130 S Kenyon Street
SO3001953D	Duwamish River	FMH Material Handling Solutions	1313 S 96th Street
SO3000474D	Duwamish River	Fog Tite Inc.	4819 W Marginal Way SW
SO3000607D	Duwamish River	Galvin Flying Service Inc.	7149 Perimeter Road S
SO3002227D	Duwamish River	Glacier Northwest, Inc.	3838 W Marginal Way SW
SO3001949D	Duwamish River	Industrial Automation, Inc.	1421 S 93rd Street
SO3008681A	Duwamish River	Insurance Auto Auctions Tukwila	8801 E Marginal Way S
SO3004509B	Duwamish River	Island Tug and Barge Terminal 7C	3546 W Marginal Way SW
SO3000056D	Duwamish River	James Hardie Gypsum	5931 E Marginal Way S
SO3003231C	Duwamish River	Jorgensen Forge Corp.	8531 E Marginal Way S
SO3000343D	Duwamish River	King County International Airport Maintenance Shop	6518 Ellis Avenue S
SO3000206D	Duwamish River	Longview Fibre Seattle[b]	5901 E Marginal Way S
SO3005617A	Duwamish River	Monster Auto Wrecking Inc.	13301 Martin Luther King Jr Way S
SO3000226D WA0000868	Duwamish River	North Boeing Field (Aircraft Manufacturing & Testing)	7700 E Marginal Way S
SO3000471D	Duwamish River	Northland Services Inc. Seattle[c]	6700 W Marginal Way SW
SO3000961D	Duwamish River	Northwest Auto and Truck Wrecking Inc.	10230 E Marginal Way S
SO3003779C	Duwamish River	Northwest Container Services Inc.[c]	6110 W Marginal Way SW Term 115
SO3001918D	Duwamish River	Northwest Grating Products	9230 4th Avenue S
SO3001901D	Duwamish River-Hamm Creek	Pacific Utility Equipment Co.	1303 S 96th Street
SO3001897D	Duwamish River	Pioneer Industries	7000 Highland Pkwy SW
SO3000264D	Duwamish River	PSF Mechanical Inc.	9322 14th Avenue S
SO3002142D	Duwamish River	Puget Sound Coatings	9220 8th Avenue S
SO3000949D	Duwamish River	Puget Sound Truck Lines Inc. Seattle	7303 8th Avenue S

Table G-1, cont. NPDES permit holders within the LDW drainage basin

PERMIT ID NO.	DRAINAGE BASIN NAME	FACILITY NAME	FACILITY ADDRESS/LOCATION[a]
SO3000015D	Duwamish River	Recycling Depot	852 Rainier Avenue S
SO3004620A	Duwamish River	Roadway Express Inc. (T870)	600 S 96th Street
SO3001134D WA0003343-3	Duwamish River	Saint Gobain Containers LLC	5801 E Marginal Way S
SO3005565A	Duwamish River	SCS Refrigerated Services – Seattle	303 South River
SO3000962D	Duwamish River	SEATAC Marine Services LLC	6701 Fox Avenue S
SO3002208D	Duwamish River	Seattle Boilerworks Inc Myrtle Street	500 S Myrtle Street
SO3003645C	Duwamish River	Seattle Iron & Metals Corp.	600 South Garden Street
SO3001958D	Duwamish River	Seattle Refrigeration & Manufacturing (AVJ)	1057 S Director Street
SO3000650D	Duwamish River-Hamm Creek	Selland Auto Transport	615 S 96th Street
SO3002346D	Duwamish River	Shultz Distributing Inc. Sea	6851 E Marginal Way S
SO3000930D	Duwamish River	Skyline Electric and Manufacturing Co. Inc.	3619 7th Avenue S
SO3000737D	Duwamish River	South Recycle and Disposal Station	8100 2nd Avenue S
SO3000617D	Duwamish River	Standard Steel Fabricating Co. Inc.	8155 1st Avenue S
SO3002471C	Duwamish River	Swan Bay Holdings Dock	7100 2nd Avenue SW
SO3000033D	Duwamish River	The Chemithon Corp.	5430 W Marginal Way SW
SO3000763D	Duwamish River	The Gear Works Seattle Inc.	500 S Portland Street
SO3000253D	Duwamish River	Tierney Electrical Manufacturing Co.	7901 7th Avenue S
SO3001155D	Duwamish River	Union Pacific Railroad Co. Dawson Street	402 S Dawson Street
SO3002137D	Duwamish River	United Iron Works	7421 5th Avenue S
SO3000434D	Duwamish River	United Parcel Service WABOE	7575 Perimeter Road S
SO3000443D	Duwamish River	United Parcel Service WASAU	4329 7th Avenue S
SO3000444D	Duwamish River	United Parcel Service WASEA	4455 7th Avenue S
SO3000453D	Duwamish River	V Van Dyke Inc.	150 S River Street
SO3000581D	Duwamish River	Waste Management of Seattle Marginal Way[d]	7201 W Marginal Way SW
SO3000582D	Duwamish River	Waste Management of Seattle Recycle AM[e]	7901 1st Avenue S
SO3002111D	Duwamish River	West Coast Wire & Rope Rigging Inc.	7777 7th Avenue S

Table G-1, cont. NPDES permit holders within the LDW drainage basin

PERMIT ID NO.	DRAINAGE BASIN NAME	FACILITY NAME	FACILITY ADDRESS/LOCATION[a]
Construction General Stormwater Permits			
WAR005100B	Duwamish River	Container Properties (Former Rhône-Poulenc)	9229 E Marginal Way S
WAR005814B	Duwamish River-Hamm Creek	City of Seattle Joint Training Facility	9401 Myers Way S
WAR004274B	Duwamish River-Green River	Valley View Apartments	13445 Martin Luther King Jr Way S
Boatyard General Permits			
WAG030091C	Duwamish River	Delta Marine Industries Inc.	1608 S 96th Street
WAG030130A	Duwamish River	Salmon Bay Boatworks LLC	4266 20th Avenue W
WAG030045C	Duwamish River	South Park Marina	8604 Dallas Avenue S
Individual Permits			
WA-003168-2	Duwamish River	City of Seattle CSO	S Brighton Street CSO and Diagonal Avenue S CSO
WA-002918-1	Duwamish River	King County CSO	Eighth Avenue S, S Brandon Street, Duwamish West, Duwamish East, Hanford No. 1, East Marginal Way pump station, East Michigan, West Michigan, Norfolk, Terminal 115
WA0002232E	Duwamish River	Lafarge Corporation	5400 W Marginal Way SW
WA0031305C	Duwamish River	Nucor Steel Seattle Inc.	2424 SW Andover Place SW
WA-003192-5	Duwamish River	Sound Transit Light Rail[f]	47.563333; -122.344167

Sources: Ecology (2007a, b, c), EDR (2006b)

[a] Addresses correspond to facility locations and not discharge points unless otherwise noted.

[b] Discharges to Metro and Duwamish River.

[c] Port of Seattle co-permittee.

[d] Solid waste discharge.

[e] Solid waste discharge. Permit combined with SO3-001114 contiguous site.

[f] Only one Sound Transit Light Rail outfall location falls within the City of Seattle's LDW basin. Location is actual point of outfall; only coordinates were available. See Table G-3 for more information regarding the outfalls included in the Sound Transit Light Rail NPDES permit.

CSO – combined sewer overflow NPDES – National Pollutant Discharge Elimination System

Table G-2. NPDES permit holders located upstream of the LDW drainage basin

Drainage Basin[a]	Permit Type	Number of Permit Holders
Black River	sand and gravel general permits	4
	statewide municipal permits	1
	industrial general stormwater	73
	construction general stormwater permits	16
	individual permits	1
Duwamish River	industrial general storm water	12
Lower Green River – east	construction general stormwater permits	1
Lower Green River – west	statewide municipal permits	1
	industrial general stormwater	6
	construction general stormwater permits	10

Source: Ecology (2007d)

[a] Drainage basin designations are according to DNR basins.

DNR – Department of Natural Resources

LDW – Lower Duwamish Waterway

NPDES – National Pollutant Discharge Elimination System

Table G-3. Sound Transit Light Rail NPDES permitted outfalls

Drainage Basin	Number of Outfalls
Duwamish River	15
Lower Green River – west	8
Black River	1

Source: Ecology (2007d)

Note: All of the Sound Transit Light Rail outfalls are outside of the LDW drainage basin except for one. It is not known whether all of these outfalls discharge to the Green-Duwamish River system of if some discharge to other water bodies such as Lake Washington.

LDW – Lower Duwamish Waterway

NPDES – National Pollutant Discharge Elimination System

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Table G-4. Facilities that have been issued King County Industrial Waste Program Permits for discharges to the sanitary sewer system

PERMIT NO.	CSO AREA[a]	FACILITY NAME	STREET ADDRESS	FACILITY TYPE
Waste Discharge Permits[b]				
7238-03	nr	Alaskan Copper Works – 6th Avenue	3200 6th Avenue S	metal finishing – CFR 433
7201-03	W	Alaskan Copper Works – Marginal Way	3600 East Marginal Way	metal finishing – CFR 433
7592-03	W	Arco/BP Petroleum Products Co.	1652 SW Lander Street	fueling facility
7722-03	nr	Art Brass Plating, Inc.	5516 3rd Avenue S	metal finishing – CFR 433
7556-02	nr	Baker Commodities Inc.	5795 S 130th Place	rendering
7594-03	nr	Boeing Commercial Airplane - North Field	7500 East Marginal Way	metal finishing – CFR 433
7789-01	nr	Container Properties, LLC	9229 East Marginal Way S	groundwater remediation – organics
7759-01	W	Da Vinci Gourmet/Kerry	7224 1st Avenue S	na
7704-02	W	Duwamish Shipyard	5658 W Marginal Way SW	boat/shipyard
7690-03	nr	Emerald Recycling	1500 Airport Way S	centralized waste treatment
7725-02	nr	Emerald Services, Inc.	7343 East Marginal Way S	chemical toilet
7130-03	W	Industrial Container Services (ICS) (aka PalEx and IFCO Systems)	7152 1st Avenue S	barrel cleaning
7004-03	nr	Industrial Plating Corp.	2411 6th Avenue S	electroplating – CFR 413
7681-02	W	Magnetic and Penetrant Services Co.	8135 1st Avenue S	metal finishing – CFR 433
7676-03	nr	Marine Vacuum Service	1516 S Graham Street	centralized waste treatment
7771-03	nr	Metro Transit South Base	12100 East Marginal Way S	transportation facility
7637-03	E/SPU CSO	Oberto Sausage Company – Airport Way	2005 Airport Way S	food processing – meats
7751-01	W	Pacific Rendering Co., Inc.	4023 West Marginal Way S	rendering
7023-02	E/KC CSO	Pepsi-Cola Company	2300 26th Avenue S	food processing – soft drinks
7670-04	nr	Philip Services Corp. – Georgetown Facility	734 South Lucile Street	groundwater remediation – organics

Table G-4, cont. Facilities that have been issued King County Industrial Waste Permits for discharges to the sanitary sewer system

PERMIT NO.	CSO AREA[a]	FACILITY NAME	STREET ADDRESS	FACILITY TYPE
7723-03	W	Pioneer Industries	7000 Highland Parkway SW	metal finishing – CFR 433
7595-04	nr	Rabanco Recycling Company	2733 3rd Avenue S	solid waste – transfer facility
7795-01	E/KC CSO	Ralph's Concrete Pumping	816 Poplar Place S	cement/ready-mix
7113-02	E/SPU CSO	Seattle Barrel Company	4716 Airport Way S	barrel cleaning
7783-01	nr	TAU Rabanco Sediment Management Facility	3225 East Marginal Way S, Terminal 25	na
7782-03	W	Todd Pacific Shipyards Corporation	1801 16th Avenue SW	boat/shipyard
7507-03	nr	Viox Corp.	6701 6th Avenue S	glass manufacturing
7116-04	E/KC CSO	WestFarm Foods/Darigold – Rainier	4058 Rainier Avenue S	food processing – dairy
Major Discharge Authorizations[c]				
210-03	W	Arco Lander GWR (TechSolv Consulting)	1652 SW Lander Street	groundwater remediation – petroleum
4009-01	nr	Ash Grove Cement Company	3801 E Marginal Way S	cement/ready-mix
4085-01	E/SPU CSO	Bloch Steel Industries	4580 Colorado Avenue	cement/ready-mix
526-04	nr	Boeing Developmental Center	9725 E Marginal Way S	manufacturing – miscellaneous
158-02	nr	Cargill Inc. – Corn Milling Division	2 S Horton Street	container washing
629-02	nr	Cedar Grove Composting, Inc. DA #629	7343 E Marginal Way S	composting – yard waste
765-01	nr	Cibo Naturals	1914 Occidental Avenue S	food processing
4068-01	E/KC CSO	Enodis Corporation	1761 22nd Avenue S	groundwater remediation – petroleum
4048-01	nr	ExxonMobil Oil Corporation 99 – MPB	2200 24th Avenue E	groundwater remediation – petroleum
543-02	nr	General Electric – Dawson Street	220 S Dawson Street	groundwater remediation – organics
550-02	nr	King County Airport – Boeing Field	7233 Perimeter Road	transportation facility
4017-01	nr	Madison Center West LLC	2800 E Madison Street	groundwater remediation – organics
476-03	nr	Metro Transit Central Base	1555 Airport Way S	transportation facility
4008-02	nr	Northwest Cascade Inc. – Seattle	3414.5 2nd Avenue S	chemical toilet

Table G-4, cont. Facilities that have been issued King County Industrial Waste Permits for discharges to the sanitary sewer system

PERMIT NO.	CSO AREA[a]	FACILITY NAME	STREET ADDRESS	FACILITY TYPE
651-02	W	Northwest Container Services, Inc.	6110 W Marginal Way SW	container washing
4011-01	E/SPU CSO	Northwest Dyeworks Inc.	4505 Airport Way S	general type
4012-01	W	Nucor Steel Corporation	2424 SW Andover	metals recycling
491-03	nr	Pyramid Breweries	91 S Royal Brougham Way	food processing - microbrewery
621-02	W	Sea Freeze Limited Partnership	206 SW Michigan Street	food processing - seafood
4072-02	W	Seattle, City of, SPU – Dallas Avenue South Remediation Project	S Donovan & 17th Avenue S - South Park	construction dewatering
416-02	W	Seattle, City of, SPU – West Seattle Vactor Decant	9200 8th Avenue SW	decant station
400-02	W	Seattle, City of, SWD – South Recycling and Disposal Station	8100 2nd Avenue S	solid waste – transfer facility
4073-02	E/KC CSO	Sound Transit – Beacon Hill Station & Tunnel	S Lander Street & Beacon Hill Avenue S	construction dewatering
4069-01	nr	South Center Oil	3215 4th Avenue S	groundwater remediation – petroleum
4086-01	W	South Park Industrial Properties, LLC	9587 8th Avenue S	groundwater remediation – organics
555-02	nr	St. Gobain Containers LLC	5801 E Marginal Way S	glass manufacturing
232-03	W	Stoneway Concrete – South Seattle Ready Mix Batch Plant	3803 E Marginal Way	cement/ready-mix
668-03	E/SPU CSO	Union Pacific Railroad – Argo Yard (Remediation)	4300 Colorado Avenue S	vehicle washing
4020-01	E/SPU CSO	United Parcel Service – Seattle	4455 7th Avenue S	vehicle washing
221-02	nr	Walker and Associates	12652 Interurban Avenue S	photo processing
Minor Discharge Authorizations[d]				
732-01	nr	Affordable Auto Wrecking	9802 Martin Luther King Jr. Way S	general type
459-02	W	Alaska Marine Lines Inc.	5600 W Marginal Way S	general type
662-02	nr	Amtrak National Railroad Passenger Corporation	240 S Holgate Street – Bldg B	chemical toilet
195-02	W	Aspen Paints	1128 SW Spokane Street	paint manufacturing

Table G-4, cont. Facilities that have been issued King County Industrial Waste Permits for discharges to the sanitary sewer system

PERMIT NO.	CSO AREA[a]	FACILITY NAME	STREET ADDRESS	FACILITY TYPE
737-01	E/KC CSO	Beacon Hill Dental Associates	3051 Beacon Avenue S	dental office
564-02	nr	Becker Trucking, Inc.	6350 S 143rd Street	solid waste – transfer facility
758-01	E/SPU CSO	Beecher's Cheese Aging Facility	4318 6th Avenue S	food processing-dairy
363-02	nr	Boeing Integrated Defense Systems	10000 E Marginal Way S	manufacturing – miscellaneous
731-01	nr	Boeing Shared Services Group – Gateway Photo Lab	12687 Gateway Drive	photo processing
118-02	nr	Buffalo Industries, Inc.	99 S Spokane Street	laundry – linen
308-02	nr	Caliber Inspection (pka ETT X-Ray)	7500 Perimeter Road S	photo processing
343-02	nr	Dressel-Collins Fish Co.	5131 S Director Street	food processing – seafood
685-02	W	Eagle Marine Services, Ltd.	3200 W Marginal Way – Terminal 5	transportation facility
745-01	nr	ECO Waterborne Coatings	420 S Hinds Street	general type
579-02	nr	ExxonMobil Oil Corporation (DA #579)	11655 Renton Avenue S	groundwater remediation – petroleum
725-01	W	Ferguson Construction	7433 5th Avenue S	vehicle washing
636-03	E/KC CSO	Gai's Bakery – Weller Street	2006 S Weller Street	food processing – bakery
510-02	W	Glacier Northwest (DA #510)	5900 W Marginal Way SW	vehicle washing
760-01	nr	Gretchen's Shoebox Express	2415 Airport Way S	food processing
701-01	nr	Group Health/Central	201 16th Avenue E	hospital
721-01	E/KC CSO	Hospital Central Services Association, Inc.	1300 E Columbia Street	laundry – linen
757-01	nr	J.D. Ott Company, Inc.	2244 6th Avenue S	machining
726-01	nr	January Company	9844 40th Avenue S	food processing – meats
739-01	nr	Kamco Seafood, Inc.	128 S Orcas Street	food processing – fish
635-02	E/KC CSO	Mondo and Sons	4225 Rainier Avenue S	food processing – meats
596-02	nr	Peter Pan Seafoods/Seablends Facility	3455 E Marginal Way S	food processing – seafood

Table G-4, cont. Facilities that have been issued King County Industrial Waste Permits for discharges to the sanitary sewer system

PERMIT NO.	CSO AREA[a]	FACILITY NAME	STREET ADDRESS	FACILITY TYPE
748-01	E/KC CSO	Photographic Center Northwest	900 12th Avenue	photo processing
197-02	E/SPU CSO	Plymouth Poultry	4500 7th Avenue S	food processing – poultry
536-02	W	Rainier Petroleum Corporation	1711 13th Avenue SW	fueling facility
595-02	nr	Richmark Label	1110 E Pine Street	printing
743-01	E/SPU CSO	Schwartz Brothers Bakery	617 S Nevada Street	food processing – bakery
750-01	nr	Seattle Iron and Metals	600 S Garden Street	vehicle washing
366-02	nr	Seattle Radiator Works	1936 1st Avenue S	radiator repair
742-01	E/SPU CSO	Seattle, City of – Department of Transportation	4200 Airport Way S	general type
179-03	E/SPU CSO	Seattle, City of – Seattle City Light – South Service Center	3613 4th Avenue S	vehicle washing
597-03	nr	Select Fish (dba WFM Select Fish)	5980 1st Avenue S	food processing – seafood
706-01	E/KC CSO	Swedish Medical Center/First Hill	747 Broadway Avenue	hospital
707-01	E/KC CSO	Swedish Medical Center/Providence	500 17th Avenue	hospital
749-01	E/KC CSO	Thanh Son Tofu	118 12th Avenue	food processing – other
723-01	E/SPU CSO	Union Pacific Railroad – Lucile Street	736 S Lucile Street	vehicle washing
717-01	nr	United Parcel Service – Boeing Field	7575 Perimeter Road	vehicle washing
746-01	E/KC CSO	University of Washington – Consolidated Laundry	2901 27th Avenue S	laundry – linen
266-03	W	Washington Federal Savings and Loan Association	SW Hudson & W Marginal Way SW	groundwater remediation – petroleum
322-02	W	Waste Management of Seattle – W Marginal Way	7201 W Marginal Way SW	solid waste – transfer facility
691-02	E/SPU CSO	Waste Management, Inc. – Alaska Street Facility	70 S Alaska Street	solid waste – transfer facility
383-02	W	West Seattle Radiator Service	4460 37th Avenue W	radiator repair
Letters of Authorization[e]				
10693-01	nr	Boeing Developmental Center	9725 E Marginal Way S	manufacturing – miscellaneous

Table G-4, cont. Facilities that have been issued King County Industrial Waste Permits for discharges to the sanitary sewer system

PERMIT NO.	CSO AREA[a]	FACILITY NAME	STREET ADDRESS	FACILITY TYPE
10032-01	nr	Penske Truck Leasing	12840 48th Avenue S	vehicle washing
10457-01	E/SPU CSO	Puget Sound Industries Services, Inc.	4429 Airport Way S	pressure washing
Facilities with Unspecified Permit Type				
10548-01	nr	Caliber Inspection (aka ETT X-Ray)	7500 Perimeter Road S	na
10214-01	W	Washington Liftruck	700 S Chicago	na

Source: King County (Tiffany 2006a, b, 2007)

[a] Definitions provided by King County (Tiffany 2006b):
E/KC CSO – Facility is located East of Duwamish Waterway; overflows would discharge to a KC CSO.
E/SPU CSO – Facility is located East of Duwamish Waterway; overflows would discharge to an SPU CSO.
W – Facility is located West of Duwamish Waterway; overflows would discharge to the West Duwamish EOF.

[b] Waste discharge permits are issued to federally regulated industries or for discharge volumes greater than 25,00 gallons per day (gpd).

[c] Major discharge authorizations are issued for discharges between 5,000 gpd and 25,000 gpd.

[d] Minor discharge authorizations are issued for discharges between 1,000 gpd and 5,000 gpd.

[e] Letters of authorization are issued for discharges less than 1,000 gpd.

CSO – combined sewer overflow
DA – discharge authorization
EOF – emergency overflow
KC – King County
na – not available
nr – not reported (facilities that discharge to the sanitary sewer system but the associated CSO/EOF area was not reported)
SPU – Seattle Public Utilities

Table G-5. Facilities within the LDW drainage basin listed as Resource Conservation and Recovery Act large-quantity waste generators

Facility Name	Street Address	EPA ID No.	Waste Category	Quantity (lbs)
Ace Galvanizing Incorporated	429 S 96th Street	WAD009286881	corrosive	54,000
Art Brass Plating Inc. Seattle	5516 3rd Avenue S	WAD981772957	ignitable	1,320
			methyl ethyl ketone	1,320
			trichloroethylene	3,960
			spent halogenated solvents	2,640
			spent non-halogenated solvents	1,320
			wastewater treatment sludges from electroplating operations	53,910
Boeing A&M Developmental Center	9725 E Marginal Way S	WAD093639946	ignitable	14,030
			corrosive	2,418
			reactive	709
			arsenic	4,816
			barium	54,688
			cadmium	46,729
			chromium	59,986
			lead	56,873
			selenium	42,061
			silver	10,395
			benzene	1,515
			methyl ethyl ketone	880
			spent halogenated solvents	47,712

Table G-5, cont. Facilities within the LDW drainage basin listed as Resource Conservation and Recovery Act large-quantity waste generators

Facility Name	Street Address	EPA ID No.	Waste Category	Quantity (lbs)
Boeing D&SG Oxbow Site	10700 W Marginal Way S	WAD981771017	nr	nr
Boeing North Boeing Field	7500 E Marginal Way	WAD980982037	ignitable	142,407
			corrosive	466
			reactive	19
			barium	260,084
			cadmium	497,491
			chromium	512,974
			lead	499,232
			selenium	255,471
			silver	2,320
			benzene	109,308
			1,4-dichlorobenzene	40
			methyl ethyl ketone	2,203
			pyridine	40
			tetrachloroethylene	210
			spent halogenated solvents	968,609
			spent non-halogenated solvents	702,719
			spent non-halogenated solvents	951,825
			wastewater treatment sludges from chemical conversion coating of aluminum	712,411
			hydrofluoric acid	291
Boeing S&CS Electronic Manufacturing Facility	7355 Perimeter Road S	WAD980980270	spent halogenated solvents	1,366

Table G-5, cont. Facilities within the LDW drainage basin listed as Resource Conservation and Recovery Act large-quantity waste generators

Facility Name	Street Address	EPA ID No.	Waste Category	Quantity (lbs)
Boeing South Park	1420 S Trenton	WAD980982672	ignitable	234
			corrosive	45
			barium	1,283
			cadmium	1,858
			chromium	1,283
			lead	1,933
			mercury	695
			selenium	1,208
			silver	650
			benzene	1,170
			methyl ethyl ketone	75
			spent halogenated solvents	400
Boeing Thompson	8701 E Marginal Way S	WAD980982912	ignitable	2,207
			barium	10,782
			cadmium	11,302
			chromium	10,857
			lead	11,407
			mercury	625
			selenium	10,677
			silver	625
			benzene	8,680
			methyl ethyl ketone	105

Table G-5, cont. Facilities within the LDW drainage basin listed as Resource Conservation and Recovery Act large-quantity waste generators

Facility Name	Street Address	EPA ID No.	Waste Category	Quantity (lbs)
Capital Industries Inc.	5801 3rd Avenue S	WAD009245465	ignitable	9,608
			spent non-halogenated solvents	16,205
			spent non-halogenated solvents	16,205
Delta Marine Industries Inc.	1608 S 96th Street	WAD052593480	ignitable	2,075
			spent non-halogenated solvents	28,509
			spent non-halogenated solvents	26,434
Ecolights Northwest	1915 S Corgiat Drive	WAH000026371	nr	nr
Graham Trucking	10108 W Marginal Place S	WAD982652885	nr	nr
Intermountain Supply Inc.	3700 6th Avenue S	WAH000022238	nr	nr
Jorgensen Forge Corp.	8531 E Marginal Way S	WAD000602813	emission control dust/sludge from the primary production of steel in electric furnaces	126,560
Kelly Moore Preservative Paint Company	6101 Airport Way S	WAD059315069	ignitable	55,424
			chromium	49,764
			lead	49,764
			methyl ethyl ketone	49,764
			spent non-halogenated solvents	55,424
			spent non-halogenated solvents	55,424
Laucks Testing Laboratories	940 S Harney Street	WAD027446608	ignitable	726
			corrosive	18,952
			chromium	152
			lead	2,619
			mercury	152
			silver	152
			spent halogenated solvents	726
			spent non-halogenated solvents	726

Table G-5, cont. Facilities within the LDW drainage basin listed as Resource Conservation and Recovery Act large-quantity waste generators

Facility Name	Street Address	EPA ID No.	Waste Category	Quantity (lbs)
Magnetic & Penetrant Services Co. Inc.	8135 1st Avenue S	WAD988482659	ignitable	26,513
			corrosive	230,100
			arsenic	12,450
			barium	12,450
			chromium	271,713
			lead	46,213
			silver	9,300
			benzene	8,000
			cresol	500
			methyl ethyl ketone	24,463
			tetrachloroethylene	8,000
			trichloroethylene	8,000
			spent halogenated solvents	500
			spent non-halogenated solvents	14,063
			spent non-halogenated solvents	500
			spent non-halogenated solvents	7,213
			wastewater treatment sludges from chemical conversion coating of aluminum	9,300
Northwest Container Services Inc. Tukwila	9229 E Marginal Way S	WAR000003517	methylbenzene	2,294
Olympic Foundry Inc.	5200 Airport Way S	WAD009271164	ignitable	2,252
			benzene	2,252
			methyl ethyl ketone	2,252
			spent non-halogenated solvents	2,252
			spent non-halogenated solvents	2,252
Orcas Business Park LLC	650 S Orcas	WAH000013367	nr	nr

Table G-5, cont. Facilities within the LDW drainage basin listed as Resource Conservation and Recovery Act large-quantity waste generators

Facility Name	Street Address	EPA ID No.	Waste Category	Quantity (lbs)
Pioneer Industries Seattle	7000 Highland Pkwy SW	WAD982657504	ignitable	2,477
			chromium	3,901
			spent non-halogenated solvents	2,477
			spent non-halogenated solvents	2,477
			wastewater treatment sludges from chemical conversion coating of aluminum	215
Precision Engineering Inc.	1231 S Director Street	WAD041338252	ignitable	400
			corrosive	16,234
			chromium	23,889
			lead	23,889
			spent non-halogenated solvents	400
			spent non-halogenated solvents	400
			wastewater treatment sludges from electroplating operations	16,234
Professional Coating Inc.	1705 S 93rd Street F22	WAD981772247	ignitable	22,257
			methyl ethyl ketone	19,628
			spent non-halogenated solvents	22,257
			spent non-halogenated solvents	22,257
Puget Sound Coatings Machinists Inc.	9220 8th Avenue S	WAD002838068	ignitable	17,163
			methyl ethyl ketone	17,163
			spent halogenated solvents	17,163
			spent halogenated solvents	17,163
			spent non-halogenated solvents	17,163
			plating bath residues	17,163

Table G-5, cont. Facilities within the LDW drainage basin listed as Resource Conservation and Recovery Act large-quantity waste generators

Facility Name	Street Address	EPA ID No.	Waste Category	Quantity (lbs)
Seattle City Light Moderate Risk Waste Facility	3613 4th Avenue S	WAD980726384	ignitable	1,533
			corrosive	170
			lead	1,219
			mercury	14
			benzene	29
			methyl ethyl ketone	941
			tetrachloroethylene	23
			spent halogenated solvents	278
			spent halogenated solvents	1,851
			spent non-halogenated solvents	1,219
			spent non-halogenated solvents	1,851
Seattle City Parks Westbridge Facility	4209 W Marginal Way SW	WAH000019059	ignitable	3,860
			corrosive	145
			barium	2,200
			lead	6,111
			2,4-d	45
			methyl ethyl ketone	2,200
Sherwin Williams Store 4317	9530 10th Avenue S	WAH000006551	nr	nr
Trim Systems	701 S Orchard Street	WAD004906376	ignitable	460
			spent halogenated solvents	4,028

Table G-5, cont. Facilities within the LDW drainage basin listed as Resource Conservation and Recovery Act large-quantity waste generators

FACILITY NAME	STREET ADDRESS	EPA ID NO.	WASTE CATEGORY	QUANTITY (lbs)
Univar USA Inc.	4000 1st Avenue S	WAR000005579	acetone	9,633
			benzene	459
			chlorobenzene	459
			chloroethene	459
			trichloromethane	4,666
			1,2-dichlorobenzene	459
			1,1-dichloroethane	4,208
			1,2-dichloroethane	4,208
			1,1-dichloroethylene	4,208
			1,2-dichloroethylene	12,923
			dichloromethane	459
			tetrachloroethene	8,716
			carbon tetrachloride	4,208
			1,1,1-trichloroethane	8,716
			trichloroethene	8,716
UPS Seattle Hub	4455 7th Avenue S The Hub	WAD053821997	ignitable	3,306
			corrosive	3,036
			barium	3,036
			cadmium	3,036
			chromium	3,036
			1,2-dichloroethane	3,036
			methyl ethyl ketone	270
			tetrachloroethylene	41

Table G-5, cont. Facilities within the LDW drainage basin listed as Resource Conservation and Recovery Act large-quantity waste generators

Facility Name	Street Address	EPA ID No.	Waste Category	Quantity (lbs)
VA PSHCS Seattle Division	1660 S Columbian Way	WA1360007313	ignitable	9,145
			corrosive	2,736
			mercury	43
			silver	1,668
			methyl ethyl ketone	500
			spent halogenated solvents	2,698
			spent non-halogenated solvents	5,363
			spent non-halogenated solvents	3,198
			sodium azide	38
			1,2-dichloroethane	2,698
			cyanogen bromide	38
Viox Corporation	6701 6th Avenue S	WAD053814091	cadmium	8,203
			lead	8,203
WA AGR King 2	8100 B 2nd Avenue S	WAH000012765	nr	nr
WA Department of Transportation Corson	6431 Corson Avenue S	WAD980981104	ignitable	3,425
			chromium	1,974
			lead	1,974
			benzene	439
			methyl ethyl ketone	1,974

Source: EDR (2006a)
Note: Waste code definitions were obtained from the Code of Federal Regulations, Title 40, Subpart C.
EPA – US Environmental Protection Agency
ID – identification
nr – not reported

Table G-6. Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]												
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
3 A Industries Inc.	3101 Martin Luther King Jr. Way S	4	3	nr	1	C		C								B			
		4	3	nr	4	B		B						S		B			
Ace Galvanizing Inc.	429 S 96th	2	nr	3	1	C			C					C					
		2	nr	3	4	C			C					C					
Advance Electroplating	9585 8th Avenue S	2	nr	5	1	C		C	C										S
		2	nr	5	2	S			C										C
		2	nr	5	3	S		C											
		2	nr	5	4	C		C	C										S
		2	nr	5	5	S			S										S
Affordable Auto Wrecking	9802 Martin Luther King Jr. Way S	2	nr	5	1	S			S					S		S		S	
		2	nr	5	2	C			S					C		S		S	
		2	nr	5	4	C			C					C		S		S	
Air National	7277 Perimeter Road S 215 Main T	4	2	nr	1	S								S		S			
		4	2	nr	4	S								S		S			
Air Tech Company	5701 1st Avenue S	4	3	nr	1	C								C					
		4	3	nr	4	C								C					

Table G-6, cont. **Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database**

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]												
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
Airgas Norpac Seattle	7700 14th Avenue S	4	2	nr	1	C			C					S					
		4	2	nr	2	S			S					S					
		4	2	nr	3	S			S					S					
		4	2	nr	4	C			C					S					
		4	2	nr	5	S			S					S					
Alaska Street Property	615 S Alaska Street	4	3	nr	1	C				C				C					
		4	3	nr	4	C				C				C					
Allied Domecq	2921 Martin Luther King Jr. Way S	4	3	nr	1	C								C		C			
		4	3	nr	4	C								C		C			
Arco Gas Station	9840 Martin Luther King Jr. Way S	4	3	nr	1	B								B					
		4	3	nr	4	R								R					
Art Brass Plating Inc. Seattle	5516 3rd Avenue S	4	3	nr	1	C		C											
		4	3	nr	4	C		C											
Associated Grocers Incorporated	3301 S Norfolk	4	1	nr	1	C		C						C		C			
		4	1	nr	4	C		S						C		C			
Belshaw Brothers Inc.	1750 22nd Avenue S	4	2	nr	1	C		C						C		C		C	
		4	2	nr	4	C		C						C		C		C	
Big Johns Truck Repair Inc.	6533 3rd Avenue S	4	2	nr	1	C										C			
		4	2	nr	4	C								C					

Table G-6, cont. **Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database**

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]												
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
Blaser Die Casting Co	5700 3rd Avenue S	1	nr	nr	1	B		B											
		1	nr	nr	3	C		C											
		1	nr	nr	4	S		S											
Bloch Steel Industries	4580 Colorado Avenue S	4	3	nr	4	R								R					
Boeing A&M Development Center	9725 E Marginal Way S	4	2	nr	1	C		C	S					C		C			
		4	2	nr	2	S		S	S					S		S			
		4	2	nr	3	S		S	S					S		S			
		4	2	nr	4	C		C	S					C		C			
		4	2	nr	5	S		S	S					S		S			
Boeing Development Center Norfolk	9725 E Marginal Way	4	3	nr	4	B						B							
Boeing Electronic Mfg	7300 Perimeter Rd S	4	2	nr	4	C												C	
Boeing Isaacson	8625 E Marginal Way	4	3	nr	1	C			C										
		4	3	nr	4	C			C										
Boeing Thompson	8541 E Marginal Way S	1	nr	nr	1	S			S										
		1	nr	nr	4	C			C										
Boeing North Field	7370 E Marginal Way S	4	2	5	1	C		C	C		S	C		C		C	S		C
		4	2	5	2	S		S	S		S	S		S		S	S		S
		4	2	5	4	C		C	C		S	S		C		C	S		C
		4	2	5	5	C		C	C		S	C		C		C	S		C

Table G-6, cont. **Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database**

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]													
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
Boeing North Field JP4 Tanks	Ellis Avenue / E Marginal Way	1	nr	nr	1	C								C					
		1	nr	nr	4	C								C					
Boeing Plant 2	7755 E Marginal Way S	4	2	1	1	C		C	C			C		C		C		C	
		4	2	1	2	C								C					
		4	2	1	3	C		C	S					C				C	
		4	2	1	4	C		C	C			C		C		C		C	
		4	2	1	5	C		S	S			C		S		S		S	
Boeing S&CS Electronic Manufacturing Facility	7355 Perimeter Rd S	1	nr	nr	1	C		C											
		1	nr	nr	4	S		S											
Brys Auto Wrecking	4025 W Marginal Way SW	4	3	3	1	S			S					S					
		4	3	3	3	S			S					S					
		4	3	3	4	C			C					C					
		4	3	3	5	S			S					S					
Burlington Environmental Inc. Georgetown	734 S Lucile Street	3	nr	nr	1	C	S	C	C			C	B	C	C	S		C	
		3	nr	nr	3	C	B	C	B			B	B	S	B	C		B	
		3	nr	nr	4	C	C	C	C			C	B	S	C	S		C	
Central Painting	4749 W Marginal Way SW	2	nr	2	1	C		C											
		2	nr	2	4	R			R							R			

Table G-6, cont. **Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database**

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]													
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
Chevron 98484	8700 14th Avenue S	4	3	nr	1	S								S					
		4	3	nr	4	C								C					
Chevron Seattle Terminal 4097	4525 Diagonal Avenue S	4	2	nr	1	C			C			S		S		S			
		4	2	nr	2	S			S			S		S		S			
		4	2	nr	4	C			C			S		C		C			
		4	2	nr	5	S			S			S		S		S			
Chevron Station 6009 3099	10805 E Marginal Way	4	3	nr	1	C								C					
		4	3	nr	4	R								R					
Chevron USA Inc. 90333	2802 Rainier Avenue S	4	3	nr	1	C								C					
		4	3	nr	4	C								C					
Cliff Housers Automotive	806 S 112th Street	1	nr	nr	1	S								S					
		1	nr	nr	4	S								S					
Consolidated Freightways Seattle	6050 E Marginal Way S	4	2	nr	1	C								C		S		S	
		4	2	nr	4	C								C					
Duwamish Marine Center	6365 1st Avenue S	4	3	nr	1	C								C		C		S	
		4	3	nr	4	C	C		C		C	C		C		S		C	

Table G-6, cont. **Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database**

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]												
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
Duwamish Shipyard Inc.	5658 W Marginal Way SW	1	nr	nr	1	C			C			C		C		C		C	
		1	nr	nr	2	S								S					
		1	nr	nr	4	C	C		R					C		C		C	
		1	nr	nr	5	C	S	S	C		S		S	S		S			
Eastern Supply Co	7745 1st Avenue S	5	nr	2	1	C		C											
		5	nr	2	4	C		C											
Emerald Tool Inc.	6332 6th S	2	nr	5	1	S		S	S							S			S
		2	nr	5	4	C		C	C							S			S
FedEx Express BFIA	651 S Alaska Street	4	3	nr	1	C			C		C			B					
		4	3	nr	4	C			C		C	B		C					
First Avenue Bridge Landfill	7700 Block of 2nd Avenue SW	2	nr	4	1	S			S										
		2	nr	4	2	S			S										
		2	nr	4	3	C			S										C
		2	nr	4	4	C			C										C
		2	nr	4	5	S			S										S
First Student, Inc.	130 S Kenyon Street	4	3	nr	4	C								C					
Former Basin Oil Co Inc. Seattle	8661 Dallas Avenue S	4	3	nr	1	C						C		S					
		4	3	nr	2	S								S					
		4	3	nr	4	C						C		S					

Table G-6, cont. **Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database**

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]												
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
Former Penthouse Drapery	4115 1st Avenue S	4	3	nr	1	C		C						C					
		4	3	nr	4	C		C											
Frank's Used Cars	6305 E Marginal Way S	4	2	nr	1	S		S	S			S		S		S			
		4	2	nr	2	C		S	S			S		C		S			
		4	2	nr	3	S		S						S		S			
		4	2	nr	4	C		S	C			C		C		S			
		4	2	nr	5	S		S	S					S		S			
General Electric Aviation Div	220 S Dawson Street	3	nr	2	1	C	C	C						C					
		3	nr	2	4	C	C	C						C					
Glacier Northwest Seattle Terminal	5900 W Marginal Way S	2	nr	1	1	C		S	C					S	C				
		2	nr	1	2	C			C					S	C				
		2	nr	1	4	C			C					S	C				
		2	nr	1	5	C			C					S	S				
Great Western Chemical Co Seattle	6900 Fox Avenue S	3	nr	1	1	C		C						C		C		C	
		3	nr	1	4	C		C						C		C		C	
Hangar Holdings Inc.	7675 Perimeter Rd S	4	3	nr	1	B		B								B		B	
		4	3	nr	4	C								C					

Table G-6, cont. **Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database**

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]												
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
Industrial Container Services WA LLC	7152 1st Avenue S	2	nr	4	1	C		C	C				C	C	C	C			
		2	nr	4	2	C		S	C		S					S			
		2	nr	4	4	C		C	C		C		C		C	C		C	
		2	nr	4	5	C		C	C		C	C			C	C			
Interstate Coatings	754 S Chicago	2	nr	2	1	S		S	S					S		S			
		2	nr	2	2	S		S	S					S		S			
		2	nr	2	3	S		S	S					S		S			
		2	nr	2	4	C		S	C					C		S			
Jorgensen Forge Corp.	8531 E Marginal Way S	4	2	1	1	S						S		S		S			
		4	2	1	4	C			C			C		S		S			
Kelly Moore Preservative Paint Co	6101 Airport Way S	2	nr	5	1	C		S	S					S		C			
		2	nr	5	4	C		S	S					S		C			
Kenworth Truck Plant	8801 E Marginal Way S	4	2	nr	1	C		C	S					C	S	C			
		4	2	nr	2	S		S	S					S	S	S			
		4	2	nr	4	C		C	S					C	C	C			
		4	2	nr	5	S		S	S					S	S	S			
Kwik Cleaners Former	2701 15th Avenue S	4	3	nr	1	C		C											
		4	3	nr	4	C		C											

Table G-6, cont. **Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database**

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]												
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
Laidlaw	7739 1st Avenue S	4	3	4	1	C		C						C					
		4	3	4	4	R		R						R					
Lockheed Shipbuilding Co	2929 16th Avenue SW	3	nr	nr	1	C		S	C					C					
		3	nr	nr	2	S		S						S					
		3	nr	nr	4	C			C			C		C				C	
		3	nr	nr	5	C			C	S		C	S	C	S	S		C	S
Longview Fibre Co	5901 E Marginal Way S	4	nr	5	1	C	C							C				C	
		4	nr	5	2	C	C							C				C	
		4	nr	5	3	C	C							C				C	
		4	nr	5	4	C								C				C	
Lower Duwamish Waterway	Lower Duwamish Waterway	3	nr	0	5	C	C	C	C			C	C	C	C		C	C	
M & T Chemicals Inc.	6000 W Marginal SW	2	nr	5	1	S			S		S								
		2	nr	5	4	S			S		S								
		2	nr	5	5	S			S		S								
Manitowak Western	8250 5th Avenue S	1	nr	nr	1	S			S					S					
		1	nr	nr	4	S			S					S					

Table G-6, cont. **Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database**

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]													
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
Marine Vacuum Service Inc.	1516 S Graham Street	3	nr	3	1	C			C					C					
		3	nr	3	2	C			C	S				C					S
		3	nr	3	3	C			C	S				C					
		3	nr	3	4	C			C	S				C					S
Markey Property Parcel 4	9520 10th Avenue S	4	nr	3	1	C			C										
		4	nr	3	2	C			C										
		4	nr	3	3	S			S										
		4	nr	3	4	C			C										
		4	nr	3	5	S			C			C		C					
McFarland Property	SW Edmunds Street & 15th Avenue SW	4	2	nr	4	C			C										
Moimoi Property	10118 Des Moines Memorial Dr S	2	nr	5	1	S			S					S					
		2	nr	5	4	C			S	S				C					
Myrtle Street Property	606 S Myrtle Street	4	2	nr	1	C								C					
		4	2	nr	4	C								C					

Table G-6, cont. **Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database**

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]													
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
North Coast Chemical Plant	6300 17th Avenue S	4	1	nr	1	C		C	S					C		S			S
		4	1	nr	2	C		S	S					S		S			S
		4	1	nr	4	C		C	C							C		C	
Northwest Auto Wrecking	10230 E Marginal Way S	1	nr	nr	1	S		S	S		S			S		S			
		1	nr	nr	2	S		S	S		S			S		S			
		1	nr	nr	3	S		S	S		S			S		S			
		1	nr	nr	4	C		S	C		S	C		C		S			
		1	nr	nr	5	C		S	C		S			C		S			
Northwest Environservice 2	8105 1st Avenue S	4	2	nr	2	S		S	S					S		S			
		4	2	nr	4	S		S	S					S		S			
Northwest Environservice 2W	1st Avenue SW & Marginal	4	2	nr	2	S		S	S					S		S			
		4	2	nr	4	S		S	S					S		S			
		4	2	nr	5	C		C	C					C		C			
Northwest Plating	825 S Dakota Street	4	2	nr	1	C		C	C										
		4	2	nr	4	C		C	C										
Nucor Steel Seattle Inc.	2424 SW Andover Street	1	nr	nr	1	C		C	C		C			C				C	C
		1	nr	nr	2	C		S	C		C	S		C	C	C		C	S
		1	nr	nr	4	C	S	C	C	S	C	C		C	S	C		C	C
		1	nr	nr	5	C		C	C		C	C		C				C	C

Table G-6, cont. **Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database**

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]												
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
Overnight Trucking	11231 E Marginal Way S	4	3	nr	1	S		S	S					S		S			
		4	3	nr	4	C		S	S					C		S			
Pacific Trucking Seattle	300 S Spokane Street	4	2	nr	1	R								R					
		4	2	nr	4	C								C					
Pioneer Enamel Manufacture	5531 Airport Way S	2	nr	4	1	S			S										
		2	nr	4	2	S			S										
		2	nr	4	4	C			C										
Ponchos Legacy Property	3685 Duwamish Avenue S	4	3	nr	1	C			C										
		4	3	nr	4	C		C	C										
Precision Engineering Inc.	1231 S Director Street	4	3	1	1	C			C					C					
		4	3	1	2	R			R					R					
		4	3	1	3	R								R					
		4	3	1	4	C			B					C					
Ralphs Concrete Pumping	1511 Rainier Avenue S	2	nr	3	2	S								S					
		2	nr	3	4	C			C					C					
Ralphs Concrete Pumping Vacant Lot	1517 Rainier Avenue S	2	nr	3	1	S			S					S					
		2	nr	3	3	S			S					S					
		2	nr	3	4	C			C					C					C

Table G-6, cont. **Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database**

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]												
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
Rhodia Inc.	9229 E Marginal Wy S	1	nr	nr	1	C			C										S
		1	nr	nr	4	C			C										C
S 96th Street Ditch	S 96th Street & Duwamish River	1	nr	nr	1	S		S	S	S	S	S	S	S	S	S	S	S	S
		1	nr	nr	2	S		S	S	S	S	S	S	S	S	S	S	S	S
		1	nr	nr	3	S		S	S	S	S		S	S	S	S		S	S
		1	nr	nr	4	C		S	C	S	C	S	S	C	S	S	S	C	C
		1	nr	nr	5	C		S	C	S	C	S	S	C	S	S	S	C	S
Sahlberg Equipment	5950 4th Avenue S	4	2	nr	1	C		C						C					
		4	2	nr	2	S		S						S					
		4	2	nr	4	R								R					
Saltys Properties	4701 Delridge Way SW	4	3	nr	4	C								C					
Samis Land Co Site	647 S Alaska Street	2	nr	5	1	S		S	S	S	S			S		S			S
		2	nr	5	3	S		S	S	S	S			S		S			S
		2	nr	5	4	C		S	S	S	S			C		C			S
Scougal Rubber Corp.	6239 Corson Avenue S	4	3	nr	1	C		C						C		C			
		4	3	nr	4	C		C						C		C			
Seafirst Bank Central Svcs	4201 W Marginal Way SW	4	3	nr	1	C								C				C	
		4	3	nr	4	C								C				C	

Table G-6, cont. **Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database**

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]												
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
Seattle Barrel & Cooperage	7th Avenue S & S Snoqualmie Street	2	nr	4	1	S		S	S					S		S			
		2	nr	4	2	S		S	S					S		S			
		2	nr	4	3	S		S	S										
		2	nr	4	4	C		S	C					C		C			
		2	nr	4	5	S		S	S					S		S			
Seattle City Light 4th Avenue S	3814 4th Avenue S	2	nr	5	1	C	C	C	C					C		C			
		2	nr	5	4	C	C	S	C			S		C		S			
Seattle City Light Moderate Risk Waste Facility	3613 4th Avenue S	2	nr	5	1	C						S		C			S		
		2	nr	5	3	S						S					S		
		2	nr	5	4	C						S		C			S		
Seattle City Light Steam Plant Georgetown	6700 13th Avenue S	2	nr	5	1	S						S		S					
		2	nr	5	4	C						S		C					
		2	nr	5	5	S						S							
Seattle City Row 2nd & Spokane	2nd Avenue S/ S Spokane Street	4	2	nr	1	S			B	S				S					S
		4	2	nr	4	S			S	S	S			B					S
Seattle Commerce Center	Delridge Way SW & Andover SW	4	2	nr	1	C			C							C			
		4	2	nr	4	C			C					S		S			
Seattle Duwamish Co	7000 E Marginal Way	1	nr	nr	2	S			S										
		1	nr	nr	5	S			S										

Table G-6, cont. **Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database**

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]												
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
Seattle Port Dallas Avenue – Terminal 117	8700 Dallas Avenue S	2	nr	1	1	C	C		C			C	C	C				C	
		2	nr	1	2	C	C		C			C						C	
		2	nr	1	3	S		S								S			
		2	nr	1	4	C	C		C			C	C				C	C	
		2	nr	1	5	S			S										
Seattle Public Utilities Operations Center	2700 Airport Way S	2	nr	5	1	C								C					
		2	nr	5	4	C								C					
Seattle S Transfer Station	8100 2nd Avenue S	4	1	nr	1	S				S									S
		4	1	nr	2	S				S									S
		4	1	nr	4	S				S									S
Selland Auto Transport	615 S 96th Street	4	2	nr	1	C								C					
		4	2	nr	4	C								C					
Signal Equipment Inc.	838 Poplar Pl S	4	3	nr	1	B								B					
		4	3	nr	4	C									C				
Spear Trusts Warehouse	4001 6th Avenue S	2	nr	5	1	C			C					C		C			
		2	nr	5	4	C			S					C		S			
		2	nr	5	5	S			S					S		S			
Spencer Industries Inc.	8410 Dallas Avenue S	4	2	nr	1	C		C											
		4	2	nr	4	B		B											

Table G-6, cont. **Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database**

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]													
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
Sternoff Metals	7201 E Marginal Way S	4	nr	5	1	C			C			C								
		4	nr	5	2	S			S			S		S						
		4	nr	5	4	C			C			C								
SW Harbor Proj Salmon Bay	26th SW/SW Spokane	3	nr	nr	1	C			C			C		C						
		3	nr	nr	2	S			S			S		S						
		3	nr	nr	4	C			C			C		C						
Swanson Property	1526 21st Avenue S	1	nr	nr	1	S		S	S		S			S						
		1	nr	nr	4	C		S	S		S			C						
Texaco Downstream 211558	1366 31st Avenue S	4	3	nr	1	C								C						
		4	3	nr	4	C								C						
Triad Machinery Incorporated	11210 Pacific Highway S	4	2	nr	1	C			S					C						
		4	2	nr	4	C			C					S						
Tullys Coffee Company	3100 Airport Way S	4	3	nr	1	C								C						
		4	3	nr	4	R								R						
Univar USA Inc.	4000 1st Avenue S	4	2	nr	1	C		C	S					S	S	C				
		4	2	nr	4	C		C	S					C	S	S				
Unocal 5473	401 Rainier Avenue S	4	3	nr	1	C														
		4	3	nr	4	C														
Unocal SS 0907 ENSR Intntl	1121 S Bailey Street	4	3	nr	1	C		S						C		C				

Table G-6, cont. **Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database**

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]												
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
Upper Hudson Street Site	4815 15th Avenue SW	4	3	nr	4	C			C										
Union Pacific Railroad Diagonal Avenue S Spur	60 Diagonal Avenue S	4	2	nr	1	C			S		S			C				C	
		4	2	nr	2	S			S		S			S				S	
		4	2	nr	3	S								S				S	
		4	2	nr	4	C			S		S			C				C	
US General Services Administration Seattle	4735 E Marginal Way S	4	3	nr	1	C								C		C			
		4	3	nr	4	C								C		C			
Warehouse Site 4130 1st Avenue S	4130 1st Avenue S	4	2	nr	4	C								C					
Washington Trucking Association	4101 4th Avenue S	4	3	nr	4	C						C		S					
Waste Management of Seattle	7201 W Marginal Way SW	2	nr	5	1	S			S					S					
		2	nr	5	2	S			S					S					
		2	nr	5	4	C			C					S					
		2	nr	5	5	S			S					S					
Waste Management of Seattle 1st Ave	7901 1st Avenue S	4	3	nr	1	C								C					
		4	3	nr	4	C								C					
West Coast Equipment 2	7746 Detroit Avenue SW	4	2	3	1	C			C					C					
		4	2	3	4	C			C					C					

Table G-6, cont. Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database

Site Name	Street Address	Ecology Status[a]	Independent Site Status[b]	WARM Bin[c]	Affected Media[d]	Affected Media Status[e]	Type of Chemical[e]													
							Base/Neutral/Acid Organic Compounds	Halogenated Organic Compounds	EPA Priority: Metals and Cyanide	Conventional Organics	Non-Priority Metals	PCBs	Pesticides	Petroleum Products	Phenols	Non-Halogenated Organic Compounds	Dioxins	PAHs	Conventional Inorganics
West Coast Equipment Inc.	7777 Detroit Avenue SW	1	nr	nr	1	S		S						S		S			
		1	nr	nr	2	S		S						S		S			
		1	nr	nr	4	C		S						C		S			
		1	nr	nr	5	S		S						S		S			

Source: EDR (2006b)

Note: The Confirmed and Suspected Contaminated Sites List (CSCSL) is used by Ecology for initial screening purposes to determine whether a site needs consideration. Once a site is added to the list, information is not always updated as new data become available. For this reason, this list is not always a reliable indicator of the type of chemical at a particular site. Site-specific reports should be referred to for correct, updated information for each site.

The Seattle/King County Public Health Department, under an Ecology grant, conducts site hazard assessments that rank sites based on the Washington State Ranking Method Model (WARM) or recommend no further action for the property. Sites with high ranking get priority for Ecology to initiate action.

[a] Definitions of Ecology status codes – indicates the current status of sites relative to the MTCA cleanup process.

1 Awaiting site hazard assessment (SHA)
2 Ranked, awaiting remedial action (RA)
3 Remedial action in progress
4 Independent remedial action
5 Construction completed, operation and maintenance underway
6 RA completed, confirmational monitoring underway
7 RA conducted, residual contamination left on site; ongoing institutional controls required
8 RA and all activities completed (no monitoring)

[b] Independent site status – only applies to those sites undergoing an independent cleanup. Codes are:

1 Release report received, awaiting assessment by PLP (potentially liable person)
2 Independent site assessment or interim RA report received
3 Final independent RA report received

Table G-6, cont. Facilities within the LDW drainage basin in Ecology's Confirmed and Suspected Contaminated Sites List database

[c] WARM BIN indicates the outcome of the Washington Ranking Model (WARM). The result of the WARM ranking will be a number between 1 and 5. A result of 1 indicates the greatest assessed risk to human health and to the environment. A result of 5 indicates the lowest assessed risk. A result of zero indicates the site is on the federal National Priorities List (NPL) and went through the federal Hazard Ranking System (HRS) rather than the state WARM ranking. A blank indicates the site has not been ranked.

[d] For each site, there may be chemical information for up to six environmental media: groundwater, surface water, air, soil, sediment or drinking water. The affected media codes are:

1 Groundwater
2 Surface water
3 Air
4 Soil
5 Sediments
6 Drinking water

[e] The affected media status codes are:

C = confirmed. The presence of hazardous substances above MTCA cleanup levels has been confirmed by laboratory analysis (or by field determination in the case of petroleum contamination).

B = below. The presence of hazardous substances below MTCA cleanup levels has been confirmed by laboratory analysis (or field determination in the case of petroleum products). The B code may only be applied following completion of analytical work in conjunction with a site hazard assessment (SHA) or remedial investigation/feasibility study (RI/FS).

S = suspected. Because of preliminary investigations and/or the nature of business operations or manufacturing processes, certain chemicals are suspected to be present at the site.

R = remediated. Chemicals have been treated, removed, or contained to meet cleanup levels established for the site. This status determination may only be made by Ecology.

nr – not reported

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

Table G-7. Facilities within the LDW drainage basin listed in Ecology's Leaking Underground Storage Tank (LUST) database that are reported to have not yet completed cleanup

Site Name	Street Address	Release Notification Date	Status Date	Release Status[A]	Affected Media			
					Soil	Ground-water	Surface Water	Sediment
Air Tec Company	5701 1st Avenue S	05/09/00	04/04/00	cleanup started	X		X	X
Allied Domecq	2921 Martin Luther King Jr. Way S	03/24/98	03/24/98	cleanup started	X	X		
Arco AM/PM	7200 E Marginal Way S	08/30/93	02/08/94	cleanup started	X	X		
Arco Gas Station	9830 Martin Luther King Jr. Way S	11/03/94	08/17/95	awaiting cleanup	X			
Associated Grocers Inc.	3301 S Norfolk Street	07/15/98	02/04/97	cleanup started	X	X		
ATC Distribution Group	401 S Webster	08/19/94	06/01/95	cleanup started	X	X		
Bob's Texaco Service	5304 1st Avenue S	02/13/91	05/24/95	awaiting cleanup	X	X		
Boeing Field Chevron	10805 E Marginal Way S	06/16/03	10/18/05	cleanup started		X		
		03/07/97	03/04/97	cleanup started	X			
		03/28/90	06/01/95	cleanup started	X	X		
BP/Arco AM/PM	665 23rd Avenue	10/28/05	09/07/05	awaiting cleanup	X	X		
Cecil Leung	3005 Rainier Avenue S	08/21/98	08/21/98	cleanup started	X	X		
Chevron 90636	5940 E Marginal Way	11/09/93	11/09/93	awaiting cleanup	X	X		
Chevron 98484	8700 14th Avenue S	02/14/91	06/01/95	cleanup started	X	X		
Clarklift of Washington Alaska, Inc.	1313 S 96th	01/04/05	09/23/98	cleanup started	X	X		X
Consolidated Freightways Seattle	6050 E Marginal Way S	06/02/88	06/01/95	cleanup started	X	X		
Cooper Elementary School	1901 SW Genesee	06/12/98	06/12/98	cleanup started	X			
Dawson Street Land Co	54 S Dawson	06/15/92	07/19/00	monitoring	X			
Deeny Construction Co, Inc.	2545 Rainier Avenue S	09/18/96	08/31/92	cleanup started	X			
Boeing Developmental Center	9725 E Marginal Way S	07/20/89	06/01/95	cleanup started	X	X		
District Headquarters Site	6431 Corson Avenue S	04/17/91	06/01/95	unknown	X			

Table G-7, cont. Facilities within the LDW drainage basin listed in Ecology's Leaking Underground Storage Tank (LUST) database that are reported to have not yet completed cleanup

Site Name	Street Address	Release Notification Date	Status Date	Release Status[A]	Affected Media			
					Soil	Ground-water	Surface Water	Sediment
Duwamish Shipyard, Inc.	5658 W Marginal Way SW	07/12/00	10/06/00	cleanup started	X			
Fisher Mills Inc.	3235 16th Avenue SW	10/17/00	07/20/00	cleanup started	X	X		
Former Gas Station	2800 Martin Luther King Jr Way S	08/12/05	08/11/05	awaiting cleanup	X	X		
Former Unocal #0166	1590 S Dearborn Street	08/07/96	11/06/96	cleanup started	X	X		
Former Unocal 6248	11845 Des Moines Way S	02/07/91	07/18/96	monitoring	X	X		
G Heileman Brewing Co	3100 Airport Way S	11/22/89	05/18/00	monitoring	X	X		
Gerald Richards	12666 Des Moines Way	07/17/89	06/01/95	cleanup started	X	X		
Glacier Northwest Inc.	5975 E Marginal Way S	06/01/89	09/28/95	cleanup started	X		X	
Glitsa American Inc.	327 S Kenyon Street	09/02/92	06/01/95	cleanup started	X			
Great Western Chemical Co Seattle	6900 Fox Avenue S	05/17/90	06/01/95	cleanup started	X			
Hangar Holdings Inc.	7675 Perimeter Rd S	08/14/01	07/25/97	cleanup started	X	X		
Incon Packaging	5801 East Marginal Way S	12/15/1989	6/1/1995	cleanup completed		X		
Interstate Coatings Inc.	754 S Chicago Street	12/04/98	09/23/98	cleanup started	X			
Kelly-Moore Paint Co	5410 Airport Way S	04/21/94	06/01/95	cleanup started	X			
Kenworth Truck Plant	8801 E Marginal Way S	05/13/97	07/15/99	cleanup started	X	X	X	
Longview Fiber Co	5901 E Marginal Way S	01/01/88	03/10/03	monitoring	X	X		
Malarkey Asphalt Co	8700 Dallas Avenue S	05/07/92	06/01/95	cleanup started	X	X		
Marine Lumber Service Shop	558 S Kenyon Street	06/28/94	06/01/95	cleanup started	X	X		
Marine Lumber Service Inc.	525 S Chicago Street / PO Box 80964	06/03/94	06/01/95	cleanup started	X			
Museum of Flight Property	9404 E Marginal Way S	08/03/01	07/30/01	awaiting cleanup	X	X		
North Coast Chemical Plant	6300 17th Avenue S	10/23/91	05/21/95	cleanup started	X	X		
Pacific Fruit and Produce	4103 2nd Avenue S	01/17/92	01/17/92	cleanup started	X	X		

Table G-7, cont. Facilities within the LDW drainage basin listed in Ecology's Leaking Underground Storage Tank (LUST) database that are reported to have not yet completed cleanup

Site Name	Street Address	Release Notification Date	Status Date	Release Status[A]	Affected Media			
					Soil	Ground-water	Surface Water	Sediment
Perfection Smokery	4660 E Marginal Way S	07/13/90	06/01/95	unknown	X	X		
Plant 2 (Boeing Plant 2)	7755 E Marginal Way S	02/02/90	06/01/95	cleanup started	X			
		09/27/91	06/01/95	cleanup started	X			
Rainier Avenue Chevron	2802 Rainier Avenue S	09/23/94	06/01/95	awaiting cleanup	X	X		
Schauer Northwest Inc.	8819 14th S	12/02/93	nr	cleanup started	X	X		
Scougal Rubber Corp.	6239 Corson Avenue S	01/01/90	06/01/95	cleanup started	X	X		
Seattle Steel Inc.	4001 28th Avenue SW	01/11/90	01/11/90	cleanup started	X			
Seattle Yard	60 Diagonal S	07/10/90	09/29/95	cleanup started	X	X		
Selland Auto Transport Inc.	615 S 96th Street	06/30/99	09/29/98	cleanup started	X	X		
Shell Oil Products	852 Rainier Avenue S	04/11/91	09/08/94	monitoring	X	X		
Signal Equipment Inc.	838 Poplar Place S	05/30/91	06/01/95	cleanup started	X	X		
Spokane Street Site	450 S Spokane Street	10/22/93	06/01/95	cleanup started	X	X		
Stephanie Crosby Property	8621 14th Avenue S	09/20/00	09/13/00	cleanup started	X			
Taniguchi Property	415 18th Avenue S	11/09/90	05/21/95	cleanup started	X			
Terminal 106 West	44 S Nevada Street	02/11/92	06/01/95	monitoring	X	X		
Terminal 115	6020-6730 W Marginal Way SW	05/06/93	06/01/95	cleanup started	X	X		
Texaco Station #63-232-0383	2424 Beacon Avenue S	12/27/90	09/28/95	cleanup started	X	X		
Texaco Station #63-232-0400	6200 Corson Avenue S	10/03/90	06/01/95	monitoring	X	X		
Texaco Station #63-232-0400	600 S Michigan	03/23/94	01/20/00	monitoring	X	X		
Time Oil Co 216	2465 S College Street	02/12/90	03/31/94	cleanup started	X	X		
Uhaul Co of Rainier Avenue 57	2515 Rainier Avenue S	08/31/98	08/31/98	cleanup started	X			
Union Pacific Motor	420 S Dawson	07/10/90	nr	monitoring	X	X		
Unocal 5473	401 Rainier Avenue S	09/24/90	07/19/96	monitoring	X	X		
Unocal SS 0907 ENSR Int	1121 S Bailey Street	12/29/04	03/21/02	cleanup started	X	X		

Table G-7, cont. Facilities within the LDW drainage basin listed in Ecology's Leaking Underground Storage Tank (LUST) database that are reported to have not yet completed cleanup

Site Name	Street Address	Release Notification Date	Status Date	Release Status[A]	Affected Media			
					Soil	Ground-water	Surface Water	Sediment
Unocal SS 5477	2415 Beacon Avenue S	10/15/90	07/18/96	monitoring	X	X		
VA Medical Center	1660 S Columbian Way	09/23/91	09/28/95	cleanup started	X	X		
Vic Markov Tire Co	7300 E Marginal Way S	05/19/93	06/01/95	monitoring		X		
WA Department of Transportation Seattle S Spokane Street	450 S Spokane Street	03/01/89	05/21/95	cleanup started	X			
Waste Management of Seattle	7201 W Marginal Way SW	04/30/92	06/01/95	cleanup started	X	X		
Washington Department of Transportation Bradner Pl Apts	1366 31st Avenue S	10/13/92	07/25/96	monitoring	X	X		
Western Peterbilt	3707 Airport Way S	03/01/89	06/01/95	cleanup started	X			
WF Carmody	220 S River Street	05/18/99	10/26/98	cleanup started	X	X		

Source: EDR (2006b)

[a] Status determinations are based on information available from Ecology's LUST database and in some cases these determinations may be dated. Subsequent remedial actions may have been completed and LUSTs may now be cleaned up.

nr – not reported

Definitions of release status categories:

Awaiting cleanup – Discovered or reported release yet no active cleanup measures taken

Cleanup started – Responsible party has initiated physical, biological, or chemical management of release

Monitoring – Groundwater monitoring is the only activity occurring at the site, or chemical levels are so low that natural attenuation is the chosen cleanup method

Unknown – Status of LUST is unknown

Table G-8. Facilities within the LDW drainage basin listed in Ecology's LUST database that are reported to be cleaned up

Site Name	Street Address	Release Notification Date	Date Cleaned Up	Affected Media			
				Soil	Ground-water	Surface Water	Sediment
23rd & Jackson Site	23rd & S Jackson	6/15/1995	1/25/1996	X			
4th South Gull #219	4115 4th Avenue S	8/16/1991	1/17/2002	X			
80 S Hudson Street Site	80 S Hudson Street	8/6/1990	4/29/1997	X			
A & T Pump	6525 Ellis Avenue S	8/21/1992	12/10/2001	X			
A N R Freight System	4501 6th Avenue S	8/17/1990	3/15/2001	X			
Ackerley Communications of the NW, Inc.	3601 6th Avenue S	5/30/1989	4/11/2000	X			
Acme Poultry Co Inc.	2001 21st S	2/19/1991	9/23/2003	X	X		
Air Data Express, Inc.	525 S Front Street	3/18/1999	8/7/2000	X	X		
Alaska Marine Lines (Shipyard)	7100 2nd Avenue SW	12/14/1992	3/8/1991	X	X		
Alaska Marine Lines 5615 W Marginal Way	5615 W Marginal Way SW	2/6/1991	6/1/1995	X	X		
Arthur J Warner	9001 14 Avenue S	1/16/1992	6/1/1995	X			
Baxter Rutherford	911 South Hosmer Street	8/8/1997	8/11/1997	X			
BFI Federal Express Station	7607 Perimeter Rd	1/12/1990	6/1/1995	X	X		
Bus And Air Parcel Service Incorporate	9004 14th S	10/18/1990	4/25/2000	X			
Cascade Machinery & Electric Inc. Seattle	4600 E Marginal Way S	9/19/1990	7/29/2002	X			
Case LLC	2702 West Valley Hwy N	4/18/1994	6/1/1995	X			
Central Services Building	4201 W Marginal Way SW	7/26/1991	12/9/2004	X	X		
Chin Brothers Inc.	2901 17th Avenue S	3/13/2001	8/28/2001	X			
D. L. Duckey Auto Freight, Inc.	2212 Rainier Avenue S	1/14/1991	6/1/1995	X			
Davis Door Service, Inc.	2021 S Grand Street	12/6/1990	2/10/2004	X			
Draper Machine Works Inc.	5055 4th Avenue S	11/22/1989	6/29/2000	X			

Table G-8, cont. Facilities within the LDW drainage basin listed in Ecology's LUST database that are reported to be cleaned up

Site Name	Street Address	Release Notification Date	Date Cleaned Up	Affected Media			
				Soil	Ground-water	Surface Water	Sediment
Earle M Jorgensen Company	8531 E Marginal Way S	2/26/1991	10/11/1999	X	X		
Farwest Taxi Facility	11180 E Marginal Way	5/9/1989	5/21/1995	X			
Firestone Retread Plant #127345	9220 E Marginal Way S	5/15/1989	6/1/1995	X			
First Student, Inc.	130 S Kenyon Street	8/13/1997	8/13/1997	X			
Fruehauf Trailer Services, Inc.	9426 8th Avenue S	4/25/1998	4/17/1999	X	X		
Gai's Seattle French Baking Company	2006 S Weller	4/15/1997	3/14/2002	X			
Galvin Flying Center	7001 Perimeter Rd	2/5/1999	2/24/1999	X			
Gary Merlino Construction Co., Inc.	9125 10th Avenue S	7/23/1999	8/31/1999	X			
General Construction Co	3838 W Marginal Way SW	9/8/1994	6/1/1995	X	X		
General Steamship (Local Agent)	5931 E Marginal Way S	1/11/1991	1/26/2001	X			
Georgetown Steam Plant (now a museum)	1131 S Elizabeth	11/6/1989	4/27/2000	X			
Glen Acres Home Assoc	1000 S 112th	1/2/1992	8/23/2000	X			
GOLDCO	12459 Des Moines Way S	2/28/1991	4/25/2000	X			
Golden Grain Seattle Distribution Center	4100 4th Avenue S	5/6/1992	8/6/2002	X			
Golden International Coop	9800 40th Avenue S	7/15/1993	6/1/1995	X			
Griffin Envelope Inc.	4301 E Marginal Way S /Po Box 24	8/15/1991	6/1/1995	X			
Happy Guests Headquarters	4703 Delridge Way SW	2/11/1997	5/20/2004	X			
Hertz Equipment Rental Corp.	10710 E Marginal Way S	10/25/1990	6/1/1995	X			
Horizon Ford	11000 Pacific Hwy	12/10/1990	6/1/1995	X			
Hurlen Construction Company	700 So Riverside Dr/Po Box 90045	4/30/1993	12/6/2000	X			
Incon Packaging	5801 E Marginal Way S	12/15/1989	6/1/1995	X	X		
James Shilling	806 S 112th	10/8/1991	6/1/1995	X			

Table G-8, cont. Facilities within the LDW drainage basin listed in Ecology's LUST database that are reported to be cleaned up

Site Name	Street Address	Release Notification Date	Date Cleaned Up	Affected Media			
				Soil	Ground-water	Surface Water	Sediment
Jones Washington Stevedoring Co.	7245 W Marginal Way SW	10/10/1994	6/1/1995	X			
Julius Rosso Wholesale Nursery Co.	6404 Ellis Avenue S	8/26/1997	1/7/1999	X			
King County Airport Maint.	6518 Ellis Avenue	12/15/1992	9/1/1998	X	X		
Lafarge Corporation	5400 W Marginal Way SW	1/23/1992	6/1/1995	X			
Lee Poletti	1622 Yesler Way	7/2/1990	6/1/1995	X			
Leo Fix Transfer & Storage Co Inc.	4700 Denver Avenue S	6/21/1993	11/4/1997	X			
Loomis Armored Inc.	5200 E Marginal Way S	1/3/1990	2/6/1991	X			
Lucks Bakery Supply	9620 Martin Luther King Jr Way S	3/23/1994	7/27/1998	X			
M Bloch & Co Inc.	4580 Colorado Avenue S, PO Box 240	6/22/1992	2/7/2005	X	X		
McCall Oil, Seattle Home HTQ-Burien	11441 Des Moines Way	5/8/1990	6/1/1995	X			
Mikes Mobil Service	6235 Airport Way So	9/24/1990	4/17/2001	X			
Motor Pool	6650 Ellis Avenue S	11/22/1991	6/1/1995	X			
National Transfer Inc.	5265 Utah Avenue S	5/24/1990	6/1/1995	X			
North Boeing Field	7500 E Marginal Way S	9/14/1989	6/1/1995	X	X		
Olympic Steel Door	7800 7th Avenue S	11/1/1999	7/28/2003	X	X		
Pacific Leasing Company	300 S Spokane Street	1/31/1990	12/9/1995	X			
Park Lake Homes	9900 8th Avenue SW	12/23/1998	9/12/2005	X			
PNB Building	707 S Orcas Street	1/16/1992	5/21/1995	X	X		
Pony Express Courier Co.	11004 E. Marginal Way S	10/6/1992	6/1/1995	X			
Pro Express Group Inc. (formerly Terminal F)	4800 Denver Avenue S	7/10/1990	5/14/1997	X			
PTL Partnership/Peninsula Truck Lines	6314 7th S	8/29/1989	7/23/2002	X			
Puget Sound Energy	6349 18th Avenue S	11/5/1997	2/12/2003	X			

Table G-8, cont. Facilities within the LDW drainage basin listed in Ecology's LUST database that are reported to be cleaned up

Site Name	Street Address	Release Notification Date	Date Cleaned Up	Affected Media			
				Soil	Ground-water	Surface Water	Sediment
Puget Sound Truck Lines Inc.	7303 8th Avenue S	6/12/1991	9/27/1995	X			
Rasmussen Equipment Co Inc.	415 South Cloverdale Street	8/29/1994	6/1/1995	X			
Razore Enterprises	500 South Sullivan	8/15/1991	6/1/1995	X			
Royal Hyway Tours	255 South Holden Street	10/11/1994	6/1/1995	X			
Scott Andrews	8520 14th Avenue S	12/20/2000	2/14/2001	X			
Seaboard Lumber Company	4540 W Marginal Way	12/4/1992	7/14/2003	X			
Seattle Air Corp.	8535 Perimeter Rd S	7/16/1996	8/26/1996	X			
Seattle Fire Station # 36	3600 23rd Avenue SW	9/5/1989	9/1/1998	X			
Seattle Fire Station 13/ Closed	3601 Beacon Avenue S	2/16/2000	8/2/2002	X			
Seattle Fire Station 27/ Closed	1000 S Myrtle Street	12/10/1999	5/31/2002	X			
Seattle School Facilities	4141 4th Avenue S	8/23/1990	5/21/1995	X			
South Seattle Community College	6000 16th Avenue SW	8/4/1994	6/1/1995	X			
South Service Center	3613 4th Avenue S	4/5/1990	7/31/2006	X	X		
Station 6/ Closed	101 23rd Avenue S	12/9/1999	2/28/2000	X			
Sunnydale Construction Co., Inc.	1119 S 96th	5/21/1997	6/2/1997	X			
Tacoma Seattle Trailer Repair	150 S Kenyon Street	8/26/1997	12/16/1999	X			
Terminal 105	4260 W Marginal Way SW	3/23/1994	6/1/1995	X			
The Burke Company	4201 Airport Way S	2/17/1989	6/1/1995	X			
Thompson Site	8701 E Marginal Way	1/1/1984	6/5/2000	X			
U S Bank Of Washington	1137 S W Hanford Street	12/15/1989	1/25/1990	X			
U S General Services Administration	4735 E Marginal Way S	10/6/1998	7/23/2003	X	X		
UPS Seattle Hub	4455 7th Avenue S The Hub	9/8/1989	6/1/1995	X	X		
Valley Market	2338 Rainier Avenue S	5/13/1991	6/1/1995	X			
Walt's Radiator 3838 4th S	3838 4th Avenue S	4/3/1995	7/6/1995	X			

Table G-8, cont. Facilities within the LDW drainage basin listed in Ecology's LUST database that are reported to be cleaned up

Site Name	Street Address	Release Notification Date	Date Cleaned Up	Affected Media			
				Soil	Ground-water	Surface Water	Sediment
Waste Management Of Seattle	7901 1st Avenue S	9/2/1997	5/20/2004	X			
Washington Department of Transportation I-90/Rainier Ave	I-90 & Rainier Avenue S	1/25/1989	5/21/1995	X			
Welch Investment Co	2211 S Jackson Street	5/25/1989	3/27/2002	X			
West Seattle #28	9200 8th Avenue S	7/11/1990	9/27/1995	X			
Yellow Freight System	11231 E. Marginal Way S	10/18/1989	6/1/1995	X			
Zellerbach Paper Company	6301 Airport Way S	8/13/1991	2/19/2002	X			
Zion Auto Rebuilders	5402 Delridge Way SW	8/22/2005	1/13/2006	X			

Source: EDR (2006b)

Table G-9. Facilities within the LDW drainage basin listed in Ecology's Solid Waste Facility/Landfill sites database

Site Name[a]	Street Address	Status	Facility ID	Type
Eastmont Transfer Station	7201 West Marginal Way SW	open	417	transfer station
Seattle Iron and Metals Corporation	601 S Myrtle	nr	1093	recycle facility
Independent Metals	747 S Monroe Street	nr	987	recycle facility
Northwest Center	7272 W Marginal Way S	nr	1355	recycling survey
Industrial Container Service	7152 1st Avenue S	nr	1299	recycling survey
Second Use Building Materials	7953 2nd Avenue S	nr	1428	recycling survey
Allmetal Company	5610 Airport Way S	nr	901	recycle facility
BPB Gypsum	5931 E Marginal Way S	nr	820	pile
Sutta Company	434 S Cloverdale Street	nr	1460	recycling survey
Art Brass Plating	5516 3rd Avenue S	nr	1187	recycling survey
Puget Sound Laser	5602 2nd Avenue S	nr	1390	recycling survey
Fibres International	9208 4th Avenue S	nr	968	recycle facility
Seadrunar Recycling	28 S Brandon Street	nr	1091	recycle facility
Ecolights Northwest	9411 8th Avenue S	nr	961	recycle facility
Emerald City Disposal	54 S Dawson	nr	1262	recycling survey
Seattle Barrel Company	4716 Airport Way S	nr	1092	recycle facility
AMS Laser Supply	430 S 96th STE 9	nr	1180	recycling survey
Bloch Steel Industries	4580 Colorado Avenue S	nr	920	recycle facility
Phelps Tire	3922 7th Avenue S	nr	1057	recycle facility
Associated Grocers	3301 S Norfolk	nr	1189	recycling survey
Buffalo Industries Inc.	99 S Spokane Street	nr	922	recycle facility
Pacific Rendering Co.	4034 W Marginal Way SW	nr	1372	recycling survey
West Seattle Recycling Center	3881 16th Avenue SW	nr	1142	recycle facility

Table G-9, cont. Facilities within the LDW drainage basin listed in Ecology's Solid Waste Facility/Landfill sites database

SITE NAME[a]	STREET ADDRESS	STATUS	FACILITY ID	TYPE
The Recycling Depot Inc.	851 Rainier Avenue S	nr	1118	recycle facility
Goodwill Industries	1400 S Lane Street	nr	1280	recycling survey

Source: EDR (2006b)

[a] The sites listed in this table are those that are currently listed in Ecology's Solid Waste/Landfill Sites records. According to the EDR definition, "SWF/LF type records typically contain an inventory of solid waste disposal facilities or landfills", and "these may be active or inactive facilities or open dumps that failed to meet RCRA Subtitle D Section 4004 criteria for solid waste landfills or disposal sites" (EDR 2006b). This table does not necessarily represent a complete list of all historical solid waste facilities or landfills in the LDW drainage basin. See Section 9.3.2.5 for a discussion of other known historical landfills not included on Ecology's Solid Waste Facility/Landfill database.

[b] This facility was listed on the CSCSL database; all information is from that database listing.

CSCSL – Confirmed and Suspected Contaminated Sites List

ID – identification

LDW – Lower Duwamish Waterway

nr – not reported

RCRA – Resource Conservation and Recovery Act

SWF/LF – Solid waste facility/landfill

Table G-10. Facilities within the LDW drainage basin listed in Ecology's Active Drycleaners or Inactive Drycleaners databases

Site Name	Street Address	Facility/Site ID	Status	Generator Status	Known Contamination?
Three Brothers Cleaners	3210 Beacon Avenue S	381836	Active	SQG	nr
WA UW Consolidated Cleaners	2901 27th Avenue S	19911937	Active	XQG	nr
Cascade Enterprises	8709 14th Avenue S	10356 and WAD988482303	Inactive	na	nr
Burned Laundry Former	1414 S Concord	14362 and WAH000013359	Inactive	na	nr
Former Penthouse Drapery	4115 1st Avenue S	1939 and WAD988472478	Inactive	na	yes
Seattle Dye Works	11 S Nevada Street	1864	Inactive	na	nr
Mount Baker Cleaners	2864 S McClellan Street	10667and WAD081927550	Inactive	na	nr
Snappy Cleaners	2204 S Jackson Street	6287and WAD021830229	Inactive	na	nr
Jackson Cleaners	2301 S Jackson Street	4715 and WAR000002402	Inactive	na	nr
Kwik Cleaners Former	2701 15th Avenue S	82774832[a]	Inactive	na	yes

Source: EDR (2006b)

[a] This is a CSCSL identification number; this facility was found listed only on the CSCSL database.

CSCSL – Confirmed and Suspected Contaminated Sites List

na – not applicable

nr – not reported

SQG – Small quantity waste generator

XQG – No dangerous or regulated waste is produced in any amount

Table G-11. Facilities within the LDW drainage basin listed in either the EPA or Ecology brownfields databases

Site Name	Street Address	Listed on US Brownfields Database?	Federal Grant Recipient Name	Listed on Ecology's Brownfields List?	Ecology Facility ID
14043 24th Avenue S	14043 24th Avenue S	yes	Public Health Seattle and King County	no	na
Ace Galvanizing Inc.	429 S 96th Street	no	na	yes	2077
Ace Radiator Shop	311 S Brandon	yes	Seattle/King County	no	na
Advanced Electroplating Inc.	9585 8th Avenue S	yes	Seattle/King County	yes	2079
Affordable Auto Wrecking	9802 Martin Luther King Jr. Way S [a]	no	na	yes	7163112
Affordable Auto Wrecking Yard	9820 Martin Luther King Jr. Way S [a]	yes	Seattle/King County	no	na
Boulevard Park/Unocal Station	11845 Des Moines Memorial Dr	yes	Seattle/King County	no	na
Bry's Auto Wrecking II/Kenyon Street	110 S Kenyon Street	yes	Seattle/King County	no	na
Central Painting	4749 W Marginal Way SW	no	na	yes	2185
Emerald Tool Inc.	6332 6th Avenue S	no	na	yes	2084
Glacier NW Terminal	5900 W Marginal Way S	yes	Seattle/King County	yes	23881883
Industrial Container Services WA LLC	7152 1st Avenue S[b]	no	na	yes	2154
Interstate Coatings	754 S Chicago	no	na	yes	2335
Kelly Moore Preservative Paint Co	6101 Airport Way S	no	na	yes	2163
Kelly Moore/Preservative Plant	5410 Airport Way S	yes	Seattle/King County	no	na
Kwick Cleaners Property	2701 15th Avenue S	yes	Seattle/King County	no	na
Long Painting	8025 10th Avenue S	yes	Seattle/King County	no	na
Marine Vacuum Service (MARVAC)	1516 S Graham Street	yes	Seattle/King County	no	na
Moimoi Property	10118 Des Moines Memorial Dr S	no	na	yes	95231135
M & T Chemicals Inc.	6000 W Marginal SW	no	na	yes	2177
Northwest Cooperage	7152 1st Avenue S [b]	yes	Seattle/King County	no	na
Pioneer Enamel Manufacturing	5531 Airport Way S	yes	Seattle/King County	yes	2161

Site Name	Street Address	Listed on US Brownfields Database?	Federal Grant Recipient Name	Listed on Ecology's Brownfields List?	Ecology Facility ID
Puget Sound Industry Services Inc.	3407 Airport Way S	yes	Seattle/King County	no	na
Ralph's Concrete Pumping	1511 Rainier Avenue S	no	na	yes	2312
Ralph's Concrete Pumping Vacant Lot	1517 Rainier Avenue S	no	na	yes	8964755
Rhône-Poulenc/Rhodia Inc./Northwest Container	9229 East Marginal Way S	yes	Seattle/King County	no	na
Samis Land Co Site	647 S Alaska Street	no	na	yes	2229
Scenic Bound Tours	300 S Orcas Street	yes	Seattle/King County	no	na
Seattle Barrel & Cooperage	7th Avenue S & S Snoqualmie Street	no	na	yes	2307
Seattle City Light 4th Avenue S	3814 4th Avenue S	no	na	yes	16777876
Seattle City Light Moderate Risk Waste Facility	3613 4th Avenue S	no	na	yes	2171
Seattle Port Dallas Ave	8700 Dallas Avenue S	no	na	yes	2202
Seattle Public Utilities Operations Center	2700 Airport Way S	no	na	yes	2376
Seattle Solstice	7506 5th Avenue S	yes	Seattle/King County	no	na
Spear Trusts Warehouse	4001 6th Avenue S	no	na	yes	2366
Sternoff Metals Property	7201 E Marginal Way	yes	Seattle/King County	no	na
Toxcon (Penberthy) Property	631 S 96th Street	yes	Seattle/King County	no	na
Waste Management of Seattle	7201 W Marginal Way SW	no	na	yes	2425

Source: EDR (2006b)

[a] Likely the same facility with one of the addresses in error.

[b] Street address listed as Northwest Cooperage in the EPA Brownfields listing and as Industrial Container Services WA LLC in the Ecology Brownfields listings.

na – not applicable

Table G-12. Facilities within the LDW drainage basin listed in EPA's Toxic Chemical Release Inventory System (TRIS)

Site Name	Street Address	Listed on Another Database?	Information On Contaminant Release?
Ace Galvanizing Inc.	429 S 96th Street	CSCSL, Brownfields	nr
Art Brass Plating Inc. Seattle	5516 3rd Avenue S	CSCSL	nr
Ash Grove Cement Co	3801 E Marginal Way S	no	nr
Boeing North Boeing Field	7500 E Marginal Way	LUST	nr
Boeing Plant 2	7755 E Marginal Way S	CSCSL	nr
Duwamish Shipyard Inc.	5658 W Marginal Way SW	CSCSL, NPDES, LUST	nr
Formula Corporation	7901 2nd Avenue S	no	nr
Glacier Northwest Inc. East Marginal Way	5975 E Marginal Way S	LUST, NPDES	nr
Jorgensen Forge Corp.	8531 E Marginal Way S	CSCSL	nr
Kelly Moore Preservative Paint Co	6101 Airport Way S	CSCSL, Brownfields	nr
Lafarge North America	5400 W Marginal Way SW	LUST, NPDES	nr
Modine Aftermarket Holdings Inc.	115 S Dawson Street	no	nr
Non-Ferrous Metals Inc.	230 S Chicago Street	no	nr
Nucor Steel Seattle Inc.	2424 SW Andover Street	CSCSL, NPDES	nr
Puget Sound Coatings Machinists Inc.	9220 8th Avenue S	no	nr
Saint Gobain Containers LLC	5801 East Marginal Way S	LUST[a]	nr
Transpro / Seattle	7951 2nd Avenue S	no	nr
TRIM Systems	701 S Orchard Street	no	nr
VIOX Corporation	6701 6th Avenue S	no	nr

Source: EDR (2006b)

[a] LUST listing at this address is under a different business name (Incon Packaging).

CSCSL – Confirmed and Suspected Contaminated Sites List
EPA – Environmental Protection Agency
LDW – Lower Duwamish Waterway
LUST – leaking underground storage tank
NPDES – National Pollutant Discharge Elimination System
nr – not reported
TRIS – Toxics Release Inventory System

Table G-13. Facilities near the LDW registered with the Puget Sound Clean Air Agency (PSCAA) for air emissions

PSCAA ID No.	Site Name	Street Address	City	ZIP Code[a]	NAICS Code	Facility Description
12068	AB Fab Welding	4725 W Marginal Way SW	Seattle	98106	332323	ornamental and architectural metal work manufacturing
11695	Ace Galvanizing Inc.	429 S 96th Street	Seattle	98108	332812	metal coating, engraving (except jewelry and silverware), and allied services to manufacturers
10436	Aero-Lac Inc.	420 S 96th Street Space #11	Seattle	98108	321918	other millwork (including flooring)
18139	Airgas-Nor Pac, Inc.	7700 14th Avenue S	Seattle	98108	325120	industrial gas manufacturing
25066G	Alamo/National Car Rental	2006 South 146th Street	SeaTac	98168	532112	passenger car leasing
10642G	Albertsons Express #473	12725 1st Avenue S	Burien	98168	445299	all other specialty food stores
17168	Alki Auto Body Inc.	5958 Corson Avenue S	Seattle	98108	811121	automotive body, paint, and interior repair and maintenance
10071	Allied Body Works Inc.	625 S 96th Street	Seattle	98108	811121	automotive body, paint, and interior repair and maintenance
12155	Alpine Auto Sales & Service	6722 Fox Avenue S	Seattle	98108	811121	automotive body, paint, and interior repair and maintenance
24140	Aluminum & Bronze Fabricators Inc.	6301 W Marginal Way SW	Seattle	98106	332312	fabricated structural metal manufacturing
10779	American Bathtub Refinishers	1412 S Henderson	Seattle	98108	332998	enameled iron and metal sanitary ware manufacturing
12133	American Collision & Refinish	14223 1st Avenue S	Seattle	98168	811121	automotive body, paint, and interior repair and maintenance
25072G	ARCO #04090	2200 4th Avenue S	Seattle	98134	447110	gasoline stations with convenience stores
10371G	ARCO AM/PM, Delridge	7301 Delridge Way SW	Seattle	98106	447110	gasoline stations with convenience stores
18892G	Armbco Inc. Phoenix Oil Co Inc.	2535 Airport Way S	Seattle	98134	447190	other gasoline stations
20086	Art Brass Plating Inc.	5516 3rd Avenue S	Seattle	98108	332813	electroplating, plating, polishing, anodizing, and coloring
12061	Art Brass Plating Inc.	1705 S 93rd Street, F-18	Seattle	98108	332813	electroplating, plating, polishing, anodizing, and coloring

Table G-13, cont. Facilities near the LDW registered with the Puget Sound Clean Air Agency (PSCAA) for air emissions

PSCAA ID No.	Site Name	Street Address	City	ZIP Code[a]	NAICS Code	Facility Description
11585	Asahipen America Inc., Aspen Paints	1128 SW Spokane Street	Seattle	98134	325510	paint and coating manufacturing
11339	Ash Grove Cement Co, E Marginal	3801 E Marginal Way S	Seattle	98134	327310	cement manufacturing
13166G	Associated Grocers Incorporated	3301 S Norfolk	Seattle	98134	424490	other grocery and related products merchant wholesalers
18283	Automated Equipment Co	10847 E Marginal Wy S	Seattle	98168	444190	other building material dealers
25805G	Aviation Fuel Storage Co & Card Lock	1495 Hardy Street	Seattle	98108	424710	petroleum bulk stations and terminals
17205	Bill's Auto Repair	1607 SW 100th Street	Seattle	98106	811121	automotive body, paint, and interior repair and maintenance
10255	Blaser Die Casting Co	5700 3rd Avenue S	Seattle	98108	331528	other nonferrous foundries (except die-casting)
12038	BMP Inc.	1922 Airport Way S	Seattle	98134	238320	painting and wall covering contractors
28803	Boeing Commercial Airplane Group Thompson	8621 E Marginal Way S	Tukwila	98108	336411	aircraft manufacturing
21147	Boeing Commercial Airplane NBF Plant 2	7700 E Marginal Way S	Seattle	98108	336411	aircraft manufacturing
17767	Boeing Commercial Airplane SDC	2201 S 142nd Street	Seatac	98168	493110	general warehousing and storage
18385	Boeing Company, EMF	7355 Perimeter Rd S	Seattle	98108	336413	other aircraft parts and auxiliary equipment manufacturing
13119	Boeing Developmental Center	9725 E Marginal Way S	Tukwila	98108	336413	other aircraft parts and auxiliary equipment manufacturing
16004	BP West Coast Products, Seattle Terminal	1652 SW Lander Street	Seattle	98134	424710	petroleum bulk stations and terminals
11195	BPB Gypsum Inc., Washington	5931 E Marginal Wy S	Seattle	98134	327420	gypsum product manufacturing
12066	Bratch's Autobody & Repair	645 S Massachusetts	Seattle	98134	811121	automotive body, paint, and interior repair and maintenance
28419	Buffalo Industries, Inc.	99 S Spokane Street	Seattle	98134	812332	industrial launderers
17854	Burhans Sharpe Co	1541 S 92nd Pl Suite A	Seattle	98108	333120	construction machinery manufacturing
13042G	Burien 76	12660 1st Avenue S	Seattle	98168	447110	gasoline stations with convenience stores

Table G-13, cont. Facilities near the LDW registered with the Puget Sound Clean Air Agency (PSCAA) for air emissions

PSCAA ID No.	Site Name	Street Address	City	ZIP Code[a]	NAICS Code	Facility Description
18160	Byrne Specialty Gases	601 S Andover Street	Seattle	98108	325120	industrial gas manufacturing
21007	Cadman Inc., Lehigh NW Cement	5225 E Marginal Way S	Seattle	98134	327320	ready-mix concrete manufacturing
10613	Cafe Fonte dba Fonte Coffee Roaster	5412 6th Avenue S	Seattle	98108	311920	coffee and tea manufacturing
11019	Caffe' D'Arte, Uno Espresso Inc.	719 S Myrtle Street	Seattle	98108	311920	coffee and tea manufacturing
21149	Caffe Umbria Inc.	6020 Airport Way S	Seattle	98108	311920	coffee and tea manufacturing
10385	Capital Industries Inc.	5801 3rd Avenue S	Seattle	98108	332999	all other miscellaneous fabricated metal product manufacturing
20417	Cascade Machinery & Electric Inc.	4600 E Marginal Wy S	Seattle	98134	423610	electrical apparatus and equipment, wiring supplies, and related equipment merchant wholesalers
10232G	Charlie's Jumbo Deli	14805 Interurban Avenue S	Tukwila	98168	447110	gasoline stations with convenience stores
12112	Checker Collision Center	11022 E Marginal Way S	Tukwila	98168	811121	automotive body, paint, and interior repair and maintenance
13182	Chemithon Corp.	5430 W Marginal Way SW	Seattle	98106	325611	soap and other detergent manufacturing
18147G	Chevron #90636	5940 E Marginal Wy S	Seattle	98134	447110	gasoline stations with convenience stores
28978	Chevron Environmental Management Company	1121 South Bailey Street	Seattle	98108	447110	gasoline stations with convenience stores
10246G	Chevron, Boeing Field	10805 E Marginal Way S	Tukwila	98168	447110	gasoline stations with convenience stores
10289G	Chevron, Boulevard Park	805 S 112th Street	Seattle	98168	447110	gasoline stations with convenience stores
21146G	Cigarette Depot	9001 Delridge Way SW	Seattle	98106	447110	gasoline stations with convenience stores
28944	Conoco Phillips Company	12805 1st Avenue S	Burien	98168	541330	engineering services
10438	Container Care International Inc.	1 S Idaho	Seattle	98134	238320	painting and wall covering contractors
21353	Costco Wholesale	4401 4th Avenue So	Seattle	98134	452910	warehouse clubs and supercenters
25001	Country Classic Inc.	420 S 96th Street, # 26	Seattle	98108	339950	sign manufacturing
28878	CRJ Construction Co	9587 8th Avenue S	Seattle	98108	337110	wood kitchen cabinet and countertop manufacturing
10872	Cunningham Manufacturing Co	318 S Webster Street	Seattle	98108	333995	fluid power cylinder and actuator manufacturing

Table G-13, cont. Facilities near the LDW registered with the Puget Sound Clean Air Agency (PSCAA) for air emissions

PSCAA ID No.	Site Name	Street Address	City	ZIP Code[a]	NAICS Code	Facility Description
13248G	Custom Roofing Inc.	8001 5th Avenue S	Seattle	98108	812930	parking lots and garages
13277G	D&A Exxon	9857 17th Avenue SW	Seattle	98106	447110	gasoline stations with convenience stores
28365	Delta Marine Industries Inc.	1608 S 96th Street	Seattle	98108	336612	boat building
28894	Design Direct Sound II LLC	527 S Monroe Street	Seattle	98108	334310	audio and video equipment manufacturing
29074	Diamond Painting	1818 S 93rd	Seattle	98108	811121	automotive body, paint, and interior repair and maintenance
29076	Diamond Painting	1601 S 92nd Place, Bldg B	Seattle	98108	811121	automotive body, paint, and interior repair and maintenance
28884	DK Auto LLC / Seatown Autoworks	720 S 96th	Seattle	98108	811121	automotive body, paint, and interior repair and maintenance
13174G	Department of Transportation Signals Branch	3700 9th Avenue S (Under I-5)	Seattle	98134	811310	commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance
10654	Duwamish Shipyard Inc.	5658 W Marginal Way SW	Seattle	98106	336611	ship building and repairing
28959	Ecolights Northwest, LLC	1915 S Corgiat Dr	Seattle	98108	423930	recyclable material merchant wholesalers
17794	Emerald City Disposal, NW Waste Ind	54 S Dawson Street	Seattle	98134	484110	general freight trucking, local
28407	Emerald Recycling Inc.	1500 Airport Way S	Seattle	98134	562920	materials recovery facilities
10298G	Eternity Parks, Inc.	7800 Detroit Avenue SW	Seattle	98106	447110	gasoline stations with convenience stores
24085	Fabriform Plastics Inc.	3300 Airport Way S	Seattle	98134	326130	laminated plastics plate, sheet (except packaging), and shape manufacturing
10789	Farwest Paint Mfg Co Inc.	4522 S 133rd Street	Tukwila	98168	325510	paint and coating manufacturing
17127	Flamespray Northwest	250 S Chicago Street	Seattle	98108	332812	metal coating, engraving (except jewelry and silverware), and allied services to manufacturers
16320	Fox Avenue Building LLC	6900 Fox Avenue S	Seattle	98108	424690	other chemical and allied products merchant wholesalers
10345G	Friendly Fuels	14620 Pacific Hwy S	Tukwila	98168	447190	other gasoline stations
13270G	Gary Merlino Construction Co	9125 10th Avenue S	Seattle	98108	812930	parking lots and garages

Table G-13, cont. Facilities near the LDW registered with the Puget Sound Clean Air Agency (PSCAA) for air emissions

PSCAA ID No.	Site Name	Street Address	City	ZIP Code[a]	NAICS Code	Facility Description
13257G	Gateway USA dba Clay Lacy Aviation	8285 Perimeter Rd S	Seattle	98108	488190	other support activities for air transportation
21163	George Heiser Body Inc.	11210 Tukwila Int'l Blvd	Tukwila	98168	811121	automotive body, paint, and interior repair and maintenance
10913	Glacier Northwest Inc., E Marginal	5975 E Marginal Way S	Seattle	98134	327320	ready-mix concrete manufacturing
11872	Glacier Northwest Inc., W Marginal	5900 W Marginal Way SW	Seattle	98106	423320	brick, stone, and related construction material merchant wholesalers
21133	Graphic Display	6545 5th Avenue S	Seattle	98108	339950	sign manufacturing
10817	Graphic Systems Inc.	4493 S 134th Pl	Tukwila	98168	323113	commercial screen printing
10220G	Gray Line Of Seattle Maintenance Facility	4500 W Marginal Way SW	Seattle	98106	447190	other gasoline stations
17311	Hammer Auto Rebuild	1209 S Bailey Street	Seattle	98108	811121	automotive body, paint, and interior repair and maintenance
10926	Heartwood Inc.	1414 S Director Street	Seattle	98108	337127	institutional furniture manufacturing
13045G	Hertz Equipment Rental Corp.	12900 48th Avenue S	Seattle	98168	447190	other gasoline stations
28471	Highline Community Hospital Specialty Center	12844 Military Rd S	Tukwila	98168	622110	general medical and surgical hospitals
21342	Highrise Cabinets Inc.	2755 Airport Way S	Seattle	98134	337110	wood kitchen cabinet and countertop manufacturing
28911	Husky Trucks LLC	11222 East Marginal Way S	Tukwila	98168	811121	automotive body, paint, and interior repair and maintenance
21300	Icon Materials Inc. #2604	1115 S 96th Street	Seattle	98108	324121	asphalt paving mixture and block manufacturing
18101	Industrial Automation Inc.	1421 S 93rd Street	Seattle	98108	333514	special die and tool, die set, jig, and fixture manufacturing
11683	Industrial Container Services - WA, LLC	7152 1st Avenue S	Seattle	98108	811310	commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance

Table G-13, cont. Facilities near the LDW registered with the Puget Sound Clean Air Agency (PSCAA) for air emissions

PSCAA ID No.	Site Name	Street Address	City	ZIP Code[a]	NAICS Code	Facility Description
10254	Ingersoll-Rand M H P	2724 6th Avenue S	Seattle	98134	333923	overhead traveling crane, hoist, and monorail system manufacturing
12152	Interior Environments Inc.	5035 1st Avenue S	Seattle	98134	321918	other millwork (including flooring)
16252	Irish Foundry	45 S Spokane	Seattle	98134	331525	copper foundries (except die-casting)
11124	Jack J A & Sons Inc.	5427 Ohio Avenue S	Seattle	98134	212312	crushed and broken limestone mining and quarrying
13209G	Jackpot #247	5235 Delridge Way	Seattle	98106	447110	gasoline stations with convenience stores
24957	Jonathan Paul's Inc.	60 S Lucille	Seattle	98134	337122	non-upholstered wood household furniture manufacturing
13460	Jorgensen Forge Corp.	8531 E Marginal Way S	Seattle	98108	332111	iron and steel forging
11948	Kelly-Moore Paints	5400 Airport Way S	Seattle	98108	325510	paint and coating manufacturing
16002	Kinder Morgan Liquids Terminal, LLC	2720 13th Avenue SW	Seattle	98134	493110	general warehousing and storage
28402	King County Department of Transportation Metro Transit Division	11911/12100/12200 E Marginal Way S	Seattle	98168	488490	other support activities for road transportation
28502	King County Department of Transportation/Metro Transit, Airport Way	1555 Airport Way S	Seattle	98134	488490	other support activities for road transportation
21407	King County International Airport	7277 Perimeter Rd S	Seattle	98108	481112	scheduled freight air transportation
10844	King County Natural Resources Wastewater Treatment	60 S Spokane Street	Seattle	98134	221320	sewage treatment facilities
13132G	King County Metro Transit Power Dist Headquarters	2255 4th Avenue S	Seattle	98134	488490	other support activities for road transportation
11237	King Electrical Mfg Co	9131 10th Avenue S	Seattle	98108	335211	electric housewares and household fan manufacturing
10812	KJM Electric Co	1048 6th Avenue S	Seattle	98134	811211	consumer electronics repair and maintenance
10829	L&R Services	4712 S 134th Place	Tukwila	98168	811121	automotive body, paint, and interior repair and maintenance
14046	Lafarge North America Inc.	5400 W Marginal Way SW	Seattle	98106	327310	cement manufacturing

Table G-13, cont. Facilities near the LDW registered with the Puget Sound Clean Air Agency (PSCAA) for air emissions

PSCAA ID No.	Site Name	Street Address	City	ZIP Code[a]	NAICS Code	Facility Description
22474	Lee's One Hour Martinizing	14450 34th Avenue S	Tukwila	98168	812320	dry cleaning and laundry services (except coin-operated)
16135	Lehigh Northwest Cement Co	3423 Klickitat Avenue SW	Seattle	98134	327310	cement manufacturing
15345	Liquid Reflections	30 S Horton	Seattle	98134	811121	automotive body, paint, and interior repair and maintenance
15019	Longview Fibre Co	5901 E Marginal Way S	Seattle	98134	322211	corrugated and solid fiber box manufacturing
17445	Maaco Auto Paint, Run & Gun Inc.	13646 1st Avenue S	Burien	98168	811121	automotive body, paint, and interior repair and maintenance
11378	Machinists Inc.	751 S Michigan Street	Seattle	98108	332710	machine shops
11575	Magnetic & Penetrant Services/MAPSCO	8135 1st Avenue S	Seattle	98108	332813	electroplating, plating, polishing, anodizing, and coloring
17365	Malo's Autobody	9827 17th Avenue SW	Seattle	98106	811121	automotive body, paint, and interior repair and maintenance
18479G	Marginal Way ARCO	7200 E Marginal Way S	Seattle	98108	447110	gasoline stations with convenience stores
12177	Meltec Inc. Div of Young Corp.	3444 13th Avenue SW	Seattle	98134	331513	steel foundries (except investment)
18074	Messenger Signs Inc.	37 S Hudson	Seattle	98134	321918	other millwork (including flooring)
28031G	MKT Southpark	9525 14th Avenue S	Des Moines	98108	447190	other gasoline stations
21257	Moeller Design & Development Inc.	620 S Industrial Way	Seattle	98108	541710	research and development in the physical, engineering, and life sciences
24167	Nemco Electric Co	207 S Horton	Seattle	98134	335121	residential electric lighting fixture manufacturing
21230	Neon Sign Systems	6606 Ursula Place South	Seattle	98108	339950	sign manufacturing
24996	New Finishes, Inc.	4235 W Marginal Way SW	Seattle	98106	337124	metal household furniture manufacturing
10049	Nitze-Stagen	2401 Utah Avenue S	Seattle	98134	531120	lessors of nonresidential buildings (except miniwarehouses)

Table G-13, cont. Facilities near the LDW registered with the Puget Sound Clean Air Agency (PSCAA) for air emissions

PSCAA ID No.	Site Name	Street Address	City	ZIP Code[a]	NAICS Code	Facility Description
18428	Non Ferrous Metals	230 S Chicago Street	Seattle	98108	331492	secondary smelting, refining, and alloying of nonferrous metal (except copper and aluminum)
28896	North Star Casteel	3401 Colorado Avenue S	Seattle	98134	331513	steel foundries (except investment)
12334	North Star Casteel Products Inc.	820 S Bradford Street	Seattle	98108	331513	steel foundries (except investment)
11659	Northwest Castings	3411 1st Avenue S	Seattle	98134	331512	steel investment foundries
11960	Nortrak North America Inc.	3422 1st Avenue S	Seattle	98134	336510	railroad rolling stock manufacturing
22360	Nu Tone Cleaners	9654 17th Avenue SW	Seattle	98106	812320	drycleaning and laundry services (except coin-operated)
10281	Nucor Steel Seattle Inc.	2424 SW Andover Street	Seattle	98106	331111	iron and steel mills
18140	NW Building Tech Inc.	215 S Austin	Seattle	98108	321999	all other miscellaneous wood product manufacturing
10563G	Oasis 76	11249 1st Avenue S	Seattle	98168	447190	other gasoline stations
28901	Obayashi Corp.	Construction site at Beacon Avenue & McClennan	Seattle	98134	327320	ready-mix concrete manufacturing
28926	Obayashi Corporation	Construction Site @ Stevens & Airport Way	Seattle	98134	327320	ready-mix concrete manufacturing
10008	Oberto Sausage Co	2005 Airport Way S	Seattle	98134	311612	meat processed from carcasses
17387	Ochsner Auto Body	309 S Cloverdale Street Bldg C-30	Seattle	98108	811121	automotive body, paint, and interior repair and maintenance
11747	Olympic Foundry Inc.	5200 Airport Wy S	Seattle	98108	332812	metal coating, engraving (except jewelry and silverware), and allied services to manufacturers
17825	Olympic Medical Corp.	5900 1st Avenue S	Seattle	98108	339112	surgical and medical instrument manufacturing
18166	Olympic Pipe Line Co, BP Pipelines Co	2444-52 13th Avenue SW	Seattle	98134	486910	pipeline transportation of refined petroleum products
18300	Pac Auto Sales Inc.	12471 Pacific Hwy S	Tukwila	98168	811121	automotive body, paint, and interior repair and maintenance

Table G-13, cont. Facilities near the LDW registered with the Puget Sound Clean Air Agency (PSCAA) for air emissions

PSCAA ID No.	Site Name	Street Address	City	ZIP Code[a]	NAICS Code	Facility Description
10917	Pacific American Commercial Co	7400 2nd Avenue S	Seattle	98108	332812	metal coating, engraving (except jewelry and silverware), and allied services to manufacturers
20765	Pacific Iron and Metal Co	2230 4th Avenue S	Seattle	98134	423930	recyclable material merchant wholesalers
18429	Pacific Rendering Co Inc.	4034 W Marginal Way SW	Seattle	98106	311613	rendering and meat byproduct processing
13293G	Penske Truck Leasing Co LP	12840 48th Avenue S	Tukwila	98168	532120	truck, utility trailer, and rv (recreational vehicle) rental and leasing
21325	Performance Automotive Refinish	9255 16th Avenue SW	Seattle	98106	811121	automotive body, paint, and interior repair and maintenance
22002	Personality Cleaners	13634 1st Avenue S	Burien	98168	812320	drycleaning and laundry services (except coin-operated)
10634G	Petrocard Systems	1617 SW Lander Street	Seattle	98134	447190	other gasoline stations
25121G	Petrocard Systems	3215 4th Avenue S	Seattle	98134	447110	gasoline stations with convenience stores
10342G	Petrocard Systems	9014 14th Avenue S	Seattle	98108	447190	other gasoline stations
18325G	Petrocard Systems	13435 Interurban Avenue S	Tukwila	98168	447110	gasoline stations with convenience stores
17007	Phelps Tire Co	3922 7th Avenue S	Seattle	98134	326212	tire retreading
17397	Phil's Finishing Touch	7401 8th Avenue S	Seattle	98108	811121	automotive body, paint, and interior repair and maintenance
17691	Pioneer Industries	7000 Highland Park Way SW	Seattle	98106	332322	sheet metal work manufacturing
29104	Planetary Fuels LLC	7800 Detroit Avenue SW	Seattle	98106	325199	all other basic organic chemical manufacturing
16333	Poppleton Electric & Machinery Co	969 S Nebraska Street	Seattle	98108	238210	electrical contractors
28993	Premier Autobody Specialist	6411 S 143rd Street	Tukwila	98168	811121	automotive body, paint, and interior repair and maintenance
11860	Puget Sound Coatings Machinists DSR	9220 8th Avenue S	Seattle	98108	332812	metal coating, engraving (except jewelry and silverware), and allied services to manufacturers

Table G-13, cont. Facilities near the LDW registered with the Puget Sound Clean Air Agency (PSCAA) for air emissions

PSCAA ID No.	Site Name	Street Address	City	ZIP Code[a]	NAICS Code	Facility Description
10362G	Rainier Valero	7301 Rainier Avenue S	Seattle	98134	447190	other gasoline stations
28482	Rasmussen Wire Rope & Rigging Co Inc.	8727 5th Avenue S	Seattle	98108	332618	other fabricated wire product manufacturing
21231	Regency Cleaners	8506 14th Avenue S	Seattle	98108	812320	drycleaning and laundry services (except coin-operated)
10153G	Rental Service Corp., RSC	5421 1st Avenue S	Seattle	98108	332312	fabricated structural metal manufacturing
10029	Repair Technology Inc.	400 S 96th Street	Seattle	98108	811310	commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance
10578G	Riveretz's Auto Care	6185 4th Avenue S	Seattle	98108	447190	other gasoline stations
18631G	Rock Enterprises	7132 Delridge Way SW	Seattle	98106	447190	other gasoline stations
16302	S F McKinnon Co Inc.	6520 5th Avenue S	Seattle	98108	321918	other millwork (including flooring)
11656	Saint-Gobain Containers Inc.	5801 E Marginal Way S	Seattle	98134	327213	glass container manufacturing
12166	Scougal Rubber Corp.	6239 Corson Avenue S	Seattle	98108	326299	all other rubber product manufacturing
11934	Seaboard Cabinet Co Inc.	1020 Airport Way S	Seattle	98134	337110	wood kitchen cabinet and countertop manufacturing
10687	Seacast Inc.	207 S Bennett Street	Seattle	98108	331512	steel investment foundries
15144	Seattle Barrell & Cooperage	4716 Airport Way S	Seattle	98108	332439	other metal container manufacturing
28470	Seattle City Light	3613 4th Avenue S	Seattle	98134	335999	all other miscellaneous electrical equipment and component manufacturing
10778G	Seattle ESD, Kent Station	1030 7th Avenue S	Seattle	98134	424710	petroleum bulk stations and terminals
13688	Seattle Industrial Motor & Machine Co (Simmco)	10831 E Marginal Way S	Tukwila	98168	335312	motor and generator manufacturing
17104	Seattle Iron & Metals Corp.	601 S Myrtle Street	Seattle	98108	423930	recyclable material merchant wholesalers
10576G	Seattle Parks & Recreation Dept, South Dist	1600 S Dakota Street	Seattle	98108	447190	other gasoline stations
21262	Seattle Parks & Recreation	4201 West Marginal Way SW	Seattle	98106	924120	administration of conservation programs

Table G-13, cont. Facilities near the LDW registered with the Puget Sound Clean Air Agency (PSCAA) for air emissions

PSCAA ID No.	Site Name	Street Address	City	ZIP Code[a]	NAICS Code	Facility Description
13157G	Seattle Police Dept, South Precinct	3001 S Myrtle Street	Seattle	98108	811198	all other automotive repair and maintenance
21147G	Seattle Police Dept, SW Precinct	2300 SW Webster Street	Seattle	98106	447110	gasoline stations with convenience stores
10500	Seattle Port Marine Maintenance Shop	25 S Horton	Seattle	98134	488310	port and harbor operations
18361	Seattle, City of, Fleet Services, Vehicle Maintenance	805 S Charles Street	Seattle	98134	811121	automotive body, paint, and interior repair and maintenance
13133G	Shell #01-284	12807 Des Moines Memorial Dr S	Seattle	98168	447110	gasoline stations with convenience stores
18765G	Shell #120598	13138 Interurban Avenue S	Tukwila	98168	447190	other gasoline stations
25133G	Shell #120993	2461 4th Avenue S	Seattle	98134	447110	gasoline stations with convenience stores
18137G	Shell #121350	511 S Dearborn	Seattle	98134	447110	gasoline stations with convenience stores
25701G	Shell #121430	600 S Michigan Street	Seattle	98108	447110	gasoline stations with convenience stores
18306G	Shell #121450	6200 Corson Avenue S	Seattle	98108	447110	gasoline stations with convenience stores
16003	Shell Oil Products Seattle Terminal ID#16003	2555 13th Avenue SW	Seattle	98134	424710	petroleum bulk stations and terminals
10316G	Shell, Cottage Grove	5445 Delridge Way SW	Seattle	98106	447190	other gasoline stations
10571	Sherwin-Williams Co, The	9530 10th Avenue South	Seattle	98108	424950	paint, varnish, and supplies merchant wholesalers
28915	Show Quality Metal Finishing	1115 S Elizabeth Street	Seattle	98108	332813	electroplating, plating, polishing, anodizing, and coloring
25127G	Shultz Distributing	465 S Holgate Street	Seattle	98134	447190	other gasoline stations
10259G	Shultz Distributing Inc.	6760 W Marginal Way SW	Seattle	98106	424710	petroleum bulk stations and terminals
15193	Skyline Electric Mfg Co Inc.	3619 7th Avenue S	Seattle	98134	335313	switchgear and switchboard apparatus manufacturing
24988	Sleepless Coffee Corp.	420 S 96th Street, #6	Seattle	98108	311920	coffee and tea manufacturing
28569	South Seattle Community College	6000 16th Avenue SW	Seattle	98106	611519	other technical and trade schools

Table G-13, cont. Facilities near the LDW registered with the Puget Sound Clean Air Agency (PSCAA) for air emissions

PSCAA ID No.	Site Name	Street Address	City	ZIP Code[a]	NAICS Code	Facility Description
25355G	Southpark 76	8819 14th Avenue S	Seattle	98108	447190	other gasoline stations
17434	Southtowne Auto Rebuild	14864 Tukwila - International Blvd S	Tukwila	98168	811121	automotive body, paint, and interior repair and maintenance
22449	Spic N' Span Cleaners #1	652 S Dearborn Street	Seattle	98134	812320	drycleaning and laundry services (except coin-operated)
18232	Starbucks Coffee Co, Seattle Pilot Plant	2401 & 2245 Utah Avenue S	Seattle	98134	311920	coffee and tea manufacturing
14093	Stoneway Concrete, E Marginal, G Merlino	3803 E Marginal Way S	Seattle	98134	327320	ready-mix concrete manufacturing
21315	Sun Auto Unibody	9812 14th Avenue SW	Seattle	98106	811121	automotive body, paint, and interior repair and maintenance
10397	System Seven Repair	10831 Pacific Hwy S	Tukwila	98168	811121	automotive body, paint, and interior repair and maintenance
17303	T & H Autobody	10832 Myers Way S	Seattle	98168	811121	automotive body, paint, and interior repair and maintenance
10522	Terex Utilities West	9426 8th Avenue S	Seattle	98108	333924	industrial truck, tractor, trailer, and stacker machinery manufacturing
13201G	Texaco, Mc Food Store	4800 Beacon Avenue S	Seattle	98108	447110	gasoline stations with convenience stores
12530	Tierney Electrical Mfg Co Inc.	7901 7th Avenue S	Seattle	98108	335311	power, distribution, and specialty transformer manufacturing
12539	Todd Pacific Shipyards Corp.	1801 16th Avenue SW	Seattle	98134	336611	ship building and repairing
10555G	Top Hat Mini Mart	10723 1st Avenue S	Seattle	98168	447190	other gasoline stations
29050	Trade-Marx Signs	818 S Dakota	Seattle	98108	339950	sign manufacturing
14002	Trim Systems	701 S Orchard Street	Seattle	98108	326199	all other plastics product manufacturing
10781G	Tukwila 76 #2611064	13310 Interurban Avenue	Tukwila	98168	447110	gasoline stations with convenience stores
18096	Tully's Coffee Corp.	3100 Airport Way S	Seattle	98134	311920	coffee and tea manufacturing
12608	United Iron Works Inc.	7421 5th Avenue S	Seattle	98108	332312	fabricated structural metal manufacturing
13193G	United Parcel Service	4455 7th Avenue S	Seattle	98108	492210	local messengers and local delivery

Table G-13, cont. Facilities near the LDW registered with the Puget Sound Clean Air Agency (PSCAA) for air emissions

PSCAA ID No.	Site Name	Street Address	City	ZIP Code[a]	NAICS Code	Facility Description
11285	United States Bakery, Franz Northern Div of U S Baking Inc. - 6th Avenue	2901 6th Avenue S	Seattle	98134	311812	commercial bakeries
12105	Univar USA Inc.	4000 1st Avenue S	Seattle	98134	562910	remediation services
18687G	Unocal	6230 Rainier Avenue S	Seattle	98108	447110	gasoline stations with convenience stores
10541	US Postal Service, 4th Avenue Garage	2460 4th Avenue S	Seattle	98134	491110	postal service
21322	US VA Puget Sound Health Care System	1660 S Columbian Way	Seattle	98108	622110	general medical and surgical hospitals
21347	Utility, Inc.	3931 1st Avenue S	Seattle	98134	321999	all other miscellaneous wood product manufacturing
10139	VIOX Corp.	6701 6th Avenue S	Seattle	98108	339999	all other miscellaneous manufacturing
10390	Washington State Air National Guard, Seattle	6736 Ellis Avenue S	Seattle	98108	928110	national security
28572	Washington State Department of Transportation Corson Avenue	6431 Corson Avenue S	Seattle	98108	926120	regulation and administration of transportation programs
11931	WESTEC Industries	8101 7th Avenue S	Seattle	98108	332312	fabricated structural metal manufacturing
18427	Western WA Painters Adv Training Inst	6770 E Marginal Way S	Seattle	98108	611513	apprenticeship training
18749G	White Center Mini Mart	1505 SW Roxbury Street	Seattle	98106	447110	gasoline stations with convenience stores
11731	Williams, O B Co	1939 1st Avenue S	Seattle	98134	321918	other millwork (including flooring)
15120	Young Corp.	3231 Utah Avenue S	Seattle	98134	332999	all other miscellaneous fabricated metal product manufacturing
18123G	76 #03153	14807 1st Avenue S	Burien	98168	447190	other gasoline stations
18637G	76 #2603154 #30116 Paras Inc.	14415 Pacific Hwy S	Tukwila	98168	447190	other gasoline stations
19601G	76, Michigan Street Gas and Wash	551 S Michigan Street	Seattle	98108	447110	gasoline stations with convenience stores
13064G	7-Eleven #22866	14207 Pacific Hwy S	Seattle	98168	447110	gasoline stations with convenience stores

Table G-13, cont. Facilities near the LDW registered with the Puget Sound Clean Air Agency (PSCAA) for air emissions

PSCAA ID No.	Site Name	Street Address	City	ZIP Code[a]	NAICS Code	Facility Description
13029G	7-Eleven #23931	11657 Des Moines Way S	Seattle	98168	447110	gasoline stations with convenience stores

Source: Puget Sound Clean Air Agency (Nehen 2007)

[a] PSCAA data is categorized by zip code. Zip codes 98106, 98108, 98134, and 98168 include the LDW drainage basin as well as some land area outside the LDW drainage basin.

LDW – Lower Duwamish Waterway

NAICS – North American Industry Classification System

PSCAA – Puget Sound Clean Air Agency

Table G-14. Spills within the LDW drainage basin reported to Ecology's Spill Prevention, Preparedness, and Response Division

Site Name	Street Address	Facility ID	Date Report Received	Material Description	Quantity	Unit	Media Affected
110 Auto Supply	720 S Orchard	528566	08/20/02	motor oil	nr	nr	paved roadway
76 Gas Station	2415 Beacon Avenue S	543705	09/23/04	gasoline	2	gallon	paved roadway
AAA Used Tires & Wheels	9004 14th Avenue S	530757	12/11/02	nr	1	gallon	surface water–fresh
Ace Radiator	311 S Brandon Street	429791	07/10/98	chemical	nr	nr	nr
Airgas Norpac Seattle	7700 14th Avenue S	525690	04/10/02	nr	300	gallon	industrial property
Alaska Marine Lines	5600 W Marginal Way	507697	11/16/99	petroleum-oil	2	gallon	surface water–fresh
Alaska Marine Lines	6701 Fox Avenue S	524941	03/11/02	fuel oil	10	gallon	surface water–fresh
Arco #5218	7200 E Marginal Way S	426419	03/24/97	gasoline	nr	nr	paved roadway
Ash Grove Cement West Inc.	3801 E Marginal Way S	547886	05/03/05	hydraulic oil	1	quart	surface water–fresh
		515425	01/12/01	dust	nr	nr	air
		537438	11/19/03	diesel fuel	40	gallon	surface water–fresh
Aspen Paint America Inc.	1128 SW Spokane Street	515016	12/08/00	petroleum- oil	100	gallon	soil
Assoc. Petroleum Products	7303 8th Avenue S	548442	06/01/05	diesel fuel	12	gallon	catch basin
Associated Grocers	3301 S Norfolk	537245	11/05/03	nr	nr	nr	catch basin
Associated Petroleum Product	9650 Martin Luther King Way S	555593	06/05/06	lube oil	6	gallon	storm drain pipe
ATI	8201 Perimeter Road S	542451	07/27/04	jet fuel	15	gallon	paved roadway
Barge Lines	7400 8th Avenue S	513189	08/31/00	nr	1,800	gallon	paved roadway
Basin Oil	8661 Dallas Avenue S	426134	02/18/97	waste/used oil	30	gallon	surface water–fresh
		525740	04/12/02	nr	nr	nr	nr
		425163	10/01/96	diesel fuel	nr	nr	unpaved roadway
Birmingham Steel Corp. (West Seattle)	2424 SW Andover Street	552499	12/28/05	hydraulic oil	1	gallon	paved roadway
Bloch Steel Industries	4580 Colorado Avenue S	526272	05/06/02	transformer oil	100	gallon	soil

Table G-14, cont. Spills within the LDW drainage basin reported to Ecology's Spill Prevention, Preparedness, and Response Division

Site Name	Street Address	Facility ID	Date Report Received	Material Description	Quantity	Unit	Media Affected
Boeing	9725 E Marginal Way S	532044	02/20/03	hydraulic oil	5	gallon	soil
Boeing	9725 E Marginal Way S (Bldg 9-43 parking)	425687	12/20/96	hydraulic oil	1	quart	paved roadway
Boeing	10000 E Marginal Way S	427580	08/15/97	hydraulic oil	1	gallon	paved roadway
Boeing	7500 E Marginal Way	541509	06/16/04	chemical	3	gallon	storm drain pipe
Boeing Developmental Center Norfolk	9725 E Marginal Way	505012	07/02/99	nr	200	gallon	surface water–fresh
		531602	01/21/03	gasoline	10	gallon	catch basin
		549828	08/08/05	chemical	10,000	gallon	surface water–fresh
Boeing Field Chevron	10805 Pacific Hwy S	543495	09/15/04	diesel fuel	nr	nr	paved roadway
Boeing Military Aircraft (DC)	9725 E Marginal Way S	513974	10/07/00	nr	13,000	gallon	surface water–fresh
		522837	12/07/01	waste water	100	gallon	surface water–fresh
Boeing	211 South 102nd ST (leased office bldg)	517721	04/24/01	diesel fuel	nr	nr	paved roadway
Boyer Towing Company	7318 4th Avenue S	534954	07/11/03	diesel fuel	2	quart	surface water-marine
Cement Company	5900 W Marginal Way SW	514914	12/04/00	chemical	50	gallon	soil
Chevron	5940 E Marginal Way	538441	01/14/04	gasoline	7	gallon	nr
City of Seattle	2061 15th Avenue NW	507739	11/16/99	petroleum- oil	5	gallon	surface water–fresh
Coastal Transportation	3629 Duwamish Avenue S	532255	03/04/03	hydraulic oil	1	gallon	catch basin
Cold Storage Facility	206 SW Michigan Street	520432	08/14/01	chemical	1,500	pound	air
Construction	5209 E Marginal Way S	519648	07/19/01	hydraulic oil	3	gallon	surface water–fresh
		505374	07/21/99	hydraulic oil	5	gallon	surface water–fresh
Delta Marine	1608 S 96th (suspected source)	537549	11/25/03	diesel fuel	1	sheen	surface water-marine
Demolition Man	7200 8th Avenue S	527688	07/12/02	motor oil	8	feet	soil
Distribution Co (Pepsi Plant)	2300 26th Avenue S	511159	05/18/00	hydraulic oil	2	gallon	nr

Table G-14, cont. Spills within the LDW drainage basin reported to Ecology's Spill Prevention, Preparedness, and Response Division

Site Name	Street Address	Facility ID	Date Report Received	Material Description	Quantity	Unit	Media Affected
Executive Real Estate	511 SW 102nd	428681	02/07/98	debris/garbage	nr	nr	nr
Former Basin Oil Co Inc. Seattle	8661 Dallas Avenue S	424316	06/13/96	petroleum	200	gallon	soil
Formerly Double Duty Automotive/B & P Automotive	2524 S Jackson Street	531800	02/07/03	petroleum	nr	nr	air
Gas Station	2450 Beacon Avenue S	508930	01/27/00	gasoline	1	gallon	nr
Gas Station	7800 Detroit Avenue SW	512997	08/20/00	gasoline	5	gallon	paved roadway
Gas Station	7200 E Marginal Way S	521009	09/13/01	gasoline	5	gallon	nr
General Construction Co	3840 W Marginal Way SW	511358	05/31/00	petroleum- oil	1	gallon	surface water–fresh
General Construction Company	3838 W Marginal Way SW	541997	07/08/04	hydraulic oil	1	gallon	surface water–fresh
General Transport Co.	402 S Dawson	506414	09/06/99	diesel fuel	150	gallon	nr
Georgetown Shell	6200 Corson	546955	03/22/05	gasoline	1	nr	paved roadway
Glacier NW Inc.	5900 W Marginal Way SW	554251	04/01/06	hydraulic oil	1	cup	surface water–fresh
		542660	08/05/04	lube oil	12	ounce	surface water–fresh
Glacier NW	3838 W Marginal Way S	528982	09/11/02	nr	2,000	ton	surface water–fresh
Harrison Transportation	402 S Dawson Street	428902	03/06/98	chemical	nr	nr	building/structure
Hiawatha Trucking	10430 E Marginal Way	428590	01/25/98	diesel fuel	nr	nr	paved roadway
Holnam Inc., Ideal Division	5400 W Marginal Way SW	510653	05/01/00	diesel fuel	1	sheen	surface water–fresh
Homeowner	2410 S 137th Street	538773	02/02/04	diesel fuel	1	sheen	surface water–fresh
Hurlen Construction	700 S Riverside Dr	427785	09/18/97	fuel oil	10	gallon	surface water–fresh

Table G-14, cont. Spills within the LDW drainage basin reported to Ecology's Spill Prevention, Preparedness, and Response Division

Site Name	Street Address	Facility ID	Date Report Received	Material Description	Quantity	Unit	Media Affected
Island Tug & Barge	3546 West Marginal Way SW	519895	07/30/01	diesel fuel	20	gallon	surface water-marine
		548730	06/15/05	diesel fuel	2	gallon	vessel
		537203	11/03/03	bilge water	1	gallon	surface water–fresh
		516195	02/10/01	diesel fuel	nr	nr	nr
J Harper Contractors	8425 1st Avenue S	503369	03/30/99	nr	nr	nr	surface water–fresh
James Hardie Gypsum	5931 E Marginal Way S	527278	06/23/02	lube oil	1	cup	surface water–fresh
Jorgenson Forge	8531 E Marginal Way S	429633	06/19/98	petroleum	nr	nr	surface water-marine
KC Metro Transit	S 112th/E Marginal Way S	553748	03/05/06	diesel fuel	75	gallon	surface water–fresh
Kenworth Truck Co/Paccar	8801 E Marginal Way S	508909	01/26/00	diesel fuel	2200	gallon	surface water–fresh
		503304	03/20/99	nr	nr	nr	surface water- fresh
KRS Marine	1641 S 92nd Pl	507987	12/01/99	hydraulic oil	2	gallon	soil
L& B Trucking	4123 2nd Avenue S	425527	11/26/96	diesel fuel	nr	nr	surface water–fresh
Leo Fix Transfer & Storage Co Inc.	4700 Denver Avenue S	533902	05/23/03	diesel fuel	50	gallon	paved roadway
		548550	06/04/05	chemical	2	gallon	nr
		554815	04/24/06	antifreeze	1	gallon	industrial property
Linen Service	1414 S Concord Street	512275	07/18/00	chemical	40	gallon	building/structure
Machine Shop	636 S Riverside Dr	520282	08/14/01	petroleum- oil	nr	nr	nr
Manson Construction	6365 1st Avenue S	524366	02/13/02	diesel fuel	15	gallon	surface water–marine
Marine Service	6700 W Marginal Way	513188	08/31/00	diesel fuel	nr	nr	surface water–fresh
Mason Construction Co	5209 E Marginal Way S	547570	04/20/05	petroleum- fuel oil	100	gallon	surface water–fresh
MCS Environmental	8604 Dallas Avenue S	553430	02/15/06	motor oil	3	quart	surface water–fresh
Meth Cook	9247 12th Avenue SW, (sidewalk	511232	05/24/00	chemical	2	container	building/structure

Table G-14, cont. Spills within the LDW drainage basin reported to Ecology's Spill Prevention, Preparedness, and Response Division

Site Name	Street Address	Facility ID	Date Report Received	Material Description	Quantity	Unit	Media Affected
	in front)						
Metro Transit	1st/Spokane	543864	10/05/04	petroleum	6	gallon	storm drain pipe
Metro Transit	Rainer Avenue S/S Walker Street	540689	05/10/04	hydraulic oil	2	gallon	catch basin
MYD Paint Distributing Co.	430 S 96th	556087	06/28/06	chemical	15	gallon	paved roadway
Neighbor	525 26th Avenue S	511309	05/26/00	pesticide	nr	nr	soil
NW Launder Center	2106 Rainier Avenue S	422814	12/29/95	chemical	nr	nr	building/structure
Olympic Tug & Barge	910 SW Spokane Street	520428	08/17/01	petroleum- oil	1	sheen	surface water–fresh
		547750	04/26/05	petroleum	1	sheen	surface water–fresh
		547763	04/27/05	diesel fuel	1	sheen	surface water–fresh
		555360	05/25/06	petroleum	1	sheen	surface water–fresh
Penski Truck Leasing	3443 1st Avenue S	528665	08/27/02	motor oil	nr	nr	soil
Port of Seattle	4140 E Marginal Way	523205	12/21/01	chemical	nr	nr	nr
Praxair	3623 E Marginal Way S	551213	10/12/05	hydraulic oil	1	Cup	paved roadway
Praxair	5300 Denver Avenue S	534695	07/01/03	hydraulic oil	5	gallon	nr
Print Shop	5628 Airport Way S	501595	12/18/98	chemical	nr	nr	surface water–fresh
Private Business	5910 Corson Avenue	514632	11/13/00	nr	nr	nr	nr
Railroad	4700 Denver Avenue S	422616	12/03/95	chemical	5	gallon	building/structure
Railroad	401 S Dawson (Union Pacific Rail Yard)	430361	09/21/98	chemical	40	gallon	soil
Ralph's Concrete Pumping Vacant Lot	1517 Rainier Avenue	513808	10/02/00	petroleum	nr	nr	surface water–fresh
Rental Services Corp.	5421 1st Avenue S	548918	06/22/05	diesel fuel	50	gallon	nr
Resident	8132 9th Avenue SW	511765	06/21/00	chemical	nr	nr	building/structure
Ruan Leasing	3301 S Norfolk Street	535143	07/24/03	diesel fuel	50	gallon	storm drain pipe
Safeway	3520 6th Avenue S	553103	01/28/06	diesel fuel	3	gallon	storm drain pipe

Table G-14, cont. Spills within the LDW drainage basin reported to Ecology's Spill Prevention, Preparedness, and Response Division

Site Name	Street Address	Facility ID	Date Report Received	Material Description	Quantity	Unit	Media Affected
Seattle City Light	4820 18th Avenue SW	516346	02/26/01	transformer oil	30	gallon	soil
Seattle City Light	3613 4th Avenue S	551466	10/28/05	chlorinated oil	1	nr	groundwater
Seattle Housing Authority	4010 19th Avenue SW	429619	06/24/98	chemical	nr	nr	surface water–fresh
Seattle Iron & Metal	601 S Myrtle Street	510912	04/27/00	hydraulic oil	100	gallon	soil
Seattle Metro Transit	23rd Avenue S/S Jackson	525377	03/29/02	diesel fuel	50	gallon	paved roadway
Seattle Metro Transit	17th/Yesler	525375	03/29/02	diesel fuel	nr	nr	soil
Seattle S Transfer Station	8100 2nd Avenue S	546888	03/17/05	hydraulic oil	35	gallon	storm drain pipe
		547194	04/01/05	chemical	nr	nr	nr
		548977	06/23/05	hydraulic oil	5	gallon	paved roadway
Seattle Water Dept.	3030 Airport Way S	425688	12/20/96	hydraulic oil	5	gallon	paved roadway
Seattle Yard	60 Diagonal S	527283	06/24/02	lube oil	75	gallon	railroad track bed
Silver Bay Logging	7760 8th Avenue S	541962	07/07/04	nr	10	drum	nr
		552235	12/08/05	diesel fuel	2	gallon	surface water–fresh
Stan Koch & Sons	3600 W Marginal Way	556429	07/17/06	diesel fuel	75	gallon	paved roadway
Texaco 632321455	600 S Michigan	525837	04/13/02	gasoline	10	gallon	paved roadway
Texaco Station #63-232-0400	6200 Corson Avenue S	514189	10/20/00	gasoline	nr	nr	nr
Transportation	6505 5th Pl S	518258	05/23/01	diesel fuel	nr	nr	paved roadway
Trucking	3429 Colorado Avenue S	501568	12/17/98	diesel fuel	50	gallon	soil
Trucking	9725 E Marginal Way S	504287	05/20/99	diesel fuel	50	gallon	paved roadway
Trucking Company	3200 W Marginal Way SW	510728	04/12/00	petroleum- oil	1	gallon	surface water–fresh
Trucking Company	200 SW Michigan Street	511158	05/18/00	gasoline	1	gallon	nr
Union Pacific RR	4700 Denver Avenue S	554023	03/22/06	nr	nr	nr	paved roadway
		551354	10/20/05	nr	nr	nr	vehicle
Union Pacific Railroad	402 S Dawson Street	509530	03/01/00	diesel fuel	4	gallon	nr

Table G-14, cont. Spills within the LDW drainage basin reported to Ecology's Spill Prevention, Preparedness, and Response Division

Site Name	Street Address	Facility ID	Date Report Received	Material Description	Quantity	Unit	Media Affected
		528501	08/10/02	hydraulic oil	30	gallon	paved roadway
		532391	03/11/03	diesel fuel	10	gallon	soil
		547639	04/21/05	diesel fuel	3	gallon	paved roadway
		522799	12/06/01	hydraulic oil	15	gallon	soil
		532098	02/20/03	diesel fuel	30	gallon	impermeable containment
		533408	04/29/03	hydraulic oil	60	gallon	nr
		534400	06/16/03	diesel fuel	50	gallon	railroad yard
		535808	08/23/03	nr	nr	nr	soil
Union Pacific Railroad	River Street/E Marginal Way	546813	03/14/05	nr	nr	nr	nr
Union Pacific Railroad Diesel Shop	402 S Dawson Street	550971	10/03/05	chlorinated oil	20	gallon	paved roadway
		552309	12/14/05	hydraulic oil	2	gallon	paved roadway
United Parcel Service	7575 Perimeter Rd S	507991	11/18/99	hydraulic oil	20	gallon	paved roadway
Unknown	9520 10th Avenue S (Suite 150)	548731	06/15/05	chemical	nr	nr	impermeable containment
Unknown	1212 S Southern	545630	01/10/05	nr	nr	nr	nr
Unknown	11610 Des Moines Memorial Drive	546167	02/05/05	petroleum	1	nr	storm drain pipe
Unknown	1225 S Southern Street	548359	05/25/05	petroleum	1	sheen	surface water–fresh
Unknown	1421 S 93rd N Highline	547288	04/07/05	diesel fuel	80	gallon/min	vehicle
Unknown	10202 1st Avenue SW	429326	05/08/98	nr	nr	nr	paved roadway
Unknown	2925 S 112th Street	549431	07/19/05	petroleum	1	sheen	surface water–fresh
Unknown	7421 5th Avenue S	537131	10/29/03	nr	4	drum	paved roadway
Unknown	3443 W Marginal Way SW	551679	11/03/05	chemical	1	nr	nr
Unknown	107th/Beacon Avenue	526664	05/28/02	petroleum- oil	4	container	paved roadway

Table G-14, cont. Spills within the LDW drainage basin reported to Ecology's Spill Prevention, Preparedness, and Response Division

Site Name	Street Address	Facility ID	Date Report Received	Material Description	Quantity	Unit	Media Affected
Unknown	122 River Street	504483	06/02/99	diesel fuel	50	gallon	surface water–fresh
Unknown	10847 24th Avenue S (by Duwamish)	506181	08/25/99	chemical	nr	nr	nr
Unknown	16 S Michigan Street	516998	03/26/01	diesel fuel	nr	nr	soil
Unknown	9999 8th Avenue S	519194	06/26/01	chemical	nr	nr	nr
Unknown	1660 S Columbian Way	519886	07/21/01	waste/used oil	4	quart	paved roadway
Unknown	S 112th/E Marginal Way	520371	08/02/01	chemical	nr	nr	nr
Unknown	10443 2nd Pl SW	520236	08/10/01	chemical	nr	nr	nr
		520950	09/06/01	chemical	nr	nr	building/structure
Unknown	4033 16th Avenue SW	521949	10/30/01	chemical	10	gallon	nr
Unknown	7th S/Chicago S	524155	02/06/02	chemical	nr	nr	nr
Unknown	8155 1st Avenue S	524203	02/08/02	diesel fuel	2	gallon	paved roadway
Unknown	11711 8th Avenue S	529003	09/08/02	chemical	nr	nr	nr
Unknown	707 S Orcas Street	530269	11/15/02	nr	nr	nr	nr
Unknown	5900 W Marginal Way	509526	03/01/00	petroleum	1	sheen	surface water–fresh
		529630	10/16/02	nr	5	ton	surface water–fresh
Unknown	7410 5th Avenue S	537147	10/29/03	nr	nr	nr	surface water–fresh
Unknown	1801 S 93rd Street	537573	11/26/03	diesel fuel	1	sheen	surface water–fresh
		540714	05/10/04	diesel fuel	nr	nr	surface water–fresh
Unknown	1050 SW Spokane Street	540198	04/09/04	nr	5	drips/ min	nr
Unknown	4700 Denver Avenue	542918	08/15/04	nr	nr	nr	nr
		549737	09/03/05	nr	1	nr	nr
Unknown	7814 8th Avenue S	547258	04/05/05	petroleum	1	sheen	surface water–fresh
Unknown	46th Avenue S/S Victor Street	510235	04/07/00	nr	55	gallon	soil

Table G-14, cont. Spills within the LDW drainage basin reported to Ecology's Spill Prevention, Preparedness, and Response Division

Site Name	Street Address	Facility ID	Date Report Received	Material Description	Quantity	Unit	Media Affected
	(corner)						
Unknown	9725 E Marginal Way S	549430	07/19/05	petroleum	1	sheen	surface water–fresh
Unknown	6545 5th Avenue S	506550	09/15/99	chemical	nr	nr	nr
Unknown	700 S Riverside Avenue	427764	09/13/97	diesel fuel	600	gallon	surface water–fresh
Unknown	5961 Corson Avenue S	551708	11/09/05	diesel fuel	nr	nr	storm drain pipe
Unknown	1608 S 96th	427331	07/22/97	petroleum	nr	nr	surface water–fresh
Unknown	10427 18th Avenue S	425547	12/01/96	petroleum- oil	4	quart	soil
Unknown	6700 W Marginal Way SW	553344	02/10/06	hydraulic oil	15	gallon	paved roadway
Unknown	523 S Riverside Dr	553605	02/28/06	nr	nr	nr	surface water–fresh
Unknown	Des Moines Memorial Dr/S 96th	554950	05/05/06	nr	nr	nr	paved roadway
Unknown	10231 E Marginal Way	556005	06/23/06	diesel fuel	nr	nr	soil
Unknown	4053 23rd Avenue SW	555052	05/10/06	chemical	nr	nr	nr
Unknown	10710 49th Avenue S	546003	01/31/05	chemical	1	drum	nr
Unknown	S Hudson/E Marginal Way	546311	02/12/05	nr	nr	nr	nr
Unknown	8600 E Marginal Way	429109	04/09/98	fuel oil	5	gallon	surface water–fresh
Unknown	5000 E Marginal Way	506693	09/23/99	nr	55	gallon	paved roadway
Unknown	7th Avenue S/S Cloverdale	507333	10/19/99	nr	5	cylinder	soil
Unknown	6701 Fox Avenue S	507660	11/12/99	hydraulic oil	1	quart	surface water–fresh
Unknown	9401 12th Avenue SW	511008	05/15/00	chemical	nr	nr	nr
Unknown	8106 13th Avenue SW (in alley behind)	511610	06/09/00	chemical	nr	nr	nr
Unknown	11500 E Marginal Way S	511985	07/03/00	chemical	17	gallon	paved roadway
Unknown	10237 10th Avenue S	516557	03/03/01	lube oil	nr	nr	soil
Unknown	7911 11th SW	516834	03/16/01	chemical	nr	nr	nr
Unknown	8801 E Marginal Way S	522646	11/19/01	diesel fuel	5	gallon	paved roadway

Table G-14, cont. Spills within the LDW drainage basin reported to Ecology's Spill Prevention, Preparedness, and Response Division

Site Name	Street Address	Facility ID	Date Report Received	Material Description	Quantity	Unit	Media Affected
Unknown	9039 12th Avenue SW	526827	06/03/02	chemical	nr	nr	nr
Unknown	9892 40th Avenue S	526632	05/24/02	nr	nr	nr	paved roadway
Unknown	6111 12th Avenue S	528360	08/11/02	debris/garbage	nr	nr	nr
Unknown	1st Avenue S/S Spokane	530636	12/06/02	chemical	1	quart	paved roadway
Unknown	3646 W Marginal Way SW	531757	02/06/03	diesel fuel	1	sheen	surface water–fresh
Unknown	3568 W Marginal Way SE	532657	03/24/03	nr	3	drum	soil
Unknown	8100 2nd Avenue S	531707	01/31/03	chemical	1	cylinder	nr
		531952	02/18/03	chemical	2	cylinder	nr
Unknown	2706 14th Avenue S	533927	05/25/03	gasoline	1	quart	soil
Unknown	705 S Fidalgo	539011	02/16/04	nr	10	gallon	nr
Unknown	6216 Corson Avenue S	547990	05/09/05	odor	1	nr	air
		540223	04/14/04	gasoline	nr	nr	building/structure
Unknown	8604 Dallas Avenue S	541245	06/04/04	diesel fuel	1,000	gallon	surface water–fresh
Unknown	8605 Dallas Avenue S- South Park Marina	517697	04/21/01	nr	nr	nr	air
Unknown	22nd Avenue S/S Norman Street	524333	02/14/02	chemical	3	gallon	paved roadway
Unknown	21st Avenue S/Plum Street	512561	08/02/00	nr	55	gallon	unpaved roadway
Unknown	707 Rainier Avenue S	523394	01/04/02	nr	2	drum	nr
Unknown	1743 26th Avenue S	426165	02/17/97	sewage/sludge	nr	nr	soil
Unknown	2301 22nd Avenue S	549360	07/14/05	hydraulic oil	25	gallon	nr
Unknown	1801 S McClellan	500950	11/06/98	diesel fuel	40	gallon	soil
Unknown	2600 25th Avenue S (Kent)	430030	08/19/98	nr	nr	nr	soil
Unknown	S Lander/Airport Way	519160	06/08/01	chemical	nr	nr	nr
Unknown	2801 Martin Luther King Jr. Way	531093	01/01/03	gasoline	1	sheen	paved roadway
Unknown	14043 24th Avenue S	551613	11/02/05	chemical	nr	nr	nr

Table G-14, cont. Spills within the LDW drainage basin reported to Ecology's Spill Prevention, Preparedness, and Response Division

Site Name	Street Address	Facility ID	Date Report Received	Material Description	Quantity	Unit	Media Affected
Unknown	24th Avenue S/138th	553368	02/13/06	petroleum	1	sheen	soil
Unknown	13725 24th Avenue S	553777	03/08/06	petroleum- oil	5	gallon	surface water–fresh
Unknown	2450 S 142nd	532763	03/30/03	chemical	nr	nr	nr
Unknown	11825 Glendale Way S	529571	10/14/02	nr	nr	nr	paved roadway
Unknown Man Repairing Car	2709 S Main Street	509462	02/26/00	petroleum- oil	nr	nr	paved roadway
Vessel Owner	3846 6th Avenue	530787	12/13/02	diesel fuel	nr	nr	surface water–fresh
Vessel Snopac	6701 S Fox Avenue	422093	09/13/95	hydraulic oil	25	gallon	surface water–fresh
Waste Management Seattle	6700 W Marginal Way SW	545752	01/18/05	hydraulic oil	3	gallon	nr
Waste Management Seattle	S 128th/20th Avenue S	540440	04/27/04	hydraulic oil	15	gallon	paved roadway
Waste Management Seattle	750 Rainier Avenue S	536060	09/09/03	hydraulic oil	5	gallon	nr
Waste Mgt	5900 1st Avenue S	554984	05/08/06	hydraulic oil	25	gallon	storm drain pipe
Western Marine Construction	7319 4th Avenue S	529478	10/09/02	hydraulic oil	1	gallon	surface water–fresh
Westwood Shipping Lines Inc.	3200 W Marginal Way SW	529864	10/26/02	nr	nr	nr	surface water–fresh

Source: EDR (2006a, c, d)

LDW – Lower Duwamish Waterway

nr – not reported by EDR. Data field for missing information designated as "other", "unknown," "not reported," etc. in Ecology's SPILLS database according to EDR report.

Table G-15. Spills reported within the LDW drainage basin investigated by the Seattle Public Utilities spill response program

Spill Location	Spill Date	Material Description	Quantity	Primary Media Affected	Secondary Media Affected
1010 8th Avenue S	3/18/2004	diesel fuel (inc. sheen)	1-5 gallons	drain/CB	street
1010 Charles Street (City)	9/30/2005	hydraulic fluid	unknown	street	nr
109 Martin Luther King Jr. Way E.	11/26/2005	unknown	100+ gallons	drain/CB	street
10th Avenue S & S Cloverdale Street	9/20/2003	gasoline	1-5 gallons	soil	drain/CB
10th Avenue S & S King	11/1/1999	unknown	unknown	drain/CB	nr
10th Avenue S & S Weller	11/3/1999	unknown	unknown	nr	nr
1206 S Southern Street	4/5/2005	diesel fuel (inc. sheen)	unknown	water bodies	nr
1212 S Southern Street	1/7/2005	unknown	100+ gallons	water bodies	nr
12th Avenue S & S Jackson	6/30/2004	cooking oil/grease	<1 gallon	street	nr
1300 S Dearborn Street	4/19/2000	unknown	1-5 gallons	drain/CB	nr
1301 Rainier Avenue S	1/2/2004	unknown	100+ gallons	drain/CB	street
14th Avenue S & S Jackson	7/11/2005	unknown	1-5 gallons	street	nr
1500 block of Occidental Avenue S	2/11/2005	unknown	<1 gallon	street	nr
1502 E. Yesler Way	9/9/2004	gasoline	1-5 gallons	drain/CB	street
1548 First Avenue S	9/30/2005	paint--latex	6-20 gallons	street	nr
1555 4th Avenue S	7/15/2004	diesel fuel (inc. sheen)	21-50 gallons	street	nr
15th Avenue E & E Valley Street	5/9/2003	hydraulic fluid	1-5 gallons	drain/CB	nr
1st Avenue S & S Lander Street	1/11/2004	diesel fuel (inc. sheen)	1-5 gallons	street	drain/CB
20 Avenue S & S Plum Street	6/9/2000	motor oil	<1 gallon	drain/CB	street
2011 24th Avenue S	2/11/2004	paint thinner/solvent	unknown	nr	nr
2025 4th Avenue	9/12/2000	hydraulic fluid	1-5 gallons	drain/CB	street
2025 Airport Way S	12/6/2006	unknown	unknown	soil	nr
2032 33rd Avenue S	12/17/1999	motor oil	1-5 gallons	soil	nr
2200 1st Avenue S	12/16/2006	motor oil	<1 gallon	drain/CB	nr
230 S Chicago Street	10/18/2005	diesel fuel (inc. sheen)	6-20 gallons	street	nr
23rd Avenue S & S Jackson Street	3/26/2005	hydraulic fluid	<1 gallon	drain/CB	street
2415 S Dawson Street	4/14/2003	paint--latex	<1 gallon	drain/CB	nr

Table G-15, cont. Spills reported within the LDW drainage basin investigated by the Seattle Public Utilities (SPU) spill response program

Spill Location	Spill Date	Material Description	Quantity	Primary Media Affected	Secondary Media Affected
2468 S College Street	11/15/2004	anti-freeze	1-5 gallons	soil	street
2535 Airport Way S	4/29/2005	diesel fuel (inc. sheen)	6-20 gallons	drain/CB	nr
26 Avenue SW & W Marginal Way SW	7/20/2000	heating oil	100+ gallons	drain/CB	street
2700 Airport Way S (OCC employee parking lot)	3/1/2005	motor oil	1-5 gallons	street	drain/CB
2700 Airport Way S (OCC)	4/13/2006	diesel fuel (inc. sheen)	1-5 gallons	vehicles/equipment	nr
2700 Airport Way S; OCC Warehouse	9/26/2000	paint--latex	1-5 gallons	nr	nr
2701 Utah Avenue S Home Depot	12/2/2004	motor oil	1-5 gallons	drain/CB	nr
2715 S Judkins Street	4/21/2006	unknown	unknown	street	nr
2724 6th Avenue S	9/4/2003	unknown	unknown	nr	nr
2805 Rainier Avenue S	10/2/2003	unknown	21-50 gallons	drain/CB	nr
2925 4th Avenue S	12/10/1999	paint--latex	1-5 gallons	drain/CB	nr
300 S Washington	3/16/2006	motor oil	<1 gallon	drain/CB	nr
3201 S Hanford Street	11/15/1999	gasoline	1-5 gallons	drain/CB	street
35th S & S Jackson	8/9/2006	unknown	<1 gallon	drain/CB	nr
36th Avenue & Adams Street	12/8/2004	motor oil	<1 gallon	drain/CB	street
4200 Airport Way S (Seattle Department of Transportation Lucky Jim Facility)	5/24/2004	motor oil	1-5 gallons	nr	nr
4208 Rainier Avenue S	5/17/2006	cooking oil/grease	21-50 gallons	drain/CB	nr
44 S Hanford	1/8/2006	hydraulic fluid	6-20 gallons	drain/CB	nr
4400 37th Avenue S	8/21/2005	hydraulic fluid	21-50 gallons	drain/CB	street
4401 Sears Dr. S	4/3/1999	motor oil	1-5 gallons	drain/CB	nr
4437 42nd Avenue SW	11/2/2005	hydraulic fluid	<1 gallon	street	nr
45th Avenue S & S Fletcher Street	9/30/2003	unknown	unknown	drain/CB	nr
4605 S Raymond Street	7/19/2006	unknown	unknown	drain/CB	nr
46th Avenue S & S Thistle	6/29/2000	hydraulic fluid	1-5 gallons	drain/CB	nr
4735 E. Marginal Way S	12/9/2004	motor oil	unknown	nr	nr
500 S Myrtle	9/26/2003	heating oil	6-20 gallons	street	nr
5027 24th Place S	7/12/2005	unknown	6-20 gallons	drain/CB	street
5400 4th Avenue S	9/8/2004	gasoline	21-50 gallons	drain/CB	street

Table G-15, cont. Spills reported within the LDW drainage basin investigated by the Seattle Public Utilities (SPU) spill response program

Spill Location	Spill Date	Material Description	Quantity	Primary Media Affected	Secondary Media Affected
5510 Martin Luther King Jr. Way S	4/27/2006	motor oil	unknown	drain/CB	nr
5705 Airport Way S	9/30/2004	diesel fuel (inc. sheen)	1-5 gallons	street	nr
5820 Oakhurst Rd. S	11/5/1999	hydraulic fluid	6-20 gallons	drain/CB	water bodies
5950 6th Avenue S	9/21/2006	diesel fuel (inc. sheen)	6-20 gallons	drain/CB	street
59th Avenue S & S Norfolk Street	12/29/1999	motor oil	1-5 gallons	drain/CB	nr
5th Avenue S & S Holden Street	3/2/2004	unknown	<1 gallon	street	nr
5th Avenue S & S Lucille Street	4/25/2006	diesel fuel (inc. sheen)	21-50 gallons	street	nr
5th Avenue S & S Michigan Street	9/10/2003	diesel fuel (inc. sheen)	21-50 gallons	street	nr
600 S Michigan Street	1/14/2003	gasoline	1-5 gallons	drain/CB	nr
601 S Andover Street	7/1/2004	unknown	unknown	soil	nr
6216 Corson Avenue S	4/14/2004	gasoline	unknown	soil	nr
6748 40th Avenue S	11/25/2005	motor oil	unknown	nr	nr
6th Avenue S & S Orcas Street	5/17/1999	diesel fuel (inc. sheen)	51-100 gallons	drain/CB	street
714 Charles Street	12/10/2004	diesel fuel (inc. sheen)	1-5 gallons	soil	drain/CB
715 23rd Avenue	5/19/2005	paint--latex	<1 gallon	drain/CB	nr
7224 1st Avenue S	8/16/2004	unknown	100+ gallons	water bodies	drain/CB
7420 5th Avenue S	10/29/2003	diesel fuel (inc. sheen)	51-100 gallons	street	nr
7430 Rainier Avenue S	2/18/2006	sewage	51-100 gallons	drain/CB	nr
7800 2nd Avenue S	3/11/2003	diesel fuel (inc. sheen)	1-5 gallons	drain/CB	street
7901 2nd Avenue S	7/23/2000	unknown	unknown	street	plants
7th Avenue S & S Court Street	9/13/2000	motor oil	21-50 gallons	nr	nr
800 Rainier Avenue S	12/13/1999	diesel fuel (inc. sheen)	100+ gallons	drain/CB	nr
8101 1st Avenue S	10/20/2006	motor oil	1-5 gallons	street	nr
8201 10th Avenue S	4/15/2006	diesel fuel (inc. sheen)	1-5 gallons	street	nr
8616 16th Avenue S	7/2/2005	motor oil	6-20 gallons	street	nr
8620 16th Avenue SE	7/9/2005	motor oil	6-20 gallons	street	nr
8th Avenue S & S Portland	1/4/2006	unknown	6-20 gallons	drain/CB	street
9021 5th Avenue S	4/16/2006	diesel fuel (inc. sheen)	100+ gallons	drain/CB	street
920 S Doris	7/10/2003	unknown	unknown	street	nr

Table G-15, cont. Spills reported within the LDW drainage basin investigated by the Seattle Public Utilities (SPU) spill response program

Spill Location	Spill Date	Material Description	Quantity	Primary Media Affected	Secondary Media Affected
9228 !0th Avenue S	7/9/2004	unknown	1-5 gallons	soil	nr
9229 10th Avenue S	2/11/2005	unknown	6-20 gallons	drain/CB	street
950 S Nebraska (behind Julie May Saloon)	7/20/2006	cooking oil/grease	51-100 gallons	drain/CB	nr
9806 60th Avenue S	4/10/2006	unknown	<1 gallon	street	nr
Charles Street Complex (1010 Charles Street)	10/5/2005	paint thinner/solvent	1-5 gallons	street	nr
Charles Street Fuel Island	9/5/2006	gasoline	1-5 gallons	street	nr
Control Works	6/18/2003	hydraulic fluid	21-50 gallons	soil	nr
Delridge Way SW & SW Orchard	1/12/1999	hydraulic fluid	unknown	drain/CB	street
E. Marginal Way S & S Hudson Street	5/31/2006	unknown	<1 gallon	drain/CB	nr
Ellis Yard	2/17/2006	hydraulic fluid	unknown	nr	nr
Fifth Avenue S & S Brandon Street	10/6/2005	motor oil	1-5 gallons	drain/CB	street
King County. International Airport	12/18/1999	gasoline	100+ gallons	drain/CB	nr
Lake Washington Blvd. S & S Juneau Street	1/6/2003	heating oil	21-50 gallons	water bodies	drain/CB
Martin Luther King Way S & S Columbian Way	12/28/2005	diesel fuel (inc. sheen)	<1 gallon	drain/CB	street
Martin Luther King Way S & S Norfolk Street	12/19/2005	diesel fuel (inc. sheen)	1-5 gallons	drain/CB	street
Martin Luther King Way S & S Lane Street	4/3/2005	gasoline	6-20 gallons	drain/CB	street
Myrtle and Ellis Street, behind fire station	2/18/2004	diesel fuel (inc. sheen)	1-5 gallons	soil	nr
Myrtle Street S & Ellis Avenue S (Ellis Yard)	12/31/1998	hydraulic fluid	1-5 gallons	soil	drain/CB
OCC	2/19/2003	diesel fuel (inc. sheen)	unknown	street	drain/CB
OCC 2700 Airport Way S	5/11/2005	hydraulic fluid	<1 gallon	street	nr
Occidental Avenue S & S River Street	6/2/1999	motor oil	100+ gallons	drain/CB	soil
Olsen Place SW & SW Cambridge Place	4/30/2004	gasoline	1-5 gallons	drain/CB	nr
Rainier Avenue S & S Genessee	7/10/2006	motor oil	unknown	street	nr
Rainier Avenue S & S Myrtle Street	8/16/2004	anti-freeze	unknown	street	nr
Rainier Avenue S & 57th Avenue S	9/30/2006	unknown	6-20 gallons	street	drain/CB
Rainier Avenue S & S Orcas Street	1/4/2005	paint--latex	1-5 gallons	street	nr
Rainier Avenue S & I-90 (S-bound exit ramp)	11/26/2003	diesel fuel (inc. sheen)	unknown	street	drain/CB
Rainier Avenue S & S Alaska Street	1/31/2003	motor oil	<1 gallon	drain/CB	nr

Table G-15, cont. Spills reported within the LDW drainage basin investigated by the Seattle Public Utilities (SPU) spill response program

Spill Location	Spill Date	Material Description	Quantity	Primary Media Affected	Secondary Media Affected
Rainier Avenue S & S Henderson	6/22/2006	diesel fuel (inc. sheen)	6-20 gallons	street	nr
Rainier Avenue S & Seward Park Avenue S	5/9/2006	anti-freeze	1-5 gallons	street	nr
S River Street / 3rd Av S	10/21/2000	unknown	6-20 gallons	drain/CB	nr
S Alaska Street & E. Marginal Way S	4/13/2003	anti-freeze	<1 gallon	drain/CB	street
S Anderson Street & Duwamish River	5/12/2003	unknown	unknown	water bodies	nr
S Columbian Way & S Spokane Street	1/3/2005	hydraulic fluid	<1 gallon	street	nr
S Dearborn Street & S Lane Street -- Goodwill Industries	4/7/2003	motor oil	51-100 gallons	street	drain/CB
S Holly Street & Holly Terrace S	6/19/2006	unknown	<1 gallon	drain/CB	nr
S Lucille Street & E. Marginal Way S	5/6/2004	unknown	unknown	street	nr
S Michigan Street & Corson Avenue S	12/16/2003	hydraulic fluid	1-5 gallons	drain/CB	street
S Myrtle Street & Ellis Avenue S	2/14/2000	diesel fuel (inc. sheen)	6-20 gallons	soil	nr
S Myrtle Street & 38th Avenue S	3/28/2005	gasoline	1-5 gallons	drain/CB	street
S Nevada Street & E. Marginal Way S	9/30/2005	unknown	21-50 gallons	drain/CB	street
S Oregon Street & E. Marginal Way S	11/10/1999	diesel fuel (inc. sheen)	unknown	water bodies	drain/CB
S Ryan Street & Renton Avenue S	2/14/2006	motor oil	unknown	drain/CB	nr
South Recyclilng & Disposal Station	11/14/2004	hydraulic fluid	1-5 gallons	nr	nr
South Recycling & Disposal Station	11/16/2004	unknown	1-5 gallons	drain/CB	nr
South Transfer Station	7/8/2004	hydraulic fluid	6-20 gallons	drain/CB	nr
South Transfer Station	3/17/2005	hydraulic fluid	21-50 gallons	street	nr
SRDS	1/22/2005	hydraulic fluid	1-5 gallons	vehicles/equipment	nr
SRDS	11/7/2004	diesel fuel (inc. sheen)	1-5 gallons	drain/CB	nr
SRDS	4/5/2006	hydraulic fluid	100+ gallons	drain/CB	vehicles/equipment
SRDS	6/23/2005	hydraulic fluid	21-50 gallons	nr	nr
SRDS -- Scale House	8/26/2005	hydraulic fluid	1-5 gallons	street	nr
SRDS -- Tipping Floor	11/22/2004	hydraulic fluid	6-20 gallons	nr	nr
SRDS (8100 2nd Avenue S)	4/4/2006	unknown	1-5 gallons	street	nr
Utah Avenue S & S Bennett Street	12/6/2005	motor oil	21-50 gallons	drain/CB	street
Utah Avenue S & S Bennett Street	10/5/2004	motor oil	51-100 gallons	drain/CB	nr
West Seattle Reservoir Pump House	7/30/1999	motor oil	1-5 gallons	nr	nr

Table G-15, cont. Spills reported within the LDW drainage basin investigated by the Seattle Public Utilities (SPU) spill response program

Source: City of Seattle (Schmoyer 2007)
CB – catch basin
SPU – Seattle Public Utilities
nr – not reported
NRDS – North (Seattle) Recycling and Disposal Station
SRDS – South (Seattle) Recycling and Disposal Station

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Appendix H. LDW Outfall Locations

Acronyms ii

Glossary of Outfall Nomenclature iii

Introduction 1

TABLE H-1. OUTFALLS ORDERED BY ID NUMBER *3*

TABLE H-2. OUTFALLS ORDERED BY OWNER/OUTFALL OPERATOR *28*

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Acronyms

Acronym	Definition
ABS	acrylonitrile butadiene styrene
CFS	cubic feet per second
CMP	composite construction
CSO	combined sewer overflow
DI	diameter
E	east
Ecology	Washington State Department of Ecology
EOF	emergency overflow
EPA	US Environmental Protection Agency
FS	Floyd Snider
gpm	gallons per minute
GPS	global positioning system
Herrera	Herrera Environmental
ID	identification
KC	King County
LDW	Lower Duwamish Waterway
na	not available
No.	number
NPDES	National Pollutant Discharge Elimination System
PVC	polyvinyl chloride
RCP	reinforced concrete pipe
RI	remedial investigation
RM	river mile
SCAP	source control action plan
SCL	Seattle City Light
SD	storm drain
SPU	Seattle Public Utilities
W	west
WA	Washington
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation

Glossary of Outfall Nomenclature

Term	Definition
CSO	Overflow point on a publicly owned and maintained combined sewer system. Combined sewers convey both sanitary wastewater and stormwater runoff. Overflows generally occur only during large storm events when the capacity of the combined sewer is exceeded and not all flow can be successfully conveyed to a treatment plant. Under these conditions, excess flow is discharged to a nearby receiving water body to prevent sewage backups.
EOF[a]	Overflow point on a combined or sanitary sewer, generally located at a pump station. Discharges are not storm related. Overflows occur as a result of mechanical failure, pipe obstruction, or power failure. Pump stations in LDW are equipped with backup generators.
CSO/SD or EOF/SD	Shared outfall that serves as both a combined sewer overflow or emergency overflow and storm drain system.
Public storm drain	Storm drains that are required to have coverage under an NPDES municipal stormwater permit (i.e., City of Seattle, King County, Port of Seattle, and WSDOT).
Private storm drain	Storm drains that collect storm and surface waters from areas in addition to those mentioned above. Discharges from these facilities may be covered under the general industrial NPDES permit, individual stormwater permits, or other site-specific requirements governing discharge to surface water bodies. In some cases, they may not be permitted.
Stream, channel or swale	Includes locations of open-air, convergent discharges into the waterway.
Abandoned outfall	Outfalls that are plugged or have existing documentation to show that an upland pipe has been disconnected.
Not an outfall	Location previously identified as an outfall in the 2003 survey; subsequent in-field investigation or identification of historical information determined the location was not an outfall (e.g., non-contact cooling water intake pipes and pressure release pipes located in a bulkhead in Slip 6).
Pipe of unresolved origin and/or use	Pipe identified as an outfall by Herrera (2004) but was of undetermined origin and/or use.

[a] This designation is also used to identify an overflow feature from a reservoir, as appropriate. Reservoir overflows are not associated with discharges from the combined or sanitary sewer.

Introduction

This appendix lists outfalls that have been identified in the Lower Duwamish Waterway (LDW), and their current status, use, and ownership information. The information included in this appendix was derived from several different sources. The majority of the information is from a low-tide outfall survey of the LDW study area conducted by Herrera Environmental (Herrera) on behalf of Seattle Public Utilities (SPU) in May 2003 (Herrera 2004). The survey was performed to locate, inspect, and collect data on the horizontal and approximate vertical locations of outfalls in the LDW. The survey also collected information on the size and composition of the outfalls and estimated, when feasible, the rate of flow (in gallons per minute [gpm]) exiting each outfall at the time of the survey. The survey area included the east and west shorelines of the LDW from the south end of Harbor Island to approximately river mile (RM) 5.0 (near the Norfolk combined sewer overflow/storm drain [CSO/SD]).

Outfalls visible during low tide were surveyed using Real Time Kinematic GPS to minimize the need to access private property (Herrera 2004). The survey was conducted in accordance with state standards for land boundary and geodetic control surveys under Washington Administrative Code (WAC) 3320130. Control points were established at 13 locations prior to the survey, and a theodolite was used in areas where the global positioning system (GPS) reception was poor (e.g., outfalls located beneath piers and near buildings). The relative accuracy for horizontal and vertical measurements is estimated at one foot in 10,000 (± 0.01%).

Outfall locations were checked using information from City of Seattle inspection files and Washington State Department of Ecology (Ecology) National Pollutant Discharge Elimination System (NPDES) permit files, when available. These records were also used to establish outfall ownership and use. When no records were available to corroborate outfall location/use, outfalls were generally designated as "unknown." However, the owner of the property on which the outfall is located was noted in the database. Outfalls located on or immediately offshore of a given property may not necessarily be the responsibility of the owner of that property, and there may have been changes in property ownership subsequent to the time of the 2003 outfall survey. LDWG has made no attempt to verify (or update) the "owner/operator" information provided by Herrera. Future site-specific investigations, including SPU's and Ecology's inspection programs, may provide additional outfall information.

Additional information from other sources was combined with the Herrera survey to provide the most up-to-date information. These sources included information from the Phase 1 RI (Windward 2003), and outfall information from Ecology, US Environmental Protection Agency (EPA), City of Seattle, City of Tukwila, The Boeing Company (Boeing), Port of Seattle, and King County (Riley 2008) records. Boeing conducted an internal records review to further evaluate the current status and ownership of the outfalls on their properties along the LDW, and completed an in-field inspection of the

shoreline along Boeing Plant 2 and the Boeing Developmental Center to identify and confirm outfall locations noted in the 2003 survey. In most cases (Boeing being an exception), LDWG members did not attempt to verify the outfall coordinates provided by Herrera. During this effort, Boeing identified additional outfall locations that had not been reported in the 2003 survey and noted other pipes that were either abandoned or improperly classified as outfalls by Herrera (2004).

In total, approximately 250 individual outfalls were identified within the LDW study area. These outfalls were categorized using the classification nomenclature presented in Table 9-7 in the main body of the RI. Maps 9-8a through 9-8f in the main body of the RI present the outfall locations, their classification, and ownership status.

The information presented in this appendix is meant to serve as an inventory of identified outfalls presently located within the LDW. The presence of an outfall within this appendix does not imply that it is a potential source of contamination to the LDW. The information in this appendix is only as accurate as the source information reviewed during compilation, which included the 2003 outfall survey completed by Herrera and subsequent confirmation investigations completed by LDWG members. Errors may exist for several reasons.

During the 2003 outfall survey, no attempt was made to verify whether each and every pipe observed during the survey was in fact an outfall. The outfall flow rates visually observed during the 2003 survey may have been influenced by recent rainfall events and tidal stages, among other variables, specific to the time of the survey, and may not represent "normal" or average flow rates. In addition, the outfall configuration of the LDW is continually changing, with new outfalls being installed and existing outfalls being decommissioned. The outfall list in this appendix is meant to serve as a snapshot of outfall conditions at the time of the survey. More recent information, when available, is reflected in the outfall discussions in Appendix I.

Table H-1. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2002	108E	0.6 E	SPU		30-in. steel	drip	KC or SPU CSO/SD	1	na	Seattle Public Utilities abandoned treatment facility outfall (Duwamish Diagonal SCAP documentation)	resolved	abandoned
2003	110E	0.7 E	SPU		12-in. steel	trickle	unknown SD	1	none found	Diagonal Ave S SD	resolved	public SD
2004	113E	0.9 E	General Services Administration		8-in. concrete	na	unknown SD	1	none found	No permit located for WA Liquor Control Board.	resolved	public SD
2005	112E	0.9 E	General Services Administration		8-in. concrete	na	unknown SD	1	none found	No permit located for WA Liquor Control Board.	resolved	public SD
2006	111E	0.7 E	Corps of Engineers		12-in. metal	trickle	unknown SD	1	none found	No information readily available.	resolved	public SD
2007	122E	1.2 E	King County		18-in. CMP	none	KC SD	1	na	King County storm drains	resolved	public SD
2008	123E	1.2 E	King County		8-in. steel	none	KC SD	1	na	King County storm drains	resolved	public SD
2009	124E	1.3 E	King County		6-in. ductile	none	KC SD	1	na	King County storm drains	resolved	public SD
2010	125E	1.4 E	King County		6-in. PVC	none	KC SD	1	na	King County storm drains	resolved	public SD
2011	126E	1.4 E	King County		12-in. PVC	none	KC SD	1	na	King County storm drains	resolved	public SD
2013	128E	1.4 E	Longview Fibre		12-in. concrete	trickle	unknown SD	1	SO3000206D	Direct discharge to LDW.	resolved	permitted private SD
2014	130E	1.6 E	James Hardie		24-in. concrete	3 gpm	Settling pond outlet	1	SO3000056D	May also be covered under this permit as an additional overflow outlet.	resolved	permitted private SD
2015	131E	1.6 E	James Hardie		na	none	unknown SD	1	SO3000056D	Permit transferred to BPD Gypsum in Jan 2004 with direct discharge to LDW. Ecology database lists three outfalls (Nos. 1 to 3).	resolved	permitted private SD
2016	132E	1.6 E	James Hardie		na	none	unknown SD	1	SO3000056D	Permit transferred to BPD Gypsum in Jan 2004 with direct discharge to LDW. Ecology database lists three outfalls (Nos. 1 to 3).	resolved	permitted private SD

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2017	129E	1.5 E	James Hardie		12-in. PVC	none	unknown SD	1	SO3000056D	Permit transferred to BPD Gypsum in Jan 2004 with direct discharge to LDW. Ecology database lists three outfalls (Nos. 1 to 3).	resolved	permitted private SD
2018	135E	1.7 E	Glacier Northwest	East Shore	8-in. PVC	none	unknown SD	1	SO3002227D WAG503191C WAG503347	Map in permit shows two clear outfalls, and mentions various other ditches/drainage points.	tentatively resolved	permitted private SD
2019	133E	1.7 E	Glacier Northwest	East Shore	24-in. concrete	2 gpm	unknown SD	1	SO3002227D WAG503191C WAG503347	Map in permit shows two clear outfalls, and mentions various other ditches/drainage points.	tentatively resolved	permitted private SD
2021	136E	1.8 E	Gilmore James Bldg		6-in. PVC	na	unknown SD	1	none found	No information readily available.	tentatively resolved	private SD
2022	137E	1.9 E	N of Bridge		8-in. PVC	0.5 gpm	unknown SD	1	none found	No information readily available. Located near several other public SDs, so may be KC or SPU outfall.	unresolved	pipe of unresolved origin and/or use
2024	141E	2.0 E	SCS Holdings		12-in. concrete	10 gpm	unknown SD	1	SCS Refrigerated Services: SO3005565A	Permit for SCS Refrigerated Services corresponds with three outfalls in the Ecology database. All permitted outfalls may be routed to this one discharge point or may be routed to a municipal treatment facility.	resolved	permitted private SD
2026	151E	2.3 E	SPU		30-in. ductile	none	City SD	1	na	Seattle Public Utility storm drain	resolved	public SD
2027	150E	2.3 E	Hopkins, Frederick		6-in. clay	none	unknown SD	1	none found	No permit located for Hopkins Frederick (this is the name of the estate holding the land). May be permitted under Schultz Distributing (SO3002346D) – four outfalls, Seattle Iron & Metal Works (SO3003645C) – one outfall, or Seattle Boilerworks (SO3002208D) – one outfall.	tentatively resolved	private SD

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2028	149E	2.3 E	Hopkins, Frederick	Estate Trust	18-in. concrete	none	unknown SD	1	none found	No permit located for Hopkins Frederick (this is the name of the estate holding the land). May be permitted under Schultz Distributing (SO3002346D) – four outfalls, Seattle Iron & Metal Works (SO3003645C) – one outfall, or Seattle Boilerworks (SO3002208D) – one outfall.	tentatively resolved	private SD
2029	147E	2.3 E	Hopkins, Frederick	Estate Trust	3-in. aluminum	none	unknown SD	1	none found	No permit located for Hopkins Frederick (this is the name of the estate holding the land). May be permitted under Schultz Distributing (SO3002346D) – four outfalls, Seattle Iron & Metal Works (SO3003645C) – one outfall, or Seattle Boilerworks (SO3002208D) – one outfall.	tentatively resolved	private SD
2030	148E	2.3 E	Hopkins, Frederick	Estate Trust	3-in. aluminum	none	unknown SD	1	none found	No permit located for Hopkins Frederick (this is the name of the estate holding the land). May be permitted under Schultz Distributing (SO3002346D) – four outfalls, Seattle Iron & Metal Works (SO3003645C) – one outfall, or Seattle Boilerworks (SO3002208D) – one outfall.	tentatively resolved	private SD
2032	146E	2.3 E	Hopkins, Frederick	Estate Trust	3-in. aluminum	none	unknown SD	1	none found	No permit located for Hopkins Frederick (this is the name of the estate holding the land). May be permitted under Schultz Distributing (SO3002346D) – four outfalls, Seattle Iron & Metal Works (SO3003645C) – one outfall, or Seattle Boilerworks (SO3002208D) – one outfall.	tentatively resolved	private SD

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2033	145E	2.3 E	Hopkins, Frederick	Estate Trust	3-in. PVC	none	unknown SD	1	none found	No permit located for Hopkins Frederick (this is the name of the estate holding the land). May be permitted under Schultz Distributing (SO3002346D) – four outfalls, Seattle Iron & Metal Works (SO3003645C) – one outfall, or Seattle Boilerworks (SO3002208D) – one outfall.	resolved	private SD
2034	152E	2.5 E	Shalmar Group		6-in. steel	none	unknown SD	1	Seattle Iron & Metal Works: SO3003645	Permit for Seattle Iron & Metal Works may correspond to this outfall.	resolved	permitted private SD
2035	153E	2.5 E	SPU		30-in. DI	trickle	City SD	1	na	Seattle Public Utility storm drains	resolved	public SD
2036	154E	2.6 E	S Othello St	Puget Sound Truck Lines, Inc.	8-in. steel	none	unknown SD	1	SO3000949	Permit for Puget Sound Trucking has five outfalls in Ecology database, which may cover these outfalls. Outfall likely also drains adjacent street surface.	resolved	permitted private SD
2037	155E	2.6 E	R&A Properties		10-in. steel	none	unknown SD	1	Puget Sound Trucking: SO300949	Permit for Puget Sound Trucking has five outfalls in Ecology database, which may cover these outfalls.	resolved	permitted private SD
2038	162E	2.6 E	R&A Properties		6-in. concrete	none	unknown SD	1	Puget Sound Trucking: SO300949	Permit for Puget Sound Trucking has five outfalls in Ecology database, which may cover these outfalls.	resolved	permitted private SD
2039	161E	2.6 E	R&A Properties		6-in. concrete	none	unknown SD	1	Puget Sound Trucking: SO300949	Permit for Puget Sound Trucking has five outfalls in Ecology database, which may cover these outfalls.	resolved	permitted private SD
2040	164E	2.6 E	R&A Properties		12-in. concrete	trickle	unknown SD	1	Puget Sound Trucking: SO300949	Permit for Puget Sound Trucking has five outfalls in Ecology database, which may cover these outfalls.	resolved	permitted private SD
2041	171E	2.7 E	Seattle City Light		4-in. concrete	na				This outfall was originally identified as the old water intake for the Georgetown steam plant but more recent investigations have determined that it is a pipe of unknown origin.	unresolved	pipe of unresolved origin and/or use

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2042	174E	2.8 E	Crowley Marine		8-in. PVC	trickle	unknown SD	1	Northland Service: SO3003646	No permit located for Crowley/Crowley Marine. Permit for Northland Services identifies six outfalls, that are fairly good matches to the six outfalls identified by City of Seattle survey at Crowley Marine.	tentatively resolved	permitted private SD
2046	157E	2.8 E	WSDOT (Slip 4)		72-in. steel	50 gpm	WSDOT SD	1	na	WSDOT storm drain. Also receives runoff from 40 ac east of I-5. May accept discharge from North Boeing Field (SO3000226) via storm drains.	resolved	public SD
2047	156E	2.8 E	Seattle City Light		72-in. CMP	na	City SD	1	na	Seattle City Light storm drain Georgetown flume.	resolved	public SD
2048	158E	2.8 E	SPU		24-in. concrete	none	City SD	1	na	North Boeing Field SD Storm drain outfall owned by SPU but only receives runoff from North Boeing Field (formerly Slip 4 CSO/SD (117).	resolved	public SD
2049	159E	2.8 E	King County		60-in. concrete	200 gpm	KC SD/SPU EOF	1	na	King County Airport SD No. 3 SPU EOF No. 117 (formerly Slip 4 SD)	resolved	EOF/SD
2050	165E	2.9 E	First South Properties	Cedar Grove/Slip 4 South	6-in. concrete	na	unknown SD	1	SO3002641C	Ecology database lists two outfalls (Outfalls A and B) that are matches for two First South locations (permitted). The remaining three outfalls are identified in the Slip 4 SCAP as storm drains.	tentatively resolved	permitted private SD
2051	169E	2.9 E	First South Properties	Cedar Grove/Slip 4 South	6-in. concrete	none	unknown SD	1	SO3002641C	Ecology database lists two outfalls (Outfalls A and B) that are matches for two First South locations (permitted). The remaining three outfalls are identified in the Slip 4 SCAP as storm drains.	tentatively resolved	permitted private SD
2052	176E	2.9 E	Boeing – Plant 2		30-in. concrete	na	unknown SD	1	SO3000482D, WA0002917	Boeing outfall A comprises twin 30-in. outfalls (Floyd|Snider 2006).	resolved	permitted private SD
2053	177E	2.9 E	Boeing – Plant 2		30-in. concrete	na	unknown SD	1	SO3000482D, WA0002917	Boeing outfall A comprises twin 30-in. outfalls (Floyd|Snider 2006).	resolved	permitted private SD
2054	211E	3.6 E	Boeing – Plant 2		4-in. iron	na	unknown SD	1		Boeing field survey indicates that pipe is abandoned. Probably an old fire water blow-off line (Floyd|Snider 2006).	resolved	abandoned

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2055	212E	3.6 E	Boeing – Plant 2		18-in. steel	trickle	unknown SD	1		Outfall Y has been rerouted to outfall Z (Floyd|Snider 2006).	resolved	abandoned
2056	213E	3.6 E	Boeing – Plant 2		36-in. concrete	20 gpm	unknown SD	1	SO3000482D, WA0002917	Accepts diverted flow from former outfalls X and Y ((Floyd|Snider 2006).	resolved	permitted private SD
2057	214E	3.6 E	Boeing – Plant 2		8-in. steel	trickle	unknown SD	1		No evidence found to support abandoned classification. Boeing survey could not locate this feature (Floyd|Snider 2006).	unresolved	pipe of unresolved origin and/or use
2058	215E	3.6 E	Boeing – Plant 2		4-in. steel	none	unknown SD	1		No evidence found to support abandoned classification. Boeing survey could not locate this feature, which was probably a fire water line or another pipe, but not an outfall (Floyd|Snider 2006).	unresolved	pipe of unresolved origin and/or use
2059	216E	3.6 E	TBD		24-in. CMP	2 gpm	unknown SD	1	SO3000482D, WA0002917	The current SD system partially drains KC airport and part of E Marginal Way and runs along Jorgensen Forge. Boeing and Jorgensen Forge also had historical connections but do not currently discharge to this SD system (Floyd|Snider 2006).	unresolved	public SD[c]
2061	228E	3.8 E	Boeing – Thompson		24-in. steel	3 gpm	private SD	1	SO3000148D	Permit indicates direct discharge to LDW, permitted under Boeing Development Center.	resolved	permitted private SD
2062	227E	3.8 E	SPU/King County		48-in. CMP	20 gpm	SPU/KC EOF	1	na	Seattle Public Utility EOF (No. 156) King County Airport SD No. 2	resolved	EOF/SD
2063	226E	3. 7 E	Boeing – Issacson		4-in. steel	none	unknown SD	1	none found	Boeing Thompson/Boeing Scientific permitted outfall from Ecology is shown on map near RM 3.3 on the west side, but Boeing has never owned property there. These coordinates are likely incorrect since the Herrera survey did not identify an outfall at this location.	unresolved	pipe of unresolved origin and/or use
2064	224E	3.7 E	Jorgensen Forge		12-in. CMP	2 gpm	unknown SD	1	SO3003231C	Five outfalls shown on Jorgensen map within the permit file that discharge directly to LDW. Ecology database lists four outfalls.	resolved	permitted private SD

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2065	223E	3.7 E	Jorgensen Forge		18-in. concrete	5 gpm	unknown SD	1	SO3003231C	Five outfalls shown on Jorgensen map within the permit file that discharge directly to LDW.	resolved	permitted private SD
2066	222E	3.7 E	Jorgensen Forge		12-in. steel	none	unknown SD	1	SO3003231C	Five outfalls shown on Jorgensen map within the permit file that discharge directly to LDW.	resolved	permitted private SD
2067	221E	3.7 E	Jorgensen Forge		12-in. concrete	none	unknown SD	1	SO3003231C	Plugged using concrete in the mid-1980s; dye tracer study confirmed closure (EAA 4 data gaps, citing Farallon and Anchor 2006).	resolved	abandoned
2068	220E	3.7 E	Jorgensen Forge		4-in. steel	none	unknown SD	1	SO3003231C	Plugged using concrete in the mid-1980s; dye tracer study confirmed closure (EAA 4 data gaps, citing Farallon and Anchor 2006).	resolved	abandoned
2069	219E	3.7 E	Jorgensen Forge		4-in. steel	none	unknown SD	1	SO3003231C	Plugged using concrete in the mid-1980s; dye tracer study confirmed closure (EAA 4 data gaps, citing Farallon and Anchor 2006).	resolved	abandoned
2070	218E	3.6 E	Jorgensen Forge		12-in. steel	none	unknown SD	1	SO3003231C	Plugged using concrete in the mid-1980s; dye tracer study confirmed closure (EAA 4 data gaps, citing Farallon and Anchor 2006).	resolved	abandoned
2071	217E	3.6 E	Jorgensen Forge		2-in. steel	none	unknown SD	1	SO3003231C	Plugged using concrete in the mid-1980s; dye tracer study confirmed closure (EAA 4 data gaps, citing Farallon and Anchor 2006).	resolved	abandoned
2072	225E	3.7 E	Jorgensen Forge		18-in. steel	trickle	unknown SD	1	SO3003231C	Five outfalls shown on Jorgensen map within the permit file that discharge directly to LDW.	resolved	permitted private SD
2073	233E	4.0 E	Kenworth Truck Co.		18-in. concrete	trickle	unknown SD	1	(Former permit SO3001784) SO3008681A	Kenworth's NPDES permit was terminated in Feb 2003. It remains unclear whether past discharges went directly into the Duwamish. Insurance Auto Auctions (SO3008681) also has 3 permitted outfalls located on the Kenworth property. These may account for 3 to 4 outfalls.	resolved	permitted private SD

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2074	232E	3.9 E	Kenworth Truck Co.		8-in. CMP	none	unknown SD	1	(Former permit SO3001784) SO3008681A	Kenworth's NPDES permit was terminated in Feb 2003. It remains unclear whether past discharges went directly into the Duwamish. Insurance Auto Auctions (SO3008681) also has three permitted outfalls located on the Kenworth property. These may account for three to four outfalls.	resolved	permitted private SD
2075	231E	3.9 E	Kenworth Truck Co.		CMP	none	unknown SD	1	(Former permit SO3001784) SO3008681A	Kenworth's NPDES permit was terminated in Feb 2003. It remains unclear whether past discharges went directly into the Duwamish. Insurance Auto Auctions (SO3008681) also has three permitted outfalls located on the Kenworth property. These may account for three to four outfalls.	resolved	permitted private SD
2076	230E	3.9 E	Kenworth Truck Co.		30-in. steel	none	unknown SD	1	(Former permit SO3001784) SO3008681A	Kenworth's NPDES permit was terminated in Feb 2003. It remains unclear whether past discharges went directly into the Duwamish. Insurance Auto Auctions (SO3008681) also has three permitted outfalls located on the Kenworth property. These may account for three to four outfalls.	resolved	permitted private SD
2077	229E	3.9 E	Boeing – Thompson		steel	1 gpm	private SD	1	SO3000148D	Permit indicates direct discharge to LDW, permitted under Boeing Development Center	resolved	permitted private SD
2078	236E	4.2 E	Container Properties LLC	Formerly Rhône-Poulenc/ Slip 6	8-in. plug iron	dripping	unknown SD	1	none found	Location identified as stormwater outfall utilized by Rhône-Poulenc. Outfall location may have been abandoned during demolition of onsite buildings. New sub-grade stormwater piping plumbed to City of Seattle storm drains.	resolved	private SD
2079	235E	4.2 E	Container Properties LLC	Formerly Rhône-Poulenc/ Slip 6	6-in. plug iron	none	unknown SD	1	none found	Location identified as stormwater outfall utilized by former Rhône-Poulenc. Pipe securely plugged according to City of Seattle survey.	resolved	abandoned

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2080	234E	4.2 E	King County		24-in. riveted steel	20 gpm	KC SD	1	na	King County Airport storm drain No. 1	resolved	public SD
2081	237E	4.2 E	Boeing Developmental Center		36-in. concrete	none	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
2082	238E	4.2 E	Boeing Developmental Center		24-in. steel	dripping	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
2083	239E	4.2 E	Slip 6 – Non-Boeing		6-in. steel	discharge	unknown SD	1	none found	Not a Boeing permitted outfall. Boeing has investigated this pipe and believes that it is a drain from an underground utility vault that predates Boeing's use of this property. Boeing is in the process of having this pipe plugged.	resolved	abandoned
2084	240E	4.2 E	Slip 6 – Non-Boeing		6-in.	dripping	unknown SD	1	none found	Not a Boeing permitted outfall. Boeing has investigated this pipe and believes that it is a drain from an underground utility vault that predates Boeing's use of this property. Boeing is in the process of having this pipe plugged.	resolved	abandoned
2085	245E	4.5 E	Boeing Developmental Center		36-in. concrete	none	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
2086	244E	4.4 E	Boeing Developmental Center		48-in. riveted CMP	low flow	unknown SD	1		Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18). Note: this outfall is bricked shut, but discharge observed during survey.	tentatively resolved	abandoned

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2087	243E	4.4 E	Boeing Developmental Center		36-in. concrete	na	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
2088	242E	4.4 E	Boeing Developmental Center		36-in. concrete	trickle	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
2089	241E	4.4 E	Boeing Developmental Center		24-in. concrete	na	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
2090	246E	4.6 E	Boeing Developmental Center		36-in. concrete	none	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
2091	247E	4.8 E	Boeing Developmental Center		36-in. CMP	0.5 gpm	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 – DC17, discontinuous. Boeing files show 18 outfalls (DC1–DC18). This outfall is likely DC5.	resolved	permitted private SD
2092	248E	4.9 E	Boeing Developmental Center		18-in. iron	none	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18). This outfall is likely DC17.	resolved	permitted private SD
2093	251E	4.9 E	Boeing Developmental Center		24-in. concrete	5 gpm	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18). This outfall is likely DC 2.	resolved	permitted private SD

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2094	252E	4.9 E	Boeing Developmental Center		12-in. concrete	none	unknown	1		Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	unresolved	pipe of unresolved origin and/or use
2095	253E	4.9 E	KC/SPU/ Boeing	KC Norfolk CSO (044)	84 in. 6 ft x 6 ft	10 gpm	KC/SPU CSO/SD	1	see notes	Public storm drain that also receives stormwater discharges from Boeing properties upstream. This discharge is permitted through Boeing Developmental Center (WA031488B or SO3000146C) as DC1. King County's Norfolk CSO (044). Seattle Public Utilities also operates an EOF that discharges through this outfall.	resolved	CSO/SD
2096	250E	4.9 E	Boeing Developmental Center		6-in. iron	dripping	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18). This outfall is likely DC 3.	resolved	permitted private SD
2097	249E	4.9 E	Boeing Developmental Center		8-in. steel	none	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18). This outfall is likely DC 4.	resolved	permitted private SD
2098	379W	4.5 W	Seattle City Light		6-in. CMP	none	City SD	1	na	Seattle City Light storm drain	resolved	public SD
2099	378W	4.4 W	Seattle City Light		6-in. CMP	dripping	City SD	1	na	Seattle City Light storm drain	resolved	public SD
2100 (A)	375W	4.2 W	King County	S 96th SD	72-in. CMP	flowing	unknown SD	1	none found	S 96th St SD	resolved	public SD
2100 (B)	376W	4.2 W	Duwamish Yacht Club		6-in. PVC	na	unknown SD	1	none found	Potentially a private SD serving adjacent waterfront property.	unresolved	pipe of unresolved origin and/or use
2101	374W	4.0 W	S 92nd Pl		18-in. concrete	none	unknown SD	1	none found	No information readily available – likely drains adjacent property.	unresolved	pipe of unresolved origin and/or use

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2103	372W	3.8 W	Boeing – South Park		12-in. concrete	0.5 gpm	storm drain	1	none found	No odor, no color. End of pipe chipped off.	unresolved	pipe of unresolved origin and/or use
2106	358W	2.8 W	S Portland St		24-in. DI	none	unknown SD	1	none found	No information readily available – likely drains adjacent property.	unresolved	pipe of unresolved origin and/or use
2107	357W	2.8 W	King County		36-in. RCP	2 gpm	KC CSO	1	na	King County Combined Sewer Overflow 8th Ave S CSO (040)	resolved	CSO
2108	359W	2.8 W	S Portland St		8-in. DI	none	unknown SD	1	none found	No information readily available – likely drains adjacent property.	unresolved	pipe of unresolved origin and/or use
2109	362W	2.9 W	S Chicago St		11-in. wood	none	unknown SD	1	none found	No information readily available – likely drains adjacent property.	unresolved	pipe of unresolved origin and/or use
2110	361W	2.9 W	S Chicago St		15-in. concrete	none	unknown SD	1	none found	No information readily available – likely drains adjacent property.	unresolved	pipe of unresolved origin and/or use
2111	360W	2.9 W	S Chicago St		12-in. DI	none	unknown SD	1	none found	No information readily available – likely drains adjacent property.	unresolved	pipe of unresolved origin and/or use
2112	356W	2.7 W	SPU		na	na	City SD	1	na	Seattle Public Utility storm drain	resolved	public SD
2113	355W	2.6 W	S Webster St		6-in. concrete	moist	unknown SD	1	none found	No information readily available – likely drains adjacent street surface and may drain upland permitted locations.	tentatively resolved	public SD
2114	354W	2.5 W	Boyer Logistics, Inc		6-in. concrete	none	unknown SD	1	SO3005598A	No specific information provided in permit, but Ecology database lists four outfalls at Boyer facility.	resolved	permitted private SD
2115	353W	2.4 W	Boyer Logistics, Inc		8-in. PVC	none	unknown SD	1	SO3005598A	No specific information provided in permit, but Ecology database lists four outfalls at Boyer facility.	resolved	permitted private SD
2116	352W	2.3 W	Boyer Logistics, Inc		6-in. plastic	none	unknown SD	1	SO3005598A	No specific information provided in permit, but Ecology database lists four outfalls at Boyer facility.	resolved	permitted private SD

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2117	351W	2.3 W	Boyer Logistics, Inc		4-in. PVC	none	unknown SD	1	SO3005598A	No specific information provided in permit, but Ecology database lists four outfalls at Boyer facility.	resolved	permitted private SD
2118	350W	2.2 W	SPU		24-in. concrete	none	City SD	1	na	Seattle Public Utility storm drain	resolved	public SD
2120	348W	2.2 W	1st Ave S Bridge (west side)		36-in. concrete	10 cfs	unknown SD	1	none found	Overflow from West Seattle reservoir; not associated with discharges from combined or sanitary sewer.	resolved	EOF
2121	346W	2.1 W	1st Ave S Bridge (west side)		12-in. concrete	na	unknown SD	1	none found	WSDOT bridge drains – no permit is likely to be located because covered under general permit. Permit for Swan Bay Holding Dock (SO3002471) has one permitted outfall that may account for this pipe.	unresolved	pipe of unresolved origin and/or use
2122	338W	1.9 W	Port – Terminal 115		24-in. concrete	1 gpm	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
2123	334W	1.9 W	Port – Terminal 115		12-in. CMP	none	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
2124	336W	1.9 W	Port – Terminal 115		18-in. concrete lined DI	na	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
2125	335W	1.9 W	SPU		72-in. concrete	100 gpm	City SD	1	na	Seattle Public Utility storm drain	resolved	public SD
2127	332W	1.5 W	SPU/King County		48-in. concrete	50 gpm	KC CSO/ City SD	1	na	Terminal 115 CSO (038)/SW Kenny SD.	resolved	CSO/SD
2128	331W	1.5 W	Port – Terminal 115	West Shore	15-in. CMP	under-water	unknown SD	1	SO3002227D WAG503191D WAG503347	Map in permit shows two clear outfalls, and mentions various other ditches/drainage points.	resolved	public SD
2129	329W	1.4 W	Duwamish Shipyard, LLC		6-in. DI	none	unknown SD	1	WA0030937C	Five outfalls listed on permit, but only 1 outfall located in City of Seattle survey. All outfalls may all be routed to single discharge point or routed to a municipal treatment facility.	tentatively resolved	permitted private SD
2130	330W	1.4 W	Glacier Northwest	West Shore	15-in. DI	none	unknown SD	1	SO3002227DWAG 503191C WAG503347	Map in permit shows two clear outfalls, and mentions various other ditches/drainage points.	tentatively resolved	permitted private SD

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2131	328W	1.3 W	Alaska Marine Lines		12-in. steel	1/8 full	unknown SD	1	SO3001365D	Pipe is probably covered by Alaska Marine permit which notes that pipes discharge directly to LDW.	resolved	permitted private SD
2132	327W	1.3 W	Alaska Marine Lines		12-in. steel	none	unknown SD	1	SO3001365D	Pipe is probably covered by Alaska Marine permit which notes that pipes discharge directly to LDW.	resolved	permitted private SD
2133	324W	1.3 W	Alaska Marine Lines		12-in. steel	¾ full	unknown SD	1	SO3001365D	Pipe is probably covered by Alaska Marine permit which notes that pipes discharge directly to LDW.	resolved	permitted private SD
2134	326W	1.3 W	Alaska Marine Lines		4-in. PVC	¾ full	unknown SD	1	SO3001365D	Pipe is probably covered by Alaska Marine permit which notes that pipes discharge directly to LDW.	resolved	permitted private SD
2135	325W	1.3 W	Alaska Marine Lines		4-in. PVC	none	unknown SD	1	SO3001365D	Pipe is probably covered by Alaska Marine permit which notes that pipes discharge directly to LDW.	resolved	permitted private SD
2136	323W	1.3 W	Alaska Marine Lines		6-in. steel	full flow	unknown SD	1	SO3001365D	Pipe is probably covered by Alaska Marine permit which notes that pipes discharge directly to LDW.	resolved	permitted private SD
2137	322W	1.2 W	Lafarge Corporation		24-in. concrete	5/8 flow	unknown SD	1	WA0002232	Permit gives range coordinates for outfalls, but no specific number. All unknowns are likely covered by this permit.	resolved	permitted private SD
2138	317W	1.0 W	Lafarge Corporation		6-in. steel	none	unknown SD	1	WA0002232	Permit gives range coordinates for outfalls, but no specific number. All unknowns are likely covered by this permit.	resolved	permitted private SD
2139	316W	1.0 W	Lafarge Corporation		6-in. DI	none	unknown SD	1	WA0002232	Permit gives range coordinates for outfalls, but no specific number. All unknowns are likely covered by this permit.	resolved	permitted private SD
2140	312W	0.5 W	Drummond	State Parks	8-in. steel	none	unknown SD	1		Permit for Evergreen Trails, Inc., mentions direct discharge to LDW through one outfall of 5 acres of paved area, similar to observations from City survey. Location/ownership of this pipe unclear.	unresolved	pipe of unresolved origin and/or use

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2141	313W	0.5 W	Drummond	State Parks	8-in. steel	none	unknown SD	1	Evergreen Trails: SO3002966C	Permit for Evergreen Trails, Inc. mentions direct discharge to LDW through one outfall of 5 acres of paved area, similar to observations from City survey. This location most closely matches latitude and longitude information provided in the permit.	tentatively resolved	permitted private SD
2142	314W	0.5 W	Drummond	State Parks	8-in. steel	none	unknown SD	1		Permit for Evergreen Trails, Inc. mentions direct discharge to LDW through one outfall of 5 acres of paved area, similar to observations from City survey. Location/ownership of this pipe unclear.	unresolved	pipe of unresolved origin and/or use
2143	315W	0.5 W	Drummond	State Parks	8-in. steel	none	unknown SD	1		Permit for Evergreen Trails, Inc. mentions direct discharge to LDW through one outfall of 5 acres of paved area, similar to observations from City survey. Location/ownership of this pipe unclear.	unresolved	pipe of unresolved origin and/or use
2144	307W	0.3 W	SW Idaho St		10-in. DI	under-water	unknown SD	1	none found	No information readily available – may drain adjacent property.	unresolved	pipe of unresolved origin and/or use
2145	308W	0.3 W	SW Idaho St		4-in. DI	none	unknown SD	1	none found	No information readily available – may drain adjacent property.	unresolved	pipe of unresolved origin and/or use
2146	306W	0.3 W	SW Idaho St		6-in. DI	none	unknown SD	1	none found	No information readily available – may drain adjacent property.	unresolved	pipe of unresolved origin and/or use
2147	305W	0.3 W	SW Idaho St		72-in. concrete	under-water	unknown SD	1	none found	SPU storm drain	resolved	public SD
2148	301W	0.0 W	Port		12-in. CPE	none	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
2149	300W	0.0 W	Port		24-in. CPE	na	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
2150	302W	0.1 W	Port		18-in. CPE	na	Port SD	1	na	Port of Seattle storm drain	resolved	public SD

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2151	104E	0.1	Port		15-in. CMP, behind headwall	none	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
2153	107E	0.5 E	King County		36-in.	na	KC CSO	1	na	Concrete stormwater system structure, not point of outfall	resolved	not an outfall
2154	103E	0.1 E	Port		6-in. concrete	none	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
2155	106E	0.5 E	SPU, King County		144-in. concrete	2 ft/sec	SPU and KC CSO/SD	1	na	Seattle Public Utility Diagonal CSO (No. 111) and King County Hanford No. 1 (031)/Bayview CSO; Seattle Public Utility SD	resolved	CSO/SD
2156	102E	0.0	Port		18-in. CMP at headwall DI	20 gpm	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
2157	309W	0.4 W	Birmingham		24-in. concrete	na	unknown SD	1	SO3002341D	Permit for General Recycling of WA discharges directly to LDW in this general location.	tentatively resolved	permitted private SD
2200	380W	4.6 W	WSDOT, Turning basin – SW shoreline		30-in. CMP	na	unknown SD	1	none found	Outfall location corresponds with WSDOT discharge point for SR 99.	resolved	public SD
2201	381W	4.6 W	WSDOT, Turning basin – NW shoreline		36-in. CMP	3 gpm	unknown SD	1	none found	Outfall location corresponds with WSDOT discharge point for SR 99.	resolved	public SD
2205	377W	4.3 W	Port of Seattle/Delta Marine		na	na	creek	1	none found	Creek outlet on Port property south of S 96th, just south of Delta crane.	resolved	stream, channel, or swale
2209	370W	3.6 W	Port		8-in. PVC	none	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
2210	369W	3.6 W	Port		4-in. and 3-in. iron	na	not an outfall	1	na	Pipe location identified as suspected abandoned in Herrera survey. Pipe noted during site activities but identified as miscellaneous shoreline debris and not an outfall.	resolved	not an outfall
2211	368W	3.6 W	Port		4-in. CPE	none	not an outfall	1	na	Pipe location identified as suspected abandoned in Herrera survey. Pipe noted during site activities but identified as miscellaneous shoreline debris and not an outfall.	resolved	not an outfall

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2212	366W	3.6 W	Port		6-in. PVC	none	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
2213	371W	3.7 W	Drainage swale		na	na	swale	1	na	Drainage/creek swale	resolved	stream, channel, or swale
2214	365W	3.5 W	South Park Marina		12-in. CMP	na	unknown SD	1	WAG030045C	Direct discharge to LDW.	resolved	permitted private SD
2215	364W	3.4 W	16th Ave Bridge (south side)		12-in. CMP	na	unknown SD	1	none found	Pipe is relatively new, and likely related to drainage from bridge. No permit is likely to be located.	resolved	public SD
2216	170E	2.9 E	First South Properties	Cedar Grove/Slip 4 South	6-in. concrete	na	unknown SD	1	SO3002641C	Ecology database lists two outfalls (Outfalls A and B) that are matches for two First South locations (permitted). The remaining three outfalls are identified in the Slip 4 SCAP as storm drains.	tentatively resolved	permitted private SDs
2217	167E	2.9 E	First South Properties	Cedar Grove/Slip 4 South	4-in. steel	na	unknown SD	1	SO3002641C	Ecology database lists two outfalls (Outfalls A and B) that are matches for two First South locations (permitted). The remaining three outfalls are identified in the Slip 4 SCAP as storm drains.	tentatively resolved	permitted private SDs
2219	166E	2.9 E	First South Properties	Cedar Grove/Slip 4 South	6-in. steel	na	unknown SD	1	SO3002641C	Ecology database lists two outfalls (Outfalls A and B) that are matches for two First South locations (permitted). The remaining three outfalls are identified in the Slip 4 SCAP as storm drains.	tentatively resolved	permitted private SDs
2220	333W	1.8 W	Port		24-in. concrete	na	Port SD	1	na	Port of Seattle storm drains	resolved	public SD
2223	121E	1.1 E	King County		18-in. ductile iron	na	KC CSO	1	na	King County Combined Sewer Overflow Brandon St. (041)	resolved	CSO
2225	109E	0.6 E	Port		18-in. concrete	none	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
2226	311W	0.5 W	Drummond		na	15 gpm	Ditch	1	na	Ditch at Drummond property	resolved	stream, channel, or swale
2232	304W	0.2 W	Port		18-in. CPE	none	Port SD	1	na	Port of Seattle storm drain	resolved	public SD

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2233	303W	0.1 W	Port		na	na	channel	1	na	Drainage channel constructed by Port at T-105	resolved	stream, channel, or swale
2244	119E	1.1 E	King County		na	na	KC SD	1	na	King County storm drain	resolved	public SD
2245	118E	0.9 E	General Services Administration		32-in. steel	na	unknown SD	1	none found	No permit located for WA Liquor Control Board.	resolved	public SD
2246	114E	0.9 E	General Services Administration		8-in. concrete	na	unknown SD	1	none found	No permit located for WA Liquor Control Board.	resolved	public SD
2247	116E	0.9 E	General Services Administration		8-in. concrete	na	unknown SD	1	none found	No permit located for WA Liquor Control Board.	resolved	public SD
2501	140E	1.9 E	unknown		48-in. concrete	none				Flapper valve in good condition.	unresolved	pipe of unresolved origin and/or use
2502	139E	1.9 E	King County		8-ft steel gate	none	KC CSO	1	na	King County Combined Sewer Overflow, E Michigan (039)	resolved	CSO
2503	138E	1.9 E	WSDOT		36-in. concrete	none	WSDOT SD	1	na	1st Ave S bridge SD	resolved	public SD
2505	340W	2.0 W	1st Ave S Bridge (west side)		12–18-in. CMP	none	unknown SD	1	none found	WSDOT bridge drains – no permit is likely to be located because covered under general permit.	resolved	public SD
2506	341W	2.0 W	King County		36-in. concrete	none	KC CSO	1	na	King County Combined Sewer Overflow, W Michigan CSO (042)	resolved	CSO
2507	344W	2.1 W	1st Ave S Bridge (west side)		8-in. steel	none	unknown SD	1	none found	WSDOT bridge drains – no permit is likely to be located because covered under general permit.	resolved	public SD
2508	343W	2.1 W	1st Ave S Bridge (west side)		18-in. concrete	none	unknown SD	1	SO3002471	Permit for Swan Bay Holding Dock (SO3002471) has one permitted outfall that most closely correlates with the pipe size and location of this discharge point.	resolved	permitted private SD
2509	345W	2.1 W	1st Ave S Bridge (west side)		12-in. concrete	none	unknown SD	1	none found	WSDOT bridge drains – no permit is likely to be located because covered under general permit.	resolved	public SD
2510	347W	2.1 W	1st Ave S Bridge (west side)		8-in. PVC	none	unknown SD	1	none found	WSDOT bridge drains – no permit is likely to be located because covered under general permit.	resolved	public SD

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
2512	342W	2.1 W	1st Ave S Bridge (west side)		4-in. ABS	none	unknown SD	1	none found	WSDOT bridge drains – no permit is likely to be located because covered under general permit.	resolved	public SD
3000	206E	3.5 E	Boeing – Plant 2		10-in. PVC	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
3001	205E	3.5 E	Boeing – Plant 2		6-in. IP	none	unknown SD	1		No color or odor reported in City survey. Likely disconnected structure piping, rather than an outfall (FS 2006).	resolved	not an outfall
3002	204E	3.5 E	Boeing – Plant 2		12-in. steel	none	unknown SD	1		Visual evidence of plug according to City survey. Boeing could not locate this outfall.	resolved	abandoned
3003	203E	3.5 E	Boeing – Plant 2		6-in. IP	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
3004	202E	3.5 E	Boeing – Plant 2		6-in. steel	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
3005	201E	3.5 E	Boeing – Plant 2		10-in. PVC	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
3006	200E	3.4 E	Boeing – Plant 2		4-in. DI	none	unknown SD	1		Location once an NPDES permitted outfall; sign posted at the outfall that says “DOE 017A monitor point.” Boeing survey indicated that pipe has since been abandoned (Floyd|Snider 2006).	resolved	abandoned
3007	199E	3.4 E	Boeing – Plant 2		6-in. DI	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
3008	198E	3.4 E	Boeing – Plant 2		4-in. DI	none	unknown SD	1		Boeing survey noted that pipe was broken and disconnected (Floyd|Snider 2006).	resolved	abandoned
3009	197E	3.4 E	Boeing – Plant 2		6-in. DI	none	unknown SD	1		Visual evidence of plug according to City survey.	resolved	abandoned
3010	196E	3.4 E	Boeing – Plant 2		4-in. steel	none	unknown SD	1		Visual evidence of plug according to City survey.	resolved	abandoned
3011	195E	3.4 E	Boeing – Plant 2		10-in. PVC	none	unknown SD	1	SO3000482D, WA0002917	Boeing field survey indicated 10-in. diameter of this pipe (Floyd|Snider 2006).	resolved	permitted private SD
3012	194E	3.4 E	Boeing – Plant 2		6-in. DI	none	unknown SD	1		Boeing field survey confirmed that pipe is abandoned, but origin is unknown (Floyd|Snider 2006).	resolved	abandoned

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
3013	193E	3.4 E	Boeing – Plant 2		6-in. PVC	none	unknown SD	1		Boeing field survey confirmed that this pipe is abandoned (Floyd|Snider 2006).	resolved	abandoned
3014	192E	3.4 E	Boeing – Plant 2		4-in. DI	na	unknown SD	1		Boeing field survey confirmed that pipe is disconnected and abandoned (Floyd|Snider 2006).	resolved	abandoned
3015	191E	3.4 E	Boeing – Plant 2		6-in. DI	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
3016	190E	3.3 E	Boeing – Plant 2		24-in. CMP	none	unknown SD	1		Confirmed abandoned in Ecology files.	resolved	abandoned
3017	207E	3.5 E	Boeing – Plant 2		10-in. DI	flushing	unknown SD	1		Outfall location noted to be flushing during 2003 survey; Boeing completed subsequent field survey confirming this location no longer an outfall, but rather a disconnected weir/pipe that was originally connected to outfall V (Floyd|Snider 2006). Pipe now abandoned.	resolved	abandoned
3018	208E	3.5 E	Boeing – Plant 2		2-in. PVC	none	unknown SD	1		2003 survey observed this outfall to be associated with DOE 013 monitor point outfall 013. Feature was not located during subsequent Boeing in-field survey (Floyd|Snider 2006); Boeing identifies as not an outfall.	resolved	not an outfall
3019	209E	3.5 E	Boeing – Plant 2		na	na	unknown SD	1		2003 survey observed this outfall to be associated with DOE 012 monitor point outfall 012.No outfall specifics were identified during survey. Feature was not located during subsequent Boeing in-field survey (Floyd|Snider 2006). Boeing identified as not an outfall.	resolved	not an outfall
3022	178E	3.1 E	Boeing – Plant 2		8-in. PVC	dripping	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
3023	179E	3.1 E	Boeing – Plant 2		6-in. PVC	none	unknown SD	1		Pipe not visibly plugged, but Boeing field survey indicates that this pipe is abandoned (Floyd|Snider 2006).	resolved	abandoned
3024	180E	3.1 E	Boeing – Plant 2		10-in. steel	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
3025	181E	3.1 E	Boeing – Plant 2		3-in. PVC	none	unknown SD	1		Visual evidence of plug according to City survey.	resolved	abandoned

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
3026	182E	3.2 E	Boeing – Plant 2		8-in. PVC	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
3027	183E	3.2 E	Boeing – Plant 2		10-in. DI	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
3028	184E	3.2 E	Boeing – Plant 2		6-in. DI	na	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
3030	185E	3.3 E	Boeing – Plant 2		24-in. CMP	dripping	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
3031	187E	3.3 E	SPU/Boeing		8-in. concrete	na	City SD	1	na	According to City records, this outfall serves the southern portion of 16th Ave S and the Boeing facility at 7755 E Marginal Way, with cross connection and discharge through outfall No. 3032. This particular location is not an outfall	resolved	not an outfall
3032	186E	3.3 E	SPU/Boeing		12-in. DI	dripping	public SD	1		Outfall drains both public roadways and Boeing Plant 2 (Outfall J). Shared-use identified (Floyd|Snider 2006). Side sewer card confirms that this pipe drains both Boeing facilities and roadway.	resolved	public SD
3034	189E	3.3 E	Boeing – Plant 2		12-in. PVC	none	unknown SD	1		3034 is a flow weir that was once connected to pipe L (3035). Pipe and weir are no longer connected (Floyd|Snider 2006).	resolved	abandoned
3035	188E	3.3 E	Boeing – Plant 2		12-in. DI	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
3037	363W	3.2 W	S Southern St		18-in. CMP	none	unknown SD	1	none found	No information readily available – likely drains adjacent street surface and may drain upland permitted locations. The City does not have any storm drains in this area .	tentatively resolved	pipe of unresolved origin and/or use
5000	115E	0.9 E	General Services Administration		32-in. steel	na	unknown SD	1	none found	No permit located for WA Liquor Control Board.	resolved	public SD
5001	117E	0.9 E	General Services Administration		32-in. steel	na	unknown SD	1	none found	No permit located for WA Liquor Control Board.	resolved	public SD

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
5002	318W	1.2 W	Lafarge Corporation		36-in. CMP	none	unknown SD	1	WA0002232E	Permit gives range coordinates for outfalls, but no specific number. All unknowns are likely covered by this permit.	resolved	permitted private SD
5003	319W	1.2 W	Lafarge Corporation		32-in. CMP	4 gpm	unknown SD	1	WA0002232E	Permit gives range coordinates for outfalls, but no specific number. All unknowns are likely covered by this permit.	resolved	permitted private SD
5004	320W	1.2 W	Lafarge Corporation		28-in. CMP	trickle	unknown SD	1	WA0002232E	Permit gives range coordinates for outfalls, but no specific number. All unknowns are likely covered by this permit.	resolved	permitted private SD
5005	321W	1.2 W	Lafarge Corporation		48-in. concrete	trickle	unknown SD	1	WA0002232E	Permit gives range coordinates for outfalls, but no specific number. All unknowns are likely covered by this permit.	resolved	permitted private SD
5006	175E	2.8 E	Crowley Marine		8-in. PVC	none	unknown SD	1	Northland Service: SO3003646	No permit located for Crowley/Crowley Marine. Permit for Northland Services identifies six outfalls, that are fairly good matches to the six outfalls identified by City of Seattle survey at Crowley Marine.	tentatively resolved	permitted private SD
5007	173E	2.8 E	Crowley Marine		8-in. PVC	none	unknown SD	1	Northland Service: SO3003646	No permit located for Crowley/Crowley Marine. Permit for Northland Services identifies six outfalls, that are fairly good matches to the six outfalls identified by City of Seattle survey at Crowley Marine.	tentatively resolved	permitted private SD
5008	172E	2.8 E	Crowley Marine		8-in. PVC	none	unknown SD	1	Northland Service: SO3003646	No permit located for Crowley/Crowley Marine. Permit for Northland Services identifies six outfalls, that are fairly good matches to the six outfalls identified by City of Seattle survey at Crowley Marine.	tentatively resolved	permitted private SD
5009	168E	2.8 E	Crowley Marine		8-in. PVC	none	unknown SD	1	Northland Service: SO3003646	No permit located for Crowley/Crowley Marine. Permit for Northland Services identifies six outfalls, that are fairly good matches to the six outfalls identified by City of Seattle survey at Crowley Marine.	tentatively resolved	permitted private SD

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
5010	163E	2.8 E	Crowley Marine		8-in. PVC	none	unknown SD	1	Northland Service: SO3003646	No permit located for Crowley/Crowley Marine. Permit for Northland Services identifies six outfalls, that are fairly good matches to the six outfalls identified by City of Seattle survey at Crowley Marine.	tentatively resolved	permitted private SD
BDC-1	(formerly Boeing 6)	4.4 E	Boeing Developmental Center		na	na	na	1	SO3000146C, SO3000148	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
BDC-2	(formerly Boeing 7)	4.7 E	Boeing Developmental Center		na	na	na	1	SO3000146C, SO3000148	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
BDC-3	(formerly Boeing 8)	4.7 E	Boeing Developmental Center		na	na	na	1	SO3000146C, SO3000148	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
BDC-4	(formerly Boeing 9)	4.7 E	Boeing Developmental Center		na	na	na	1	SO3000146C, SO3000148	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
BDC-5	(formerly Boeing 10)	4.9 E	Boeing Developmental Center		na	na	na	1	SO3000146C, SO3000148	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18). This is likely DC 16.	resolved	permitted private SD
Boeing 1		3.0 E	Boeing – Plant 2		na	na	na	1	SO3000482D, WA0002917	Outfall added during Boeing update.	resolved	permitted private SD
Boeing 2		3.1 E	Boeing – Plant 2		na	na	na	1	SO3000482D, WA0002917	Outfall added during Boeing update.	resolved	permitted private SD
Boeing 3		3.4 E	Boeing – Plant 2		na	na	na	1	SO3000482D, WA0002917	Outfall was not identified by Herrera but is an active outfall (Floyd|Snider 2006).	resolved	permitted private SD
Boeing 4		3.5 E	Boeing – Plant 2		na	na	na	1	SO3000482D, WA0002917	Outfall added by Boeing since it was not located by Herrera/City.	resolved	permitted private SD

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Boeing 5		3.5 E	Boeing – Plant 2		na	na	na	1	SO3000482D, WA0002917	Outfall is active, but buried in embankment (Floyd|Snider 2006).	resolved	permitted private SD
Boeing 6	(formerly Boeing 11)	3.3 E	Boeing – Plant 2		na	na	na	1	SO3000482D, WA0002917	This 4-in. pipe was not located by Herrera or Boeing but is presumed to be located near outfall J (Floyd|Snider 2006).	resolved	permitted private SD
Boeing 7	(formerly Boeing 12)	3.5 E	Boeing – Plant 2		na	na	na	1	SO3000482D, WA0002917	Outfall added by Boeing since it was not located by Herrera/City.	resolved	permitted private SD
Boeing 8	(formerly Boeing 13)	3. 7 E	Boeing – Plant 2		na	na	na	1	SO3000482D, WA0002917	Outfall X was missed during Herrera survey. This outfall is now abandoned, and flow is routed through outfall Z (Floyd|Snider 2006).	resolved	abandoned
Boeing 9	(formerly Boeing 14)	3.6 E	Boeing – Plant 2		na	na	na	1	SO300048D, WA0002917	This outfall (located just north of 2059) was not located by Herrera. Outfall formerly drained a portion of the South Yard but is not abandoned (Floyd|Snider 2006).	resolved	permitted private SD
HRE 1		0.1	Port/Harbor Real Estate				unknown SD	1	none found	Outfall located on Port property adjacent to Harbor Real Estate. Discharge of stormwater from both properties likely.	tentatively resolved	public SD
Port - SF		1.9 W	Port – Sea Freeze				Port SD	1	na	Port of Seattle storm drain	resolved	public SD
S Brighton St		2.1 E	SPU				SPU CSO/SD	1	na	Seattle Public Utility CSO/SD – old outfall layer. Outfall not found during field survey. Location plotted from SPU GIS.	resolved	CSO/SD
SP 1		3.9 W	Boeing – South Park		12-in. concrete	0.5 gpm	unknown SD	1	SO3001009D	Permit for Boeing South Park Facility lists five outfalls (SP1 to SP5)	resolved	permitted private SD
SP 2		3.9 W	Boeing – South Park		na	na	na	1	SO3001009D	Permit for Boeing South Park Facility lists five outfalls (SP1 to SP5)	resolved	permitted private SD
SP 3		3.8 W	Boeing – South Park		na	na	na	1	SO3001009D	Permit for Boeing South Park Facility lists five outfalls (SP1 to SP5)	resolved	permitted private SD
SP 4		3.8 W	Boeing – South Park		na	na	na	1	SO3001009D	Permit for Boeing South Park Facility lists five outfalls (SP1 to SP5)	resolved	permitted private SD

Table H-1, cont. Outfalls ordered by ID number

Outfall Identification		River Mile	Land Owner/Operator ID		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Outfall No.	Secondary ID[a]		Land Owner/ Outfall Operator	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
SP 5		3.7 W	Boeing – South Park		na	na	na	1	SO3001009D	Permit for Boeing South Park Facility lists five outfalls (SP1 to SP5)	resolved	permitted private SD
Duwamish Pump Station East (035)		0.5 E	King County		36-in.	na	KC CSO	1	na	King County EOF Duwamish Pump Station East (035)	resolved	EOF
East Marginal Way S Pump Station (043)		2.8 E	King County					1	na	East Marginal Way South Pump Station King County EOF	resolved	EOF

[a] Numbers assigned by SPU that run sequentially from north to south along waterway for easier identification of outfall locations. E-W indicates east and west side of waterway.

[b] Visual observations from field survey completed May 16 to 20, 2003, and June 2 to 11, 2003.

[c] Because the ownership of this outfall is to be determined, the proposed designation reflects current use of the outfall only.

ABS – acrylonitrile butadiene styrene
CFS – cubic feet per second
CMP – composite construction
CSO – combined sewer overflow
DI – diameter
E – east
EOF – emergency overflow
FS – Floyd Snider
gpm – gallon per minute
ID – identification
KC – King County
LDW – Lower Duwamish Waterway
na – not available
NPDES – National Pollutant Discharge Elimination System
PVC – polyvinyl chloride
RCP – reinforced concrete pipe
RI – remedial investigation
SCAP – source control action plan
SCL – Seattle City Light
SD – storm drain
SPU – Seattle Public Utilities
TBD – to be determined
W – west
WA – Washington
WSDOT – Washington State Department of Transportation

Table H-2. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
1st Ave S Bridge (west side)	2120	2.2 W	348W		36-in. concrete	10 cfs	unknown SD	1	none found	Overflow from West Seattle reservoir; not associated with discharges from combined or sanitary sewer.	resolved	EOF
1st Ave S Bridge (west side)	2121	2.1 W	346W		12-in. concrete	na	unknown SD	1	none found	WSDOT bridge drains – no permit is likely to be located because covered under general permit. Permit for Swan Bay Holding Dock (SO3002471) has one permitted outfall that may account for this pipe.	unresolved	pipe of unresolved origin and/or use
1st Ave S Bridge (west side)	2505	2.0 W	340W		12–18-in. CMP	none	unknown SD	1	none found	WSDOT bridge drains – no permit is likely to be located because covered under general permit.	resolved	public SD
1st Ave S Bridge (west side)	2507	2.1 W	344W		8-in. steel	none	unknown SD	1	none found	WSDOT bridge drains – no permit is likely to be located because covered under general permit.	resolved	public SD
1st Ave S Bridge (west side)	2508	2.1 W	343W		18-in. concrete	none	unknown SD	1	SO3002471	Permit for Swan Bay Holding Dock (SO3002471) has one permitted outfall that most closely correlates with the pipe size and location of this discharge point.	resolved	permitted private SD
1st Ave S Bridge (west side)	2509	2.1 W	345W		12-in. concrete	none	unknown SD	1	none found	WSDOT bridge drains – no permit is likely to be located because covered under general permit.	resolved	public SD
1st Ave S Bridge (west side)	2510	2.1 W	347W		8-in. PVC	none	unknown SD	1	none found	WSDOT bridge drains – no permit is likely to be located because covered under general permit.	resolved	public SD
1st Ave S Bridge (west side)	2512	2.1 W	342W		4-in. ABS	none	unknown SD	1	none found	WSDOT bridge drains – no permit is likely to be located because covered under general permit.	resolved	public SD
16th Ave Bridge (south side)	2215	3.4 W	364W		12-in. CMP	na	unknown SD	1	none found	Pipe is relatively new, and likely related to drainage from bridge. No permit is likely to be located.	resolved	public SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Alaska Marine Lines	2131	1.3 W	328W		12-in. steel	1/8 full	unknown SD	1	SO3001365D	Pipe is probably covered by Alaska Marine permit which notes that pipes discharge directly to LDW.	resolved	permitted private SD
Alaska Marine Lines	2132	1.3 W	327W		12-in. steel	none	unknown SD	1	SO3001365D	Pipe is probably covered by Alaska Marine permit which notes that pipes discharge directly to LDW.	resolved	permitted private SD
Alaska Marine Lines	2133	1.3 W	324W		12-in. steel	¾ full	unknown SD	1	SO3001365D	Pipe is probably covered by Alaska Marine permit which notes that pipes discharge directly to LDW.	resolved	permitted private SD
Alaska Marine Lines	2134	1.3 W	326W		4-in. PVC	¾ full	unknown SD	1	SO3001365D	Pipe is probably covered by Alaska Marine permit which notes that pipes discharge directly to LDW.	resolved	permitted private SD
Alaska Marine Lines	2135	1.3 W	325W		4-in. PVC	none	unknown SD	1	SO3001365D	Pipe is probably covered by Alaska Marine permit which notes that pipes discharge directly to LDW.	resolved	permitted private SD
Alaska Marine Lines	2136	1.3 W	323W		6-in. steel	full flow	unknown SD	1	SO3001365D	Pipe is probably covered by Alaska Marine permit which notes that pipes discharge directly to LDW.	resolved	permitted private SD
Birmingham	2157	0.4 W	309W		24-in. concrete	na	unknown SD	1	SO3002341D	Permit for General Recycling of WA discharges directly to LDW in this general location.	tentatively resolved	permitted private SD
Boeing Developmental Center	2081	4.2 E	237E		36-in. concrete	none	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
Boeing Developmental Center	2082	4.2 E	238E		24-in. steel	dripping	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Boeing Developmental Center	2085	4.5 E	245E		36-in. concrete	none	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
Boeing Developmental Center	2086	4.4 E	244E		48-in. riveted CMP	low flow	unknown SD	1		Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18). Note: this outfall is bricked shut, but discharge observed during survey.	tentatively resolved	abandoned
Boeing Developmental Center	2087	4.4 E	243E		36-in. concrete	na	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
Boeing Developmental Center	2088	4.4 E	242E		36-in. concrete	trickle	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
Boeing Developmental Center	2089	4.4 E	241E		24-in. concrete	na	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
Boeing Developmental Center	2090	4.6 E	246E		36-in. concrete	none	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
Boeing Developmental Center	2091	4.8 E	247E		36-in. CMP	0.5 gpm	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 – DC17, discontinuous. Boeing files show 18 outfalls (DC1–DC18). This outfall is likely DC5.	resolved	permitted private SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Boeing Developmental Center	2092	4.9 E	248E		18-in. iron	none	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18). This outfall is likely DC17.	resolved	permitted private SD
Boeing Developmental Center	2093	4.9 E	251E		24-in. concrete	5 gpm	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18). This outfall is likely DC 2.	resolved	permitted private SD
Boeing Developmental Center	2094	4.9 E	252E		12-in. concrete	none	unknown	1		Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	unresolved	pipe of unresolved origin and/or use
Boeing Developmental Center	2096	4.9 E	250E		6-in. iron	dripping	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18). This outfall is likely DC 3.	resolved	permitted private SD
Boeing Developmental Center	2097	4.9 E	249E		8-in. steel	none	private SD	1	SO3000146D, SO3000148D	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18). This outfall is likely DC 4.	resolved	permitted private SD
Boeing Developmental Center	BDC-1	4.4 E	(formerly Boeing 6)		na	na	na	1	SO3000146C, SO3000148	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Boeing Developmental Center	BDC-2	4.7 E	(formerly Boeing 7)		na	na	na	1	SO3000146C, SO3000148	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
Boeing Developmental Center	BDC-3	4.7 E	(formerly Boeing 8)		na	na	na	1	SO3000146C, SO3000148	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
Boeing Developmental Center	BDC-4	4.7 E	(formerly Boeing 9)		na	na	na	1	SO3000146C, SO3000148	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18).	resolved	permitted private SD
Boeing Developmental Center	BDC-5	4.9 E	(formerly Boeing 10)		na	na	na	1	SO3000146C, SO3000148	Ecology database shows 14 permitted outfalls for BDC, but numbers are DC1 to DC17, discontinuous. Boeing files show 18 outfalls (DC1 to DC18). This is likely DC 16.	resolved	permitted private SD
Boeing – Issacson	2063	3. 7 E	226E		4-in. steel	none	unknown SD	1	none found	Boeing Thompson/Boeing Scientific permitted outfall from Ecology is shown on map near RM 3.3 on the west side, but Boeing has never owned property there. These coordinates are likely incorrect since the Herrera survey did not identify an outfall at this location.	unresolved	pipe of unresolved origin and/or use
Boeing – Plant 2	2052	2.9 E	176E		30-in. concrete	na	unknown SD	1	SO3000482D, WA0002917	Boeing outfall A comprises twin 30-in. outfalls (Floyd|Snider 2006).	resolved	permitted private SD
Boeing – Plant 2	2053	2.9 E	177E		30-in. concrete	na	unknown SD	1	SO3000482D, WA0002917	Boeing outfall A comprises twin 30-in. outfalls (Floyd|Snider 2006).	resolved	permitted private SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Boeing – Plant 2	2054	3.6 E	211E		4-in. iron	na	unknown SD	1		Boeing field survey indicates that pipe is abandoned. Probably an old fire water blow-off line (Floyd|Snider 2006).	resolved	abandoned
Boeing – Plant 2	2055	3.6 E	212E		18-in. steel	trickle	unknown SD	1		Outfall Y has been rerouted to outfall Z (Floyd|Snider 2006).	resolved	abandoned
Boeing – Plant 2	2056	3.6 E	213E		36-in. concrete	20 gpm	unknown SD	1	SO3000482D, WA0002917	Accepts diverted flow from former outfalls X and Y ((Floyd|Snider 2006).	resolved	permitted private SD
Boeing – Plant 2	2057	3.6 E	214E		8-in. steel	trickle	unknown SD	1		No evidence found to support abandoned classification. Boeing survey could not locate this feature (Floyd|Snider 2006).	unresolved	pipe of unresolved origin and/or use
Boeing – Plant 2	2058	3.6 E	215E		4-in. steel	none	unknown SD	1		No evidence found to support abandoned classification. Boeing survey could not locate this feature, which was probably a fire water line or another pipe, but not an outfall (Floyd|Snider 2006).	unresolved	pipe of unresolved origin and/or use
Boeing – Plant 2	3000	3.5 E	206E		10-in. PVC	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
Boeing – Plant 2	3001	3.5 E	205E		6-in. IP	none	unknown SD	1		No color or odor reported in City survey. Likely disconnected structure piping, rather than an outfall (FS 2006).	resolved	not an outfall
Boeing – Plant 2	3002	3.5 E	204E		12-in. steel	none	unknown SD	1		Visual evidence of plug according to City survey. Boeing could not locate this outfall.	resolved	abandoned
Boeing – Plant 2	3003	3.5 E	203E		6-in. IP	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
Boeing – Plant 2	3004	3.5 E	202E		6-in. steel	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
Boeing – Plant 2	3005	3.5 E	201E		10-in. PVC	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Boeing – Plant 2	3006	3.4 E	200E		4-in. DI	none	unknown SD	1		Location once an NPDES permitted outfall; sign posted at the outfall that says "DOE 017A monitor point." Boeing survey indicated that pipe has since been abandoned (Floyd|Snider 2006).	resolved	abandoned
Boeing – Plant 2	3007	3.4 E	199E		6-in. DI	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
Boeing – Plant 2	3008	3.4 E	198E		4-in. DI	none	unknown SD	1		Boeing survey noted that pipe was broken and disconnected (Floyd|Snider 2006).	resolved	abandoned
Boeing – Plant 2	3009	3.4 E	197E		6-in. DI	none	unknown SD	1		Visual evidence of plug according to City survey.	resolved	abandoned
Boeing – Plant 2	3010	3.4 E	196E		4-in. steel	none	unknown SD	1		Visual evidence of plug according to City survey.	resolved	abandoned
Boeing – Plant 2	3011	3.4 E	195E		10-in. PVC	none	unknown SD	1	SO3000482D, WA0002917	Boeing field survey indicated 10-in. diameter of this pipe (Floyd|Snider 2006).	resolved	permitted private SD
Boeing – Plant 2	3012	3.4 E	194E		6-in. DI	none	unknown SD	1		Boeing field survey confirmed that pipe is abandoned, but origin is unknown (Floyd|Snider 2006).	resolved	abandoned
Boeing – Plant 2	3013	3.4 E	193E		6-in. PVC	none	unknown SD	1		Boeing field survey confirmed that this pipe is abandoned (Floyd|Snider 2006).).	resolved	abandoned
Boeing – Plant 2	3014	3.4 E	192E		4-in. DI	na	unknown SD	1		Boeing field survey confirmed that pipe is disconnected and abandoned (Floyd|Snider 2006).	resolved	abandoned
Boeing – Plant 2	3015	3.4 E	191E		6-in. DI	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
Boeing – Plant 2	3016	3.3 E	190E		24-in. CMP	none	unknown SD	1		Confirmed abandoned in Ecology files.	resolved	abandoned

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Boeing – Plant 2	3017	3.5 E	207E		10-in. DI	flushing	unknown SD	1		Outfall location noted to be flushing during 2003 survey; Boeing completed subsequent field survey confirming this location no longer an outfall, but rather a disconnected weir/pipe that was originally connected to outfall V (Floyd|Snider 2006). Pipe now abandoned.	resolved	abandoned
Boeing – Plant 2	3018	3.5 E	208E		2-in. PVC	none	unknown SD	1		2003 survey observed this outfall to be associated with DOE 013 monitor point outfall 013. Feature was not located during subsequent Boeing in-field survey (Floyd|Snider 2006); Boeing identifies as not an outfall.	resolved	not an outfall
Boeing – Plant 2	3019	3.5 E	209E		na	na	unknown SD	1		2003 survey observed this outfall to be associated with DOE 012 monitor point outfall 012.No outfall specifics were identified during survey. Feature was not located during subsequent Boeing in-field survey (Floyd|Snider 2006). Boeing identified as not an outfall.	resolved	not an outfall
Boeing – Plant 2	3022	3.1 E	178E		8-in. PVC	dripping	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
Boeing – Plant 2	3023	3.1 E	179E		6-in. PVC	none	unknown SD	1		Pipe not visibly plugged, but Boeing field survey indicates that this pipe is abandoned (Floyd|Snider 2006).	resolved	abandoned
Boeing – Plant 2	3024	3.1 E	180E		10-in. steel	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
Boeing – Plant 2	3025	3.1 E	181E		3-in. PVC	none	unknown SD	1		Visual evidence of plug according to City survey.	resolved	abandoned
Boeing – Plant 2	3026	3.2 E	182E		8-in. PVC	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
Boeing – Plant 2	3027	3.2 E	183E		10-in. DI	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Boeing – Plant 2	3028	3.2 E	184E		6-in. DI	na	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
Boeing – Plant 2	3030	3.3 E	185E		24-in. CMP	dripping	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
Boeing – Plant 2	3034	3.3 E	189E		12-in. PVC	none	unknown SD	1		3034 is a flow weir that was once connected to pipe L (3035). Pipe and weir are no longer connected (Floyd|Snider 2006).	resolved	abandoned
Boeing – Plant 2	3035	3.3 E	188E		12-in. DI	none	unknown SD	1	SO3000482D, WA0002917		resolved	permitted private SD
Boeing – Plant 2	Boeing 1	3.0 E			na	na	na	1	SO3000482D, WA0002917	Outfall added during Boeing update.	resolved	permitted private SD
Boeing – Plant 2	Boeing 2	3.1 E			na	na	na	1	SO3000482D, WA0002917	Outfall added during Boeing update.	resolved	permitted private SD
Boeing – Plant 2	Boeing 3	3.4 E			na	na	na	1	SO3000482D, WA0002917	Outfall was not identified by Herrera but is an active outfall (Floyd|Snider 2006).	resolved	permitted private SD
Boeing – Plant 2	Boeing 4	3.5 E			na	na	na	1	SO3000482D, WA0002917	Outfall added by Boeing since it was not located by Herrera/City.	resolved	permitted private SD
Boeing – Plant 2	Boeing 5	3.5 E			na	na	na	1	SO3000482D, WA0002917	Outfall is active, but buried in embankment (Floyd|Snider 2006).	resolved	permitted private SD
Boeing – Plant 2	Boeing 6	3.3 E	(formerly Boeing 11)		na	na	na	1	SO3000482D, WA0002917	This 4-in. pipe was not located by Herrera or Boeing but is presumed to be located near outfall J (Floyd|Snider 2006).	resolved	permitted private SD
Boeing – Plant 2	Boeing 7	3.5 E	(formerly Boeing 12)		na	na	na	1	SO3000482D, WA0002917	Outfall added by Boeing since it was not located by Herrera/City.	resolved	permitted private SD
Boeing – Plant 2	Boeing 8	3. 7 E	(formerly Boeing 13)		na	na	na	1	SO3000482D, WA0002917	Outfall X was missed during Herrera survey. This outfall is now abandoned, and flow is routed through outfall Z (Floyd|Snider 2006).	resolved	abandoned

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Boeing – Plant 2	Boeing 9	3.6 E	(formerly Boeing 14)		na	na	na	1	SO300048D, WA0002917	This outfall (located just north of 2059) was not located by Herrera. Outfall formerly drained a portion of the South Yard but is not abandoned (Floyd|Snider 2006).	resolved	permitted private SD
Boeing – South Park	SP 1	3.9 W			12-in. concrete	0.5 gpm	unknown SD	1	SO3001009D	Permit for Boeing South Park Facility lists five outfalls (SP1 to SP5)	resolved	permitted private SD
Boeing – South Park	SP 2	3.9 W			na	na	na	1	SO3001009D	Permit for Boeing South Park Facility lists five outfalls (SP1 to SP5)	resolved	permitted private SD
Boeing – South Park	SP 3	3.8 W			na	na	na	1	SO3001009D	Permit for Boeing South Park Facility lists five outfalls (SP1 to SP5)	resolved	permitted private SD
Boeing – South Park	SP 4	3.8 W			na	na	na	1	SO3001009D	Permit for Boeing South Park Facility lists five outfalls (SP1 to SP5)	resolved	permitted private SD
Boeing – South Park	SP 5	3.7 W			na	na	na	1	SO3001009D	Permit for Boeing South Park Facility lists five outfalls (SP1 to SP5)	resolved	permitted private SD
Boeing – South Park	2103	3.8 W	372W		12-in. concrete	0.5 gpm	storm drain	1	none found	No odor, no color. End of pipe chipped off.	unresolved	pipe of unresolved origin and/or use
Boeing – Thompson	2061	3.8 E	228E		24-in. steel	3 gpm	private SD	1	SO3000148D	Permit indicates direct discharge to LDW, permitted under Boeing Development Center.	resolved	permitted private SD
Boeing – Thompson	2077	3.9 E	229E		steel	1 gpm	private SD	1	SO3000148D	Permit indicates direct discharge to LDW, permitted under Boeing Development Center	resolved	permitted private SD
Boyer Logistics, Inc	2114	2.5 W	354W		6-in. concrete	none	unknown SD	1	SO3005598A	No specific information provided in permit, but Ecology database lists four outfalls at Boyer facility.	resolved	permitted private SD
Boyer Logistics, Inc	2115	2.4 W	353W		8-in. PVC	none	unknown SD	1	SO3005598A	No specific information provided in permit, but Ecology database lists four outfalls at Boyer facility.	resolved	permitted private SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Boyer Logistics, Inc	2116	2.3 W	352W		6-in. plastic	none	unknown SD	1	SO3005598A	No specific information provided in permit, but Ecology database lists four outfalls at Boyer facility.	resolved	permitted private SD
Boyer Logistics, Inc	2117	2.3 W	351W		4-in. PVC	none	unknown SD	1	SO3005598A	No specific information provided in permit, but Ecology database lists four outfalls at Boyer facility.	resolved	permitted private SD
Container Properties LLC	2078	4.2 E	236E	Formerly Rhône-Poulenc/ Slip 6	8-in. plug iron	dripping	unknown SD	1	none found	Location identified as stormwater outfall utilized by Rhône-Poulenc. Outfall location may have been abandoned during demolition of onsite buildings. New sub-grade stormwater piping plumbed to City of Seattle storm drains.	resolved	private SD
Container Properties LLC	2079	4.2 E	235E	Formerly Rhône-Poulenc/ Slip 6	6-in. plug iron	none	unknown SD	1	none found	Location identified as stormwater outfall utilized by former Rhône-Poulenc. Pipe securely plugged according to City of Seattle survey.	resolved	abandoned
Corps of Engineers	2006	0.7 E	111E		12-in. metal	trickle	unknown SD	1	none found	No information readily available.	resolved	public SD
Crowley Marine	2042	2.8 E	174E		8-in. PVC	trickle	unknown SD	1	Northland Service: SO3003646	No permit located for Crowley/Crowley Marine. Permit for Northland Services identifies six outfalls, that are fairly good matches to the six outfalls identified by City of Seattle survey at Crowley Marine.	tentatively resolved	permitted private SD
Crowley Marine	5006	2.8 E	175E		8-in. PVC	none	unknown SD	1	Northland Service: SO3003646	No permit located for Crowley/Crowley Marine. Permit for Northland Services identifies six outfalls, that are fairly good matches to the six outfalls identified by City of Seattle survey at Crowley Marine.	tentatively resolved	permitted private SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Crowley Marine	5007	2.8 E	173E		8-in. PVC	none	unknown SD	1	Northland Service: SO3003646	No permit located for Crowley/Crowley Marine. Permit for Northland Services identifies six outfalls, that are fairly good matches to the six outfalls identified by City of Seattle survey at Crowley Marine.	tentatively resolved	permitted private SD
Crowley Marine	5008	2.8 E	172E		8-in. PVC	none	unknown SD	1	Northland Service: SO3003646	No permit located for Crowley/Crowley Marine. Permit for Northland Services identifies six outfalls, that are fairly good matches to the six outfalls identified by City of Seattle survey at Crowley Marine.	tentatively resolved	permitted private SD
Crowley Marine	5009	2.8 E	168E		8-in. PVC	none	unknown SD	1	Northland Service: SO3003646	No permit located for Crowley/Crowley Marine. Permit for Northland Services identifies six outfalls, that are fairly good matches to the six outfalls identified by City of Seattle survey at Crowley Marine.	tentatively resolved	permitted private SD
Crowley Marine	5010	2.8 E	163E		8-in. PVC	none	unknown SD	1	Northland Service: SO3003646	No permit located for Crowley/Crowley Marine. Permit for Northland Services identifies six outfalls, that are fairly good matches to the six outfalls identified by City of Seattle survey at Crowley Marine.	tentatively resolved	permitted private SD
Drainage swale	2213	3.7 W	371W		na	na	swale	1	na	Drainage/creek swale	resolved	stream, channel, or swale
Drummond	2140	0.5 W	312W	State Parks	8-in. steel	none	unknown SD	1		Permit for Evergreen Trails, Inc., mentions direct discharge to LDW through one outfall of 5 acres of paved area, similar to observations from City survey. Location/ownership of this pipe unclear.	unresolved	pipe of unresolved origin and/or use

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Drummond	2141	0.5 W	313W	State Parks	8-in. steel	none	unknown SD	1	Evergreen Trails: SO3002966C	Permit for Evergreen Trails, Inc. mentions direct discharge to LDW through one outfall of 5 acres of paved area, similar to observations from City survey. This location most closely matches latitude and longitude information provided in the permit.	tentatively resolved	permitted private SD
Drummond	2142	0.5 W	314W	State Parks	8-in. steel	none	unknown SD	1		Permit for Evergreen Trails, Inc. mentions direct discharge to LDW through one outfall of 5 acres of paved area, similar to observations from City survey. Location/ownership of this pipe unclear.	unresolved	pipe of unresolved origin and/or use
Drummond	2143	0.5 W	315W	State Parks	8-in. steel	none	unknown SD	1		Permit for Evergreen Trails, Inc. mentions direct discharge to LDW through one outfall of 5 acres of paved area, similar to observations from City survey. Location/ownership of this pipe unclear.	unresolved	pipe of unresolved origin and/or use
Drummond	2226	0.5 W	311W		na	15 gpm	Ditch	1	na	Ditch at Drummond property	resolved	stream, channel, or swale
Duwamish Shipyard, LLC	2129	1.4 W	329W		6-in. DI	none	unknown SD	1	WA0030937C	Five outfalls listed on permit, but only 1 outfall located in City of Seattle survey. All outfalls may all be routed to single discharge point or routed to a municipal treatment facility.	tentatively resolved	permitted private SD
Duwamish Yacht Club	2100 (B)	4.2 W	376W		6-in. PVC	na	unknown SD	1	none found	Potentially a private SD serving adjacent waterfront property.	unresolved	pipe of unresolved origin and/or use
First South Properties	2216	2.9 E	170E	Cedar Grove/Slip 4 South	6-in. concrete	na	unknown SD	1	SO3002641C	Ecology database lists two outfalls (Outfalls A and B) that are matches for two First South locations (permitted). The remaining three outfalls are identified in the Slip 4 SCAP as storm drains.	tentatively resolved	permitted private SDs

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
First South Properties	2217	2.9 E	167E	Cedar Grove/Slip 4 South	4-in. steel	na	unknown SD	1	SO3002641C	Ecology database lists two outfalls (Outfalls A and B) that are matches for two First South locations (permitted). The remaining three outfalls are identified in the Slip 4 SCAP as storm drains.	tentatively resolved	permitted private SDs
First South Properties	2219	2.9 E	166E	Cedar Grove/Slip 4 South	6-in. steel	na	unknown SD	1	SO3002641C	Ecology database lists two outfalls (Outfalls A and B) that are matches for two First South locations (permitted). The remaining three outfalls are identified in the Slip 4 SCAP as storm drains.	tentatively resolved	permitted private SDs
First South Properties	2050	2.9 E	165E	Cedar Grove/Slip 4 South	6-in. concrete	na	unknown SD	1	SO3002641C	Ecology database lists two outfalls (Outfalls A and B) that are matches for two First South locations (permitted). The remaining three outfalls are identified in the Slip 4 SCAP as storm drains.	tentatively resolved	permitted private SD
First South Properties	2051	2.9 E	169E	Cedar Grove/Slip 4 South	6-in. concrete	none	unknown SD	1	SO3002641C	Ecology database lists two outfalls (Outfalls A and B) that are matches for two First South locations (permitted). The remaining three outfalls are identified in the Slip 4 SCAP as storm drains.	tentatively resolved	permitted private SD
General Services Administration	2004	0.9 E	113E		8-in. concrete	na	unknown SD	1	none found	No permit located for WA Liquor Control Board.	resolved	public SD
General Services Administration	2005	0.9 E	112E		8-in. concrete	na	unknown SD	1	none found	No permit located for WA Liquor Control Board.	resolved	public SD
General Services Administration	2245	0.9 E	118E		32-in. steel	na	unknown SD	1	none found	No permit located for WA Liquor Control Board.	resolved	public SD
General Services Administration	2246	0.9 E	114E		8-in. concrete	na	unknown SD	1	none found	No permit located for WA Liquor Control Board.	resolved	public SD
General Services Administration	2247	0.9 E	116E		8-in. concrete	na	unknown SD	1	none found	No permit located for WA Liquor Control Board.	resolved	public SD
General Services Administration	5000	0.9 E	115E		32-in. steel	na	unknown SD	1	none found	No permit located for WA Liquor Control Board.	resolved	public SD
General Services Administration	5001	0.9 E	117E		32-in. steel	na	unknown SD	1	none found	No permit located for WA Liquor Control Board.	resolved	public SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Gilmore James Bldg	2021	1.8 E	136E		6-in. PVC	na	unknown SD	1	none found	No information readily available.	tentatively resolved	private SD
Glacier Northwest	2018	1.7 E	135E	East Shore	8-in. PVC	none	unknown SD	1	SO3002227D WAG503191C WAG503347	Map in permit shows two clear outfalls, and mentions various other ditches/drainage points.	tentatively resolved	permitted private SD
Glacier Northwest	2019	1.7 E	133E	East Shore	24-in. concrete	2 gpm	unknown SD	1	SO3002227D WAG503191C WAG503347	Map in permit shows two clear outfalls, and mentions various other ditches/drainage points.	tentatively resolved	permitted private SD
Glacier Northwest	2130	1.4 W	330W	West Shore	15-in. DI	none	unknown SD	1	SO3002227DWA G503191C WAG503347	Map in permit shows two clear outfalls, and mentions various other ditches/drainage points.	tentatively resolved	permitted private SD
Hopkins, Frederick	2027	2.3 E	150E		6-in. clay	none	unknown SD	1	none found	No permit located for Hopkins Frederick (this is the name of the estate holding the land). May be permitted under Schultz Distributing (SO3002346D) – four outfalls, Seattle Iron & Metal Works (SO3003645C) – one outfall, or Seattle Boilerworks (SO3002208D) – one outfall.	tentatively resolved	private SD
Hopkins, Frederick	2028	2.3 E	149E	Estate Trust	18-in. concrete	none	unknown SD	1	none found	No permit located for Hopkins Frederick (this is the name of the estate holding the land). May be permitted under Schultz Distributing (SO3002346D) – four outfalls, Seattle Iron & Metal Works (SO3003645C) – one outfall, or Seattle Boilerworks (SO3002208D) – one outfall.	tentatively resolved	private SD
Hopkins, Frederick	2029	2.3 E	147E	Estate Trust	3-in. aluminum	none	unknown SD	1	none found	No permit located for Hopkins Frederick (this is the name of the estate holding the land). May be permitted under Schultz Distributing (SO3002346D) – four outfalls, Seattle Iron & Metal Works (SO3003645C) – one outfall, or Seattle Boilerworks (SO3002208D) – one outfall.	tentatively resolved	private SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Hopkins, Frederick	2030	2.3 E	148E	Estate Trust	3-in. aluminum	none	unknown SD	1	none found	No permit located for Hopkins Frederick (this is the name of the estate holding the land). May be permitted under Schultz Distributing (SO3002346D) – four outfalls, Seattle Iron & Metal Works (SO3003645C) – one outfall, or Seattle Boilerworks (SO3002208D) – one outfall.	tentatively resolved	private SD
Hopkins, Frederick	2032	2.3 E	146E	Estate Trust	3-in. aluminum	none	unknown SD	1	none found	No permit located for Hopkins Frederick (this is the name of the estate holding the land). May be permitted under Schultz Distributing (SO3002346D) – four outfalls, Seattle Iron & Metal Works (SO3003645C) – one outfall, or Seattle Boilerworks (SO3002208D) – one outfall.	tentatively resolved	private SD
Hopkins, Frederick	2033	2.3 E	145E	Estate Trust	3-in. PVC	none	unknown SD	1	none found	No permit located for Hopkins Frederick (this is the name of the estate holding the land). May be permitted under Schultz Distributing (SO3002346D) – four outfalls, Seattle Iron & Metal Works (SO3003645C) – one outfall, or Seattle Boilerworks (SO3002208D) – one outfall.	resolved	private SD
James Hardie	2014	1.6 E	130E		24-in. concrete	3 gpm	Settling pond outlet	1	SO3000056D	May also be covered under this permit as an additional overflow outlet.	resolved	permitted private SD
James Hardie	2015	1.6 E	131E		na	none	unknown SD	1	SO3000056D	Permit transferred to BPD Gypsum in Jan 2004 with direct discharge to LDW. Ecology database lists three outfalls (Nos. 1 to 3).	resolved	permitted private SD
James Hardie	2016	1.6 E	132E		na	none	unknown SD	1	SO3000056D	Permit transferred to BPD Gypsum in Jan 2004 with direct discharge to LDW. Ecology database lists three outfalls (Nos. 1 to 3).	resolved	permitted private SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
James Hardie	2017	1.5 E	129E		12-in. PVC	none	unknown SD	1	SO3000056D	Permit transferred to BPD Gypsum in Jan 2004 with direct discharge to LDW. Ecology database lists three outfalls (Nos. 1 to 3).	resolved	permitted private SD
Jorgensen Forge	2064	3.7 E	224E		12-in. CMP	2 gpm	unknown SD	1	SO3003231C	Five outfalls shown on Jorgensen map within the permit file that discharge directly to LDW. Ecology database lists four outfalls.	resolved	permitted private SD
Jorgensen Forge	2065	3.7 E	223E		18-in. concrete	5 gpm	unknown SD	1	SO3003231C	Five outfalls shown on Jorgensen map within the permit file that discharge directly to LDW.	resolved	permitted private SD
Jorgensen Forge	2066	3.7 E	222E		12-in. steel	none	unknown SD	1	SO3003231C	Five outfalls shown on Jorgensen map within the permit file that discharge directly to LDW.	resolved	permitted private SD
Jorgensen Forge	2067	3.7 E	221E		12-in. concrete	none	unknown SD	1	SO3003231C	Plugged using concrete in the mid-1980s; dye tracer study confirmed closure (EAA 4 data gaps, citing Farallon and Anchor 2006).	resolved	abandoned
Jorgensen Forge	2068	3.7 E	220E		4-in. steel	none	unknown SD	1	SO3003231C	Plugged using concrete in the mid-1980s; dye tracer study confirmed closure (EAA 4 data gaps, citing Farallon and Anchor 2006).	resolved	abandoned
Jorgensen Forge	2069	3.7 E	219E		4-in. steel	none	unknown SD	1	SO3003231C	Plugged using concrete in the mid-1980s; dye tracer study confirmed closure (EAA 4 data gaps, citing Farallon and Anchor 2006).	resolved	abandoned
Jorgensen Forge	2070	3.6 E	218E		12-in. steel	none	unknown SD	1	SO3003231C	Plugged using concrete in the mid-1980s; dye tracer study confirmed closure (EAA 4 data gaps, citing Farallon and Anchor 2006).	resolved	abandoned
Jorgensen Forge	2071	3.6 E	217E		2-in. steel	none	unknown SD	1	SO3003231C	Plugged using concrete in the mid-1980s; dye tracer study confirmed closure (EAA 4 data gaps, citing Farallon and Anchor 2006).	resolved	abandoned

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Jorgensen Forge	2072	3.7 E	225E		18-in. steel	trickle	unknown SD	1	SO3003231C	Five outfalls shown on Jorgensen map within the permit file that discharge directly to LDW.	resolved	permitted private SD
Kenworth Truck Co.	2073	4.0 E	233E		18-in. concrete	trickle	unknown SD	1	(Former permit SO3001784) SO3008681A	Kenworth's NPDES permit was terminated in Feb 2003. It remains unclear whether past discharges went directly into the Duwamish. Insurance Auto Auctions (SO3008681) also has 3 permitted outfalls located on the Kenworth property. These may account for 3 to 4 outfalls.	resolved	permitted private SD
Kenworth Truck Co.	2074	3.9 E	232E		8-in. CMP	none	unknown SD	1	(Former permit SO3001784) SO3008681A	Kenworth's NPDES permit was terminated in Feb 2003. It remains unclear whether past discharges went directly into the Duwamish. Insurance Auto Auctions (SO3008681) also has three permitted outfalls located on the Kenworth property. These may account for three to four outfalls.	resolved	permitted private SD
Kenworth Truck Co.	2075	3.9 E	231E		CMP	none	unknown SD	1	(Former permit SO3001784) SO3008681A	Kenworth's NPDES permit was terminated in Feb 2003. It remains unclear whether past discharges went directly into the Duwamish. Insurance Auto Auctions (SO3008681) also has three permitted outfalls located on the Kenworth property. These may account for three to four outfalls.	resolved	permitted private SD
Kenworth Truck Co.	2076	3.9 E	230E		30-in. steel	none	unknown SD	1	(Former permit SO3001784) SO3008681A	Kenworth's NPDES permit was terminated in Feb 2003. It remains unclear whether past discharges went directly into the Duwamish. Insurance Auto Auctions (SO3008681) also has three permitted outfalls located on the Kenworth property. These may account for three to four outfalls.	resolved	permitted private SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
King County	2007	1.2 E	122E		18-in. CMP	none	KC SD	1	na	King County storm drains	resolved	public SD
King County	2008	1.2 E	123E		8-in. steel	none	KC SD	1	na	King County storm drains	resolved	public SD
King County	2009	1.3 E	124E		6-in. ductile	none	KC SD	1	na	King County storm drains	resolved	public SD
King County	2010	1.4 E	125E		6-in. PVC	none	KC SD	1	na	King County storm drains	resolved	public SD
King County	2011	1.4 E	126E		12-in. PVC	none	KC SD	1	na	King County storm drains	resolved	public SD
King County	2049	2.8 E	159E		60-in. concrete	200 gpm	KC SD/SPU EOF	1	na	King County Airport SD No. 3 SPU EOF No. 117 (formerly Slip 4 SD)	resolved	EOF/SD
King County	2080	4.2 E	234E		24-in. riveted steel	20 gpm	KC SD	1	na	King County Airport storm drain No. 1	resolved	public SD
King County	2100 (A)	4.2 W	375W	S 96th SD	72-in. CMP	flowing	unknown SD	1	none found	S 96th St SD	resolved	public SD
King County	2107	2.8 W	357W		36-in. RCP	2 gpm	KC CSO	1	na	King County Combined Sewer Overflow 8th Ave S CSO (040)	resolved	CSO
King County	2153	0.5 E	107E		36-in.	na	KC CSO	1	na	Concrete stormwater system structure, not point of outfall	resolved	not an outfall
King County	2223	1.1 E	121E		18-in. ductile iron	na	KC CSO	1	na	King County Combined Sewer Overflow Brandon St. (041)	resolved	CSO
King County	2244	1.1 E	119E		na	na	KC SD	1	na	King County storm drain	resolved	public SD
King County	2502	1.9 E	139E		8-ft steel gate	none	KC CSO	1	na	King County Combined Sewer Overflow, E Michigan (039)	resolved	CSO
King County	2506	2.0 W	341W		36-in. concrete	none	KC CSO	1	na	King County Combined Sewer Overflow, W Michigan CSO (042)	resolved	CSO
King County	Duwamish Pump Station East (035)	0.5 E			36-in.	na	KC CSO	1	na	King County EOF Duwamish Pump Station East (035)	resolved	EOF

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
King County	East Marginal Way S Pump Station (043)	2.8 E						1	na	East Marginal Way South Pump Station King County EOF	resolved	EOF
King County/SPU/ Boeing	2095	4.9 E	253E	KC Norfolk CSO (044)	84 in. 6 ft x 6 ft	10 gpm	KC/SPU CSO/SD	1	see notes	Public storm drain that also receives stormwater discharges from Boeing properties upstream. This discharge is permitted through Boeing Developmental Center (WA031488B or SO3000146C) as DC1. King County's Norfolk CSO (044). Seattle Public Utilities also operates an EOF that discharges through this outfall.	resolved	CSO/SD
Lafarge Corporation	2137	1.2 W	322W		24-in. concrete	5/8 flow	unknown SD	1	WA0002232	Permit gives range coordinates for outfalls, but no specific number. All unknowns are likely covered by this permit.	resolved	permitted private SD
Lafarge Corporation	2138	1.0 W	317W		6-in. steel	none	unknown SD	1	WA0002232	Permit gives range coordinates for outfalls, but no specific number. All unknowns are likely covered by this permit.	resolved	permitted private SD
Lafarge Corporation	2139	1.0 W	316W		6-in. DI	none	unknown SD	1	WA0002232	Permit gives range coordinates for outfalls, but no specific number. All unknowns are likely covered by this permit.	resolved	permitted private SD
Lafarge Corporation	5002	1.2 W	318W		36-in. CMP	none	unknown SD	1	WA0002232E	Permit gives range coordinates for outfalls, but no specific number. All unknowns are likely covered by this permit.	resolved	permitted private SD
Lafarge Corporation	5003	1.2 W	319W		32-in. CMP	4 gpm	unknown SD	1	WA0002232E	Permit gives range coordinates for outfalls, but no specific number. All unknowns are likely covered by this permit.	resolved	permitted private SD
Lafarge Corporation	5004	1.2 W	320W		28-in. CMP	trickle	unknown SD	1	WA0002232E	Permit gives range coordinates for outfalls, but no specific number. All unknowns are likely covered by this permit.	resolved	permitted private SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Lafarge Corporation	5005	1.2 W	321W		48-in. concrete	trickle	unknown SD	1	WA0002232E	Permit gives range coordinates for outfalls, but no specific number. All unknowns are likely covered by this permit.	resolved	permitted private SD
Longview Fibre	2013	1.4 E	128E		12-in. concrete	trickle	unknown SD	1	SO3000206D	Direct discharge to LDW.	resolved	permitted private SD
N of Bridge	2022	1.9 E	137E		8-in. PVC	0.5 gpm	unknown SD	1	none found	No information readily available. Located near several other public SDs, so may be KC or SPU outfall.	unresolved	pipe of unresolved origin and/or use
Port	2148	0.0 W	301W		12-in. CPE	none	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
Port	2149	0.0 W	300W		24-in. CPE	na	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
Port	2150	0.1 W	302W		18-in. CPE	na	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
Port	2151	0.1	104E		15-in. CMP, behind headwall	none	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
Port	2154	0.1 E	103E		6-in. concrete	none	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
Port	2156	0.0	102E		18-in. CMP at headwall DI	20 gpm	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
Port	2209	3.6 W	370W		8-in. PVC	none	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
Port	2210	3.6 W	369W		4-in. and 3-in. iron	na	not an outfall	1	na	Pipe location identified as suspected abandoned in Herrera survey. Pipe noted during site activities but identified as miscellaneous shoreline debris and not an outfall.	resolved	not an outfall
Port	2211	3.6 W	368W		4-in. CPE	none	not an outfall	1	na	Pipe location identified as suspected abandoned in Herrera survey. Pipe noted during site activities but identified as miscellaneous shoreline debris and not an outfall.	resolved	not an outfall

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Port	2212	3.6 W	366W		6-in. PVC	none	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
Port	2220	1.8 W	333W		24-in. concrete	na	Port SD	1	na	Port of Seattle storm drains	resolved	public SD
Port	2225	0.6 E	109E		18-in. concrete	none	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
Port	2232	0.2 W	304W		18-in. CPE	none	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
Port	2233	0.1 W	303W		na	na	channel	1	na	Drainage channel constructed by Port at T-105	resolved	stream, channel, or swale
Port of Seattle/Delta Marine	2205	4.3 W	377W		na	na	creek	1	none found	Creek outlet on Port property south of S 96th, just south of Delta crane.	resolved	stream, channel, or swale
Port/Harbor Real Estate	HRE 1	0.1					unknown SD	1	none found	Outfall located on Port property adjacent to Harbor Real Estate. Discharge of stormwater from both properties likely.	tentatively resolved	public SD
Port – Sea Freeze	Port - SF	1.9 W					Port SD	1	na	Port of Seattle storm drain	resolved	public SD
Port – Terminal 115	2122	1.9 W	338W		24-in. concrete	1 gpm	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
Port – Terminal 115	2123	1.9 W	334W		12-in. CMP	none	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
Port – Terminal 115	2124	1.9 W	336W		18-in. concrete lined DI	na	Port SD	1	na	Port of Seattle storm drain	resolved	public SD
Port – Terminal 115	2128	1.5 W	331W	West Shore	15-in. CMP	under-water	unknown SD	1	SO3002227D WAG503191D WAG503347	Map in permit shows two clear outfalls, and mentions various other ditches/drainage points.	resolved	public SD
R&A Properties	2037	2.6 E	155E		10-in. steel	none	unknown SD	1	Puget Sound Trucking: SO300949	Permit for Puget Sound Trucking has five outfalls in Ecology database which may cover these outfalls.	resolved	permitted private SD
R&A Properties	2038	2.6 E	162E		6-in. concrete	none	unknown SD	1	Puget Sound Trucking: SO300949	Permit for Puget Sound Trucking has five outfalls in Ecology database which may cover these outfalls.	resolved	permitted private SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
R&A Properties	2039	2.6 E	161E		6-in. concrete	none	unknown SD	1	Puget Sound Trucking: SO300949	Permit for Puget Sound Trucking has five outfalls in Ecology database which may cover these outfalls.	resolved	permitted private SD
R&A Properties	2040	2.6 E	164E		12-in. concrete	trickle	unknown SD	1	Puget Sound Trucking: SO300949	Permit for Puget Sound Trucking has five outfalls in Ecology database which may cover these outfalls.	resolved	permitted private SD
SCS Holdings	2024	2.0 E	141E		12-in. concrete	10 gpm	unknown SD	1	SCS Refrigerated Services: SO3005565A	Permit for SCS Refrigerated Services corresponds with three outfalls in the Ecology database. All permitted outfalls may be routed to this one discharge point or may be routed to a municipal treatment facility.	resolved	permitted private SD
Seattle City Light	2041	2.7 E	171E		4-in. concrete	na				This outfall was originally identified as the old water intake for the Georgetown steam plant but more recent investigations have determined that it is a pipe of unknown origin.	resolved	pipe of unresolved origin and/or use
Seattle City Light	2047	2.8 E	156E		72-in. CMP	na	City SD	1	na	Seattle City Light storm drain Georgetown flume	resolved	public SD
Seattle City Light	2098	4.5 W	379W		6-in. CMP	none	City SD	1	na	Seattle City Light storm drain	resolved	public SD
Seattle City Light	2099	4.4 W	378W		6-in. CMP	dripping	City SD	1	na	Seattle City Light storm drain	resolved	public SD
Shalmar Group	2034	2.5 E	152E		6-in. steel	none	unknown SD	1	Seattle Iron & Metal Works: SO3003645	Permit for Seattle Iron & Metal Works may correspond to this outfall.	resolved	permitted private SD
Slip 6 – Non-Boeing	2083	4.2 E	239E		6-in. steel	discharge	unknown SD	1	none found	Not a Boeing permitted outfall. Boeing has investigated this pipe and believes that it is a drain from an underground utility vault that predates Boeing's use of this property. Boeing is in the process of having this pipe plugged.	resolved	abandoned

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
Slip 6 – Non-Boeing	2084	4.2 E	240E		6-in.	dripping	unknown SD	1	none found	Not a Boeing permitted outfall. Boeing has investigated this pipe and believes that it is a drain from an underground utility vault that predates Boeing's use of this property. Boeing is in the process of having this pipe plugged.	resolved	abandoned
S 92nd Pl	2101	4.0 W	374W		18-in. concrete	none	unknown SD	1	none found	No information readily available – likely drains adjacent property.	unresolved	pipe of unresolved origin and/or use
S Chicago St	2109	2.9 W	362W		11-in. wood	none	unknown SD	1	none found	No information readily available – likely drains adjacent property.	unresolved	pipe of unresolved origin and/or use
S Chicago St	2110	2.9 W	361W		15-in. concrete	none	unknown SD	1	none found	No information readily available – likely drains adjacent property.	unresolved	pipe of unresolved origin and/or use
S Chicago St	2111	2.9 W	360W		12-in. DI	none	unknown SD	1	none found	No information readily available – likely drains adjacent property.	unresolved	pipe of unresolved origin and/or use
S Othello St	2036	2.6 E	154E	Puget Sound Truck Lines, Inc.	8-in. steel	none	unknown SD	1	SO3000949	Permit for Puget Sound Trucking has five outfalls in Ecology database which may cover these outfalls. Outfall likely also drains adjacent street surface.	resolved	permitted private SD
S Portland St	2106	2.8 W	358W		24-in. DI	none	unknown SD	1	none found	No information readily available – likely drains adjacent property.	unresolved	pipe of unresolved origin and/or use
S Portland St	2108	2.8 W	359W		8-in. DI	none	unknown SD	1	none found	No information readily available – likely drains adjacent property.	unresolved	pipe of unresolved origin and/or use

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
S Southern St	3037	3.2 W	363W		18-in. CMP	none	unknown SD	1	none found	No information readily available – likely drains adjacent street surface and may drain upland permitted locations. The City does not have any storm drains in this area .	tentatively resolved	pipe of unresolved origin and/or use
S Webster St	2113	2.6 W	355W		6-in. concrete	moist	unknown SD	1	none found	No information readily available – likely drains adjacent street surface and may drain upland permitted locations.	tentatively resolved	public SD
South Park Marina	2214	3.5 W	365W		12-in. CMP	na	unknown SD	1	WAG030045C	Direct discharge to LDW.	resolved	permitted private SD
SPU	2002	0.6 E	108E		30-in. steel	drip	KC or SPU CSO/SD	1	na	Seattle Public Utilities abandoned treatment facility outfall (Duwamish Diagonal SCAP documentation)	resolved	abandoned
SPU	2003	0.7 E	110E		12-in. steel	trickle	unknown SD	1	none found	Diagonal Ave S SD	resolved	public SD
SPU	2026	2.3 E	151E		30-in. ductile	none	City SD	1	na	Seattle Public Utility storm drain	resolved	public SD
SPU	2035	2.5 E	153E		30-in. DI	trickle	City SD	1	na	Seattle Public Utility storm drains	resolved	public SD
SPU	2048	2.8 E	158E		24-in. concrete	none	City SD	1	na	North Boeing Field SD Storm drain outfall owned by SPU but only receives runoff from North Boeing Field (formerly Slip 4 CSO/SD (117).	resolved	public SD
SPU	2112	2.7 W	356W		na	na	City SD	1	na	Seattle Public Utility storm drain	resolved	public SD
SPU	2118	2.2 W	350W		24-in. concrete	none	City SD	1	na	Seattle Public Utility storm drain	resolved	public SD
SPU	2125	1.9 W	335W		72-in. concrete	100 gpm	City SD	1	na	Seattle Public Utility storm drain	resolved	public SD
SPU	S Brighton St	2.1 E					SPU CSO/SD	1	na	Seattle Public Utility CSO/SD – old outfall layer. Outfall not found during field survey. Location plotted from SPU GIS.	resolved	CSO/SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
SPU/Boeing	3031	3.3 E	187E		8-in. concrete	na	City SD	1	na	According to City records, this outfall serves the southern portion of 16th Ave S and the Boeing facility at 7755 E Marginal Way, with cross connection and discharge through outfall No. 3032. This particular location is not an outfall	resolved	not an outfall
SPU/Boeing	3032	3.3 E	186E		12-in. DI	dripping	public SD	1		Outfall drains both public roadways and Boeing Plant 2 (Outfall J). Shared-use identified (Floyd|Snider 2006). Side sewer card confirms that this pipe drains both Boeing facilities and roadway.	resolved	public SD
SPU/King County	2062	3.8 E	227E		48-in. CMP	20 gpm	SPU/KC EOF	1	na	Seattle Public Utility EOF (No. 156) King County Airport SD No. 2	resolved	EOF/SD
SPU/King County	2127	1.5 W	332W		48-in. concrete	50 gpm	KC CSO/ City SD	1	na	Terminal 115 CSO (038)/SW Kenny SD.	resolved	CSO/SD
SPU/King County	2155	0.5 E	106E		144-in. concrete	2 ft/sec	SPU and KC CSO/SD	1	na	Seattle Public Utility Diagonal CSO (No. 111) and King County Hanford No. 1 (031)/Bayview CSO; Seattle Public Utility SD	resolved	CSO/SD
SW Idaho St	2144	0.3 W	307W		10-in. DI	under-water	unknown SD	1	none found	No information readily available – may drain adjacent property.	unresolved	pipe of unresolved origin and/or use
SW Idaho St	2145	0.3 W	308W		4-in. DI	none	unknown SD	1	none found	No information readily available – may drain adjacent property.	unresolved	pipe of unresolved origin and/or use
SW Idaho St	2146	0.3 W	306W		6-in. DI	none	unknown SD	1	none found	No information readily available – may drain adjacent property.	unresolved	pipe of unresolved origin and/or use
SW Idaho St	2147	0.3 W	305W		72-in. concrete	under-water	unknown SD	1	none found	SPU storm drain	resolved	public SD

Table H-2, cont. Outfalls ordered by owner/outfall operator

Land Owner/Operator ID		River mile	Outfall Identification		Pipe Description		Outfall Type	No. of Outfalls	Permit Number	Notes from Permit and Other Pertinent Information	Current Status	Proposed Designation
Land Owner/ Outfall Operator	Outfall No.		Secondary ID[a]	Secondary Owner ID	Diameter/ Material	Flow Rate[b]						
TBD	2059	3.6 E	216E		24-in. CMP	2 gpm	unknown SD	1	SO3000482D, WA0002917	The current SD system partially drains KC airport and part of E Marginal Way and runs along Jorgensen Forge. Boeing and Jorgensen Forge also had historical connections but do not currently discharge to this SD system (Floyd|Snider 2006).	unresolved	public SD[c]
unknown	2501	1.9 E	140E		48-in. concrete	none				Flapper valve in good condition.	unresolved	pipe of unresolved origin and/or use
WSDOT	2503	1.9 E	138E		36-in. concrete	none	WSDOT SD	1	na	1st Ave S bridge SD	resolved	public SD
WSDOT (Slip 4)	2046	2.8 E	157E		72-in. steel	50 gpm	WSDOT SD	1	na	WSDOT storm drain. Also receives runoff from 40 ac east of I-5. May accept discharge from North Boeing Field (SO3000226) via storm drains.	resolved	public SD
WSDOT, Turning basin – SW shoreline	2200	4.6 W	380W		30-in. CMP	na	unknown SD	1	none found	Outfall location corresponds with WSDOT discharge point for SR 99.	resolved	public SD
WSDOT, Turning basin – NW shoreline	2201	4.6 W	381W		36-in. CMP	3 gpm	unknown SD	1	none found	Outfall location corresponds with WSDOT discharge point for SR 99.	resolved	public SD

[a] Numbers assigned by SPU that run sequentially from north to south along waterway for easier identification of outfall locations. E-W indicates east and west side of waterway.

[b] Visual observations from field survey completed May 16 to 20, 2003, and June 2 to 11, 2003.

[c] Because the ownership of this outfall is to be determined, the proposed designation reflects current use of the outfall only.

ABS – acrylonitrile butadiene styrene
CFS – cubic feet per second
CMP – composite construction
CSO – combined sewer overflow
DI – diameter
E – east
EOF – emergency overflow
FS – Floyd Snider
gpm – gallon per minute
ID – identification
KC – King County
LDW – Lower Duwamish Waterway
na – not available
NPDES – National Pollutant Discharge Elimination System
PVC – polyvinyl chloride
RCP – reinforced concrete pipe
RI – remedial investigation
SCAP – source control action plan
SCL – Seattle City Light
SD – storm drain
SPU – Seattle Public Utilities
TBD – to be determined
W – west
WA – Washington
WSDOT – Washington State Department of Transportation

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Appendix I. Source Control Area-Related Facility Information

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I.1 Introduction

The Washington State Department of Ecology (Ecology), in consultation with the US Environmental Protection Agency (EPA), has identified 23 areas for source evaluation in the Lower Duwamish Waterway (LDW), in accordance with their source control strategy (Ecology 2004b, 2007f). This appendix outlines the overall approach used to summarize source control area (SCA)-related information and presents selected information for 11 SCAs based in large part on source information in Ecology documents. Additional information related to work by EPA, Ecology, and the Source Control Work Group (SCWG) is summarized in Section 9.2 of the main body of the RI.

I.2 Methods Used to Develop the SCA Information Summaries

Ecology's source control evaluation program is a continuous and dynamic process that will continue well beyond the completion of the remedial investigation/ feasibility study (RI/FS). In order to focus source-related information for presentation in the RI, Ecology and EPA identified 11 of the 23 SCAs that, at a minimum, had a draft data gaps report available for review as of March 2008 (see Section 9 of the main document for additional information about the contents of data gaps reports). This date was used to determine which SCAs would be included in this appendix,[1] and was selected based on discussions held with EPA and Ecology during the development of the scope and methods to be used for the SCA summaries. The 12 other SCAs that did not have a data gaps report available for review as of March 2008 are not summarized in this appendix. Information for SCAs not summarized in this appendix can be found in the data gaps reports and source control action plans (SCAPs) available on Ecology's website. The 11 SCAs summarized in this appendix are listed in Table I-1. Updated information for these 11 SCAs can also be found in the SCAPs on Ecology's website.

[1] Although March 2008 was used as the date for determining which SCAs would be included in this appendix (based on whether a draft data gaps report was available for an SCA, at a minimum), the date of July 11, 2008, was used as the cutoff date for which documents prepared for the 11 selected SCAs (source control action plans, data gaps, or other reports issued by Ecology) were eligible for review and summary in this appendix. This date was also determined based on discussions with EPA and Ecology.

Table I-1. SCAs identified for discussion in the RI

Source Control Area	Section	Approximate River Mile[a]
Duwamish/Diagonal Way (EAA 1)	I.4.1	0.2 to 0.9 E
Slip 3 to Seattle Boiler Works	I.4.2	2.0 to 2.2 E
Seattle Boiler Works to Slip 4	I.4.3	2.2 to 2.9 E
Slip 4 (EAA 3)	I.4.4	2.8 to 2.9 E
Boeing Plant 2/Jorgensen Forge (EAA 4)	I.4.5	2.9 to 3.7 E
Boeing Isaacson/Central KCIA (EAA 6)	I.4.6	3.7 to 3.9 E
Slip 6	I.4.7	3.9 to 4.3E
Norfolk CSO/SD[b] (EAA 7)	I.4.8	4.9 to 5.0 E
Glacier Bay	I.4.9	1.2 to 1.5 W
Trotsky Inlet (EAA 2)	I.4.10	2.2 to 2.3 W
Terminal 117 (EAA 5)	I.4.11	3.4 to 3.8 W

[a] River miles were estimated and rounded to the nearest tenth of a mile based on the boundaries established by Ecology on July 8, 2008 (Good 2008).

[b] A City pump station EOF also discharges through this outfall.

CSO – combined sewer overflow
KCIA – King County International Airport
RI – remedial investigation
SCA – source control area
SD – storm drain

Source control information available in data gaps reports, SCAPs, and other Ecology-issued reports (e.g., property review reports and source control status reports [SCSRs]) were used to develop the SCA-specific summaries included in this appendix. In addition to the information in these documents, any other relevant source-tracing data collected through December 31, 2007, by the Lower Duwamish Waterway Group (LDWG) members and reported by the cut-off date of July 11, 2008,[2] were also included, as applicable. Collectively, these documents and data sources are referred to in the SCA summaries as the source documents. The information in these documents provides a snapshot of available source control information for the 11 identified SCAs at the time that the RI was drafted.

The summaries in this section provide an overview of surface sediment data and potential source-related information for the facilities and outfalls discussed in the source documents for each of the 11 SCAs. In addition, the Duwamish/Diagonal Way and Norfolk combined sewer overflow/storm drain (CSO/SD) SCA summaries discuss sediment monitoring data collected since removal actions were conducted in each of these areas.

[2] These dates were also selected based on discussions with EPA and Ecology during development of the scope and methods for the SCA summaries.

The information summarized in this appendix was derived from more-detailed information presented in Ecology's SCAPs, data gaps reports, SCSRs, and other source documents for the associated upland facilities. The source documents should be reviewed for more detailed information pertaining to the SCAs. It is not the intent of this appendix to provide any conclusions about the origin of or responsibility for contamination found in sediments in the LDW study area or to determine whether the data reported are sufficient to make such a judgment. Source control efforts within the LDW drainage basin are ongoing. Information presented in tables and maps in this section reflects information available through July 17, 2009. Ecology will continue to issue status reports, update source control information, and post these reports on their website.

The information included in the source documents has not been independently verified for the summaries presented in this appendix. Therefore, information included in this appendix should not be considered complete, nor should it be relied upon to draw conclusions about the extent of contamination or the status of source control at these facilities. Additional evaluation of the raw data and primary source materials would be required for a quantitative evaluation. Furthermore, the level of quality assurance/quality control (QA/QC) and data validation for chemistry data presented in this section was not reviewed; it is likely that the data presented here represent varying levels of QA/QC.

I.3 Information Included in SCA Summaries

Information compiled for the 11 SCAs was included based on the SCA boundaries and the format agreed upon by EPA and Ecology. Boundaries for the individual SCAs were initially established by Ecology in February 2007 (Ecology 2007f). As Ecology's approach to producing data gaps reports and SCAPs evolved, these boundaries were updated (and generally expanded) in February 2008 (Ecology and SAIC 2008). The February 2007 SCA boundaries were used in this appendix to identify surface sediment data because these SCA boundaries were established at the time the draft RI was written. The February 2008 SCA boundaries were used to identify the upland features (e.g., facilities, outfalls) summarized for each SCA based on agreements reached with EPA and Ecology. The availability of source control information and the complexity of the individual SCAs varied; therefore, the following summaries present more information for some of the SCAs than for others. The volume of information presented for each SCA should not be interpreted as an indication of the relative importance of individual SCAs; instead, it reflects the current availability of source information meeting the criteria for this summation effort.

The following types of information were reviewed for each of the 11 SCAs, as available:

- **Surface sediment chemistry in the RI baseline dataset.** Section 4.1.2.1 in the main body of the RI defines the baseline dataset. Based on the February 2007 SCA boundaries and the RI baseline surface sediment dataset, the list of chemicals with concentrations exceeding the sediment quality standards (SQS) of the Washington State Sediment Management Standards (SMS) were identified. The list of chemicals was then used to focus the review and summary of upland media, porewater, and source-tracing data.
- History, ownership, environmental investigation, and remedial action information for several of the upland facilities associated with each SCA. Information was summarized for upland facilities that are adjacent to the LDW shoreline within each SCA (based on Ecology's February 2008 boundaries) and for other upland facilities if relevant[3] source-tracing data were available for the facility. The source documents may contain summarized information for additional upland facilities that are not included in this appendix. The SCAP and data gaps reports should be reviewed for additional information on all facilities associated with the SCAs.
- **History, ownership, and environmental and source-tracing investigation information for outfalls that discharge to each SCA.** Information was summarized for outfalls located within each SCA based on Ecology's February 2008 boundaries. In some cases, discrepancies existed between the outfall layer (discussed in Appendix H) and the source documents regarding the configuration or location of an outfall; these discrepancies are acknowledged where they exist.
- **Bank soil data collected from facilities adjacent to the LDW shoreline within each SCA.** Data from bank soil samples that were collected through December 2007 were summarized for each SCA (based on Ecology's February 2008 boundaries). The source documents also contain other soil data for samples collected away from the bank. These data were not summarized for this appendix in order to focus the scope of the data presented to samples collected along the LDW. Ecology will use both bank and upland soil data in their source control evaluations.

[3] Relevant source-tracing data were defined as the most recent data collected from a drainage structure (e.g., catch basin or drainage line), provided that the drainage structure was still in use at a facility.

- **Groundwater data for upland facilities adjacent to the LDW shoreline.** Groundwater data collected through December 2007 from shoreline facilities were summarized for each SCA (based on Ecology's February 2008 boundary). If both upland and shoreline wells were identified in the source documents for these facilities, only data from the wells nearest the shoreline were included in order to focus the data presentation on conditions likely to be most representative of groundwater in close association with the LDW. If no distinction was made between upland and shoreline wells, all groundwater data were included. The source documents may have also included additional groundwater data from facilities that are not adjacent to the LDW shoreline (i.e., from upland facilities). Ecology will consider all available groundwater data in their source control evaluations.
- **Seep and porewater data collected within each SCA.** Data from seep and porewater samples that were collected through December 2007 were summarized for each SCA (based on Ecology's February 2008 boundaries).
- **Stormwater data collected from outfalls or drainage systems discharging directly to each SCA.** Stormwater samples that were collected from drainage systems located within Ecology's February 2008 boundary and were collected through December 2007 were summarized for each SCA.
- **Source-tracing data collected within drainage basins discharging to each SCA.** Source-tracing data collected from drainage systems through December 2007 were summarized for each SCA (based on Ecology's February 2008 boundaries).
- **Other pertinent information depending on the unique aspects of each SCA.**

The following sections provide additional detail on how the different types of information included in these SCA summaries were selected and summarized.

I.3.1 FACILITY INFORMATION

The majority of Ecology's SCAPs and data gaps reports made a distinction between adjacent facilities (those immediately bordering the LDW) and upland facilities (farther inland or within the drainage basin discharging to the SCA). If the Ecology documentation did not differentiate between adjacent and upland facilities, the adjacent facilities were identified based on a review of the SCA-specific maps. The first table in each of the SCA summaries provides facility-specific information for the adjacent facilities and for those upland facilities with source-tracing information. The inclusion of a facility does not necessarily imply that it is a potential source of sediment contaminants to the SCA, nor does the exclusion of a facility imply that it is not a potential source of sediment contaminants.

Although all facilities identified in the data gaps reports and SCAPs are listed in Appendix I, some are not discussed in detail or shown on maps because they did not meet the facility selection criteria (i.e., adjacent to the LDW or located upland with source-tracing data) (Table I-2). No analysis has been conducted as part of the RI to assess the potential significance of excluded facilities as sources; excluded facilities could represent potential sources to the LDW. Instead, the list of facilities with summarized information was limited to focus the SCA summaries on shoreline facilities or upland facilities with source-tracing data. Information for all facilities associated with the SCAs is provided in the data gaps reports and SCAPs.

Table I-2. List of facilities associated with each SCA as identified in the data gaps reports and SCAPs

Facilities Identified in SCAP and Data Gaps Reports for Each SCA	Facility Information Provided in the SCA Summaries in This Appendix?[a]	Facility Included on SCA-Specific Maps in This Appendix?[b]
Duwamish/Diagonal Way		
Terminal 106 SW (currently T-106)	yes	yes
Terminal 106 SE (no longer Port of Seattle property)	no	yes
Terminal 106 NE (no longer Port of Seattle property)	no	yes
Federal Center South	yes	yes
Union Pacific Railroad Argo Yard	yes	yes
Terminal 108	yes	yes
JANCO United Inc. (historical)	no	no
Slip 3 to Seattle Boiler Works		
Bunge Foods	yes	yes
Glacier Marine Services	yes	yes
SCS Refrigerated Services	yes	yes
Rainier Petroleum Corporation	yes	yes
Shultz Distributing	no	yes
Seattle Distribution Center	yes	yes
Cascade Columbia Distribution	no	yes
South Seattle Community College	no	yes
Riverside Industrial Park	no	yes
V. Van Dyke property	no	yes
Muckleshoot Seafood Products	yes	yes
Seattle Boiler Works to Slip 4		
Seattle Iron and Metals Corp.	yes	yes
Puget Sound Truck Lines	yes	yes
Crowley Marine Services	yes	yes
SCL Pumping Station	yes	yes

Table I-2, cont. List of facilities associated with each SCA as identified in the data gaps reports and SCAPs

Facilities Identified in SCAP and Data Gaps Reports for Each SCA	Facility Information Provided in the SCA Summaries in This Appendix?[a]	Facility Included on SCA-Specific Maps in This Appendix?[b]
Seattle Boiler Works	yes	yes
Bunge Foods/Guimont parcel	yes	yes
Sternoff parcel (former)	yes	yes
Fox Avenue Building (GWI)	no	yes
Fox Avenue Building No. 2 (GWI)	no	yes
El Gallo D'Oro/James Dore	no	yes
Markey Machinery Co.	no	yes
Nelson Trucking	no	yes
Nitze-Stagen/Frye parcels	no	yes
Trim Systems	no	yes
Whitehead Company, Inc./former Tyee Industries/former Perkins Lot	no	yes
Slip 4		
Crowley Marine Services	yes	yes
First South Properties/Emerald Services	yes	yes
Boeing Plant 2	yes	yes
North Boeing Field	yes	yes
KCIA[c]	yes	yes
Georgetown Steam Plant	yes	yes
Boeing Plant 2/Jorgensen Forge		
Boeing Plant 2	yes	yes
Jorgensen Forge	yes	yes
KCIA[c]	yes	yes
E Marginal Way S	no	yes
Boeing Isaacson/Central KCIA		
Boeing Isaacson	yes	yes
Boeing Thompson	yes	yes
KCIA[c]	yes	yes
Slip 6		
Rhône-Poulenc (former)	yes	yes
Boeing Developmental Center (northern drainage area)	yes	yes
PACCAR/Kenworth Trucking (former)	yes	yes
Museum of Flight	no	yes
KCIA[c]	yes	yes
Norfolk CSO/SD[d]		
Boeing Developmental Center (southern drainage area)	yes	yes

Table I-2, cont. List of facilities associated with each SCA as identified in the data gaps reports and SCAPs

Facilities Identified in SCAP and Data Gaps Reports for Each SCA	Facility Information Provided in the SCA Summaries in This Appendix?[a]	Facility Included on SCA-Specific Maps in This Appendix?[b]
Boeing Military Flight Center	yes	yes
KCIA[c]	yes	yes
Arco gas station	yes	yes
Associated Grocers	no	yes
Northwest Auto Wrecking	no	yes
Affordable Auto Wrecking	no	yes
Glacier Bay		
Alaska Marine Lines	yes	yes
Duwamish Shipyard (former)	yes	yes
Glacier Northwest	yes	yes
Former MRI Corporation (historical)	yes	yes
Chemithon Corp.	yes	yes
Alaska Marine Lines (ancillary properties)	no	yes
Wise Property (vacant)	no	no
DV Klier parcel	no	no
Allen property	no	no
Sayler property	no	no
City of Seattle Parks Department parcels	no	yes
Trotsky Inlet		
Alaska Marine Lines/Douglas Management Company	yes	yes
Industrial Container Services/Trotsky property/former NW Cooperage	yes	yes
Boyer Towing	yes	yes
Wells Trucking and Leasing	yes	yes
Da Vinci Gourmet	no	no
Boyer Logistics/Boyer Alaska Barge Lines	no	no
Vacant parcel	no	no
NW Center for the Retarded	no	no
Pioneer Human Services	no	yes
Pacific Plumbing Supply	no	no
Pacific American Commercial	no	yes
PCT Construction	no	no
WHECO	no	no
Cunningham Manufacturing	no	no
United Iron Works	no	yes
Ferguson Construction	no	no
Alki Construction Co.	no	no

Table I-2, cont. List of facilities associated with each SCA as identified in the data gaps reports and SCAPs

Facilities Identified in SCAP and Data Gaps Reports for Each SCA	Facility Information Provided in the SCA Summaries in This Appendix?[a]	Facility Included on SCA-Specific Maps in This Appendix?[b]
Hurlen Construction	no	no
Alaska Washington Co.	no	no
Fox Plumbing and Heating	no	no
Pacific NW Fasteners/Twilley Industrial Tool	no	no
W.G. Wright and Associates	no	no
Tucker-Weitzel and Associates	no	no
ATC Distribution Group/Automatic Transmission Parts	no	no
Cascade Mattress Factory	no	no
J & M Stamp and Form/M & M Roofing	no	no
Industrial Battery Systems	no	no
NW Building Tech, Inc.	no	no
Terminal 117		
Terminal 117	yes	yes
Basin Oil Co.	yes	yes
South Park Marina	yes	yes
Boeing South Park	yes	yes
City of Seattle Street Rights-of-Way (Dallas Ave S vicinity)	yes	yes

[a] Facilities that are either adjacent to the LDW or that have source-tracing data available are discussed in the SCA summaries; for information on SCA-associated facilities not discussed in this appendix, see the appropriate data gaps reports and SCAPs.

[b] Properties that are not included on Appendix I maps were, in most cases, either located outside of the map coverage area or had insufficient information to allow a determination of their exact location.

[c] KCIA drains to several different SCAs. All portions of KCIA are associated with SCAs, depending on the ultimate discharge location of site drainage.

[d] A City pump station EOF also discharges through this outfall.

CSO – combined sewer overflow
EOF – emergency overflow
GWI – Great Western International
KCIA – King County International Airport
LDW – Lower Duwamish Waterway
SCA – source control area
SCAP – source control action plan
SD – storm drain

For the facilities with information summaries in this appendix, summary tables have been developed to provide an overview of current property ownership, current and historical operations, environmental investigations, remedial activities, and ongoing or planned source control activities or investigations for each facility, as available. An additional table summarizing facility identification information (i.e., street addresses and parcel numbers) and regulatory information (e.g., permit types and identification numbers) is also included in Attachment I-1 for the same facilities.

I.3.2 OUTFALL AND DRAINAGE BASIN INFORMATION

Outfalls within each SCA (based on the February 2008 SCA boundaries) are shown on the SCA-specific maps at the locations identified in the 2003 LDW outfall survey (Herrera 2004). Information on these outfalls is presented in the individual SCA summaries. Some outfalls (in general, publicly owned outfalls with relatively large drainage basins) were discussed as individual source control entities in the data gaps reports and SCAPs, or were otherwise identified as individual source control entities by Ecology; these outfalls are referred to as major outfalls in the SCA summaries. Other outfalls (in general, private storm drains with relatively small drainage basins) are also included in the summaries based on the information derived from the LDW outfall survey (see Appendix H) and information provided in the source documents. These outfalls are referred to as other outfalls. When available, the drainage basins and stormwater systems are shown on the SCA-specific maps. Drainage basin information was provided by Seattle Public Utilities (SPU) (Schmoyer 2008a) and in SCAP and data gaps reports.

Appendix H provides additional information on outfalls in the entire LDW study area based on the LDW outfall survey (Herrera 2004), which is the source of the outfall location information for the maps in the RI. Several discrepancies exist between the number, system configuration, or location of outfalls identified in the LDW outfall survey and the outfalls discussed in the SCA-specific source documents. The discrepancies are generally the result of changes in outfall configuration or the discovery of additional outfall information since the LDW outfall survey was conducted in 2003. The symbology on the SCA-specific maps is consistent with the results of the 2003 survey and with the presentation on the other maps throughout the RI. The discrepancies are discussed in the text and noted on tables and maps, when appropriate. Maps provided in the data gaps reports and SCAPs, which are sometimes included in the summaries, may have different outfall names or locations because they may have been produced based on different outfall source information derived using different methods or survey periods.

I.3.3 SUMMARY OF SOURCE CONTROL CHEMICAL INFORMATION BY MEDIA TYPE

For each of the 11 SCAs, surface sediment data in the RI baseline dataset (see Section 4.1.2.1) were reviewed to identify chemicals with at least one SQS exceedance[4] within the SCA boundaries delineated by Ecology in February 2007 (Ecology 2007f) (Map I-1). In addition, dioxin and furan data were summarized if the dioxin and furan toxic equivalent (TEQ) was highly elevated (i.e., greater than 100 ng/kg dw) in at least one sediment sample within the SCA; SMS criteria do not exist for dioxins and furans.

[4] Note that some chemicals in surface sediment may be of concern at concentrations below the SQS. Additional source analyses may be conducted prior to remediation for specific sites as part of cleanup-related activities.

The February 2007 boundaries were used because they were the boundaries that were available when the draft RI was produced. Once the lists of chemicals for each of the SCAs had been generated, the source documents were reviewed to assess whether these same chemicals were detected in upland media (i.e., bank soil, groundwater, seep, and stormwater samples), porewater, or source-tracing samples.

The lists of chemicals derived using the methods described above often differed from the chemical of concern (COC) lists provided for the SCAs in the data gaps reports and SCAPs (Table I-3). These discrepancies are the result of differences in the methods used by EPA and Ecology to define COCs and temporal differences between the RI baseline dataset and sediment datasets used by the agencies. In many cases, the lists of COCs in the data gaps reports and SCAPs were based on several different types of data, including surface sediment, subsurface sediment, and upland media. The lists of chemicals developed for use in the SCA summaries in this appendix were generated based only on SQS exceedances (or dioxin and furan TEQs greater than 100 ng/kg dw) in surface sediment samples collected within the February 2007 SCA boundaries and included in the RI baseline dataset. The differences in chemical lists are not the result of any additional analyses of source control information.

Matrix tables were developed for each SCA to provide a broad overview of the types of data reported for that SCA. The matrix table presented in each SCA summary section indicates which chemicals were detected above the SQS in at least one RI baseline surface sediment sample (within the 2007 SCA boundaries) and were also identified as being present in one or more types of environmental media collected within the SCA (including soil, groundwater, stormwater, source-tracing samples, seep water, or porewater [5], based on information in the source documents.

An "X" is used in the matrix tables to indicate that a chemical detected above the SQS in surface sediment was also identified in another media type. The presence of an "X" does not infer a connection between contamination in surface sediment and other media types. Instead, it indicates that further evaluation may be appropriate. Conversely, the absence of an "X" in any cell in the table does not imply the absence of a chemical in specified media; in many cases, that chemical may not have been analyzed in that media type.

[5] A chemical was considered to be identified if either actual analytical data were reported in the source documents or if the source documents made reference to investigations in which the chemical was detected in analytical samples in one or more types of environmental media.

Table I-3. Comparison of Appendix I SCA chemical lists to lists of COCs provided in data gaps reports, SCAPs, and source control status reports

CHEMICALS CURRENTLY INCLUDED IN SCA SUMMARIES[a]	COCS IDENTIFIED IN DATA GAPS REPORTS AND SCAPS	BASIS FOR COCS IDENTIFIED IN DATA GAPS REPORTS AND SCAPS	COCS IDENTIFIED IN SCSRS
Duwamish/ Diagonal Way			
PCBs, *cadmium, chromium*, lead, mercury, *silver*, zinc, *2-methylnaphthalene*, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzo-fluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, total HPAHs, total LPAHs, BEHP, BBP, *dimethyl phthalate*, *1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol, n-nitrosodiphenylamine, phenol, dioxins and furans TEQ*	No data gaps report will be produced for this SCA. SCAP: The COCs identified were lead, mercury, PCBs, BEHP, BBP, chrysene, and "any other chemical that could recontaminate sediment" (Ecology 2004a).	No data gaps report will be produced for this SCA. SCAP: COCs were identified based on sediment data collected in 1994 and modeling studies of sediment deposition off the Duwamish/Diagonal CSO/SD outfall conducted by King County in 1999 and 2001 (Ecology 2004a).	2007 SCSR: The COCs identified in the 2007 SCSR (Ecology 2007f) were the same as those identified in the SCAP. May 2008 SCSR: The COCs identified were lead, zinc, PCBs, BEHP, and PAHs (individual PAHs not specified) (Ecology and SAIC 2008).
Slip 3 to Seattle Boiler Works			
Arsenic and benzyl alcohol	Data gaps report:: The COCs identified were arsenic, benzyl alcohol**, copper, lead, mercury, zinc, acenapthene, bezo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAH, PCBs, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, cadmium, chromium, oil, grease, TPH-G, TPH, benzene, ethylbenzene, toluene, xylenes, PCE, TCE, vinyl chloride, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, 1,1,1-TCA, 1,2-DCA, pentachlorophenol, chlorinated dioxins and furans, methylene chloride, and 1,4-dichlorobenzene** (Ecology and Environment 2008a). A SCAP has not yet been completed for this SCA.	Data gaps report:: Arsenic, benzyl alcohol**, copper, lead, mercury, zinc, acenapthene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAH, PCBs, 1,2,4-trichlorobenzene,** and **1,2-dichlorobenzene** were identified as COCs because they were detected above the SQS in either surface or subsurface sediment based on data in the draft Phase 2 LDW RI (Ecology queried the online RI sediment database). **Cadmium, chromium, oil, grease, TPH-G, TPH, benzene, ethylbenzene, toluene, xylenes, PCE, TCE, vinyl chloride, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, 1,1,1-TCA, 1,2-DCA, pentachlorophenol, chlorinated dioxins and furans, methylene chloride, and 1,4-dichlorobenzene**were also identified as COCs because they were detected above applicable screening levels in one or more samples of upland media (stormwater, seeps, soil, groundwater, storm drain solids) (Ecology and Environment 2008a). A SCAP has not yet been completed for this SCA.	2007 SCSR: No information was provided for this SCA in the 2007 status report (Ecology 2007f). May 2008 SCSR: No information was provided for this SCA in the 2008 status report (Ecology and SAIC 2008).

Table I-3, cont. Comparison of Appendix I SCA chemical lists to lists of COCs provided in data gaps, SCAP, and source control status update reports

CHEMICALS CURRENTLY INCLUDED IN SCA SUMMARIES[a]	COCS IDENTIFIED IN DATA GAPS REPORTS AND SCAPS	BASIS FOR COCS IDENTIFIED IN DATA GAPS REPORTS AND SCAPS	COCS IDENTIFIED IN SCSRS
Seattle Boiler Works to Slip 4			
Mercury, fluoranthene, and PCBs(VOCs included for groundwater: 1,1-dichloroethene, 1,2-dichlorobenzene, 1,2-dichloroethane, 1,2-dichloropropane, 1,4-dichlorobenzene, benzene, cis-1,2-dichloroethene, tetrachloroethene, toluene, trans-1,2-dichloroethene, trichloroethene, vinyl chloride)	Data gaps report:: The COCs identified were mercury, fluoranthene, PCBs, b**enzo(a)anthracene, chrysene, dibenzofuran, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAH, total LPAH, dioxins and furans,** and **organo-tin compounds** (Ecology and Environment 2008a). A SCAP has not yet been completed for this SCA.	Data gaps report:: COCs were identified as chemicals with concentrations greater than the SQS in RM 2.3 to RM 2.8 E surface or subsurface sediments (Ecology and Environment 2008a). Dioxins and furans were also identified because of their presence in "high concentrations," Organo-tin compounds were selected as COCs because of their presence at "various locations." The data gaps report stated that chemicals detected above regulatory standards or screening levels in soil, groundwater, stormwater, or storm solids were not selected as COCs. A SCAP has not yet been completed for this SCA.	2007 SCSR: No information was provided for this SCA in the 2007 status report (Ecology 2007f). May 2008 SCSR: No information was provided for this SCA in the 2008 status report (Ecology and SAIC 2008).
Slip 4			
Mercury, *acenaphthene*, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, total HPAHs, BBP, BEHP, and PCBs (VOCs included for groundwater: acetone, cis-1,2-dichloroethene, and dichloromethane)	NBF/GTSP data gaps report: PCBs and BEHP were identified as the primary COCs; and metals, phthalates, pesticides, and other organics were identified as other COCs (SAIC 2007e). Slip 4 data gaps report: The COCs identified were PCBs, **cadmium, lead,** mercury, **zinc,** BEHP, BBP, **di-n-octyl phthalate,** benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, chrysene, fluoranthene, **phenanthrene**, total HPAHs, **n nitrosodiphenylamine, DDT, dieldrin,** and **alpha-chlordane** (SEA 2004)**.** SCAP**:** The COCs identified were PCBs and BEHP (Ecology 2006).	NBF/GTSP data gaps report: The COCs identified were the same as those identified in the SCAP, with the addition of chemicals identified as "potential sources of sediment recontamination" (SAIC 2007e). Slip 4 data gaps report: COCs were identified as chemicals detected above the SQS (or the SL if no SQS is available for a chemical) in at least one surface sediment sample (SEA 2004). SCAP: PCBs and BEHP were identified as COCs because they "are the most common problem chemicals in waterway sediment" (Ecology 2006). PAHs and metals were also noted to have been detected in Slip 4 surface and subsurface sediment, but the SCAP stated, "remediation of PCB-contaminated sediment will also result in the cleanup of areas where PAHs and metals exceed the SQS or CSL."	2007 SCSR: The 2007 SCSR (Ecology 2007f) identified the same COCs as the SCAP. May 2008 SCSR: The COCs identified were PCBs, phthalates, PAHs, metals (Ecology and SAIC 2008).

Table I-3, cont. Comparison of Appendix I SCA chemical lists to lists of COCs provided in data gaps, SCAP, and source control status update reports

CHEMICALS CURRENTLY INCLUDED IN SCA SUMMARIES[a]	COCS IDENTIFIED IN DATA GAPS REPORTS AND SCAPS	BASIS FOR COCS IDENTIFIED IN DATA GAPS REPORTS AND SCAPS	COCS IDENTIFIED IN SCSRS
Boeing Plant 2/Jorgensen Forge			
Cadmium, chromium, copper, lead, mercury, silver, zinc, acenaphthene, benzo(a)anthracene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAH, total LPAH, BBP, BEHP, *phenol*, PCBs, and *dioxins and furans* (VOCs included for groundwater: 1,1-dichloroethene, benzene, cis-1,2-dichloroethene, ethylbenzene, tetrachloroethene, toluene, trans-1,2 dichloroethene, trichloroethene, vinyl chloride, m,p-xylene, and o-xylene)	Data gaps report:: The COCs identified were PCBs, **antimony, arsenic**, cadmium, copper, **cyanide,** hexavalent chromium, lead, **manganese**, mercury, **nickel, selenium,** silver, **thallium,** and zinc (Ecology and Environment 2007b). SCAP: The COCs identified in the SCAP (Ecology 2007c) were the same as those in the data gaps report.	Data gaps report:: COCs were selected based on the results of fill sampling conducted between 2004 and 2007 in the southeast corner (i.e., 2-40s, 2-60s, and 2-66s areas) (Ecology and Environment 2007b). SCAP: COCs were selected using the same criteria as those in the data gaps report (Ecology 2007c).	2007 SCSR: PCBs, phthalates, PAHs, and metals were identified as COCs because they have been identified "at levels of concern" (Ecology 2007f). May 2008 SCSR: The COCs identified were PCBs, phthalates, PAHs, and metals (Ecology and SAIC 2008).
Boeing Isaacson/Central KCIA			
Arsenic, BEHP, BBP, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, benzoic acid, and PCBs	Data gaps report:: The COCs identified were arsenic, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, BEHP, BBP, benzoic acid, **benzyl alcohol,** and PCBs (SAIC 2008b). Draft SCAP: The COCs identified in the draft SCAP (Ecology 2008a) were the same as those in the data gaps report.	Data gaps report:: COCs were identified based on surface or subsurface sediment concentrations above the SQS (SAIC 2008b). Chemicals in upland media were not considered to be COCs. Draft SCAP: COCs in the draft SCAP were selected using the same criteria as those in the data gap report (Ecology 2008a).	2007 SCSR: COCs were not identified (Ecology 2007f). May 2008 SCSR: The COCs identified were arsenic, PAHs, phthalates, PCBs, benzoic acid, benzyl alcohol, and dibenzofuran (Ecology and SAIC 2008).

Table I-3, cont. Comparison of Appendix I SCA chemical lists to lists of COCs provided in data gaps, SCAP, and source control status update reports

CHEMICALS CURRENTLY INCLUDED IN SCA SUMMARIES[a]	COCS IDENTIFIED IN DATA GAPS REPORTS AND SCAPS	BASIS FOR COCS IDENTIFIED IN DATA GAPS REPORTS AND SCAPS	COCS IDENTIFIED IN SCSRS
Slip 6			
Lead, mercury, acenaphthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAHs, BBP, BEHP, benzoic acid, phenol, PCBs, and, *dioxins/furans* (VOCs included for groundwater: 1,1 dichloroethene, cis-1,2-dichloroethene, methylene chloride, tetrachloroethene, trichloroethene, vinyl chloride, and toluene)	Data gaps report:: The COCs identified were mercury, lead, PCBs, benzoic acid, phenols, BBP, BEHP, PAHs, dibenzofuran, **arsenic, chromium, copper, nickel, selenium, vanadium, zinc, PCE, TCE, cis-1,2-DCE, 1,1-DCE, toluene, vinyl chloride,** phthalates, and **petroleum hydrocarbons** (Ecology and Environment 2008b). Draft SCAP: The COCs identified included the same list as that in the data gaps report, except acenaphthene, benzo(g,h,i)perylene, dibenzo(a,h,)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, and total HPAHs were listed instead of just "PAHs;" phenol and **pentachlorophenol** were listed instead of just "phenols;" and **diethyl phthalate, di-n-octyl phthalate**, and benzoic acid were added (Ecology and Ecology and Environment 2008).	Data gaps report:: Mercury, lead, PCBs, benzoic acid, phenols, BBP, BEHP, PAHs, and dibenzofuran were identified as COCs because they were detected above the SQS in one or more Slip 6 surface sediment samples. **Arsenic, chromium, copper,** lead, mercury, **nickel, selenium, vanadium, zinc, PCE, TCE, cis-1,2-DCE, 1,1-DCE, toluene, vinyl chloride,** PCBs, PAHs, phenols, phthalates, and **petroleum hydrocarbons** were also identified as COCs because they were detected above "an applicable screening level" in one or more samples of upland media (Ecology and Environment 2008b). Draft SCAP: COCs were identified because they were detected above the SQS in either surface or subsurface sediment or because they were detected above an "applicable screening level" in one or more samples of upland media (Ecology and Ecology and Environment 2008).	2007 SCSR: COCs were not specified for this SCA (Ecology 2007f). May 2008 SCSR: The COCs identified were metals, PCBs, PAHs, phthalates, VOCs, and petroleum hydrocarbons(Ecology and SAIC 2008).
Norfolk CSO/SD			
fluoranthene, BBP, BEHP, 1,4-dichlorobenzene, PCBs	Data gaps report:: The COCs identified were **benzo(g,h,i)perylene**, BEHP, BBP, **hexachlorobenzene**, PCBs, **2,4-dimethylphenol, 2-methylnaphthalene, dibenzo(a,h)anthracene, dibenzofuran, hexachlorobutadiene, and n-nitrosodiphenylamine**. (Ecology and Environment 2007a)**.** SCAP: The COCs identified in the SCAP (Ecology 2007d) were the same as those in the data gaps report.	Data gaps report:: B**enzo(g,h,i)perylene**, BEHP, BBP, **hexachlorobenzene**, and PCBs were identified as COCs because they were detected above the SQS in one or more surface sediment samples in the SCA. N**-nitrosodiphenylamine, 2,4-dimethylphenol, 2-methylnaphthalene, dibenzo(a,h)anthracene, dibenzofuran, and hexachlorobutadiene** were also identified as COCs because the MDLs of non-detected results were above the SQS (Ecology and Environment 2007a). SCAP: COCs were selected in the SCAP (Ecology 2007d) using the same criteria as those in the data gaps report.	2007 SCSR: COCs were not specified for this SCA (Ecology 2007f). May 2008 SCSR: The COCs identified were PCBs, PAHs, phthalates, hexachlorobenzene, metals (Ecology and SAIC 2008).

Table I-3, cont. Comparison of Appendix I SCA chemical lists to lists of COCs provided in data gaps, SCAP, and source control status update reports

CHEMICALS CURRENTLY INCLUDED IN SCA SUMMARIES[a]	COCS IDENTIFIED IN DATA GAPS REPORTS AND SCAPS	BASIS FOR COCS IDENTIFIED IN DATA GAPS REPORTS AND SCAPS	COCS IDENTIFIED IN SCSRS
Glacier Bay			
PCBs, arsenic, copper, lead, mercury, zinc, BBP, BEHP, acenaphthene, chrysene, fluoranthene, phenanthrene, benzo(g,h,i,)perylene, indeno(1,2,3,-cd)pyrene, total HPAHs, pentachlorophenol, and dioxins/furans (VOCs included for groundwater: benzene and vinyl chloride)	Data gaps report:: The COCs identified were PCBs, arsenic, **antimony**, copper, lead, mercury, **tin**, zinc, dioxins/furans, BEHP, BBP, PAHs (individual PAHs not specified), **1,2-dichlorobenzene**, pentachlorophenol, **benzyl alcohol**, and **organo-tin compounds** (SAIC 2007d)**.** SCAP: The COCs identified were the same as in the data gaps report (Ecology 2007e).	Data gaps report:: A COC was identified as any detected chemical with a concentration greater than the SQS in surface or subsurface sediment "offshore of the Glacier Bay SCA." Dioxins and furans were also identified as COCs because they were detected at "high concentrations," and organo-tin compounds were identified as COCs because of their presence at various locations (SAIC 2007d). SCAP: COCs were selected using the same criteria as the those in the data gaps report (Ecology 2007e).	2007 SCSR: The list of COCs was the same as that identified in the data gaps report except organo-tins were not listed (Ecology 2007f). May 2008 SCSR: The COCs identified in the May 2008 SCSR (Ecology and SAIC 2008) were the sameas those identified in the data gaps report.
Trotsky Inlet			
Lead, mercury, zinc, BEHP, *BBP*, PCBs, *dioxins and furans* (VOCs included for groundwater: benzene, methylene chloride, trans-1,2-dichloroethylene, and vinyl chloride)	Data gaps report:: The COCs identified were PCBs, **DDT,** mercury, BEHP, **dieldrin**, lead, and zinc (SAIC 2007c). SCAP: The COCs identified were the same as those in the data gaps report (Ecology 2007b).	Data gaps report:: A COC was identified as any detected chemical with a concentration greater than the SQS in surface sediment samples (SAIC 2007c). SCAP: COCs were selected using the same criteria as those in the data gaps report; data from one additional sediment sample (a subsurface sample collected in 2006) were reviewed, but no additional COCs were added (Ecology 2007b).	2007 SCSR: The list of COCs was the same as that identified in the data gaps report (Ecology 2007f). May 2008 SCSR: The list of COCs was the same as that identified in the data gaps report (Ecology and SAIC 2008).

Table I-3, cont. Comparison of Appendix I SCA chemical lists to lists of COCs provided in data gaps, SCAP, and source control status update reports

CHEMICALS CURRENTLY INCLUDED IN SCA SUMMARIES[a]	COCS IDENTIFIED IN DATA GAPS REPORTS AND SCAPS	BASIS FOR COCS IDENTIFIED IN DATA GAPS REPORTS AND SCAPS	COCS IDENTIFIED IN SCSRS
Terminal 117			
2-Methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, phenol, total HPAHs, total LPAHs, benzyl alcohol, PCBs	Data gaps report:: Sediment COCs were not identified in the data gaps report (Windward et al. 2003). SCAP: The COCs identified were PCBs, phenol, PAHs, **BBP, BEHP, hexachlorobenzene, 1,2-dichlorobenzene, 1,2,4-trichlorobenzene, DDT, dieldrin, pentachlorophenol, benzoic acid**, benzyl alcohol, lead, **arsenic, zinc, cadmium,** and **silver** (Ecology 2005)**.**	Data gaps report:: Sediment COCs were not identified in the data gaps report (Windward et al. 2003). SCAP: PCBs, phenol, PAHs, **BBP,** and **BEHP** were identified as COCs because they were detected above the SQS in sediment (the SCAP did not indicate whether both surface and subsurface data were reviewed). **Hexachlorobenzene, 1,2-dichlorobenzene,** and **1,2,4-trichlorobenzene** were identified as COCs because they had MDLs that exceeded the SQS (Ecology 2005). **DDT** and **dieldrin** were identified as COCs based on either detected (DDT) or non-detected (dieldrin) concentrations. **Pentachlorophenol, benzoic acid**, benzyl alcohol, lead, **arsenic, zinc, cadmium,** and **silver** were also identified as COCs because they were identified in upland soil or catch basin sediments.	2007 SCSR: The COCs identified included PCBs, phenol, phthalates, and DDT (Ecology 2007f). May 2008 SCSR: The COCs identified were PCBs, PAHs, phenol, phthalates, and DDT (Ecology and SAIC 2008).

[a] The SMS chemicals listed are those that were detected at concentrations greater than the SQS in the RI baseline surface sediment dataset within the 2007 SCA boundaries. VOCs were added to the groundwater and porewater tables in Appendix I at the request of the agencies. The VOCs were selected based on VOCs of concern identified in the groundwater pathways assessment (Appendix G in Windward 2003a) and chemicals identified in the source documents with concentrations greater than a cleanup standard or screening level. Dioxins and furans were identified as COCs if the dioxin and furan TEQ was greater than 100 ng/kg dw at any location in the RI baseline surface sediment dataset within the 2007 SCA boundaries.

Chemicals in *italics* are currently included in Appendix I but are not listed as COCs for the associated SCA in the data gaps report or SCAP.

Chemicals in **bold** are listed as COCs for the SCA in the data gaps report or SCAP but are not currently included in Appendix I.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
COC – chemical of concern
CSO – combined sewer overflow
DCA – dichloroethane
DCE – dichloroethene
DDT – dichlorodiphenyltrichloroethane
EAA – early action area
GTSP – Georgetown Steam Plant
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
KCIA – King County International Airport
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
MDL – method detection limit
NBF – North Boeing Field
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PCE – tetrachloroethene
RM – river mile
SAIC – Science Applications International Corporation
SCA – source control area
SCAP – source control action plan
SCSR – source control status report
SD – storm drain
SMS – Washington State Sediment Management Standards
SQS – sediment quality standards
TCA – trichloroethane
TCE – trichloroethene
TEQ – toxic equivalent
TPH – total petroleum hydrocarbons (includes diesel, oil, and all other petroleum products)
TPH-G – total petroleum hydrocarbons – gasoline
VOC – volatile organic compound

I.3.4 UPLAND AND OTHER MEDIA INFORMATION

In addition to the matrix tables, media-specific data tables are provided to summarize data reported in the SCA source documents. Chemicals included in these tables are those that exceeded the SQS in the RI baseline surface sediment dataset within the boundaries for each SCA established in February 2007 (Ecology 2007f) or were added at the request of the agencies (volatile organic compounds [VOCs], dioxins and furans).

If sufficient data were provided in the source documents for a chemical in a given media type, ranges of detected concentrations, median concentrations, and detection frequencies were presented. The ranges and median concentrations in these tables do not take into consideration non-detected values. For this reason, estimated ranges and median values presented in the media-specific data tables may be skewed higher than the actual ranges or median values (using non-detect values). Significant figures were kept consistent with the values reported in the source document, and the units in which the data were reported were converted for consistency, when necessary.

Bank soil data were tabulated for each SCA if it was clear from source documentation that the soil sample was collected from the bank or shoreline of the SCA. Soil data from the banks were included in order to focus the data presentation on conditions along the LDW shoreline. Other soil data were reported in the data gaps reports and SCAPs but are not summarized in this appendix; all soil data will be considered by Ecology as part of their source control evaluations.

Groundwater data were included for adjacent (shoreline) facilities associated with each SCA. If both upland and shoreline wells were identified in the source documents for these facilities, only data from the shoreline wells were included in order to focus the data presentation on conditions likely to be most representative of groundwater in close association with the LDW. If both historical and recent groundwater data were available for a facility, only the data collected during the most recent reported monitoring events were selected in order to present data as close to representative of current conditions as possible.

All groundwater data were included in the table if: 1) the source documentation did not identify shoreline wells, 2) it was unclear whether samples collected in separate years were from the same location, or 3) few groundwater data were reported. Historical data were selected if they were the only groundwater data available for a facility. All groundwater data (for both shoreline and upland facilities) will be considered by Ecology as part of their source control evaluations; the data gaps reports and SCAPs should be reviewed for information on additional groundwater data not summarized in this appendix.

Within the individual SCA summaries, there are several instances where an "X" appears in the matrix table but an associated media-specific data table is not presented. This would be the situation in cases where:

- None of the soil data available for an SCA were collected from the bank (only bank soil data are presented in media-specific data tables).
- None of the groundwater data available for an SCA were collected from a shoreline facility (only groundwater data from shoreline facilities are presented in media-specific data tables).
- None of the chemicals that exceeded the SQS in the RI baseline surface sediment dataset within the February 2007 boundary for an SCA were detected in samples of that media type (the media-specific data tables only include chemicals with detected concentrations that exceeded the SQS in surface sediment).
- Actual data for a given media type were either not presented in the source documents or were not available in a format that would allow the data to be summarized in the media-specific data tables. For example, the existence of stormwater data were reported for the Alaska Marine Lines and Duwamish Shipyard facilities in the Glacier Bay SCA, and the source documents reported that copper and zinc were detected in stormwater samples; however, actual copper and zinc data were not reported in the source documents so a stormwater data table was not included for that SCA.

VOC groundwater data were also summarized by facility, if available, for each of the 11 SCAs. A large number of groundwater VOC data were reported in the data gaps reports and SCAPs for some facilities. Individual VOCs for which data were summarized in the groundwater tables for these facilities were selected based on discussions with EPA and Ecology (Hiltner 2008). Individual VOCs were selected for the data summary if they had been evaluated in the groundwater pathways assessment in the Phase 1 RI (Appendix G in Windward 2003a) or if they were reported in the source documents as having been detected in groundwater above a cleanup standard or screening level used by Ecology. Detected VOC porewater data collected for the RI were also summarized for the same individual VOCs, if available. All groundwater data will be considered by Ecology as part of their source control evaluations.

Seep and porewater data reported in the LDW RI data reports (Windward 2004, 2006a) or in the SCAPs, data gaps reports, or other source documents were also summarized for each SCA. If known, metal concentrations are reported to be either dissolved (filtered) or total (unfiltered). Concentrations of organic chemicals are total (unfiltered), unless otherwise specified.VOC porewater data were also included in the SCA data summary tables.

Stormwater data were also tabulated for each area, when available. Stormwater data were collected from outfalls discharging to the SCAs, or in some cases, from surface water runoff discharging directly to the SCA. Stormwater data were reported as total or dissolved concentrations when the information was available.

As part of ongoing source control efforts in the LDW, source-tracing samples have been collected to help identify potential sources of contamination. Source-tracing data provided in the SCAPs, data gaps reports, and other source documents or data files provided by LDWG members were included in tables in the SCA summaries. Source-tracing samples include samples from catch basins, manholes, oil/water separators, and in-line sediment traps. In-line sediment grab samples and samples of joint caulking materials were also included. Additional information about the different types of source-tracing samples is provided in Section 9.4.4.7 of the main body of the RI.

Most of the available source-tracing data were collected between 2000 and 2007; in some cases, historical source-tracing data are also available. When multiple rounds of source-tracing data from the same sampling location were available, only the most recent data were included in the data summary tables. If the only source-tracing data available for a certain location or drainage basin were historical data, these data were included in the table. Samples collected from locations within decommissioned drainage lines or other components of drainage systems that are no longer in service were not included in the data tables. The focus on the most recent data is intended to provide a snapshot of current conditions. The source documents should be reviewed for information on additional source-tracing data not presented in this appendix; all source-tracing data will be considered by Ecology as part of their source control evaluations. Also note that the focus on current conditions in this appendix is in contrast to the source-tracing data summarized in Section 9 of the main body of the RI, where all data collected through December 2007 were summarized together.

The City of Seattle has identified several drainage basins that discharge to the LDW (SPU 2008). When possible, data in the source-tracing tables were presented according to the drainage basin from which they were collected. For areas that do not have delineated drainage basins, data were presented according to the facility from which they were collected. When available, the various drainage basins currently delineated along the LDW were also provided on SCA-specific maps.

I.3.5 SCA MAPS

As part of each SCA summary, multiple maps were prepared to provide a visual summary of pertinent information for each area. These maps include text boxes that provide surface sediment data for chemicals with detected concentrations exceeding the SQS or CSL in the RI baseline dataset within the SCA boundaries identified by Ecology in February 2007 (Ecology 2007f). Dioxin and furan data were also presented

In text boxes on the maps if the dioxin and furan TEQ[6] was highly elevated (i.e., greater than 100 ng/kg dw) in at least one sediment sample within the February 2007 SCA boundary. In addition to the data text boxes, surface sediment exceedances of SMS criteria based on the RI baseline dataset within the February 2008 SCA boundaries (Ecology and SAIC 2008) were indicated with color-coded symbols on the SCA maps; however, chemical-specific data were not provided on the maps for samples collected in the area between the 2007 and 2008 boundaries. All surface sediment data will be considered by Ecology during their source control evaluations.

In addition to surface sediment sampling locations, seep, porewater, and source-tracing sampling locations are also shown on the maps if location information (i.e., geographic coordinates) was available.

Facilities associated with each SCA are outlined and labeled on the maps if they were selected for the summary in the text and tables (based on the criteria discussed in Section I.3.1). Facilities associated with the SCAs but not selected for the summary are also labeled on the maps in most cases (but are not outlined). In a few instances, upland facilities are not labeled on the maps because the map coverage does not extend to their location or because insufficient information was available to determine their exact location.[7] For facilities selected for the summary in this appendix, and outlined and labeled on the maps, information on environmental and source control investigations and regulatory status was provided in text boxes, when available.

All outfalls associated with the SCAs (based on the February 2008 SCA boundaries) are shown on the maps as they were identified in the 2003 LDW outfall survey (Herrera 2004). The outfalls are labeled with identification and ownership information linking them to further information provided in Appendix H. If information was available, drainage basins and drain line networks associated with the SCA outfalls were also shown on the maps (this information was generally only available for outfalls designated as major outfalls). It is important to note that the SCA maps only display the drainage basins that discharge to the specific SCA being shown. Areas adjacent to the drainage basin boundaries shown on the SCA maps also likely discharge to the LDW. The full extent of all the LDW drainage basins is shown on Map 9-1 of the main body of the RI.

As noted earlier, in some instances, there are differences between the LDW outfall survey and the source documents regarding the configuration or location of outfalls. In these instances, the discrepancies are acknowledged in text and tables. In addition, if the source documents provided maps that clearly showed outfall locations or configurations different than those shown on the SCA maps, the map from the source document has also been included for comparison.

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[6] SMS criteria do not exist for dioxins and furans.

[7] The facilities for which this situation applies are noted in Table I-2.

A matrix table was also prepared for each SCA for inclusion on the maps to indicate the availability of data for each media type for the facilities selected for information summary in the appendix and for major outfalls associated with the SCA. An X on these matrix tables indicates that data exist for the specified media type based on information in the SCA source documents; however, the analytical data may not have been provided in the source documentation. The absence of an X on these matrix tables indicates that data were not identified during information compilation for the source documents.

For the Duwamish/Diagonal Way and Norfolk CSO/SD SCAs, maps displaying sediment monitoring data collected since removal actions were conducted at each of these areas were also included. All of these monitoring data are not included in the RI baseline dataset.

I.4 SCA Summaries

The following sections include the 11 SCA-specific summaries for those areas identified for inclusion in the RI. These summaries were developed based on the approaches outlined in the sections above. The size and complexity of each summary varies greatly because of the level of information available and presented in the source documents and because of the unique histories of the facilities in each area.

I.4.1 DUWAMISH/DIAGONAL WAY SOURCE CONTROL AREA (RM 0.2 E TO RM 0.9 E, EAA 1)

The Duwamish/Diagonal Way SCA was originally identified as a priority cleanup area by the Elliott Bay/Duwamish Restoration Program in the mid-1990s because of contamination associated with the Diagonal Avenue S CSO/SD and Duwamish emergency overflow (EOF) outfalls. Subsequently, the area was identified as one of seven early action areas (EAAs) because of contaminated surface sediment (Windward 2003c). Removal actions were implemented in this SCA between November 2003 and March 2004 and a project closure report was prepared in 2005 (King County and SPU 2005). A thin-layer cap of sand was placed to the west and south of the Area B cap in February 2005 in response to elevated chemical concentrations that resulted from the previous dredging activity (Ecology 2004a). The removal and capping actions were not intended to address all of the sediment contamination within this SCA. The Duwamish/Diagonal Way SCA is shown on Map I-2.

As part of the ongoing source control efforts for the LDW, Ecology prepared a SCAP for the Duwamish/Diagonal Way SCA in December 2004 (Ecology 2004a). One of the main purposes of the SCAP was to identify potential sources of recontamination to the dredged and capped sediment area. Property reviews have also been completed for several of the upland properties associated with this SCA (Ecology 2008b, c, d, e), and source control status update reports for the LDW included information for the Duwamish/Diagonal Way SCA (Ecology 2007f; Ecology and SAIC 2008). An

environmental site assessment report (Pinnacle Geosciences 2005) prepared for the Port of Seattle also contained information on some of the upland properties associated with this SCA. In addition, source-tracing data provided by the City of Seattle (Schmoyer 2008d), bank soil data collected as part of Duwamish/Diagonal sediment remediation monitoring program by King County (Anchor 2007a), groundwater data collected by the Port of Seattle (Pacific Groundwater Group 2006, 2007), and seep data collected as part of the RI (Windward 2004) are also summarized in this section. These references are referred to collectively as the "source documents" throughout this section and on the maps.

CSL exceedances in the surface sediment in this SCA, prior to the removal action, included bis(2-ethylhexyl) phthalate (BEHP), butyl benzyl phthalate (BBP), dimethyl phthalate, total polychlorinated biphenyls (PCBs), 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, 2-methylnaphthalene, n-nitroso-diphenylamine, 4-methylphenol, 2,4-dimethylphenol, cadmium, chromium, mercury, silver, and several polycyclic aromatic hydrocarbons (PAHs) (Map I-3).[8] SQS exceedances included phenol, several other individual PAHs, total high-molecular-weight PAHs (HPAHs), total low-molecular-weight PAHs (LPAHs), and zinc. These exceedances are based on the RI baseline surface sediment dataset (which is prior to the removal action) and the 2007 SCA boundary, as discussed in the introduction to this appendix. A dioxin and furan TEQ of 180 ng/kg dw was also detected in this area prior to the removal action; dioxins and furans have no related SMS criteria for comparison. Ecology identified COCs for this SCA based on different criteria (Table I-3); therefore, the chemicals identified for summary in this appendix are different than the COCs that Ecology identified for this SCA.

Commercial and industrial operations within the vicinity of the SCA have included vehicle manufacturing (historical), upland PCB dredge material disposal (historical), shipping container transfer and refurbishing (historical and current), warehouse storage and transfer (historical and current), and railroad refueling (historical and current). A former wastewater treatment plant (WWTP) (historical), and federal government offices and warehouses (historical and current) have also been located within the SCA.

Several upland facilities were discussed in source documents associated with the Duwamish/Diagonal Way SCA. Adjacent facilities included Federal Center South, Terminal 106 (T-106) SW,[9] and Terminal 108 (T-108) (Map I-2). Upland properties

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[8] The CSL and SQS exceedances discussed and displayed on Map I-3 are based on the surface sediment baseline dataset and represent surface sediment conditions prior to the sediment remedial actions in 2003-2004, and thin-layer cap placement in 2005.

[9] T-106 was formerly divided into several properties that were named T-106 NW, SW, NE, and SE. Currently the name T-106 applies only to the property that was formerly called T106 SW. The property that was formerly called T-106 NW is now named Terminal 104 (T-104).

identified in the source documents included T-106 W, former T-106 NE, former T-106 SE,[10] JANCO-United, and the Union Pacific Railroad (UPRR) Argo fueling site. The UPRR Argo fueling site is located approximately a half mile east of the LDW. Table I-4 summarizes facility-specific information for the adjacent facilities associated with the Duwamish/Diagonal Way SCA. With the exception of the UPRR Argo fueling site, no upland (non-shoreline) properties are discussed in this section because of the lack of source-tracing information (Table I-2). The SCAP, property reviews, and LDW status reports present additional information on all facilities associated with this SCA.

Five major outfalls that discharge into the Duwamish/Diagonal Way SCA were identified in the SCAP (Ecology 2004a). These outfalls include the Diagonal Avenue S CSO/SD (No. 2155), the Duwamish EOF (No. 2153), and the Diagonal Avenue S SD (No. 2003) (Maps I-2 through I-4). The former Diagonal Avenue S WWTP outfall (No. 2002) was also identified as a major outfall in the Duwamish/Diagonal Way SCAP. This outfall has been decommissioned and is no longer in use. Based on information in the SCAP (Ecology 2004a), the Nevada Street storm drain is located on the northern portion of the T-106 SW shoreline (Map I-5). This outfall is active, but was not found during the LDW low-tide outfall survey (Herrera 2004); therefore, it is not shown on Maps I-2 through I-4.[11]

In total, runoff from approximately 2,620 ac of land discharges to the Duwamish/Diagonal Way CSO/SD basin. The drainage basin for the Diagonal Ave S CSO/SD system is shown on Map I-6. The Diagonal Avenue S CSO/SD basin makes up the majority of the drainage area; the Nevada Street storm drain and Diagonal Avenue S storm drain basins are relatively small in comparison. Stormwater runoff also has the potential to discharge directly to the Duwamish/Diagonal Way SCA from adjacent facilities, either through private storm drains or as surface flow. Four private storm drains discharge to the Duwamish/Diagonal Way SCA from Federal Center South (Nos. 2005, 2006, 2246, and 2247), and one Port of Seattle public storm drain (No. 2225) discharges from T-108 (Maps I-2 through I-4).

[10] The properties referred to as T-106 NE and T-106 SE in the source documents were purchased by a private landowner; they are no longer referred to as T-106 NE and T-106 SE.

[11] The maps produced for this appendix are based on outfall locations provided in the 2003 LDW outfall survey (Herrera 2004) because this is the outfall information source used throughout the RI. The treatment of discrepancies between outfall configurations shown on the RI maps and the maps provided in source documents is discussed in the introduction to this appendix.

Table I-4. Summary of facility information for the Duwamish/Diagonal Way SCA

Facility[a]	Current Ownership	Current Operations	Historical Operations	Environmental Investigations	Remedial Activities	Source Control Activities/Investigations
Federal Center South	US Government	leased office space	facility used by several entities in the past including the Ford Motor Company, USACE, Federal Bureau of Investigation, US Air Force, and Bureau of Indian Affairs	A hazardous waste inspection was conducted by Ecology in 1993. Soil and groundwater investigations conducted in the 1990s in association with UST removals identified a gasoline plume in groundwater; an environmental site assessment was conducted in 2001.	Five USTs were removed in the 1990s. Three additional USTs were pumped dry in the early 2000s.	A site inspection was conducted by Ecology in 2004 and 2005 to assess whether surface water, soil, or groundwater from the facility were potential sources to LDW sediment.
T-106 SW[b]	Port of Seattle	shipping container, chassis, and refrigeration unit storage and repair (tenant is ConGlobal Industries)	similar to current operations since at least 1990; information on historical operations prior to 1990 not reported in source documents but expected to be similar to current operations	Site inspections have been conducted by Ecology and SPU; historical soil and groundwater investigations were conducted in association with a compressor area, a steam cleaning area, and with UST removals.	Three USTs were decommissioned in 1991 (one may have been closed in place). Petroleum-contaminated soil associated with the compressor area was removed in early 1990s.	Business inspections have been conducted by Ecology and SPU at T-106 SW, and the Port of Seattle is conducting stormwater compliance inspections at all terminals. One catch basin solids sample was collected by SPU in 2003.
T-108	Port of Seattle	shipping container and chassis storage and repair (tenant is ConGlobal Industries)	wastewater treatment plant, PCB-contaminated sediment settling ponds/ disposal pits, equipment storage, soil treatment, cement storage and shipment facility	Numerous soil and groundwater investigations have been conducted over the past 20 years; site inspections have been conducted by Ecology and SPU.	No remedial activities were reported in source documents.	A source control strategy plan for this property is being developed.

Table I-4, cont. Summary of facility information for the Duwamish/Diagonal Way SCA

Facility[a]	Current Ownership	Current Operations	Historical Operations	Environmental Investigations	Remedial Activities	Source Control Activities/Investigations
UPRR Argo fueling site	UPRR	railroad fueling site	railroad fueling site	A groundwater plume related to a diesel release at the fueling site was identified in the late 1990s; Seattle-King County Public Health is planning to conduct a site hazard assessment at the property.	Groundwater remediation operations, including pumping and air sparging, were conducted between 2001 and 2004; over 38,000 gal. of diesel were recovered. An independent cleanup by UPRR under MTCA is underway.	Stormwater samples were collected from the Diagonal Avenue S CSO/SD by King County after discontinuation of the air sparging system in 2004 to assess whether petroleum hydrocarbons were entering the system. A source-tracing sample was collected from the facility by SPU in 2002.

Sources: Ecology (2004a, 2007f, 2008b, c, d), Ecology and SAIC (2008), Pinnacle Geosciences (2005), King County (2008b)

[a] Facilities listed are those identified as adjacent properties in the SCAP (Ecology 2004a) and property reviews (Ecology 2008b, c, d). The UPRR Argo fueling site (identified as an upland property in the source documents) is also included because source-tracing data were included in the source documentation.

[b] This property is also referred to as Container Care International (the former tenant of the property) in the SCAP (Ecology 2004a) and property report (Ecology 2008c). The property is currently referred to as T-106 (rather than T-106 SW).

CSO – combined sewer overflow
Ecology – Washington State Department of Ecology
GSA – General Services Administration
LDW – Lower Duwamish Waterway
MTCA – Model Toxics Control Act
PCB – polychlorinated biphenyl
SAIC – Science Applications International Corporation
SCA – source control area
SCAP – source control action plan
SD – storm drain
SPU – Seattle Public Utilities
T-106 – Terminal 106
T-108 – Terminal 108
UPRR – Union Pacific Railroad
USACE – US Army Corps of Engineers
UST – underground storage tank
US – United States

Nine separate overflow points exist from the combined sewer system to the Duwamish Avenue S CSO/SD outfall, eight owned by the City, with a combined service area of approximately 624 ac and one owned by King County with a total service area of 4,890 ac. In the event of a CSO discharge from the Diagonal Avenue S CSO/SD, sanitary sewer and runoff from up to about 4,890 ac could potentially discharge to the Duwamish/Diagonal Way SCA. In the event of an EOF discharge from the Duwamish EOF outfall, sanitary sewage/runoff from a combined sewer service area of approximately 2,200 ac (1,200 ac in West Seattle and 1,000 ac in drainage basins upstream of the Duwamish pump station) could potentially discharge to the SCA (Ecology 2004a).

Industrial facilities and contaminated sites within both the storm drain basin and the combined sewer service area have the potential to contribute chemicals to the Duwamish/Diagonal Way SCA through storm drain, CSO, and EOF discharges. There are approximately 37 confirmed or suspected contaminated sites, 105 LUSTs, and 196 underground storage tanks (USTs) in the Duwamish/Diagonal Way SCA drainage basin (Ecology 2004a). King County and SPU have inspected over 130 businesses in the Duwamish/Diagonal Way drainage basin (Ecology and SAIC 2008) as part of their source control efforts within the basin. The business inspection program is discussed in additional detail in Section 9.4.4.5 in the main body of the RI. Environmental investigations as well as remedial and source control activities also have been conducted in association with the public outfalls in the Duwamish/Diagonal Way SCA. Information on the outfalls within this SCA is included in Table I-5 and on Map I-4; additional details are provided in Appendix H.

Table I-5. Summary of specific information for outfalls in the Duwamish/Diagonal Way SCA

Outfall	Current Ownership	Current Operations	Historical Operations	Environmental and Source-Tracing Investigations	Remedial and Source Control Activities
Outfalls Identified in the SCAP as Major Outfalls[a]					
Nevada Street SD outfall[b]	City of Seattle	Storm drain is 24-in. in diameter and drains approximately 26 ac of land, including portions of T-106 SW.	No historical operations were reported.	Source-tracing sediment sample was collected for the Elliott Bay Action Program in 1985. Manholes connected to the drainage system were inspected by SPU in 2005. Additional source-tracing sampling is planned.	Discharges from T-106 SW are regulated under the Port of Seattle's NPDES permit.
Diagonal Avenue S CSO/SD outfall (No. 2155)	City of Seattle and King County	Concrete outfall is 144 in. in diameter and discharges an average 1,100 million gallons of stormwater per year. The stormwater drainage basin is approximately 2,600 ac in size and includes approximately 3.6 mi of I-5 and parts of the Central District, Duwamish industrial area, Rainier Valley, and Beacon Hill. In the event of a CSO discharge, stormwater and wastewater from nine other CSO systems (one (one owned by King County [i.e., the Hanford CSO, also referred to as Hanford No. 1 or Hanford at Rainier] and eight owned by the City of Seattle) could discharge through this outfall.	No historical operations were reported.	Stormwater samples were collected by King County in 1995 and in the early 2000s. Source-tracing solids were collected for the Elliott Bay Action Program in 1985 and by SPU from 2003 through 2007. Source-tracing investigations are ongoing. Business inspections have been conducted within the drainage basin.	The City of Seattle cleaned approximately 6,200 LF of pipe in the lower portion of the drainage system in 2002 through 2004. The main trunk line was cleaned in 2003 and 2004. The lines were video inspected after being cleaned. The City of Seattle also cleaned all catch basins located in the right-of-way (over 3,500 structures) in 2007 and 2008.

Table I-5, cont. Summary of specific information for outfalls in the Duwamish/Diagonal Way SCA

Outfall	Current Ownership	Current Operations	Historical Operations	Environmental and Source-Tracing Investigations	Remedial and Source Control Activities
Duwamish EOF outfall (No. 035)	King County	Outfall (36-in.) serves as the emergency overflow for the Duwamish pump station and Duwamish Siphon. In the event of an EOF, discharge from the siphon, stormwater, and wastewater could be conveyed from the Delridge Trunk Sewer and the Chelan Avenue Regulator Station in West Seattle (in total comprising a CSO basin of approximately 1,200 ac). In the event of an EOF discharge from the Duwamish pump station, stormwater and wastewater could be conveyed from approximately 1,000 ac of land in drainage basins upstream of the pump station.	Outfall has historically been an EOF for the Duwamish pump station and Duwamish siphon; the EOF has not discharged since 1989.	No environmental or source-tracing investigations were reported.	No remedial or source control activities were reported.
Diagonal Avenue S SD outfall (No. 2003)	City of Seattle	Steel SD (12-in.) drains approximately 12 ac of land, including the portion of Diagonal Avenue S west of E Marginal Way S.	No historical operations were reported.	A source-tracing sediment sample was collected for the Elliott Bay Action Program in 1985. Business inspections have been conducted by SPU within the drainage basin.	No remedial or source control activities were reported.
Former Diagonal Avenue S WWTP outfall (No. 2002)	City of Seattle	Steel outfall (30-in.) is no longer in use.	Formerly served as an outfall for the Diagonal Avenue S WWTP (1938-1969) which discharged primary-treated sewage and stormwater effluent originating from 5,100 ac of land on the eastern side of the LDW.	No environmental or source-tracing investigations were reported.	No remedial or source control activities were reported. The WWTP was decommissioned in 1969.

Table I-5, cont. Summary of specific information for outfalls in the Duwamish/Diagonal Way SCA

Outfall	Current Ownership	Current Operations	Historical Operations	Environmental and Source-Tracing Investigations	Remedial and Source Control Activities
Other Outfalls					
T-108 public SD outfall (No. 2225)	Port of Seattle	Concrete SD (18-in.) drains the southwestern portion of T-108.	No historical operations were reported.	No environmental or source-tracing investigations were reported.	The Port of Seattle is conducting stormwater compliance inspections at all terminals to identify and control sources.
Federal Center South private SD outfalls (Nos. 2005, 2006, 2246, and 2247[c])	USACE (No. 2006) and GSA/US Gov. (Nos. 2005, 2246, and 2247)	Outfalls discharge stormwater from the Federal Center South property.	No historical operations were reported.	Site inspections were conducted at Federal Center South by Ecology in 2004 and 2005 to assess whether surface water draining from the site was a potential source to LDW sediment.	Cleanout and repair of the SD system at Federal Center South is planned by the GSA.

Sources: Ecology (2004a, 2007f), Ecology and SAIC (2008), Schmoyer (2008d)

[a] Major outfalls listed are those discussed as individual source control entities in the SCAP (Ecology 2004a).

[b] The Nevada Street SD outfall was not found during the LDW low-tide outfall survey (Herrera 2004); however, it is located on the northern portion of the T-106 SW shoreline and is shown on Map I-5, which was provided in the SCAP for the Duwamish/Diagonal Way SCA (Ecology 2004a) .

[c] Outfall No. 2247 is located on the boundary of the Duwamish/Diagonal Way SCA and the Slip 1 SCA.

CSO – combined sewer overflow
Ecology – Washington State Department of Ecology
EOF – emergency overflow
GSA – General Services Administration
I-5 – Interstate 5
LDW – Lower Duwamish Waterway
NPDES – National Pollutant Discharge Elimination System
SAIC – Science Applications International Corporation
SCA – source control area
SCAP – source control action plan
SD – storm drain
SPU – Seattle Public Utilities
T-106 – Terminal 106
T-108 – Terminal 108
USACE – US Army Corps of Engineers
WWTP – wastewater treatment plant

Several remedial activities and environmental investigations have been completed or are currently in progress within the Duwamish/Diagonal Way SCA (Tables I-4 and I-5). Information about these activities has been summarized in the source documents. Several of the chemicals that have been detected above the SMS criteria in surface sediment in the Duwamish/Diagonal Way SCA have also been detected in various upland media, including soil, groundwater, seeps, stormwater, and source-tracing solids (Table I-6). In both Table I-6 and the table on Map I-4, an X indicates that the source documents reported data or indicated that data exist; therefore, an X does not necessarily mean that the actual data were presented in the source document. Data are only summarized in media-specific and source-tracing tables if the data were reported in the source documents and if they met the criteria for data summation discussed in the introduction to this appendix (e.g., soil data were collected along the SCA shoreline; groundwater data were collected from shoreline facilities). The availability of data (by media type) is also presented in the table on Map I-4 for each of the facilities and major outfalls associated with this SCA. The identification of a chemical in these media at facilities or within the drainage systems of the Duwamish/Diagonal Way SCA does not necessarily indicate that these potential sources contributed to sediment contamination in the past or will result in sediment contamination in the future.

Table I-6. Chemicals identified in various media in the Duwamish/Diagonal Way SCA

Chemical[a]	Soil	Groundwater	Seep	Porewater[b]	Stormwater[c]	Source-Tracing Samples	Sources
Cadmium	X		X		X	X	Ecology (2004b); Windward (2004); Anchor (2007a)
Chromium	X	X			X	X	Ecology (2004b); Anchor (2007a); Pacific Groundwater Group (2006, 2007)
Lead	X	X	X		X	X	Ecology (2004b); Windward (2004); Schmoyer (2008d); Anchor (2007a); Pacific Groundwater Group (2006, 2007)
Mercury	X	X	X		X	X	Ecology (2004b); Windward (2004); Schmoyer (2008d); Anchor (2007a); Pacific Groundwater Group (2006, 2007)
Silver			X				Windward (2004)
Zinc	X	X	X		X	X	Ecology (2004b); Windward (2004); Schmoyer (2008d); Anchor (2007a); Pacific Groundwater Group (2006, 2007)

Chemical[a]	Soil	Groundwater	Seep	Porewater[b]	Stormwater[c]	Source-Tracing Samples	Sources
2-Methylnaphthalene[d]							
Benzo(a)anthracene	X					X	Ecology (2004b); Schmoyer (2008d); Anchor (2007a)
Benzo(a)pyrene	X					X	Ecology (2004b); Schmoyer (2008d); Anchor (2007a)
Benzo(g,h,i)perylene	X					X	Ecology (2004b); Schmoyer (2008d); Anchor (2007a)
Benzofluoranthenes	X					X	Ecology (2004b); Schmoyer (2008d); Anchor (2007a)
Chrysene	X					X	Ecology (2004b); Schmoyer (2008d); Anchor (2007a)
Dibenzo(a,h)anthracene	X					X	Ecology (2004b); Schmoyer (2008d); Anchor (2007a)
Fluoranthene	X				X	X	Ecology (2004b); Schmoyer (2008d); Anchor (2007a)
Indeno(1,2,3-cd)pyrene	X					X	Ecology (2004b); Schmoyer (2008d); Anchor (2007a)
Naphthalene		X				X	Schmoyer (2008d); Pacific Groundwater Group (2006, 2007)
Phenanthrene	X					X	Ecology (2004b); Schmoyer (2008d); Anchor (2007a)
Pyrene	X				X	X	Schmoyer (2008d); Anchor (2007a)
Total HPAHs	X					X	Ecology (2004b); Schmoyer (2008d); Anchor (2007a)
Total LPAHs	X					X	Ecology (2004b); Schmoyer (2008d); Anchor (2007a)
BEHP	X				X	X	Ecology (2004a); Schmoyer (2008d); Anchor (2007a)
BBP	X				X	X	Ecology (2004b); Schmoyer (2008d); Anchor (2007a)
Dimethyl phthalate					X	X	Ecology (2004b)
1,2,4-Trichlorobenzene[d]							
1,2-Dichlorobenzene	X					X	Ecology (2004b); Anchor (2007a)
1,4-Dichlorobenzene						X	Ecology (2004b)
2,4-Dimethylphenol						X	Schmoyer (2008d)
4-Methylphenol						X	Ecology (2004b)
Benzoic acid	X						Anchor (2007a)
Benzyl alcohol[d]							
n-Nitrosodiphenylamine[d]							
Phenol	X					X	Ecology (2004b); Schmoyer (2008d); Anchor (2007a)

Chemical[a]	Soil	Groundwater	Seep	Porewater[b]	Stormwater[c]	Source-Tracing Samples	Sources
Total PCBs	X	X				X	Ecology (2004a); Schmoyer (2008d); Anchor (2007a); Pacific Groundwater Group (2006, 2007)
Dioxins and furans TEQ[d, e]							

Note: An X indicates that the source documents reported that data are available for the identified media. The absence of an X in any cell in this table does not necessarily mean that the chemical is absent in the upland media or in source-tracing samples; in some cases, that chemical may not have been analyzed for or, if analyzed, could have been present but at concentrations below the RL.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Duwamish/Diagonal Way SCA. The chemical list is based on SMS exceedances in the RI baseline surface sediment dataset and the 2007 SCA boundary. Therefore, this list may differ from the list of exceedances in source documents. The baseline surface sediment dataset includes only data collected before the Duwamish/Diagonal cleanup action (see Section 4.1.2.1 of the main body of the RI).

[b] No porewater data were identified in the source documents for any chemical.

[c] Based on information contained in the SCAP (Ecology 2004a), a surface water sample was collected from the Federal Center South facility; however, no data were provided for this sample. Stormwater data collected from the Diagonal Avenue S CSO/SD were provided in the SCAP (Ecology 2004a).

[d] No soil, groundwater, seep, porewater, stormwater, or source-tracing data were identified in the source documents for this chemical.

[e] There are no SMS criteria for dioxins and furans. They were included in this table because they are a risk driver chemical with highly elevated concentrations (i.e., TEQ > 100 ng/kg dw) in one or more surface sediment samples in this area.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
CSO – combined sewer overflow
Ecology – Washington State Department of Ecology
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
RI – remedial investigation
RL – reporting limit
SCA – source control area
SD – storm drain
SMS – Washington State Sediment Management Standards
SQS – sediment quality standard
TEQ – toxic equivalent

Upland data for these media have been summarized in the source documents. The following is a summary of the upland data as they were presented in these documents for bank soil, groundwater, seep water, stormwater, and source-tracing samples. No porewater data were provided in the source documents for this area.

If sufficient data were provided in the source documents, ranges of detected concentrations, medians, and sample count (n) are provided accordingly. In some instances, the source documents acknowledged the existence of certain data but did not provide actual concentrations. Data were included on these tables only if specific concentrations or a range of concentrations were included in the source documents.

Data from two bank soil samples were identified within the Duwamish/Diagonal Way SCA (Table I-7). Both samples were collected from the northern portion of the T-108 shoreline by King County in 2005 (Anchor 2007a) as part of the sediment removal area monitoring program. No bank soil data were identified for any of the other

shoreline properties within the SCA. Table I-8 summarizes the groundwater data presented in groundwater investigation reports provided by the Port of Seattle for T-108 (Pacific Groundwater Group 2006, 2007). The source documents did not include any VOC groundwater data; however, they reported that a diesel plume is present beneath the UPRR Argo fueling site. Groundwater remediation has been conducted at the UPRR Argo fueling site. The diesel plume may still be migrating toward the LDW (Ecology 2004a). Groundwater information for several of the shoreline facilities within this SCA (T-106, T-108, and Federal Center South) is also summarized in Table 9-15, in Section 9 of the main body of the RI. Table I-9 presents the seep data collected as part of the LDW RI (Windward 2004); no seep data were presented in the SCAP. Stormwater data collected in 1995 from the Duwamish/Diagonal CSO/SD system are summarized in Table I-10 as they were presented in the SCAP.

Table I-7. Summary of chemical concentrations detected in bank soil in the Duwamish/Diagonal Way SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/kg dw, unless noted)[c, d]	Sampling Location	Sources	Additional Information
T-108	cadmium	2005	0.28 mg/kg dw n = 1/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	chromium	2005	31, 55.9 mg/kg dw n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	lead	2005	7.8, 94.4 mg/kg dw n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	mercury	2005	0.031, 0.468 mg/kg dw n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	silver	2005	0.79, 2.62 mg/kg dw n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	zinc	2005	61.9, 85.8 mg/kg dw n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	benzo(a)anthracene	2005	8.36, 41 n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.

Table I-7, cont. Summary of chemical concentrations detected in bank soil in the Duwamish/Diagonal Way SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/kg dw, unless noted)[c, d]	Sampling Location	Sources	Additional Information
T-108	benzo(a)pyrene	2005	13.7, 47.4 n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	benzo(g,h,i)perylene	2005	13.2, 45.8 n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	benzofluoranthenes	2005	29.1, 107.9 n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	chrysene	2005	14.8, 55 n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	dibenzo(a,h)anthracene	2005	3.3 n = 1/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	fluoranthene	2005	22.6, 112 n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	indeno(1,2,3-cd)pyrene	2005	10.9, 38.9 n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	phenanthrene	2005	8.84, 43.8 n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.

Table I-7, cont. Summary of chemical concentrations detected in bank soil in the Duwamish/Diagonal Way SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/kg dw, unless noted)[c, d]	Sampling Location	Sources	Additional Information
T-108	pyrene	2005	19.5, 98.8 n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	total HPAHs	2005	135.46, 546.8 n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	total LPAHs	2005	8.84, 43.8 n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	BEHP	2005	39.3, 138 n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	BBP	2005	61.1 n = 1/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	1,2-dichlorobenzene	2005	7.21 n = 1/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	benzoic acid	2005	116, 846 n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.
T-108	phenol	2005	14.7, 1,300 n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.

Table I-7, cont. Summary of chemical concentrations detected in bank soil in the Duwamish/Diagonal Way SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/kg dw, unless noted)[c, d]	Sampling Location	Sources	Additional Information
T-108	total PCBs	2005	16.5, 815 n = 2/2	along the northern portion of the T-108 shoreline at approximately RM 0.5	Anchor (2007a)	Two bank soil samples were collected by King County as part of the Duwamish/Diagonal cap monitoring plan.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Duwamish/Diagonal Way SCA.

[b] Dimethyl phthalate, 2-methylnapthalene, naphthalene, 1,2,4-trichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzyl alcohol, n-nitrosodiphenylamine, and dioxins and furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from µg/kg to mg/kg), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges were calculated using only detected data. For this reason, some estimated ranges may be higher than actual concentrations.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
CSO – combined sewer overflow
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
RM – river mile
SCA – source control area
SD – storm drain
SQS – sediment quality standard
T-108 – Terminal 108

Table I-8. Summary of chemical concentrations detected in groundwater in the Duwamish/Diagonal Way SCA

FACILITY	CHEMICAL[a, b]	YEAR COLLECTED	LOCATION	CONCENTRATION INFORMATION (µg/L)[c, d, e]	SOURCES	ADDITIONAL INFORMATION
T-108	chromium	2006 – 2007	multiple groundwater wells throughout the facility	1.27 – 13.5 (total) median = 8.32 n = 10/18	Pacific Groundwater Group (2006, 2007)	Groundwater samples were collected by the Port of Seattle.
T-108	chromium	2006 – 2007	multiple groundwater wells throughout the facility	1.08 –14.3 (dissolved) median = 2.31 n = 16/18	Pacific Groundwater Group (2006, 2007)	Groundwater samples were collected by the Port of Seattle.
T-108	lead	2006 – 2007	multiple groundwater wells throughout the facility	2.49 – 16.8 (total) median = 5.27 n = 4/18	Pacific Groundwater Group (2006, 2007)	Groundwater samples were collected by the Port of Seattle.
T-108	zinc	2006 – 2007	multiple groundwater wells throughout the facility	10.1 – 360 (total) median = 46.8 n = 8/18	Pacific Groundwater Group (2006, 2007)	Groundwater samples were collected by the Port of Seattle.
T-108	zinc	2006 – 2007	multiple groundwater wells throughout the facility	12.9 – 435 (dissolved) median = 43.6 n = 5/18	Pacific Groundwater Group (2006, 2007)	Groundwater samples were collected by the Port of Seattle.
T-108	naphthalene	2006 – 2007	multiple groundwater wells throughout the facility	0.136 n = 1/19	Pacific Groundwater Group (2006, 2007)	Groundwater samples were collected by the Port of Seattle.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Duwamish/Diagonal Way SCA.

[b] Silver, BBP, BEHP, dimethyl phthalate, 2-methylnapthalene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, total HPAHs, total LPAHs, 1,2-dichlorobenzene, 1,2,4-trichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol, n-nitrosodiphenylamine, phenol, and dioxins and furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table. .

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[e] One groundwater sampling result was rejected (R-qualified) because of poor sample quality. Limited groundwater yield resulted in low sample volume, and it was concluded that suspended solids were likely present in the sample (Pacific Groundwater Group 2006). Rejected sample results were not included in the range, median, or n calculations. Total PCBs and cPAHs were detected in the rejected sample.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
cPAH – carcinogenic polycyclic aromatic hydrocarbon
CSO – combined sewer overflow
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SCA – source control area
SD – storm drain
SQS – sediment quality standard
T-108 – Terminal 108

Table I-9. Summary of chemical concentrations detected in seeps in the Duwamish/Diagonal Way SCA

Facility	Chemical[a, b]	Year Collected	Location	Concentration Information (µg/L)[c, d]	Sources	Additional Information
Federal Center South	cadmium	2004	central portion of property at approximately RM 0.8	0.021 (dissolved) n = 1/1	Windward (2004)	Seep samples were collected as part of the LDW RI.
Federal Center South	lead	2004	central portion of property at approximately RM 0.8	0.056 (dissolved) n = 1/1	Windward (2004)	Seep samples were collected as part of the LDW RI.
Federal Center South	mercury	2004	central portion of property at approximately RM 0.8	0.00077 (dissolved) n = 1/1	Windward (2004)	Seep samples were collected as part of the LDW RI.
Federal Center South	silver	2004	central portion of property at approximately RM 0.8	0.081 (dissolved) n = 1/1	Windward (2004)	Seep samples were collected as part of the LDW RI.
Federal Center South	zinc	2004	central portion of property at approximately RM 0.8	5.35 (dissolved) n = 1/1	Windward (2004)	Seep samples were collected as part of the LDW RI.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Duwamish/Diagonal Way SCA.

[b] Chromium, total PCBs, BBP, BEHP, dimethyl phthalate, 2-methylnapthalene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, total HPAHs, total LPAHs, 1,2-dichlorobenzene, 1,2,4-trichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol, n-nitrosodiphenylamine, and phenol were not detected, and dioxins and furans were not analyzed.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
CSO – combined sewer overflow
LDW – Lower Duwamish Waterway
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low- molecular-weight polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
RI – remedial investigation
RM – river mile
SCA – source control area
SD – storm drain
SQS – sediment quality standard

Table I-10. Summary of chemical concentrations detected in stormwater in the Duwamish/Diagonal Way SCA

Outfall	Chemical[a, b]	Year Collected	Location	Concentration Information (µg/L)[c, d]	Sources[e]	Additional Information
Duwamish/Diagonal CSO/SD	cadmium	1995	samples collected from two locations (the 8th Avenue S and S Hinds Street lateral and the 13th Avenue S and S Horton Street lateral); data for both locations presented together as one set in source documents)	0.4 – 1.3 median = nr n = 10/10	Stern (2002), as cited in Ecology (2004a)	Ten unfiltered stormwater samples were collected by King County. The data for both locations were presented together as one set in the source documents.
Duwamish/Diagonal CSO/SD	chromium	1995	samples collected from two locations (the 8th Avenue S and S Hinds Street lateral and the 13th Avenue S and S Horton Street lateral)	2 – 22 median = nr n = 10/10	Stern (2002), as cited in Ecology (2004a)	Ten unfiltered stormwater samples were collected by King County. The data for both locations were presented together as one set in the source documents.
Duwamish/Diagonal CSO/SD	lead	1995	samples collected from two locations (the 8th Avenue S and S Hinds Street lateral and the 13th Avenue S and S Horton Street lateral)	9 – 68 median = nr n = 10/10	Stern (2002), as cited in Ecology (2004a)	Ten unfiltered stormwater samples were collected by King County. The data for both locations were presented together as one set in the source documents.
Duwamish/Diagonal CSO/SD	mercury	1995	samples collected from two locations (the 8th Avenue S and S Hinds Street lateral and the 13th Avenue S and S Horton Street lateral)	0.3 n = 1/10	Stern (2002), as cited in Ecology (2004a)	Ten unfiltered stormwater samples were collected by King County. The data for both locations were presented together as one set in the source documents.
Duwamish/Diagonal CSO/SD	zinc	1995	samples collected from two locations (the 8th Avenue S and S Hinds Street lateral and the 13th Avenue S and S Horton Street lateral)	50 – 225 median = nr n = 10/10	Stern (2002), as cited in Ecology (2004a)	Ten unfiltered stormwater samples were collected by King County. The data for both locations were presented together as one set in the source documents.

Table I-10, cont. Summary of chemical concentrations detected in stormwater in the Duwamish/Diagonal Way SCA

Outfall	Chemical[a, b]	Year Collected	Location	Concentration Information (µg/L)[c, d]	Sources[e]	Additional Information
Duwamish/Diagonal CSO/SD	fluoranthene	1995	samples collected from two locations (the 8th Avenue S and S Hinds Street lateral and the 13th Avenue S and S Horton Street lateral)	0.84 n = 1/10	Stern (2002), as cited in Ecology (2004a)	Ten unfiltered stormwater samples were collected by King County. The data for both locations were presented together as one set in the source documents.
Duwamish/Diagonal CSO/SD	pyrene	1995	samples collected from two locations (the 8th Avenue S and S Hinds Street lateral and the 13th Avenue S and S Horton Street lateral)	0.998 n = 1/10	Stern (2002), as cited in Ecology (2004a)	Ten unfiltered stormwater samples were collected by King County. The data for both locations were presented together as one set in the source documents.
Duwamish/Diagonal CSO/SD	BEHP	1995	samples collected from two locations (the 8th Avenue S and S Hinds Street lateral and the 13th Avenue S and S Horton Street lateral)	0.9 – 14.7 median = nr n = 9/10	Stern (2002), as cited in Ecology (2004a)	Ten unfiltered stormwater samples were collected by King County. The data for both locations were presented together as one set in the source documents.
Duwamish/Diagonal CSO/SD	BBP	1995	samples collected from two locations (the 8th Avenue S and S Hinds Street lateral and the 13th Avenue S and S Horton Street lateral)	0.79 – 1 median = nr n = 5/10	Stern (2002), as cited in Ecology (2004a)	Ten unfiltered stormwater samples were collected by King County. The data for both locations were presented together as one set in the source documents.
Duwamish/Diagonal CSO/SD	dimethyl phthalate	1995	samples collected from two locations (the 8th Avenue S and S Hinds Street lateral and the 13th Avenue S and S Horton Street lateral)	0.825 n = 1/10	Stern (2002), as cited in Ecology (2004a)	Ten unfiltered stormwater samples were collected by King County. The data for both locations were presented together as one set in the source documents.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Duwamish/Diagonal Way SCA.

Table I-10, cont. Summary of chemical concentrations detected in stormwater in the Duwamish/Diagonal Way SCA

[b] Silver, total PCBs, 2-methylnapthalene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, total HPAHs, total LPAHs, 1,2-dichlorobenzene, 1,2,4-trichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol, n-nitrosodiphenylamine, phenol, and dioxins and furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
CSO – combined sewer overflow
Ecology – Washington State Department of Ecology
LPAH – low- molecular-weight polycyclic aromatic hydrocarbon
nr – not reported
PCBs – polychlorinated biphenyls
SCA – source control area
SD – storm drain
SQS – sediment quality standard

Several types of source-tracing data have been collected from the Diagonal Avenue S CSO/SD basin and from the Nevada Street and Diagonal Avenue S storm drains. Data reported in the SCAP (Ecology 2004a) and by SPU (Schmoyer 2008d) were reviewed. Table I-11 presents source-tracing data collected within the Duwamish/Diagonal Way SCA. Most of the source-tracing data from the Diagonal Avenue S CSO/SD basin were collected since 2002 as part of SPU's source-tracing program. Data collected prior to 2004 were included in Table I-11 only if newer data from the same sampling locations were not available. In the case of the Diagonal Avenue S and Nevada Street storm drains, the only source-tracing data available in source documents were collected in the mid-1980s. Data relevant to source-tracing efforts include data from various sample types, drainage lines, and in-line sediment trap samples. Map I-6 shows the locations of stormwater drainage lines and source-tracing samples within the Duwamish/Diagonal Way SCA.[12] Additional details on source-tracing sampling programs conducted within the Diagonal Avenue S CSO/SD SCA are presented in Section 9.4.4.7 of the main body of the RI. King County and SPU have inspected several businesses within this SCA as part of ongoing source control efforts. The business inspection program is discussed in Section 9.4.4.5 of the main body of the RI.

[12] Source-tracing sampling locations were mapped when coordinates were available. Therefore, not all source-tracing samples with chemical data are mapped.

Table I-11. Summary of chemical concentrations detected in source-tracing samples in the Duwamish/Diagonal Way SCA

Sample Source	Year Collected	Concentration Information (mg/kg dw)[a, b, c, d]					Concentration Information (µg/kg dw unless noted)[a, b, c, d]				Sources[e]	Additional Information
		Cadmium	Chromium	Lead	Mercury	Zinc	Benzo(a)-anthracene	Benzo(a)pyrene	Benzo(g,h,i)-perylene	Benzo-fluoranthenes		
Onsite Catch Basin Solids Samples												
Diagonal Avenue S CSO/SD (excluding Rainier Commons facility)[f]	2003 – 2005 and 2007	nr	nr	10 – 5,830 median = 120 n = 43/44	0.06 – 2.05 median = 0.14 n = 28/44	55 – 3,940 median = 430 n = 44/44	120 – 27,000 median = 610 n = 19/39	130 – 30,000 median = 510 n = 17/39	66 – 12,000 median = 370 n = 17/39	74 – 57,000 median = 1,300 n = 25/39	Schmoyer (2008d)	Multiple onsite catch basin solids samples were collected within the Diagonal Avenue S CSO/SD basin. The most recent round of data collected from each location is included in this data presentation.
Diagonal Avenue S CSO/SD (Rainier Commons facility)[f]	2005	nr	nr	430 n = 1/1	1.51 n = 1/1	1,810 n = 1/1	190 n = 1/1	98 n = 1/1	nd	370 n = 1/1	Schmoyer (2008d)	Four onsite catch basin solids samples were collected from the Rainier Commons facility. All samples were analyzed for PCBs; only one sample was analyzed for other chemicals.
ROW Catch Basin Solids Samples												
Diagonal Avenue S CSO/SD (excluding Rainier Commons facility)[f]	2004 - 2006	nr	nr	19 – 1,370 median = 100 n = 36/36	0.07 – 1.17 median = 0.2 n = 16/36	85 – 966 median = 265 n = 36/36	42 – 1,700 median = 280 n = 25/36	47 – 2,200 median = 260 n = 27/36	40 – 1,300 median = 180 n = 21/36	81 – 4,000 median = 490 n = 28/36	Schmoyer (2008d)	Multiple ROW catch basin solids samples were collected within the Diagonal Avenue S CSO/SD basin. Each location has been sampled one time.
Diagonal Avenue S CSO/SD (Rainier Commons facility)[f]	2004	nr	nr	61, 62 n = 2/2	nd	189, 213 n = 2/2	180, 520 n = 2/2	160, 420 n = 2/2	63, 130 n = 2/2	590, 1,300 n = 2/2	Schmoyer (2008d)	Six ROW catch basin solids samples were collected from the Rainier Commons facility. All samples were analyzed for PCBs; only two samples were analyzed for other chemicals.
In-line Sediment Trap Samples												
Diagonal Avenue S CSO/SD	2007	nr	nr	59 – 124 median = 95 n = 6/6	0.06 – 0.28 median = 0.12 n = 5/6	277 – 620 median = 430 n = 6/6	180 – 1,400 median = 270 n = 5/6	210 – 1,400 median = 310 n = 5/6	130 – 680 median = 170 n = 4/6	420 – 3,000 median = 770 n = 6/6	Schmoyer (2008d)	Samples were collected from six trap locations. Multiple rounds of samples were collected from each trap; the most recent round of data is included in this data presentation.
Other In-line Samples (e.g., manhole solids, sediment grabs)												
Diagonal Avenue S CSO/SD	2002 – 2004 and 2007	nr	nr	15 – 4,910 median = 60 n = 24/24	0.08 – 3.30 median = 0.61 n = 6/24	85 – 718 median = 245 n = 24/24	31 – 1,300 median = 260 n = 18/23	29 – 1,700 median = 250 n = 19/23	21 – 900 median = 110 n = 15/23	60 – 2,800 median = 360 n = 21/23	Schmoyer (2008d)	Multiple in-line solids samples, including manhole solids and sediment grabs, were collected within the Diagonal Avenue S CSO/SD basin. The most recent round of data collected from each location is included in this data presentation.
Diagonal Avenue S CSO/SD	1985	nr	nr	nr	nr	293, 419 n = 2/2	12, 210 mg/kg OC n = 2/2	3.4, 140 mg/kg OC n = 2/2	130 mg/kg OC n = 1/2	66, 350 mg/kg OC n = 2/2	Tetra Tech (1988) as cited in Ecology (2004a)	Samples were collected for the Elliott Bay Action Program.
Diagonal Avenue S SD	1985	nr	287 n = 1/1	nr	nr	675 n = 1/1	nr	nr	nr	nr	Tetra Tech (1988) as cited in Ecology (2004a)	Samples were collected for the Elliott Bay Action Program.
S Nevada Street SD	1985	12.3 n = 1/1	1,790 n = 1/1	1,330 n = 1/1	nr	654 n = 1/1	nr	nr	nr	nr	Tetra Tech (1988) as cited in Ecology (2004a)	Samples were collected for the Elliott Bay Action Program.

Table I-11, cont. Summary of chemical concentrations detected in source tracing samples in the Duwamish/Diagonal Way SCA

Sample Source	Year Collected	Concentration Information (µg/kg dw unless noted)[a, b, c, d]									Sources[e]	Additional information
		Chrysene	Dibenzo(a,h)-anthracene	Fluoranthene	Indeno(1,2,3-cd)-pyrene	Naphthalene	Phenanthrene	Pyrene	Total HPAHs[g]	Total LPAHs[g]		
Onsite Catch Basin Solids Samples												
Diagonal Avenue S CSO/SD (excluding Rainier Commons facility)[f]	2003 – 2005 and 2007	80 – 26,000 median = 705 n = 30/39	250 – 6,800 median = 630 n = 5/39	120 – 50,000 median = 1,400 n = 30/39	69 – 16,000 median = 280 n = 16/39	40 – 9,500 median = 1,700 n = 13/39	67 – 32,000 median = 1,400 n = 32/39	160 – 32,000 median = 1,400 n = 35/39	320 – 260,000 median = 4,800 n = 35/39	67 – 45,000 median = 2,700 n = 33/39	Schmoyer (2008d)	Multiple onsite catch basin solids samples were collected within the Diagonal Avenue S CSO/SD basin. The most recent round of data collected from each location is included in this data presentation.
Diagonal Avenue S CSO/SD (Rainier Commons facility)[f]	2005	280 n = 1/1	nd	920 n = 1/1	44 n = 1/1	2,500 n = 1/1	870 n = 1/1	490 n = 1/1	2,400 n = 1/1	3,500 n = 1/1	Schmoyer (2008d)	Four onsite catch basin solids samples were collected from the Rainier Commons facility. All samples were analyzed for PCBs; only one sample was analyzed for other chemicals.
ROW Catch Basin Solids Samples												
Diagonal Avenue S CSO/SD (excluding Rainier Commons facility)[f]	2004 - 2006	63 – 3,100 median = 370 n = 32/36	130, 590 n = 2/36	100 – 6,000 median = 585 n = 34/36	55 – 1,300 median = 270 n = 12/36	83 – 520 median = 180 n = 5/36	57 – 5,900 median = 460 n = 33/36	100 – 4,600 median = 550 n = 33/36	360 – 24,000 median = 1,800 n = 34/36	57 – 8,900 median = 560 n = 33/36	Schmoyer (2008d)	Multiple ROW catch basin solids samples were collected within the Diagonal Avenue S CSO/SD basin. Each location has been sampled one time.
Diagonal Avenue S CSO/SD (Rainier Commons facility)[f]	2004	360, 750 n = 2/2	nd	640, 1,700 n = 2/2	140 n = 1/2	70 n = 1/2	570, 1,000 n = 2/2	700, 1,600 n = 2/2	2,700, 6,600 n = 2/2	750, 1,500 n = 2/2	Schmoyer (2008d)	Six ROW catch basin solids samples were collected from the Rainier Commons facility. All samples were analyzed for PCBs; only two samples were analyzed for other chemicals.
In-line Sediment Trap Samples												
Diagonal Avenue S CSO/SD	2007	340 – 2,000 median = 520 n = 6/6	nd	630 – 4,600 median = 900 n = 6/6	100 – 620 median = 140 n = 3/6	nd	310 – 2,200 median = 520 n = 6/6	430 – 2,700 median = 700 n = 6/6	2,310 – 16,400 median = 3,600 n = 6/6	310 – 2,200 median = 570 n = 6/6	Schmoyer (2008d)	Samples were collected from six trap locations. Multiple rounds of samples were collected from each trap; the most recent round of data is included in this data presentation.

Table I-11, cont. Summary of chemical concentrations detected in source tracing samples in the Duwamish/Diagonal Way SCA

Sample Source	Year Collected	Concentration Information (µg/kg dw unless noted)[a, b, c, d]									Sources[e]	Additional information
		Chrysene	Dibenzo(a,h)-anthracene	Fluoranthene	Indeno(1,2,3-cd)-pyrene	Naphthalene	Phenanthrene	Pyrene	Total HPAHs[g]	Total LPAHs[g]		
Other In-line Samples (e.g., manhole solids, sediment grabs)												
Diagonal Avenue S CSO/SD	2002 – 2004 and 2007	42 – 2,300 median = 260 n = 22/23	100, 210 n = 2/23	52 – 4,100 median = 540 n = 22/23	23 – 1,000 median = 120 n = 13/23	41, 50 n = 2/23	54 – 4,000 median = 400 n = 18/23	49 – 4,200 median = 450 n = 22/23	140 – 15,000 median = 2,000 n = 22/23	54 – 4,000 median = 460 n = 18/23	Schmoyer (2008d)	Multiple in-line solids samples, including manhole solids and sediment grabs, were collected within the Diagonal Avenue S CSO/SD basin. The most recent round of data collected from each location is included in this data presentation.
Diagonal Avenue S CSO/SD	1985	29, 240 mg/kg OC n = 2/2	47 mg/kg OC n = 1/2	74, 230 mg/kg OC n = 2/2	170 mg/kg OC n = 1/2	nr	49, 270 mg/kg OC n = 2/2	nr	1,001, 1,697 mg/kg OC n = 2/2	379 mg/kg OC, 574 mg/kg OC n = 2/2	Tetra Tech (1988) as cited in Ecology (2004a)	Samples were collected for the Elliott Bay Action Program.
Diagonal Avenue S SD	1985	nr	nr	nr	85 mg/kg OC n = 1/1	nr	nr	nr	nr	nr	Tetra Tech (1988) as cited in Ecology (2004a)	Samples were collected for the Elliott Bay Action Program.
Nevada Street SD	1985	nr	nr	nr	nr	nr	nr	nr	nr	nr	Tetra Tech (1988) as cited in Ecology (2004a)	Samples were collected for the Elliott Bay Action Program.

Table I-11, cont. Summary of chemical concentrations detected in source tracing samples in the Duwamish/Diagonal Way SCA

Sample Source	Year Collected	Concentration Information (µg/kg dw unless noted)[a, b, c, d]									Sources[e]	Additional Information
		BEHP	BBP	Dimethyl Phthalate	1,2-Dichloro-benzene	1,4-Dichlorobenzene	2,4-Dimethyl-phenol	4-Methylphenol	Phenol	Total PCBs[g]		
Onsite Catch Basin Solids Samples												
Diagonal Avenue S CSO/SD (excluding Rainier Commons facility)[f]	2003 – 2005 and 2007	130 – 200,000 median = 17,000 n = 39/39	20 – 18,000 median = 930 n = 27/39	nr	nr	nr	58 – 89,000 median = 1,800 n = 18/39	nr	52 – 5,700 median = 650 n = 11/39	18 – 3,200 median = 150 n = 28/39	Schmoyer (2008d)	Multiple onsite catch basin solids samples were collected within the Diagonal Avenue S CSO/SD basin. The most recent round of data collected from each location is included in this data presentation.
Diagonal Avenue S CSO/SD (Rainier Commons facility)[f]	2005	13,000 n = 1/1	1,000 n = 1/1	nr	nr	nr	17,000 n = 1/1	nr	1,900 n = 1/1	20,000 - 2,200,000 median = 760,000 n = 4/4	Schmoyer (2008d)	Four onsite catch basin solids samples were collected from the Rainier Commons facility. All samples were analyzed for PCBs; only one sample was analyzed for other chemicals.
ROW Catch Basin Solids Samples												
Diagonal Avenue S CSO/SD (excluding Rainier Commons facility)[f]	2004 - 2006	740 – 48,000 median = 4,200 n = 36/36	60 – 37,000 median = 300 n = 28/36	nr	nr	nr	nd	nr	58 – 2,000 median = 280 n = 6/36	21 – 670 median = 59 n = 22/36	Schmoyer (2008d)	Multiple ROW catch basin solids samples were collected within the Diagonal Avenue S CSO/SD basin. Each location has been sampled one time.
Diagonal Avenue S CSO/SD (Rainier Commons facility)[f]	2004	4,400, 8,300 n = 2/2	280, 410 n = 2/2	nr	nr	nr	nd	nr	nd	160 – 23,000 median = 9,800 n = 6/6	Schmoyer (2008d)	Six ROW catch basin solids samples were collected from the Rainier Commons facility. All samples were analyzed for PCBs; only two samples were analyzed for other chemicals.
In-line Sediment Trap Samples												
Diagonal Avenue S CSO/SD	2007	4,300 – 12,000 median = 7,100 n = 6/6	150 – 1,800 median = 280 n = 4/6	nr	nr	nr	nd	nr	93, 1,100 n = 2/6	101 – 890 median = 180 n = 6/6	Schmoyer (2008d)	Samples were collected from six trap locations. Multiple rounds of samples were collected from each trap; the most recent round of data is included in this data presentation.

Table I-11, cont. Summary of chemical concentrations detected in source tracing samples in the Duwamish/Diagonal Way SCA

Sample Source	Year Collected	Concentration Information (µg/kg dw unless noted)[a, b, c, d]									Sources[e]	Additional information
		BEHP	BBP	Dimethyl Phthalate	1,2-Dichloro-benzene	1,4-Dichlorobenzene	2,4-Dimethyl-phenol	4-Methylphenol	Phenol	Total PCBs[g]		
Other In-line Samples (e.g., manhole solids, sediment grabs)												
Diagonal Avenue S CSO/SD	2002 – 2004 and 2007	230 – 8,900 median = 1,400 n = 23/23	23 – 900 median = 87 n = 10/23	nr	nr	nr	110 – 7,500 median = 180 n = 3/23	nr	nd	20 – 940 median = 196 n = 10/23	Schmoyer (2008d)	Multiple in-line solids samples, including manhole solids and sediment grabs, were collected within the Diagonal Avenue S CSO/SD basin. The most recent round of data collected from each location is included in this data presentation.
Diagonal Avenue S CSO/SD	1985	nr	nr	56 mg/kg OC n = 1/2	39 mg/kg OC n = 1/2	5, 200, 7,100 mg/kg OC n = 2/2	nr	870, 5,900 mg/kg OC n = 2/2	75, 1,500 mg/kg OC n = 2/2	nr	Tetra Tech (1988) as cited in Ecology (2004a)	Samples were collected for the Elliott Bay Action Program.
Diagonal Avenue S SD	1985	nr	nr	nr	nr	nr	nr	nr	nr	nr	Tetra Tech (1988) as cited in Ecology (2004a)	Samples collected for the Elliott Bay Action Program.
Nevada Street SD	1985	nr	nr	nr	nr	nr	nr	nr	nr	nr	Tetra Tech (1988) as cited in Ecology (2004a)	

Note: If multiple rounds of data were available for a single location, only the data collected during the most recent event were presented in order to represent the most current conditions possible.

a Chemicals with at least one detected exceedance of an SQS in surface sediment within the Duwamish/Diagonal Way SCA.

b Silver, 2-methylnaphthalene, 1,2,4-trichlorobenzene, benzoic acid, benzyl alcohol, n-nitrosodiphenylamine, and dioxins and furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

c Significant figures are reported as available in source documentation; when converting units (i.e., from mg/kg to µg/kg), the number of significant figures was kept consistent with the number in the reported value.

d n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

e Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

f Onsite and ROW catch basin sampling at the Rainier Commons facility (formerly the Rainier Brewery) identified PCB-containing paint present on the exterior of the building . The buildings at the facility have been pressure washed and repainted, and storm drain lines and catch basins have been cleaned. SPU is continuing source-tracing investigations at this facility.

g Only detected concentrations were used in calculating total HPAHs, total LPAHs, and total PCBs.

BEHP – bis(2-ethylhexyl) phthalate
BBP – butyl benzyl phthalate
CSO – combined sewer overflow
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
nd – not detected
nr – not reported
OC – organic carbon
PCB – polychlorinated biphenyl
ROW – right-of-way
SCA – source control area
SD – storm drain
SPU – Seattle Public Utilities
SQS – sediment quality standard

An early action sediment removal was initiated in 1994 in response to elevated chemical concentrations in surface sediment in that area. Removal actions including sediment dredging and capping were implemented in a portion of the SCA sediment area between November 2003 and March 2004 (King County et al. 2005). Between November 2003 and January 2004, sediment was dredged from an approximately 7-ac area between River Mile (RM) 0.4 and RM 0.6 (Maps I-7 and I-8). The dredged area was then capped between January and March of 2004 by placing clean cap material over a 5-ac rectangle (Area A) and a 2-ac rectangle (Area B), as shown on Maps I-7 and I-8.

Prior to the removal actions, BEHP had the most exceedances of SMS criteria in surface sediment in the area (26 CSL and 14 SQS), followed by BBP (3 CSL and 23 SQS), total PCBs (7 CSL and 27 SQS), and mercury (3 CSL and 5 SQS) (Map I-3). CSL exceedances of metals (i.e., cadmium, chromium, and silver) were detected in the southern dredged area. PAHs exceeded the CSL primarily in the northern dredged area within the vicinity of the Diagonal Ave S CSO/SD and Duwamish EOF outfalls, and one sample had a dioxin and furan TEQ of 180 ng/kg dw in this area. Monitoring of surface sediment chemistry was conducted prior to and following completion of removal activities. Monitoring events were conducted in October 2003, March and June 2004, January, March, April, and August[13] 2005, March 2006, and April 2007 (Table I-12). Monitoring data for total PCBs and BEHP collected within the capped areas are shown on Map I-7, and data collected from the thin-layer placement area are presented on Map I-8. These data provide information on the quality of sediment that is currently accumulating in this portion of the Duwamish/Diagonal Way SCA. Long-term sediment monitoring of the removal area will continue until 2014.

Table I-12. Monitoring information for the Area A cap, Area B cap, and thin-layer placement area

Sampling Event	Date	Stations Monitored[a]	Detected Chemicals Exceeding SQS	Detected Chemicals Exceeding CSL	Notes
Duwamish/Diagonal perimeter monitoring – pre dredge	October 2003	3C, 4C, 5C, 6C, 7C	mercury, BEHP, 1,4-dichlorobenzene, total PCBs	1,4-dichlorobenzene, total PCBs	thin-layer cap stations monitored prior to initiation of dredging and capping activities
Duwamish/Diagonal March 2004 post-dredge perimeter sediment characterization	March 2004	3C, 4C, 5C, 6C, 7C	BEHP, BBP, total PCBs	BEHP, total PCBs	thin-layer cap stations monitored just after placement of Area A and B caps but prior to placement of thin-layer cap

[13] Only monitoring station 2B was sampled in August 2005.

Sampling Event	Date	Stations Monitored[a]	Detected Chemicals Exceeding SQS	Detected Chemicals Exceeding CSL	Notes
Duwamish/Diagonal June 2004 baseline cap monitoring – year 0 (post-cap placement)	June 2004[b]	1A, 2A, 4A, 5A, 1B, 2B, 3B	BEHP	None	Area A cap and Area B cap stations monitored after dredging and capping completed in these areas
Duwamish/Diagonal January-February 2005 post-dredge perimeter – before thin-layer cap placement	January 2005	3C, 4C, 5C, 6C, 7C, 14C, 15C	BEHP, total PCBs	total PCBs	thin-layer cap stations monitored prior to placement of a thin layer of clean material
Duwamish/Diagonal March 2005 post-dredge perimeter – after thin-layer cap placement	March 2005	3C, 4C, 5C, 6C, 7C, 14C, 15C	None	None	thin-layer cap stations monitored after placement of thin layer clean material
Duwamish/Diagonal April 2005 baseline cap monitoring – year 1	April 2005[c]	1A, 2A, 3A, 4A, 5A, 1B	fluoranthene, BEHP, BBP, dimethyl phthalate, benzyl alcohol, total PCBs	BEHP, benzyl alcohol	Area A cap and Area B cap stations monitored after dredging, capping, and thin-layer placement
Duwamish/Diagonal August 2005 baseline cap monitoring – year 1	August 2005	2B	None	None	one station on Area B cap monitored after dredging, capping, and thin-layer placement
Duwamish/Diagonal March 2006 cap monitoring – year 2, perimeter sediment characterization and enhanced natural recovery cap sediment characterization – year 1	March 2006	1A, 2A, 3A, 4A, 5A, 1B, 2B, 3B, 3C, 4C, 5C, 6C, 7C, 14C, 15C	BEHP, BBP, benzoic acid, total PCBs	BEHP, benzoic acid	Area A cap, Area B cap, and thin-layer cap stations monitored after dredging, capping, and thin-layer placement
Duwamish/Diagonal March 2007 cap monitoring – year 3	April 2007	1A, 2A, 3A, 4A, 5A, 1B, 2B, 3B, 3C, 4C, 5C, 6C, 7C, 14C, 15C	BEHP, BBP	BEHP	Area A Cap, Area B Cap, and thin-layer cap stations monitored after dredging, capping, and thin-layer placement

[a] Station locations that include an "A" are located within the Area A cap, locations that include a "B" are located within the Area B cap, and locations that include a "C" are located within the thin-layer cap area.

[b] Location 3A was not sampled in June 2004 because the substrate was cobble.

[c] Locations 2B and 3B were not sampled in April 2005 because the presence of barges would not allow access to the sampling locations.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
CSL – cleanup screening level
PCB – polychlorinated biphenyl
SCA – source control area
SQS – sediment quality standard

Dredging and capping were completed in cap Areas A and B in June 2004. Monitoring data collected in these areas from June 2004 to March 2006 showed that fluoranthene, BEHP, BBP, dimethyl phthalate, benzyl alcohol, benzoic acid, and total PCBs have been detected above SMS criteria in at least one round of monitoring (Table I-12). In the most recent monitoring round, conducted in April 2007, only BEHP and BBP were detected at concentrations that exceeded SMS criteria in these areas. Temporal trends in BEHP and total PCB concentrations in cap Areas A and B during the monitoring period are shown on Map I-7. BEHP concentrations have declined over the monitoring period in samples collected within the vicinity of the Diagonal Avenue S CSO/SD and Duwamish EOF outfalls (Map I-7).

A thin layer of clean sand material was placed south and west of cap Areas A and B in February 2005. No chemicals were detected in this area above SMS criteria in any of the monitoring samples collected in this area in March 2005, March 2006, and April 2007[14]. Concentrations of total PCBs and BEHP in this area declined after placement of the clean sand material in February 2005 (Map I-8).

Monitoring is ongoing in the dredged and capped areas of the Duwamish/Diagonal Way SCA. In addition, source-tracing efforts, other source control activities, and remedial actions are ongoing in the SCA. Ecology will continue to publish source control status updates for the Duwamish/Diagonal Way SCA and the greater LDW study area. For the most current information on the Duwamish/Diagonal Way SCA, visit Ecology's website.

I.4.2 SLIP 3 TO SEATTLE BOILER WORKS SOURCE CONTROL AREA (RM 2.0 E TO RM 2.2 E)

The Slip 3 to Seattle Boiler Works SCA[15] is one of 23 areas identified by Ecology along the LDW for source control evaluation. A data gaps report for the Slip 3 to Seattle Boiler Works SCA was prepared in 2008 (Ecology and Environment 2008a); the completion of a SCAP is currently scheduled for 2010. The data gaps report will be referred to as the "source document" throughout this section and on associated maps.

CSL exceedances in surface sediment in this SCA included benzyl alcohol and SQS exceedances included arsenic. These exceedances are based on the RI baseline surface sediment dataset and the 2007 SCA boundary, as discussed in the introduction to this appendix. Ecology has identified COCs for this SCA based on different criteria (Table I-3); therefore, the chemicals identified for summary in this appendix are different than the COCs identified by Ecology. Surface sediment chemistry information for this SCA is provided on Map I-9.

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[14] Chemicals listed in Table I-12 as exceeding SMS criteria in the March 2006 and April 2007 monitoring events were detected at locations within cap Area A only.

[15] In other documents, this SCA is sometimes referred to as the RM 2.0 to RM 2.3 East SCA.

Commercial and industrial operations in the vicinity of the Slip 3 to Seattle Boiler Works SCA include cargo transport, barge berthing, general warehousing and cold storage (current and historical); oil storage and distribution (current); shipbuilding, truck storage and maintenance (current and historical); and auto repair (historical). Historically, residential areas were also located in the vicinity of the Slip 3 to Seattle Boiler Works SCA.

Several upland facilities were discussed in the source document associated with the Slip 3 to Seattle Boiler Works SCA. Adjacent facilities included Bunge Foods,[16] Glacier Marine Services, Seattle Distribution Center, SCS Refrigerated Services, Rainier Petroleum, and Muckleshoot Seafood Products (Map I-10). Upland properties included Cascade Columbia Distribution, Schultz Distributing, South Seattle Community College, Riverside Industrial Park, and the V. Van Dyke property (Ecology and Environment 2008a) (Map I-11). Table I-13 summarizes facility-specific information for the adjacent facilities. The upland facilities are not included in this summary (Table I-2) because of the lack of source-tracing data (see the introduction for more information on facility selection criteria). The data gaps report and SCAP should be reviewed for additional information on all facilities associated with this SCA.

[16] The Bunge Foods facility is also included in the Seattle Boiler Works to Slip 4 SCA; in the source documents for that SCA, the facility is referred to as the Guimont Parcel and Dawn Food Products.

Table I-13. Summary of facility information for the Slip 3 to Seattle Boiler Works SCA

FACILITY[a]	CURRENT OWNERSHIP	CURRENT OPERATIONS	HISTORICAL OPERATIONS	ENVIRONMENTAL INVESTIGATIONS	REMEDIAL ACTIVITIES	SOURCE CONTROL ACTIVITIES/ INVESTIGATIONS
Bunge Foods[b]	William P. Guimont	distribution warehouse	food supplier, manufacturer of wooden igloos, shipyard, gasoline station	No environmental investigations were reported.	No remedial activities were reported.	No source control activities or investigations were reported.
Glacier Marine Services	Seatac Marine Properties	marine equipment shipping (assumed based on historical operations at Northland Services)	paint factory; industrial manufacturing; seafood products; shipbuilding, repair, and construction; marine shipping	Sampling of storm drain solids, sediment, and water has been conducted. A dive survey and site assessment were also conducted.	Three USTs were removed in 1993.	Hazardous waste compliance inspections were conducted in 1989 and 2002.
Seattle Distribution Center	CLPF-Seattle Distribution Center	warehouses for distribution of products	lumber facility, mill, ice manufacturing	No environmental investigations were reported.	No remedial activities were reported.	No source control activities or investigations were reported.
SCS Refrigerated Services	SCS Holdings	cold storage, refrigerated warehouse space (facility is currently for sale and the business is relocating)	residences, boat shop, concrete block factory, log facility, cold storage, ice manufacturing	Sediment sampling was conducted in 2006.	No remedial activities were reported.	A NPDES stormwater compliance inspection was conducted by Ecology in 2007.
Rainier Petroleum	Rainier Petroleum Corporation[c]	not reported	historical operations not reported	No environmental investigations were reported.	No remedial activities were reported.	No source control activities or investigations were reported.
Muckleshoot Seafood Products	Muckleshoot Tribe[c]	not reported	historical operations not reported. but facility previously owned by Silver Bay Logging Inc.	No environmental investigations were reported.	No remedial activities were reported.	No source control activities or investigations were reported.

Source: Ecology and Environment (2008a)

[a] Facilities listed are those identified as adjacent properties in the source document. None of the identified upland properties had source-tracing data and thus were not included in this table.

[b] The Bunge Foods property is also included in the Seattle Boiler Works to Slip 4 SCA; in the source documents for that SCA, the property is referred to as the Guimont Parcel and Dawn Food Products.

[c] Ownership information for these facilities was not reported in the source document; these entities were listed as the property taxpayers on the King County parcel viewer webpage (King County 2008b).

NPDES – National Pollutant Discharge Elimination System

SCA – source control area

UST – underground storage tank

Two outfalls were observed in the Slip 3 to Seattle Boiler Works SCA during the 2003 LDW outfall survey (Herrera 2004): the South Brighton Street CSO/SD, which was identified as a major outfall in the source document; and a permitted private storm drain owned by SCS Holdings (No. 2024), which is located at the head of Slip 3 (Map I-9).[17] Information on these outfalls is provided on Table I-14; additional details are provided in Appendix H.

Three additional outfalls (not identified in the 2003 LDW outfall survey) are discussed in information on SCS Holdings' National Pollutant Discharge Elimination System (NPDES) permit; it is unclear from the information provided whether these three outfalls discharge to the LDW or discharge to the municipal storm drain system (Ecology and Environment 2008a). The source document also refers to a South River Street SD and another permitted private SD, but these outfalls were also not found during the 2003 outfall survey (Herrera 2004). SPU later dye tested the S River St SD to confirm its location (Schmoyer 2009), which is shown on Map I-11.

[17] A seep was also identified during the LDW outfall survey (Herrera 2004) in the southeast corner of Slip 3. The seep was located in an area where an outfall was expected (but not found) and was assigned ID No. 2025. This seep location is mapped as an outfall and a seep (No. 2025) in the source document, as shown on Map I-11.

Table I-14. Summary of specific information for outfalls in the Slip 3 to Seattle Boiler Works SCA

Outfall	Current Ownership	Current Operations	Historical Operations	Environmental and Source-Tracing Investigations	Remedial and Source Control Activities
Outfalls Identified in the Data Gaps Report as Major Outfalls[a]					
South Brighton Street CSO/SD (No. 116)	Seattle Public Utilities	CSO/SD drains approximately 18 acres, including Glacier Marine Services, Shultz Distributing, and the southern portion of the Seattle Distribution Center. The CSO service area encompasses approximately 29 acres located on the east side of E Marginal Way S.	Stormwater from MP&E may have been discharged through South Brighton Street CSO/SD.	No environmental or source-tracing investigations were reported.	SPU has been monitoring overflow volumes and frequencies at this station since 2000. No overflows have been recorded.
South River Street SD[b]	Seattle Public Utilities	SD drains an area of about 7.6 acres located on north side of S River St between E Marginal Way W and the 1st Ave S bridge.	No historical operations were reported.	A source-tracing sample was collected in 1986 from South River Street, near the present-day Muckleshoot Seafood Products facility.	No remedial or source control activities were reported.
Other Outfalls[c]					
SCS Refrigerated Services Permitted Private SD outfall (No. 2024)[d]	SCS Holdings	Concrete outfall (12-in.) that drains SCS Refrigerated Services and the northern portion of the Seattle Distribution Center.	No historical operations were reported.	No environmental or source-tracing investigations were reported.	No remedial or source control activities were reported.
Private SD[e]	not reported	not reported	not reported	not reported	not reported

Source: Ecology and Environment (2008a)

[a] Major outfalls listed are those discussed as individual source control entities in the source documents.

[b] The South River Street SD was not identified during the LDW outfall survey (Herrera 2004); therefore, it is not included on Map I-9 or Map I-10. Since completion of the outfall survey, SPU identified the location of the S River Street SD with dye testing. It is located at the end of S River Street under the 1st Avenue S bridge. The location of the outfall is identified on Map I-11.

[c] Map I-11 shows an outfall in the southeast corner of Slip 3 (No. 2025). This is the location where a seep was identified during the LDW outfall survey (Herrera 2004). An outfall was expected at this location but was not identified.

[d] According to the data gaps report (2008a), three outfalls are covered under the NPDES permit for SCS Refrigerated Services. The only outfall that was identified during the LDW outfall survey (Herrera 2004) at this facility was outfall No. 2024; the data gaps report states that the other two outfalls either discharge through outfall No. 2024 or discharge to the City of Seattle storm drain system.

[e] Based on information in the data gaps report (2008a), this outfall potentially discharges from the Glacier Marine Services facility. The outfall was not identified during the LDW outfall survey (Herrera 2004), and no additional information was provided for it in the data gaps report.

CSO – combined sewer outfall
ID – identification
MP&E – Marine Power and Equipment
SCA – source control area
SD – storm drain
SPU – Seattle Public Utilities

Few remedial activities and environmental investigations have been completed within the Slip 3 to Seattle Boiler Works SCA (Tables I-13 and I-14). Information about these activities has been summarized in the data gaps report (Ecology and Environment 2008a). The two chemicals detected above the SQS in surface sediment within the Slip 3 to Seattle Boiler Works SCA have also been detected in various other media, including soil, porewater, stormwater, and source-tracing samples (Table I-15). The availability of data (by media type) is also presented in the table on Map I-10 for each of the facilities and major outfalls associated with this SCA. In both Table I-15 and the table on Map I-10, an X indicates that the source documents reported data or indicated that data exist; therefore, an X does not necessarily mean that the actual data were presented in the source document. Data are only summarized in the media-specific and source-tracing tables if the data were reported in the source documents and if they met the criteria for data summation discussed in the introduction to this appendix (e.g., soil data were collected along the SCA shoreline; groundwater data were collected from shoreline facilities). The identification of a chemical in these media at facilities or within the drainage systems does not necessarily indicate that these potential sources contributed to sediment contamination in the past or that they will result in sediment contamination in the future.

Table I-15. Chemicals identified in various media in the Slip 3 to Seattle Boiler Works SCA

Chemical[a]	Soil	Groundwater[b]	Seep[c]	Porewater	Stormwater	Source-Tracing Samples	Sources
Arsenic	X			X	X	X	Ecology and Environment (2008a), Weston (1999)
Benzyl alcohol	X						Ecology and Environment (2008a)

Note: An X indicates that the source document reported that data are available for the identified media. The absence of an X in any cell does not necessarily mean that the chemical is absent in the upland media or in source-tracing samples; in some cases, the chemical may not have been analyzed for or, if analyzed, could have been present but at concentrations below the RL.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Slip 3 to Seattle Boiler Works SCA. The chemical list is based on SMS exceedances in the RI baseline surface sediment dataset within the 2007 SCA boundary. Therefore, this list may differ from the list of exceedances in source documents.

[b] No groundwater data were identified in the source documents for any chemical.

[c] Two seep samples were collected along the Bunge Foods/Guimont Parcel shoreline as part of the LDW seep study (Windward 2006). The seep samples were collected as part of investigations to characterize the Great Western International facility (this facility is also referred to as the Fox Avenue Building and Fox Avenue Building No. 2, which are associated with the Seattle Boiler Works to Slip 4 SCA) and were analyzed for VOCs. Arsenic and benzyl alcohol were not analyzed in either of the seep samples; therefore, no seep data are provided in this section. Information on these seeps is provided in association with the Bunge Foods/Guimont Parcel and the Great Western International facilities in Table 9-15 of the main body of the RI.

LDW – Lower Duwamish Waterway
RI – remedial investigation
RL – reporting limit
SCA – source control area
SMS – Washington State Sediment Management Standards
SQS – sediment quality standard
VOC – volatile organic compound

Data in the media tables were included only if specific concentrations or a range of concentrations was included in these reports or if these data were presented in a section of the main body of the RI. The following is a summary of the upland data as they were presented in the source document for stormwater and source-tracing samples. Soil data are not presented in this section because no bank soil data were available for this SCA. No specific groundwater data were provided in the source document; however, data from one porewater sample were available for this SCA (Table I-16). Two seep samples were collected near the Bunge Foods/Guimont Parcel shoreline; however, neither was analyzed for arsenic or benzyl alcohol and so seep data are not presented in this section. Additional porewater information for Glacier Marine Services and seep information for Bunge Foods is also summarized in Table 9-15 in the main body of the RI. Data from the one stormwater sample collected within the Slip 3 to Seattle Boiler Works SCA were available in the source document and are summarized in Table I-17.

Table I-16. Summary of chemical concentrations detected in the porewater sample collected from the Slip 3 to Seattle Boiler Works SCA

Facility	Chemical[a, b]	Year Collected	Location	Concentration Information (µg/L)[c, d]	Source	Additional Information
Glacier Marine Services	arsenic	1998	offshore from facility within Slip 3	103 n = 1/1	Weston (1999)	Sample was collected near center of Slip 3 offshore from Glacier Marine Services.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Slip 3 to Seattle Boiler Works SCA.

[b] Benzyl alcohol was either not analyzed or was not detected, or the data for this chemical were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. .

SCA – source control area

SQS – sediment quality standard

Table I-17. Summary of chemical concentrations detected in the stormwater sample from the Slip 3 to Seattle Boiler Works SCA

Facility	Chemical[a, b]	Year Collected	Location	Concentration Information (µg/L)[c, d]	Source	Additional Information
Glacier Marine Services	arsenic	1984	northwest portion of property	6.5 n = 1/1	Ecology and Environment (2008a)	Sample is a dock runoff water sample.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Slip 3 to Seattle Boiler Works SCA.

[b] Benzyl alcohol was either not analyzed or was not detected, or the data for this chemical were not reported in the source documents in a format that would allow them to be summarized in this table. .

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed.

SCA – source control area

SQS – sediment quality standard

Source-tracing samples have been collected from Glacier Marine Services and from the South River Street SD; data from these samples were reported in the source document (Table I-18). The drainage basins for Slip 3 to Seattle Boiler Works SCA are presented on Map I-11. Additional details on source-tracing sampling programs conducted within the larger LDW drainage basin are presented in Section 9.4.4.7 of the main body of the RI.

Table I-18. Summary of chemical concentrations detected in source-tracing samples from the Slip 3 to Seattle Boiler Works SCA

Sample Source	Year Collected	Arsenic (mg/kg dw) [a, b, c, d]	Source	Additional Information
Storm Drain Solids				
Glacier Marine Services	1984	26.5 – 3,709 median = 215 n = 7/7	Ecology and Environment (2008a)	Samples were collected from the north and west sides of the facility when the site was occupied by MP&E.
Glacier Marine Services	1986	111.8 – 3,871[e] median = 2,043.5 n = 11/11	Ecology and Environment (2008a)	Samples were collected from the north and west sides of the facility when the site was occupied by MP&E.
South River Street SD	1986	183.3 n = 1/1	Ecology and Environment (2008a)	Sample was collected from South River Street, near the Muckleshoot Seafood Products facility.

Note: If multiple rounds of data were available for a single location, only the data collected during the most recent event were presented in order to represent the most current conditions possible.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Slip 3 to Seattle Boiler Works SCA.

[b] Benzyl alcohol was either not analyzed or was not detected, or the data for this chemical were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (e.g., from µg/kg to mg/kg), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[e] The source document did not specify if the chemical concentrations were dry weight.

dw – dry weight

MP&E – Marine Power and Equipment

RM – river mile

SCA – source control area

SQS – sediment quality standard

Limited investigation work has been completed within the Slip 3 to Seattle Boiler Works SCA; however, source identification and control efforts are ongoing. Additional information on the Slip 3 to Seattle Boiler Works SCA is provided on Ecology's website.

I.4.3 SEATTLE BOILER WORKS TO SLIP 4 SOURCE CONTROL AREA (RM 2.2 E TO RM 2.9 E)

The Seattle Boiler Works to Slip 4 SCA is one of 23 areas identified by Ecology along the LDW for source control evaluation. As part of ongoing source control efforts for this SCA, a data gaps report was completed in May 2008 (SAIC 2008a). A draft SCAP is scheduled for release in December 2008. In addition to the data gaps report, the seep survey conducted for the RI (Windward 2004) was also reviewed. These documents are referred to collectively as the "source documents" throughout this section and on the associated maps.

Surface sediment samples collected from this SCA had CSL exceedances of total PCBs and mercury and SQS exceedances of total PCBs, mercury, and fluoranthene. These exceedances are based on the RI baseline surface sediment dataset and the 2007 SCA boundary, as discussed in the introduction to this appendix. Ecology has identified COCs for this SCA based on different criteria (Table I-3); therefore, the chemicals identified for summary in this appendix are different than the COCs identified by Ecology. Map I-12 provides a summary of the RI baseline surface sediment data for this SCA. This SCA does not include Slip 4, which is discussed in Section I.4.4.[18]

Commercial and industrial operations in the vicinity of the Seattle Boiler Works to Slip 4 SCA include warehousing (current), storage (current), shipping (current), fabrication of metal products (current); sale of recyclable metal (current); trucking (historical and current); processing of construction, demolition, and land-clearing debris (current); pipe-dipping (historical), pole dipping (historical), food supply (historical); wooden igloo manufacturing (historical); steel construction (historical); transportation of hazardous waste (historical); marine construction (historical); trailer manufacturing (historical); and metal salvage (historical). Facilities in the vicinity also included a pumping station (current), lumber mill (historical), shipyard (historical), gas station (historical), seafood company (historical), a dump truck company (historical), machine shops (historical), and a pipe company (historical).

Adjacent facilities in the SCA that were identified in the data gaps report included Crowley Marine Services, the Bunge Foods/Guimont Parcel (Dawn Food Products),[19]

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[18] Information for Crowley Marine Services is included in this section as well as in Section I.4.4 (Slip 4 SCA). Presentation of the information was divided according to the location of the sample. Information on the direction of groundwater flow was not sufficient to determine which SCA receives groundwater discharge represented by monitoring wells on the Crowley property. Therefore, all groundwater data are discussed in Section I.4.4 (Slip 4 SCA) to keep the data together. One source-tracing sample was collected from a catch basin on the Crowley property. Data for this catch basin sample are included in the Slip 4 SCA because that drainage likely discharges to the Slip 4 SCA based on the location of the catch basin.

[19] The Guimont Parcel (Dawn Food Products) is also included in the Slip 3 to Seattle Boiler Works SCA; in the source documents for that SCA, the facility is referred to as Bunge Foods.

Puget Sound Truck Lines, Seattle Boiler Works, Seattle City Light Pumping Station, and Seattle Iron & Metals Corporation (Map I-13).

Facility-specific information for adjacent properties is summarized in Table I-19. In addition to the adjacent properties, the data gaps report also identified the following upland properties: Great Western International (Fox Avenue Building and Fox Avenue Building No. 2),[20] El Gallo D'Oro/James Dore, Markey Machinery Company, Nelson Trucking, Nitze-Stagen/Frye parcels, former Sternoff parcel, Trim Systems, Whitehead Company, Inc./former Tyee Industries, and Whitehead Company, Inc./former Perkins lot. With the exception of the former Sternoff parcel,[21] these upland properties are not included in this summary (Table I-2) because source-tracing data were not available in the source documents (see the introduction for more information on facility selection criteria). Groundwater information for the Great Western International facility (Fox Avenue Buildings) is summarized in Section 9.4.6 of the main body of the RI. The data gaps report and SCAP should be reviewed for additional information on all facilities associated with this SCA.

[20] Ecology has completed negotiations for the Agreed Order for the Fox Avenue site under MTCA.

[21] Stormwater from the former Sternoff parcel drains to the combined sewer system, not to the Seattle Boiler Works to Slip 4 SCA (SAIC 2008a).

Table I-19. Summary of facility information for the Seattle Boiler Works to Slip 4 SCA

Facility[a]	Current Ownership	Current Operations	Historical Operations	Environmental Investigations	Remedial Activities	Source Control Activities/ Investigations
Crowley Marine Services	Crowley Marine Services	container storage, shipping, and barge berthing (tenant is Alaska Logistics)	manufacturing facilities, pipe-dipping, lumber mill, and pole-dipping	Several environmental investigations and site inspections have been conducted. They were related to tank leaks, site characterization and hazard assessment, and characterization in preparation for Slip 4 sediment removal action. There are plans for an RI/FS to be conducted on the property (Sutton 2008a).	Several USTs have been removed. An RI/FS will be conducted at the property under a MTCA order. The Agreed Order is being negotiated between Ecology and the identified PLPs (Sutton 2008b). After completion of the order, a work plan for the RI/FS will be developed.	Source-tracing investigations and business inspections have been conducted; however, site operations have changed since these investigations were conducted. Additional source control activities and investigations will be conducted at the facility as part of the RI/FS, as necessary (Sutton 2008b).
Guimont Parcel/ Bunge Foods (Dawn Food Products)[b]	William P. Guimont	distribution warehouse	food supplier, manufacturer of wooden igloos, shipyard, gasoline station	No environmental investigations were reported.	No remedial activities were reported.	No source control activities or investigations were reported.
Puget Sound Truck Lines	R&A Properties; Puget Sound Truck Lines	truckload carrier of general freight commodities and bulk wood residuals	pipe company	No environmental investigations were reported.	Soil cleanup activities related to a LUST were conducted in 1995.	SPU inspected the facility in 2007 (Schmoyer 2008e).
Seattle Boiler Works	Frederick J. Hopkins Family Trust	fabrication of metal products (e.g., storage tanks, pressure vessels, boilers, heat exchangers, columns, stacks, and tank heaters)	steel construction	No environmental investigations were reported.	No remedial activities were reported.	A stormwater compliance inspection was conducted by Ecology in 2007.
Seattle City Light	Seattle City Light	pumping station	not reported	No environmental investigations were reported.	No remedial activities were reported.	No source control activities or investigations were reported.

Table I-19, cont. Summary of facility information for the Seattle Boiler Works to Slip 4 SCA

FACILITY[a]	CURRENT OWNERSHIP	CURRENT OPERATIONS	HISTORICAL OPERATIONS	ENVIRONMENTAL INVESTIGATIONS	REMEDIAL ACTIVITIES	SOURCE CONTROL ACTIVITIES/ INVESTIGATIONS
Seattle Iron & Metals Corporation	Shalmar Group	recyclable metal wholesaler	seafood company, transportation of hazardous waste, marine construction, machine shops, pipe company, trucking company	Soil investigations have been conducted.	An independent remedial action (i.e., capping) was conducted prior to 1998 in response to soil and groundwater contamination. A restrictive covenant was placed on the property, and an NFA was issued.	Stormwater compliance inspections were conducted by Ecology. Ecology recently issued an order to improve an onsite stormwater treatment facility (Schmoyer 2008e).
Sternoff parcel (former)	Ellis Garage	processing of construction, demolition, and land-clearing debris	manufacturing of trailers for logging trucks, metal salvage yard, dump truck hauling	Groundwater and soil sampling was conducted in 1986. In 1986, Ecology performed inspections related to concerns over a potential cement batch plant and a water treatment system on the property. Another soil and groundwater investigation and an FS were also completed after 1986. Storm drains and floor drains were sampled during the FS. Groundwater and soil were sampled again in 1999. SPU conducted a dye test on the property in 2006.	A trash pile and underlying soils were removed in 1999.	Storm drain sediments were cleaned out in 1987. Catch basins have been cleaned in 2006.

Source: SAIC (2008a)

[a] Facilities listed are those identified as adjacent properties in the data gaps report (SAIC 2008a). The former Sternoff parcel (identified as an upland property in the source documents) is also included because source-tracing data were included in the source documents; however, most of the runoff from the parcel discharges to the combined sewer system, not to the Seattle Boiler Works to Slip 4 SCA (SAIC 2008a). A portion of the driveway entrance drains to the street; however, most of this runoff ponds in the right-of-way and does not reach the waterway because there is no formal drainage system in this area (Schmoyer 2009).

[b] The Guimont Parcel (Dawn Food Products) is also included in the Slip 3 to Seattle Boiler Works SCA; in the source documents for that SCA, the facility is referred to as Bunge Foods.

FS – feasibility study
LUST – leaking underground storage tank
MTCA – Model Toxics Control Act
NFA – no further action
PLP – potentially liable party
RI – remedial investigation
SCA – source control area
SPU – Seattle Public Utilities
UST – underground storage tank

Sixteen outfalls currently drain to the Seattle Boiler Works to Slip 4 SCA: two public outfalls and fourteen private storm drains. Both public storm drains (Nos. 2026 and 2035) are owned and operated by the City of Seattle. Six of the private storm drains are listed under Frederick Hopkins (see Appendix H). Five of the other private storm drains are permitted to Puget Sound Truck Lines (four are associated with R&A Properties; one is associated with S Othello Street). Two additional private storm drains are listed under Crowley Marine Services. The remaining private storm drain is likely permitted under Seattle Iron & Metal Works.

Three additional private outfalls on the Crowley Marine Services property, near the southern tip of the Seattle Boiler Works to Slip 4 SCA, discharge to Slip 4 and are discussed in Section I.4.4 (Slip 4 SCA). Another outfall (No. 2041) located on the Seattle City Light parcel was originally identified as the old cooling water intake for the Georgetown Steam Plant (GTSP) (SAIC 2008a) and listed as "not an outfall" (SAIC 2008a; Herrera 2004). More recent investigations have determined that it is a pipe of unknown origin (Schmoyer 2009). Information on the outfalls within the Seattle Boiler Works to Slip 4 SCA is summarized in Table I-20 and the locations of these outfalls are provided on Map I-12; see Appendix H for additional outfall information.

Table I-20. Summary of specific information for outfalls in the Seattle Boiler Works to Slip 4 SCA

Outfall	Current Ownership	Current Operations	Historical Operations	Environmental and Source-Tracing Investigations	Remedial and Source Control Activities
Outfalls Identified as Major Outfalls by Ecology[a]					
Public SD outfall at S Myrtle Street (No. 2026)	SPU	Outfall collects runoff from S Myrtle Street and properties located on the south side of S Myrtle Street (Schmoyer 2008e).	No historical operations were reported.	No environmental or source-tracing investigations were reported.	SPU collected samples for source-tracing in 2009 (Schmoyer 2008e).
Public SD outfall at S Garden Street (No. 2035)	SPU	Outfall receives effluent from the Seattle Iron and Metals onsite stormwater treatment system and collects runoff from S Garden Street and other parcels located along S Garden Street up to 8th Avenue S (Schmoyer 2008e).	No historical operations were reported.	No environmental or source-tracing investigations were reported.	SPU collected samples for source-tracing in 2009 (Schmoyer 2008e).
Other Outfalls					
Crowley Marine permitted private SD outfalls (Nos. 2042 and 5006)	Crowley Marine	No current operations were reported.	No historical operations were reported.	SPU collected one sediment sample from an onsite catch basin in 2004.	Stormwater and in-line solids sampling will be conducted as part of the RI/FS. Cleanout of onsite catch basins and SD lines will also be conducted as part of the RI/FS if necessary.
Frederick Hopkins private SD outfalls (Nos. 2027 to 2030, 2032, and 2033)	Frederick Hopkins	No current operations were reported.	No historical operations were reported.	No environmental or source-tracing investigations were reported.	No remedial or source control activities were reported.
R&A Properties permitted private SD outfalls (Nos. 2036,[b] to 2040)	R&A Properties	No current operations were reported.	No historical operations were reported.	No environmental or source-tracing investigations were reported.	No remedial or source control activities were reported.
Shalmar Group permitted private SD outfall (No. 2034)	Shalmar Group	No current operations were reported.	No historical operations were reported.	No environmental or source-tracing investigations were reported.	No remedial or source control activities were reported.

Source: SAIC (2008a)

Table I-20, cont. Summary of specific information for outfalls in the Seattle Boiler Works to Slip 4 SCA

[a] No major outfalls were identified as individual source control entities in the source documents, but the S Myrtle Street and S Garden Street outfalls were identified as major outfalls by Ecology because they are publicly owned outfalls.

[b] The outfall survey completed by Herrera (2004) referred to this outfall as S Othello Street but with unknown ownership. The data gaps report (SAIC 2008a) identifies this outfall as belonging to Puget Sound Truck Lines, which leases the northern parcel from R&A Properties. Maps I-12 and I-13 label outfall 2036 as S Othello Street, as identified in the 2003 outfall survey (Herrera 2004) because this is the outfall information source used throughout the RI. The treatment of discrepancies between outfall configurations shown on the RI maps and the maps provided in source documents is discussed in the introduction to this appendix.

FS – feasibility study
RI – remedial investigation
SAIC – Science Applications International Corporation
SCA – source control area
SD – storm drain
SPU – Seattle Public Utilities

Several environmental investigations have been completed within the Seattle Boiler Works to Slip 4 SCA and the associated adjacent properties. These investigations have detected chemicals at concentrations above the SQS in surface sediment. Many of these chemicals have also been detected in various upland media, including soil, groundwater, seep, and source-tracing samples (Table I-21). The availability of data (by media type) is also presented in the table on Map I-13 for each of the facilities associated with this SCA. In both Table I-21 and the table on Map I-13, an X indicates that the source documents reported data or indicated that data exist; therefore, an X does not necessarily mean that the actual data were presented in the source document. Data are only summarized in media-specific and source-tracing tables if the data were reported in the source documents and if they met the criteria for data summation discussed in the introduction to this appendix (e.g., soil data were collected along the SCA shoreline; groundwater data were collected from shoreline facilities). The identification of a chemical in these media at facilities or within the drainage systems of the Seattle Boiler Works to Slip 4 SCA does not necessarily indicate that these potential sources contributed to sediment contamination in the past or will result in sediment contamination in the future.

Table I-21. Chemicals identified in various media in the Seattle Boiler Works to Slip 4 SCA

Chemical[a]	Soil	Groundwater	Seep	Porewater[b]	Stormwater[c]	Source-Tracing Samples	Sources
Mercury	X	X	X			X	SAIC (2008a); Windward (2004)
Fluoranthene	X	X					SAIC (2008a)
Total PCBs	X	X				X	SAIC (2008a)

Note: An X indicates that the source documents reported that data are available for the identified media. The absence of an X in any cell does not necessarily mean that the chemical is absent in the upland media or in source-tracing samples; in some cases, the chemical may not have been analyzed for or, if analyzed, could have been present but at concentrations below the RL.

[a] Chemicals with at least one detected exceedance of an SQS in sediment within the Seattle Boiler Works to Slip 4 SCA. The chemical list is based on SMS exceedances in the RI baseline surface sediment dataset within the 2007 SCA boundary. Therefore, this list may differ from the list of exceedances in source documents.

[b] Porewater data were collected from this SCA as part of the LDW RI; however, these samples were analyzed only for VOCs.

[c] No stormwater data were reported in source documents for any chemical.

PCB – polychlorinated biphenyl
RI – remedial investigation
RL – reporting limit
SAIC – Science Applications International Corporation
SCA – source control area
SMS – Washington State Sediment Management Standards
SQS – sediment quality standard
VOC – volatile organic compound

Seep data collected as part of the LDW RI (Windward 2004) are presented in Table I-22. Map I-12 shows the locations of seeps sampled in this SCA. Porewater data collected as part of the LDW RI are presented in Table I-23; these samples were analyzed only for VOCs (Windward 2006a). Soil and groundwater data are not presented in this section because no bank soil were available for this SCA, the groundwater samples were not collected from shoreline facilities, or actual data for either media were not provided in the source documents. No stormwater data were reported in the source documents.

Table I-22. Summary of chemical concentrations detected in seep samples collected from the Seattle Boiler Works to Slip 4 SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources	Additional Information
Crowley Marine Services	mercury	2004	0.00074 (dissolved) n = 1/1	near northern edge of parcel boundary	Windward (2004)	Samples were collected as part of the LDW RI.
Crowley Marine Services	mercury	2004	0.00518 (total) n = 1/1	near northern edge of parcel boundary	Windward (2004)	Samples were collected as part of the LDW RI.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Seattle Boiler Works to Slip 4 SCA.

[b] Fluoranthene and total PCBs were not detected in the seep sample.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed.

LDW – Lower Duwamish Waterway
PCB – polychlorinated biphenyl
RI – remedial investigation
SCA – source control area
SQS – sediment quality standard

Table I-23. Summary of chemical concentrations detected in porewater samples collected from the Seattle Boiler Works to Slip 4 SCA

Facility[a]	Chemical[b, c]	Year Collected	Concentration Information (µg/L)[d, e]	Location	Sources	Additional Information
GWI	1,1-dichloroethene	2005	0.3 - 4.9 n = 3/10	Myrtle Street embayment	(Windward 2006a)	Two of the 10 samples from GWI were field replicates collected at PE-08.
GWI	1,2-dichlorobenzene	2005	0.5 – 1.2 n = 3/10	Myrtle Street embayment	(Windward 2006a)	Two of the 10 samples from GWI were field replicates collected at PE-08.
GWI	1,2-dichloroethane	2005	7.4 - 15 n = 2/10	Myrtle Street embayment	(Windward 2006a)	Two of the 10 samples from GWI were field replicates collected at PE-08.
GWI	1,2-dichloropropane	2005	1.7 - 2.5 n = 2/10	Myrtle Street embayment	(Windward 2006a)	Two of the 10 samples from GWI were field replicates collected at PE-08.
GWI	1,4-dichlorobenzene	2005	0.3 - 0.3 n = 2/10	Myrtle Street embayment	(Windward 2006a)	Two of the 10 samples from GWI were field replicates collected at PE-08.
GWI	benzene	2005	9.4 n = 1/10	Myrtle Street embayment	(Windward 2006a)	Two of the 10 samples from GWI were field replicates collected at PE-08.
GWI	cis-1,2-dichloroethene	2005	0.5 - 2,900 n = 10/10	Myrtle Street embayment	(Windward 2006a)	Two of the 10 samples from GWI were field replicates collected at PE-08.
GWI	tetrachloroethene	2005	0.4 - 1.1 n = 2/10	Myrtle Street embayment	(Windward 2006a)	Two of the 10 samples from GWI were field replicates collected at PE-08.
GWI	toluene	2005	0.3 - 3.5 n = 5/10	Myrtle Street embayment	(Windward 2006a)	Two of the 10 samples from GWI were field replicates collected at PE-08.
GWI	trans-1,2-dichloroethene	2005	0.3 - 21 n = 7/10	Myrtle Street embayment	(Windward 2006a)	Two of the 10 samples from GWI were field replicates collected at PE-08.

Table I-23, cont. Summary of chemical concentrations detected in porewater samples collected from the Seattle Boiler Works to Slip 4 SCA

Facility[a]	Chemical[b, c]	Year Collected	Concentration Information (µg/L)[d, e]	Location	Sources	Additional Information
GWI	trichloroethene	2005	0.4 - 2.5 n = 4/10	Myrtle Street embayment	(Windward 2006a)	Two of the 10 samples from GWI were field replicates collected at PE-08.
GWI	vinyl chloride	2005	0.4 - 2,500 n = 10/10	Myrtle Street embayment	(Windward 2006a)	Two of the 10 samples from GWI were field replicates collected at PE-08.

[a] Porewater data were collected as part of the RI for the GWI facility. The GWI facility is not discussed in this section because it is not adjacent to the SCA, and no source-tracing data were available. Porewater data for the GWI facility were included in this section at EPA's request and because the samples were collected within the SCA.

[b] VOC data were summarized, as available, at EPA's request, and not because of SQS exceedances in surface sediment in the SCA.

[c] Mercury, fluoranthene and total PCBs were not analyzed in the porewater samples.

[d] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[e] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

EPA – US Environmental Protection Agency

GWI – Great Western International

RI – remedial investigation

SCA – source control area

SQS – sediment quality standard

VOC – volatile organic compound

Source-tracing data were reported for one of the facilities within the Seattle Boiler Works to Slip 4 SCA (SAIC 2008a); these data are summarized in Table I-24 and the associated storm drain system is shown on Map I-14. The drainage basin that discharges to the Seattle Boiler Works to Slip 4 SCA has not been fully delineated. Additional details about source-tracing sampling programs conducted in the larger LDW drainage basin are presented in Section 9.4.4.7 of the main body of the RI.

Table I-24. Summary of chemical concentrations detected in source-tracing samples collected from the Seattle Boiler Works to Slip 4 SCA

Sample Source	Year Collected	Concentration Information[a, b, c, d]		Source[e]	Additional Information
		Mercury (mg/kg dw)	Total PCBs (µg/kg dw)		
Storm Drain Solids Samples					
Former Sternoff Property	1990	0.9 – 4.35 median = 2.2 n = 7/7	2,200 – 163,000 median = 18,800 n = 7/7	SEACOR (1990), as cited in SAIC (2008a)	SPU conducted additional source tracing in 2008-2009 under grant with Ecology.
Floor Drain Solids Samples					
Former Sternoff Property	1990	4.41 n = 1/1	31,000 n = 1/1	SEACOR (1990), as cited in SAIC (2008a)	The floor drain sample was a composite of four samples.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Slip 4 to Seattle Boiler Works SCA.

[b] Fluoranthene was either not analyzed or was not detected, or the data for this chemical were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/kg to µg/kg), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

dw – dry weight
PCB – polychlorinated biphenyl
SAIC – Science Applications International Corporation
SCA – source control area
SQS – sediment quality standard

Source control investigations have been conducted at some of the adjacent facilities (Table I-19) and investigations are expected to continue. Source control activities in the LDW are ongoing. Additional information on the Seattle Boiler Works to Slip 4 SCA is provided on Ecology's website.

I.4.4 Slip 4 Source Control Area (RM 2.8 E to RM 2.9 E, EAA 3)

The Slip 4 SCA was one of the seven candidate EAAs recommended to EPA and Ecology (Windward 2003c) and is a candidate for a non-time-critical removal action (NTCRA). Several documents have been prepared by Ecology, the SCWG, the City of Seattle, and King County in preparation of the NTCRA and to assess source control in

the Slip 4 drainage basin. These documents include two data gaps reports[22] (SAIC 2007e; SEA 2004), a draft engineering evaluation/cost analysis (EE/CA) (Integral 2006b), a 100% design analysis report (Integral 2007), a SCAP (Ecology 2006), a property review for Crowley Marine Services and First South Properties (SAIC 2006b), a technical memorandum on the status of Slip 4 source control (SAIC 2007a), and source control status update reports for the LDW that include information for the Slip 4 SCA (Ecology 2007f; Ecology and SAIC 2008). A preliminary engineering report (RoseWater 2006) and SEPA checklist prepared in preparation for the GTSP flume remediation and replacement project were reviewed for general information about the project. All documents above provided the information summarized in this section for the Slip 4 SCA. In addition, source-tracing data provided by the City of Seattle (Schmoyer 2008d), bank soil data collected by Ecology (Parametrix 2005), and seep data collected as part of the RI (Windward 2004) are also summarized in this section. These references will be referred to collectively as the "source documents" throughout this section and on the maps.

CSL exceedances in the surface sediment in this SCA have included total PCBs, BEHP, mercury, and four individual PAHs (Map I-15). SQS exceedances have included total PCBs, BEHP, BBP, mercury, total HPAHs, and nine individual PAHs. These exceedances are based on the RI baseline surface sediment dataset and the 2007 SCA boundary, as discussed in the introduction to this appendix. COCs were identified for this SCA based on a different dataset in the 2004 data gaps report (SEA 2004) (Table I-3). Based on available data, total PCB concentrations in Slip 4 surface sediment have consistently been highest at the head of the slip but have generally decreased with time (see Section 4.2.3.1 of the main body of the RI).

Commercial and industrial operations in the vicinity of the Slip 4 SCA include airplane manufacturing (historical manufacturing and current airplane finishing/testing), airport operations (historical and current), steam power generation (historical), container storage and shipping (historical and current), manufacturing of various metal products (historical), pole-dipping and pipe-dipping (historical), lumber milling and processing (historical), and lime and asphalt production (historical).

Adjacent and upland facilities associated with this SCA were identified in the SCAP (Ecology 2006). The adjacent properties included Boeing Plant 2, Crowley Marine Services, and First South Properties[23] (Table I-25 and Map I-16). The upland properties identified in the SCAP included the GTSP, King County International Airport (KCIA), and North Boeing Field (NBF) (Table I-21 and Map I-17).

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[22] Ecology is developing a supplemental data gaps report for North Boeing Field and the GTSP (Good 2009).

[23] Information for Crowley Marine Services is also included in Section I.4.3 as this facility is also part of the Seattle Boiler Works to Slip 4 SCA. Presentation of the information (outfalls, concentrations in media) was divided based on the location of the sample, as available.

Table I-25. Summary of facility information for the Slip 4 SCA

FACILITY[a]	CURRENT OWNERSHIP	CURRENT OPERATIONS	HISTORICAL OPERATIONS	ENVIRONMENTAL INVESTIGATIONS	REMEDIAL ACTIVITIES	SOURCE CONTROL ACTIVITIES/INVESTIGATIONS
Boeing Plant 2 (northern portion of facility)[b]	The Boeing Company	vehicle maintenance, operations/ support of aerospace research, and development activities	manufacturing of aluminum alloy, steel alloy, and titanium alloy parts and electronics for airplanes	Soil and groundwater environmental investigations were conducted on the northwestern portion of Boeing Plant 2 in the 1990s.	Remedial activities were conducted during site redevelopment when Building 2-01 was demolished and Building 2-122 was constructed in the early 1990s.	Ecology inspected Building 2-122 in 2007.
Crowley Marine Services	Crowley Marine Services	container storage, shipping, and barge berthing (tenants are Alaska Logistics and UPRR)	manufacturing facilities, pipe-dipping, lumber mill, and pole-dipping	Several environmental investigations and site inspections have been conducted. They were related to tank leaks, site characterization and hazard assessment, and characterization in preparation for Slip 4 sediment removal action. An SHA was conducted by Ecology in 2008. There are plans for an RI/FS to be conducted on the property (Sutton 2008a). Both new and historical data (e.g., groundwater data) and other information will be gathered and reviewed as part of the RI/FS.	Several USTs have been removed. An RI/FS will be conducted at the property under a MTCA order. The Agreed Order is being negotiated between Ecology and the identified PLPs (Sutton 2008b). After completion of the order, a work plan for the RI/FS will be developed.	Source-tracing investigations and business inspections have been conducted; however, site operations have changed since these investigations were conducted. Additional source control activities and investigations will be conducted at the facility as part of the RI/FS, as necessary (Sutton 2008b).
First South Properties	First South Properties	storage of portable toilets, dumpsters, storage tanks, and containers (tenant is Emerald Services)	machinery and storage company, lime plant, asphalt plant, lumber industries, compost company, and marine leasing	Several environmental investigations related to tank leaks, site characterization, and remediation of historical soil and groundwater contamination have been conducted. Other investigations included characterization in preparation for Slip 4 sediment removal action.	Cleanup was conducted in the 1980s and 1990s in response to historical soil and groundwater contamination (petroleum and metals) associated with tank leaks. Soil removal was conducted as part of drainage system redevelopment.	Source-tracing investigations and business inspections have been conducted.

Table I-25, cont. Summary of facility information for the Slip 4 SCA

Facility[a]	Current Ownership	Current Operations	Historical Operations	Environmental Investigations	Remedial Activities	Source Control Activities/Investigations
GTSP	City of Seattle	museum and equipment storage	power plant, machine shop, substation, and fire-fighting training	Several investigations involving soil and groundwater sampling related to tank leaks and site characterization, including investigation of a low-lying drainage area, have been conducted. The site will be further assessed under a MTCA Agreed Order as part of the RI/FS for the NBF/GTSP site.[c] A draft supplemental data gaps report has been prepared and is under review (Goldberg 2009).	PCB-contaminated soil from the low-lying drainage area was removed, and an interim remedial action was conducted to remove additional soil and to control erosion.	Source-tracing investigations have been conducted. Ecology is planning additional sampling at the facility, including stormwater sampling (Good 2009; Goldberg 2009).
KCIA (north drainage basin)	King County	commercial and recreational airport	commercial and recreational airport, military operations, and fire-fighting training; electronics manufacturing and equipment cleaning at the Electronics Manufacturing Facility[d]	Several investigations related to spill response, tank leaks, soil removals, and joint sealant material sampling have been completed. The site will be further assessed under MTCA as part of the RI/FS for the NBF/GTSP site.[c]	Soil and sediment removals associated with tank leaks, spills, and storm drain system cleanouts have been conducted.	Several source-tracing investigations and business inspections have been conducted. Flight lines and taxiways are swept on a frequent basis per Federal Aviation Administration requirements.
NBF[e]	King County owns the majority of the north drainage basin of KCIA but currently leases 117 ac to The Boeing Company; the City of Seattle and The Boeing Company also own some parcels	aircraft research and development, finishing and testing, and fueling/ defueling (tenant is Boeing)	aircraft research and development; painting, flight testing, aircraft delivery, fueling, and defueling; Army and National Guard air operations	Several environmental investigations have been conducted since the 1980s in an effort to identify the source of PCB contamination on the northern portion of the property. Recent investigations have been conducted to characterize joint caulk material on NBF and to characterize soil along the NBF/GTSP property line. The site is being further assessed under a MTCA Agreed Order as part of the RI/FS for the NBF/GTSP site.[c] A draft supplemental data gaps report has been prepared and is under review (Goldberg 2009).	Cleanup activities related to UST, oil/water separator, and contaminated soil removal have been conducted. Cleanup has also been conducted in response to spills and related to remediation of LNAPL from groundwater, and flight line area concrete joint sealant material removal.	Several source-tracing investigations have been conducted since the 1980s in an effort to identify the source of PCB contamination in the northern SD line. Source-tracing samples have also been collected on other portions of NBF. Portions of the SD system have been cleaned out on several occasions. Sections of the northern SD line were replaced or re-routed and soil sampling was conducted. Several catch basins and manholes were sealed or replaced. Source-tracing investigations are ongoing, and Ecology is planning additional sampling, including stormwater sampling, at the facility (Good 2009; Goldberg 2009).

Table I-25, cont. Summary of facility information for the Slip 4 SCA

Sources: Ecology (2006), Ecology and SAIC (2008), Integral (2006b), SAIC (2006b, 2007a, e), SEA (2004)

[a] Facilities listed are those identified as adjacent or upland properties in the data gaps report (SEA 2004) and the SCAP (Ecology 2006).

[b] Information included in this table pertains only to the 17.5-ac northwestern portion of Boeing Plant 2 that drains to Slip 4. Additional information on the rest of the Boeing Plant 2 property is discussed in the Boeing Plant 2/Jorgensen Forge SCA summary (Section I.4.5).

[c] The Boeing Company, King County, the City of Seattle, and Ecology have signed an administrative order to conduct an RI/FS at the NBF/GTSP site. Ecology will conduct the RI/FS.

[d] Information pertaining to the Electronics Manufacturing Facility is discussed in the Boeing Plant 2/Jorgensen Forge SCA section (Section I.4.5) because groundwater from the EMF flows toward the Boeing Plant 2/Jorgensen Forge SCA.

[e] Although NBF is part of KCIA, it is considered a separate facility for the purposes of this SCA summary. The location and extent of NBF, in relation to the larger KCIA facility, is shown on Map I-17.

Ecology – Washington State Department of Ecology
GTSP – Georgetown Steam Plant
KCIA – King County International Airport
MTCA – Model Toxics Control Act
LNAPL – light non-aqueous phase liquid
NBF – North Boeing Field
PLP – potentially liable party
PCB – polychlorinated biphenyl
RI/FS – remedial investigation/feasibility study
SAIC – Science Applications International Corporation
SCA – source control area
SCAP – source control action plan
SD – storm drain
SEA – Striplin Environmental Associates
SHA – site hazard assessment
UPRR – Union Pacific Railroad
UST – underground storage tank

Five major outfalls were identified in the source documents that discharge to the Slip 4 SCA. These outfalls discharge at the head of the Slip 4 SCA, and include the I-5 SD (No. 2046), the GTSP flume SD (No. 2047), the NBF SD (No. 2048), the KCIA SD No. 3/Pump Station 44 (PS44) emergency overflow (EOF) (No. 2049), and the E Marginal Way S EOF (No. 043) (Table I-26 and Map I-15). In total, storm drainage from approximately 490 ac of land discharges to Slip 4 (Map I-17). In addition, in the event of an EOF discharge, drainage from a combined sewer service area of approximately 6,200 ac could potentially discharge to Slip 4 (King County and SPU 2005).

Stormwater runoff also has the potential to discharge directly to Slip 4 from adjacent upland facilities. Eleven other outfalls identified during the 2003 outfall survey (Herrera 2004) are located within the Slip 4 SCA. Four of these are private storm drains located on Crowley Marine Services (Nos. 5007 to 5010), five are private storm drains located on First South Properties[24] (Nos. 2216, 2217, 2219, 2050, and 2051), and two are private storm drains located on the northern portion of Boeing Plant 2 (Nos. 2052 and 2053). Environmental investigations and remedial activities have been conducted in association with the outfalls in the Slip 4 SCA. Information on the outfalls within this SCA is summarized in Table I-26 and the locations of these outfalls are shown on Maps I-15 through I-17; additional outfall information is provided in Appendix H.

[24] Currently, one active private storm drain outfall remains on First South Properties (SAIC 2007a).The five outfalls formerly located on the property were replaced by a single outfall when the property was redeveloped in 2006. Maps I-15 through I-17 show the five outfalls formerly present on the property as identified in the 2003 outfall survey (Herrera 2004) because this is the outfall information source used throughout the RI. The treatment of discrepancies between outfall configurations shown on the RI maps and the maps provided in source documents is discussed in the introduction to this appendix.

Table I-26. Summary of specific information for outfalls in the Slip 4 SCA

Outfall	Current Ownership	Current Operations	Historical Operations	Environmental and Source-Tracing Investigations	Remedial and Source Control Activities
Outfalls Identified in the SCAP and Data Gaps Report as Major Outfalls[a]					
E Marginal Way EOF outfall (No. 043)	King County	Outfall is an EOF for the E Marginal Way pump station located on E Marginal Way S.	Served as an EOF for the EBI pump station located on E Marginal Way S (no recorded discharges have occurred since 1968). Prior to construction of the EBI, this outfall functioned as an EOF and overflow for pump station No. 10 (PS10) on the old Henderson-E Marginal Way sewer system. Prior to the construction of PS10, the outfall was used as a raw sewage outfall for the E. Marginal Trunk (Stern 2008).	Environmental investigations related to the E Marginal Way EOF were not reported.	No remedial or source control activities were reported.
GTSP flume outfall (No. 2047)	City of Seattle	Outfall discharges stormwater runoff from approximately 6 ac of surrounding land, including portions of the GTSP property, NBF, and the Aero Motel property; S Myrtle St and properties along S Myrtle St; open sections of the flume potentially receive overland runoff from adjacent properties including the Willow Street substation and the former Ellis substation.	Discharged cooling water from the GTSP condenser pit, received discharges southwest of the GTSP (via either permitted or illicit connections) of wastewater, cooling water, and stormwater from neighboring industrial properties including the GTSP, a power substation, a motel, and facilities on and adjacent to NBF.	Soil and sediment sampling has been conducted within the flume and at industrial facilities on and adjacent to NBF where some surface water runoff drains into the flume. Several historical investigations were conducted to identify illicit connections to the flume and potential sources of PCBs and to investigate spills into the flume. Site characterization and design studies for cleanup and removal of the flume have recently been completed.	Most connections to the flume have been terminated. Soil and sediment in the flume have been cleaned out several times. The City of Seattle is working to remove contaminated soil and sediment from the flume, decommission wooden portions of the flume, remove contaminated soil from Willow Street and Ellis substations, and replace the flume with a new underground SD system. Construction began in May 2009 and is scheduled for completion by December 2009 (Goldberg 2009).
I-5 SD outfall (No. 2046)	WSDOT	Outfall discharges stormwater from approximately 153 ac including 44 ac of residential land east of I-5, 1.5 mi of I-5, approximately 44 ac of industrial property west of I-5 and adjacent to Airport Way S, and 1 to 2 ac of the northern end of KCIA.	The outfall was constructed in 1965 in association with the construction of I-5. The outfall was formerly referred to as the S Albro St SD (Schmoyer 2008b).	Source-tracing investigations have been conducted by the City of Seattle within the drainage basin; however, none of the sampling locations were within the I-5 corridor.	The City will conduct routine catch basin cleaning as required under its NPDES permit. Additional catch basin and SD line cleaning will be conducted as necessary.

Table I-26, cont. Summary of specific information for outfalls in the Slip 4 SCA

Outfall	Current Ownership	Current Operations	Historical Operations	Environmental and Source-Tracing Investigations	Remedial and Source Control Activities
KCIA SD No. 3/PS44 EOF outfall (No. 2049)	City of Seattle and King County[b]	The system's drain line discharges through a pump station to Slip 4. Outfall discharges stormwater from approximately 290 ac of the northern end of KCIA and NBF and also functions as an EOF for City of Seattle PS44, which is on the sanitary sewer. The EOF functions only in the event of pump failure or an obstruction in the drain line (King County and SPU 2005).	No historical operations were reported; the EOF has not discharged since record-keeping began in the late 1990s.	Source-tracing investigations have been conducted by the City of Seattle, King County, and Boeing; these investigations are ongoing.	Some SD lines that drain to the KCIA SD No. 3/PS44 EOF system have been cleaned out. Catch basins and oil/water separators located within the northern drainage basin of KCIA are cleaned biannually.
NBF SD outfall (No. 2048)	City of Seattle	Outfall discharges stormwater from approximately 1 ac of the northern end of NBF.	Initially served as a combined sewer, which discharged directly to Slip 4, for portions of the Georgetown neighborhood and industrial facilities in the vicinity of what is now the northern end of KCIA and NBF. In 1926, the combined sewers in the Georgetown neighborhood were diverted to the Michigan Street sewer system (City of Seattle 1925); and, in 1976, a new sanitary sewer was installed, which routed wastewater from the northern end of KCIA and NBF to the sanitary sewer on E Marginal Way S. After 1976, this outfall functioned as a storm drain, collecting runoff from about 90 acres on NBF and also served as an EOF for PS44. Stormwater from these areas and the EOF was redirected to the KCIA SD No. 3/PS44 EOF outfall (No. 2049) during 1987 to make way for the construction of the Boeing Building 3-380.	No environmental investigations related to the NBF SD were reported.	No remedial or source control activities were reported.

Table I-26, cont. Summary of specific information for outfalls in the Slip 4 SCA

Outfall	Current Ownership	Current Operations	Historical Operations	Environmental and Source-Tracing Investigations	Remedial and Source Control Activities
Other Outfalls					
Crowley Marine Services Private SD outfalls (Nos. 5007 through 5010)	Crowley Marine Services	Private SD outfalls drain stormwater from a portion of the Crowley Marine Services property.	No historical operations were reported.	SPU collected one sediment sample from an onsite catch basin in 2004.	Stormwater and in-line solids sampling will be conducted as part of the RI/FS. Cleanout of onsite catch basins and SD lines will also be conducted as part of the RI/FS if necessary.
First South Properties Private SD outfalls (Nos. 2050, 2051, 2216, 2217, and 2219)[c]	First South Properties	These five outfalls and an unpaved drainage swale were replaced by a single outfall in 2006. Maps I-15 through I-17 display the five outfalls formerly present on the property (SAIC 2007a).	No historical operations were reported.	In 2005, SPU collected samples from two catch basins upstream and downstream of an oil/water separator located on the southwest corner of the property and from a small drainage ditch located on the northwest corner of the property.	Oil/water separators were replaced in 2006 and runoff from the site was diverted to a single outfall when the property was redeveloped in 2006 and 2007.
Boeing Plant 2 Private SD outfalls (Nos. 2052 and 2053)	The Boeing Company	Private SD outfalls drain stormwater from vehicle parking areas and roof drains; stormwater flows through bioswales prior to discharge to the LDW.	No historical operations were reported.	No environmental investigations were reported.	Ecology has plans to sample storm drain solids on the northern portion of Boeing Plant 2 as part of site inspection activities.

Sources: Ecology (2006), Ecology and SAIC (2008), RoseWater (2006), SAIC (2006b, 2007a, e), Schmoyer (2008d), SEA (2004), Seattle City Light (2008)

[a] Major outfalls listed are those discussed as individual source control entities in the SCAP (Ecology 2006) and data gaps report (SEA 2004).

[b] King County owns the SD system, and the City of Seattle operates the pump station and EOF.

[c] Currently, only one active private storm drain outfall remains on First South Properties.

EBI – Elliott Bay Interceptor
Ecology – Washington State Department of Ecology
EOF – emergency overflow
GTSP – Georgetown Steam Plant
I-5 – Interstate 5
KCIA – King County International Airport
LDW – Lower Duwamish Waterway
NBF – North Boeing Field
PCB – polychlorinated biphenyl
PS – pump station
SAIC – Science Applications International Corporation
SCA – source control area
SCAP – source control action plan
SD – storm drain
SEA – Striplin Environmental Associates
WSDOT – Washington State Department of Transportation

Several remedial activities and environmental investigations have been completed or are currently in progress within the Slip 4 SCA (Tables I-25 and I-26, Maps I-16 and I-17). Information about these activities has been summarized in the source documents. Several of the chemicals that have been detected above the SQS in Slip 4 surface sediment have also been detected in various upland media, including soil, groundwater, seep, and source-tracing samples (Table I-27). The availability of data (by media type) is also presented in the table on Map I-16 for each of the facilities and major outfalls associated with this SCA. In Table I-27, and in the table on Map I-16, an X indicates that the source documents reported data or indicated that data exist; therefore, an X does not necessarily mean that the actual data were presented in the source documents. Data are only summarized in the media-specific and source-tracing tables if the data were reported in the source documents and if they met the criteria for data summation discussed in the introduction to this appendix (e.g., soil data were collected along the SCA shoreline; groundwater data were collected from shoreline facilities). The identification of a chemical in these media at facilities or within the drainage systems of the Slip 4 SCA does not necessarily indicate that these potential sources contributed to sediment contamination in the past or will result in sediment contamination in the future.

Table I-27. Chemicals identified in various media in the Slip 4 SCA

Chemical[a]	Soil	Groundwater	Seep	Porewater[b]	Stormwater[c]	Source-Tracing Samples	Sources
Mercury	X		X			X	Ecology (2006), King County and SPU (2005), SAIC (2007e), Schmoyer (2008d), Windward (2004)
Acenaphthene		X				X	SAIC (2006b), Schmoyer (2008d)
Benzo(a)anthracene	X	X				X	SAIC (2006b, 2007e), Schmoyer (2008d)
Benzo(a)pyrene	X	X				X	Ecology (2006), King County and SPU (2005), SAIC (2006b, 2007e), Schmoyer (2008d)
Benzofluoranthenes	X	X				X	SAIC (2006b, 2007e), Schmoyer (2008d)
Benzo(g,h,i)perylene	X					X	Ecology (2006), King County and SPU (2005), SAIC (2007e), Schmoyer (2008d)
Chrysene	X	X				X	SAIC (2006b, 2007e), Schmoyer (2008d)

Chemical[a]	Soil	Ground-water	Seep	Pore-water[b]	Storm-water[c]	Source-Tracing Samples	Sources
Dibenzo(a,h)anthracene	X					X	Ecology (2006), King County and SPU (2005), SAIC (2007e), Schmoyer (2008d)
Fluoranthene	X	X				X	SAIC (2006b), Schmoyer (2008d); SAIC (2007e)
Indeno(1,2,3-cd)pyrene	X					X	Ecology (2006), King County and SPU (2005), SAIC (SAIC 2007e), Schmoyer (2008d)
Total HPAHs						X	Schmoyer (2008d)
BBP						X	Schmoyer (2008d)
BEHP	X	X				X	Ecology (2006), King County and SPU (2005), SAIC (2007e), Schmoyer (2008d)
Total PCBs	X	X	X			X	Ecology (2006), King County and SPU (2005), SAIC (2007a, e), Schmoyer (2008d), Integral (2007)

Note: An X indicates that the source documents reported that data are available for the identified media. The absence of an X in any cell does not necessarily mean that the chemical is absent in the upland media or in source-tracing samples; in some cases, the chemical may not have been analyzed for or, if analyzed, could have been present but at concentrations below the RL.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Slip 4 SCA. The chemical list is based on SMS exceedances in the RI baseline surface sediment dataset within the 2007 SCA boundary. Therefore, this list may differ from the list of exceedances in source documents.

[b] A porewater sample was collected from approximately the center of Slip 4 by EPA in 1998. The sample was analyzed for metals and trace elements. None of the chemicals with SQS exceedances in surface sediment in the SCA were detected in the porewater sample.

[c] Stormwater sampling has been conducted at NBF, according to the data gaps report (SAIC 2007e); however, none of the chemicals with SQS exceedances in surface sediment in the SCA have been analyzed in storm water because they are not required to be monitored under the general stormwater permit conditions.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
Ecology – Washington State Department of Ecology
EPA – Environmental Protection Agency
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
NBF – North Boeing Field
PCB – polychlorinated biphenyl
RI – remedial investigation
RL – reporting limit
SAIC – Science Applications International Corporation
SCA – source control area
SPU – Seattle Public Utilities
SMS – Washington State Sediment Management Standards
SQS – sediment quality standard

This section summarizes the upland data as they were presented in the source documents for bank soil, groundwater, seep water, and source-tracing samples. Data for one porewater sample collected in Slip 4 were identified. The sample was analyzed for metals; mercury was not detected in the porewater sample (SEA 2004), and

therefore, no data for porewater are presented in the media tables in this section. No stormwater data were presented in the source documents.

Soil sampling has been conducted at several of the facilities within the Slip 4 SCA. The facilities with available soil data are indicated in the table on Map I-16. Bank soil data collected along the Slip 4 shoreline are summarized in Table I-28. Bank soil samples were collected from the shoreline portions of the Boeing Plant 2, Crowley Marine Services, and First South Properties facilities. Most of the bank samples were collected from areas within the sediment removal action boundary for Slip 4. Soil data collected from upland areas are included in the source documents, such as the property review for Crowley Marine Services and First South Properties (SAIC 2006b). Groundwater data collected in close proximity to Slip 4 (from the shoreline properties owned by Crowley Marine Services and First South Properties) are summarized in Table I-29. Groundwater sampling was conducted on these properties in the late 1980s and early 1990s; all data presented in the property review for Crowley Marine Services and First South Properties (SAIC 2006b) are summarized in the table. Additional groundwater data, which included some results for VOCs in groundwater at the Crowley Marine Services property, were also provided in the data gaps report for the Seattle Boiler Works to Slip 4 SCA (SAIC 2008a). These VOC data are included in this section. Data were available for several seep samples collected within the Slip 4 SCA. Two of the seep samples had detected concentrations of chemicals that had exceeded the SQS in Slip 4 surface sediment; these data are presented in Table I-30.

Table I-28. Summary of chemical concentrations detected in bank soil in the Slip 4 SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (mg/kg dw unless noted)[c, d]	Location	Sources[e]	Additional Information
Boeing Plant 2	total PCBs	2005	0.876 n = 1/1	northern portion of property	Parametrix (2005)	Sampling locations appear to be within the Slip 4 sediment removal action boundary.
Boeing Plant 2	total PCBs	2005	0.711 n = 1/1	along the northern portion of the property	Parametrix (2005)	Samples were subsurface soil borings collected from the bank; sampling locations appear to be within the Slip 4 sediment removal action boundary.
Crowley Marine Services	mercury	2004	0.06, 0.06 n = 2/2	near the head of the slip	SEA (2004) as cited in Integral (2006b)	Two samples were collected from the same location and had the same concentration.
Crowley Marine Services	total PCBs	2004	0.023 n = 1/1	near head of slip	SEA (2004) as cited in Integral (2006b)	Sampling locations appear to be within the Slip 4 sediment removal action boundary.
First South Properties	total PCBs	2005	1.08 – 8.49 mg/kg OC median = 6.20 mg/kg OC n = 3/4	along property shoreline	CH2M HILL (2005) as cited in Integral (2006b)	Sampling locations appear to be within the Slip 4 sediment removal action boundary.
First South Properties	total PCBs	2005	0.215 – 9.64 median = 0.617 n = 5/5	along property shoreline	Parametrix (2005)	Sampling locations appear to be within the Slip 4 sediment removal action boundary.
First South Properties	total PCBs	2005	0.146 – 9.54 median = 1.594 n = 5/5	along the property shoreline	Parametrix (2005)	Samples were subsurface soil borings collected from the bank; sampling locations appear to be within the Slip 4 sediment removal action boundary.
First South Properties	mercury	2004	0.05 – 0.38 median = 0.15 n = 7/7	along property shoreline	SEA (2004) as cited in Integral (2006b)	Sampling locations appear to be within the Slip 4 sediment removal action boundary.
First South Properties	total PCBs	2004	0.79 – 4.7 median = 1.3 n = 5/5	along property shoreline	SEA (2004) as cited in Integral (2006b)	Sampling locations appear to be within the Slip 4 sediment removal action boundary.
First South Properties and Boeing Plant 2	total PCBs	2005	0.14 – 0.44 median = 0.36 n = 3/3	First South Properties and Boeing Plant 2 property boundary	Bach (2005) as cited in Integral (2006b)	Sampling locations appear to be within the Slip 4 sediment removal action boundary.

Table I-28, cont. Summary of chemical concentrations detected in bank soil in the Slip 4 SCA

FACILITY	CHEMICAL[a, b]	YEAR COLLECTED	CONCENTRATION INFORMATION (mg/kg dw unless noted)[c, d]	LOCATION	SOURCES[e]	ADDITIONAL INFORMATION
First South Properties and Boeing Plant 2	total PCBs	2005	1.88 – 3.14 mg/kg OC median = 2.22 mg/kg OC n = 3/3	First South Properties and Boeing Plant 2 property boundary	CH2M HILL (2005), as cited in Integral (2006b)	Sampling locations appear to be within the Slip 4 sediment removal action boundary.
First South Properties and Boeing Plant 2	total PCBs	2004	7.8 n = 1/1	First South Properties and Boeing Plant 2 property boundary	SEA (2004) as cited in Integral (2006b)	Sampling locations appear to be within the Slip 4 sediment removal action boundary.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Slip 4 SCA.

[b] BBP, BEHP, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, and total HPAHs were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from µg/kg to mg/kg), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
OC – organic carbon
PCB – polychlorinated biphenyl
SCA – source control area
SQS – sediment quality standard

Table I-29. Summary of chemical concentrations detected in groundwater in the Slip 4 SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Chemicals with Detected Concentrations Above SQS in Surface Sediment						
Crowley Marine Services	acenaphthene	1989 – 1990	3.1 – 250 median = 15.9 n = 4/12	multiple groundwater wells throughout the facility	Hart Crowser (1989a, b, 1990) and Landau (1990), as cited in SAIC (2006b)	Groundwater data were collected to characterize the property for potential real estate transactions and in relation to tank removals.
Crowley Marine Services	benzo(a)anthracene	1989 – 1990	0.5, 8.6 n = 2/12	multiple groundwater wells throughout the facility	Hart Crowser (1989a, b, 1990) and Landau (1990), as cited in SAIC (2006b)	Groundwater data were collected to characterize the property for potential real estate transactions and in relation to tank removals.
Crowley Marine Services	benzo(a)pyrene	1989 – 1990	1.6 n = 1/12	multiple groundwater wells throughout the facility	Hart Crowser (1989a, b, 1990) and Landau (1990), as cited in SAIC (2006b)	Groundwater data were collected to characterize the property for potential real estate transactions and in relation to tank removals.
Crowley Marine Services	benzofluoranthenes	1989 – 1990	0.7 – 5.6 median = 2.0 n = 3/12	multiple groundwater wells throughout the facility	Hart Crowser (1989a, b, 1990) and Landau (1990), as cited in SAIC (2006b)	Groundwater data were collected to characterize the property for potential real estate transactions and in relation to tank removals.
Crowley Marine Services	chrysene	1989 – 1990	0.5, 8.8 n = 2/12	multiple groundwater wells throughout the facility	Hart Crowser (1989a, b, 1990) and Landau (1990), as cited in SAIC (2006b)	Groundwater data were collected to characterize the property for potential real estate transactions and in relation to tank removals.
Crowley Marine Services	fluoranthene	1989 – 1990	5.2 – 11 median = 9.6 n = 3/12	multiple groundwater wells throughout the facility	Hart Crowser (1989a, b, 1990) and Landau (1990), as cited in SAIC (2006b)	Groundwater data were collected to characterize the property for potential real estate transactions and in relation to tank removals.
Crowley Marine Services	BEHP	1989 – 1990	0.047 – 29 median = 9.35 n =10/10	multiple groundwater wells throughout the facility	Hart Crowser (1989a, b, 1990) and Landau (1990), as cited in SAIC (2006b)	Groundwater data were collected to characterize the property for potential real estate transactions and in relation to tank removals.
First South Properties	acenaphthene	1990	0.12, 1.8 n = 2/4	four groundwater wells throughout the facility	Landau (1990) as cited in SAIC (2006b)	Groundwater data were collected to characterize the property for potential real estate transactions and in relation to tank removals.

Table I-29, cont. Summary of chemical concentrations detected in groundwater in the Slip 4 SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
First South Properties	BEHP	1990	8.5 – 31 median = 25 n = 3/3	three groundwater wells throughout the facility	Landau (1990) as cited in SAIC (2006b)	Groundwater data were collected to characterize the property for potential real estate transactions and in relation to tank removals.
VOCs[f]						
Crowley Marine Services	acetone	1990	7.0 n = nr	one groundwater well located on the western portion of the facility	Landau (1990) as cited in SAIC (2008a)	Groundwater data were collected to characterize the property for a potential real estate transaction.
Crowley Marine Services	cis-1,2-dichloroethene	1990	1.5 n = nr	one groundwater well located on the southern portion of the facility	Landau (1990) as cited in SAIC (2008a)	Groundwater data were collected to characterize the property for a potential real estate transaction.
Crowley Marine Services	dichloromethane	1990	0.5 – 1.4 median = 0.9 n = nr	six groundwater wells throughout the facility	Landau (1990) as cited in SAIC (2008a)	Groundwater data were collected to characterize the property for a potential real estate transaction.

Note: Groundwater data for the shoreline properties (Crowley Marine Services and First South Properties) are presented as they were in the Slip 4 source documents and the data gaps report for the Seattle Boiler Works to Slip 4 SCA. The only available groundwater data for these two properties are from the late 1980s and early 1990s.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Slip 4 SCA.

[b] PCBs, mercury, BBP, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and total HPAHs were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

[f] The VOC data for Crowley Marine Services were provided in the Seattle Boiler Works to Slip 4 SCA data gaps report (2008a). Only detected data were provided; sample counts were not reported. VOC data were summarized, as available, at EPA's request and not because of SQS exceedances in surface sediment in the SCA.

BEHP – bis(2-ethylhexyl) phthalate
BBP – butyl benzyl phthalate
EPA – US Environmental Protection Agency
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
nr – not reported
SAIC – Science Applications International Corporation
SCA – source control area
SQS – sediment quality standard
VOC – volatile organic compound

Table I-30. Summary of chemical concentrations detected in seeps in the Slip 4 SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Crowley Marine Services	total PCBs	2006	0.02, 0.1 (dissolved) n = 2/6	along property shoreline	Integral (2006a) as cited in SAIC (2007a)	Seep sample was collected as part of Slip 4 sediment removal action design planning.
First South Properties	mercury	2004	0.00092 (dissolved) n = 1/1	along property shoreline	Windward (2004)	Seep sample was collected as part of the LDW RI.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Slip 4 SCA.

[b] BBP, BEHP, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, and total HPAHs were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples. Concentration ranges were calculated using only detected data. For this reason, some estimated ranges may be higher than actual concentrations.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

BEHP – bis(2-ethylhexyl) phthalate
BBP – butyl benzyl phthalate
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LDW – Lower Duwamish Waterway
PCB – polychlorinated biphenyl
RI – remedial investigation
SAIC – Science Applications International Corporation
SCA – source control area
SQS – sediment quality standard

Source-tracing samples have been collected from several facilities and drainage systems associated with the Slip 4 SCA (see the table on Map I-16), and data from these samples are available in the source documents. Table I-31 presents source-tracing data collected within the Slip 4 SCA. Most source-tracing data were collected between 2000 and 2007 because many of the source-tracing programs within the LDW were initiated within this time period.[25] Data relevant to source-tracing efforts include: samples of catch basin solids, manhole and stormwater vault solids, solids from oil/water separators, joint caulking material used as sealant on paved areas, samples from sediment traps, in-line sediment samples, and samples from filter bags placed over catch basins or water flow intake points within storm drain systems. When multiple rounds of data were collected from the same sampling location, only the most recent round was selected for presentation in order to represent current conditions. Additional details on source-tracing sampling programs conducted within the Slip 4 SCA and the larger LDW drainage basin are presented in Section 9.4.4.7 of the main body of the RI. King County and SPU have inspected over 50 businesses in the Slip 4 basin (King County and SPU 2005) as part of their source control efforts within the basin. The business inspection program is discussed in Section 9.4.4.5 of the main body of the RI.

[25] Data from 2008 are not included in Table I-31. Many of the 2008 data are not yet validated or are otherwise not yet ready for use. Sediment trap data collected in March 2008 are presented on Map I-18. Additional rounds of data were collected prior to 2008 and in July 2008 from the sediment traps within the Slip 4 SCA drainage basin.

Table I-31. Summary of chemical concentrations detected in source-tracing samples in the Slip 4 SCA

Sample Source	Year Collected	Concentration Information[a, b, c]								Sources[e]	Additional Information
		Mercury (mg/kg dw)	Acenaphthene (µg/kg dw)	Benzo(a)-Anthracene (µg/kg dw)	Benzo(a)-pyrene (µg/kg dw)	Benzo-fluoranthenes (µg/kg dw)[d]	Benzo(g,h,i)-perylene (µg/kg dw)	Chrysene (µg/kg dw)	Dibenzo(a,h)-anthracene (µg/kg dw)		
Onsite Catch Basin Solids Samples											
GTSP flume	2004 - 2005	0.12, 0.32 n = 2/2	82 n = 1/2	1,400 n = 1/2	1,500 n = 1/2	360, 4,700 n = 2/2	530 n = 1/2	290, 1,800 n = 2/2	85 n = 1/2	Schmoyer (2008d)	Two onsite catch basin solids samples were collected from the GTSP flume basin.
I-5 SD	2004 and 2006	0.1 – 0.34 median = 0.3 n = 3/3	760 n = 1/3	110, 13,000 n = 2/3	120, 15,000 n = 2/3	380, 30,000 n = 2/3	7,300 n = 1/3	110 – 20,000 median = 170 n = 3/3	2,700 n = 1/3	Schmoyer (2008d)	Three onsite catch basin solids samples were collected from the I-5 SD basin.
KCIA SD No. 3/PS44 EOF	2004 - 2007	0.2 n = 1/1	nd	27,000 n = 1/1	32,000 n = 1/1	68,000 n = 1/1	16,000 n = 1/1	43,000 n = 1/1	5,400 n = 1/1	Schmoyer (2008d)	Multiple onsite catch basin solids samples were collected from the KCIA SD No. 3/PS44 EOF drainage basin. For all except one sample, only PCB data are available. The single sample for which data are available for other chemicals was collected in 2004.
Private SDs (Crowley Marine Services facility)	2004	0.08 n = 1/1	170 n = 1/1	610 n = 1/1	200 n = 1/1	800 n = 1/1	nd	1,000 n = 1/1	nd	Schmoyer (2008d)	An onsite catch basin solids sample was collected from the Crowley Marine Services facility.
Private SDs (First South Properties facility)	2005 - 2006	0.11, 0.2 n = 2/2	nd	130, 730 n = 2/2	200, 830 n = 2/2	500, 2,500 n = 2/2	230, 570 n = 2/2	290, 1,800 n = 2/2	150 n = 1/2	Schmoyer (2008d)	Two onsite catch basin solids samples were collected from the First South Properties facility.
ROW Catch Basin Solids Samples											
GTSP flume	2007	nr	nr	nr	nr	nr	nr	nr	nr	Schmoyer (2008d)	Seven ROW catch basin solids samples were collected from the GTSP flume drainage basin and analyzed for PCBs.
I-5 SD	2006 - 2007	nd	nd	36 n = 1/3	38 n = 1/3	32 – 100 median = 85 n = 3/3	32 n = 1/3	28 – 140 median = 49 n = 3/3	nd	Schmoyer (2008d)	Three right-of-way catch basin solids samples were collected from the I-5 SD basin.
In-Line Sediment Trap Samples											
I-5 SD	2007	nd	nr	nr	nr	nr	nr	nr	nr	Schmoyer (2008d)	A sediment trap sample was collected from the I-5 SD basin in May 2007. The sample was analyzed for metals and PCBs.
KCIA SD No. 3/PS44 EOF	2007	0.07 – 4.40 median = 0.45 n = 6/8	nd	440 – 1,500 median = 570 n = 3/3	390 – 1,200 median = 830 n = 3/3	2,600 – 6,900 median = 2,700 n = 3/3	120 n = 1/3	1,200 – 3,100 median = 1,200 n = 3/3	nd	Schmoyer (2008d)	Sediment trap samples were collected from nine locations within the KCIA SD No. 3/PS44 EOF drainage basin. Only PCB data were available for six of the samples.
Other In-line Samples (e.g., oil/water separators,[f] manholes, stormwater vaults,[g] flume samples)											
GTSP flume	2005 - 2006	0.08 – 1.70 median = 0.20 n = 11/16	10 – 660 median = 81 n = 6/16	38 – 7,900 median = 370 n = 15/16	56 – 8,600 median = 290 n = 15/16	162 – 20,000 median = 1,000 n = 15/16	20 – 2,500 median = 190 n = 15/16	91 – 8,400 median = 595 n = 16/16	7 – 1,000 median = 40 n = 10/16	Schmoyer (2008d)	Twenty-seven in-line sediment samples were collected from the GTSP flume. One sampling location was a manhole located at the downstream end of the flume. Not all samples had data available for all chemicals (for many, only PCB data were available).
I-5 SD	2005	nd	nd	nd	26 n = 1/1	34 n = 1/1	nd	31 n = 1/1	nd	Schmoyer (2008d)	One manhole solids sample was collected within the I-5 SD basin.

Table I-31, cont. Summary of chemical concentrations detected in source tracing samples in the Slip 4 SCA

Sample Source	Year Collected	Concentration Information[a, b, c]								Sources[e]	Additional Information
		Mercury (mg/kg dw)	Acenaphthene (µg/kg dw)	Benzo(a)-Anthracene (µg/kg dw)	Benzo(a)-pyrene (µg/kg dw)	Benzo-fluoranthenes (µg/kg dw)[d]	Benzo(g,h,i)-perylene (µg/kg dw)	Chrysene (µg/kg dw)	Dibenzo(a,h)-anthracene (µg/kg dw)		
KCIA SD No. 3/PS44 EOF	1992 - 2007	0.07 – 0.70 median = 0.23 n = 14/15	800 – 1,000 median = 930 n = 3/15	280 – 35,500 median = 3,000 n = 15/15	300 – 50,000 median = 3,400 n = 15/15	760 – 142,000 median = 9,000 n = 15/15	170 – 44,800 median = 3,100 n = 15/15	400 – 70,100 median = 4,690 n = 15/15	184 – 12,900 median = 3,100 n = 9/15	Schmoyer (2008d)	Solids samples were collected from manholes, oil/water separators,[f] and stormwater vaults[g] located within the KCIA SD No. 3/PS44 EOF drainage basin. The majority of the samples were collected between 2005 and 2007; single sampling results from 1992 and 1998 were included because newer data were not available from the sampling locations where these samples were collected.
Filter Bag Samples[h]											
KCIA SD No. 3/PS44 EOF	2004	nr	nr	nr	nr	nr	nr	nr	nr	ARI (2005) as cited in SAIC SAIC (2007e)	Samples were collected from filter bags.[h] Source documents did not specify whether the reported PCB concentration was for mg/kg filter bag material or for the concentration of the retained solids concentration as back-calculated from the filter bag material concentration.
KCIA SD No. 3/PS44 EOF	2005	nr	nr	nr	nr	nr	nr	nr	nr	Boeing (2005) as cited in SAIC (2007e)	Samples were collected from filter bags[h] used to remove suspended solids from the storm drain system. The filter bag and its contents were analyzed together and the concentration on the retained solids was then back-calculated.

Table I-31, cont. Summary of chemical concentrations detected in source tracing samples in the Slip 4 SCA

Sample Source	Year Collected	Concentration Information[a, b, c]							Additional Information
		Fluoranthene (µg/kg dw)	Indeno(1,2,3-cd)-pyrene (µg/kg dw)	Total HPAH[i] (µg/kg dw)[i]	BBP (µg/kg dw)	BEHP (µg/kg dw)	Total PCBs[i] (µg/kg dw)	Sources[e]	
Onsite Catch Basin Solids Samples									
GTSP flume	2004 - 2005	410, 4,700 n = 2/2	710 n = 1/2	1,400, 18,000 n = 2/2	430 n = 1/2	77, 10,000 n = 2/2	180, 250 n = 2/2	Schmoyer (2008d)	Two onsite catch basin solids samples were collected from the GTSP flume basin.
I-5 SD	2004 and 2006	110 – 31,000 median = 240 n = 3/3	8,600 n = 1/3	380 – 150,000 median = 1,200 n = 3/3	120, 490 n = 2/3	430 – 8,800 median = 2,900 n = 3/3	189 – 470 median = 310 n = 3/3	Schmoyer (2008d)	Three onsite catch basin solids samples were collected from the I-5 SD basin.
KCIA SD No. 3/PS44 EOF	2004 - 2007	85,000 n = 1/1	19,000 n = 1/1	340,000 n = 1/1	nd	30,000 n = 1/1	66 – 320,000 median = 5,500 n = 43/44	Schmoyer (2008d)	Multiple onsite catch basin solids samples were collected from the KCIA SD No. 3/PS44 EOF drainage basin. For all except one sample, only PCB data are available. The one sample for which data are available for other chemicals was collected in 2004.
Private SDs (Crowley Marine Services facility)	2004	3,600 n = 1/1	nd	8,800 n = 1/1	1,300 n = 1/1	1,600 n = 1/1	nd	Schmoyer (2008d)	An onsite catch basin solids sample was collected from the Crowley Marine Services facility in 2004.
Private SDs (First South Properties facility)	2005 - 2006	310, 1,700 n = 2/2	96, 410 n = 2/2	2,200, 14,000 n = 2/2	1,000 n = 1/2	12,000, 120,000 n = 2/2	300, 620 n = 2/2	Schmoyer (2008d)	Two onsite catch basin solids samples were collected from the First South Properties facility.
ROW Catch Basin Solids Samples									
GTSP Flume	2007	nr	nr	nr	nr	nr	33 – 570 median = 65 n = 7/7	Schmoyer (2008d)	Seven ROW catch basin solids samples were collected from the GTSP flume drainage basin and analyzed for PCBs.
I-5 SD	2006 - 2007	44 – 200 median = 110 n = 3/3	24 n = 1/3	140, 640 median = 490 n = 3/3	150, 250 n = 2/3	300 – 2,000 median = 360 n = 3/3	19 – 189 median = 28 n = 3/3	Schmoyer (2008d)	Three ROW catch basin solids samples were collected from the I-5 SD basin.
In-line Sediment Trap Samples									
I-5 SD	2007	nr	nr	nr	nr	nr	nd	Schmoyer (2008d)	A sediment trap sample was collected from the I-5 SD basin in May 2007. The sample was analyzed for metals and PCBs.
KCIA SD No. 3/PS44 EOF	2007	2,200 – 5,800 median = 2,200 n = 3/3	170, 300 n = 2/3	8,100 – 21,500 median = 9,600 n = 3/3	390, 690 n = 2/3	2,900 – 13,000 median = 8,000 n = 3/3	78 – 62,000 median = 450 n = 8/9	Schmoyer (2008d)	Sediment trap samples were collected from nine locations within the KCIA SD No. 3/PS44 EOF drainage basin. Only PCB data were available for six of the samples.
Other In-line Samples (e.g., oil/water separators,[f] manholes, stormwater vaults,[g] flume samples)									
GTSP flume	2005 - 2006	130 – 18,000 median = 990 n = 16/16	20 – 3,000 median = 180 n = 15/16	610 – 84,000 median = 3,000 n = 16/16	86 – 160 median = 110 n = 5/12	120 – 3,800 median = 1,000 n = 12/12	38 – 92,000 median = 2,800 n = 26/27	Schmoyer (2008d)	Twenty-seven in-line sediment samples were collected from the GTSP flume. One sampling location was a manhole located at the downstream end of the flume. Not all samples had data available for all chemicals (for many, only PCB data were available).
I-5 SD	2005	44 n = 1/1	nd	185 n = 1/1	nd	180 n = 1/1	nd	Schmoyer (2008d)	One manhole solids sample was collected within the I-5 SD basin.
KCIA SD No. 3/PS44 EOF	1992 - 2007	750 – 132,000 median = 11,000 n = 15/15	180 – 42,500 median = 2,570 n = 15/15	9,380 – 630,000 median = 157,000 n = 15/15	62 – 4,090 median = 2,610 n = 9/15	430 – 232,000 median = 31,600 n = 15/15	111 – 426,000 median = 3,500 n = 45/48	Schmoyer (2008d)	Solids samples were collected from manholes, oil/water separators,[f] and stormwater vaults[g] located within the KCIA SD No. 3/PS44 EOF drainage basin. PCB data were the only data available for many of the samples. The majority of the samples were collected between 2005 and 2007; single sampling results from 1992 and 1998 were included because no newer data were available from the sampling locations where these samples were collected.
Filter Bag Samples[h]									
KCIA SD No. 3/PS44 EOF	2005	nr	nr	nr	nr	nr	510,000[j] median = nr n = nr/3	ARI (2005) as cited in SAIC (2007e)	Samples were collected from filter bags.[h] Source documents did not specify whether the reported PCB concentration was for mg/kg filter bag material or for the concentration of the retained solids concentration as back-calculated from the filter bag material concentration.

Table I-31, cont. Summary of chemical concentrations detected in source tracing samples in the Slip 4 SCA

Sample Source	Year Collected	Concentration Information[a, b, c]							Additional Information
		Fluoranthene (µg/kg dw)	Indeno(1,2,3-cd)-pyrene (µg/kg dw)	Total HPAH[i] (µg/kg dw)[j]	BBP (µg/kg dw)	BEHP (µg/kg dw)	Total PCBs[i] (µg/kg dw)	Sources[e]	
KCIA SD No. 3/PS44 EOF	2004	nr	nr	nr	nr	nr	67 – 300[j] median = 170[j] n = 3/3	Boeing (2005) as cited in SAIC (2007e)	Samples were collected from filter bags[h] used to remove suspended solids from the storm drain system. The filter bag and its contents were analyzed together and the concentration on the retained solids was then back-calculated.

Note: Data are not included for drainage structures that have been removed subsequent to sampling, such as data collected from the drainage swale formerly located on First South Properties. If multiple rounds of data were available for a single location, only the data collected during the most recent event were presented in order to represent the most current conditions possible.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Slip 4 SCA.

[b] Significant figures are reported as available in source documentation; when converting units (e.g., from µg/kg to mg/kg), the number of significant figures was kept consistent with the number in the reported value.

[c] n is the ratio of the number of detects to the total number of samples analyzed. In some cases (those with an "nr"), the total number of samples analyzed was not indicated in the source documents. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[d] The concentrations provided for benzofluoranthenes are the sum of individual benzofluoranthene concentrations provided for each sample.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

[f] Oil/water separators remove suspended solids and oil from stormwater. Solids collected from these structures are expected to have high TOC concentrations; source-tracing samples collected from oil/water separators should not be considered representative of typical storm drain solids that could discharge to the LDW through storm drain outfalls.

[g] The majority of the stormwater vaults include oil/water separator infrastructure (Tiffany 2008b). See footnote f.

[h] Storm drain filter bags are used to filter suspended solids from stormwater; the filter bag and its contents were analyzed together after a known volume of stormwater had passed through the bags.

[i] Only detected concentrations were used in calculating total HPAHs and total PCBs.

[j] Concentrations presented in source documents were reported in mg/kg and are assumed to be in dw units.

ARI – Analytical Resources, Inc.
BEHP – bis(2-ethylhexyl) phthalate
BBP – butyl benzyl phthalate
dw – dry weight
EOF – emergency overflow
GTSP – Georgetown Steam Plant
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
I-5 – Interstate 5
KCIA – King County International Airport
LDW – Lower Duwamish Waterway
nd – not detected
NBF – North Boeing Field
nr – not reported
PCB – polychlorinated biphenyl
PS – pump station
ROW – right-of-way
TOC – total organic carbon
SAIC – Science Applications International Corporation
SCA – source control area
SCAP – source control action plan
SD – storm drain
SPU – Seattle Public Utilities
SQS – sediment quality standard

The Slip 4 SCA is a candidate for early action sediment removal; a 100% design analysis report has been completed in preparation for the removal action (Integral 2007). Construction of the removal action will begin once Ecology has determined that sources are sufficiently controlled within the Slip 4 drainage basin to prevent the recontamination of sediment after the cleanup.

Source identification and control efforts are ongoing. Planned activities include continued source tracing at NBF, KCIA, Crowley Marine Services, Boeing Plant 2, and other locations within the Slip 4 drainage basin; cleanout of SD line structures in the I-5 SD system, at Boeing Plant 2, and at Crowley Marine Services; additional site inspections at upland facilities; remediation and replacement of the GTSP flume; and a groundwater investigation at the Crowley Marine Services facility (SAIC 2007a). For the most current information on the Slip 4 SCA, visit Ecology's website.

The Boeing Company, King County, and the City of Seattle have entered into an Agreed Order with Ecology for the purpose of completing an RI/FS and for potentially implementing remedial actions at North Boeing Field/GTSP. A supplemental data gaps report has been prepared as part of the RI/FS process and is under review (Goldberg 2009).

I.4.5 BOEING PLANT 2/JORGENSEN FORGE SOURCE CONTROL AREA (RM 2.9 E TO RM 3.7 E, EAA 4)

The Boeing Plant 2/Jorgensen Forge SCA is one of 23 areas identified by Ecology along the LDW for source control evaluation and one of the seven candidate EAAs recommended to EPA and Ecology (Windward 2003c). Since the late 1980s, various soil, groundwater, and sediment investigations have been conducted within the Boeing Plant 2/Jorgensen Forge SCA under both the Resource Conservation Recovery Act (RCRA) and the Model Toxics Control Act (MTCA). As part of ongoing source control efforts for this SCA, a data gaps report (Ecology and Environment 2007b) and a SCAP (Ecology 2007c) were completed in August 2007; future updates to the SCAP by Ecology are expected.

Extensive data gaps investigations have recently been completed of upland areas at Boeing Plant 2. Reports completed to date include the South Yard Area (Environmental Partners and Golder Associates 2007a) and 2-60 and 2-66 areas (Environmental Partners and Golder Associates 2007b, c) of Boeing Plant 2. In addition, the 2-40s area and the North Area have recently been sampled; a work plan for a data gaps investigation in the 2-31 area has been submitted to EPA. A draft work plan for the final area, the 2-10 area, is being prepared.

Beginning in 2001, quarterly shoreline groundwater monitoring of Boeing Plant 2 has been implemented; in 2008, this monitoring switched to a semi-annual basis (Environmental Partners 2008). In 2005, a stormwater source-tracing investigation was completed (Floyd|Snider 2005), which led to annual stormwater source control monitoring beginning in 2007 (Golder Associates 2007).

Information and data presented in tables in this section were based largely on the information and data presented in the data gaps report and SCAP. In addition to these documents, a seep survey (2004), a porewater study (Windward 2006a), and a groundwater pathways assessment (Windward 2003b) were conducted for the LDW, including the area of this SCA. Some of the data presented in the Ecology source documents were corrected and some data were added based on a QA/QC review (Colligan 2008). The corrections resulted either from cross-checking against the original source materials or querying the Boeing Plant 2 database. These documents are referred to collectively as the "source documents" throughout this section and on the associated maps. Data from Golder Associates (2007), Floyd|Snider (2005), Weston (1998), Pentec (2002), and Environmental Partners (2008) were collected or included at the request of a LDWG member.

CSL exceedances in surface sediment in this SCA included total PCBs, BBP, BEHP, cadmium, chromium, copper, lead, mercury, silver, zinc, and phenol. SQS exceedances were reported for individual PAHs, total HPAHs, and total LPAHs. These exceedances are based on the RI baseline surface sediment dataset and the 2007 SCA boundary, as discussed in the introduction to this appendix. Ecology has identified COCs for this SCA based on different criteria (Table I-3); therefore, the chemicals identified for summary in this appendix are different than the COCs identified by Ecology. Surface sediment chemistry information for the Boeing Plant 2/Jorgensen Forge SCA is provided on Maps I-19 through I-21. Dioxins and furans were detected above a TEQ of 100 ng/kg dw in a surface sediment sample within the SCA. No dioxin and furan data were available for upland facilities in the source documents.

Commercial and industrial operations in the vicinity of this SCA have included warehousing (current), vehicle fleet maintenance (current), aerospace research and development (current), forging (current and historical), general aviation (current and historical), airplane manufacturing (historical), heat treating and galvanizing (historical), and metals fabrication (historical) (Ecology and Environment 2007b). Raw materials such as metals (e.g., chrome, zinc, copper, cadmium, and silver), lead-based paints, solvents, petroleum products, and acids have also been used at nearby properties.

Ecology has identified Boeing Plant 2 and Jorgensen Forge as adjacent facilities associated with this SCA (Map I-22) (Ecology and Environment 2007b). Ecology also identified KCIA and E Marginal Way S as upland facilities (Ecology and Environment 2007b). Facility-specific information for adjacent properties is presented in Table I-32. KCIA is also summarized in Table I-32 because source-tracing data were reported in the source documents. E Marginal Way S is not included in the summary because source-tracing data were not available (see the introduction for more information on facility selection criteria). Groundwater information for Boeing Plant 2 is also included in Section 9.4.6 of the main body of the RI. The data gaps reports and SCAP present additional information on all facilities associated with this SCA.

Table I-32. Summary of facility information for the Boeing Plant 2/Jorgensen Forge SCA

Facility[a]	Current Ownership	Current Operations	Historical Operations	Environmental Investigations	Remedial Activities	Source Control Investigations/ Activities
Boeing Plant 2	The Boeing Company	warehousing, vehicle fleet maintenance, aerospace research and development	aircraft assembly and manufacturing of aluminum alloy, steel alloy, and titanium alloy parts for airplanes	Numerous soil and groundwater investigations have been completed since the late 1980s. Boeing has completed many unit-based investigations under RCRA, involving (but not limited to) TSDs, USTs, holding areas, oil/water separators, machine pits, sumps, cisterns, a reclamation yard, a retention tank, a dilute chrome tank, transformer vaults, a TCE degreaser, and paint booths. Boeing also completed several data gaps investigations and a PCB investigation on the southwest corner of the property. Quarterly monitoring of groundwater at monitoring wells along the Boeing Plant 2 shoreline has taken place since 2001.	Numerous cleanup activities and several interim closures of RCRA waste management units have been conducted. Interim corrective measures have included the installation of three sheet pile containment structures in 1993 and a groundwater convection well/vapor extraction system in 2004. Other remedial activities have included various soil excavations, decommissioning or removal of vaults or sumps, UST removals, and decommissioning of stormwater lines. Remedial actions associated with a chlorinated VOC plume are ongoing. The plume originates at the EMF site on the east side of KCIA and transits the 2-40s area. Information on these and other actions are provided on the EPA website.	Several source-tracing investigations and source control measures have been conducted within the storm drain system. Source-tracing samples included catch basin solids, pavement caulking, whole water, and suspended solids in stormwater (Golder Associates 2008d, c). Paved surfaces are mechanically swept on a routine basis (Ernst 2008).

Table I-32, cont. Summary of facility information for the Boeing Plant 2/Jorgensen Forge SCA

Facility[a]	Current Ownership	Current Operations	Historical Operations	Environmental Investigations	Remedial Activities	Source Control Investigations/ Activities
Jorgensen Forge	Jorgensen Forge	manufacturing and precision-machine forging from various materials, including carbon and low-alloy steels, duplex stainless grades, aluminum alloys, titanium alloys, and nickel-base alloys for commercial aircraft, aerospace, energy (i.e., oil exploration), power generation, automotive, and shipbuilding industries	fabrication of structural steel, tractors, and road equipment; forging; heat-treating and galvanizing; steel distribution; and cutting of prefabricated steel rods	Numerous soil and groundwater investigations have been completed since 1990. Several petroleum releases were identified and a pool of cutting oil was identified. An investigation following an Administrative Order on Consent was conducted between 2003 and 2006. The investigation involved soil borings, shoreline sediment sampling, catch basin sampling, an inactive outfall video reconnaissance survey, a site stormwater drainage survey, subsurface fill sampling, shoreline bank fill sampling, debris pile sampling, and sampling of outfall discharges. A MTCA Agreed Order has also been negotiated between Jorgensen Forge and Ecology to conduct a source control investigation at the facility.	In 1991, three USTs were removed, and an air sparging and vapor extraction remediation system was installed. From 1991 to 1996, interim remedial actions were completed on the property for soil and groundwater contaminated with petroleum hydrocarbons.	Two source-tracing investigations were completed in 2000 and 2005, and an additional source control investigation is in progress under the MTCA Agreed Order (Good 2009).
KCIA[b]	King County	general aviation airport	community aviation center, US Army operations, passenger and commercial traffic operations, general aviation	No environmental investigations were reported.	No remedial activities were reported.	Flight lines and taxi ways are mechanically swept on a frequent basis per Federal Aviation Administration requirements (2008a).

Sources: Ecology and Environment (2007b); Ecology (2007c)

[a] Facilities listed are those identified as adjacent properties in the data gaps report (Ecology and Environment 2007b). KCIA (identified as an upland property in the source documents) is also included because source-tracing data were included in the source documentation.

[b] KCIA information in this section pertains only to the area of KCIA that drains to the Boeing Plant 2/Jorgensen Forge SCA.

EMF – Electronics Manufacturing Facility
EPA – Environmental Protection Agency
KCIA – King County International Airport
MTCA – Model Toxics Control Act
PCB – polychlorinated biphenyl
RCRA – Resource Conservation and Recovery Act
SCA – source control area
TCE – trichloroethene
TSD – treatment, storage and disposal
UST – underground storage tank
VOC – volatile organic compound

Numerous active outfalls have been identified along the shoreline of the Boeing Plant 2/Jorgensen Forge SCA (Maps I-22 through I-24) (Herrera 2004; Windward 2006b). In addition to privately owned storm drains along Boeing Plant 2 and Jorgensen Forge, there is also a publicly owned storm drain (No. 3032) and one outfall (No. 2059) that includes drainage from KCIA and E Marginal Way. The public outfall (No. 3032) discharges storm water from 16th Avenue South and an adjacent section of Boeing Plant 2 in the vicinity of the 16th Avenue South Bridge (Map I-23). Note that the SCAP (Ecology 2007c) and data gaps report (Ecology and Environment 2007b) discuss Boeing Plant 2 Outfall A (twin outfalls Nos. 2052 and 2053). These outfalls are not located within the Boeing Plant 2/ Jorgensen Forge SCA boundary and are included in the Slip 4 SCA discussion (Section I.4.4).

Stormwater from all of these outfalls originates primarily from the two adjacent properties (Boeing Plant 2 and Jorgensen Forge). A portion of KCIA and a small portion of E Marginal Way S also drain to this SCA via the 24-in. diameter property line outfall (No. 2059). The total stormwater drainage basin from these four areas is approximately 132 ac (Ecology and Environment 2007b). Most of the stormwater from the adjacent upland areas is collected in storm drains that run through various catch basins (some of which also have oil/water separators, catch basin inserts, and/or advanced filtration systems) before discharging to the LDW. Some of the stormwater collected from upland areas in the vicinity of the SCA also enters systems that eventually discharge to the storm drain system. Information on the outfalls within the Boeing Plant 2/Jorgensen Forge SCA is included in Table I-33; the locations of these outfalls are provided on Maps I-19 through I-21. Drainage system lines on adjacent properties are shown on Maps I-25 through I-27.

Table I-33. Summary of specific information for outfalls in the Boeing Plant 2/Jorgensen Forge SCA

Outfall[a]	Current Ownership	Current Operations	Historical Operations	Environmental and Source-Tracing Investigations	Remedial and Source Control Activities
Boeing Plant 2 outfalls (Nos. 3022 through 3028, 3030, 3034, 3035, 3000 through 3019, 2054 through 2058, and Boeing 1 through 9)	The Boeing Company	Forty-four outfalls have been identified along the Boeing Plant 2 shoreline. Sixteen of these outfalls have been abandoned. Three have been designated as "not an outfall" because the locations were previously identified as an outfall in a 2003 survey but subsequent investigation determined they were not outfalls. Many of the outfalls drain rooftops and parking lots on Boeing property.	Stormwater lines (X and Y) used to service the 2-60s and 2-66 building areas. These lines have been fully decommissioned under EPA supervision.	A storm system survey was conducted in 2005. During this effort, source-tracing samples were collected within the drainage system. This effort was followed by more detailed sampling of specific storm drain lines. Beginning in 2007, monitoring of suspended solids in stormwater has also occurred at five separate storm lines (Golder Associates 2008d).	Source control activities have been conducted since the 1990s, including plugging or sealing manholes, addition of catch basin inserts and/or filter socks, jetting of lines,; and replacing drainage lines (Golder Associates 2008b). Two entire stormwater lines (X and Y) were decommissioned in 2006. An advanced filtration manhole was added to the storm drain system (Golder Associates 2008b). Catch basins and catch basin inserts and/or filtration devices and oil/water separators are inspected yearly. Accumulated solids in stormwater catch basins are cleaned out regularly and storm lines have been jetted (Golder Associates 2008a).
Jorgensen Forge outfalls (Nos. 2064 to 2072)	Jorgensen Forge	Nine outfalls have been identified along the Jorgensen Forge shoreline. Five of these outfalls have been abandoned. The remaining four active outfalls serve the paved areas on the property as well as the building roof drains. These outfalls also drain groundwater that accumulates in sumps and pits, and discharge non-contact cooling water from the cooling tower system.	Historically, all nine outfalls discharged to the LDW. These outfalls drained rooftops and other unknown sources.	A video survey of three of the five abandoned outfalls was conducted in 2004 to confirm that flow from these outfalls no longer discharges to the LDW. A comprehensive site stormwater drainage investigation study was conducted in 2004. This study confirmed that there was no discharge from any of the five abandoned outfalls. Source-tracing samples, including solids and water samples, have been collected within the drainage system.	Five outfalls were plugged with concrete in the mid-1980s. Oil-absorbent booms and filter fabrics have been installed in catch basins since 1998 and are replaced regularly. Catch basins are cleaned semi-annually. Samples collected included stormwater catch basin sediment samples, trench sediment samples (2005 only), and pavement caulk samples.

Table I-33, cont. Summary of specific information for outfalls in the Boeing Plant 2/Jorgensen Forge SCA

OUTFALL[a]	CURRENT OWNERSHIP	CURRENT OPERATIONS	HISTORICAL OPERATIONS	ENVIRONMENTAL AND SOURCE-TRACING INVESTIGATIONS	REMEDIAL AND SOURCE CONTROL ACTIVITIES
Public SD outfall (No. 3032)[b]	City of Seattle[c]	A public outfall exists along the Boeing Plant 2 shoreline. The SD drains Boeing property as well as public roadways.	No historical operations were reported.	Source-tracing samples were collected by Boeing in 2005 at a location prior to discharge into the public storm system. (Floyd|Snider 2005) SPU collected source-tracing samples from this system in 2008-2009.	Boeing's inputs to the public SD are being managed as part of Boeing Plant 2 source control efforts (Golder Associates 2008d).
Combined use outfall (No. 2059)	To be determined	One outfall located on Jorgensen Forge, parallel to the Boeing Plant 2 property line. The SD system on Jorgensen Forge also receives drainage originating from KCIA and E. Marginal Way.	Historical connections to Jorgensen Forge and Boeing Plant 2 were identified.	Solids were collected by Boeing in 2005 from manholes along this storm line. Catch basin and joint caulk samples were collected in 2001 and 2005.	Source control activities are in the process of being coordinated. King County Airport removes accumulated solids from catch basins semi-annually, and cleans oil/water separators annually.

Sources: Ecology and Environment (2007b); Ecology (2007c)

[a] No major outfalls were identified as individual source control entities in the data gaps report (Ecology and Environment 2007b) or the SCAP (Ecology 2007c).

[b] Two public outfalls were identified along the Boeing Plant 2 shoreline at the South Park bridge (Nos. 3031 and 3032) during the survey conducted by Herrera (2004). According to the City of Seattle's plans (Schmoyer 2008c), there is only one outfall that drains the Boeing property as well as portions of 16th Avenue S and E Marginal Way S. Outfall No. 3031 is not an actual outfall; it is most likely a broken section of the original outfall No. 3032 (Floyd|Snider 2006). Maps I-19 and I-23 show the two outfalls on the property because the 2003 outfall survey (Herrera 2004) is the outfall information source used throughout the RI. The treatment of discrepancies between outfall configurations shown on the RI maps and the maps provided in source documents is discussed further in the introduction to this appendix.

[c] Ownership information for outfall No. 3032 is unclear. The survey conducted by Herrera (2004) identified the City of Seattle and The Boeing Company as owners but subsequent investigation by Boeing identified SPU as the owner (Floyd|Snider 2006).

CMS – corrective measures study
EPA – Environmental Protection Agency
KCIA – King County International Airport
LDW – Lower Duwamish Waterway
SCA – source control area
SCAP – source control action plan
SD – storm drain
SPU – Seattle Public Utilities

Numerous remedial activities and environmental investigations have been completed or are currently in progress within the Boeing Plant 2/Jorgensen Forge SCA (Maps I-22 through I-24). These investigations have detected chemicals at concentrations above the SQS in Boeing Plant 2/Jorgensen Forge surface sediment. Many of these chemicals have also been detected in various other media, including soil, groundwater, seep, stormwater, and source-tracing samples (Table I-34). The availability of data (by media type) is also presented in the tables on Maps I-22 through I-24 for each of the facilities and major outfalls associated with this SCA. In Table I-34, and in the table on Maps I-22 through I-24, an X indicates that the source documents reported data or indicated that data exist; therefore, an X does not necessarily mean that the actual data were presented in the source document. Data are only summarized in media-specific and source-tracing tables if the data were reported in the source documents and if they met the criteria for data summation discussed in the introduction to this appendix (e.g., soil data were collected along the SCA shoreline; groundwater data were collected from shoreline facilities). The identification of a chemical in these media at facilities or within drainage systems of the Boeing Plant 2/Jorgensen Forge SCA does not necessarily indicate that these potential sources contributed to sediment contamination in the past or will result in sediment contamination in the future.

Table I-34. Chemicals identified in various media in the Boeing Plant 2/ Jorgensen Forge SCA

Chemical[a]	Soil	Groundwater	Seep	Porewater[b]	Stormwater	Source-Tracing Samples	Source
Cadmium	X	X				X	Ecology and Environment (2007b), Floyd|Snider (2005), Golder Associates (2007)
Chromium	X	X				X	Ecology and Environment (2007b) Floyd|Snider (2005), Golder Associates (2007)
Copper	X	X	X		X	X	Ecology and Environment (2007b), Golder Associates (2007), Windward (2004), Weston (1998)
Lead	X	X	X		X	X	Ecology and Environment (2007b), Golder Associates (2007), Windward (2004), Floyd|Snider (2005), Colligan (2008)

Chemical[a]	Soil	Groundwater	Seep	Porewater[b]	Stormwater	Source-Tracing Samples	Source
Mercury	X	X	X		X	X	Ecology and Environment (2007b), Golder Associates (2007), Weston (1998), Windward (2004), Colligan (2008)
Silver		X	X			X	Ecology and Environment (2007b), Windward (2004), Floyd|Snider (2005), Golder Associates (2007)
Zinc	X	X	X		X	X	Ecology and Environment (2007b), Golder Associates (2007), Windward (2004), Weston (1998)
Acenaphthene	X				X		Ecology and Environment (2007b), Golder Associates (2007)
Benzo(a)anthracene	X						Ecology and Environment (2007b)
Benzofluoranthenes	X						Ecology and Environment (2007b)
Benzo(g,h,i)perylene	X						Ecology and Environment (2007b)
Chrysene	X				X		Ecology and Environment (2007b), Golder Associates (2007)
Dibenzo(a,h)anthracene	X						Ecology and Environment (2007b)
Dibenzofuran	X						Ecology and Environment (2007b)
Fluoranthene	X				X		Ecology and Environment (2007b), Golder Associates (2007)
Fluorene					X		Golder Associates (2007)
Indeno(1,2,3-cd)pyrene	X						Ecology and Environment (2007b)
Phenanthrene	X				X		Ecology and Environment (2007b), Golder Associates (2007)
Total HPAHs[c]							
Total LPAHs[c]							

Chemical[a]	Soil	Ground-water	Seep	Pore-water[b]	Storm-water	Source-Tracing Samples	Source
BBP	X					X	Ecology and Environment (2007b)
BEHP	X				X	X	Ecology and Environment (2007b), Golder Associates (2007)
Phenol		X					Ecology and Environment (2007b)
Total PCBs	X	X				X	Ecology and Environment (2007b), Floyd|Snider (2005)
Dioxins and furans[c, d]							

Note: An X indicates that the source documents reported that data are available for the identified media. The absence of an X in any cell does not necessarily mean that the chemical is absent in the upland media or in source-tracing samples; in some cases, the chemical may not have been analyzed for or, if analyzed, could have been present but at concentrations below the RL.

[a] Chemicals included in this table are chemicals with at least one detected exceedance of an SQS in surface sediment within the Boeing Plant 2/Jorgensen Forge SCA. The chemical list is based on SMS exceedances in the RI baseline surface sediment dataset within the 2007 SCA boundary. Therefore, this list may differ from the list of exceedances in source documents.

[b] Porewater data were collected from this SCA as part of the LDW RI; however, these samples were analyzed only for VOCs.

[c] No total HPAH, total LPAH, or dioxin/furan data were identified in the source documents for soil, groundwater, seep, porewater, stormwater, or source-tracing samples.

[d] SMS criteria do not exist for dioxins and furans. They were included in this table because they are a risk driver chemical with highly elevated concentrations (i.e., TEQ > 100 ng/kg dw) in one surface sediment sample in this area.

BBP – butyl benzyl phthalate
BEHP –bis(2-ethylhexyl) phthalate
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LDW – Lower Duwamish Waterway
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PCBs – polychlorinated biphenyls
RI – remedial investigation
RL – reporting limit
SCA – source control area
SMS – Washington State Sediment Management Standards
SQS – sediment quality standard
TEQ – toxic equivalent
VOC – volatile organic compound

Upland data have been summarized in the source documents; this section summarizes the bank soil, groundwater, seep, stormwater, and source-tracing data presented. Porewater data collected as part of the LDW RI are also presented; these samples were analyzed only for VOCs (Windward 2006a).

If sufficient data were available in the source documents, ranges of detected concentrations, median concentrations, and sample counts (n) are provided accordingly. In some instances, the source documents acknowledge the existence of certain data but do not provide actual concentrations. Data were included only if specific concentrations or a range of concentrations was included in the source documents. Most of the data are presented as they were reported in the source documents.

Multiple soil investigations have been conducted at the Boeing Plant 2 and Jorgensen Forge facilities (Ecology 2007c; Ecology and Environment 2007b). Data are included in this section if the SCAP (Ecology 2007c) or data gaps report (Ecology and Environment 2007b) clearly reported that the sample was in close proximity to the shoreline.

Boeing conducts quarterly shoreline groundwater monitoring. Since multiple rounds of data were collected from the same sampling location, only the most recent round of data was selected for presentation in order to represent current conditions. The Groundwater Pathways Assessment (Windward 2003b) identified nine VOCs of concern for groundwater at the Boeing Plant 2/Jorgensen Forge site. The groundwater data presented in Windward (2003b) and the most recent quarterly monitoring report (Environmental Partners 2008) were also included for these VOCs. Some of the data presented in the SCAP and data gaps report were corrected based on a QA/QC of the data relative to those presented in the source documents. The corrections resulted from cross-checking against the original source materials or querying the Boeing Plant 2 database (Colligan 2008). Data from the 2-66 area were also added. A chlorinated VOC plume (originating at the Electronics Manufacturing Facility [EMF]) has been identified in groundwater underlying the 2-40s area. Remedial actions occurred between 2002 and 2005 and Boeing plans to continue remediation (Ecology and Environment 2007b).

The seep data presented in this section were collected as part of the LDW RI (Windward 2004) and Boeing Plant 2 RFI (Weston 1998); no seep data were presented in the SCAP (Ecology 2007c) or the data gaps report (Ecology and Environment 2007b). In addition, no porewater or stormwater data were identified in the SCAP (Ecology 2007c) or data gaps report (Ecology and Environment 2007b). Stormwater data collected by Golder Associates (2007) on behalf of The Boeing Company were summarized in this section. Tables I-35 through I-39 summarize bank soil, groundwater, seep, and stormwater data for the Boeing Plant 2/Jorgensen Forge SCA that were reported in the source documents.

Table I-35. Summary of chemical concentrations detected in bank soil in the Boeing Plant 2/Jorgensen Forge SCA

Facility	Chemical[a, b]	Year(s) Collected	Concentration Information (mg/kg dw)[c, d]	Location	Sources[e]	Additional Information
Boeing Plant 2	chromium	1995, 2001	15.5 – 792 median = 35.9 n = 11/11	southwest bank area	Pentec (2002)[f]	Sample was collected from bank or closest upland boring to bank.
Boeing Plant 2	copper	1995, 2001	12.8 – 28,100 median = 989 n = 21/21	southwest bank area	Pentec (2002)[f]	Sample was collected from fill material.
Boeing Plant 2	cadmium	1995, 2001	1.3 – 121 median =23.05 n = 18/21	southwest bank area	Pentec (2002)[f]	Sample was collected from fill material.
Boeing Plant 2	lead	1995, 2001	2.28 – 22,600 median = 471 n = 21/21	southwest bank area	Pentec (2002)[f]	Sample was collected from fill material.
Boeing Plant 2	silver	1995, 2001	0.8 – 39 median = 12.7 n = 11/11	southwest bank area	Pentec (2002)[f]	Sample was collected from fill material.
Boeing Plant 2	zinc	1995, 2001	32.1 – 16,600 median = 960 n = 28/28	southwest bank area	Pentec (2002)[f]	Sample was collected from fill material.
Boeing Plant 2	total PCBs	1995, 2001	0.045 – 160 median = 18 n = 31/33	southwest bank area	Pentec (2002)[f]	Sample was collected from fill material.
Jorgensen Forge	chromium	2004	350, 386 n = 2/2	along the shoreline bank face	Farallon and Anchor (2006), as cited in Ecology and Environment (2007b); Ecology (2007c)	Sample was collected from fill material.
Jorgensen Forge	copper	2004	72.4 – 561.0 median = nr n = nr	along the shoreline bank face	Farallon and Anchor (2006), as cited in Ecology and Environment (2007b); Ecology (2007c)	Sample was collected from fill material.

Table I-35, cont. Summary of chemical concentrations detected in bank soil in the Boeing Plant 2/Jorgensen Forge SCA

Facility	Chemical[a, b]	Year(s) Collected	Concentration Information (mg/kg dw)[c, d]	Location	Sources[e]	Additional Information
Jorgensen Forge	lead	2004	1,010 – 5,450 median = nr n = nr	along the shoreline bank face	Farallon and Anchor (2006), as cited in Ecology and Environment (2007b); Ecology (2007c)	Sample was collected from fill material.
Jorgensen Forge	zinc	2004	986 – 5,430 median = nr n = nr	along the shoreline bank face	Farallon and Anchor (2006), as cited in Ecology and Environment (2007b); Ecology (2007c)	Sample was collected from fill material.
Jorgensen Forge	total PCBs	2004	0.0255 – 4.54 median = nr n = nr	along the shoreline bank face	Farallon and Anchor (2006), as cited in Ecology and Environment (2007b); Ecology (2007c)	Sample was collected from fill material.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Boeing Plant 2/Jorgensen Forge SCA

[b] Mercury, acenaphthene, benzo(a)anthracene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total LPAHs, total HPAHs, BBP, BEHP, phenol, and dioxins and furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from µg/kg to mg/kg) the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[e] Primary source materials (i.e., any documents listed "as cited in") were not reviewed to compile this table.

[f] Data and citation provided by The Boeing Company.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
nr – not reported
PCB – polychlorinated biphenyl
SCA – source control area
SQS – sediment quality standard

Table I-36. Summary of chemical concentrations detected in groundwater in the Boeing Plant 2/ Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Chemicals with Detections Above SQS in Surface Sediment						
Boeing Plant 2	cadmium	2006	0.3 – 127 (total) median = 1.8 n = 9/82	2-66 Area	Environmental Partners and Golder Associates (2007c)[f]	
Boeing Plant 2	cadmium	2006	0.2 – 128 (dissolved) median = 2 n = 11/125	2-66 Area		
Boeing Plant 2	cadmium	2005	2.0 (total) n = 1/31	South Yard Area	Environmental Partners and Golder Associates (2005), as cited in Ecology and Environment (2007b)	Data are from Table 1 in Ecology and the Environment (2007b). Samples were collected from monitoring wells.
Boeing Plant 2	cadmium	2005	n = 0/31 (dissolved)	South Yard Area		
Boeing Plant 2	cadmium	2007	154 (total) n = 1/24	shoreline monitoring wells	Environmental Partners (2008)	
Boeing Plant 2	cadmium	2007	2, 76 (dissolved) n = 2/24	shoreline monitoring wells	Environmental Partners (2008)	
Boeing Plant 2	chromium	2006	0.5 – 31 (total) median = 2 n = 34/82	2-66 Area	Environmental Partners and Golder Associates (2007c)[f]	
Boeing Plant 2	chromium	2006	0.5 – 6 (dissolved) median = 1.8 n = 38/125	2-66 Area		
Boeing Plant 2	chromium	2005	6 – 160 (total) median = 21 n = 5/31	South Yard Area	Environmental Partners and Golder Associates (2006b), as cited in Ecology and Environment (2007b)	Data are from Table 1 in Ecology and Environment (2007b). Samples were collected from monitoring wells.
Boeing Plant 2	chromium	2005	6 – 11 (dissolved) median = 6 n = 3/31	South Yard Area		

Table I-36, cont. Summary of chemical concentrations detected in groundwater in the Boeing Plant 2/ Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Boeing Plant 2	chromium	2005	12 (chromium VI) (dissolved) n = 1/7	South Yard Area		
Boeing Plant 2	chromium	2005	8 (dissolved) n = 1/12	South Yard Area	Environmental Partners and Golder Associates (2006b), as cited in Ecology and Environment (2007b)	Samples were collected from 12 direct push probe locations (A-level aquifer); data are from Table 3 in Ecology and Environment (2007b).
Boeing Plant 2	chromium	2007	6 – 30 (total) median = 10 n = 7/24	shoreline monitoring wells	Environmental Partners (2008)	
Boeing Plant 2	chromium	2007	6 – 20 (dissolved) median = 10 n = 5/24	shoreline monitoring wells	Environmental Partners (2008)	
Boeing Plant 2	copper	2005	0.5 – 52.4 (total) median = 1.7 n = 13/31	South Yard Area	Environmental Partners and Golder Associates (2006b), as cited in Ecology and Environment (2007b)	Data are from Table 1 in Ecology and Environment (2007b);. Samples were collected from monitoring wells. Source document did not specify whether the concentration was dissolved or total.
Boeing Plant 2	copper	2005	0.6 – 1.3 (dissolved) median = 0.8 n = 9/31	South Yard Area		
Boeing Plant 2	copper	2005	0.5 – 14.6 (total) median = 5.0 n = 17/29	2-60s Area	Environmental Partners and Golder Associates (2005), as cited in Ecology and Environment (2007b)	Data are from Table 3 in Ecology and Environment (2007b). Some total results were discarded by Environmental Partners and Golder Associates because of high turbidity. Samples were collected from monitoring wells. Source document did not specify whether the concentration was dissolved or total.
Boeing Plant 2	copper	2005	0.6 – 13.8 (dissolved) median = 5.6 n = 15/29	2-60s Area		

Table I-36, cont. Summary of chemical concentrations detected in groundwater in the Boeing Plant 2/ Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Boeing Plant 2	copper	2005	0.6 – 74.6 (dissolved) median = 2.6 n = 34/44	2-60s Area	Environmental Partners and Golder Associates (2005), as cited in Ecology and Environment (2007b)	Samples were collected from 26 direct push probe locations (A-level aquifer) and 18 probe locations (B-level aquifer); data are from Table 3 in Ecology and Environment (2007b). Some total results were discarded by Environmental Partners and Golder Associates because of high turbidity. Source document did not specify whether the concentration was dissolved or total.
Boeing Plant 2	copper	1992 – 1994	3 – 5 median = nr n = nr	2-10 Area	Weston Solutions (2000), as cited in Ecology and Environment (2007b)	The number of samples analyzed was not reported in the data gaps report Ecology and Environment (2007b). Source document did not specify whether the concentration was dissolved or total.
Boeing Plant 2	copper	2007	0.6 – 31 (total) median = 3.8 n = 8/24	shoreline monitoring wells	Environmental Partners (2008)	
Boeing Plant 2	copper	2007	0.5 – 28 (dissolved) median = 3 n = 9/24	shoreline monitoring wells	Environmental Partners (2008)	
Boeing Plant 2	lead	2006	4.0 – 7.0 (total) median = 5 n = 4/82	2-66 Area	Environmental Partners and Golder Associates (2007c)[f]	
Boeing Plant 2	lead	2006	1.0 – 12.0 (dissolved) median = 3.5 n = 4/125	2-66 Area		
Boeing Plant 2	lead	2005	12 (total) n = 1/31	South Yard Area	Environmental Partners (2006), as cited in Ecology and Environment (2007b)	Data are from Table 1 in Ecology and Environment (2007b). Samples were collected from monitoring wells.
Boeing Plant 2	lead	2005	n = 0/31 (dissolved)	South Yard Area		

Table I-36, cont. Summary of chemical concentrations detected in groundwater in the Boeing Plant 2/ Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Boeing Plant 2	lead	2005	3.0, 9.5 (total) n = 2/29	2-60s Area	Environmental Partners and Golder Associates (2005), as cited in Ecology and Environment (2007b)	Data are from Table 3 in Ecology and Environment (2007b). Samples were collected from monitoring wells.
Boeing Plant 2	lead	2005	3, 3 (dissolved) n = 2/29	2-60s Area		
Boeing Plant 2	lead	2005	2.9 (dissolved) n = 1/44	2-60s Area	Environmental Partners and Golder Associates (2005), as cited in Ecology and Environment (2007b)	Samples were collected from 26 direct push probe locations (A-level aquifer) and 18 probe locations (B-level aquifer); data are from Table 3 in Ecology and Environment (2007b).
Boeing Plant 2	mercury	2006	0.0866, 0.0872 (total) n = 2/82	2-66 Area	Environmental Partners and Golder Associates (2007c)[f]	
Boeing Plant 2	mercury	2006	0.0392, 0.332 (dissolved) n = 2/132	2-66 Area		
Boeing Plant 2	mercury	2005	0.0332 (total) n = 1/31	South Yard Area	Environmental Partners (2006), as cited in Ecology and Environment (2007b)	Data are from Table 1 in Ecology and Environment (2007b). Samples were collected from monitoring wells.
Boeing Plant 2	mercury	2005	0.0604 (dissolved) n = 1/31	South Yard Area		
Boeing Plant 2	mercury	2005	n = 0/30 (total)	2-60s Area	Environmental Partners and Golder Associates (2005), as cited n Ecology and Environment (2007b)	Data are from Table 3 in Ecology and Environment (2007b). Samples were collected from monitoring wells.
Boeing Plant 2	mercury	2005	0.106 (dissolved) n = 1/44	2-60s Area	Environmental Partners and Golder Associates (2005), as cited in Ecology and Environment (2007b)	Samples were collected from 26 direct push probe locations (A-level aquifer) and 18 probe locations (B-level aquifer); data are from Table 3 in Ecology and Environment (2007b).

Table I-36, cont. Summary of chemical concentrations detected in groundwater in the Boeing Plant 2/ Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Boeing Plant 2	silver	2005	0.2 (total) n = 1/31	South Yard Area	Environmental Partners and Golder Associates (2005), as cited in Ecology and Environment (2007b)	Data are from Table 3 in Ecology and Environment (2007b). Samples were collected from monitoring wells.
Boeing Plant 2	silver	2005	n = 0/31 (dissolved)	South Yard Area		
Boeing Plant 2	silver	2005	0. 2 – 56.9 (total) median = 0.3 n = 13/82	South Yard Area	Environmental Partners and Golder Associates (2007c)[f]	
Boeing Plant 2	silver	2005	0.2 – 55.4 (dissolved) median = 0.4 n = 9/125	South Yard Area		
Boeing Plant 2	silver	2007	25.2 (total) n = 1/24	shoreline monitoring wells	Environmental Partners (2008)	
Boeing Plant 2	silver	2007	0.2, 27 (dissolved) n = 2/24	shoreline monitoring wells	Environmental Partners (2008)	
Boeing Plant 2	zinc	2005	6.0 – 953.0 (total) median = 19 n = 7/31	South Yard Area	Environmental Partners (2006), as cited in Ecology and Environment (2007b)	Data are from Table 1 in Ecology and Environment (2007b). Samples were collected from monitoring wells.
Boeing Plant 2	zinc	2005	16 – 717.0 (dissolved) median = 26 n = 4/31	South Yard Area		
Boeing Plant 2	zinc	2005	7 – 45 (dissolved) median = 15 n = 10/12	South Yard Area	Environmental Partners (2006), as cited in Ecology and Environment (2007b)	Samples were collected from 12 direct push probe locations (A-level aquifer); data are from Table 1 in Ecology and Environment (2007b).
Boeing Plant 2	zinc	2005	6.0 – 28.0 (total) median = 8 n = 14/29	2-60s Area	Environmental Partners and Golder Associates (2005), as cited in Ecology and Environment (2007b)	Data are from Table 3 in Ecology and Environment (2007b). Samples were collected from monitoring wells.
Boeing Plant 2	zinc	2005	6.0 – 19 (dissolved) median = 8 n = 16/29	2-60s Area		

Table I-36, cont. Summary of chemical concentrations detected in groundwater in the Boeing Plant 2/ Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Boeing Plant 2	zinc	2005	6 – 158 (dissolved) median = 11 n = 35/44	2-60s Area	Environmental Partners and Golder Associates (2005), as cited in Ecology and Environment (2007b)	Samples were collected from 26 direct push probe locations (A-level aquifer) and 18 probe locations (B-level aquifer); data are from Table 3 in Ecology and Environment (2007b).
Boeing Plant 2	zinc	2007	75 - 3330 (total) median = 340 n = 3/24	shoreline monitoring wells	Environmental Partners (2008)	
Boeing Plant 2	zinc	2007	50 – 1720 (dissolved) median = 280 n = 3/24	shoreline monitoring wells	Environmental Partners (2008)	
Boeing Plant 2	BEHP	2005	1.6 – 3.4 median = 3.2 n = 3/20	2-60s Area	Environmental Partners and Golder Associates (2005), as cited in Ecology and Environment (2007b)	Samples were collected from 12 direct push probe locations (A-level aquifer) and 8 probe locations (B-level aquifer); data are from Table 3 in Ecology and Environment (2007b). Twenty samples were referred to in the data gaps report Ecology and Environment (2007b), but the data table provided in the report indicated that twenty-two samples were analyzed. Source document did not specify whether the concentration was dissolved or total.
Boeing Plant 2	phenol	2005	3.2 n = 1/13	South Yard Area	Environmental Partners (2006), as cited in Ecology and Environment (2007b)	Data are from Table 1 in Ecology and Environment (2007b). Samples were collected from monitoring wells. Source document did not specify whether the concentration was dissolved or total.
Boeing Plant 2	total PCBs	2005	0.016 – 0.073 median = 0.035 n = 4/10	2-60s Area	Environmental Partners and Golder Associates (2005), as cited in Ecology and Environment (2007b)	Samples were collected from 8 direct push probe locations (A-level aquifer) and 2 probe locations (B-level aquifer); data are from Table 3 in Ecology and Environment (2007b). Source document did not specify whether the concentration was dissolved or total.

Table I-36, cont. Summary of chemical concentrations detected in groundwater in the Boeing Plant 2/ Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Boeing Plant 2	total PCBs	2007	0.015 n = 1/2	shoreline monitoring wells	Environmental Partners (2008)	Two wells were sampled in November 2007.
VOCs[g]						
Boeing Plant 2	1,1-dichloroethene	2006	< 0.2[h] – 100 median = nr n = 4/73	2-60s Area	Environmental Partners and Golder Associates (2006a), as cited in Ecology and Environment (2007b)	
Boeing Plant 2	1,1-dichloroethene	2005	< 0.2[h] – 1.9 median = nr n = nr/45	South Yard	Environmental Partners and Golder Associates (2006b), as cited in Ecology and Environment (2007b)	
Boeing Plant 2	1,1-dichloroethene	2005	0.3 n = 1/29	2-60s Area	Ecology and Environment (2007b)	Data are from Table 3 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	1,1-dichloroethene	2005	0.2 – 0.3 median = 0.3 n = 3/44	2-60s Area	Ecology and Environment (2007b)	Samples were collected from 26 direct push probe locations (A-level aquifer) and 18 probe locations (B-level aquifer); data are from Table 3 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations.
Boeing Plant 2	1,1-dichloroethene	2005	0.2 – 1.9 median = 1.3 n = 3/32	South Yard Area	Ecology and Environment (2007b)	Data are from Table 1 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.

Table I-36, cont. Summary of chemical concentrations detected in groundwater in the Boeing Plant 2/ Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Boeing Plant 2	1,1-dichloroethene	2005	0.4 n = 1/12	South Yard Area	Ecology and Environment (2007b)	Samples were collected from 12 direct push probe locations (A-level aquifer); data are from Table 1 in Ecology and Environment (2007b); only detected concentrations are presented.
Boeing Plant 2	1,1-dichloroethene	1990-1996	2.6 n = 1/nr	2-10 Area	Weston Solutions (2000) as cited in Ecology and Environment (2007b)	
Boeing Plant 2	benzene	2006	< 0.2[h] – 110 median = nr n = 10/73	2-60s Area	Environmental Partners and Golder Associates (2006a), as cited in Ecology and Environment (2007b)	
Boeing Plant 2	benzene	2006	2.6 n = 1/18	shoreline monitoring wells	Environmental Partners (2006), as cited in Ecology and Environment (2007b)	Eighteen of the twenty-eight monitoring wells were sampled.
Boeing Plant 2	benzene	2005	0.2 – 110 median = 3.75 n = 8/29	2-60s Area	Ecology and Environment (2007b)	Data are from Table 3 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	benzene	2005	0.3, 1.1 n = 2/44	2-60s Area	Ecology and Environment (2007b)	Samples were collected from 26 direct push probe locations (A-level aquifer) and 18 probe locations (B-level aquifer); data are from Table 3 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations.
Boeing Plant 2	benzene	2005	0.3, 0.8 n = 2/12	South Yard Area	Ecology and Environment (2007b)	Samples were collected from 12 direct push probe locations (A-level aquifer); data are from Table 1 in Ecology and Environment (2007b); only detected concentrations are presented.

Table I-36, cont. Summary of chemical concentrations detected in groundwater in the Boeing Plant 2/ Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Boeing Plant 2	benzene	2005	0.3 – 5.3 median = 0.9 n = 6/32	South Yard Area	Ecology and Environment (2007b)	Data are from Table 1 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	cis-1,2-dichloroethene	2007	2 – 460 median = 3.4 n = 3/24	shoreline monitoring wells	Environmental Partners (2008)	Twenty-four monitoring wells were sampled in November 2007.
Boeing Plant 2	cis-1,2-dichloroethene	2005	0.2 – 37 median = 0.6 n = 15/29	2-60s Area	Ecology and Environment (2007b)	Data are from Table 3 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	cis-1,2-dichloroethene	2005	0.2 – 90 median = 0.8 n = 19/44	2-60s Area	Ecology and Environment (2007b)	Samples were collected from 26 direct push probe locations (A-level aquifer) and 18 probe locations (B-level aquifer); data are from Table 3 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations.
Boeing Plant 2	cis-1,2-dichloroethene	2005	0.2 – 49 median = 2.3 n = 14/32	South Yard Area	Ecology and Environment (2007b)	Data are from Table 1 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	cis-1,2-dichloroethene	2005	0.3 – 83 median = 1.35 n = 9/12	South Yard Area	Ecology and Environment (2007b)	Samples were collected from 12 direct push probe locations (A-level aquifer); data are from Table 1 in Ecology and Environment (2007b); only detected concentrations are presented.
Boeing Plant 2	ethylbenzene	2006	< 0.2[h] – 900 median = nr n = 4/73	2-60s Area	Environmental Partners and Golder Associates (2006a), as cited in Ecology and Environment (2007b)	

Table I-36, cont. Summary of chemical concentrations detected in groundwater in the Boeing Plant 2/ Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Boeing Plant 2	ethylbenzene	2005	0.5 – 875 median = 765 n = 4/29	2-60s Area	Ecology and Environment (2007b)	Data are from Table 3 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	ethylbenzene	2005	0.2 – 1 median = 0.6 n = 2/32	South Yard Area	Ecology and Environment (2007b)	Data are from Table 1 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	tetrachloro-ethene	2006	< 0.2[h] – 15 median = nr n = 11/73	2-60s Area	Environmental Partners and Golder Associates (2006a), as cited in Ecology and Environment (2007b)	
Boeing Plant 2	tetrachloro-ethene	2005	0.2 – 6.3 median = 0.95 n = 6/44	2-60s Area	Ecology and Environment (2007b)	Samples were collected from 26 direct push probe locations (A-level aquifer) and 18 probe locations (B-level aquifer); data are from Table 3 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations.
Boeing Plant 2	tetrachloro-ethene	2005	0.85 – 6.8 median = 1.55 n = 5/29	2-60s Area	Ecology and Environment (2007b)	Data are from Table 3 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	tetrachloro-ethene	2005	0.2 – 3.8 median = 1.2 n = 3/32	South Yard Area	Ecology and Environment (2007b)	Data are from Table 1 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	toluene	2007	1.1 n = 1/24	shoreline monitoring wells	Environmental Partners (2008)	Twenty-four shoreline wells along Plant 2 were sampled in November 2007.

Table I-36, cont. Summary of chemical concentrations detected in groundwater in the Boeing Plant 2/ Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Boeing Plant 2	toluene	2005	0.2 – 67 median = 26 n = 4/29	2-60s area	Ecology and Environment (2007b)	Data are from Table 3 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	toluene	2005	0.2 – 18 median = 0.6 n = 3/32	South Yard Area	Ecology and Environment (2007b)	Data are from Table 1 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	trichloroethene	2007	1.4 – 16 median = 2.3 n = 4/24	shoreline monitoring wells	Environmental Partners (2008)	Twenty-four shoreline wells along Plant 2 were sampled in November 2007.
Boeing Plant 2	trichloroethene	2006	< 0.2[h] – 250 median = nr n = 32/73	2-60s Area	Environmental Partners and Golder Associates (2006a), as cited in Ecology and Environment (2007b)	
Boeing Plant 2	trichloroethene	2005	< 0.2[h] – 110 median = nr n = nr/45	South Yard Area	EPI and Golder Associates (2006b), as cited in Ecology and Environment (2007b)	
Boeing Plant 2	trichloroethene	2005	0.65 – 29 median = 7.7 n = 11/29	2-60s Area	Ecology and Environment (2007b)	Data are from Table 3 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	trichloroethene	2005	0.2 – 250 median = 1.5 n = 21/44	2-60s Area	Ecology and Environment (2007b)	Samples were collected from 26 direct push probe locations (A-level aquifer) and 18 probe locations (B-level aquifer); data are from Table 3 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations.

Table I-36, cont. Summary of chemical concentrations detected in groundwater in the Boeing Plant 2/ Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Boeing Plant 2	trichloroethene	2005	0.3 – 110 median = 2.5 n = 12/32	South Yard Area	Ecology and Environment (2007b)	Data are from Table 1 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	trichloroethene	2005	15 n = 1/12	South Yard Area	Ecology and Environment (2007b)	Samples were collected from 12 direct push probe locations (A-level aquifer); data are from Table 1 in Ecology and Environment (2007b); only detected concentrations are presented.
Boeing Plant 2	vinyl chloride	2007	21, 130 n = 2/24	shoreline monitoring wells	Environmental Partners (2008)	Twenty-four shoreline wells along Plant 2 were sampled in November 2007.
Boeing Plant 2	vinyl chloride	2006	< 0.2[h] – 15 median = nr n = 28/73	2-60s Area	EPI and Golder Associates(2006a), as cited in Ecology and Environment (2007b)	
Boeing Plant 2	vinyl chloride	2005	< 0.2[h] – 31 median = nr n = nr/45	South Yard Area	EPI and Golder Associates (2006b), as cited in Ecology and Environment (2007b)	
Boeing Plant 2	vinyl chloride	2005	0.3 – 3.9 median = 0.9 n = 11/29	2-60s Area	Ecology and Environment (2007b)	Data are from Table 3 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	vinyl chloride	2005	0.2 – 14 median = 0.7 n = 17/44	2-60s Area	Ecology and Environment (2007b)	Samples were collected from 26 direct push probe locations (A-level aquifer) and 18 probe locations (B-level aquifer); data are from Table 3 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations.

Table I-36, cont. Summary of chemical concentrations detected in groundwater in the Boeing Plant 2/ Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Boeing Plant 2	vinyl chloride	2005	1.2 – 14 median = 5.2 n = 15/32	South Yard Area	Ecology and Environment (2007b)	Data are from Table 1 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	vinyl chloride	2005	0.6 – 31 median = 6.25 n = 8/12	South Yard Area	Ecology and Environment (2007b)	Samples were collected from 12 direct push probe locations (A-level aquifer); data are from Table 1 in Ecology and Environment (2007b); only detected concentrations are presented.
Boeing Plant 2	xylene (m,p-)	2007	1.1 n = 1/24	shoreline monitoring wells	Environmental Partners (2008)	Twenty-four shoreline wells along Plant 2 were sampled in November 2007.
Boeing Plant 2	xylene (m,p-)	2005	0.5 – 1950 median = 250 n = 4/29	2-60s Area	Ecology and Environment (2007b)	Data are from Table 3 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	xylene (o-)	2005	0.4 – 430 median = 28.5 n = 4/29	2-60s Area	Ecology and Environment (2007b)	Data are from Table 3 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	xylene (m,p-)	2005	3.8 n = 1/32	South Yard Area	Ecology and Environment (2007b)	Data are from Table 1 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.
Boeing Plant 2	xylene (o-)	2005	1.8 n = 1/32	South Yard Area	Ecology and Environment (2007b)	Data are from Table 1 in Ecology and Environment (2007b); the range and median presented here include only detected concentrations. Samples were collected from monitoring wells.

Table I-36, cont. Summary of chemical concentrations detected in groundwater in the Boeing Plant 2/ Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Jorgensen Forge	cis-1,2-dichloroethene	2007	14 n = 1/4	Shoreline monitoring wells	Environmental Partners (2008)[f]	Four wells along the Jorgensen shoreline near Plant 2 were sampled by Boeing.
Jorgensen Forge	benzene	2007	6.2 n = 1/4	Shoreline monitoring wells	Environmental Partners (2008)	Wells along the Jorgensen shoreline near Plant 2 were sampled by Boeing.
Jorgensen Forge	vinyl chloride	2007	7.9, 500 n = 2/4	Shoreline monitoring wells	Environmental Partners (2008)	Wells along the Jorgensen shoreline near Plant 2 were sampled by Boeing.

Note: If duplicate samples were presented in data tables in the source documents, an average was calculated and included in the presented range, median, and sample count. Dilutions were not included unless it was clear that they superseded another sample (i.e., E or ES qualified). Samples that were reanalyzed were not included in this table.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Boeing Plant 2/Jorgensen Forge SCA.

[b] Acenaphthene, benzo(a)anthracene, benzo(g,h,i)perylene, benzofluoranthene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, ideno(1,2,3-cd)pyrene, phenanthrene, total LPAHs, total HPAHs, BBP, and dioxins and furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

[f] Data and citation provided by The Boeing Company.

[g] VOC data were summarized, as available, at EPA's request and not because of SQS exceedances in surface sediment in the SCA. The Groundwater Pathways Assessment (Windward 2003b) and the Early Action Area 4 data gaps report (Ecology and Environment 2007b) identified VOCs of concern for groundwater at the Boeing Plant 2/Jorgensen Forge site. Data for these VOCs were included in this table. VOCs identified in the Early Action Area 4 data gaps report for the Boeing Plant 2/Jorgensen Forge properties were based on a comparison to the surface water screening levels or as indicated in the data gaps report text (Ecology and Environment 2007b).

[h] The range reported in the source document presented a minimum that was a non-detect concentration, the minimum detected concentration was not reported.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
EPA – US Environmental Protection Agency
EPI – Environmental Partners Inc.
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LDW – Lower Duwamish Waterway
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
nr – not reported
NTU – nephelometric turbidity unit
PCB – polychlorinated biphenyl
SCA – source control area
SCAP – source control action plan
SQS – sediment quality standard
VOC – volatile organic compound

Table I-37. Summary of chemical concentrations detected in seeps in the Boeing Plant 2/Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources	Additional Information
Boeing Plant 2	chromium	1995	6 – 49 (total) median = 14 n = 6/17	various seeps along Boeing Plant 2 shoreline	Weston (1998)	
Boeing Plant 2	copper	1995	8 (dissolved) n = 1/10	various seeps along Boeing Plant 2 shoreline	Weston (1998)	
Boeing Plant 2	copper	1995	2 – 60 (total) median = 15 n = 11/17	various seeps along Boeing Plant 2 shoreline	Weston (1998)	
Boeing Plant 2	lead	1995	1 – 104 (total) median = 5.5 n = 14/17	various seeps along Boeing Plant 2 shoreline	Weston (1998)	
Boeing Plant 2	mercury	1995	0.2 – 0.2 (total) median = 0.2 n = 3/17	various seeps along Boeing Plant 2 shoreline	Weston (1998)	
Boeing Plant 2	zinc	1995	30 – 90 (dissolved) median = 35 n = 3/10	various seeps along Boeing Plant 2 shoreline	Weston (1998)	
Boeing Plant 2	zinc	1995	6 – 200 (total) median = 50 n = 14/17	various seeps along Boeing Plant 2 shoreline	Weston (1998)	
Boeing Plant 2	fluoranthene	1995	1.3 (total) n = 1/17	various seeps along Boeing Plant 2 shoreline	Weston (1998)	
Boeing Plant 2	phenanthrene	1995	1.0 (total) n = 1/17	various seeps along Boeing Plant 2 shoreline	Weston (1998)	
Boeing Plant 2	total PCBs	1995	0.93 – 4.6 (total) median = 1.75 n = 4/17	various seeps along Boeing Plant 2 shoreline	Weston (1998)	
Jorgensen Forge	copper	2004	10.2 (total) n = 1/1	southern end of property at approximately RM 3.7	Windward (2004)	Samples were collected as part of the LDW RI.
Jorgensen Forge	copper	2004	8.16 (dissolved) n = 1/1	southern end of property at approximately RM 3.7	Windward (2004)	Samples were collected as part of the LDW RI.

Table I-37, cont. Summary of chemical concentrations detected in seeps in the Boeing Plant 2/Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources	Additional Information
Jorgensen Forge	lead	2004	1.44 (total) n = 1/1	southern end of property at approximately RM 3.7	Windward (2004)	Samples were collected as part of the LDW RI.
Jorgensen Forge	lead	2004	0.096 (dissolved) n = 1/1	southern end of property at approximately RM 3.7	Windward (2004)	Samples were collected as part of the LDW RI.
Jorgensen Forge	mercury	2004	0.00061 (total) n = 1/1	southern end of property at approximately RM 3.7	Windward (2004)	Samples were collected as part of the LDW RI.
Jorgensen Forge	mercury	2004	0.00062 (dissolved) n = 1/1	southern end of property at approximately RM 3.7	Windward (2004)	Samples were collected as part of the LDW RI.
Jorgensen Forge	silver	2004	0.086 (total) n = 1/1	southern end of property at approximately RM 3.7	Windward (2004)	Samples were collected as part of the LDW RI.
Jorgensen Forge	silver	2004	0.112 (dissolved) n = 1/1	southern end of property at approximately RM 3.7	Windward (2004)	Samples were collected as part of the LDW RI.
Jorgensen Forge	zinc	2004	10.8 (total) n = 1/1	southern end of property at approximately RM 3.7	Windward (2004)	Samples were collected as part of the LDW RI.
Jorgensen Forge	zinc	2004	8.08 (dissolved) n = 1/1	southern end of property at approximately RM 3.7	Windward (2004)	Samples were collected as part of the LDW RI.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Boeing Plant 2/Jorgensen Forge SCA.

[b] Cadmium, acenaphthene, benzo(a)anthracene, benzofluoranthenes, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, ideno(1,2,3-cd)pyrene, phenanthrene, total LPAHs, total HPAHs BBP, BEHP, phenol, and dioxins and furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LDW – Lower Duwamish Waterway
LDWG – Lower Duwamish Waterway Group
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PCBs – polychlorinated biphenyls
RFI – RCRA facility investigation
RI – remedial investigation
RM – river mile
SCA – source control area
SQS – sediment quality standard

Table I-38. Summary of chemical concentrations detected in porewater in the Boeing Plant 2/Jorgensen Forge SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources	Additional Information
Boeing Plant 2 Jorgensen Forge	cis-1,2-dichloroethene	2005	0.2 – 1.7 n = 7/10	near the Jorgensen Forge/ Boeing Plant 2 boundary	Windward (2006a)	Two of the 10 samples from Boeing Plant 2 were field replicates collected at PE-10.
Boeing Plant 2/ Jorgensen Forge	trichloroethene	2005	0.2 – 0.2 n = 2/10	near the Jorgensen Forge/ Boeing Plant 2 boundary	Windward (2006a)	Two of the 10 samples from Boeing Plant 2 were field replicates collected at PE-10.
Boeing Plant 2/ Jorgensen Forge	vinyl chloride	2005	1.1 – 13 n = 2/10	near the Jorgensen Forge/ Boeing Plant 2 boundary	Windward (2006a)	Two of the 10 samples from Boeing Plant 2 were field replicates collected at PE-10.

[a] VOC data were summarized, as available, at EPA's request and not because of SQS exceedances in surface sediment in the SCA.

[b] Cadmium, chromium, copper, lead, mercury, silver, zinc, acenaphthene, benzo(a)anthracene, benzofluornthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, Ideno(1,2,3-cd)pyrene, phenanthrene, total HPAH, total LPAH, BBP, BEHP, phenol, total PCBs, and dioxins and furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges were calculated using only detected data. For this reason, some estimated ranges may be higher than actual concentrations.

BBP – butyl benzyl phthalate

BEHP – bis(2-ethylhexyl) phthalate

EPA – US Environmental Protection Agency

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon

SCA – source control area

PCB – polychlorinated biphenyl

Table I-39. Summary of chemical concentrations detected in stormwater in the Boeing Plant 2/Jorgensen Forge SCA

FACILITY	CHEMICAL[a, b]	YEAR COLLECTED	CONCENTRATION INFORMATION (µg/L)[c, d]	LOCATION	SOURCES	ADDITIONAL INFORMATION
Boeing Plant 2	copper	2007	3 n = 1/1	Outfall A	Golder Associates (2007)	Samples were filtered for coarse materials (5-µm filter).
Boeing Plant 2	copper	2007	9 n = 1/1	Outfall A	Golder Associates (2007)	Sample was not filtered.
Boeing Plant 2	copper	2007	4 n = 1/1	Outfall B	Golder Associates (2007)	Sample was filtered.
Boeing Plant 2	copper	2007	5 n = 1/1	Outfall B	Golder Associates (2007)	Samples were filtered for coarse materials (5-µm filter).
Boeing Plant 2	copper	2007	5 n = 1/1	Outfall B	Golder Associates (2007)	Sample was not filtered.
Boeing Plant 2	copper	2007	10 n = 1/1	Outfall J	Golder Associates (2007)	Sample was filtered.
Boeing Plant 2	copper	2006	15 n=1/1	Outfall V	Golder Associates (2007)	Sample was filtered .
Boeing Plant 2	copper	2007	5 n = 1/1	Outfall Z	Golder Associates (2007)	Sample was filtered.
Boeing Plant 2	copper	2007	9 n = 1/1	Outfall Z	Golder Associates (2007)	Samples were filtered for coarse materials (5-µm filter).
Boeing Plant 2	copper	2007	12 n = 1/1	Outfall Z	Golder Associates (2007)	Sample was not filtered.
Boeing Plant 2	lead	2007	1 n = 1/1	Outfall A	Golder Associates (2007)	Sample was filtered.
Boeing Plant 2	lead	2007	5 n = 1/1	Outfall A	Golder Associates (2007)	Samples were filtered for coarse materials (5-µm filter)
Boeing Plant 2	lead	2007	9 n = 1/1	Outfall A	Golder Associates (2007)	Sample was not filtered.
Boeing Plant 2	lead	2007	3 n = 1/1	Outfall B	Golder Associates (2007)	Samples were filtered for coarse materials (5-µm filter)
Boeing Plant 2	lead	2007	4 n = 1/1	Outfall B	Golder Associates (2007)	Sample was not filtered.
Boeing Plant 2	lead	2007	2 n = 1/1	Outfall Z	Golder Associates (2007)	Samples were filtered for coarse materials (5-µm filter).

Table I-39, cont. Summary of chemical concentrations detected in stormwater in the Boeing Plant 2/Jorgensen Forge SCA

FACILITY	CHEMICAL[a, b]	YEAR COLLECTED	CONCENTRATION INFORMATION (µg/L)[c, d]	LOCATION	SOURCES	ADDITIONAL INFORMATION
Boeing Plant 2	lead	2007	5 n = 1/1	Outfall Z	Golder Associates (2007)	Sample was not filtered.
Boeing Plant 2	mercury	2006	0.0245 n = 1/1	Outfall V	Golder Associates (2007)	Sample was filtered.
Boeing Plant 2	zinc	2007	110 n = 1/1	Outfall A	Golder Associates (2007)	Sample was filtered.
Boeing Plant 2	zinc	2007	220 n = 1/1	Outfall A	Golder Associates (2007)	Samples were filtered for coarse materials (5-µm filter).
Boeing Plant 2	zinc	2007	300 n = 1/1	Outfall A	Golder Associates (2007)	Sample was not filtered.
Boeing Plant 2	zinc	2007	178 n = 1/1	Outfall B	Golder Associates (2007)	Sample was filtered.
Boeing Plant 2	zinc	2007	204 J n = 1/1	Outfall B	Golder Associates (2007)	Samples were filtered for coarse materials (5-µm filter).
Boeing Plant 2	zinc	2007	200 J n = 1/1	Outfall B	Golder Associates (2007)	Sample was not filtered.
Boeing Plant 2	zinc	2007	24 n = 1/1	Outfall I	Golder Associates (2007)	Sample was filtered.
Boeing Plant 2	zinc	2006	81 n = 1/1	Outfall J	Golder Associates (2007)	Sample was filtered.
Boeing Plant 2	zinc	2007	98 n = 1/1	Outfall J	Golder Associates (2007)	Sample was filtered.
Boeing Plant 2	zinc	2007	74 n = 1/1	Outfall L	Golder Associates (2007)	Sample was filtered.
Boeing Plant 2	zinc	2007	91 n = 1/1	Outfall V	Golder Associates (2007)	Sample was filtered.
Boeing Plant 2	zinc	2007	45 n = 1/1	Outfall Z	Golder Associates (2007)	Sample was filtered.
Boeing Plant 2	zinc	2007	59 n = 1/1	Outfall Z	Golder Associates (2007)	Samples were filtered for coarse materials (5-µm filter).
Boeing Plant 2	zinc	2007	76 n = 1/1	Outfall Z	Golder Associates (2007)	Sample was not filtered.
Boeing Plant 2	acenaphthene	2007	0.53 n = 1/1	Outfall G	Golder Associates (2007)	

Table I-39, cont. Summary of chemical concentrations detected in stormwater in the Boeing Plant 2/Jorgensen Forge SCA

FACILITY	CHEMICAL[a, b]	YEAR COLLECTED	CONCENTRATION INFORMATION (µg/L)[c, d]	LOCATION	SOURCES	ADDITIONAL INFORMATION
Boeing Plant 2	chrysene	2007	0.13 n = 1/1	Outfall G	Golder Associates (2007)	
Boeing Plant 2	dibenzofuran	2007	0.54 n = 1/1	Outfall G	Golder Associates (2007)	
Boeing Plant 2	fluoranthene	2007	1.6 n = 1/1	Outfall G	Golder Associates (2007)	
Boeing Plant 2	fluorene	2007	1.3, 1.5 n = 2/2	Outfall G	Golder Associates (2007)	Samples were collected using different methods.
Boeing Plant 2	phenanthrene	2007	4.8, 5.6 n = 2/2	Outfall G	Golder Associates (2007)	Samples were collected using different methods.
Boeing Plant 2	BEHP	2007	1.5 n = 1/2	Outfall J	Golder Associates (2007)	

Note: If duplicate samples were presented in data tables in the source documents, an average was calculated and presented in this table

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Boeing Plant 2/Jorgensen Forge SCA.

[b] Cadmium, chromium, silver, benzo(a)anthracene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, ideno(1,2,3-cd)pyrene, phenanthrene, total LPAHs, total HPAHs, BBP, phenol, and dioxins and furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L) the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges were calculated using only detected data. For this reason, some estimated ranges may be higher than actual concentrations.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
SCA – source control area
SQS – sediment quality standard

Source-tracing data have been collected from several of the facilities and drainage systems within the Boeing Plant 2/Jorgensen Forge SCA. Data reported in the SCAP (Ecology 2007c), data gaps report (Ecology and Environment 2007b), and two stormwater documents (Floyd|Snider 2005) and (Golder Associates 2007) were reviewed.

Table I-40 presents source-tracing data collected since 2004 within the Boeing Plant 2/Jorgensen Forge SCA. When multiple rounds of data were collected from the same sampling location, only the most recent round was selected for presentation in order to represent current conditions. Data collected prior to 2004 are included in Table I-40 only if newer data from the same sampling locations were not available. Data relevant to source-tracing efforts include various sample types, including catch basin samples, manhole samples, joint caulking samples, and in-line sediment trap or sediment filtered from stormwater samples. Maps I-25 through I-27 show the locations of stormwater drainage lines on the Boeing Plant 2 and Jorgensen Forge facilities. Additional details on source-tracing sampling programs conducted in the Boeing Plant 2/Jorgensen Forge SCA and the associated drainage basins are presented in Section 9.4.4.7 of the main body of the RI.

Table I-40. Summary of chemical concentrations detected in source-tracing samples in the Boeing Plant 2/Jorgensen Forge SCA

Sample Source	Year Collected	Concentration Information (mg/kg dw)[a, b, c, d]							Concentration Information (µg/kg dw)[a, b, c, d]	Sources[e]	Additional Information[f]
		Cadmium	Chromium	Copper	Lead	Mercury	Silver	Zinc	Total PCBs		
Catch Basin Solids Samples											
Boeing Plant 2	2005	2.1, 14.8 n = 2/2	47, 80 n = 2/2	nr	127, 293 n = 2/2	0.20 n = 2/2	nd	nr	260 n = 1/2	Floyd|Snider (2005)	Catch basin solids samples were collected from Line A.
Boeing Plant 2	2005	11.5 n = 1/1	216 n = 1/1	nr	1,390 n = 1/1	0.42 n = 1/1	nd	nr	940 n = 1/1	Floyd|Snider (2005)	Catch basin solids samples were collected from Line B.
Boeing Plant 2	2005	4, 11.9 n = 2/2	154, 214 n = 2/2	nr	302, 3610 n = 2/2	0.50, 1.39 n = 2/2	nd	nr	360 – 3,100 median = 1,005 n = 6/6	Floyd|Snider (2005)	Catch basin solids from Line I. Catch basins along Line I were cleaned out in 2006.
Boeing Plant 2	2005	2.8, 6.7 n = 2/2	76, 135 n = 2/2	nr	184, 429 n =2/2	0.23, 1.00 n = 2/2	51 n = 1/2	nr	290– 850 n = 2/2	Floyd|Snider (2005)	Catch basin solids samples were collected from Line J.
Boeing Plant 2	2005	0.6 n = 1/1	37 n = 1/1	nr	52 n = 1/1	1.88 n = 1/1	0.6 n = 1/1	nr	130 n = 1/1	Floyd|Snider (2005)	Catch basin solids samples were collected from Line V.
Boeing Plant 2	2005	10 – 46 median = 13 n = 9/9	203 – 1,390 median = 344 n = 9/9	nr	416 – 15,300 Median = 1,640 n = 9/9	0.6 – 49 median = 1.23 n = 9/9	1.4 – 21.2 median = 3.7 n = 9/9	nr	3,930 – 2,600,000 median = 28,500 n = 14/14	Floyd|Snider (2005)	Catch basin solids from Line X. Samples were collected before cleanout; line was decommissioned in 2006.
Boeing Plant 2	2005	5.7 – 33.2 median = 11 n = 7/7	192 – 6100 median = 672 n = 7/7	nr	453 – 47,200 median = 3040 n = 7/7	0.3 – 14 median = 1 n = 7/7	1 – 19 median = 2.9 n = 7/7	nr	8,800 –134,000 median = 35,000 n = 7/7	Floyd|Snider (2005)	Catch basin solids from Line Y. Samples were collected before cleanout; line was decommissioned in 2006.
Boeing Plant 2	2005	0.4 n = 1/1	22 n = 1/1	nr	14 n = 1/1	nd	nd	nr	116 n = 1/1	Floyd|Snider (2005)	Catch basin solids samples were collected from Line Z.
Jorgensen Forge	2004	nr	nr	nr	nr	nr	nr	nr	129 – 302 median = nr n = 4/nr	Farallon and Anchor (2006), as cited in Ecology and Environment (2007b)	Catch basin solids from western, central, and eastern portions of property
KCIA	2001	0.411 – 21.9 median = nr n = 4/nr	nr	nr	33.4 – 294 median = nr n = 4/nr	nr	nr	nr	nr	IT Corporation (2001), as cited in Ecology and Environment (2007b), Colligan (2008)	Catch basin samples were collected from the Boeing Plant 2/Jorgensen Forge SCA drainage area.
Manhole Samples											
Boeing Plant 2	2005	nr	nr	nr	nr	nr	nr	nr	7,400 – 350,000 median = nr n = 4/nr	Floyd|Snider and Weston Solutions (2005), as cited in Colligan (2008)	Manhole solids samples from abandoned 12-in. stormwater line pipe traversing Jorgensen that originates on Boeing Plant 2. This is an inactive storm drain, but as a temporary measure, Boeing plugged the abandoned outlet to the waterway at the most downgradient manhole along this line prior to a full cleaning of this line.
Jorgensen Forge	2005	nr	nr	nr	nr	nr	nr	nr	68,000 – 10,000,000 median = 214,500 n = 8/8	Ecology and Environment (2007b)	Manhole solids samples collected along the active 24-in.-diameter stormwater line pipe traversing Jorgensen Forge.
In-line Sediment Samples											
Boeing Plant 2	2007	10 [b]	131 [b]	196 [b]	540 [b]	nd	2 [b]	1,280 [b]	2,407 n = nr	Golder Associates (2007)	Sample collected from filtered stormwater passing through the farthest down-gradient catch basin of Outfall B. The suspended solids and the entire filter bag were extracted together and the suspended solids concentration was then back-calculated based on weight of sediment collected.
Boeing Plant 2	2007	nr	nr	nr	nr	nr	nr	nr	5,429 n = nr	Golder Associates (2007)	Sample collected from filtered stormwater in the farthest-down-gradient catch basin of Outfall I. The suspended solids and a portion of the filter bag were extracted together and the suspended solids concentration was then back-calculated based on weight of sediment collected

Table I-40, cont. Summary of chemical concentrations detected in source tracing samples in the Boeing Plant 2/Jorgensen Forge SCA

Sample Source	Year Collected	Concentration Information (mg/kg dw)[a, b, c, d]							Concentration Information (µg/kg dw)[a, b, c, d]	Sources[e]	Additional Information[f]
		Cadmium	Chromium	Copper	Lead	Mercury	Silver	Zinc	Total PCBs		
Boeing Plant 2	2006	nr	nr	nr	nr	nr	nr	nr	6,444 n = nr	Golder Associates (2007)	Sample collected from filtered stormwater passing through a catch basin in Outfall J prior to discharge into the public roadway drainage system. The suspended solids and the entire filter bag were extracted together and the suspended solids concentration was then back-calculated based on weight of sediment collected.
Jorgensen Forge	2005	nr	nr	nr	nr	nr	nr	nr	6,500, 1,100,000 n = 2/2	Farallon and Anchor (2006), as cited in Ecology and Environment (2007b)	Black silty sand collected within 12-in. side sewer pipe extending from Jorgensen Forge. This side sewer pipe connects to the 24-in. line pipe. Samples were collected by cutting pipe and collecting the black silty sand. SPU installed a sediment trap in the 24" SD between Boeing Plant 2 and Jorgensen in 2008 under grant with Ecology. Trap sample was retrieved in 2009.
KCIA	2005	nr	nr	nr	nr	nr	nr	nr	2,670 n = nr	Renaud (2007), as cited in Ecology and Environment (2007b)	Catch basin sample was collected from trench 2 near the FAA tower. SPU installed a sediment trap in the KCIA SD in 2008 under grant with Ecology. Trap sample was retrieved in 2009.
Caulking Material Samples											
Boeing Plant 2	2005	nr	nr	nr	nr	nr	nr	nr	1,810 – 740,000 median = 10,550 n = 6/8	Floyd|Snider (2005)	Caulk material samples were collected along storm line X.
Boeing Plant 2	2005	n	nr	nr	nr	nr	nr	nr	1,590 – 40,500,000 median = 8,600 n = 9/9	Floyd|Snider (2005)	Caulk material samples were collected along storm line Y.
Boeing Plant 2	2006	nr	nr	nr	nr	nr	nr	nr	740,000 (joint caulking) 350,000 (floor sealant) (maximum) n = nr	Environmental Partners and Golder Associates (2007b), as cited in Ecology and Environment (2007b)	Floor caulking and sealant samples are from building slab and roadways along Line X. Both concentrations are maximum concentrations.
Boeing Plant 2	2006	nr	nr	nr	nr	nr	nr	nr	40,500,000 (joint caulking) 54,000 (floor sealant) n = nr	Environmental Partners and Golder Associates (2007b), as cited in Ecology and Environment (2007b)	Floor caulking and sealant samples are from building slab and roadways along Line Y. Only maximum concentrations are presented because the minimum detected concentrations were not reported in the data gaps report.
KCIA	2005	nr	nr	nr	nr	nr	nr	nr	1,690 n = nr	Renaud (2007), as cited in Ecology and Environment (2007b)	Joint caulking sample was collected near the FAA tower.

Note: If multiple rounds of data were available for a single location, only the data collected during the most recent event were presented in order to represent the most current conditions possible. Data are not included for drainage structures that have been removed subsequent to sampling. Also, data for Outfall A have been excluded from this table because Outfall A discharges to the north in Slip 4, which is not included in the Boeing Plant 2/Jorgensen Forge SCA boundary.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Boeing Plant 2/Jorgensen Forge SCA.

[b] Acenaphthene, benzo(a)anthracene, benzofluoranthenes, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, ideno(1,2,3-cd)pyrene, phenanthrene, total LPAHs, total HPAHs, BBP, BEHP, phenol, and dioxins and furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/kg to µg/kg), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

[f] A map of Boeing outfalls and associated storm drain lines can be found in Golder Associates (2007). The 12- and 24- in. storm drain lines each have connecting side sewer lines. The 12- and 24-in. storm drain lines running along the Jorgensen Forge boundary are identified in the table as line pipes as opposed to side sewer pipes.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
dw – dry weight
FAA – Federal Aviation Administration
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
KCIA – King County International Airport
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
nd – not detected
nr – not reported
PCB – polychlorinated biphenyl
SCA – source control area
SCAP – source control action plan
SQS – sediment quality standard

Additional information on the Boeing Plant 2 site is available on EPA's RCRA website for Boeing Plant 2 (EPA 2008). Additional information on the Jorgensen Forge site is available at EPA's Superfund website for Jorgensen Forge. These websites will be updated as new information becomes available. For additional details and the most up-to-date information pertaining to source control efforts within the Boeing Plant 2/Jorgensen Forge SCA, see Ecology's website.

I.4.6 BOEING ISAACSON/CENTRAL KCIA SOURCE CONTROL AREA (RM 3.7 E TO RM 3.9 E, EAA 6)

The Boeing Isaacson/Central KCIA SCA is one of 23 areas identified by Ecology along the LDW for source evaluation. This SCA was also one of the seven candidate EAAs recommended to EPA and Ecology for early cleanup based on surface sediment chemistry data (Windward 2003c). As part of the ongoing source control efforts for the LDW, Ecology prepared a data gaps report for Boeing Isaacson/ Central KCIA SCA in May 2008 (SAIC 2008b).[26] A draft SCAP has also been prepared for this SCA (Ecology 2008a). Source-tracing data provided by the City of Seattle was also reviewed (Schmoyer 2008d). These three documents are collectively referred to as the "source documents" in this section. The Boeing Isaacson/Central KCIA SCA is presented on Map I-28.

CSL exceedances in the surface sediment in this SCA have included several individual PAHs, BEHP, and benzoic acid (Map I-28). SQS exceedances have included arsenic, total PCBs, dibenzofuran, and BBP. These exceedances are based on the RI baseline surface sediment dataset and the 2007 SCA boundary, as discussed in the introduction to this appendix. Ecology has identified COCs for this SCA based on different criteria (Table I-3); therefore, the chemicals identified for summary in this appendix are different than the COCs identified by Ecology.

Commercial and industrial operations in the vicinity of the Boeing Isaacson/Central KCIA SCA include agricultural operations (historical); lumber milling and treatment (historical); steel fabrication and zinc galvanizing (historical); aircraft parts assembly (historical); airport operations, including transport of passengers and goods, aircraft maintenance, deicing, and fueling (historical and current); and storage of vehicles and aircraft parts/equipment (current).

Adjacent facilities identified in source documents included the Boeing Isaacson and Boeing Thompson properties (Map I-28).[27] The central drainage basin of KCIA was

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[26] The Boeing Isaacson/Central KCIA SCA is also referred to as RM 3.7- 3.9 E and EAA 6 in the draft SCAP (Ecology 2008a) and in the data gaps report (SAIC 2008b).

[27] Although it is identified as an adjacent facility in the source documents, it should be noted that the Boeing Isaacson property is not actually immediately adjacent to the LDW; there is a narrow strip of land owned by the Port of Seattle, extending toward the LDW from inshore of the top of the bank.

identified as an upland facility. Several environmental investigations and remedial activities have been conducted at these facilities within this SCA (Table I-41, Map I-29).

Table I-41. Summary of facility information for the Boeing Isaacson/Central KCIA SCA

Facility[a]	Current Ownership	Current Operations	Historical Operations	Environmental Investigations	Remedial Activities	Source Control Activities/ Investigations
Boeing Isaacson	The Boeing Company	no current operations	used as pasture land and hop fields, brewery, race track residential land, lumber milling and treatment, steel fabrication, zinc galvanization, parts storage, office space[b]	Numerous soil and groundwater investigations have been conducted since the 1980s; most have focused on arsenic. Several groundwater monitoring events have been conducted since 1991. There are plans for an RI/FS to be conducted on the property (Good 2009). Additional site characterization will be conducted as part of the RI/FS.	Numerous remedial activities were conducted throughout the 1980s and 1990s, including soil removal and on-site soil treatment and capping. In 2006, a sump and adjacent soil were removed from the northeast corner of the property. An RI/FS will be conducted at the property under a MTCA order (Good 2009). The Agreed Order is being negotiated between Ecology and The Boeing Company, and a scope of work is being developed.	No source control activities were reported. SD system inspections will be conducted, and source-tracing samples will be collected from catch basins on the property. Additional source control investigations may be conducted at the facility as part of the RI/FS, if necessary (Good 2009). The responsibility for conducting source control investigations (i.e., the roles of Ecology and The Boeing Company) are still under negotiation.
Boeing Thompson	The Boeing Company	storage of vehicles and aircraft parts/ equipment, preparation of the site for reuse or resale	lumber milling, aircraft assembly (including priming, painting, copper plating, sealing and bonding, and fuel systems testing)	Site inspections have been conducted by Ecology. Soil and groundwater investigations, primarily focused on arsenic, have been conducted since the 1990s. There are plans for an RI/FS to be conducted on the property (Good 2009). Additional site characterization will be conducted as part of the RI/FS.	Two USTs were removed in the 1990s and one was closed in place in 2003. An RI/FS will be conducted at the property under a MTCA order (Good 2009). The Agreed Order is being negotiated between Ecology and The Boeing Company, and a scope of work is being developed.	Source control activities related to NPDES permit compliance have been conducted. Source control and stormwater compliance inspections will be conducted, and source-tracing sampling is planned; however, responsibility for conducting these source control investigations (i.e., the roles of Ecology and The Boeing Company) are still under negotiation. Additional source control investigations and activities may be conducted at the facility as part of the RI/FS, if necessary (Good 2009).

Table I-41, cont. Summary of facility information for the Boeing Isaacson/Central KCIA SCA

Facility[a]	Current Ownership	Current Operations	Historical Operations	Environmental Investigations	Remedial Activities	Source Control Activities/ Investigations
KCIA (central drainage basin)	King County	aircraft maintenance, fueling, and deicing, air cargo transport, X-ray and other equipment testing, hangar space, flight schools, and aircraft maintenance technical training	operated as an airport since 1928	Site inspections have been conducted by SPU and Ecology at several of the tenant facilities. Soil and groundwater sampling was conducted at the Hangar Holdings tenant facility.	Soil and groundwater investigations and remediation have been conducted at a former tenant facility (Federal Express) in association with a LUST. Multiple USTs and petroleum-contaminated soil were removed from another tenant facility (Hangar Holdings); Ecology will confirm that cleanup actions at these facilities are complete. USTs have been removed and a voluntary cleanup action has been conducted at a third tenant facility (Clay Lacy).	Corrective actions identified as needed during business inspections have been implemented at most facilities within the drainage basin. Source control practices related to NPDES permit compliance are in place at several of the tenant facilities. Catch basins and oil/water separators are cleaned biannually. Flight lines and taxiways are swept on a frequent basis per Federal Aviation Administration requirements. Source-tracing investigations, including sampling of joint caulking material, and SD system inspections are planned.

Sources: Ecology (2008a), SAIC (2008b), Schmoyer (2008d)

[a] Facilities listed are those identified as adjacent properties in the source documents. KCIA (identified as an upland property in the source documents) is also included because source-tracing data were included in the source documentation.

[b] The Ecology source documents report that historically this area was used as hop fields, a brewery, and a race track; however, Boeing records do not indicate any such prior uses.

Ecology – Washington State Department of Ecology
FS – feasibility study
KCIA – King County International Airport
LUST – leaking underground storage tank
MTCA – Model Toxics Control Act
NBF – North Boeing Field
NPDES – National Pollutant Discharge Elimination System
RI – remedial investigation
SAIC – Science Applications International Corp.
SCA – source control area
SPU – Seattle Public Utilities
UST – underground storage tank

There are three outfalls that discharge within the Boeing Isaacson/Central KCIA SCA and one pipe of unknown origin. The KCIA SD No.2/Pump Station 78 (PS78) EOF[28] (No. 2062), which was identified as a major outfall in the source documents, is a public outfall that discharges stormwater from 237 ac of the central portion of KCIA and from one catch basin on the northwest portion of the Boeing Thompson facility (Ecology 2008a). The KCIA SD No.2/PS78 EOF outfall also serves as an EOF for the city's pump station No. 78. In the event of an EOF, discharge from the sanitary sewer could enter the Boeing Isaacson/Central KCIA SCA. SPU has inspected many of the tenants that operate on the central portion of KCIA and collected source-tracing samples as part of their source control efforts within the basin (SAIC 2008b). The business inspection program is discussed in Section 9.4.4.5 of the main body of the RI.

Two private storm drains that are located on the Boeing Thompson property (Nos. 2061 and 2077) discharge to this SCA. A pipe of unknown origin (No. 2063) is also located along the Boeing Isaacson property shoreline; the purpose of this pipe is not known. Information on the outfalls within the Boeing Isaacson/Central KCIA SCA is summarized in Table I-42; the locations of these outfalls are provided on Maps I-28 and I-29.

[28] The pump station with which this outfall is associated was referred to as Pump Station 45 in the data gaps report (SAIC 2008b); however, based on updated information from SPU, the pump station designation has been changed to Pump Station 78.

Table I-42. Summary of specific information for each outfall in the Boeing Isaacson/Central KCIA SCA

Outfall	Current Ownership	Current Operations	Historical Operations	Environmental and Source-Tracing Investigations	Remedial and Source Control Activities
Outfalls Identified in the Draft SCAP and Data Gaps Report as Major Outfalls[a]					
KCIA SD No.2/PS78 EOF outfall (No. 2062)	City of Seattle and King County[b]	Outfall discharges stormwater from 237 ac of the central portion of KCIA, including areas used for aircraft fueling and maintenance, and from one catch basin in the northwest portion of the Boeing Thompson facility. It also serves as an EOF for the City's sanitary sewer Pump Station No. 78.	The outfall formerly discharged from the head of Slip 5, but the location of the outfall was extended to the LDW in the late-1960s after Slip 5 was filled. It was relocated again to its current location in 1990. The EOF has not discharged since at least 2000 when record-keeping began.	One catch basin sample (collected from the Ameriflight tenant facility) and one ROW catch basin sample (collected from Airport Way S) have been collected from the central portion of KCIA. Additional source-tracing investigations and inspections of the SD system are planned.	The Ameriflight catch basin was cleaned in 2004 or 2005. Catch basins are cleaned out on a regular basis at another tenant facility (Galvin Flying Services). Ecology is planning to conduct source control inspections at facilities within the drainage basin.
Other Outfalls					
Boeing Thompson private SD outfalls (Nos. 2061 and 2077)	The Boeing Company	Outfalls discharge stormwater from the Boeing Isaacson and Thompson facilities.	Historical operations were not reported.	Source-tracing activities are planned.	Source control practices related to NPDES permit compliance are in place.
Boeing Isaacson[c] pipe of unresolved origin and/or use (No. 2063)	not reported	Current operations were not reported.	Historical operations were not reported.	The status of this pipe is being investigated.	No information on remedial or source control activities was reported.

Sources: Ecology (2008a), SAIC (2008b), Schmoyer (2008d)

[a] Major outfalls listed are those discussed as individual source control entities in the data gaps report (SAIC 2008b) and the draft SCAP (Ecology 2008a).

[b] King County owns the SD system; the City of Seattle operates the pump station and EOF.

[c] The pipe is located along the Boeing Isaacson shoreline, but is not necessarily owned by The Boeing Company; no information on the ownership or use of this pipe is available.

Ecology – Washington State Department of Ecology
EOF – emergency overflow
KCIA – King County International Airport
NPDES – National Pollutant Discharge Elimination System
PS – pump station
ROW – right-of-way
SCA – source control area
SAIC – Science Applications International Corp.
SCAP – source control action plan
SD – storm drain
SPU – Seattle Public Utilities

Several remedial activities and environmental investigations have been completed or are currently in progress within the Boeing Isaacson/Central KCIA SCA (Tables I-41 and I-42 and Map I-29). Information about these activities has been summarized in the data gaps report (SAIC 2008b) and draft SCAP (Ecology 2008a). Several of the chemicals that have been detected above the SQS in surface sediment in the SCA have also been detected in various upland media, including soil, groundwater, seep water, and source-tracing solids (Table I-43). The availability of data (by media type) is also presented in the table on Map I-29 for each of the facilities associated with this SCA and for the KCIA SD No.2/PS78 EOF. In both Table I-43 and the table on Map I-29, an X indicates that the source documents reported data or indicated that data exist; therefore, an X does not necessarily mean that the actual data were presented in the source documents. Data are only summarized in media-specific and source-tracing tables if the data were reported in the source documents and if they met the criteria for data summation discussed in the introduction to this appendix (e.g., soil data were collected along the SCA shoreline; groundwater data were collected from shoreline facilities). The identification of a chemical in these media at facilities or within the drainage systems of the Boeing Isaacson/Central KCIA SCA does not necessarily indicate that these potential sources contributed to sediment contamination in the past or will result in sediment contamination in the future.

Table I-43. Chemicals identified in various media in the Boeing Isaacson/Central KCIA SCA

Chemical[a]	Soil	Groundwater	Seep	Porewater[b]	Stormwater[c]	Source-Tracing Samples	Sources
Arsenic	X	X	X		X		SAIC (2008b), Ecology (2008a)
BEHP						X	Schmoyer (2008d)
BBP						X	Schmoyer (2008d)
Acenaphthene						X	Schmoyer (2008d)
Benzo(a)anthracene						X	Schmoyer (2008d)
Benzo(a)pyrene						X	Schmoyer (2008d)
Benzofluoranthenes						X	Schmoyer (2008d)
Benzo(g,h,i)perylene						X	Schmoyer (2008d)
Chrysene						X	Schmoyer (2008d)
Dibenzo(a,h)anthracene						X	Schmoyer (2008d)
Dibenzofuran[d]							
Fluoranthene						X	Schmoyer (2008d)
Fluorene						X	Schmoyer (2008d)
Indeno(1,2,3-cd)pyrene						X	Schmoyer (2008d)
Phenanthrene						X	Schmoyer (2008d)
Total HPAHs						X	Schmoyer (2008d)

Chemical[a]	Soil	Groundwater	Seep	Porewater[b]	Stormwater[c]	Source-Tracing Samples	Sources
Total LPAHs						X	Schmoyer (2008d)
Benzoic acid[d]							
Total PCBs	X					X	Schmoyer (2008d), Ecology (2008a)

Note: An X indicates that the source documents reported that data are available for the identified media. The absence of an X in any cell does not necessarily mean that the chemical is absent in the upland media or in source-tracing samples; in some cases, the chemical may not have been analyzed for or, if analyzed, could have been present but at concentrations below the RL.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Boeing Isaacson/Central KCIA SCA. The chemical list is based on SMS exceedances in the RI baseline surface sediment dataset within the 2007 SCA boundary. Therefore, this list may differ from the list of exceedances in source documents.

[b] No porewater data were identified in the source documents for any chemical.

[c] The presence of stormwater data collected in 1983 from the Boeing Isaacson facility was reported in the draft SCAP (Ecology 2008a); however, actual data were not presented in the source documents.

[d] No soil, groundwater, seep, porewater, stormwater, or source-tracing data were identified in the source documents for this chemical.

BBP –butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
Ecology – Washington State Department of Ecology
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
KCIA – King County International Airport
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
RI – remedial investigation
RL – reporting limit
SAIC – Science Applications International Corp.
SCA – source control area
SCAP – source control action plan
SMS – Washington State Sediment Management Standards
SQS – sediment quality standard

This section summarizes the upland data for groundwater, seep, and source-tracing samples provided in the source documents. No porewater data were reported. Soil data are not presented because the data in the source documents were not collected along the bank or actual data were not provided in the source documents. Stormwater data from 1983 are discussed in the draft SCAP (Ecology 2008a); however, actual data were not presented in the source documents.

If sufficient data were presented in the source documents, ranges of detected concentrations, median concentrations, and sample counts (n) are provided accordingly. In some instances, the source documents acknowledged the existence of certain data without providing actual concentrations. Data were included in this section only if specific concentrations or a range of concentrations were included in the source documents.

Table I-44 summarizes the groundwater data collected in close proximity to the SCA sediment boundary (from the shoreline properties Boeing Isaacson and Boeing Thompson) that were presented in the data gaps report (SAIC 2008b). Historical groundwater data collected in the 1980s, 1990s, and in 2000 were also available for these facilities; data collected in 2006 and 2007 were presented because they are the most representative of current conditions. Groundwater data for VOCs were not

reported for the shoreline properties. Groundwater information for Boeing Isaacson and Boeing Thompson is also included in Section 9.4.6 of the main body of the RI.

Table I-45 summarizes seep data collected in 2000 during a hydrogeologic investigation of the Boeing Isaacson property that were presented in the data gaps report (SAIC 2008b).

Table I-44. Summary of chemical concentrations detected in groundwater from the Boeing Isaacson/Central KCIA SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Boeing Isaacson	arsenic	2007	0.9 – 3,600 (dissolved) median = 140 n = 3/3	two wells located near the shoreline and one well located along E Marginal Way S	Ecology (2007a) and McCrone (2008), as cited in SAIC (2008b)	The source documents presented the highest detected concentration reported when multiple samples were collected from the same sampling location in a given month.
Boeing Thompson	arsenic	2007	28[f] – 720 (dissolved) n = 2/2	two wells located near the shoreline	Ecology (2007a) and McCrone (2008), as cited in SAIC (2008b)	The source documents presented the highest detected concentration reported when multiple samples were collected from the same sampling location in a given month.
Boeing Thompson	arsenic	2006	10.2, 181 (total) n = 2/2	two wells located near the shoreline	Ecology (2007) and McCrone (2008), as cited in SAIC (2008b)	The source documents presented the highest detected concentration reported when multiple samples were collected from the same sampling location in a given month.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Boeing Isaacson/Central KCIA SCA.

[b] Total PCBs, BBP, BEHP, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, benzoic acid and dibenzofuran were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

[f] One sample was analyzed by two different methods (Method 6010B and Method 200.8); the result of one analysis was non-detect while the result of the other analysis was 28 µg/L. The detected result has been included in the range, median, and n calculations for this facility.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
Ecology – Washington State Department of Ecology
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
KCIA – King County International Airport
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SAIC – Science Applications International Corporation
SCA – source control area
SQS – sediment quality standard

Table I-45. Summary of chemical concentrations detected in seeps from the Boeing Isaacson/Central KCIA SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (in µg/L)[c, d]	Location	Sources[e]	Additional Information
Boeing Isaacson	arsenic	2000	7 (dissolved) n = 1/1	near the Boeing Thompson and Boeing Isaacson property boundary	ERM (2000), as cited in SAIC (2008b)	The seep sample was collected as part of a hydrogeologic investigation of the Boeing Isaacson property.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Boeing Isaacson/Central KCIA SCA.

[b] Total PCBs, BBP, BEHP, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, benzoic acid, and dibenzofuran were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L) the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
ERM – Environmental Resources Management
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
KCIA – King County International Airport
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SAIC – Science Applications International Corporation
SCA – source control area
SQS – sediment quality standard

Two source-tracing samples were collected within the Central KCIA drainage basin between 2004 and 2006[29] (Schmoyer 2008d). One source-tracing sample was collected from an onsite catch basin at a KCIA tenant facility, and one sample was collected from a right-of-way catch basin along Airport Way S (Map I-29). Data from these samples are presented in Table I-46. Drainage lines on the facilities associated with this SCA are shown on Maps I-29 and I-30. Additional information on source-tracing sampling programs is presented in Section 9.4.4.7 of the main body of the RI.

[29] A sediment trap sampling location is also located within the central KCIA drainage basin near E Marginal Way S (Map I-29). Data were not available from this trap prior to the end of 2007, and therefore, data for the sediment trap are not presented in Table I-46.

Table I-46. Summary of chemical concentrations detected in source-tracing samples from the Boeing Isaacson/Central KCIA SCA

Sample Source	Year Collected	Concentration Information (µg/kg dw)[a, b, c, d]							Sources	Additional Information
		Acenaphthene	Benzo(a)anthracene	Benzo(a)pyrene	Benzofluoranthenes	Benzo(g,h,i)perylene	Chrysene	Dibenzo(a,h)anthracene		
Onsite Catch Basin Solids Samples										
KCIA SD No. 2/PS78 EOF	2004	850 n = 1/1	12,000 n = 1/1	14,000 n = 1/1	33,800 n = 1/1	7,200 n = 1/1	21,000 n = 1/1	1,400 n = 1/1	Schmoyer (2008d)	One onsite catch basin sample was collected within the KCIA SD No.2/PS78 EOF drainage basin.
ROW Catch Basin Solids Samples										
KCIA SD No. 2/PS78 EOF	2006	nd	1,900 n = 1/1	nd	1,900 n = 1/1	nd	2,200 n = 1/1	nd	Schmoyer (2008d)	One ROW catch basin sample was collected from the KCIA SD No.2/PS78 EOF drainage basin; the catch basin is located within the Airport Way S ROW. SPU installed a sediment trap in KCIA SD#2 in 2008 under a grant with Ecology. Trap sample was retrieved in 2009.

Sample Source	Year Collected	Concentration Information (µg/kg dw)[a, b, c, d]									Source[a]	Additional Information
		Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Phenanthrene	Total HPAHs	Total LPAHs	BEHP	BBP	Total PCBs		
Onsite Catch Basin Solids Samples												
KCIA SD No.2/PS78 EOF	2004	33,000 n = 1/1	1,000 n = 1/1	9,200 n = 1/1	19,000 n = 1/1	155,600 n = 1/1	23,900 n = 1/1	5,500 n = 1/1	5,100 n = 1/1	6,600 n = 1/1	Schmoyer (2008d)	One onsite catch basin sample was collected within the KCIA SD No. 2/PS78 EOF drainage basin.
ROW Catch Basin Solids Samples												
KCIA SD No.2/PS78 EOF	2006	3,600 n = 1/1	nd	nd	1,900 n = 1/1	13,000 n = 1/1	1,900 n = 1/1	nd	nd	nd	Schmoyer (2008d)	One ROW catch basin sample was collected from the KCIA SD No. 2/PS78 EOF drainage basin; the catch basin is located within the Airport Way S ROW.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Boeing Isaacson/Central KCIA SCA.
[b] Benzoic acid and dibenzofuran were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.
[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/kg to µg/kg), the number of significant figures was kept consistent with the number in the reported value.
[d] n is the ratio of the number of detects to the total number of samples analyzed.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
EOF – emergency overflow
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
KCIA – King County International Airport
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
nd – not detected
PCB – polychlorinated biphenyl
PS – pump station
ROW – right-of-way
SCA – source control area
SD – storm drain
SQS – sediment quality standard

Numerous investigations have been completed within the Boeing Isaacson/Central KCIA SCA since the 1980s; environmental investigations are expected to continue. Source control activities in the LDW are ongoing. For the most current information on the Boeing Isaacson/Central KCIA SCA, visit Ecology's website.

I.4.7 SLIP 6 SOURCE CONTROL AREA (RM 3.9 E TO RM 4.3 E)

The Slip 6 SCA is one of the 23 SCAs selected by Ecology for source control evaluations. As part of ongoing source control efforts for the Slip 6 SCA, a data gaps report (Ecology and Environment 2008b) was completed in February 2008, and a SCAP (Ecology and Ecology and Environment 2008) was completed in September 2008. In addition, source-tracing data provided by the City of Seattle (Schmoyer 2008d) and groundwater information evaluated in the Phase 1 RI (Windward 2003b) were also reviewed. These references will be referred to collectively as the "source documents" throughout this section and on the maps.

CSL exceedances in the surface sediment in this SCA included benzoic acid, phenol, total PCBs, lead, and mercury. SQS exceedances were reported for BBP, BEHP, eight individual PAHs, and total HPAHs (Map I-31). These exceedances are based on the RI baseline surface sediment dataset and the 2007 SCA boundary, as discussed in the introduction to this appendix. Ecology has identified COCs for this SCA based on different criteria (Table I-3); therefore, the chemicals identified for summary in this appendix are different than the COCs identified by Ecology.

Commercial and industrial operations in the vicinity of the Slip 6 SCA include wrecked vehicle storage (current); airport operations (historical and current); missile and airplane manufacturing, research, and development (historical and current); cargo handling and storage (historical); vehicle manufacturing and storage (historical); lumber milling (historical); resin, glue, and chemical manufacturing (historical); welding supply (historical); meat-packing operations (historical); sawmill operations (historical); stockyard operations (historical); warehousing (historical); parking (historical); auto wrecking (historical); propane distribution (historical); agriculture (historical); and granary operations (historical). Historically, a grocery store, tavern, gas station, winery, and a construction yard were also located in the vicinity of this SCA.

Six properties were identified as associated with the Slip 6 SCA in the source documents. Adjacent properties included the Boeing Developmental Center (BDC), the former Kenworth Truck Company/PACCAR (PACCAR) facility, and the former Rhône-Poulenc facility (two contiguous parcels) (Map I-32). Upland properties with drainage to the Slip 6 SCA included the south-central portion of the KCIA and two Museum of Flight properties. Table I-47 summarizes facility-specific information for the facilities determined to be adjacent to the Slip 6 SCA. The south-central portion of the KCIA is also included because source-tracing information was presented in the source documents.

Table I-47. Summary of facility information for the Slip 6 SCA

Facility[a]	Current Ownership	Current Operations	Historical Operations	Environmental Investigations	Remedial Activities	Source Control Activities/ Investigations
BDC (northern drainage area)	The Boeing Company	missile and airplane research, development, and manufacturing	agriculture, welding supply, meat-packing plant, sawmill, stockyard, grocery store, warehousing, tavern, gas station, winery, parking lot, construction yard, auto wrecking, propane distribution, granary, and aircraft and missile manufacturing	No environmental investigations were reported. An evaluation of USTs in the drainage area is planned.	No remedial activities were reported.	NPDES permit and SWPPP monitoring requirements have been established for this property. An evaluation of the drainage system and the current SWPPP is planned.
PACCAR/ Kenworth Trucking (Former)	Merrill Creek Holdings	wrecked vehicle storage	truck and heavy equipment manufacturing, truck and airplane assembly, auto body manufacturing	An environmental site assessment was conducted in 1987. An interim VOC investigation was conducted in 1998. An ambient indoor air investigation was conducted in 2002. Phase I and II data gaps investigations were conducted in 2002 and 2004, respectively. A sediment evaluation was conducted under an Agreed Order with Ecology in 2006. Wet and dry season groundwater studies were conducted in 2006 and 2007, respectively. Studies of tidal influences were conducted in 1998, 2002, and 2006. Focused soil and groundwater investigations have been conducted. Planned investigations include a soil and groundwater investigation of the southern shoreline and northwest corner, additional sediment coring, and a review of the current O&M plan.	Closure and removal of USTs took place between 1986 and 2004. Groundwater extraction took place between 1993 and 1995. Petroleum contaminated soils have been excavated and removed. Oxygen-releasing compound was applied to soils and groundwater between 2003 and 2004. Pilot testing and installation of AS/SVE system to treat VOCs took place from 2003 to the present.	No source control activities or investigations were reported.

Table I-47, cont. Summary of facility information for the Slip 6 SCA

FACILITY[a]	CURRENT OWNERSHIP	CURRENT OPERATIONS	HISTORICAL OPERATIONS	ENVIRONMENTAL INVESTIGATIONS	REMEDIAL ACTIVITIES	SOURCE CONTROL ACTIVITIES/ INVESTIGATIONS
Rhône-Poulenc (Former) (west parcel)	Container Properties	wrecked vehicle storage	World War II internment camp; glue, paint, and resin manufacturing; wood preservative handling; vanillin production; container storage	A site screening investigation was conducted in 1986. A RCRA facility assessment was conducted in 1990. An independent site assessment was conducted in 1991. A RCRA facility investigation was conducted in 1995. Investigations in support of interim measure design and focused investigations have been conducted. Quarterly monitoring of groundwater is ongoing. Planned investigations include a shoreline bank contamination investigation, and review of the O&M plan.	An SVE system operated between 2000 and 2001. A hydraulic control interim measure was implemented in 2003. A PCB removal action and hazardous waste storage area cleanup were conducted in 2006. A northwest corner soil removal action and west parcel redevelopment took place in 2007.	No source control activities or investigations were reported.
Rhône-Poulenc (Former) (east parcel)	Museum of Flight	not reported	World War II internment camp; glue, paint, and resin manufacturing; wood preservative handling; vanillin production; container storage	A site screening investigation was conducted in 1986. A RCRA facility assessment was conducted in 1990. An independent site assessment was conducted in 1991. A RCRA facility investigation was conducted in 1995. Geoprobe and east parcel soil characterization investigations were conducted in 2001 and 2006, respectively. Planned investigations include a review of the O&M plan.	A PCB removal action took place in 1995. A transformer area cleanup and east parcel voluntary interim measure were conducted in 2006.	Stormwater and storm sewer system was evaluated in 1998, and stormwater system was redeveloped in 2007. A review of the stormwater system is planned.
KCIA (south central basin)	King County	air terminal and hangars	air terminal and hangars, agriculture	No environmental investigations were reported.	No remedial activities were reported.	An evaluation of joint caulk material for PCBs is planned.

Sources: Ecology and Environment (2008b), Ecology and Ecology and Environment (2008), Schmoyer (Schmoyer 2008d)

[a] Facilities listed are those determined to be adjacent to the Slip 6 SCA. The south-central portion of the KCIA is also included because source-tracing data were reported in the source documentation.

AS/SVE – air sparging/soil vapor extraction
BDC – Boeing Developmental Center
KCIA – King County International Airport
NPDES – National Pollutant Discharge Elimination System
O&M – operation and maintenance
O/W – oil/water
PCB – polychlorinated biphenyl
RCRA – Resource Conservation and Recovery Act
SCA – source control area
SWPPP – stormwater pollution prevention plan
UST – underground storage tank
VOC – volatile organic compound

Eight outfalls that discharge to the Slip 6 SCA are identified on Map I-31; these include a KCIA stormwater outfall (No. 2080), four PACCAR private stormwater outfalls (Nos. 2073, 2074, 2075, and 2076), one Rhône-Poulenc private stormwater outfall (No. 2078), and two BDC private stormwater outfalls (Nos. 2081 and 2082). Of the four permitted private PACCAR outfalls, two are on the northern shoreline (Nos. 2075 and 2076), one is on the middle shoreline (No. 2074), and one is on the southern shoreline (No. 2073). Source documents indicate that the middle outfall was closed in 2004 and only one of the outfalls (No. 2076) on the northern shoreline of PACCAR is still in operation.[30]

Although a private stormwater outfall (No. 2078) from Rhône-Poulenc is shown to discharge into Slip 6 on Map I-31, source documents indicate that both the east and west parcels of Rhône-Poulenc drain directly into the KCIA drainage system with discharge to the LDW via outfall No. 2080. In total, storm drainage from approximately 150 ac of land discharges to Slip 6 (Map I-33). Information on the outfalls within the Slip 6 SCA is summarized in Table I-48; additional information is provided in Appendix H.

[30] Maps I-31 and I-32 show outfalls as identified in the 2003 outfall survey (Herrera 2004) because this is the outfall information source used throughout the RI. The treatment of discrepancies between outfall configurations shown on the RI maps and the maps provided in source documents is discussed in the introduction to this appendix.

Table I-48. Summary of specific information for each outfall in the Slip 6 SCA

Outfall[a]	Current Ownership	Current Operations	Historical Operations	Environmental and Source-Tracing Investigations	Remedial and Source Control Activities
BDC permitted private SD outfalls (Nos. 2081 and 2082)	The Boeing Company	Two outfalls drain approximately 18 ac of the northern portion of the BDC property and possibly 5.5 ac of Museum of Flight property (former BDC property).	There is no information suggesting the existence of any outfalls from the BDC prior to the two current outfalls.	No environmental or source-tracing investigations were reported.	In-line O/W separators are directly upstream of both outfalls. BDC property operates under an NPDES permit, and a SWPPP has been developed.
KCIA SD outfall (No. 2080)	King County	One outfall discharges stormwater from approximately 70 ac of KCIA property, 20 ac of former Rhône-Poulenc property, and 11.44 ac of Museum of Flight east property.	This outfall discharged stormwater from the KCIA and the Rhône-Poulenc site.	Source-tracing samples were collected from this storm drain as part of the Elliott Bay Action Program in the 1980s (Tetra Tech 1988); the source documents do not present those data. One catch basin solids sample was collected in September 2004. Additional stormwater and solids source-tracing investigation and upland site inspections are planned.	Airport catch basins are cleaned semi-annually; airport O/W separators are cleaned annually.
PACCAR/Kenworth Truck Company permitted private SD outfalls (Nos. 2073, 2074, 2075, and 2076)[b]	Merrill Creek Holdings	Two outfalls drain approximately 24.3 ac of the former PACCAR property.	Four stormwater outfalls drained the PACCAR property.	Stormwater catch basins and drain lines were sampled during Phase I and Phase II data gaps investigations. A north storm drain investigation was conducted in 2006. Stormwater monitoring under a NPDES permit/SWPPP is ongoing.	Stormwater catch basins and drain lines were cleaned out during the Phase I and Phase II data gaps investigations. Closure of the middle outfall and complete stormwater system cleaning was completed in 2004.The north storm drain was repaired in 2006. Stormwater quality improvements were done in 2008.
Rhône-Poulenc private SD outfall (No. 2078)[c]	Container Properties	One outfall may drain a portion of the Rhône-Poulenc property.	Several outfalls drained the Rhône-Poulenc property.	The stormwater and storm sewer system was evaluated in 1998. A review of the stormwater system is planned.	The stormwater system was replaced by a collection and treatment system in 2007.

Sources: Ecology and Environment (2008b), Ecology and Ecology and Environment (2008), Schmoyer (2008d)

[a] No major outfalls were identified as individual source control entities in the source documents.

[b] The source documents indicated that the middle outfall (No. 2074) was closed in 2004 and only one of the outfalls (No. 2076) on the northern shoreline of PACCAR is still in operation.

[c] The source documents indicated that both the east and west parcels of Rhône-Poulenc drain directly into the KCIA drainage system with discharge to the LDW via outfall No. 2080.

BDC – Boeing Developmental Center
KCIA – King County International Airport
NPDES – National Pollutant Discharge Elimination System
O/W – oil/water
SCA – source control area
SWPPP – stormwater pollution prevention plan

Several remedial activities and environmental investigations have been completed or are currently in progress within the Slip 6 SCA (Tables I-47 and I-48). Information about these activities were summarized in the source documents. Several of the chemicals that have been detected above the SQS in the Slip 6 SCA surface sediment have also been detected in various upland media, including soil, groundwater, seep, porewater, stormwater, and source-tracing samples (Table I-49). The availability of data (by media type) for each of the facilities associated with the Slip 6 SCA is also presented in the table on Map I-32. An X in Table I-49 and the table on Map I-32 indicates that the source documents reported data or indicated that data exist; therefore, an X does not necessarily mean that the actual data were presented in the source document. Data are only summarized in media-specific and source-tracing tables if the data were reported in the source documents and if they met the criteria for data summation discussed in the introduction to this appendix (e.g., soil data were collected along the SCA shoreline; groundwater data were collected from shoreline facilities). The identification of a chemical in these media at facilities or within the drainage systems does not necessarily indicate that these potential sources contributed to sediment contamination in the past or that they will result in sediment contamination in the future.

Table I-49. Chemicals identified in various media in the Slip 6 SCA

Chemical[a]	Soil	Groundwater	Seep	Porewater	Stormwater	Source-Tracing Samples	Sources
Lead	X	X	X		X	X	Ecology and Environment (2008b), Schmoyer (2008a),
Mercury	X	X	X	X	X	X	Ecology and Environment (2008b), Schmoyer (2008a), EPA (2005)
Acenaphthene		X	X			X	Ecology and Environment (2008b), Schmoyer (2008d)
Benzo(g,h,i) perylene			X			X	Ecology and Environment (2008b)
Dibenzo(a,h) anthracene						X	Ecology and Environment (2008b)
Dibenzofuran		X					Ecology and Environment (2008b)
Fluoranthene		X	X	X		X	Ecology and Environment (2008b), EPA (2005)
Fluorene		X	X			X	Ecology and Environment (2008b)
Indeno(1,2,3-cd) pyrene			X			X	Ecology and Environment (2008b)

Chemical[a]	Soil	Groundwater	Seep	Porewater	Stormwater	Source-Tracing Samples	Sources
Phenanthrene		X	X			X	Ecology and Environment (2008b)
Total HPAHs		X	X	X		X	Ecology and Environment (2008b), EPA (2005)
BBP						X	Ecology and Environment (2008b), Schmoyer (2008d)
BEHP		X	X	X	X	X	Ecology and Environment (2008b), Schmoyer (2008d), EPA (2005)
Benzoic acid						X	Ecology and Environment (2008b)
Phenol[b]							
Total PCBs	X	X			X	X	Ecology and Environment (2008b)
Dioxins and furans[c]						X	Ecology and Environment (2008b)

Note: An X indicates that the source documents reported that data are available for the identified media. The absence of an X in any cell does not necessarily mean that the chemical is absent in the upland media or in source-tracing samples; in some cases, the chemical may not have been analyzed for or, if analyzed, could have been present but at concentrations below the RL.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Slip 6 SCA. The chemical list is based on SMS exceedances in the RI baseline surface sediment dataset within the 2007 SCA boundary. Therefore, this list may differ from the list of exceedances in source documents.

[b] No soil, groundwater, seep, porewater, stormwater, or source-tracing data were identified in the source documents for this chemical.

[c] SMS criteria do not exist for dioxins and furans. They were included in this table because they are a risk driver chemical with highly elevated concentrations (i.e., TEQ > 100 ng/kg dw) in surface sediment in this area.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
HPAH – high-molecular-weight polycyclic aromatic hydrocarbons
PCB – polychlorinated biphenyls
RI – remedial investigation
RL – reporting limit
SCA – source control area
SMS – Washington State Sediment Management Standards
SQS – sediment quality standard
TEQ – toxicity equivalent

This section summarizes data as presented in the source documents for groundwater, seep, porewater, stormwater, and source-tracing samples. Soil data are not presented because the data in the source documents were not collected along the bank. In addition to the groundwater data included in this section, groundwater information for the Boeing Developmental Center, PACCAR, and the former Rhône-Poulenc facility is also included in Section 9.4.6 of the main body of the RI.

If sufficient data were available in the Slip 6 source documents, ranges of detected concentrations, median concentrations, and sample counts (n) are provided in the tables. In some instances, the source documents acknowledged the existence of certain

data without providing actual concentrations. Data were included only if specific concentrations or a range of concentrations were available in the source documents.

Groundwater data presented in the source documents for adjacent or upland properties associated with the Slip 6 SCA are summarized in Table I-50. Rhône-Poulenc is the only property adjacent to the Slip 6 SCA with detected concentrations of at least one chemical listed in Table I-49 in groundwater. In addition to groundwater information for those chemicals detected above the SQS in surface sediment in this SCA, Table I-50 also includes VOC groundwater data for PACCAR and Rhône-Poulenc provided in the source documents. Data are presented in Table I-50 for VOCs that were identified for these properties in the groundwater pathways analysis completed as part of the Phase 1 LDW RI (Windward 2003a).

Table I-50. Summary of chemical concentrations detected in groundwater for the Slip 6 SCA

FACILITY	CHEMICAL[a, b]	YEAR COLLECTED	CONCENTRATION INFORMATION (µg/L)[c, d]	LOCATION	SOURCES[e]	ADDITIONAL INFORMATION
Chemicals with Detections Above SQS in Surface Sediment						
Rhône-Poulenc	lead	2002	1 – 12 (total) median = 3 n = 6/9	nearshore	GeoEngineers (2002), as cited in Windward (2003b)	Samples were collected before HCIM implementation.
Rhône-Poulenc	mercury	2002 – 2006	0.1 – 0.5 (total) median = 0.1 n = 13/174	outside HCIM barrier wall	Geomatrix (2007), as cited in Ecology and Environment (2008b)	Samples were collected after HCIM implementation.
Rhône-Poulenc	mercury	2002	1, 1 (total) n = 2/9	nearshore	GeoEngineers(2002), as cited in Windward (2003b)	Samples were collected before HCIM implementation.
VOCs[f]						
PACCAR	1,1 dichloroethene	2002 – 2007	0.3 – 1.26 median = 0.6 n = 6/105	nearshore	Kennedy/Jenks (2007), as cited in Ecology and Environment (2008b)	Samples are from AS/SVE system monitoring.
PACCAR	1,1 dichloroethene	1996	1.2, 38 n = 2/2	north fire aisle	Kennedy/Jenks (1996), as cited in Windward (2003b)	The reported samples are from the two wells closest to the waterway.
PACCAR	cis-1,2-dichloroethene	2002 – 2007	0.3 – 57 median = 7.67 n = 43/105	nearshore	Kennedy/Jenks (2007), as cited in Ecology and Environment (2008b)	Samples are from AS/SVE system monitoring.
PACCAR	cis-1,2-dichloroethene	1996	43, 110 n = 2/2	north fire aisle	Kennedy/Jenks (1996), as cited in Windward (2003b)	The reported samples are from the two wells closest to the waterway.
PACCAR	methylene chloride	2002 – 2007	3.6, 4.1 n = 2/105	nearshore	Kennedy/Jenks (2007), as cited in Ecology and Environment (2008b)	Samples are from AS/SVE system monitoring.
PACCAR	tetrachloroethene	1996	1.8 n = 1/2	north fire aisle	Kennedy/Jenks (1996), as cited in Windward (2003b)	The reported samples are from the two wells closest to the waterway.
PACCAR	trichloroethene	2002 – 2007	0.4 – 47 median = 4.3 n = 33/105	nearshore	Kennedy/Jenks (2007), as cited in Ecology and Environment (2008b)	Samples are from AS/SVE system monitoring.
PACCAR	trichloroethene	1996	1.3, 160 n = 2/2	north fire aisle	Kennedy/Jenks (1996), as cited in Windward (2003b)	The reported samples are from the two wells closest to the waterway.

Table I-50, cont. Summary of chemical concentrations detected in groundwater for the Slip 6 SCA

FACILITY	CHEMICAL[a, b]	YEAR COLLECTED	CONCENTRATION INFORMATION (µg/L)[c, d]	LOCATION	SOURCES[e]	ADDITIONAL INFORMATION
PACCAR	vinyl chloride	2002 – 2007	0.5 – 51 median = 4.65 n = 34/105	nearshore	Kennedy/Jenks (2007), as cited in Ecology and Environment (2008b)	Samples are from AS/SVE system monitoring.
PACCAR	vinyl chloride	1996	30, 190 n = 2/2	north fire aisle	Kennedy/Jenks (1996), as cited in Windward (2003b)	The reported samples are from the two wells closest to the waterway.
Rhône-Poulenc	toluene	2007	1,300 n = 1/nr	southwest corner of former maintenance building area	EPA (2006), as cited in Ecology and Environment (2008b)	Sample collected after the removal action.
Rhône-Poulenc	toluene	2006	90,000 n = 1/nr	southwest corner of former maintenance building area	EPA (2006), as cited in Ecology and Environment (2008b)	Reported value is the maximum. Sample collected before the removal action.
Rhône-Poulenc	toluene	2002 – 2006	0.38 – 260 median = 42 n = 53/174	outside HCIM barrier wall	Geomatrix (2007), as cited in Ecology and Environment (2008b)	Samples include quarterly monitoring since September 2002.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Slip 6 SCA.

[b] Mercury, BBP, BEHP, acenaphthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, benzoic acid, phenol, total PCBs and dioxins and furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[d] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

[f] VOC data were summarized, as available, at EPA's request and not because of SQS exceedances in surface sediment in the SCA.

AS/SVE – air sparging/soil vapor extraction
BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
HCIM – hydraulic control interim measure
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
nr – not reported
PCB – polychlorinated biphenyl
SCA – source control area
SQS – sediment quality standard
UST – underground storage tank
VOC – volatile organic compound

Data are also available for several seep and porewater samples collected within the Slip 6 SCA. Source documents indicated that seven seep samples were collected from the Rhône-Poulenc shoreline in 1996, and several seep samples were collected from the PACCAR shoreline in 2002. Data from seep samples are presented in Table I-51. Porewater data were collected as part of the Rhône-Poulenc sediment and porewater investigation (EPA 2005) (Table I-52). Table I-53 presents the data for chemicals detected in stormwater samples collected from drainage basin associated with the Slip 6 SCA. Data from PACCAR drainage systems included data collected since 2004, after the entire storm drainage system was cleaned out and the middle outfall was closed (2008b). No stormwater data were presented for Rhône-Poulenc, BDC, or the KCIA properties in the source documents.

Table I-51. Summary of chemical concentrations detected in seeps in the Slip 6 SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
PACCAR	lead	2002	16 (total) n = 1/nr	southern shoreline	Kennedy/Jenks (2002) , as cited in Ecology and Environment (2008b)	Value is the maximum detected concentration.
Rhône-Poulenc	lead	1996	44 (total) n = 1/7	southwest shoreline	Rhône-Poulenc (1996), as cited in Windward (2003b)	Samples were collected prior to HCIM implementation.
Rhône-Poulenc	mercury	1996	0.65 (total) n = 1/7	Slip 6 shoreline	Rhône-Poulenc (1996), as cited in Windward (2003b)	Samples were collected prior to HCIM implementation.
Rhône-Poulenc	BEHP	1996	14, 27 (total) n = 2/7	shoreline	Rhône-Poulenc (1996), as cited in Windward (2003b)	Samples were collected prior to HCIM implementation.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Slip 6 SCA.

[b] BBP, acenaphthene, benzo(g,h,i)perylene , dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, benzoic acid, phenol, total PCBs, and dioxins and furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges were calculated using only detected data. For this reason, some estimated ranges may be higher than actual concentrations.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
HCIM – hydraulic control interim measure
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
nr – not reported
PCB – polychlorinated biphenyl
SCA – source control area
SQS – sediment quality standard

Table I-52. Summary of chemical concentrations detected in porewater in the Slip 6 SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources	Additional Information
Rhône-Poulenc	mercury	2004	0.0016 – 0.408 n = 10/15	along the Rhône-Poulenc shoreline	EPA (2005)	Samples were collected with a mini-peizometer and seepage meter.
Rhône-Poulenc	fluoranthene	2004	0.26 n = 1/9	along the Rhône-Poulenc shoreline	EPA (2005)	Samples were collected with a mini-peizometer and seepage meter.
Rhône-Poulenc	total HPAH	2004	0.69 n = 1/9	along the Rhône-Poulenc shoreline	EPA (2005)	Samples were collected with a mini-peizometer and seepage meter.
Rhône-Poulenc	BEHP	2004	2 – 390 n = 5/9	along the Rhône-Poulenc shoreline	EPA (2005)	Samples were collected with a mini-peizometer and seepage meter.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Slip 6 SCA.

[b] Lead, BBP, acenaphthene, benzo(g,h,i)perylene , dibenzo(a,h)anthracene, dibenzofuran, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, benzoic acid, phenol, total PCBs, and dioxins and furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the Rhône-Poulenc (Rhodia) sediment and porewater investigation data report (EPA 2005) in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges were calculated using only detected data. For this reason, some estimated ranges may be higher than actual concentrations.

BBP – butyl benzyl phthalate

BEHP – bis(2-ethylhexyl) phthalate

EPA – US Environmental Protection Agency

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

SCA – source control area

SQS – sediment quality standard

Table I-53. Summary of chemical concentrations detected in stormwater samples from the Slip 6 SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
PACCAR	lead	2006 – 2007	1 – 21 median = 3.5 n = 4/4	north storm drain system	Anchor (2003b), as cited in Ecology and Environment (2007b, 2008)	Samples were collected after the 2004 system cleanout. Samples were not filtered.
PACCAR	lead	2006 – 2007	3 – 96 median = 26 n = 3/4	south storm drain system	Anchor (2008b), as cited in Ecology and Environment (2007b, 2008)	Samples were collected after the 2004 system cleanout. Samples were not filtered.
PACCAR	mercury	2006 – 2007	0.0566 n = 1/4	north storm drain system	Anchor (2008b), as cited in Ecology and Environment (2007b, 2008)	Samples were collected after the 2004 system cleanout. Samples were not filtered.
PACCAR	mercury	2006 – 2007	0.0512 n = 1/4	south storm drain system	Anchor (2008b), as cited in Ecology and Environment (2007b, 2008)	Samples were collected after the 2004 system cleanout. Samples were not filtered.
PACCAR	BEHP	2006 – 2007	3.2, 14 n = 2/4	south storm drain system	Anchor (2008b), as cited in Ecology and Environment (2007b, 2008)	Samples were collected after the 2004 system cleanout.
PACCAR	total PCBs	2006 – 2007	0.012, 0.018 n = 2/4	north storm drain system	Anchor (2008b), as cited in Ecology and Environment (2007b, 2008)	Samples were collected after the 2004 system cleanout.
PACCAR	total PCBs	2006 – 2007	0.055, 0.11 n = 2/4	south storm drain system	Anchor (2008b), as cited in Ecology and Environment (2007b, 2008)	Samples were collected after the 2004 system cleanout.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Slip 6 SCA.

[b] BBP, acenaphthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAH, benzoic acid, phenol, and dioxins/furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SCA – source control area
SQS – sediment quality standard

Source-tracing samples have been collected at the former PACCAR facility and the KCIA drainage systems associated with the Slip 6 SCA. Data from these samples were reported in the source documents. Table I-54 presents the source-tracing data collected from drainages associated with the Slip 6 SCA. The drainage basin and storm drain system features within the Slip 6 SCA are included on Maps I-32 and I-33. Data from the PACCAR drainage systems include data collected starting in 2004, after the entire storm drainage system was cleaned out and the middle outfall was closed (Ecology and Environment 2008b). No source-tracing data were reported in the source documents for the Rhône-Poulenc drainage system since the complete system was redeveloped in 2007 (Ecology and Environment 2008b). No data were available in the source documents for Rhône-Poulenc prior to the system redevelopment. No source-tracing data were reported for the BDC drainage system associated with the Slip 6 SCA. Additional details on source-tracing sampling programs conducted within the Slip 6 SCA are presented in Section 9.4.4.7.

Table I-54. Summary of chemical concentrations detected in source-tracing samples collected from the Slip 6 SCA

Sample Source	Year Collected	Concentration Information (mg/kg dw)[a, b, c, d]		Concentration Information (µg/kg dw)[a, b, c, d]					Sources	Additional Information
		Lead	Mercury	Acenaphthene	Benzo(g,h,i)perylene	Dibenzo(a,h)anthracene	Fluoranthene	Fluorene		
Catch Basin Solids Samples										
PACCAR south storm drain system	2006 – 2007	128, 660 n = 2/2	0.09, 0.3 n = 2/2	nd	320, 910 n = 2/2	160 n = 1/2	1,600, 7,100 n = 2/2	93 n = 1/2	Ecology and Environment (2008b)	Samples were collected after system cleanout in 2004.
PACCAR north storm drain system	2006 – 2007	175, 764 n = 2/2	0.08, 0.9 n = 2/2	nd	2,100 n = 1/2	84, 320 n = 2/2	380, 9,500 n = 2/2	220 n = 1/2	Ecology and Environment (2008b)	Samples were collected after system cleanout in 2004.
KCIA SD No.1	2004	232 n = 1/1	0.17 n = 1/1	1,400 n = 1/1	nd	nd	nd	nd	Schmoyer (2008d)	Sample was collected by SPU as part of LDW source control program. SPU installed a sediment trap in KCIA SD#1 in 2008 under a grant with Ecology. Trap sample was retrieved in 2009.

Sample Source	Year Collected	Concentration Information (µg/kg dw)[a, b, c, d]							Sources	Additional Information
		Indeno(1,2,3-cd)pyrene	Phenanthrene	Total HPAHs	BBP	BEHP	Benzoic Acid	Total PCBs		
Catch Basin Solids Samples										
PACCAR south storm drain system	2006 – 2007	280, 750 n = 2/2	810, 2,300 n = 2/2	7,836, 26,760 n = 2/2	280, 5,100 n = 2/2	4,500, 46,000 n = 2/2	4,200 n = 1/2	160, 313 n = 2/4	Ecology and Environment (2008b)	Samples were collected after system cleanout in 2004.
PACCAR north storm drain system	2006 – 2007	1,500 n = 1/2	780, 3,000 n = 2/2	1,300, 36,020 n = 2/2	1,100, 1,300 n = 2/2	10,000, 62,000 n = 2/2	3,700 n = 1/2	950 n = 1/2	Ecology and Environment (2008b)	Samples were collected after system cleanout in 2004.
KCIA SD #1	2004	nd	nd	nd	2,600 n = 1/1	41,000 n = 1/1	nd	nd	Schmoyer (2008d)	Sample was collected as part of a larger source-tracing project by King County.

Note: Data are not included for drainage structures that have been removed subsequent to sampling. If multiple rounds of data were available for a single location, only the data collected during the most recent event were presented in order to represent the most current conditions possible.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Slip 6 SCA.

[b] Acenaphthene, dibenzofuran, phenol, and dioxins/furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/kg to µg/kg), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges were calculated using only detected data. For this reason, some estimated ranges may be higher than actual concentrations.

BBP –butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
KCIA – King County International Airport
nd – not detected
PCB – polychlorinated biphenyl
SQS – sediment quality standard
SCA – source control area

Source identification and control efforts are ongoing for the Slip 6 SCA. Additional information for the Slip 6 SCA is provided on Ecology's website.

I.4.8 NORFOLK CSO/SD SOURCE CONTROL AREA (RM 4.9 E TO RM 5.0 E, EAA 7)

The area just offshore of the Norfolk CSO/SD[31] outfall was originally identified as a priority cleanup area by the Elliott Bay/Duwamish Restoration Program (EBDRP) in 1991 because of sediment contamination associated with the Norfolk CSO/SD discharge (King County 1999). Subsequently, the area was identified through the RI process as a candidate EAA (EAA 7) because of contaminated surface sediment (Windward 2003c). As part of ongoing source control efforts for this SCA, a data gaps report (Ecology and Environment 2007a) and a SCAP (Ecology 2007d) were completed in September 2007. Source-tracing data provided by the City of Seattle were also reviewed (Schmoyer 2008d). These three documents are collectively referred to as the "source documents" in this section.

In 1994, King County investigated sediment contamination near the Norfolk CSO/SD outfall and determined that contaminated sediments should be dredged and the area capped with clean sediment (Map I-34). Dredging began in February 1999, and backfilling within the dredged area was completed by March 1999. Sediment from the Upper Turning Basin was used to backfill the dredged area. A project closure report was prepared in 1999 (King County 1999).

In 2003, Boeing used a specialized vacuum excavator to remove approximately 60 cy of PCB-contaminated sediment near Boeing outfall DC2, sometimes referred to as the south storm drain outfall (No. 2093 on Map I-34). The purpose of excavation was to remove PCB-contaminated sediment near outfall DC2. Neither of these actions was intended to address all of the sediment contamination within this SCA.

CSL exceedances in surface sediment in this SCA included total PCBs, BEHP, and 1,4-dichlorobenzene. SQS exceedances were reported for total PCBs, BEHP, BBP, 1,4-dichlorobenzene, and fluoranthene (Map I-34). These exceedances are based on data included in the baseline dataset[32] for sampling locations within the 2007 SCA boundary (as discussed in the introduction to this appendix), and they form the basis for the discussion and data compilation in this section. Ecology has identified COCs for this SCA based on different criteria (Table I-3); therefore, the chemicals identified for summary in this appendix are different than the COCs identified by Ecology. For

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[31] A City pump station EOF also discharges through this outfall.

[32] Surface sediment samples in the baseline dataset include: 1) post-dredge samples collected within the 1999 Norfolk dredged area; 2) pre-removal samples collected within the 2003 Boeing removal area; 3) samples collected prior to the 1999 dredge event from locations outside of the dredged area; and 4) samples collected after the 2003 dredge from locations outside of the removal area.

the most part, the SMS exceedances in the RI baseline dataset were outside of the removal areas. Within the Norfolk CSO/SD removal area, concentrations of total PCBs and BBP exceeded the SQS in 2002 and 2001, respectively. PCBs and BBP concentrations in surface sediment samples did not exceed the SQS in subsequent sampling conducted in 2006.

Commercial and industrial operations in the vicinity of the Norfolk CSO/SD SCA have included aircraft and aerospace research (historical and current); flight line support aircraft storage, flight preparation, general servicing, and maintenance and repair (current); general aviation airport operations (current); wholesale foods and merchandise (current); auto wrecking (historical and current); vehicle parts salvage and sale, crushing of cars and parts (current); farming (historical); commercial operations (historical); warehousing (historical); propane distribution (historical); commercial trucking (historical); and airplane and missile manufacturing (historical). Historically, a grocery store, tavern, gas station, winery, granary, and a construction yard were also located in the vicinity of this SCA.

Ecology (2007b) has identified BDC, the Boeing Military Flight Center (MFC), and the southern drainage basin of KCIA as adjacent properties associated with this SCA (Map I-34) (Ecology 2007c). The Norfolk CSO/SD SCA also receives stormwater runoff from a large drainage basin that includes industrial and residential areas (Map I-35). Upland properties identified in the source documents included Associated Grocers, Inc., Northwest Auto Wrecking, Affordable Auto Wrecking, and an Arco gas station. Table I-55 summarizes facility-specific information for adjacent facilities associated within the Norfolk CSO/SD SCA. The Arco Gas Station is also summarized in Table I-55 because source-tracing data were reported in the source documents. Associated Grocers, Inc., Northwest Auto Wrecking, and Affordable Auto Wrecking[33] are not included in this summary because source-tracing data for these facilities were not identified (see the introduction for more information on facility selection criteria). The data gaps report and SCAP should be reviewed for additional information on all of the facilities associated with this SCA.

[33] Runoff from most of the Affordable Auto Wrecking property has been diverted to the combined sewer on MLK Way. This site no longer drains to the Norfolk outfall (Schmoyer 2009).

Table I-55. Summary of facility information for the Norfolk CSO/SD SCA

Facility[a]	Current Ownership	Current Operations	Historical Operations	Environmental Investigations	Remedial Activities	Source Control Activities/Investigations
Arco Gas Station	John Eastey	former gas station	gas station	Groundwater sampling was conducted in 2004, 2005, and 2006.	Soil contamination has been remediated. Between 1991 and 1992, 26 USTs were removed from the facility.	No source control activities or investigations were reported.
Boeing Developmental Center[b]	The Boeing Company	aircraft and aerospace research and development	farmland, commercial operations, grocery store, gasoline station, tavern, warehouse, winery, auto wrecking, construction yard, propane distributor, commercial trucking, granary, airplane and missile manufacturing	EPA conducted a RCRA facility assessment of the BDC in 1994.	PCB-contaminated sediment near the south storm drain was removed and the area was then backfilled with clean sediment. Storm drain lines have been investigated and cleaned, and an end-of-pipe sediment trap for the south storm drain line has been installed (Project Performance Corporation 2002, 2003; Ecology 2007c).	Boeing has implemented multiple source investigations and control activities. A SWPPP was prepared to identify and assist in the prevention of releases from potential sources of stormwater pollution (Project Performance Corporation 2001, 2003; Landau 2004; Ecology 2007c)
Boeing Military Flight Center	The Boeing Company	flight line support, aircraft storage, flight preparation, general servicing, maintenance and repair	No historical operations were reported.	In 2005, Boeing conducted an investigation of joint caulking material to determine the extent of PCB contamination on the property.	Joint caulking removal activities took place in 2005 and 2006.	A SWPPP was prepared to identify and prevent releases from potential sources of stormwater pollution.
KCIA (southern drainage basin)	King County	general aviation airport	general aviation and military airport	No environmental investigations were reported.	No remedial activities were reported.	No source control activities or investigations were reported.

Source: Ecology and Environment (2007a), Ecology (2007b)

[a] Facilities listed are those identified in the data gaps report(Ecology and Environment 2007a) and the SCAP (Ecology 2007c). Arco Gas Station (identified as an upland property in the source documents) is also included because source-tracing data were included in the source documentation.

[b] Much of the information presented in the data gaps report(Ecology and Environment 2007a) and the SCAP (Ecology 2007c) for the BDC is for RCRA units that are north of the area that drains to the Norfolk CSO/SD SCA.

BDC – Boeing Developmental Center
CSO – combined sewer overflow
ESA – Environmental site assessment
KCIA – King County International Airport
PCB – polychlorinated biphenyl
SCA – source control area
SCAP – source control action plan
SD – storm drain
SWPPP – storm water pollution prevention plan
UST – underground storage tank
VCP – voluntary cleanup program

The source documents identified the Norfolk CSO/SD (No. 2095) as a major outfall for this SCA. The Norfolk CSO/SD is owned by King County and the City of Seattle with contributions from King County, the City of Seattle, the City of Tukwila, and The Boeing Company. It is the only public outfall discharging to this SCA (Ecology 2007c); it serves as an outfall for the municipal storm drain system, which is operated by both the City of Seattle and the City of Tukwila. The Norfolk SD drainage basin collects stormwater from approximately 769 ac (including about 100 ac of the I-5 corridor) and the outfall also serves as a CSO for an area of 4,900 ac (Maps I-35 and I-36). Land use in the Norfolk SD drainage basin is primarily industrial. The Norfolk outfall also serves as an emergency overflow for City of Seattle pump station No.17 (Schmoyer 2008d).

In addition, four other outfalls discharge into the SCA: Boeing DC16 (BDC-5), Boeing DC3 (No. 2096), Boeing DC2 (No. 2093), and a pipe of unresolved origin and/or use (No. 2094) located just south of outfall No. 2093. The first three of these outfalls are permitted under the BDC. The source documents list two other outfalls as discharging to the Norfolk SCA (Nos. 2092 and 2097), but these outfalls are located to the north of the SCA boundary and thus are not included in this section. The Boeing outfalls primarily drain rooftops and paved areas near buildings on the BDC. A single catch basin at the BDC is also connected to the Norfolk CSO/SD. Stormwater drainage features are shown on Maps I-35 and I-36. Information on the outfalls within the Norfolk SCA is included in Table I-56 and the locations of these outfalls are shown on Map I-34; additional outfall information is provided in Appendix H.

Table I-56. Summary of specific information for each outfall in the Norfolk SCA

Outfall	Current Ownership	Current Operations	Historical Operations	Environmental and Source-Tracing Investigations	Remedial and Source Control Activities
Outfalls Identified in the SCAP and DGR as Major Outfalls[a]					
Norfolk CSO/SD outfall[b] (No. 2095)	King County, City of Seattle	This outfall serves as a CSO for King County, as an emergency overflow for City of Seattle pump station No.17 (Schmoyer 2008e), and as a storm drain outfall for the municipal storm drain system. The stormwater basin is approximately 769 ac, and the combined sewer service area is approximately 4,900 ac. Both untreated (Norfolk) and treated (Henderson/MLK) CSOs discharge at this outfall. The outfall also receives stormwater discharges from Boeing properties and areas within the City of Tukwila.	Outfall served as a CSO, EOF, and SD for King County and the City of Seattle. CSOs were untreated prior to the construction of a CSO treatment facility (Henderson).	In-line sediment samples were collected by SPU between 2003 and 2005 to evaluate disposal options in preparation for a pipe cleaning project in the MLK Way sub-basin. Approximately 2,200 linear feet of pipe were cleaned in 2005 (Schmoyer 2008e).	In 1995, the Allentown diversion, which sent much of the flow to the South Plant and greatly reduced CSO events, was completed (King County 2008a). In 2005, the Henderson/MLK CSO treatment facility (storage and treatment tunnel) was constructed, which sends treated CSO discharges to the Norfolk outfall.
Other Outfalls					
BDC outfalls (Nos. 2093 [DC2], 2096 [DC3], and BDC-5 [DC16])	The Boeing Company	Three of the eighteen outfalls from the BDC storm drain system discharge to the Norfolk SCA; one catch basin at the BDC connects to the Norfolk CSO/SD. The BDC outfalls primarily drain rooftops and paved areas.	No historical operations were reported.	Boeing has conducted extensive investigation of the potential sources of PCBs within the south storm drain system (Ecology 2007c; Project Performance Corporation 2001).	Boeing has implemented source control activities within the south storm drain system, including cleanout of the pipes, installation of a sediment trap, and periodic monitoring. A SWPPP was prepared to identify and assist in the prevention of releases from potential sources of stormwater pollution (Ecology 2007c; Project Performance Corporation 2001, 2003).
Outfall No. 2094	unknown	Outfall No. 2094 is a pipe of unresolved origin and/or use within the Norfolk SCA boundary.	No historical operations were reported.	No environmental or source-tracing investigations were reported.	No remedial or source control activities were reported.

Source: Ecology and Environment (2007a), Ecology (2007b)

[a] Major outfalls listed are those discussed as individual source control entities in the data gaps report (2007a) and the SCAP (2007b).

[b] A City pump station EOF also discharges through this outfall.

BDC – Boeing Developmental Center
CSO – combined sewer overflow
SCA – source control area
SD – storm drain
SWPPP – storm water pollution prevention plan

Several remedial activities and environmental investigations have been completed or are currently in progress within the Norfolk CSO/SD SCA (Tables I-55 and I-56, Map I-36). These investigations have detected some of the chemicals that occur at concentrations above the SQS in surface sediment within this SCA in various upland media, including soil, groundwater, stormwater, and source-tracing solids (Table I-57). The availability of data (by media type) is also presented in the table on Map I-36 for each facility associated with this SCA. An X in Table I-57 and the table on Map I-36 indicates that the source documents reported data or indicated that data exist; therefore, an X does not necessarily mean that the actual data were presented in the source document. Data are only summarized in media-specific and source-tracing tables if the data were reported in the source documents and if they met the criteria for data summation discussed in the introduction to this appendix (e.g., soil data were collected along the SCA shoreline; groundwater data were collected from shoreline facilities). The identification of a chemical in these media at facilities or within the drainage systems does not necessarily indicate that these potential sources contributed to sediment contamination in the past or that they will result in sediment contamination in the future.

Table I-57. Chemicals identified in various media in the Norfolk CSO/SDSCA

Chemical[a]	Soil	Groundwater	Seep[b]	Porewater[b]	Stormwater	Source-Tracing Samples	Sources
Fluoranthene						X	Ecology and Environment (2007a)
BBP						X	Ecology and Environment (2007a)
BEHP						X	Schmoyer (2008d)
1,4-dichlorobenzene	X[c]	X[c]				X	Ecology and Environment (2007a)
Total PCBs	X				X	X	Ecology (2007c)

Note: An X indicates that the source documents reported that data are available for the identified media. The absence of an X in any cell in this table does not necessarily mean that the chemical is absent in the upland media or in source-tracing samples; in many cases, that chemical may not have been analyzed or, if analyzed, could have been present but at concentrations below the RL.

[a] Chemicals included are those with at least one detected exceedance of an SQS in sediment within the SCA identified by Ecology. The chemical list is based on SMS exceedances in the RI baseline surface sediment dataset within the 2007 SCA boundary. Therefore, this list may differ from the list of exceedances in source documents.

[b] No porewater or seep data were identified in the source documents for any chemical.

[c] Unspecified halogenated organic compounds have been identified in soil and groundwater on the Associated Grocers property.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
CSO – combined sewer overflow
PCB – polychlorinated biphenyl
RI – remedial investigation
RL – reporting limit
SCA – source control area
SD – storm drain
SMS – Washington State Sediment Management Standards
SQS – sediment quality standard

This section summarizes the upland data provided in the source documents. No seep or porewater data were reported in the source documents. Soil and groundwater data are not presented in this section because the samples were not collected along the bank (soil) or from adjacent properties (groundwater) or actual data were not provided in the source documents.

If sufficient data for this SCA were available in the source documents, ranges of detected concentrations, median concentrations, and sample counts (n) are provided accordingly. In some instances, the source documents acknowledge the existence of certain data but do not provide actual concentrations. Data were included in the tables only if specific concentrations or a range of concentrations were included in the source documents. Table I-58 summarizes stormwater data as presented in the source documents.

Table I-58. Summary of chemical concentrations detected in stormwater in the Norfolk CSO/SD SCA

Facility	Chemical[a, b]	Year Collected	Location	Concentration Information (µg/L)[c, d]	Sources[e]	Additional Information
Boeing Developmental Center	total PCBs	2001	south end of property	4.2[f] n = 1/1	Project Performance Corporation (2001) as cited in Ecology and Environment (2007a)	Concentration presented is for Aroclor 1248 in a water sample (with suspended sediments) collected from a manhole within the south storm drain system.

Source: Ecology and Environment (2007a)

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Norfolk SCA.

[b] Fluoranthene, BBP, BEHP, and 1,4 dichlorobenzene were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

[f] Two samples were collected at the end-of-pipe. PCBs were not detected in either sample at an RL of 1 µg/L (Project Performance Corporation 2001).

BBP – butyl benzyl phthalate
BDC – Boeing Developmental Center
BEHP – bis(2-ethylhexyl) phthalate
CSO – combined sewer overflow
PCB – polychlorinated biphenyl
SCA – source control area
SD – storm drain
SQS – sediment quality standard

Most source-tracing data were collected between 2000 and 2007 because many of the source-tracing programs within the LDW were initiated within this time period.[34] Data relevant to source-tracing efforts include data from various sample types, including catch basin samples, samples of joint caulking and other construction materials, and in-line sediment samples. When multiple rounds of data were collected from the same sampling location, only the most recent round was selected for presentation in order to represent current conditions. Map I-36 shows the locations of storm drain lines on the properties upland of the Norfolk CSO/SD SCA. Additional details about source-tracing sampling programs conducted in the Norfolk CSO/SD SCA and the larger LDW drainage basin are presented in Section 9.4.4.7. Table I-59 summarizes source-tracing data as presented in the source documents. Map I-37 shows the locations of source-tracing samples for this SCA.

[34] Data from 2008 are not included in Table I-59. Many of the 2008 data are not yet validated or are otherwise not yet ready for use.

Table I-59. Summary of chemical concentrations detected in source-tracing samples in the Norfolk CSO/SD SCA

Sample Source	Year	Concentration Information (µg/kg dw)[a, b, c]					Sources[d]	Additional Information
		Fluoranthene	BEHP	BBP	1,4-Dichloro-benzene	Total PCBs		
Onsite Catch Basin Solids Samples								
Norfolk CSO/EOF/SD	2005	290 – 130,000 median = 6,100 n = 5/5	4,100 – 45,000 median = 13,000 n = 5/5	450 – 4,600 median = 750 n = 4/5	nr	320 n = 1/5	Schmoyer (2008d)	Samples were collected in the southern portion of the Norfolk SD basin.
BDC south storm drain (No. 2093)	2000	nr	nr	nr	nr	190 – 760,000 (initial analysis) 300 – 1,100,000 (split analysis) median = nr n = nr	Project Performance Corporation (2001), as cited in Ecology and Environment (2007a)	Concentrations presented are for Aroclor 1254. Samples were collected from catch basins and manholes within the BDC south storm drain system.
BDC south storm drain (No. 2093)	2001	nr	nr	nr	nr	2,600, 3,700 n = 2/nr	Project Performance Corporation (2001), as cited in Ecology and Environment (2007a)	Concentrations presented are for Aroclor 1254 in organic sludge/solids samples within the BDC south storm drain system.
ROW Catch Basin Solids Samples								
Norfolk CSO/EOF/SD	2007	99, 140 n = 2/4	270 – 2,700 median = 570 n = 4/4	640 n = 1/4	nr	nd	Schmoyer (2008d)	
Norfolk CSO/EOF/SD	2004	1,300 n = 1/1	21,000 n = 1/1	350 n = 1/1	nr	138 n = 1/1	Schmoyer (2008d)	
In-Line Sediment Samples								
Norfolk CSO/EOF/SD	2007	130 – 2,000 median = 1,065 n = 4/4	82 – 7,500 median = 2,960 n = 4/4	370 n = 1/4	nr	50 – 150 median = 68 n = 3/4	Schmoyer (2008d)	
Norfolk CSO/EOF/SD	2005	230 – 8,200 median = 3,300 n = 3/3	400 – 28,000 median = 22,000 n = 3/3	nd	nr	25, 110 n = 2/3	Schmoyer (2008d)	Samples were collected from three manholes.
Norfolk CSO/EOF/SD	2004	450 n = 1/2	63, 620 n = 2/2	nd	nr	108 n = 1/2	Schmoyer (2008d)	Samples were collected from WSDOT stormwater treatment pond.
Norfolk CSO/EOF/SD	2003	790, 1,800 n = 2/2	6,800, 24,000 n = 2/2	1,900 n = 1/1	nr	43, 79 n = 2/2	Schmoyer (2008d)	

Table I-59, cont. Summary of chemical concentrations detected in source tracing samples in the Norfolk CSO/SD SCA

Sample Source	Year	Concentration Information (µg/kg dw)[a, b, c]					Sources[d]	Additional Information
		Fluoranthene	BEHP	BBP	1,4-Dichloro-benzene	Total PCBs		
BDC south storm drain (No. 2093)	2004	nr	nr	nr	nr	7,100, 20,000 n = 2/2	CALIBRE (2006), as cited in Ecology and Environment (2007a)	Sediment samples were collected from manholes on the BDC property. The sample with the higher concentration was collected upstream of a sediment trap/oil/water separator and the sample with the lower concentration was collected downstream of the separator.
	2005	nr	nr	nr	nr	12,600, 61,500 n = 2/2		
	2006	nr	nr	nr	nr	5,900, 38,000 n = 2/2		
	2007	nr	nr	nr	nr	2,280, 3,200 n = 2/2		
Samples of Joint Caulking and Other Construction Materials								
Military Flight Center	2005	nr	nr	nr	nr	3,900 – 99,000,000 median = nr n = nr	Downey (2005) as cited in Ecology and Environment (2007a)	Nine different types of joint caulking material were identified and sampled at the BDC.
BDC south storm drain (No. 2093)	2001	nr	nr	nr	nr	500 – 2,100 median = nr n = nr	Project Performance Corporation (2001) as cited in Ecology and Environment (2007a)	PCB concentrations presented are for Aroclor 1254. Samples of joint caulking material, paint chips, asphalt, etc. were collected along the BDC south storm drain system.

Note: If multiple rounds of data were available for a single location, only the data collected during the most recent event were presented in order to represent the most current conditions possible.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Norfolk CSO/SD SCA.

[b] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/k to µg/kg), the number of significant figures was kept consistent with the number in the reported value.

[c] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[d] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

BBP – butyl benzyl phthalate
BDC – Boeing Developmental Center
BEHP – bis (2-ethylhexyl) phthalate
CSO – combined sewer overflow
dw – dry weight
nd – not detected
nr – non reported
PCB – polychlorinated biphenyl
ROW – right of way
SCA – source control area
SD – storm drain
SPU – Seattle Public Utilities
SD – storm drain
SPU – Seattle Public Utilities
WSDOT – Washington State Department of Transportation

PCB-contaminated sediments offshore of the Norfolk CSO/SD were dredged and capped between February and March 1999. Surface sediment samples collected prior to this action had CSL exceedances of 1,4-dichlorobenzene, mercury, total PCBs, benzoic acid, and BEHP, and SQS exceedances of BBP and several individual PAHs (King County 1996).

Subsequently, four cap locations (NFK501, NFK502, NFK503, and NFK504) were monitored on an annual basis by King County until 2004. These same locations were also sampled in October 2006 as part of the RI (Windward 2007). The monitoring data provide information on the quality of the sediment currently accumulating in this portion of the Norfolk CSO/SD SCA. Table I-60 summarizes chemicals with detected concentrations that exceeded SMS criteria during monitoring (Map I-38). Figure I-1 presents surface sediment data for the 0-to-10-cm interval for total PCBs and BEHP[35] for each of the monitoring locations.

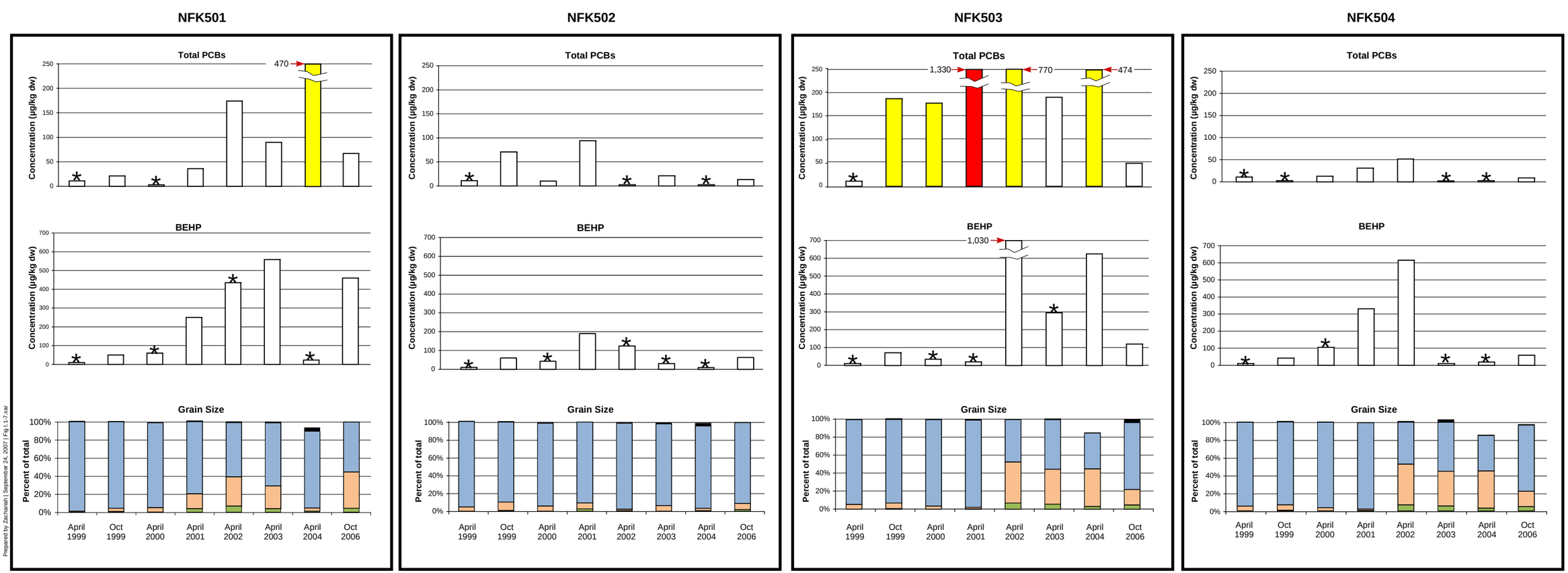
Table I-60. Monitoring information for the Norfolk CSO/SD cap placement area

Sampling Event	Date	Sampling Locations	Detected Chemicals Exceeding SQS	Detected Chemicals Exceeding CSL
Norfolk CSO 5-year monitoring program – post backfill	April 1999	NFK501, NFK502, NFK503, NFK504	none	none
Norfolk CSO 5-year monitoring program – 6-month post construction	October 1999	NFK501, NFK502, NFK503, NFK504	total PCBs	none
Norfolk CSO 5-year monitoring program – supplemental nearshore sampling	February 2000	NFK501, NFK502, NFK503, NFK504[a]	total PCBs	none
Norfolk CSO 5-year monitoring program – 12-month post-construction	April 2000	NFK501, NFK502, NFK503, NFK504	total PCBs	none
Norfolk CSO 5-year monitoring program, year 2	April 2001	NFK501, NFK502, NFK503, NFK504	total PCBs, BBP	total PCBs
Norfolk CSO 5-year monitoring program, year 3	April 2002	NFK501, NFK502, NFK503, NFK504	total PCBs	none
Norfolk CSO 5-year monitoring program, year 4	April 2003	NFK501, NFK502, NFK503, NFK504	none	none
Norfolk CSO 5-year monitoring program, year 5	April 2004	NFK501, NFK502, NFK503, NFK504	total PCBs	none
LDW RI – surface sediment sampling for chemical analyses	October 2006	LDW-SS341, LDW-SS342, LDW-SS343, LDW-SS344	none	none

[a] Samples were also collected at locations NFK505, NFK506, NFK507, NFK508 during this event. BEHP (NFK507), BBP (NFK507), and total PCBs (NFK507 and NFK508) exceeded the CSL. Exceedances for these locations were not included because they were located outside of the dredging limits and cannot be compared to other years.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
CSL – cleanup screening level
CSO – combined sewer overflow
LDW – Lower Duwamish Waterway
PCB – polychlorinated biphenyl
SD – storm drain
SQS – sediment quality standard
RI – remedial investigation

[35] Other analytes were also included in the monitoring program, but results have been limited to total PCBs and BEHP to focus the discussion.



Legend

SQS/CSL category

- > CSL
- > SQS, ≤ CSL
- ≤ SQS
- ⋆ Chemical was not detected at this location (one-half RL)

Concentrations are presented in µg/kg dw for the 0-to-10-cm depth interval surface sediment samples. SQS and CSL exceedances are based on OC-normalized concentrations if TOC is ≥ 0.5% and ≤ 4.0%. For samples with TOC < 0.5% or > 4.0%, the dry weight concentrations were compared to AETs to determine the exceedance status.

Grain size

- Gravel
- Sand
- Silt
- Clay

Because of the inherent imprecision in measuring each grain size category using multiple sieves, it is common for the calculated total of all size categories to range between 90% and 110% for any given sample.

Wind Ward environmental LLC

Figure I-1. Changes in total PCB and BEHP concentrations and grain size over time at four monitoring locations near the Norfolk CSO and BDC South storm drain

PCB-contaminated sediments offshore of the Boeing Developmental Center's south storm drain outfall (No. 2093) were removed and capped by Boeing in 2003 (Map I-38). Three locations on the cap offshore of the south storm drain were monitored for PCBs in surface sediment in 2004, 2005, and 2007 (Map I-38), including S01**,** the location that had the highest PCB concentration (46,000 µg/kg dw) after sediment removal but before cap placement. Table I-61 summarizes chemicals with detected concentrations that exceeded SMS criteria during monitoring.

Table I-61. Monitoring information for the BDC south storm drain cap placement area

SAMPLING EVENT	DATE	SAMPLING LOCATIONS	DETECTED CHEMICALS EXCEEDING SQS	DETECTED CHEMICALS EXCEEDING CSL
BDC monitoring	September 2004	S01, S02, S03	none	none
BDC monitoring	November 2005	S01, S02, S03	total PCBs	none
BDC monitoring	June 2007	S01, S02, S03	total PCBs	none

BDC – Boeing Developmental Center
CSL – cleanup screening level
PCB – polychlorinated biphenyl
SQS – sediment quality standards

PCBs were detected only at location S01 in 2004 and 2005, but at concentrations lower than those detected before the remedial action. In 2005, total PCB concentrations exceeded the SQS at location S01, but the field duplicate sample at this location did not contain a detectable concentration of PCBs at an RL of 32 µg/kg dw. In 2007, total PCB concentrations at S01 were lower than in 2005 although still marginally above the SQS (CALIBRE 2005, 2006, 2007, 2008).

Source control activities, including environmental investigations and source-tracing efforts, are ongoing within the Norfolk CSO/SD SCA. Additional information on the Norfolk CSO/SD SCA is provided on Ecology's website.

I.4.9 GLACIER BAY SOURCE CONTROL AREA (RM 1.2 W TO RM 1.5 W)

The Glacier Bay SCA is one of 23 areas identified by Ecology along the LDW for source control evaluation. Since the late 1980s, various soil, groundwater, source-tracing, and sediment investigations have been conducted within the Glacier Bay SCA. As part of the ongoing source control efforts for this SCA, a data gaps report (SAIC 2007d) and a SCAP (Ecology 2007e) were prepared in 2007. Information relevant to the Glacier Bay SCA was also available in the 2004 seep survey completed as part of the RI (Windward 2004) and in source-tracing information provided by the City of Seattle (Schmoyer 2008d). These documents are collectively referred to as the "source documents" throughout this section and on associated maps.

CSL exceedances in the surface sediment in this SCA included total PCBs, arsenic, copper, lead, mercury, and zinc. SQS exceedances included BBP, BEHP, acenaphthene, chrysene, fluoranthene, phenanthrene, benzo(g,h,i,)perylene, indeno(1,2,3,-cd)pyrene,

total HPAHs, and pentachlorophenol. Dioxins and furans were also detected in the SCA area at concentrations that were the highest reported for the LDW (Schmoyer 2008d). These exceedances are based on the RI baseline surface sediment dataset and the 2007 SCA boundary, as discussed in the introduction to this appendix. Ecology has identified COCs for this SCA based on different criteria (Table I-3); therefore, the chemicals identified for summary in this appendix are different than the COCs identified by Ecology. Surface sediment chemistry information for the Glacier Bay SCA is provided on Map I-39.

Commercial and industrial operations in the vicinity of the Glacier Bay SCA include cargo handling and storage (historical and current), vessel repair and maintenance (historical), concrete manufacturing (historical and current), lumber milling (historical), charcoal production (historical), glue and resin manufacturing (historical), and tin reclamation (historical) (SAIC 2007d).

Several adjacent and upland facilities were discussed in source documents associated with the Glacier Bay SCA. Adjacent facilities included Alaska Marine Lines, the former Duwamish Shipyard, Glacier Northwest, and the former MRI Corporation. Upland properties identified in the source documents included the Chemithon Corporation, several additional parcels owned by Alaska Marine Lines to the west of W Marginal Way SW, the vacant Wise Property, the DV Klier parcel, the Allen property, the Sayler property, and two parcels owned by the City of Seattle Parks Department. Table I-62 summarizes facility-specific information for the adjacent facilities associated with the Glacier Bay SCA. With the exception of the Chemithon Corporation property, no upland properties are discussed in this section because of the lack of source-tracing information (see the introduction for more information on facility selection criteria); these properties are also not labeled on Maps I-39 or I-40 because they were not adjacent to the shoreline and did not have available source-tracing data. The data gaps report and SCAP present additional information on all facilities associated with this SCA.

Table I-62. Summary of facility information for the Glacier Bay SCA

Facility[a]	Current Ownership	Current Operations	Historical Operations	Environmental Investigations	Remedial Activities	Source Control Activities/ Investigations
Alaska Marine Lines (six parcels total)	Alaska Marine Lines (owned by Lynden)	container freight, barge terminal, and warehouse; fueling of onsite equipment; vehicle maintenance	graving dock operations, barge terminal	Several environmental investigations have been completed related to UST issues, test pitting in a former storage area, and general site characterization.	Several USTs and associated contaminated soil have been removed.	Groundwater sampling to assess historical contaminant sources is scheduled, inspections to follow up on previous concerns, NPDES permit compliance reviews, and graving dock remediation program verification.
Chemithon Corporation	Chemithon Corporation	design of surfactant plants; sales and service; new product and equipment testing	no information available	SPU completed site inspections at the property.	No remedial activities were reported.	Source-tracing sampling of storm drain system is completed. PCBs found in storm drain traced to old paint. Runoff from a large portion of this property was disconnected from the combined system in 2007 and now discharges to the LDW. Update to SWPPP underway; follow-up inspections scheduled.
Duwamish Shipyard	Duwamish Shipyard	equipment and container storage (tenant is Alaska Marine Lines)	shipyard operations, including repair and maintenance	Numerous environmental investigations have been completed involving general site characterization and assessment of spilled materials (sandblast grit; waste oil), illicit discharges (untreated wastewater), NPDES compliance (numerous discharge violations noted), and outfall effluent. An RI/FS will be conducted on the property under a MTCA order (Good 2009).	Four USTs and contaminated soil were removed in 2000. Ecology is negotiating an Agreed Order for this facility; a draft CAP will be included as part of the order, and additional remedial activities will be conducted (Good 2009).	Source control activities have included catch basin sampling and storm drain system cleaning. The Agreed Order will address further site characterization and source control requirements, if necessary.

Table I-62, cont. Summary of facility information for the Glacier Bay SCA

Facility[a]	Current Ownership	Current Operations	Historical Operations	Environmental Investigations	Remedial Activities	Source Control Activities/ Investigations
Glacier Northwest	Glacier Northwest	cement production and terminal; construction and lumber yard operations; truck stop	lumber plant; charcoal filter and whetlerite production; production of adhesives, water-soluble glues, formaldehyde, wood-preserving resins, pentachlorophenol, hydrochloric acid, plastic polymers; cement terminal operations	Several environmental investigations have been completed including soil and groundwater sampling of the former impoundment area, truck washout area, and tank farm. Seep samples have also been analyzed. An RI/FS will be conducted on the property under a MTCA order (Good 2009).	Remedial activities have been conducted, but documents were not available for review. Ecology is negotiating an Agreed Order for this facility; a draft CAP will be included as part of the order (Good 2009).	Additional site investigation will be implemented. Source control inspections (including stormwater pathway) are underway.
MRI Corporation (former)	Port of Seattle (T-115)	building material distribution (Polar Supply Company under lease from the Port of Seattle)	tin reclamation	Several investigations have been completed to date, including an analysis of stockpiled black mud and general site characterization (including areas of two former unlined settling/evaporation lagoons). An RI/FS will be conducted on the property under a MTCA order (Good 2009).	No remedial activities were reported. Ecology is planning to negotiate an Agreed Order for this facility; a draft CAP will be included as part of the order (Good 2009).	Ongoing source-tracing inspections will be completed. Additional investigation into potential for groundwater/ stormwater transport to Glacier Bay will be investigated.

Sources: SAIC (2007d); Ecology(2007e)

[a] Facilities listed are those identified as adjacent properties in the data gaps report (SAIC 2007d) and the SCAP (Ecology 2007e). The Chemithon Corporation (identified as an upland property in the source documents) is also included because source-tracing data were reported in the source documentation.

CAP – cleanup action plan
FS – feasibility study
LDW – Lower Duwamish Waterway
MTCA – Model Toxics Control Act
NPDES – National Pollutant Discharge Elimination System
PAH – polycyclic aromatic hydrocarbons
PCB – polychlorinated biphenyls
RI – remedial investigation
SCA – source control area
SPU – Seattle Public Utilities
SWPPP – stormwater pollution prevention plan
T-115 – Terminal 115
UST – underground storage tank

Numerous active outfalls that discharge stormwater to the LDW have been identified along the shoreline of the Glacier Bay SCA (Herrera 2004). Most of the stormwater from adjacent properties associated with this SCA is collected in catch basins and runs through various private storm drain systems (many of which have operating oil/water separators) prior to discharging to the LDW. In addition to the privately owned storm drain systems, a city-owned storm drain line collects stormwater from approximately 164 ac of land along W Marginal Way SW, including portions of Terminal 115 (T-115), prior to discharge to the LDW, via a 48-in. pipe that traverses the border between the Glacier Northwest and T-115 properties (No. 2127) (SPU 2008). Some of the stormwater from adjacent facilities in the area also discharges into this city-owned stormwater line. In addition, King County's T-115 CSO also discharges through this 48-in. pipe during an overflow event. This city-owned outfall, with potential contributions from the T-115 CSO, is discussed as a major outfall in the source documents.

In addition to the major public outfall, seven privately owned outfalls were identified along the shoreline of this SCA during the 2003 outfall survey, including five at Alaska Marine Lines (Nos. 2132 to 2136), one at the former Duwamish Shipyard (No. 2129), and one at Glacier Northwest (No. 2130) (Herrera 2004). Information in the source documentation points to the existence of additional outfalls at the Alaska Marine Line and the former Duwamish Shipyard properties, which is inconsistent with the results of the outfall survey. Only information on those outfalls identified in the outfall survey is discussed in this section.

A Port of Seattle outfall (No. 2128) collects stormwater from the northern portion of T-115 and discharges into Glacier Bay. This outfall may also collect some of the stormwater from the area of the former MRI Corporation property. Information on the outfalls within the Glacier Bay SCA is included in Table I-63 and the locations of these outfalls are provided on Map I-39; additional outfall information is provided in Appendix H.

Table I-63. Summary of specific information for outfalls in the Glacier Bay SCA

Outfall	Current Ownership	Current Operations	Historical Operations	Environmental and Source-Tracing Investigations	Remedial and Source Control Activities
Outfalls Identified in the SCAP and Data Gaps Report as Major Outfalls[a]					
King County T-115 CSO/City of Seattle SW Kenny St SD (No. 2127)	King County/City of Seattle	Outfall (48-in.) drains approximately 164 ac along W Marginal Way SW with contributions from, Alaska Marine Lines, Glacier Northwest, and T-115. King County's T-115 CSO discharges through this 48-in pipe.	Outfall used to collect stormwater from public ROW and neighboring industrial facilities. Outfall was also the discharge point for the T-115 CSO.	ROW catch basin sampling within the SW Kenny St basin was conducted in 2006.	SPU collected samples from 4 ROW catch basins within SW Kenny Street SD basin in 2006. A sediment trap was installed in 2008. One inline grab and one trap sample have been collected at this location
Other Outfalls					
Alaska Marine Lines outfalls (Nos. 2132 to 2136)[b]	Alaska Marine Lines	Discharge is directed through sand filtration and O/W separator.	Outfall used to collect stormwater from industrial area and graving dock (graving dock previously owned by Duwamish Shipyard).	No environmental or source-tracing investigations were reported.	No remedial or source control activities were reported.
Duwamish Shipyard private outfall (No. 2129)[c]	Duwamish Shipyard	Outfall collects stormwater from southern portion of property.	Outfall used to collect stormwater from industrial area along the southern portion of the property.	Catch basin samples and NPDES point of compliance samples were collected in 2006.	Additional NPDES compliance samples are scheduled for collection based on permit requirements.
Glacier Northwest private outfall (No. 2130)	Glacier Northwest	Outfall drains eastern portions of property that do not drain into W Marginal Way SW mainline.	Outfall used to collect stormwater from eastern portion of industrial property.	No environmental or source-tracing investigations were reported.	No remedial or source control activities were reported.
Port of Seattle outfall (No. 2128)[d]	Port of Seattle	Outfall drains northern portion of T-115 with discharge into Glacier Bay via Glacier Northwest property.	Outfall used to collect stormwater from the northern portion of T-115 (with potential contributions from the former MRI Corporation site).	No environmental or source-tracing investigations were reported.	No remedial or source control activities were reported.

Sources: SAIC (2007d); Ecology (2007e)

[a] Major outfalls listed are those discussed as individual source control entities in the source documents.

[b] Outfall Nos. 2133, 2135, and 2136 are associated with a graving dock previously owned and operated by Duwamish Shipyard. Outfalls are identified on Duwamish Shipyard's NPDES permit; the graving dock is now inactive.

Table I-63, cont. Summary of specific information for outfalls in the Glacier Bay SCA

[c] The outfall survey completed by Herrera (2004) identified one outfall associated with this property; Duwamish Shipyard NPDES documentation included in the source documentation notes that there are four active outfalls at the Duwamish Shipyard (in addition to those originally associated with the former graving dock), which is inconsistent with the information developed from the outfall survey. Only information on the one outfall identified during the 2004 survey is discussed in this table.

[d] T-115 is not identified as an adjacent property in the source documents; however, because this outfall discharges into Glacier Bay, it is included in this table.

CSO – combined sewer overflow
NPDES – National Pollutant Discharge Elimination System
O/W – oil/water
ROW – right-of-way
SAIC – Science Applications International Corporation
SCAP – source control action plan
SD – storm drain
T-115 – Terminal 115

Several remedial activities and environmental investigations have been completed or are currently in progress within the Glacier Bay SCA (Tables I-62 and I-63). Information about these activities has been summarized in the source documents and is provided on Map I-40. Several of the chemicals that have been detected above the SQS in Glacier Bay SCA surface sediment have also been detected in various upland media, including soil, groundwater, seep, and source-tracing samples (Table I-64). The availability of data (by media type) is also presented in the table on Map I-40 for each of the facilities in Table I-62 and the major outfall associated with this SCA. An X on Table I-64 and the table on Map I-40 indicates that the source documents reported data or indicated that data exist; therefore, an X does not necessarily mean that the actual data were presented in the source document. Data are only summarized in media-specific and source-tracing tables if the data were reported in the source documents and if they met the criteria for data summation discussed in the introduction to this appendix (e.g., soil data were collected along the SCA shoreline; groundwater data were collected from shoreline facilities). The identification of a chemical in these media at facilities or within the drainage systems of the Glacier Bay SCA does not necessarily indicate that these potential sources contributed to sediment contamination in the past or that they will result in sediment contamination in the future.

Table I-64. Chemicals identified in various media in the Glacier Bay SCA

Chemical[a]	Soil	Groundwater	Seep	Porewater[b]	Stormwater	Source-Tracing Samples	Sources
Arsenic	X	X	X			X	SAIC (2007d), Windward (2004), Schmoyer (2008d)
Copper			X		X	X	SAIC (2007d), Windward (2004), Schmoyer (2008a)
Lead	X	X	X			X	SAIC (2007d), Windward (2004), Schmoyer (2008a)
Mercury	X	X	X			X	SAIC (2007d), Windward (2004), Schmoyer (2008d)
Zinc	X	X	X		X	X	SAIC (2007d), Windward (2004), Schmoyer (2008d)
Acenaphthene	X					X	SAIC (2007d), Schmoyer (2008d)
Chrysene	X					X	SAIC (2007d), Schmoyer (2008d)
Benzo(g,h,i)pyrene	X					X	SAIC (2007d), Schmoyer (2008d)
Fluoranthene						X	SAIC (2007d), Schmoyer (2008d)
Indeno (1,2,3-cd)pyrene	X					X	SAIC (2007d), Schmoyer (2008a)
Phenanthrene	X					X	SAIC (2007d), Schmoyer (2008d)
Total HPAHs						X	Schmoyer (2008d)
BBP						X	SAIC (2007d), Schmoyer (2008d)
BEHP						X	SAIC (2007d), Schmoyer (2008d)
PCP		X					SAIC (2007d)

Chemical[a]	Soil	Groundwater	Seep	Porewater[b]	Stormwater	Source-Tracing Samples	Sources
Total PCBs	X					X	SAIC (2007d), Schmoyer (2008d)
Dioxins and furans[c]	X						SAIC (2007d)

Note: An X indicates that the source documents reported that data are available for the identified media. The absence of an X in any cell in this table does not necessarily mean that the chemical is absent in the upland media or in source-tracing samples; in many cases, that chemical may not have been analyzed or, if analyzed, could have been present but at concentrations below the RL.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Glacier Bay SCA. The chemical list is based on SMS exceedances in the RI baseline surface sediment dataset within the 2007 SCA boundary. Therefore, this list may differ from the list of exceedances in source documents.

[b] No porewater data were identified in the source documents for any chemical.

[c] SMS do not exist for dioxins and furans. They were included in this table because they are a risk driver chemical with highly elevated concentrations (i.e., TEQ > 100 ng/kg dw) in surface sediment in this area.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
HPAH – high-molecular-weight polycyclic aromatic hydrocarbons
PCB – polychlorinated biphenyl
PCP – pentachlorophenol
RL – reporting limit
SCA – source control area
SQS – sediment quality standard
TEQ – toxic equivalent

The following is a summary of the upland data as they were presented in the source documents for groundwater, seep, and source-tracing samples. No actual bank soil, porewater, or stormwater data were provided in the source documents for this area.

If sufficient data for this SCA were available in the Glacier Bay source documents, ranges of detected concentrations, median concentrations, and sample counts (n) are provided accordingly. In some instances, the source documents acknowledged the existence of certain data but did not provide actual concentrations. Data were included in these tables only if specific concentrations or a range of concentrations were included in the source documents.

Groundwater data collected in close proximity to the LDW (from shoreline properties Duwamish Shipyard and Glacier Northwest) are summarized in Table I-65 based on data presented in the data gaps report (2007d). Groundwater sampling was completed at Glacier Northwest in 1990 and at Duwamish Shipyard in 2006. In addition to groundwater information for those chemicals detected above the SQS in surface sediment in this SCA, Table I-65 also includes groundwater VOC data provided in the source documents. Seep sampling was conducted along the shoreline of Glacier Bay in 1995 and in 2004 as part of the RI (Windward 2004). Seep samples with detected concentrations of chemicals that exceeded the SQS in the Glacier Bay SCA surface sediment are presented in Table I-66.

Table I-65. Summary of chemical concentrations detected in groundwater samples from the Glacier Bay SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Chemicals with Detections Above the SQS in Surface Sediment						
Duwamish Shipyard	arsenic	2006	6.7 – 84.4 median = 11.2 n = 9/12	multiple groundwater wells throughout the facility	Anchor (2006), as cited in SAIC (2007d)	Source documents did not indicate whether these samples were total or dissolved.
Duwamish Shipyard	lead	2006	27 – 55 n = 2/2	multiple groundwater wells throughout the facility	Anchor (2006), as cited in SAIC (2007d)	Source documents did not indicate whether these samples were total or dissolved.
Glacier Northwest	arsenic	1990	150 – 330 n = 2/3	three wells on facility	Parametrix (1990), as cited in SAIC (2007d)	Source documents did not indicate whether these samples were total or dissolved.
Glacier Northwest	PCP	1990	2,800 – 3,000 n = 2/4	two wells; two sampling events	Parametrix (1990), as cited in SAIC (2007d)	Two wells were sampled for pentachlorophenol subsequent to the initial groundwater event. The range represents the range of detected values from same well over two sampling events.
VOCs[f]						
Alaska Marine Lines	benzene	1990	330 n= 1/1	collected within UST excavation	Dames and Moore (1991), as cited in SAIC (2007d)	Water sample collected from base of excavation after UST removal.
Duwamish Shipyard	benzene	2006	180 – 210 n = 2/12	multiple groundwater wells throughout the facility	Anchor (2006), as cited in SAIC (2007d)	
Duwamish Shipyard	vinyl chloride	2006	0.3 – 0.6 median = 0.4 n = 3/12	multiple groundwater wells throughout the facility	Anchor (2006), as cited in SAIC (2007d)	

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Glacier Bay SCA.

[b] Total PCBs, copper, mercury, zinc, BBP, BEHP, acenaphthene, benzo(g,h,i)perylene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAH, and dioxins/furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

[f] VOC data were summarized, as available, at EPA's request and not because of SQS exceedances in surface sediment in the SCA.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PCP – pentachlorophenol
SAIC – Science Applications International Corporation
SCA – source control area
SQS – sediment quality standard
UST – underground storage tank

Table I-66. Summary of chemical concentrations detected in seep samples from the Glacier Bay SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources[e]	Additional Information
Glacier Northwest	arsenic	1995	82 – 85[f] n = 2/2	two seep locations	Hart Crowser (1996), as cited in SAIC (2007d)	Exact locations of seep sample collection not provided in source documents.
Glacier Northwest	arsenic	2004	67.2 (total) n = 1/1	sample collected from western shoreline of Glacier Bay	Windward (2004)	Seep sample was collected as part of LDW RI.
Glacier Northwest	arsenic	2004	72.4 (dissolved) n = 1/1	sample collected from western shoreline of Glacier Bay	Windward (2004)	Seep sample was collected as part of LDW RI.
Glacier Northwest	arsenic	2004	6.84 (dissolved) n = 1/1	sample collected from northwest shoreline of Glacier Bay	Windward (2004)	Seep sample was collected as part of LDW RI; total sample not analyzed.
Glacier Northwest	lead	2004	0.240 (total) n = 1/1	sample collected from western shoreline of Glacier Bay	Windward (2004)	Seep sample was collected as part of LDW RI.
Glacier Northwest	lead	2004	0.088 (dissolved) n = 1/1	sample collected from western shoreline of Glacier Bay	Windward (2004)	Seep sample was collected as part of LDW RI.
Glacier Northwest	lead	2004	0.1 (dissolved) n = 1/1	sample collected from northwest shoreline of Glacier Bay	Windward (2004)	Seep sample was collected as part of LDW RI; total sample not analyzed.
Glacier Northwest	mercury	2004	0.00216 (total) n = 1/1	sample collected from western shoreline of Glacier Bay	Windward (2004)	Seep sample was collected as part of LDW RI.
Glacier Northwest	mercury	2004	0.00099 (dissolved) n = 1/1	sample collected from western shoreline of Glacier Bay	Windward (2004)	Seep sample was collected as part of LDW RI.
Glacier Northwest	mercury	2004	0.00256 (dissolved) n = 1/1	sample collected from northwest shoreline of Glacier Bay	Windward (2004)	Seep sample was collected as part of LDW RI; total sample not analyzed.
Glacier Northwest	zinc	2004	3.49 (total) n = 1/1	sample collected from western shoreline of Glacier Bay	Windward (2004)	Seep sample was collected as part of LDW RI.
Glacier Northwest	zinc	2004	3.29 (dissolved) n = 1/1	sample collected from western shoreline of Glacier Bay	Windward (2004)	Seep sample was collected as part of LDW RI.

Table I-66, cont. Summary of chemical concentrations detected in seep samples from the Glacier Bay SCA

FACILITY	CHEMICAL[a, b]	YEAR COLLECTED	CONCENTRATION INFORMATION (µg/L)[c, d]	LOCATION	SOURCES[e]	ADDITIONAL INFORMATION
Glacier Northwest	zinc	2004	12.2 (dissolved) n = 1/1	sample collected from northwest shoreline of Glacier Bay	Windward (2004)	Seep sample was collected as part of LDW RI; total sample was not analyzed.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Glacier Bay SCA.

[b] Copper, BBP, BEHP, acenaphthene, benzo(g,h,i)perylene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, PCP, total HPAH, and dioxins and furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples. Concentration ranges were calculated using only detected data. For this reason, some estimated ranges may be higher than actual concentrations.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

[f] It was not reported if the sample was filtered.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LDW – Lower Duwamish Waterway
PCP – pentachlorophenol
RI – remedial investigation
SAIC – Science Applications International Corporation
SCA – source control area
SQS – sediment quality standard

Source-tracing samples have been collected from the Duwamish Shipyard and Chemithon Corporation facilities and from the storm drain systems associated with the Glacier Bay SCA (see table on Map I-40), and data from these samples are available in the source documents. Table I-67 presents source-tracing data collected within the Glacier Bay SCA since 2004 in order to represent relatively current conditions; 2004 was selected because most of the data have been collected since 2004. Data collected prior to 2004 were included in Table I-67 only if newer data from the same sampling locations were not available. Source-tracing samples include onsite catch basin solids samples and right-of-way (ROW) catch basin solids samples. Information on the drainage basin area in which the ROW samples were collected and the basin's point of discharge is presented on Map I-41. Additional details on source-tracing sampling programs conducted within the Glacier Bay SCA are presented in Section 9.4.4.7. SPU has inspected several businesses within this area as part of ongoing source control efforts. The business inspection program is discussed in Section 9.4.4.5.

Table I-67. Summary of chemical concentrations detected in source-tracing samples from the Glacier Bay SCA

Sample Source	Year Collected	Concentration Information (mg/kg dw)[a, b, c, d]					Concentration Information (µg/kg dw unless noted)[a, b, c, d]		Sources[e]	Additional Information
		Arsenic	Copper	Lead	Mercury	Zinc	Acenaphthene	Benzo(g,h,i)perylene		
Catch Basin Solids Samples										
Duwamish Shipyard	2006	nr	2,450	nr	1.05	2,600	22.6 mg/kg OC	nr	Anchor (2006), as cited in SAIC (2007d)	
Chemithon Catch Basins	2006-2007	7 – 150 median = 30 n = 8/9	139 – 1,820 median = 734 n = 9/9	47 – 1,760 median = 185 n = 9/9	0.07 – 9.4 median = 0.31 n = 9/9	314 – 3,290 median = 1,380 n = 9/9	58 – 530 median = 200 n = 5/9	100 – 2,100 median = 380 n = 9/9	Schmoyer (2008d)	
ROW Catch Basin Solids Samples										
SW Kenny Street SD	2006	7 – 20 median = 11 n = 4/4	36 – 183 median = 77 n = 4/4	11 – 402 median = 31 n = 4/4	0.09 n = 1/4	78 – 635 median = 315 n = 4/4	nr	160 – 3,500 n = 2/4	Schmoyer (2008d)	Samples were collected along W Marginal Way SW ROW. SPU installed a sediment trap in Kenny SD in 2008 under a grant with Ecology. Trap sample was retrieved in 2009.

Sample Source	Year Collected	Concentration Information (µg/kg dw unless noted)[a, b, c, d]								Sources[e]	Additional Information
		Chrysene	Fluoranthene	Indeno(1,2,3-cd)pyrene	Phenanthrene	Total HPAH	BEHP	BBP	Total PCBs		
Catch Basin Solids Samples											
Duwamish Shipyard	2006	nr	nr	nr	nr	nr	488 mg/kg OC	14.3 mg/kg OC	na	Anchor(2006), as cited in SAIC(2007d)	
Chemithon Catch Basins	2006-2007	240 – 7,000 median = 1,400 n = 9/9	560 – 16,000 median = 2,600 n = 9/9	92 – 2,200 median = 410 n = 9/9	150 – 7,000 median = 1,500 n = 9/9	nr	1,100 – 65,000 median = 5,050 n = 8/9	220 – 5,200 median = 1,000 n = 8/9	440 – 7,000 median = 1,450 n = 8/9	Schmoyer (2008d)	
ROW Catch Basin Samples											
SW Kenny Street SD	2006	220 – 4,900 median = 270 n = 3/4	180 – 5,700 median = 460 n = 3/4	130 – 3,300 n = 2/4	69 – 2,500 median = 400 n = 3/4	600 – 36,520 median = 2,052 n = 3/4	190 – 3,800 median = 1,000 n = 4/4	60 – 1,100 median = 325 n = 3/4	10 – 58 median = 27 n = 2/4	Schmoyer (2008d)	Samples were collected along W Marginal Way SW ROW. SPU installed a sediment trap in Kenny SD in 2008 under a grant with Ecology. Trap sample was retrieved in 2009.

Note: Data are not included for drainage structures that have been removed subsequent to sampling. If multiple rounds of data were available for a single location, only the data collected during the most recent event were presented in order to represent the most current conditions possible.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Glacier Bay SCA.

[b] PCP and dioxins and furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (e.g., from µg/kg to mg/kg), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
dw – dry weight
HPAH – high-molecular weight polycyclic aromatic hydrocarbons
nr – not reported
OC – organic carbon
PCB – polychlorinated biphenyl
PCP –pentachlorophenol
ROW – right of way
SAIC – Science Applications International Corporation
SCA – source control area
SQS – sediment quality standard

Source control activities in the LDW are ongoing. Additional characterization and remedial action efforts at facilities associated with the Glacier Bay SCA are scheduled for the future. Additional information on the Glacier Bay SCA is provided on Ecology's website.

I.4.10 TROTSKY INLET SOURCE CONTROL AREA (RM 2.2 W TO RM 2.3 W, EAA 2)

The Trotsky Inlet SCA is one of 23 areas identified by Ecology along the LDW for source evaluation. The Trotsky Inlet was also one of the seven candidate EAAs recommended to EPA and Ecology for early cleanup based on sediment chemistry data (Windward 2003c). As part of ongoing source control efforts at this SCA, a data gaps report was completed in February 2007 (SAIC 2007c) and was used as a basis for the development of a SCAP, which was finalized in June 2007 (Ecology 2007b). In addition, a site characterization activities data report was completed in July of 2007 (SAIC 2007b). Source-tracing data provided by the City of Seattle was also reviewed (Schmoyer 2008d). These three documents and an LDW seep survey conducted for the RI (Windward 2004) are collectively referred to as the "source documents" in this section.

CSL exceedances in surface sediment in this SCA included lead, mercury, total PCBs, and BEHP. SQS exceedances were reported for lead, mercury, zinc, total PCBs, BEHP, and BBP. These exceedances are based on the RI baseline surface sediment dataset and the 2007 SCA boundary, as discussed in the introduction to this appendix. Ecology has identified COCs for this SCA based on different criteria (Table I-3); therefore, the chemicals identified for summary in this appendix are different than the COCs identified by Ecology. This list of chemicals is also different from the COCs identified in the site characterization activities data report (SAIC 2007b) because the data included in that report were not in the RI baseline surface sediment dataset. Surface sediment chemistry information for the Trotsky Inlet SCA is provided on Map I-42. Dioxin and furan data were detected above a TEQ of 100 ng/kg dw in a surface sediment sample within the SCA. No dioxin and furan data were available for upland facilities in the source documents.

Commercial and industrial operations in the vicinity of this SCA include steel drum reconditioning (historical and current), storage (current), terminal operations (current), tractor maintenance (current), shipping container transportation (current), ship dismantling (historical), wrecking and salvaging (historical), wooden vessel construction (historical), sand and gravel batch plant operations (historical), parking (historical), and gravel transport (historical) (Ecology 2007b).

Ecology (2007b) has identified Douglas Management Company (operated as Alaska Marine Lines), Industrial Container Services (Trotsky/former Northwest Cooperage property, hereafter referred to as Trotsky), and the Boyer Towing, Inc., properties, which include three parcels, as adjacent facilities associated with this SCA (Map I-43). Boyer Towing, Inc. owns 13 parcels in the vicinity of the Trotsky Inlet SCA, but only 3

were discussed in this section because these parcels are adjacent to the SCA. Facility-specific information for adjacent properties is summarized in Table I-68. The data gaps reports also identified 26 associated upland properties. Information for Wells Trucking and leasing (an upland property) are also summarized in Table I-68 because source-tracing data were reported in the source documents (see the introduction for more information on facility selection criteria). The data gaps report and SCAP should be reviewed for additional information on these facilities.

Table I-68. Summary of facility information for the Trotsky Inlet SCA

Facility[a]	Current Ownership	Current Operations	Historical Operations	Environmental Investigations	Remedial Activities	Source Control Activities/Investigations
Boyer Towing (three parcels)[b]	Boyer Towing	storage, terminal operations	No historical operations were reported.	No environmental investigations were reported.	No remedial activities were reported.	Source-tracing samples (sediment collected from an oil/water separator) were collected by SPU in 2003.
Douglas Management Company	Douglas Management Company	storage for Alaska Marine Lines, automobile loading	ship dismantling, wrecking and salvaging, large wooden vessel construction, sand and gravel batch plant, bus parking, gravel transport	A LUST investigation was conducted for an Alaska Marine Lines property, which may have been located on the Douglas Management Company property.	A cleanup of a LUST was completed prior to 1999.	Additional site characterization will be conducted.
Trotsky	Herman and Jacqueline Trotsky	steel drum reconditioning facility (cleaning, storage, and repainting)	drum refurbishing	A three-phase soil and groundwater assessment was conducted in 1986. Additional groundwater sampling and a site hazard assessment were conducted in 1991. A site characterization study was conducted in 2007. Site inspections have also been conducted. A report for additional site characterization activities is in review by Ecology in association with Agreed Order negotiations under MTCA (Good 2009). An RI/FS will also be conducted according to the Agreed Order.	No remedial activities were reported. Ecology is negotiating an Agreed Order for the property under MTCA (Good 2009). A draft CAP for the property will be included in the Agreed Order.	A pretreatment facility was installed around 1970, and all runoff from process areas was directed to the combined sewer system (Schmoyer 2008e). In 1973, the site was bermed with concrete in response to a spill. Additional source control investigations and activities will be conducted under an Agreed Order with Ecology (Good 2009).
Wells Trucking and Leasing	Boyer Towing	tractor storage and maintenance, shipping container transport	No historical operations were reported.	SPU inspected the facility in 2002.	No remedial activities were reported.	Catch basins were cleaned in 2002. Samples were collected from catch basins in 2003.

Sources: SAIC (2007b, c), Ecology (2007b)

[a] Facilities listed are those identified as adjacent properties in the data gaps report (SAIC 2007c). Wells Trucking and Leasing (identified as an upland property in the source documents) is also included because source-tracing data were included in the source documentation.

[b] Only 3 of the 13 Boyer Towing, Inc., parcels were included in this table because these parcels are the only parcels that are adjacent to the SCA.

CAP – cleanup action plan
Ecology – Washington State Department of Ecology
FS – feasibility study
LUST – leaking underground storage tank
MTCA – Model Toxics Control Act
O/W – oil/water
RI – remedial investigation
SAIC – Science Applications International Corporation
SCA – source control area
SD – storm drain
SPU – Seattle Public Utilities

Three outfalls have been identified in the Trotsky Inlet SCA. One of the outfalls (No. 2117), located on the south side of Trotsky Inlet near the mouth, is a private permitted storm drain outfall owned by Boyer Logistics. Outfall No. 2120, located at the head of Trotsky Inlet, is the overflow from the City of Seattle's West Seattle drinking water reservoir. Outfall No. 2118 is located on the south side near the Trotsky/former Northwest Cooperage property and was identified as a major outfall in the SCAP (Ecology 2007b) and data gaps report (SAIC 2007c). Ownership of this outfall is uncertain. City records indicate that SPU obtained an easement in 2000 to install a tide gate on this system (Ticeson 2007). Additional information on these outfalls is available in Appendix H. Information on the outfalls within the Trotsky Inlet SCA is included in Table I-69; the locations of these outfalls are provided on Map I-42. The drainage basin associated with the Trotsky Inlet SCA (the 2nd Avenue S drainage basin) is shown on Map I-44, and stormwater drainage features are shown on Map I-45.

Table I-69. Summary of specific information for outfalls in the Trotsky Inlet SCA

Outfall	Current Ownership	Current Operations	Historical Operations	Environmental and Source-Tracing Investigations	Remedial and Source Control Activities
Outfalls Identified in the SCAP and Data Gaps Report as Major Outfalls[a]					
2nd Avenue S SD outfall (No. 2118)	SPU	The 2nd Avenue S sub-basin collects drainage between SR 99 and the LDW from S Austin Street to the Trotsky Inlet SCA (approximately 36 ac). The outfall is served by open ditches and culverts that run along 2nd Avenue S.	The outfall discharged stormwater from streets and adjacent properties within the 36-ac basin.	In-line sediment samples were collected from drainage ditches in 2005.	SPU conducted additional source-tracing in this basin in 2009 (Schmoyer 2008e) under a grant with Ecology.
Other Outfalls					
Boyer Logistics outfall (No. 2117)	Boyer Logistics	No current operations were reported.	No historical operations were reported.	No environmental or source-tracing investigations were reported.	No remedial or source control activities were reported.
Reservoir outfall (No. 2120)	SPU	The outfall drains overflow from a City of Seattle reservoir and tower in West Seattle and is not a stormwater outfall.	The outfall drained overflow from a City of Seattle reservoir and tower in West Seattle.	No environmental or source-tracing investigations were reported.	No remedial or source control activities were reported.

Sources: SAIC (2007c), Ecology (2007b)

[a] Major outfalls listed are those identified as such in the SCAP (Ecology 2007b) and data gaps report (SAIC 2007c).

LDW – Lower Duwamish Waterway
SAIC – Science Applications International Corporation
SCA – source control area
SCAP – source control action plan
SD – storm drain
SPU – Seattle Public Utilities
SR – state route

Several environmental investigations have been completed within the Trotsky Inlet SCA and the adjacent properties (Tables I-68 and I-69). Several of the chemicals that have been detected at concentrations above the SQS in Trotsky Inlet surface sediment have also been detected in various upland media, including soil, groundwater, seeps, stormwater, and source-tracing solids samples (Table I-70). The availability of data (by media type) is also presented in the table on Map I-43 for each facility associated with this SCA. An X in Table I-70 and the table on Map I-43 indicates that the source documents reported data or indicated that data exist; therefore, an X does not necessarily mean that the actual data were presented in the source document. Data are only summarized in media-specific and source-tracing tables if the data were reported in the source documents and if they met the criteria for data summation discussed in the introduction to this appendix (e.g., soil data were collected along the SCA shoreline; groundwater data were collected from shoreline facilities). The identification of a chemical in these media at adjacent facilities or within the drainage systems of the Trotsky Inlet SCA does not necessarily indicate that these potential sources contributed to sediment contamination in the past or that they will result in sediment contamination in the future.

Table I-70. Chemicals identified in various media in the Trotsky Inlet SCA

Chemical[a]	Soil	Groundwater	Seep	Porewater[b]	Stormwater	Source-Tracing Samples	Sources
Lead	X	X	X		X	X	Ecology (2007b), SAIC (2007b), Windward (2004)
Mercury	X	X	X			X	Ecology (2007b), SAIC (2007b), Windward (2004)
Zinc	X	X	X		X	X	SAIC (2007c), Windward (2004)
BEHP	X	X				X	SAIC (2007b, c)
BBP	X				X	X	SAIC (2007b, c)
Total PCBs	X	X	X			X	Ecology (2007b), SAIC (2007b), Windward (2004)
Dioxins and furans[c, d]							

Note: An X indicates that the source documents reported that data are available for the identified media. The absence of an X in any cell does not necessarily imply that the chemical is absent in the upland media or in source-tracing samples; in some cases, the chemical may not have been analyzed for or, if analyzed, could have been present but at concentrations below the RL.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Trotsky Inlet SCA. The chemical list is based on SMS exceedances in the RI baseline surface sediment dataset within the 2007 SCA boundary. Therefore, this list may differ from the list of exceedances in source documents.

[b] No porewater data were identified in the source documents for any chemical.

[c] No dioxin/furan data were identified in the source documents for soil, groundwater, seep, porewater, storm water, or source-tracing samples.

[d] SMS criteria do not exist for dioxins and furans. They were included in this table because they are a risk driver chemical with highly elevated concentrations (i.e., TEQ> 100 ng/kg dw) in one surface sample in this area.

BBP – butyl benzyl phthalate SAIC – Science Applications International Corporation

BEHP – bis(2-ethylhexyl) phthalate
Ecology – Washington State Department of Ecology
PCB – polychlorinated biphenyl
RI – remedial investigation
SCA – source control area
SMS – Washington State Sediment Management Standards
SQS – sediment quality standard

Upland data for soil, groundwater, seep, stormwater, and source-tracing samples have been summarized in the source documents; this section summarizes the data presented in the source documents. Seep data collected as part of the LDW RI (Windward 2004) are also presented. No porewater data were reported.

Table I-71 summarizes bank soil data from soil borings collected along the southern side of the inlet. Table I-72 summarizes the groundwater data presented in the source documents for the Trotsky Inlet SCA. If multiple years of data were collected from the same sampling location, only the most recent data are included in Table I-72. In addition to groundwater data for chemicals detected above the SQS in surface sediment, VOC data presented in the source documents were also summarized in Table I-72. Table I-73 includes the seep data presented in the source documents and data collected as part of the LDW RI (Windward 2004). Map I-42 shows the locations of the seeps sampled in the Trotsky Inlet SCA. Stormwater data were reported in the source documents for the 2nd Avenue S SD, located near the Trotsky property (Table I-74 and Map I-43).

Table I-71. Summary of chemical concentrations detected in bank soil in the Trotsky Inlet SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/kg dw, unless noted)[c, d]	Sampling Location	Sources	Additional Information
Trotsky	lead	2007	1,820 – 836,000 n=6/6	along the South side of the inlet	(SAIC 2007b)	Sample depths ranged from 5 to 15 ft below ground surface.
Trotsky	mercury	2007	19 – 2,010 n=6/6	along the South side of the inlet	(SAIC 2007b)	Sample depths ranged from 5 to 15 ft below ground surface.
Trotsky	zinc	2007	18,100 – 220,000 n=6/6	along the South side of the inlet	(SAIC 2007b)	Sample depths ranged from 5 to 15 ft below ground surface.
Trotsky	BEHP	2007	5.1 – 2,700 n=6/6	along the South side of the inlet	(SAIC 2007b)	Sample depths ranged from 5 to 15 ft below ground surface.
Trotsky	total PCBs	2007	211 – 76,500 n=5/6	along the South side of the inlet	(SAIC 2007b)	Sample depths ranged from 5 to 15 ft below ground surface.

Note: If duplicate samples were presented in data tables in the source documents, an average was calculated and included in the range, median, and sample count.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Trotsky Inlet SCA.

[b] BBP and dioxins and furans were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from µg/kg to mg/kg), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges were calculated using only detected data. For this reason, some estimated ranges may be higher than actual concentrations.

BEHP – bis(2-ethylhexyl) phthalate

PCB – polychlorinated biphenyl

SAIC – Science Applications International Corporation

SCA – source control area

SQS – sediment quality standard

Table I-72. Summary of chemical concentrations detected in groundwater samples collected from the Trotsky Inlet SCA

FACILITY	CHEMICAL[a]	YEAR COLLECTED	LOCATION	CONCENTRATION INFORMATION (µg/L)[b, c]	SOURCES[d]	ADDITIONAL INFORMATION
Chemicals Detected Above SQS in Surface Sediment						
Trotsky	lead	2007	monitoring wells on the property	0.065 – 70.7 (total) median = 26.2 n = 5/5	SAIC (2007b)	
Trotsky	lead	2007	monitoring wells on the property	0.038 – 22.3 (dissolved) median = 0.95 n = 5/5	SAIC (2007b)	
Trotsky	lead	1986 – 1987	monitoring well near the west end of Orchard Street	27 (dissolved) n = 1/1	Hart Crowser (1986), as cited in SAIC (2007c)	
Trotsky	mercury	2007	monitoring wells on the property	0.03 – 0.38 (total) median = 0.12 n = 5/5	SAIC (2007b)	
Trotsky	mercury	2007	monitoring wells on the property	0.03 – 0.09 (dissolved) median = 0.03 n = 4/5	SAIC (2007b)	
Trotsky	zinc	2007	monitoring wells on the property	1.68 – 94.6 (total) median = 34.4 n = 5/5	SAIC (2007b)	
Trotsky	zinc	2007	monitoring wells on the property	0.45 – 17.38 (dissolved) median = 7.580 n = 5/5	SAIC (2007b)	
Trotsky	zinc	1991	monitoring well near the west end of Orchard Street	29 (dissolved) n = 1/1	Hart Crowser (1986), as cited in SAIC (2007c)	
Trotsky	zinc	1986	two monitoring wells on the property	10, 110 (dissolved) n = 2/2	Hart Crowser (1986), as cited in SAIC (2007c)	Sample with the lower concentration was collected from a well identified as a background well.
Trotsky	BEHP	2007	monitoring wells on the property	0.840[e] n = 1/5	SAIC (2007b)	
Trotsky	BBP	2007	monitoring wells on the property	0.079[e] n = 1/5	SAIC (2007c)	

Table I-72, cont. Summary of chemical concentrations detected in groundwater samples from the Trotsky Inlet SCA

FACILITY	CHEMICAL[a]	YEAR COLLECTED	LOCATION	CONCENTRATION INFORMATION (µg/L)[b, c]	SOURCES[d]	ADDITIONAL INFORMATION
Trotsky	total PCBs	2007	monitoring wells on the property	0.18 – 3.79[e] median = 1.78 n = 4/5	SAIC (2007b)	
VOCs[f]						
Trotsky	benzene	1991	near the west end of Orchard Street	13 n = 1/1	Cabuco (1991), as cited in SAIC (2007c)	
Trotsky	benzene	1991	near the west end of Orchard Street	17 n = 1/1	Ecology (2007b)	
Trotsky	methylene chloride	1986	near the west end of Orchard Street	8,11 n = 2/2	SAIC (2006a), as cited in SAIC (2007c)	
Trotsky	trans-1,2-dichloroethylene	1986	near the west end of Orchard Street	190 n = 1/1	SAIC (2006a), as cited in SAIC (2007c)	
Trotsky	vinyl chloride	1991	near the west end of Orchard Street	25 n = 1/1	Cabuco (1991), as cited in SAIC (2007c)	
Trotsky	vinyl chloride	1991	near the west end of Orchard Street	310 n = 1/1	Ecology (2007b)	

Note: If duplicate samples were presented in data tables in the source documents, an average was calculated and included in the range, median, and sample count.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Trotsky Inlet SCA.

[b] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[c] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[d] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

[e] The site characterization activities data report (SAIC 2007b) did not specify whether the sample was filtered or unfiltered.

[f] VOC data were summarized, as available, at EPA's request and not because of SQS exceedances in surface sediment in the SCA. All detected VOC concentrations reported in the source documents were included.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
PCB – polychlorinated biphenyl
SAIC – Science Applications International Corporation
SCA – source control area
SQS – sediment quality standard
VOC – volatile organic compound

Table I-73. Summary of chemical concentrations detected in seep samples from the Trotsky Inlet SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Sources	Additional Information
Douglas Management Company	lead	2004	296 (total) n = 1/1	south side of inlet	Windward (2004)	Seep was identified as being adjacent to the former Swan Bay Holdings.
Douglas Management Company	lead	2004	0.703 (dissolved) n = 1/1	south side of inlet	Windward (2004)	Seep was identified as being adjacent to the former Swan Bay Holdings.
Douglas Management Company	mercury	2004	0.582 (total) n = 1/1	south side of inlet	Windward (2004)	Seep was identified as being adjacent to the former Swan Bay Holdings.
Douglas Management Company	mercury	2004	0.0132 (dissolved) n = 1/1	south side of inlet	Windward (2004)	Seep was identified as being adjacent to the former Swan Bay Holdings.
Douglas Management Company	zinc	2004	322 (total) n = 1/1	south side of inlet	Windward (2004)	Seep was identified as being adjacent to the former Swan Bay Holdings.
Douglas Management Company	zinc	2004	5.45 (dissolved) n = 1/1	south side of inlet	Windward (2004)	Seep was identified as being adjacent to the former Swan Bay Holdings.
Douglas Management Company	total PCBs	2004	8.9 (total) n = 1/1	south side of inlet	Windward (2004)	Seep was identified as being adjacent to the former Swan Bay Holdings.
Douglas Management Company	total PCBs	2004	0.26 (dissolved) n = 1/1	south side of inlet	Windward (2004)	Seep was identified as being adjacent to the former Swan Bay Holdings.
Trotsky	lead	2007	0.842, 11.8 (total) n = 2/2	south side of inlet	SAIC (2007b)	
Trotsky	lead	2007	0.163, 0.28 (dissolved) n = 2/2	south side of inlet	SAIC (2007b)	
Trotsky	mercury	2007	0.04 (total) n = 1/2	south side of inlet	SAIC (2007b)	
Trotsky	zinc	2007	27, 32.3 (total) n = 2	south side of inlet	SAIC (2007b)	
Trotsky	zinc	2007	6.3, 23.2 (dissolved) n = 2/2	south side of inlet	SAIC (2007b)	
Trotsky	total PCBs	2007	0.0254, 0.5[e] n = 2/2	south side of inlet	SAIC (2007b)	

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Trotsky Inlet SCA.

Table I-73, cont. Summary of chemical concentrations detected in seep samples from the Trotsky Inlet SCA

[b] BEHP and BBP were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges were calculated using only detected data. For this reason, some estimated ranges may be higher than actual concentrations.

[e] The site characterization activities data report (SAIC 2007b) did not specify whether the sample was filtered or unfiltered.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
PCB – polychlorinated biphenyl
SAIC – Science Applications International Corporation
SCA – source control area
SQS – sediment quality standard

Table I-74. Summary of chemical concentrations detected in stormwater in the Trotsky Inlet SCA

Facility	Chemical[a]	Year Collected	Concentration Information (µg/L)[b, c, d]	Location	Sources	Additional Information
2nd Avenue S SD (2118)	lead	2007	0.249 (dissolved) n = 1/1	near Trotsky property on south side of inlet	SAIC (2007b)	Sample was identified as outfall water.
2nd Avenue S SD (2118)	lead	2007	2.06 (total) n = 1/1	near Trotsky property on south side of inlet	SAIC (2007b)	Sample was identified as outfall water.
2nd Avenue S SD (2118)	zinc	2007	70.5 (dissolved) n = 1/1	near Trotsky property on south side of inlet	SAIC (2007b)	Sample was identified as outfall water.
2nd Avenue S SD (2118)	zinc	2007	57.8 (total) n = 1/1	near Trotsky property on south side of inlet	SAIC (2007b)	Sample was identified as outfall water.
2nd Avenue S SD (2118)	BBP	2007	0.073 n = 1/1	near Trotsky property on south side of inlet	SAIC (2007b)	Sample was identified as outfall water.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Trotsky Inlet SCA.

[b] Mercury, total PCBs and BEHP were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
PCB – polychlorinated biphenyl
SAIC – Science Applications International Corporation
SCA – source control area
SQS – sediment quality standard
SD – storm drain

Source-tracing data have been collected from several of the facilities and drainage systems within the Trotsky Inlet SCA (Map I-45). Table I-75 summarizes the source-tracing data collected within the Trotsky Inlet SCA and presented in the source documents. If multiple years of data were collected from the same sampling location, only the most recent data are included in Table I-75. Data relevant to source-tracing efforts in the Trotsky Inlet SCA include catch basin samples and in-line sediment samples. Maps I-44 and I-45 show the locations of stormwater drainage lines on the Trotsky and Boyer Towing, Inc. properties. Additional details about source-tracing sampling programs conducted in the Trotsky Inlet SCA and its associated drainage basin are presented in Section 9.4.4.7.

Table I-75. Summary of chemical concentrations detected in source-tracing samples collected from the Trotsky Inlet SCA

Sample Source	Year Collected	Concentration Information (mg/kg dw) [a, b, c]			Concentration Information (µg/kg dw unless noted) [a, b, c]			Sources[d]	Additional Information
		Lead	Mercury	Zinc	BEHP	BBP	Total PCBs		
Catch Basin Sediment Samples									
2nd Avenue S sub-basin	2003	157, 421 n = 2/2	0.12, 0.1 n = 2/2	729, 2,570 n = 2/2	37,000, 150,000 n = 2/2	4,100, 5,300 n = 2/2	200 µg/kg OC, 220 µg/kg OC n = 2/2	SPU (2003), as cited in SAIC (2007c)	Samples were collected from drums containing material that had been removed from oil/water separator.
2nd Avenue S sub-basin	2007	25 n = 1/1	nd	111 n = 1/1	4,200 n = 1/1	190 n = 1/1	20 n = 1/1	Schmoyer (2008a)	
ROW Catch Basin Samples									
2nd Avenue S sub-basin	2007	115, 547 n = 2/2	1.46, 0.13 n = 2/2	592, 655 n = 2/2	2,100, 21,000 n = 2/2	95 n = 1/2	203, 1,650 n = 2/2	Schmoyer (2008a)	SPU collected additional source tracing samples in 2008-2009.
In-Line Sediment Grab Samples									
2nd Avenue S sub-basin	2005	87, 113 n = 2/2	0.06 n = 1/2	394, 444 n = 2/2	1,600, 7,800 n = 2/2	200 n = 1/2	122 µg/kg OC, 250 µg/kg OC n = 2/2	Schmoyer (2008a), SPU (2006), both as cited in SAIC (2007b)	Samples collected from drainage ditch on west side of 2nd Ave S
2nd Avenue S sub-basin	2007	225 n = 1/1	0.296 n = 1/1	255 n = 1/1	2,200 n = 1/1	880 n = 1/1	3,600 n = 1/1	SAIC (2006)	Sample was collected from 2nd Avenue S SD outfall (1 ft inside the end of the pipe).

Note: If multiple rounds of data were available for a single location, only the data collected during the most recent event were presented in order to represent the most current conditions possible.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the Trotsky Inlet SCA.

[b] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges were calculated using only detected data. For this reason, some estimated ranges may be higher than actual concentrations.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/kg to µg/kg), the number of significant figures was kept consistent with the number in the reported value.

[d] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
dw – dry weight
nd – not detected
OC – organic carbon
PCB – polychlorinated biphenyl
SAIC – Science Applications International Corporation
SCA – source control area
SD – storm drain
SPU – Seattle Public Utilities
SQS – sediment quality standard

Numerous investigations have been completed since the late 1980s (see Table I-68) and are expected to continue. Source control activities in the LDW are ongoing. For the most current information on the Trotsky Inlet SCA, see Ecology's website.

I.4.11 T-117 SOURCE CONTROL AREA (RM 3.4 W TO RM 3.8 W, EAA 5)

The Terminal 117 (T-117) SCA is one of 23 areas identified by Ecology along the LDW for source evaluation. T-117 was also one of the seven candidate EAAs recommended to EPA and Ecology for early cleanup based on sediment chemistry data (Windward 2003c). The T-117 SCA is shown on Map I-46.

An NTCRA for sediment and soils in the adjacent bank area was approved in 2005 for T-117. However, the discovery of PCB soil contamination in adjacent upland areas prompted EPA to implement a time-critical removal action (TCRA) and to expand the site boundary to include the Port of Seattle's T-117 upland property and adjoining City of Seattle street ROWs, in addition to the bank and sediment. An EE/CA is being prepared by the Port of Seattle and the City of Seattle for the facility and surrounding streets as part of the expanded NTCRA.

As part of ongoing source control efforts for this SCA, a data gaps report (Windward et al. 2003) and a SCAP (Ecology 2005) were completed in September 2003 and July 2005, respectively. In addition, property reviews for Basin Oil Company, South Park Marina, Boeing South Park, and T-117 have also been completed by Ecology (Ecology 2004c, d, e, f) and a site characterization activities report (SAIC 2008c) has been prepared. The 2005 and 2008 EE/CA documents (Windward et al. 2005b; 2008) were reviewed as well as data tables provided by the City of Seattle (City of Seattle 2004; Schmoyer 2008a). Collectively, these documents are referred to as the "source documents" in this section. Data provided in SAIC (2008c), City of Seattle (2004), Schmoyer (2008a), and Windward et al. (Windward et al. 2005b; 2008) were collected for or included at the request of a LDWG member.

CSL exceedances in the surface sediment in this SCA have included total PCBs, phenol, total LPAH, and 11 individual PAHs. SQS exceedances have included total PCBs, phenol, benzyl alcohol, total HPAHs, total LPAH, and 11 individual PAHs. These exceedances are based on the RI baseline surface sediment dataset and the 2007 SCA boundary, as discussed in the introduction to this appendix. Ecology has identified COCs for this SCA based on different criteria (Table I-3); therefore, the chemicals identified for summary in this appendix are different than the COCs identified by Ecology. Surface sediment chemistry information for the T-117 SCA is provided on Map I-47.

Commercial and industrial operations in the vicinity of the T-117 SCA have included asphalt manufacturing (historical), marina operations (current), boat maintenance and storage (current), boat building (current), barrel reconditioning (historical), lumber storage (historical), cargo handling and storage (historical), metal fabrication

(historical), food processing (historical), and oil reclamation (historical) (Windward et al. 2003).

Adjacent properties discussed in the data gaps report and SCAP included T-117, South Park Marina, and Boeing South Park. Upland properties identified in the source documents included Basin Oil and City of Seattle street ROWs. Table I-76 provides information on the adjacent and upland facilities associated with the T-117 SCA.

Table I-76. Summary of facility information for the T-117 SCA

Facility[a]	Current Ownership	Current Operations	Historical Operations	Environmental Investigations	Remedial Activities	Source Control Activities/ Investigations
T-117	Port of Seattle	manufacturing and industrial activities	roofing asphalt manufacturing, oily water separation, petroleum storage, untreated lumber storage and loading	Sampling of groundwater, soil, and catch basin solids has been conducted throughout the property. Sediment and shoreline seep sampling has been conducted. Focused site characterization and inspection, asbestos survey, site hazard assessment, and TSCA inspections have also been conducted.	Four USTs were decommissioned in 1992, and one UST was removed in 2000. A below-ground utility corridor, which contained asphalt and oil, was cleaned out in 2000. Two CERCLA removal actions, which included the removal of PCB contaminated soil, were conducted in 1999/2000 and 2006. After both removal actions, clean back fill and an asphalt cap was installed in the removal areas. After both removal actions, the onsite drainage system was cleaned and restored.	The soil cover barrier was checked and outdoor storage practices were inspected in 2006. An erosion and sediment control inspection was also conducted. The catch basins include filter fabric and filter socks in inlets and are surrounded by hay bales. O & M activities are ongoing at the site.
South Park Marina	South Park Marina	residential and commercial activity (e.g., boat storage, closed-loop boat washing, hull refinishing, maintenance)	reconditioning and repainting of used barrels and drums; miscellaneous trades and commercial activities	Soil sampling was conducted in 2005 near the T-117/South Park Marina boundary and ground water and soil sampling was conducted in the southern portion of the Marina. In the location of the former A&B Barrel Co. Modeling of the fate and transport of contaminants is being conducted (Good 2009).	No remedial activities were reported.	Ecology conducted a permit compliance inspection in 2005, investigating sewer connections, discharge locations, a waste lagoon, and sampling catch basins. Water quality and stormwater compliance inspections have also been conducted.
Boeing South Park	The Boeing Company	manufacturing and industrial activities (e.g., laboratories, flight simulator training)	various training, information technology, and research activities	An initial site characterization has been conducted.	No remedial activities were reported.	In 2005, the property was inspected for potential sources of contamination.

Table I-76, cont. Summary of facility information for the T-117 SCA

Facility[a]	Current Ownership	Current Operations	Historical Operations	Environmental Investigations	Remedial Activities	Source Control Activities/ Investigations
Basin Oil	Basin Oil	currently inactive	used oil and oily wastewater processing, antifreeze storage, empty drum and equipment storage	Site visits have been conducted, and a complaint alleging violation of the Clean Water Act was investigated.	Tanks and contaminated soil have been removed.	Sludge samples were collected from the oil/water separator and one catch basin was sampled in 2004 by Ecology and SPU. Site was remediated in 2006 with Ecology oversight.
City of Seattle street ROWs (Dallas Avenue S vicinity)	City of Seattle	street ROWs	street ROWs	Street dust and other soil samples were collected.	In 2004 and 2005, streets were paved, shoulders were excavated and re-graveled, a temporary storm drain system was installed, and some PCB contaminated soils were removed.	SPU continues to collect stormwater samples as required under its discharge authorization with King County. Catch basin sediment monitoring was conducted as part of the interim action in 2004 and again in 2005 and 2007.

Source: Windward et al. (2003), Ecology (2005)

[a] Facilities listed are those identified as adjacent properties in the data gaps report (Windward et al. 2003) and the SCAP (Ecology 2005).

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
Ecology – Washington State Department of Ecology
EPA – Environmental Protection Agency
O & M – operation and maintenance
PCB – polychlorinated biphenyl
ROW – right-of-way
SCA – source control area
SPCC – spill prevention, control, and countermeasure
SPU – Seattle Public Utilities
T-117 – Terminal 117
TSCA – Toxic Substances Control Act
UST – underground storage tank

Six outfalls were identified that discharge to the T-117 SCA, including T-117 storm drains (Nos. 2209 and 2212), the South Park Marina private storm drain (No. 2214), 16th Avenue Bridge public storm drain (No. 2215), and Boeing South Park private storm drains (Nos. SP-4 and SP-5). There is also a small ditch (No. 2213) on the southern boundary between the Boeing South Park and T-117 properties that may collect roof drainage from the warehouse on the sound end of T-117 and runoff from the hillside between these two properties, which discharges to a mudflat area on the LDW (Windward et al. 2008). . Information on these outfalls is provided on Table I-77; additional details are provided in Appendix H. King County and SPU have inspected businesses in the T-117 basin as part of their source control efforts within the basin (King County and SPU 2005). The business inspection program is discussed in Section 9.4.4.5.

Table I-77. Summary of specific information for each outfall in the T-117 SCA

Outfall[a]	Current Ownership	Current Operations	Historical Operations	Environmental and Source-Tracing Investigations	Remedial and Source Control Activities
Public SD (No. 2215)	16th Avenue Bridge (south side)	Composite construction storm drain pipe (12-in.) is relatively new and likely discharges drainage from bridge.	No historical operations were reported.	No environmental or source-tracing investigations were reported.	No remedial or source control activities were reported.
South Park Marina permitted private SD (No. 2214)	South Park Marina	Composite construction storm drain (12-in.) collects stormwater in two catch basins; the water is passed through an oil/water separator before being discharged to the LDW.	Outfall may have served as a stormwater discharge point for North Star Trading Co., Evergreen Boat Transport, RP Boatbuilding, A&B Barrel, and Dekker Engineering.	Catch basin sampling was performed.	Water quality and stormwater compliance inspection was performed by Ecology in 2005.
Port of Seattle SD (No. 2212)	Port of Seattle	PVC outfall (6-in.) drains stormwater from the northern portions of the T-117 upland property; stormwater is collected in a catch basin before it is discharged to the LDW.	Outfall served as a stormwater discharge point for Malarkey Asphalt Co. and Evergreen West Wholesale.	Catch basin sampling was performed throughout T-117.	Catch basins on T-117 were cleaned in 2006.
Port of Seattle SD (No. 2209)	Port of Seattle	PVC outfall (8-in.) drains stormwater from the central and southern portion of the T-117 upland property; stormwater is collected in catch basins before it is discharged to the LDW.	Outfall used to discharge stormwater runoff from Basin Oil parcels, which entered the catch basin and discharged to LDW via outfall No. 2209. Outfall also served as a stormwater discharge point for Allied Bolt Co.	Catch basin sampling was performed throughout T-117 and at the Basin Oil.	Catch basins on T-117 were cleaned in 2006. Catch basins at Basin Oil were cleaned in 2007. The Basin Oil site was demolished in 2006-2007. No drainage structures exist on this property.
Boeing South Park permitted private SDs (Nos. SP-4 and SP-5)	Boeing South Park	Storm drains discharge stormwater from the facility.	No historical operations were reported.	No environmental or source-tracing investigations were reported.	No remedial or source control activities were reported.

Source: Windward et al. (2003), Ecology (2005)

[a] Outfalls listed are those discussed in the SCAP (Ecology 2005) or data gaps report (Windward et al. 2003); none of the outfalls were identified as major outfalls.

LDW – Lower Duwamish Waterway
PVC – polyvinyl chloride
SCA – source control area
SD – storm drain

Several remedial activities and environmental investigations have been completed or are currently in progress within the T-117 SCA (Tables I-76 and I-77). Information about these activities has been summarized based on information in the source documents. Several of the chemicals that have been detected above the SQS in T-117 surface sediment have also been detected in various upland media, including soil, groundwater, seeps, stormwater, and source-tracing solids as indicated on Table I-78. The availability of data (by media type) is also presented in the table on Map I-48 for each of the facilities and outfalls associated with this SCA. In both Table I-78 and the table on Map I-48, an X indicates that the source documents reported data or indicated that data exist; therefore, an X does not necessarily mean that the actual data were presented in the source document. Data are only summarized in media-specific and source-tracing tables if the data were reported in the source documents and if they met the criteria for data summation discussed in the introduction to this appendix (e.g., soil data were collected along the SCA shoreline; groundwater data were collected from shoreline facilities). The identification of a chemical in these media at the adjacent facilities or within the drainage systems of the T-117 SCA does not necessarily indicate that these potential sources contributed to sediment contamination in the past or that they will result in sediment contamination in the future.

Table I-78. Chemicals identified in various media in the T-117 SCA

Chemical[a]	Soil	Groundwater	Seep	Porewater[b]	Stormwater	Source-Tracing Samples	Sources
2-methylnaphthalene	X					X	City of Seattle (2004), Windward et al. (2005b; 2008)
Acenaphthene	X	X				X	Schmoyer (2008a), Windward et al. (2003, 2005b; 2008)
Anthracene	X					X	Schmoyer (2008a), Windward et al. (2008)
Benzo(a)anthracene	X	X				X	SAIC (2008c), Schmoyer (2008a), Windward et al. (2003, 2005b; 2008)
Benzo(a)pyrene	X					X	SAIC (2008c), Schmoyer (2008a), Windward et al. (2005b; 2008)
Benzo(g,h,i)perylene	X					X	SAIC (2008c), Schmoyer (2008a), Windward et al. (2008)
Benzofluoranthenes	X	X				X	Schmoyer (2008a), Windward et al. (2003; 2008)
Chrysene	X	X				X	SAIC (2008c), Schmoyer (2008a), Windward et al. (2003; 2008)

Chemical[a]	Soil	Groundwater	Seep	Porewater[b]	Stormwater	Source-Tracing Samples	Sources
Dibenzo(a,h) anthracene	X					X	SAIC (2008c), Schmoyer (2008a), Windward et al. (2005b; 2008)
Dibenzofuran	X						Windward et al. (2008), SAIC (2008c)
Fluoranthene	X					X	SAIC (2008c), Schmoyer (2008a), Windward et al. (2003, 2005b; 2008)
Fluorene	X	X				X	SAIC (2008c), Schmoyer (2008a), Windward et al. (2003, 2005b; 2008)
Indeno (1,2,3-cd)pyrene	X					X	SAIC (2008c), Schmoyer (2008a), Windward et al. (2005b; 2008)
Phenanthrene	X					X	Schmoyer (2008a), Windward et al. (2005b; 2008)
Phenol		X					Windward et al. (2008)
Total HPAHs	X	X					Windward et al. (2003; 2008)
Total LPAHs	X	X				X	Windward et al. (2003, 2005b; 2008)
Benzyl alcohol	X						SAIC (2008c), Windward et al. (2008)
Total PCBs	X	X	X		X	X	Schmoyer (2008a), Windward et al. (2005b; 2008)

Note: An X indicates that the source documents reported that data are available for the identified medium. The absence of an X in any cell does not necessarily mean that the chemical is absent in the upland media or in source-tracing samples; in some cases, the chemical may not have been analyzed for or, if analyzed, could have been present but at concentrations below the RL.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the T-117 SCA. The chemical list is based on SMS exceedances in the RI baseline surface sediment dataset within the 2007 SCA boundary. Therefore, this list may differ from the list of exceedances in source documents.

[b] No porewater data were identified in the source documents for any chemical.

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RI – remedial investigation

SAIC – Science Applications International Corporation

SCA – source control area

SMS – Washington State Sediment Management Standards

SQS – sediment quality standard

Upland data for these media from adjacent properties have been summarized in the source documents. This section summarizes the upland data as they were presented in these documents for bank soil, groundwater, seep, stormwater, and source-tracing samples. No data were reported for porewater. In some instances, the source

documents acknowledged the existence of certain data while not providing actual concentrations. Data were included only if specific concentrations or a range of concentrations was included in the source documents.

Soil sampling has been conducted at several of the facilities associated with the T-117 SCA. Extensive soil sampling has been conducted throughout the T-117 upland property. This summary focuses on the soil samples collected along the bank because bank soils can be a direct source (via erosion) to the sediment. Bank soil data were presented in the EE/CA (Windward et al. 2008) and the South Park Marina site characterization activities data report (SAIC 2008c); these data are summarized in Table I-79. Bank soil samples were collected along the shorelines of the South Park Marina and T-117, including the southern drainage ditch. Groundwater sampling has been conducted within the T-117 SCA since the early 1990s; the most recent data for each location are presented in Table I-80. Data are also available for seep samples collected within the T-117 SCA (Table I-81). Additional groundwater and seep information for T-117 and Basin Oil is also included in Section 9.4.6 of the main body of the RI. Stormwater sampling has been conducted within one area associated with the T-117 SCA; the data are summarized in Table I-82. Stormwater sampling locations include five 18,000-gal. holding tanks, which are located just south of 17th Avenue S next to Boeing South Park; these tanks collect stormwater from the adjacent paved streets.

Table I-79. Summary of chemical concentrations detected in bank soil in the T-117 SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/kg dw, unless noted)[c, d]	Location	Sources	Additional Information
South Park Marina	benzo(a)-anthracene	2007	58 n = 1/4	southern South Park Marina bank area, close to T-117 property line	SAIC (2008c)	Samples include shallow soil collected from the shoreline bank.
South Park Marina	benzo(a)pyrene	2007	76 n = 1/4	southern South Park Marina bank area, close to T-117 property line	SAIC (2008c)	Samples include shallow soil collected from the shoreline bank.
South Park Marina	benzo(g,h,i)-perylene	2007	92, 290 n = 2/4	southern South Park Marina bank area, close to T-117 property line	SAIC (2008c)	Samples include shallow soil collected from the shoreline bank.
South Park Marina	benzyl alcohol	2007	11 – 940 median = 48 n = 3/4	southern South Park Marina bank area, close to T-117 property line	SAIC (2008c)	Samples include shallow soil collected from the shoreline bank.
South Park Marina	chrysene	2007	120 n = 1/4	southern South Park Marina bank area, close to T-117 property line	SAIC (2008c)	Samples include shallow soil collected from the shoreline bank.
South Park Marina	dibenzo(a,h)-anthracene	2007	4.2 – 64 median = 15 n = 3/4	southern South Park Marina bank area, close to T-117 property line	SAIC (2008c)	Samples include shallow soil collected from the shoreline bank.
South Park Marina	dibenzofuran	2007	3.7 n = 1/4	southern South Park Marina bank area, close to T-117 property line	SAIC (2008c)	Samples include shallow soil collected from the shoreline bank.
South Park Marina	fluoranthene	2007	170 n = 1/4	southern South Park Marina bank area, close to T-117 property line	SAIC (2008c)	Samples include shallow soil collected from the shoreline bank.
South Park Marina	fluorene	2007	4.6, 12 n = 2/4	southern South Park Marina bank area, close to T-117 property line	SAIC (2008c)	Samples include shallow soil collected from the shoreline bank.
South Park Marina	indeno(1,2,3-cd)pyrene	2007	98, 330 n = 2/4	southern South Park Marina bank area, close to T-117 property line	SAIC (2008c)	Samples include shallow soil collected from the shoreline bank.

Table I-79, cont. Summary of chemical concentrations detected in bank soil in the T-117 SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/kg dw, unless noted)[c, d]	Location	Sources	Additional Information
T-117	2-methyl-naphthalene	2003	65, 260 n = 2/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include soil borings up to 1.5 ft deep and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.
T-117	acenaphthene	2003	39, 190 n = 2/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include soil borings up to 1.5 ft deep and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.
T-117	anthracene	2003	26, 950 n = 2/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include soil borings up to 1.5 ft deep and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.
T-117	benzo(a)-anthracene	2003	59 – 2,200 median = 210 n = 5/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include soil borings up to 1.5 ft deep and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.
T-117	benzo(a)pyrene	2003	89 – 3,800 median = 230 n = 5/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include soil borings up to 1.5 ft deep and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.
T-117	benzo(g,h,i)-perylene	2003	110 – 1,100 median = 190 n = 5/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include soil borings up to 1.5 ft deep and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.
T-117	total benzo-fluoranthenes	2003	190 – 9,100 median = 890 n = 5/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include soil borings up to 1.5 ft deep and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.

Table I-79, cont. Summary of chemical concentrations detected in bank soil in the T-117 SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/kg dw, unless noted)[c, d]	Location	Sources	Additional Information
T-117	benzyl alcohol	2003	190 – 1,000 median = 860 n = 3/3	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include soil samples from the southern drainage ditch collected from the shoreline bank.
T-117	chrysene	2003	63 – 4,000 median = 250 n = 6/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include surface/subsurface soil borings and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.
T-117	dibenzo(a,h)-anthracene	2003	41 –400 median = 175 n = 4/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include surface/subsurface soil borings and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.
T-117	dibenzofuran	2003	81, 470 n = 2/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include surface/subsurface soil borings and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.
T-117	fluoranthene	2003	24 – 9,300 median = 550 n = 6/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include surface/subsurface soil borings and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.
T-117	fluorene	2003	35, 770 n = 2/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include surface/subsurface soil borings and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.
T-117	indeno(1,2,3-cd)pyrene	2003	62 – 1,200 median = 210 n = 5/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include surface/subsurface soil borings and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.

Table I-79, cont. Summary of chemical concentrations detected in bank soil in the T-117 SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/kg dw, unless noted)[c, d]	Location	Sources	Additional Information
T-117	phenanthrene	2003	22 – 9,000 median = 203 n = 8/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include surface/subsurface soil borings and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.
T-117	total HPAH	2003	24 – 39,600 median = 940 n = 9/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include surface/subsurface soil borings and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.
T-117	total LPAH	2003	22 – 12,500 median = 210 n = 9/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include surface/subsurface soil borings and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.
T-117	total PCBs	2003	16 – 15,000 median = 1,900 n = 10/15	southern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include surface/subsurface soil borings and three soil samples from the southern drainage ditch; all samples were collected from the shoreline bank.
T-117	total PCBs	2003	4,000 n = 1/1	northern T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Sample was a composite surface grab sample collected from the bank.
T-117	total PCBs	2004	5,000 – 100,000 median = 34,000 n = 8/8	north and central T-117 bank area	Windward et al. (2005a) as cited in Windward et al. (2008)	Samples include shallow soil borings collected from the shoreline bank.
T-117	total PCBs	2005	8.2 – 530,000 median = 6,550 n = 42/49	northern and southern-most T-117 bank area	Windward et al. (2005c) as cited in Windward et al. (2008)	Samples include surface and subsurface soil collected from the shoreline bank.

Table I-79, cont. Summary of chemical concentrations detected in bank soil in the T-117 SCA

FACILITY	CHEMICAL[a, b]	YEAR COLLECTED	CONCENTRATION INFORMATION (µg/kg dw, unless noted)[c, d]	LOCATION	SOURCES	ADDITIONAL INFORMATION
T-117	total PCBs	2005	1,900 – 47,000 median = 15,700 n = 4/4	northern T-117 bank area	Windward et al. (2005d) as cited in Windward et al. (2008)	Samples include surface and subsurface soil collected from the shoreline bank.
T-117/ South Park Marina	total PCBs	2006	81.5 – 3,200 median = 405 n = 4/4	T-117/South Park Marina property line	Windward and DOF (2006), as cited in Windward et al. (2008)	Samples include shallow soil collected from the shoreline bank.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the T-117 SCA.

[b] Phenol was either not analyzed or was not detected, or the data for this chemical were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/kg to µg/kg), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SCA – source control area
SQS –sediment quality standard
T-117 – Terminal 117

Table I-80. Summary of chemical concentrations detected in groundwater in the T-117 SCA

FACILITY	CHEMICAL[a, b]	YEAR COLLECTED	CONCENTRATION INFORMATION (µg/L)[c, d, e]	LOCATION	SOURCES[f]	ADDITIONAL INFORMATION
T-117	acenaphthene	2003 – 2007	0.39 n = 1/3	central portion of T-117	Onsite (2003), as cited in Windward et al. (2003)	
T-117	benzo(a)anthracene	2003	0.016 n = 1/3	central portion of T-117	Onsite (2003), as cited in Windward et al. (2003)	
T-117	total benzofluoranthenes	2003	0.013 n = 1/3	central portion of T-117	Windward et al. (2008)	
T-117	chrysene	2003	0.10 n = 1/3	central portion of T-117	Onsite (2003), as cited in Windward et al. (2003)	
T-117	fluorene	2003	1.6 n = 1/3	central portion of T-117	Onsite (2003), as cited in Windward et al. (2003)	
T-117	phenol	2006	5.8 n = 1/3	central portion of T-117	Windward and DOF (2006), as cited in Windward et al. (2008)	
T-117	total HPAHs	2003	0.1 n = 1/3	central portion of T-117	Windward and DOF (2006), as cited in Windward et al. (2008)	
T-117	total LPAHs	2003	2.0 n = 1/3	central portion of T-117	Windward and DOF (2006), as cited in Windward et al. (2008)	
T-117	total PAHs	2003	2.1 n = 1/3	central portion of T-117	Windward and DOF (2006), as cited in Windward et al. (2008)	
T-117	total PCBs	2003 – 2006	0.010 – 0.32 median = 0.029 n = 7/22	T-117	Windward and DOF (2006), as cited in Windward et al. (2008)	Samples from multiple wells.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the T-117 SCA.

[b] 2-Methylnaphthalene, anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzyl alcohol, dibenzofuran, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, and phenanthrene were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

[e] Concentrations reported are from samples that were not filtered.

[f] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PAH – polycyclic aromatic hydrocarbon
SCA – source control area
PCB – polychlorinated biphenyl
SQS – sediment quality standard
T-117 – Terminal 117

Table I-81. Summary of chemical concentrations detected in seeps in the T-117 SCA

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/L)[c, d]	Location	Source	Additional Information
T-117	total PCBs	2003	0.94 n = 1/4	northern portion of T-117	Windward et al. (2008)	Three seeps were sampled along the T-117 along the base of shoreline riprap. One sample at northern end of T-117 was not filtered or centrifuged. This seep was subsequently re-sampled, and centrifuged generating a fourth PCB results. PCBs were not detected in the re-sampled seep.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the T-117 SCA.

[b] 2-Methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzyl alcohol, benzofluoranthenes, chrysene, dibenzofuran, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, phenol, total LPAHs, and total HPAHs were not detected.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed during the sampling event (s) when a chemical was detected.

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SCA – source control area
SQS – sediment quality standard
T-117 – Terminal 117

Table I-82. Summary of chemical concentrations detected in stormwater in the T-117 SCA

Facility	Chemical[a, b]	Year Collected	Sampling Location	Concentration Information (µg/L)[c, d]	Sources[e]	Additional Information
17th Avenue S and associated catchment area	total PCBs	2005	holding tanks located just south of intersection of 17th Avenue S and S Donovan Street	0.141 – 0.383 median = nr n = nr	Ecology (2007f), as cited in Windward et al. (2008)	Samples were collected from the temporary stormwater system, which collects runoff from the adjacent paved streets and releases it to the combined sewer system.
17th Avenue S and associated catchment area	total PCBs	2005-2008	holding tanks located just south of intersection of 17th Avenue S and S Donovan Street	0.12 n = 1/30	Ecology (2007f), as cited in Windward et al. (2008)	Samples are collected from the temporary stormwater system every month that a discharge occurs. The temporary system collects runoff from the adjacent paved streets and Basin Oil property. Stormwater is stored in five 18,000-gal. tanks and released at a controlled rate to the combined sewer system. During large storm events or periods of extended rainfall, when the capacity of the tanks is exceeded, runoff is routed to the Port of Seattle's storm drain system on T-117 and discharged to the LDW.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the T-117 SCA.

[b] 2-Methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzyl alcohol, benzofluoranthenes, chrysene, dibenzofuran, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, phenol, total LPAHs, and total HPAHs were either not analyzed or were not detected, or the data for these chemicals were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/L to µg/L), the number of significant figures was kept consistent with the number in the reported value.

[d] n was not reported for these sampling events. Concentration ranges were calculated using only detected data. For this reason, some estimated ranges may be higher than actual concentrations.

[e] Primary source materials (i.e., any documents listed as "as cited in") were not reviewed to compile this table.

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
nr – not reported
PCB – polychlorinated biphenyl
SCA – source control area
SQS – sediment quality standard
T-117 – Terminal 117

Source-tracing samples have been collected from the T-117 SCA, and data from these sampling efforts are available in the source documents. Data relevant to source-tracing efforts include onsite catch basin solids and right-of-way catch basin solids; these data are presented in Table I-83. The drainage basin associated with the T-117 SCA is shown on Map I-48. Additional details on source-tracing sampling programs conducted within the T-117 SCA and the larger LDW drainage basin are presented in Section 9.4.4.7.

Table I-83. Summary of chemical concentrations detected in catch basins at the T-117 SCA

FACILITY	CHEMICAL[a, b]	YEAR COLLECTED	CONCENTRATION INFORMATION (µg/kg dw, unless noted)[c d]	LOCATION	SOURCES
T-117	2-methylnaphthalene	2003	62, 810 n = 2/3	T-117 central and southern areas near bank	SAIC (2008c)
T-117	acenaphthene	2003	79 n = 1/3	T-117 central and southern areas near bank	SAIC. (2008c)
T-117	anthracene	2003	93, 95 n = 2/3	T-117 central and southern areas near bank	SAIC (2008c)
T-117	benzo(a)anthracene	2003	73, 290 n = 2/3	T-117 central and southern areas near bank	SAIC (2008c)
T-117	benzo(a)pyrene	2003	79 – 280 median = 240 n = 3/3	T-117 central and southern areas near bank	SAIC (2008c)
T-117	benzo(g,h,i)perylene	2003	67 – 210 median = 150 n = 3/3	T-117 central and southern areas near bank	SAIC (2008c)
T-117	total benzofluoranthenes	2003	390 – 980 median = 910 n = 3/3	T-117 central and southern areas near bank	SAIC (2008c)
T-117	benzyl alcohol	2003	57, 87 n = 2/3	T-117 central and southern areas near bank	SAIC (2008c)
T-117	chrysene	2003	160 – 510 median = 440 n = 3/3	T-117 central and southern areas near bank	SAIC (2008c)
T-117	dibenzo(a,h)-anthracene	2003	54 n = 1/3	T-117 central and southern areas near bank	SAIC (2008c)
T-117	dibenzofuran	2003	86, 95 n = 2/3	T-117 central and southern areas near bank	SAIC (2008c)
T-117	fluoranthene	2003	230 – 1,300 median = 880 n = 3/3	T-117 central and southern areas near bank	SAIC (2008c)
T-117	fluorene	2003	130, 380 n = 2/3	T-117 central and southern areas near bank	SAIC (2008c)

Facility	Chemical[a, b]	Year Collected	Concentration Information (µg/kg dw, unless noted)[c d]	Location	Sources
T-117	indeno(1,2,3-cd)pyrene	2003	190, 230 n = 2/3	T-117 central and southern areas near bank	SAIC (2008c)
T-117	phenanthrene	2003	160 – 960 median = 910 n = 3/3	T-117 central and southern areas near bank	SAIC (2008c)
T-117	total HPAH	2003	1,530 – 5,300 median = 4,800 n = 3/3	T-117 central and southern areas near bank	SAIC (2008c)
T-117	total LPAH	2003	160 – 1,650 median = 1,350 n = 3/3	T-117 central and southern areas near bank	SAIC (2008c)
T-117	total PCBs	2003-2006	620 – 50,000 median = 2,800 n = 10/10	T-117 central and southern areas near bank	SAIC (2008c)
T-117	total PCBs	2004	140 n = 1/1	T-117 southern area (inland) near Dallas Avenue	SAIC (2008c)
Dallas Avenue S	chrysene	2007	310 n = 1/1	Sample was collected from CB installed during 2004 emergency cleanup on Dallas Avenue between T-117 and Basin Oil facilities.	Schmoyer (2008a)
Dallas Avenue S	fluoranthene	2007	470 n = 1/1	Sample was collected from CB installed during 2004 emergency cleanup on Dallas Avenue between T-117 and Basin Oil facilities.	Schmoyer (2008a)
Dallas Avenue S	phenanthrene	2007	180 n = 1/1	Sample was collected from Dallas Avenue between T-117 and Basin Oil facilities. Sample was collected from CB installed during 2004 emergency cleanup on Dallas Avenue between T-117 and Basin Oil facilities.	Schmoyer (2008a)
Dallas Avenue S	total PCBs	2007	310 n = 1/1	Sample was collected from CB installed during 2004 emergency cleanup on Dallas Avenue between T-117 and Basin Oil facilities.	SAIC (2008c)

Note: If multiple rounds of data were available for a single location, only the data collected during the most recent event were presented in order to represent the most current conditions possible.

[a] Chemicals with at least one detected exceedance of an SQS in surface sediment within the T-117 SCA.

[b] Phenol was either not analyzed or was not detected, or the data for this chemical were not reported in the source documents in a format that would allow them to be summarized in this table.

[c] Significant figures are reported as available in source documentation; when converting units (i.e., from mg/kg to µg/kg), the number of significant figures was kept consistent with the number in the reported value.

[d] n is the ratio of the number of detects to the total number of samples analyzed. Concentration ranges and median values were calculated using only detected data. For this reason, some estimated ranges and median values may be higher than actual concentrations.

dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
T-117 – Terminal 117

Source identification and control efforts in the T-117 SCA are ongoing. Planned activities include a NTCRA cleanup under CERCLA at T-117 to address elevated PCB concentrations, a follow-up on compliance issues at Basin Oil as part of Ecology's Hazardous Waste Program, additional sampling at South Park Marina to characterize potential residual contamination from the A&B Barrel Co., and the Dallas Avenue S interim PCB cleanup (Ecology 2007f). Additional information on the T-117 SCA is provided on Ecology's website.

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Attachment 1. LDW Source Control Area Facility Tables

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Acronyms and Abbreviations

Acronym	Definition
ac	acre
CSCSL	Confirmed and Suspected Contaminated Sites List
CSO	combined sewer overflow
E	east
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
ID	identification
KC	King County
KCIA	King County International Airport
KCIWP	King County Industrial Waste Program
LDW	Lower Duwamish Waterway
No.	number
NPDES	National Pollutant Discharge Elimination System
PSCAA	Puget Sound Clean Air Agency
RI	remedial investigation
SCA	source control area
SD	storm drain
SPU	Seattle Public Utilities
TRI	toxic release inventory
UST/LUST	underground storage tank/leaking underground storage tank
W	west

Introduction

The tables included in this attachment include facility-specific information for adjacent properties associated with each of the 11 source control areas (SCAs) summarized in Appendix I. A facility table was also prepared for upland properties associated with the 11 SCAs if source tracing data were reported in source documents for a given SCA. The facility tables summarize information presented in the source documents for each SCA (see individual source document lists in Appendix I), the King County Parcel Viewer website (King County 2008), and a corridor study report for the Lower Duwamish Waterway(LDW) (EDR 2002).

1 DUWAMISH/DIAGONAL WAY SCA

Table 1-1. T-106 SW

FACILITY SUMMARY	
Address	1 S Idaho Street
Property Owner	Port of Seattle
Property Leasee/Operator	Container Care International (name changed to ConGlobal Industries)
Tax Parcel No.	7666700390[a]
Parcel Size	31.30 ac[a] (approximately 14 ac of the SW portion of parcel is T-106 SW)
Facility/Site ID	54918197 (Container Care ID No.), 17818733 (former Coastal Trailer Repair, Inc. ID No.)
EPA ID No.	WAD040197014
NPDES Permit No.	S03-001581
UST/LUST ID No.	nr
Listed on CSCSL	No
TRI No.	nr
KCIWP No.	nr
PSCAA ID	10438

Note: This property is currently referred to as T-106 (rather than T-106 SW).

[a] Parcel number and acreage includes both T-106SW and T-106W.

Table 1-2. T-108

FACILITY SUMMARY	
Address	4525 Diagonal Avenue S
Property Owner	Port of Seattle
Property Leasee/Operator	Container Care International (name changed to ConGlobal Industries)
Tax Parcel No.	7666700515 and 7666700510
Parcel Size	approximately 20 ac for both parcels
Facility/Site ID	2344
EPA ID No.	nr
NPDES Permit No.	SO3-010569 (ConGlobal Industries)
UST/LUST ID No.	None
Listed on CSCSL	yes; ID No.2344 (Chevron Seattle Terminal 4097)
TRI No.	nr
KCIWP No.	nr

Table 1-3. Federal Center South

FACILITY SUMMARY	
Address	4735 E Marginal Way S
Property Owner	U.S. Government
Property Leasee/Operator	General Services Administration
Tax Parcel No.	3573200975
Parcel Size	32.99 ac
Facility/Site ID	10233917
EPA ID No.	WA8470031891
NPDES Permit No.	nr
UST/LUST ID No.	10042
Listed on CSCSL	yes; ID No. 10233917
TRI No.	nr
KCIWP No.	nr
Listed in SPU Spills Database	yes

Table 1-4. UPRR Argo Fueling

FACILITY SUMMARY	
Address	4300 Colorado Ave S and 4700 Denver Ave S
Property Owner	Union Pacific Railroad Co.
Property Leasee/Operator	Union Pacific Railroad Co.
Tax Parcel No.	1824049008 and 7666207525
Parcel Size	11.11 ac
Facility/Site ID	21429717 (UPRR/Argo Yard) and 23236296 (Leo Fix Transfer and Storage Co Inc)
EPA ID No.	WAH000000992
NPDES Permit No.	nr
UST/LUST ID No.	1621 (Leo Fix Transfer and Storage Co Inc)
Listed on CSCSL	No
TRI No.	nr
KCIWP No.	668-03
Ecology's Spill List	IDs 554023 and 551354

2 SLIP 3 TO SEATTLE BOILER WORKS SCA

Table 2-1. SCS Refrigerated Services

FACILITY SUMMARY	
Address	303 South River Street
Property Owner	SCS Holding LLC
Property Leasee/Operator	SCS Refrigerated Services
Tax Parcel No.	5367204100
Parcel Size	3.58 acres
Facility/Site ID	34383748
EPA ID No.	nr
NPDES Permit No.	SO3005565
UST/LUST ID No.	nr
Listed on CSCSL	No
TRI No.	nr
KCIWP No.	nr
OTHER	nr

Table 2-2. Seattle Distribution Center

FACILITY SUMMARY	
Address	6701 East Marginal Way South
Property Owner	CLPF-Seattle Distribution Center LP
Property Leasee/Operator	Seattle Distribution Center
Tax Parcel No.	5367204080
Parcel Size	6.96 acres
Facility/Site ID	nr
EPA ID No.	nr
NPDES Permit No.	nr
UST/LUST ID No.	nr
Listed on CSCSL	No
TRI No.	nr
KCIWP No.	nr
OTHER	nr

Table 2-3. Glacier Marine Services

FACILITY SUMMARY	
Address	6701 Fox Avenue South
Property Owner	Seatac Marine Properties LLC
Property Leasee/Operator	Glacier Marine Services
Tax Parcel No.	0001800104 (north) 0001800128 (south)
Parcel Size	5.85 acres (north) 5.24 acres (south)
Facility/Site ID	22653378
EPA ID No.	WAD980977128 (inactive since 12/31/2004)
NPDES Permit No.	SO3000962
UST/LUST ID No.	11256
Listed on CSCSL	No
TRI No.	nr
KCIWP No.	nr
OTHER	nr

3 SEATTLE BOILER WORKS TO SLIP 4 SCA

Table 3-1. Crowley Marine Services

FACILITY SUMMARY	
Address	7400 8th Ave S
Property Owner	Crowley Marine Services
Property Leasee/Operator	Alaska Logistics
Tax Parcel No.	2136200641
Parcel Size	15.86 ac
Facility/Site ID	1940187 (Crowley Marine Services) and 63123962 (Alaska Logistics)
EPA ID No.	WAD981768377 (Crowley Marine Services; inactive), WAD988470647 (Alaska Logistics), WAD980981846 (Samson Tug and Barge)
NPDES Permit No.	WAR009728 (expired 5/31/08)
UST/LUST ID No.	nr
Listed on CSCSL	No
TRI No.	nr
KCIWP No.	nr

Table 3-2. Guimont Parcel (Dawn Food Products)

FACILITY SUMMARY	
Address	6901 Fox Avenue S
Property Owner	William P. Guimont
Property Leasee/Operator	Dawn Food Products, Inc.
Tax Parcel No.	00018000113
Parcel Size	5.42 acres
Facility/Site ID	57331171
EPA ID No.	nr
NPDES Permit No.	SO3000098 (inactive)
UST/LUST ID No.	nr
Listed on CSCSL	nr
TRI No.	nr
KCIWP No.	7043 (KC Discharge permit)
SIC Code	2045: Prepared Flour Mixes/Doughs

Table 3-3. Puget Sound Truck Lines

FACILITY SUMMARY	
Address	7303 8th Avenue S (Puget Sound Truck Lines), 7401 8th Avenue S (Phil's Finishing Touch)
Property Owner	R&A Properties, LLC (Parcel 0681), Puget Sound Truck lines (Parcel 0670)
Property Leasee/Operator	Puget Sound Truck Lines
Tax Parcel No.	2136200681, 2136200670
Parcel Size	3.83 acres, 2.50 acres
Facility/Site ID	41684823 (Puget Sound Truck Lines), 26468911 (Phil's Finishing Touch)
EPA ID No.	WAD173274499 (inactive), WAD982653271 (inactive)
NPDES Permit No.	WAR000949, SO3000949D
UST/LUST ID No.	7820
Listed on CSCSL	nr
TRI No.	nr
KCIWP No.	nr
SIC Code	7538 (General Automotive Repair Shops), 4231 (Terminal Maintenance Facilities for Motor Freight Transportation), 7532 (Top, Body, and Upholstery Repair Shops and Paint Shops)

Table 3-4. Seattle Boiler Works

FACILITY SUMMARY	
Address	500 S Myrtle Street
Property Owner	Frederick J. Hopkins Family Trust
Property Leasee/Operator	Seattle Boiler Works
Tax Parcel No.	001800091
Parcel Size	4.40 acres
Facility/Site ID	17577864
EPA ID No.	nr
NPDES Permit No.	SO3002208
UST/LUST ID No.	8147
Listed on CSCSL	nr
TRI No.	nr
KCIWP No.	nr
SIC Code	3499: Fabrication of metal products

Table 3-5. Seattle City Light

FACILITY SUMMARY	
Address	7551 8th Avenue S
Property Owner	Sandra L. Campbell
Property Leasee/Operator	Seattle City Light
Tax Parcel No.	2136200666
Parcel Size	0.27 acres
Facility/Site ID	nr
EPA ID No.	nr
NPDES Permit No.	nr
UST/LUST ID No.	nr
Listed on CSCSL	nr
TRI No.	nr
KCIWP No.	nr
SIC Code	nr

Table 3-6. Seattle Iron and Metals Corporation

FACILITY SUMMARY	
Address	601 S Myrtle Street, 620 S Othello Street
Property Owner	Shalmar Group
Property Leasee/Operator	Seattle Iron and Metals Corporation
Tax Parcel No.	213620076, 2924049089
Parcel Size	8.22 acres, 1.44 acres
Facility/Site ID	12153465 (Myrtle Street property), 94727791 (Seattle Iron and Metals), 9872313 (whitehead Company), 6368989 (All Alaskan Seafoods)
EPA ID No.	WAH000010678
NPDES Permit No.	WA0031968A (Individual), SO3003645 (General- to be canceled)
UST/LUST ID No.	9634 (Whitehead Company), 10855 (Manson Construction)
Listed on CSCSL	nr
TRI No.	nr
KCIWP No.	nr
VCP ID	NW0093

Table 3-7. Former Sternoff site

FACILITY SUMMARY	
Address	7201 East Marginal Way S.
Property Owner	Ellis Garage, LLC
Property Leasee/Operator	CDL Recycle
Tax Parcel No.	2136200075
Parcel Size	1.85 acres
Facility/Site ID	2057
EPA ID No.	WAH000023432 (inactive)
NPDES Permit No.	nr
UST/LUST ID No.	nr
Listed on CSCSL	nr
TRI No.	nr
KCIWP No.	nr
SIC Code	33: Primary Metal Industries

4 SLIP 4 SCA

Table 4-1. Boeing Plant 2

FACILITY SUMMARY	
Address	1135 S Webster St, 7700 and 7755 E Marginal Way S
Property Owner	The Boeing Company
Property Leasee/Operator	The Boeing Company
Tax Parcel No.	0022000005
Parcel Size	37.45 ac[a]
Facility/Site ID	2100
EPA ID No.	WAR000482
NPDES Permit No.	SO3000482D, WAR000482
UST/LUST ID No.	2100
Listed on CSCSL	Yes; facility ID 2100
TRI No.	98108BNGRS77
KCIWP No.	nr
PSCAA ID No.	21147

[a] The Slip 4 SCA includes 17.5 acres of the northwestern portion of the parcel; the rest of the parcel is discussed in the Boeing Plant 2/Jorgensen Forge SCA.

Table 4-2. Crowley Marine Services

FACILITY SUMMARY	
Address	7400 8th Ave S
Property Owner	Crowley Marine Services
Property Leasee/Operator	Alaska Logistics
Tax Parcel No.	2136200641
Parcel Size	15.86 ac
Facility/Site ID	1940187 (Crowley Marine Services) and 63123962 (Alaska Logistics)
EPA ID No.	WAD981768377 (Crowley Marine Services; inactive), WAD988470647 (Alaska Logistics), WAD980981846 (Samson Tug and Barge)
NPDES Permit No.	WAR009728 (expired 5/31/08)
UST/LUST ID No.	nr
Listed on CSCSL	No
TRI No.	nr
KCIWP No.	nr

Table 4-3. First South Properties

FACILITY SUMMARY	
Address	7343 E Marginal Way S
Property Owner	First South Properties
Property Leasee/Operator	Emerald Services
Tax Parcel No.	2924049043
Parcel Size	5.27 ac
Facility/Site ID	nr
EPA ID No.	WAD058364647
NPDES Permit No.	SO3002641C (Cedar Grove Composting, expired 9/20/07)
UST/LUST ID No.	nr
Listed on CSCSL	2462 (NFA granted; listing was for Evergreen Marine Leasing, a former tenant)
TRI No.	nr
KCIWP No.	7725-02 (Emerald Services)

Table 4-4. Georgetown Steam Plant

FACILITY SUMMARY	
Address	6605 13th Avenue S
Property Owner	Seattle City Light
Property Leasee/Operator	Seattle City Light
Tax Parcel No.	7006700570
Parcel Size	7.29 ac
Facility/Site ID	6487827
EPA ID No.	nr
NPDES Permit No.	nr
UST/LUST ID No.	63485131
Listed on CSCSL	6487827
TRI No.	nr
KCIWP No.	nr

Table 4-5. King County International Airport (northern drainage basin)

FACILITY SUMMARY	
Address	multiple street addresses along Perimeter Road S
Property Owner	King County
Property Leasee/Operator	multiple tenants on KCIA site, including The Boeing Company at NBF
Tax Parcel No.	2824049007
Parcel Size	564.80 ac[a]
Facility/Site ID	2051
EPA ID No.	WAD980986848
NPDES Permit No.	SO3000343D
UST/LUST ID No.	2051
Listed on CSCSL	2051 (NFA)
TRI No.	nr
KCIWP No.	nr
PSCAA ID	21407

[a] Parcel acreage includes the portion leased by The Boeing Company as NBF.

Table 4-6. North Boeing Field

FACILITY SUMMARY	
Address	7400 E Marginal Way S
Property Owner	The Boeing Company and King County
Property Leasee/Operator	The Boeing Company
Tax Parcel No.	2824049007 (parcel owned by King County), 2924049106 and 2924049066 (owned by The Boeing Company)
Parcel Size	approximately 130 ac of the 565-ac KCIA parcel no. 2824049007
Facility/Site ID	2117
EPA ID No.	WAD980982037
NPDES Permit No.	SO3000226D, WA0000868, and WAR000226
UST/LUST ID No.	2753918
Listed on CSCSL	No
TRI No.	98108THBNG7500E
KCIWP No.	550-02
PSCAA ID	21147
RCRA LQG	RCRA ID No. WAD980982037

5 BOEING PLANT 2/JORGENSEN FORGE SCA

Table 5-1. Boeing Plant 2

FACILITY SUMMARY	
Address	7755 E Marginal Way S, 1135 S Webster Street
Property Owner	Boeing
Property Leasee/Operator	Boeing
Tax Parcel No.	0001600020, 3324049002, 2824049009, 2185000005, 0022000005, 2924049056, 2924049112, 0022000195
Parcel Size	29.99 acres, 28.65 acres, 8.02 acres, 6.07 acres, 37.5 acres, 0.23 acres, 1.61 acres, 0.5 acres
Facility/Site ID	2100
EPA ID No.	WAD009256819
NPDES Permit No.	SO3000482D
UST/LUST ID No.	Not listed
Listed on CSCSL	No
TRI No.	98108BNGRS7755E
KCIWP No.	7811-01
SIC code	3728

Table 5-2. Jorgensen Forge

FACILITY SUMMARY	
Address	8531 E Marginal Way S
Property Owner	Jorgensen Forge Corporation
Property Leasee/Operator	Jorgensen Forge Corporation
Tax Parcel No.	0001600023
Parcel Size	21.6 acres
Facility/Site ID	2382
EPA ID No.	WAD000602813
NPDES Permit No.	SO3003231C
UST/LUST ID No.	nr
Listed on CSCSL	No
TRI No.	98108RLMJR8531E
KCIWP No.	nr

Table 5-3. KCIA

FACILITY SUMMARY	
Address	6505 Perimeter Road S (portion in EAA-4), 7277 Perimeter Road S, 6518 Ellis Avenue
Property Owner	King County
Property Leasee/Operator	King County
Tax Parcel No.	2824049007
Parcel Size	564.77
Facility/Site ID	2387398
EPA ID No.	WAD980986848
NPDES Permit No.	SO3000343D
UST/LUST ID No.	None within the Boeing Plant 2/Jorgensen Forge SCA drainage basin
Listed on CSCSL	nr
TRI No.	None
KCIWP No.	4109-01

6 BOEING ISAACSON/CENTRAL KCIA SCA

Table 6-1. Boeing Isaacson

FACILITY SUMMARY	
Address	8541 and 8625 E Marginal Way S
Property Owner	The Boeing Company
Property Leasee/Operator	The Boeing Company
Tax Parcel No.	0001600014
Parcel Size	9.84 ac
Facility/Site ID	1138721 (Boeing Isaacson Property) and 2218 (Boeing Isaacson Thompson)
EPA ID No.	WAD980836159 (inactive)
NPDES Permit No.	SO3000148
UST/LUST ID No.	nr
Listed on CSCSL	Yes
TRI No.	nr
KCIWP No.	nr

Table 6-2. Boeing Thompson

FACILITY SUMMARY	
Address	8541, 8701, 8770, and 8811 E Marginal Way S
Property Owner	The Boeing Company
Property Leasee/Operator	The Boeing Company
Tax Parcel No.	0007400033
Parcel Size	19.35 ac
Facility/Site ID	83767996 (Boeing Thompson), 4274402 (Boeing Thompson Site), and 2218 (Boeing Isaacson Thompson)
EPA ID No.	WAD980982912
NPDES Permit No.	SO3000148
UST/LUST ID No.	10410
Listed on CSCSL	Yes
TRI No.	nr
KCIWP No.	nr
Listed on RCRA-LQG	Yes

Table 6-3. KCIA (central drainage basin)

FACILITY SUMMARY	
Address	8700 East Marginal Way S and 6771 and 7299 Perimeter Rd S
Property Owner	King County
Property Leasee/Operator	Various tenants
Tax Parcel No.	0001600019, 0001600049, 3324049011, 0007400032, 5422600160, and 2824049007
Parcel Size	585.92 ac (for all parcels combined)
Facility/Site ID	2387398
EPA ID No.	WAH000031371 (Inactive)
NPDES Permit No.	SO3000343 (KCIA Maintenance Facility and runways)
UST/LUST ID No.	nr
Listed on CSCSL	Multiple airport tenant facilities are listed on the CSCSL
TRI No.	nr
KCIWP No.	nr

7 SLIP 6 SCA

Table 7-1. Boeing Developmental Center (northern drainage area)

FACILITY SUMMARY	
Address	9725 East Marginal Way South
Property Owner	The Boeing Company
Tax Parcel No./Size	5624201032 (25.78 acres)
	5624201038 (3.78 acres)
	5624201036 (1.63 acres)
Facility/Site ID	2101
EPA ID No.	WAD093639946
NPDES Permit No.	SO3000146D
UST/LUST ID No.	10408
Listed on CSCSL	Yes
TRI No.	98108BNGDV9725E
KCIWP	526-04
Other	nr

Table 7-2. Former PACCAR site

FACILITY SUMMARY	
Address	8801 East Marginal Way South
Property Owner	Merrill Creek Holdings, LLC
Property Lessee/Operator	Insurance Auto Auction, Inc.
Tax Parcel No.	5422600060
Parcel Size	24.30 acres
Facility/Site ID	2072
EPA ID No	WAD009249509
NPDES Permit No.	SO3008681A (IAAI)
UST/LUST ID No.	8218 / 552588
Listed on CSCSL	Yes
TRI No.	98108KNWRT8801E
KCIWP	nr
Other	nr

Table 7-3. Former Rhone-Poulenc site

FACILITY SUMMARY	
Address	9229 East Marginal Way South
Property Owner	Container Properties (West Parcel)
	Museum of Flight (East Parcel)
Property Lessee/Operator	IAAI (West Parcel)
Tax Parcel No.	5422600010 (West Parcel)
	5422600020 (East Parcel)
Parcel Size	13.15 acres (West Parcel)
	6.47 acres (East Parcel)
Facility/Site ID	2150
EPA ID No.	WAD009282302
NPDES Permit No.	SO3008681A (West Parcel)
UST/LUST ID No.	Not Listed
Listed on CSCSL	Yes
TRI No.	98108RHNPL9229E
KCIWP	7789-01 (West Parcel)
Other	nr

Table 7-4. King County International Airport (south-central drainage basin)

FACILITY SUMMARY	
Address	7277 Perimeter Road South (KCIA)
	6518 Ellis Avenue (KCIA Maintenance Facility)
	6505 Perimeter Road South (Parcel within Slip 6)
Property Owner	King County
Tax Parcel No.	2824049007
Parcel Size	564.77 acres
Facility/Site ID	2387398 (KCIA)
	2051 (KCIA Maintenance Facility)
EPA ID No.	WAH000031371 (inactive)
	WAD980986848 (KCIA Maintenance Facility)
NPDES Permit No.	SO3000343 (KCIA Maintenance Facility and runways)
UST/LUST ID No.	8341 (KCIA Maintenance Facility)
Listed on CSCSL	nr
TRI No.	nr
KCIWP No.	4109-01 (Transportation Facility Operations)
Other	nr

8 NORFOLK CSO/SD SCA

Table 8-1. Arco Gas Station

FACILITY SUMMARY	
Address	9834 Martin Luther King Jr Way S, 9830 Martin Luther King Way S (former)
Property Owner	John Eastey
Property Leasee/Operator	nr
Tax Parcel No.	0323049008
Parcel Size	2.95 acre
Facility/Site ID	29429665
EPA ID No.	nr
NPDES Permit No.	nr
UST/LUST ID No.	Listed (under 9840 Martin Luther King Way S)
Listed on CSCSL	Listed (under 9840 Martin Luther King Way S)
TRI No.	nr
KCIWP No.	nr

Table 8-2. Boeing Developmental Center

FACILITY SUMMARY	
Address	9725 East Marginal Way South
Property Owner	The Boeing Company, East Marginal Associates, Mellon Trust of Washington-Desimone
Property Leasee/Operator	The Boeing Company
Tax Parcel No.	0003400028, 562401032,5624201036, 5624201038, 0423049183, 0423049016, 0003400048, 0003400026, 5624200990
Parcel Size	2.25 acres, 25.78 acres, 3.25 acres, 3.78 acres, 0.81 acres, 3.07 acres, 1.38 acres, 3.88 acres, 14.21 acres
Facility/Site ID	2101
EPA ID No.	WAD093639946
NPDES Permit No.	SO3000146D
UST/LUST ID No.	10408
Listed on CSCSL	Yes
TRI No.	98108BNGDV9725E
KCIWP	526-04

Table 8-3. Boeing Military Flight Center

FACILITY SUMMARY	
Address	10002 E Marginal Way S
Property Owner	The Boeing Company
Property Leasee/Operator	The Boeing Company
Tax Parcel No.	0003400021
Parcel Size	24.6 acres
Facility/Site ID	7711519
EPA ID No.	WAD988475943
NPDES Permit No.	SO3000150D (Stormwater general permit)
UST/LUST ID No.	nr
Listed on CSCSL	nr
TRI No.	nr
KCIWP No.	363-02

Table 8-4. King County International Airport (southern drainage basin)

FACILITY SUMMARY	
Address	7277 Perimeter Road S, 6518 Ellis Avenue, 6505 Perimeter Road S
Property Owner	King County
Property Leasee/Operator	King County International Airport
Tax Parcel No.	2824049007
Parcel Size	564.77 acres
Facility/Site ID	nr
EPA ID No.	nr
NPDES Permit No.	SO3000343D
UST/LUST ID No.	Listed
Listed on CSCSL	nr
TRI No.	nr
KCIWP No.	nr

9 GLACIER BAY SCA

Table 9-1. Alaska Marine Lines

FACILITY SUMMARY	
Address	5615 W Marginal Way SSW
Property Owner	Alaska Marine Lines
Property Leasee/Operator	Alaska Marine Lines
Tax Parcel No.	1924049026
Parcel Size	13.8 acres
Facility/Site ID	nr
EPA ID No.	RCRA WA0000062323
NPDES Permit No.	SO3-001365D
UST/LUST ID No.	On LUST database; no ID provided
Listed on CSCSL	nr
TRI No.	nr
KCIWP No.	459-02

Table 9-2. Chemithon Corporation

FACILITY SUMMARY	
Address	5430 W Marginal Way SW
Property Owner	Chemithon Corporation
Property Leasee/Operator	Chemithon Corporation
Tax Parcel No.	1924049098
Parcel Size	2.66 acres
Facility/Site ID	nr
EPA ID No.	RCRA WAD009244898
NPDES Permit No.	SO3-000033D
UST/LUST ID No.	nr
Listed on CSCSL	nr
TRI No.	nr
KCIWP No.	nr
PSCAA No.	13182

Table 9-3. Duwamish Shipyard

FACILITY SUMMARY	
Address	5658 W Marginal Way SW
Property Owner	Duwamish Shipyard, Inc.
Property Leasee/Operator	Duwamish Shipyard, Inc.
Tax Parcel No.	1924049028
Parcel Size	4.93 acres
Facility/Site ID	nr
EPA ID No.	RCRA WAD009244997
NPDES Permit No.	WA0030937C
UST/LUST ID No.	On LUST database; no ID provided
Listed on CSCSL	YES
TRI No.	nr
KCIWP No.	nr
METRO Waste Discharge Permit:	7704-01 (effective 10/16/00); 7704-02 (effective 10/19/05)
Clean Air Act ID No.	5303300106
PSCAA No.	10654

Table 9-4. Glacier Northwest

FACILITY SUMMARY	
Address	5900 W Marginal Way SW
Property Owner	Glacier Northwest, Inc.
Property Leasee/Operator	Glacier Northwest, Inc.
Tax Parcel No.	1924049029
Parcel Size	18.2 acres
Facility/Site ID	nr
EPA ID No.	RCRA WAD151474368 (cement terminal)
EPA ID No.	RCRA WAH000007773 (truck stop)
NPDES Permit No.	WAG-50-3347 (Sand and Gravel – effective 12/04/01, cancelled 01/25/06)
UST/LUST ID No.	nr
Listed on CSCSL	Yes
TRI No.	nr
KCIWP No.	510-02
PSCAA ID No.	11872

Table 9-5. Former MRI Corporation site

FACILITY SUMMARY	
Address	600 W Marginal Way SW
Property Owner	Port of Seattle
Property Leasee/Operator	Polar Supply
Tax Parcel No.	5367202505 (as part of Terminal 115 property)
Parcel Size	1.88 acres (under lease from the Port of Seattle)
Facility/Site ID	nr
EPA ID No.	nr
NPDES Permit No.	nr
UST/LUST ID No.	nr
Listed on CSCSL	Yes
TRI No.	nr
KCIWP No.	7067

10 TROTSKY INLET SCA

Table 10-1. Boyer Towing

FACILITY SUMMARY	
Address	7201 Second Avenue S
Property Owner	Boyer Towing, Inc
Property Leasee/Operator	nr
Tax Parcel No.	6871200045, 6871200620, 6871200811
Parcel Size	0.13 acres, 0.79 acres, 0.27 acres
Facility/Site ID	None
EPA ID No.	nr
NPDES Permit No.	nr
UST/LUST ID No.	nr
Listed on CSCSL	nr
TRI No.	nr
KCIWP No.	nr

Table 10-2. Douglas Management Company

FACILITY SUMMARY	
Address	7100 Second Avenue SW (Alaska Marine lines)
Property Owner	Douglas management Company
Property Leasee/Operator	Alaska Marine Lines
Tax Parcel No.	2924049090
Parcel Size	3.09
Facility/Site ID	None
EPA ID No.	nr
NPDES Permit No.	SO3-002471 (stormwater discharge permit for Alaska Marine Lines)
UST/LUST ID No.	nr
Listed on CSCSL	nr
TRI No.	nr
KCIWP No.	nr

Table 10-3. Trotsky

FACILITY SUMMARY	
Address	7152 First Avenue S
Property Owner	Industrial Container Services, LLC
Property Leasee/Operator	Herman and Jacqueline Trotsky
Tax Parcel No.	292409108, 2924049030, 2924049004
Parcel Size	1 acre, 5.09 acres, 1.04 acres
Facility/Site ID	nr
EPA ID No.	WAD000066084
NPDES Permit No.	nr
UST/LUST ID No.	nr
Listed on CSCSL	Listed
TRI No.	nr
KCIWP No.	7130
PSCAA Air permit No.	11683

Table 10-4. Wells Trucking and Leasing

FACILITY SUMMARY	
Address	7265 Second Ave. S.
Property Owner	Boyer Towing
Property Leasee/Operator	Wells Trucking and Leasing
Tax Parcel No.	6871200750
Parcel Size	0.62 acres
Facility/Site ID	nr
EPA ID No.	nr
NPDES Permit No.	nr
UST/LUST ID No.	nr
Listed on CSCSL	nr
TRI No.	nr
KCIWP No.	nr

11 TERMINAL-117 SCA

Table 11-1. Terminal 117

FACILITY SUMMARY	
Address	8700 Dallas Ave S, 98108
Property Owner	Port of Seattle
Property Leasee/Operator	Port of Seattle
Tax Parcel No.	0001600044
Parcel Size	2.39 acres
Facility/Site ID	2202
EPA ID No.	WAR000010413
NPDES Permit No.	nr
UST/LUST ID No.	nr
Listed on CSCSL	Yes
TRI No.	nr
KCIWP No.	nr

Table 11-2. South Park Marina

FACILITY SUMMARY	
Address	8604 Dallas Ave S, 8544 Dallas Ave S (marina), 1415 S Thistle Street (ricks master marine), 8510 Dallas Ave S (tire factory)
Property Owner	South Park Marina
Property Leasee/Operator	South Park Marina
Tax Parcel No.	0001600001, 2185600025, and 2185600070
Parcel Size	1.96 acres, 1.39 acres, and 0.38 acres
Facility/Site ID	44653368
EPA ID No.	WAD988513248
NPDES Permit No.	WAG030045
UST/LUST ID No.	nr
Listed on CSCSL	No
TRI No.	nr
KCIWP No.	nr

Table 11-3. Basin Oil

FACILITY SUMMARY	
Address	8661/8701 Dallas Ave S
Property Owner	Basin Oil Co Inc
Property Leasee/Operator	Basin Oil Co Inc
Tax Parcel No.	7884100110 and 7884100145
Parcel Size	0.38 acres and 0.12 acres
Facility/Site ID	83476734
EPA ID No.	WAD988477501
NPDES Permit No.	SO3-002273
UST/LUST ID No.	nr
Listed on CSCSL	Yes
TRI No.	nr
KCIWP No.	nr

Table 11-4. Boeing South Park

FACILITY SUMMARY	
Address	1420 S Trenton St, 98108
Property Owner	The Boeing Company
Property Leasee/Operator	The Boeing Company
Tax Parcel No.	7883608601
Parcel Size	27.73 acres
Facility/Site ID	60381981
EPA ID No.	WAD 980982672 (SQG and LQG)
NPDES Permit No.	SO3001009
UST/LUST ID No.	nr
Listed on CSCSL	No
TRI No.	nr
KCIWP No.	nr

References

EDR. 2002. Corridor study report, lower Duwamish River, Seattle, WA. Environmental Data Resources, Inc., Southport, CT.

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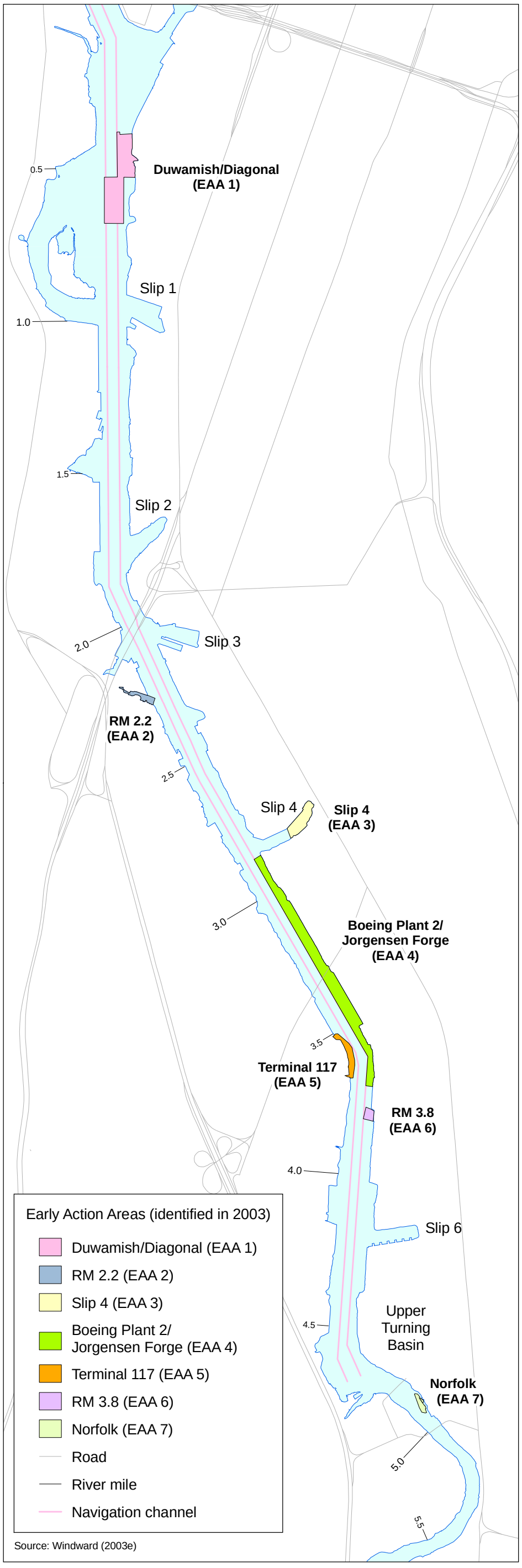
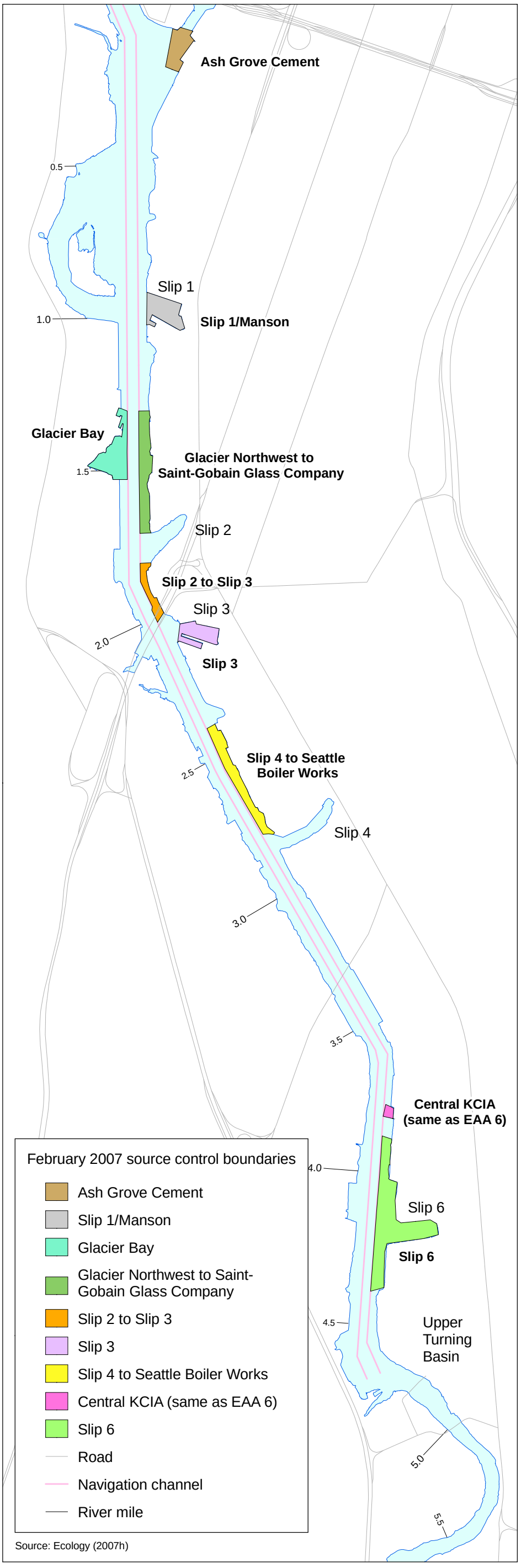




Early Action Areas (identified in 2003)

- Duwamish/Diagonal (EAA 1)
- RM 2.2 (EAA 2)
- Slip 4 (EAA 3)
- Boeing Plant 2/ Jorgensen Forge (EAA 4)
- Terminal 117 (EAA 5)
- RM 3.8 (EAA 6)
- Norfolk (EAA 7)
- Road
- River mile
- Navigation channel

Source: Windward (2003e)

February 2007 source control boundaries

- Ash Grove Cement
- Slip 1/Manson
- Glacier Bay
- Glacier Northwest to Saint-Gobain Glass Company
- Slip 2 to Slip 3
- Slip 3
- Slip 4 to Seattle Boiler Works
- Central KCIA (same as EAA 6)
- Slip 6
- Road
- Navigation channel
- River mile

Source: Ecology (2007h)

Windward environmental LLC

N

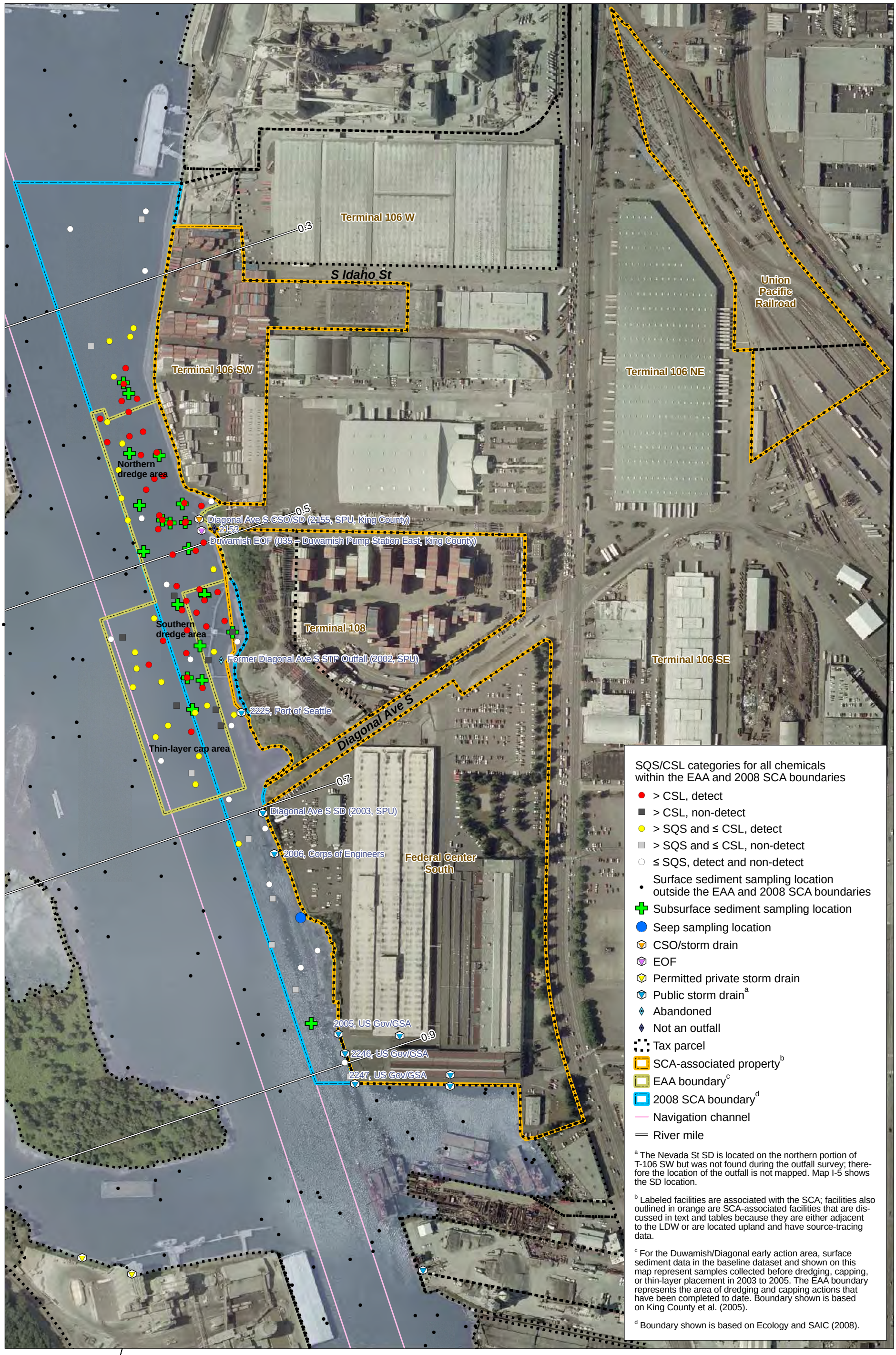
0 0.25 0.5 Miles

0 0.4 0.8 Kilometers

Scale is the same for each inset map

Map I-1. Early Action Areas (identified in 2003) and Ecology's February 2007 source control boundaries

Prepared by CEH, 07/08/2010. Map 2849: W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Source Control\Appendix I



WindWard environmental LLC

N

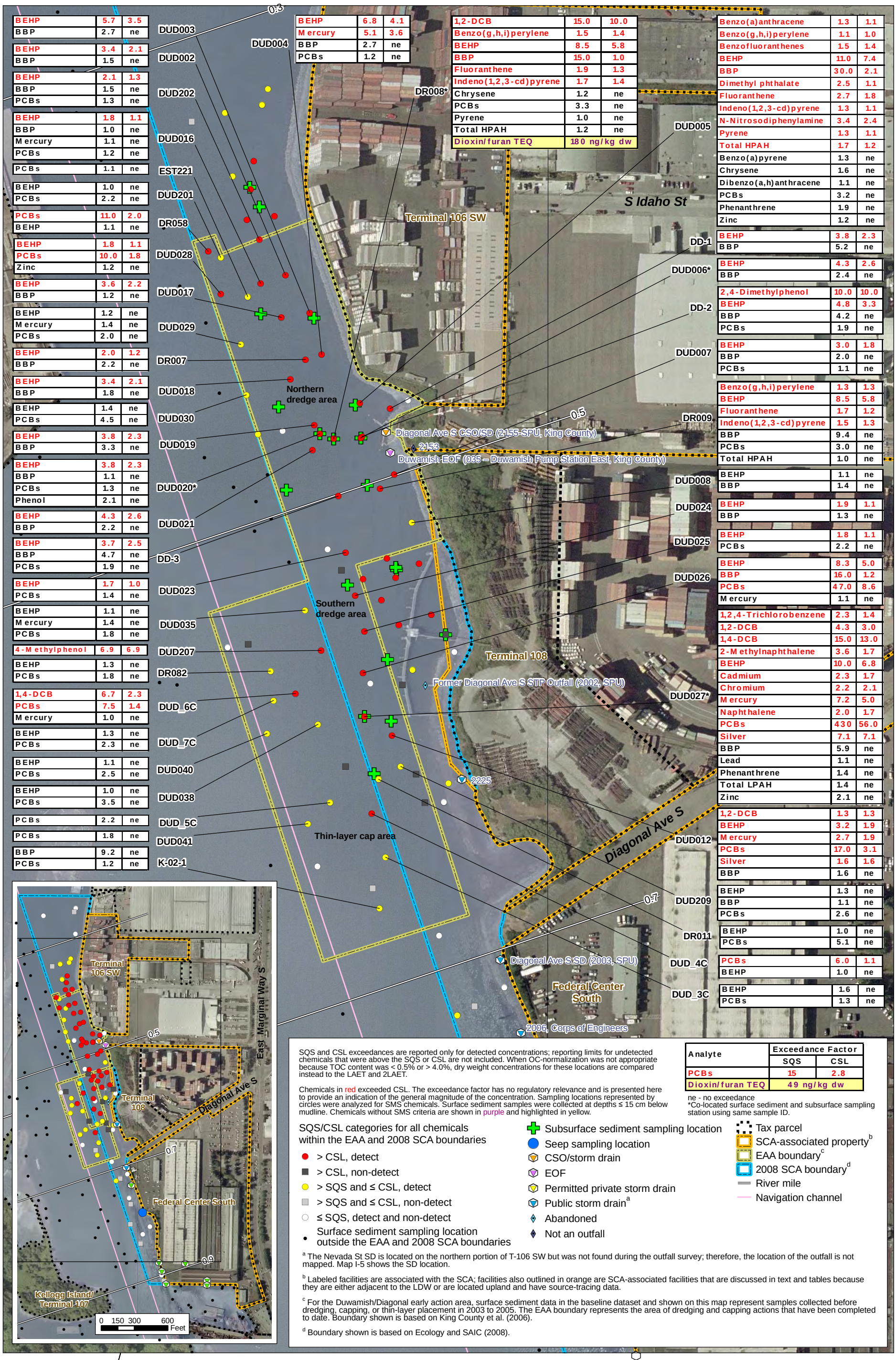
0 100 200 400 Feet

0 25 50 100 Meters

Map I-2. Duwamish/Diagonal Way SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/08/2010: MAP 3424: W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Source Control\Appendix I



BEHP	5.7	3.5
BBP	2.7	ne

BEHP	3.4	2.1
BBP	1.5	ne

BEHP	2.1	1.3
BBP	1.5	ne
PCBs	1.3	ne

BEHP	1.8	1.1
BBP	1.0	ne
Mercury	1.1	ne
PCBs	1.2	ne

PCBs	1.1	ne

BEHP	1.0	ne
PCBs	2.2	ne

PCBs	11.0	2.0
BEHP	1.1	ne

BEHP	1.8	1.1
PCBs	10.0	1.8
Zinc	1.2	ne

BEHP	3.6	2.2
BBP	1.2	ne

BEHP	1.2	ne
Mercury	1.4	ne
PCBs	2.0	ne

BEHP	2.0	1.2
BBP	2.2	ne

BEHP	3.4	2.1
BBP	1.8	ne

BEHP	1.4	ne
PCBs	4.5	ne

BEHP	3.8	2.3
BBP	3.3	ne

BEHP	3.8	2.3
BBP	1.1	ne
PCBs	1.3	ne
Phenol	2.1	ne

BEHP	4.3	2.6
BBP	2.2	ne

BEHP	3.7	2.5
BBP	4.7	ne
PCBs	1.9	ne

BEHP	1.7	1.0
PCBs	1.4	ne

BEHP	1.1	ne
Mercury	1.4	ne
PCBs	1.8	ne

4-Methylphenol	6.9	6.9

BEHP	1.3	ne
PCBs	1.8	ne

1,4-DCB	6.7	2.3
PCBs	7.5	1.4
Mercury	1.0	ne

BEHP	1.3	ne
PCBs	2.3	ne

BEHP	1.1	ne
PCBs	2.5	ne

BEHP	1.0	ne
PCBs	3.5	ne

PCBs	2.2	ne

PCBs	1.8	ne

BBP	9.2	ne
PCBs	1.2	ne

BEHP	6.8	4.1
Mercury	5.1	3.6
BBP	2.7	ne
PCBs	1.2	ne

1,2-DCB	15.0	10.0
Benzo(g,h,i)perylene	1.5	1.4
BEHP	8.5	5.8
BBP	15.0	1.0
Fluoranthene	1.9	1.3
Indeno(1,2,3-cd)pyrene	1.7	1.4
Chrysene	1.2	ne
PCBs	3.3	ne
Pyrene	1.0	ne
Total HPAH	1.2	ne
Dioxin/furan TEQ	180 ng/kg dw	

Benzo(a)anthracene	1.3	1.1
Benzo(g,h,i)perylene	1.1	1.0
Benzofluoranthenes	1.5	1.4
BEHP	11.0	7.4
BBP	30.0	2.1
Dimethyl phthalate	2.5	1.1
Fluoranthene	2.7	1.8
Indeno(1,2,3-cd)pyrene	1.3	1.1
N-Nitrosodiphenylamine	3.4	2.4
Pyrene	1.3	1.1
Total HPAH	1.7	1.2
Benzo(a)pyrene	1.3	ne
Chrysene	1.6	ne
Dibenzo(a,h)anthracene	1.1	ne
PCBs	3.2	ne
Phenanthrene	1.9	ne
Zinc	1.2	ne

BEHP	3.8	2.3
BBP	5.2	ne

BEHP	4.3	2.6
BBP	2.4	ne

2,4-Dimethylphenol	10.0	10.0
BEHP	4.8	3.3
BBP	4.2	ne
PCBs	1.9	ne

BEHP	3.0	1.8
BBP	2.0	ne
PCBs	1.1	ne

Benzo(g,h,i)perylene	1.3	1.3
BEHP	8.5	5.8
Fluoranthene	1.7	1.2
Indeno(1,2,3-cd)pyrene	1.5	1.3
BBP	9.4	ne
PCBs	3.0	ne
Total HPAH	1.0	ne

BEHP	1.1	ne
BBP	1.4	ne

BEHP	1.9	1.1
BBP	1.3	ne

BEHP	1.8	1.1
PCBs	2.2	ne

BEHP	8.3	5.0
BBP	16.0	1.2
PCBs	47.0	8.6
Mercury	1.1	ne

1,2,4-Trichlorobenzene	2.3	1.4
1,2-DCB	4.3	3.0
1,4-DCB	15.0	13.0
2-Methylnaphthalene	3.6	1.7
BEHP	10.0	6.8
Cadmium	2.3	1.7
Chromium	2.2	2.1
Mercury	7.2	5.0
Naphthalene	2.0	1.7
PCBs	430	56.0
Silver	7.1	7.1
BBP	5.9	ne
Lead	1.1	ne
Phenanthrene	1.4	ne
Total LPAH	1.4	ne
Zinc	2.1	ne

1,2-DCB	1.3	1.3
BEHP	3.2	1.9
Mercury	2.7	1.9
PCBs	17.0	3.1
Silver	1.6	1.6
BBP	1.6	ne

BEHP	1.3	ne
BBP	1.1	ne
PCBs	2.6	ne

BEHP	1.0	ne
PCBs	5.1	ne

PCBs	6.0	1.1
BEHP	1.0	ne

BEHP	1.6	ne
PCBs	1.3	ne

SQS and CSL exceedances are reported only for detected concentrations; reporting limits for undetected chemicals that were above the SQS or CSL are not included. When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

Chemicals in red exceeded CSL. The exceedance factor has no regulatory relevance and is presented here to provide an indication of the general magnitude of the concentration. Sampling locations represented by circles were analyzed for SMS chemicals. Surface sediment samples were collected at depths ≤ 15 cm below mudline. Chemicals without SMS criteria are shown in purple and highlighted in yellow.

Analyte	Exceedance Factor	
	SQS	CSL
PCBs	15	2.8
Dioxin/furan TEQ	49 ng/kg dw	

ne - no exceedance
*Co-located surface sediment and subsurface sampling station using same sample ID.

SQS/CSL categories for all chemicals within the EAA and 2008 SCA boundaries

- > CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the EAA and 2008 SCA boundaries

- Subsurface sediment sampling location
- Seep sampling location
- CSO/storm drain
- EOF
- Permitted private storm drain
- Public storm drain[a]
- Abandoned
- Not an outfall

- Tax parcel
- SCA-associated property[b]
- EAA boundary[c]
- 2008 SCA boundary[d]
- River mile
- Navigation channel

[a] The Nevada St SD is located on the northern portion of T-106 SW but was not found during the outfall survey; therefore, the location of the outfall is not mapped. Map I-5 shows the SD location.

[b] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset and shown on this map represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. The EAA boundary represents the area of dredging and capping actions that have been completed to date. Boundary shown is based on King County et al. (2006).

[d] Boundary shown is based on Ecology and SAIC (2008).

Wind Ward environmental LLC

N

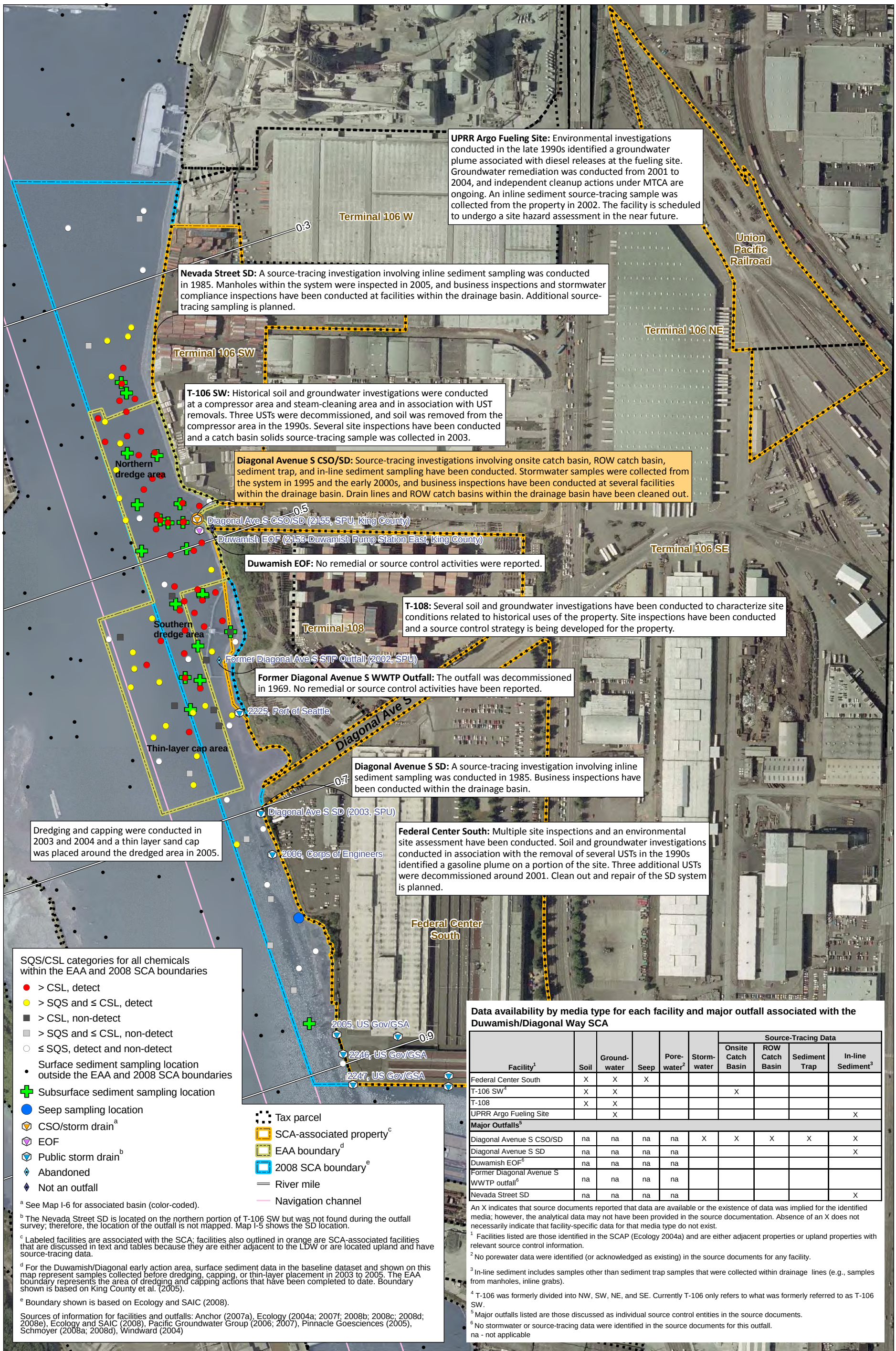
0 50 100 200 Feet

0 12.5 25 50 Meters

Map I-3. Surface sediment information for the Duwamish/Diagonal Way SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/08/2010; MAP 3015; W:\Projects\00-08-06_Duwamish_R\data\GIS\Phase2 RI\Source Control\Appendix I



[a] See Map I-6 for associated basin (color-coded).

[b] The Nevada Street SD is located on the northern portion of T-106 SW but was not found during the outfall survey; therefore, the location of the outfall is not mapped. Map I-5 shows the SD location.

[c] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[d] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset and shown on this map represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. The EAA boundary represents the area of dredging and capping actions that have been completed to date. Boundary shown is based on King County et al. (2005).

[e] Boundary shown is based on Ecology and SAIC (2008).

Sources of information for facilities and outfalls: Anchor (2007a), Ecology (2004a; 2007f; 2008b; 2008c; 2008d; 2008e), Ecology and SAIC (2008), Pacific Groundwater Group (2006; 2007), Pinnacle Goesciences (2005), Schmoyer (2008a; 2008d), Windward (2004)

Data availability by media type for each facility and major outfall associated with the Duwamish/Diagonal Way SCA

Facility[1]	Soil	Ground-water	Seep	Pore-water[2]	Storm-water	Source-Tracing Data: Onsite Catch Basin	ROW Catch Basin	Sediment Trap	In-line Sediment[3]
Federal Center South	X	X	X						
T-106 SW[4]	X	X				X			
T-108	X	X							
UPRR Argo Fueling Site		X							X
Major Outfalls[5]									
Diagonal Avenue S CSO/SD	na	na	na	na	X	X	X	X	X
Diagonal Avenue S SD	na	na	na	na					X
Duwamish EOF[6]	na	na	na	na					
Former Diagonal Avenue S WWTP outfall[6]	na	na	na	na					
Nevada Street SD	na	na	na	na					X

An X indicates that source documents reported that data are available or the existence of data was implied for the identified media; however, the analytical data may not have been provided in the source documentation. Absence of an X does not necessarily indicate that facility-specific data for that media type do not exist.

[1] Facilities listed are those identified in the SCAP (Ecology 2004a) and are either adjacent properties or upland properties with relevant source control information.

[2] No porewater data were identified (or acknowledged as existing) in the source documents for any facility.

[3] In-line sediment includes samples other than sediment trap samples that were collected within drainage lines (e.g., samples from manholes, inline grabs).

[4] T-106 was formerly divided into NW, SW, NE, and SE. Currently T-106 only refers to what was formerly referred to as T-106 SW.

[5] Major outfalls listed are those discussed as individual source control entities in the source documents.

[6] No stormwater or source-tracing data were identified in the source documents for this outfall.

na - not applicable

Windward environmental LLC

N

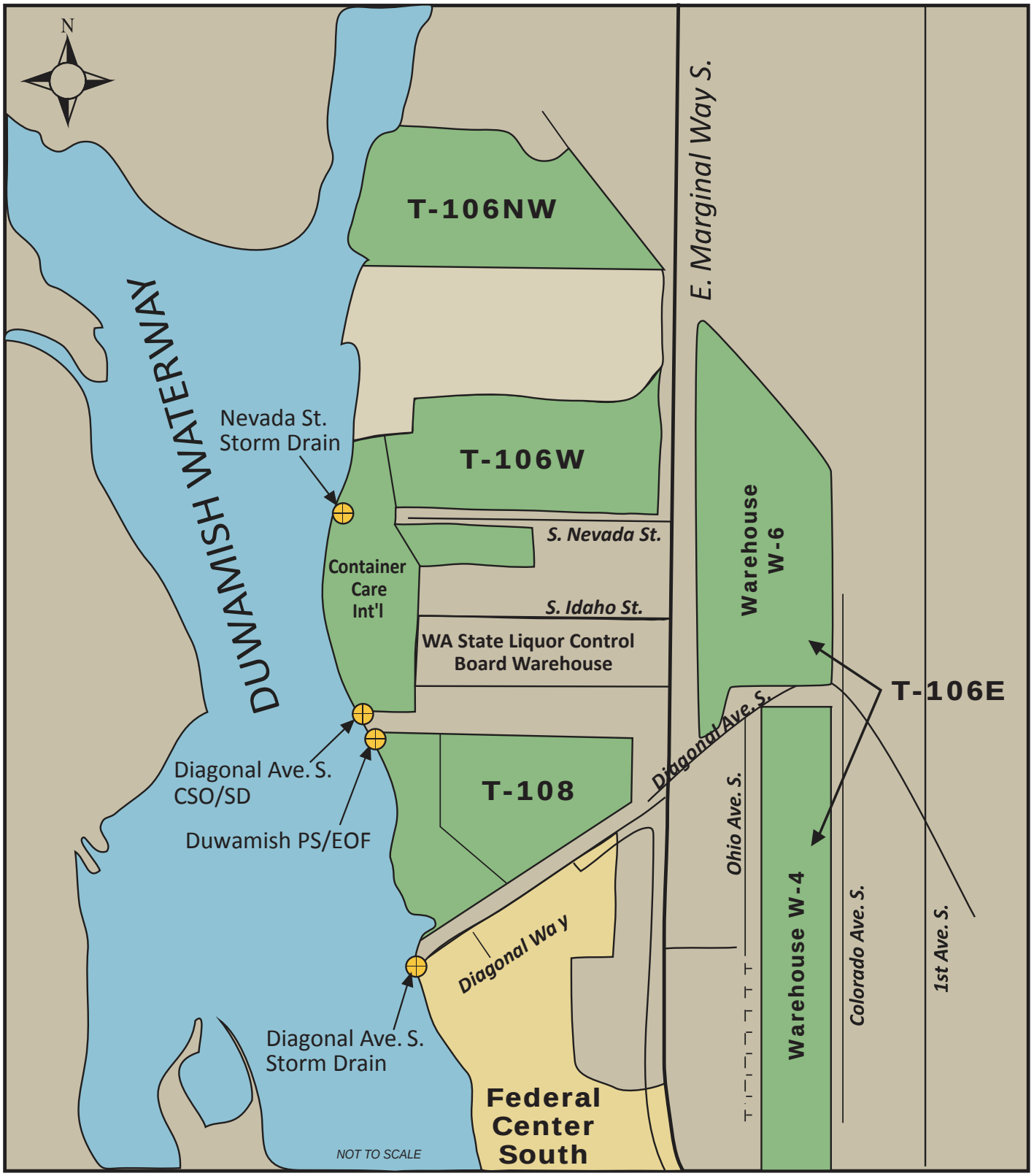
0 125 250 500 Feet

0 25 50 100 Meters

Map I-4. Regulatory investigation and remediation status of the Duwamish/ Diagonal Way SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/08/2010. MAP 3439. W:\Projects\00-08-06 Duwamish R\data\GIS\Phase2 RI\Source Control\Appendix I



Source: Ecology (2004a)

LEGEND

- Publicly-owned storm drain or CSO
- Port of Seattle
- Federal Ctr South

Map I-5. Location of Nevada Street storm drain

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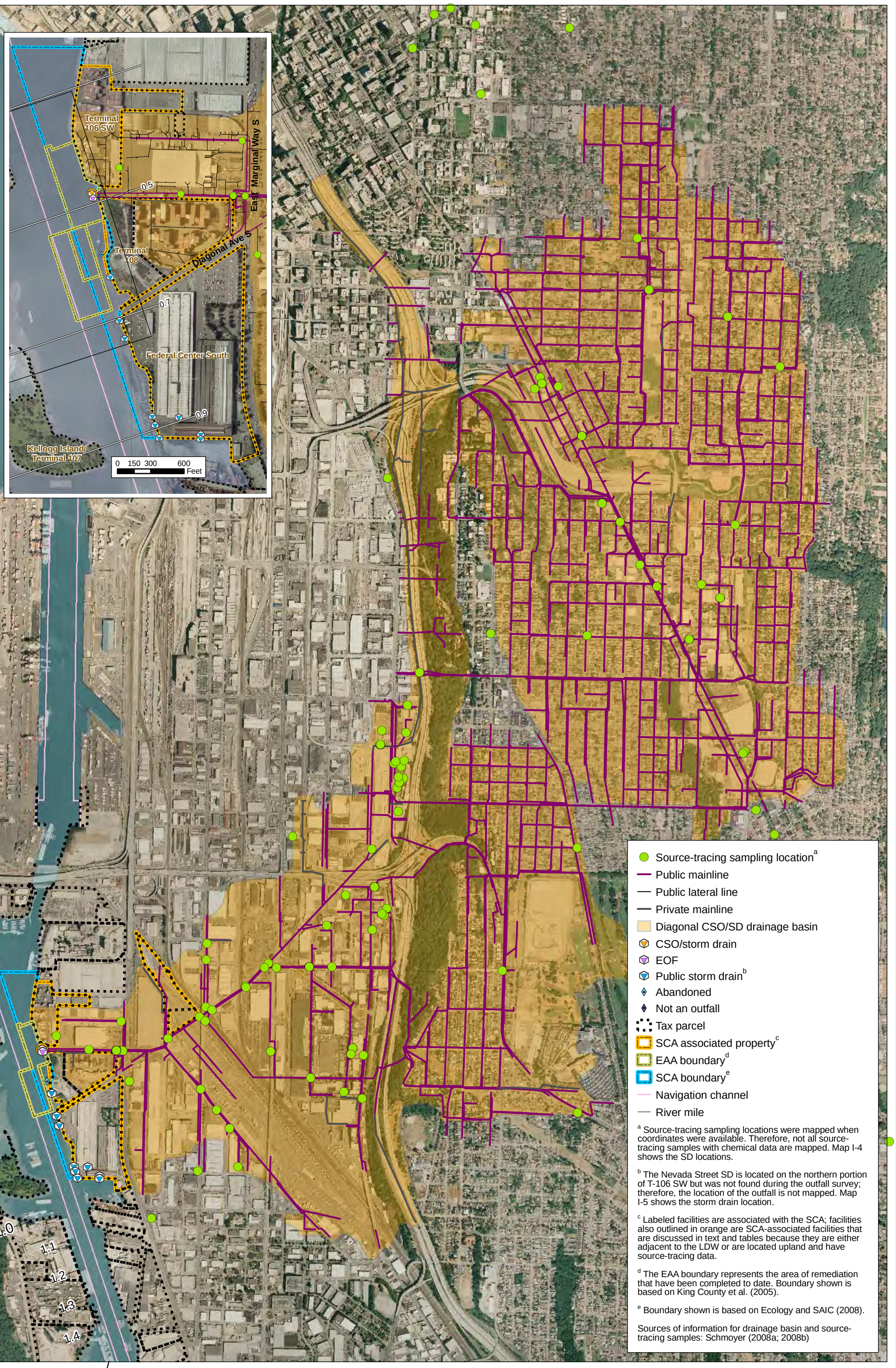


[a] Source-tracing sampling locations were mapped when coordinates were available. Therefore, not all source-tracing samples with chemical data are mapped. Map I-4 shows the SD locations.

[b] The Nevada Street SD is located on the northern portion of T-106 SW but was not found during the outfall survey; therefore, the location of the outfall is not mapped. Map I-5 shows the storm drain location.

[c] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[d] The EAA boundary represents the area of remediation that have been completed to date. Boundary shown is based on King County et al. (2005).

[e] Boundary shown is based on Ecology and SAIC (2008).

Sources of information for drainage basin and source-tracing samples: Schmoyer (2008a; 2008b)

WindWard environmental LLC

N

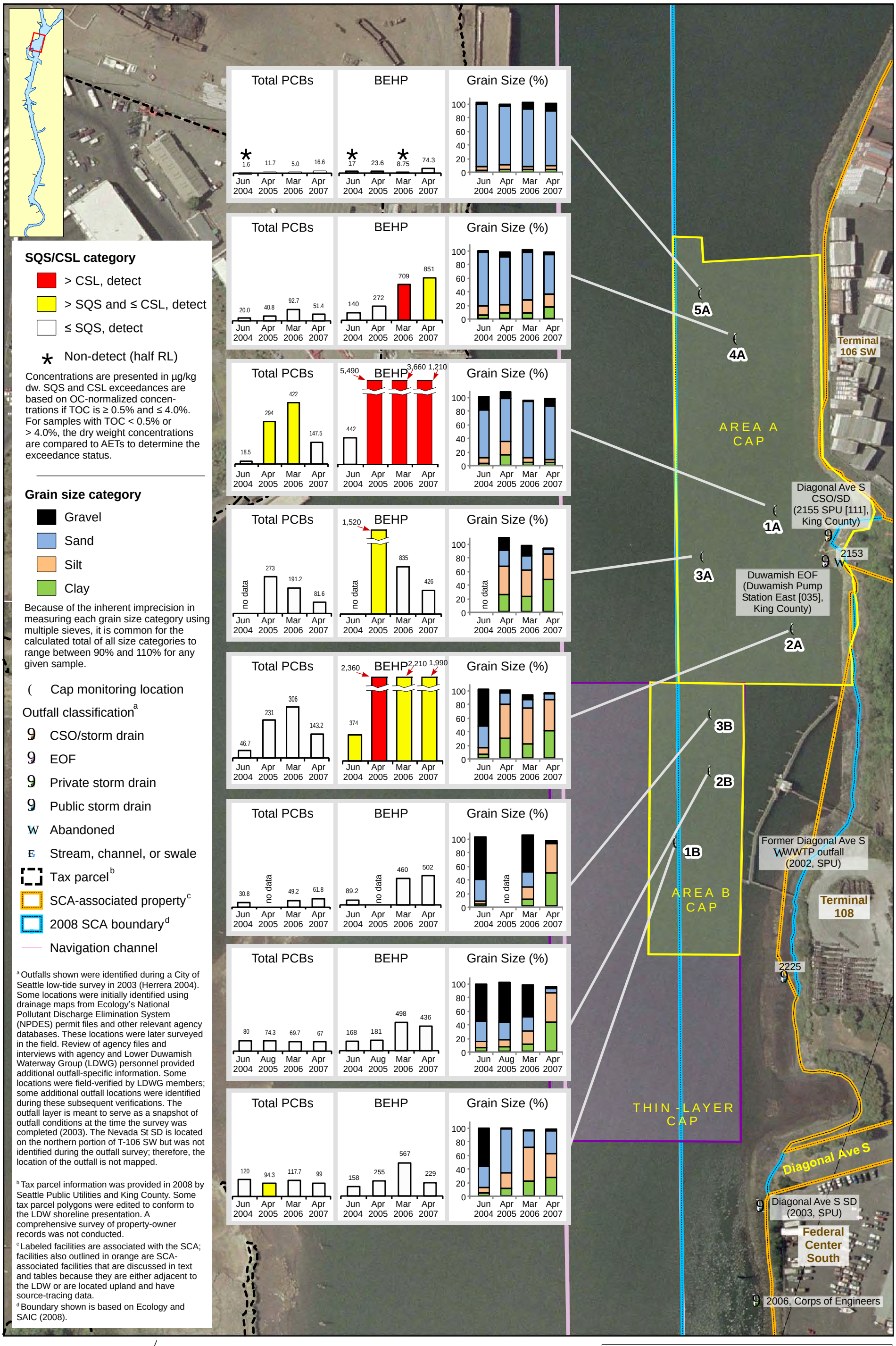
0 0.125 0.25 0.5 Miles

0 0.125 0.25 0.5 Kilometers

Map I-6. Duwamish/Diagonal Way SCA drainage basin

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/08/2010: MAP 3440: W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Appendix I



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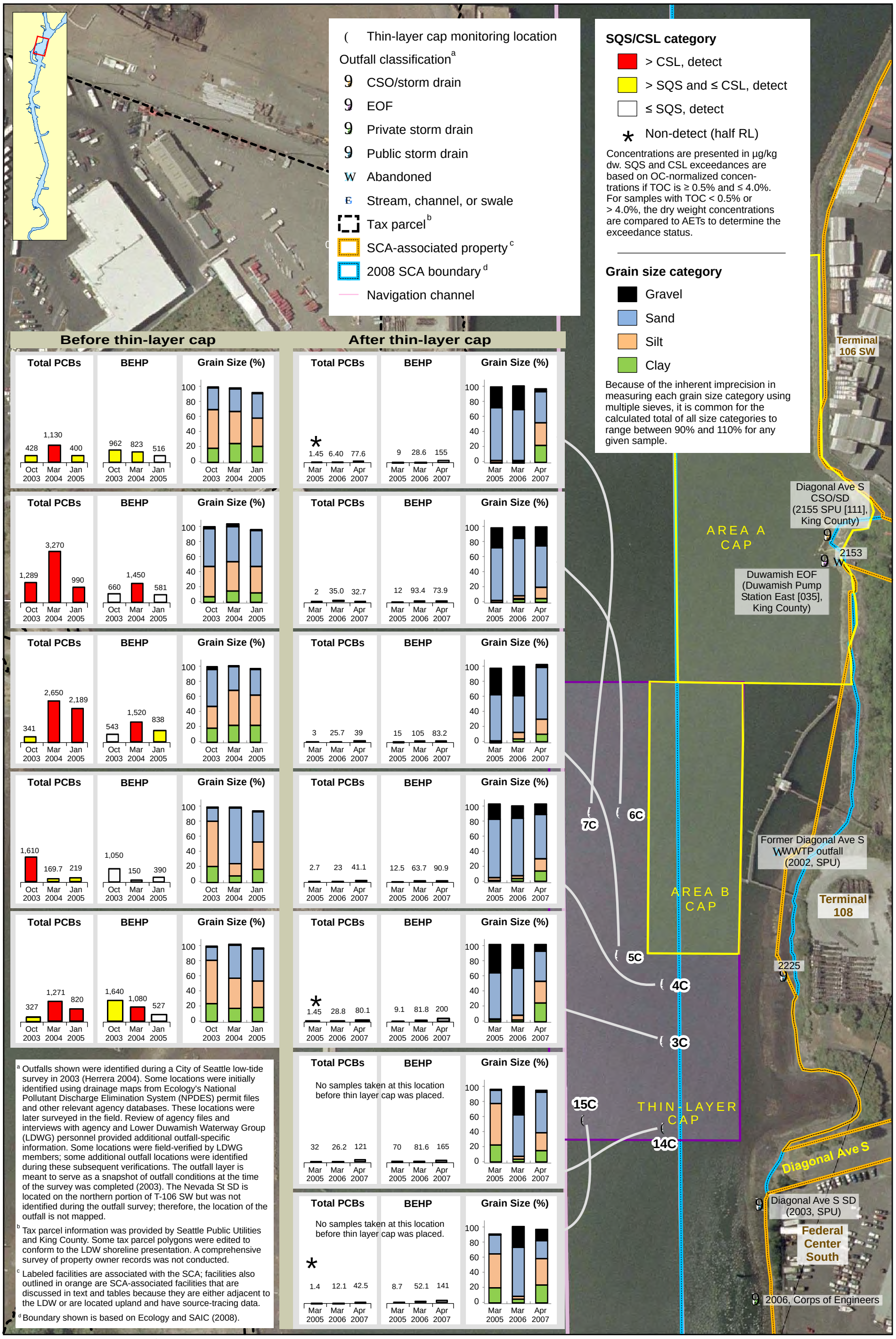
Map I-7. Surface sediment data at cap monitoring locations

Modified by Zachariah from GIS Map 2852 | July 16, 2009 | Map I-7 (2582).xar



[a] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time of the survey was completed (2003). The Nevada St SD is located on the northern portion of T-106 SW but was not identified during the outfall survey; therefore, the location of the outfall is not mapped.

[b] Tax parcel information was provided by Seattle Public Utilities and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

[c] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[d] Boundary shown is based on Ecology and SAIC (2008).

Wind Ward environmental LLC

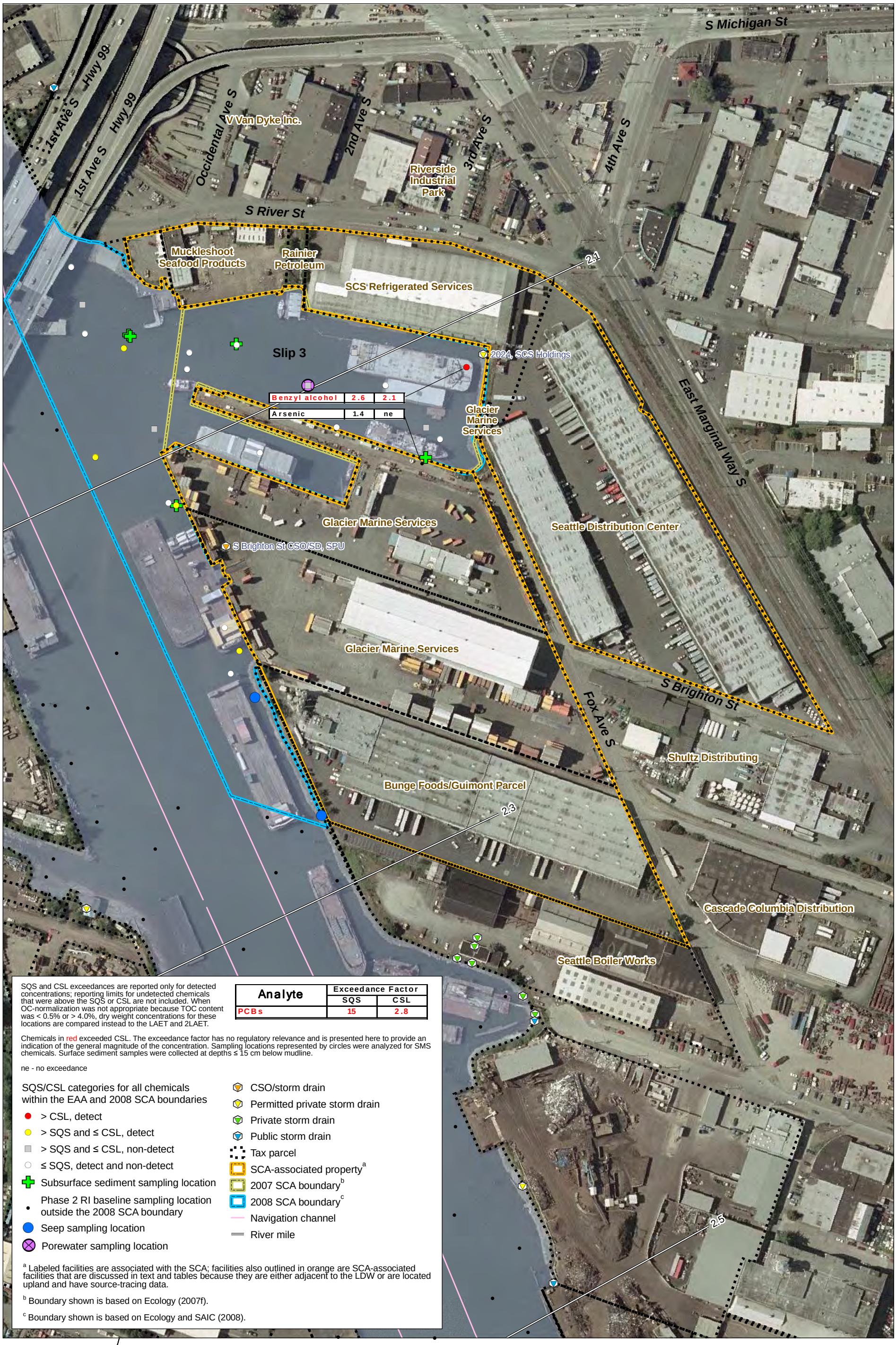
N

0 100 200 Feet

0 25 50 Meters

Map I-8. Surface sediment data at thin-layer cap monitoring locations

Modified by Zachariah from GIS Map 2584 | July 16, 2009 | Map I-8 (2584).xar



SQS and CSL exceedances are reported only for detected concentrations; reporting limits for undetected chemicals that were above the SQS or CSL are not included. When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

Analyte	Exceedance Factor	
	SQS	CSL
PCBs	15	2.8

Chemicals in red exceeded CSL. The exceedance factor has no regulatory relevance and is presented here to provide an indication of the general magnitude of the concentration. Sampling locations represented by circles were analyzed for SMS chemicals. Surface sediment samples were collected at depths ≤ 15 cm below mudline.

ne - no exceedance

SQS/CSL categories for all chemicals within the EAA and 2008 SCA boundaries

- > CSL, detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Subsurface sediment sampling location
- Phase 2 RI baseline sampling location outside the 2008 SCA boundary
- Seep sampling location
- Porewater sampling location

- CSO/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Tax parcel
- SCA-associated property[a]
- 2007 SCA boundary[b]
- 2008 SCA boundary[c]
- Navigation channel
- River mile

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] Boundary shown is based on Ecology (2007f).

[c] Boundary shown is based on Ecology and SAIC (2008).

Wind Ward environmental LLC

N

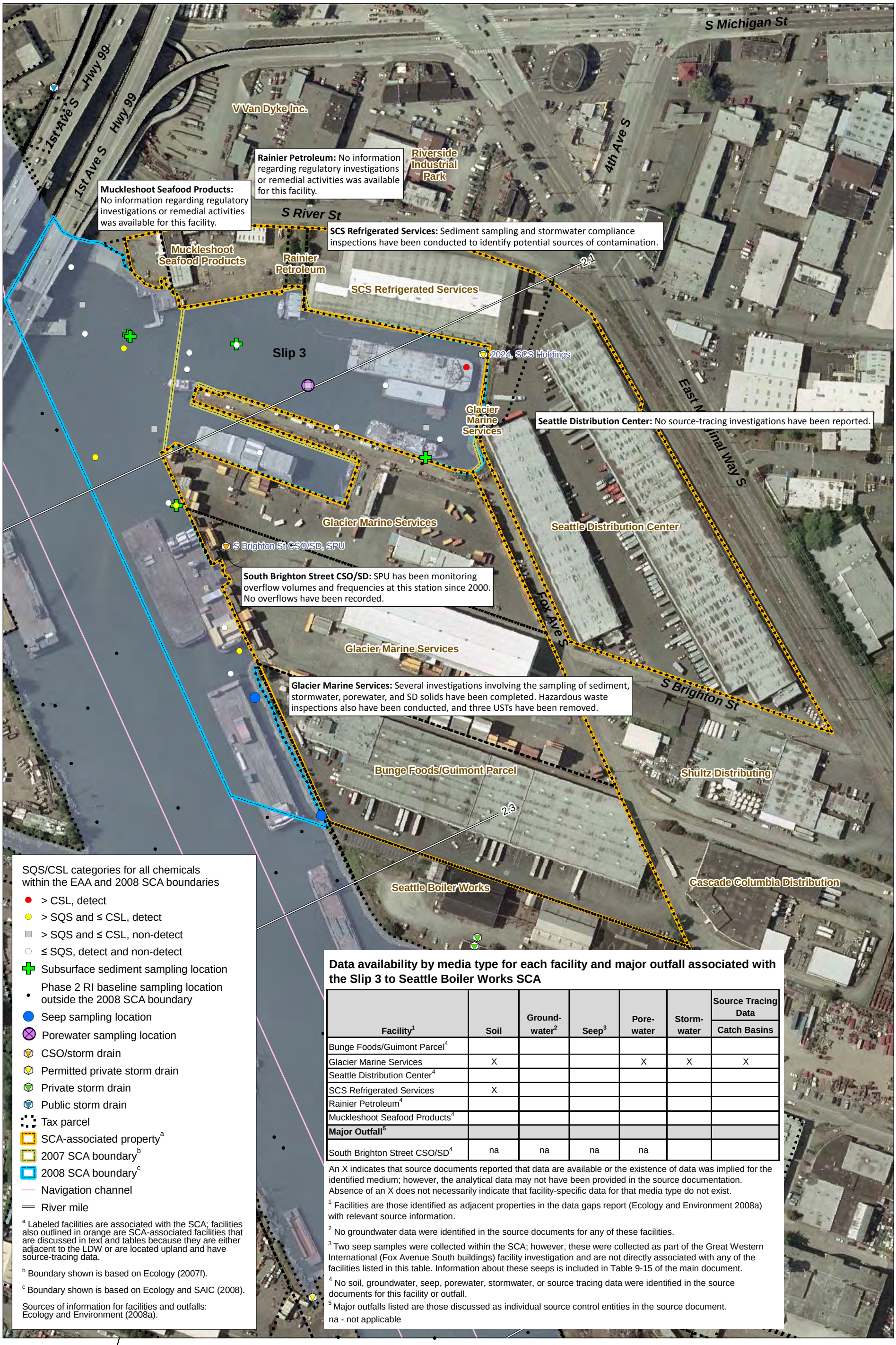
0 200 400 Feet

0 50 100 Meters

Map I-9. Surface sediment information for the Slip 3 to Seattle Boiler Works SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/08/2010; MAP #3005; W:\Projects\010-08-06_Duwamish_Rt\data\gis\Phase2 RI\Source Control\Appendix I



SQS/CSL categories for all chemicals within the EAA and 2008 SCA boundaries

- > CSL, detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Subsurface sediment sampling location
- Phase 2 RI baseline sampling location outside the 2008 SCA boundary
- Seep sampling location
- Porewater sampling location
- CSO/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Tax parcel
- SCA-associated property[a]
- 2007 SCA boundary[b]
- 2008 SCA boundary[c]
- Navigation channel
- River mile

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] Boundary shown is based on Ecology (2007f).

[c] Boundary shown is based on Ecology and SAIC (2008).

Sources of information for facilities and outfalls: Ecology and Environment (2008a).

Data availability by media type for each facility and major outfall associated with the Slip 3 to Seattle Boiler Works SCA

Facility[1]	Soil	Ground-water[2]	Seep[3]	Pore-water	Storm-water	Source Tracing Data: Catch Basins
Bunge Foods/Guimont Parcel[4]						
Glacier Marine Services	X			X	X	X
Seattle Distribution Center[4]						
SCS Refrigerated Services	X					
Rainier Petroleum[4]						
Muckleshoot Seafood Products[4]						
Major Outfall[5]						
South Brighton Street CSO/SD[4]	na	na	na	na		

An X indicates that source documents reported that data are available or the existence of data was implied for the identified medium; however, the analytical data may not have been provided in the source documentation. Absence of an X does not necessarily indicate that facility-specific data for that media type do not exist.

[1] Facilities are those identified as adjacent properties in the data gaps report (Ecology and Environment 2008a) with relevant source information.

[2] No groundwater data were identified in the source documents for any of these facilities.

[3] Two seep samples were collected within the SCA; however, these were collected as part of the Great Western International (Fox Avenue South buildings) facility investigation and are not directly associated with any of the facilities listed in this table. Information about these seeps is included in Table 9-15 of the main document.

[4] No soil, groundwater, seep, porewater, stormwater, or source tracing data were identified in the source documents for this facility or outfall.

[5] Major outfalls listed are those discussed as individual source control entities in the source document.

na - not applicable

Wind Ward LLC environmental

0 200 400 Feet

0 50 100 Meters

Map I-10. Regulatory investigation and remediation status of the Slip 3 to Seattle Boiler Works SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

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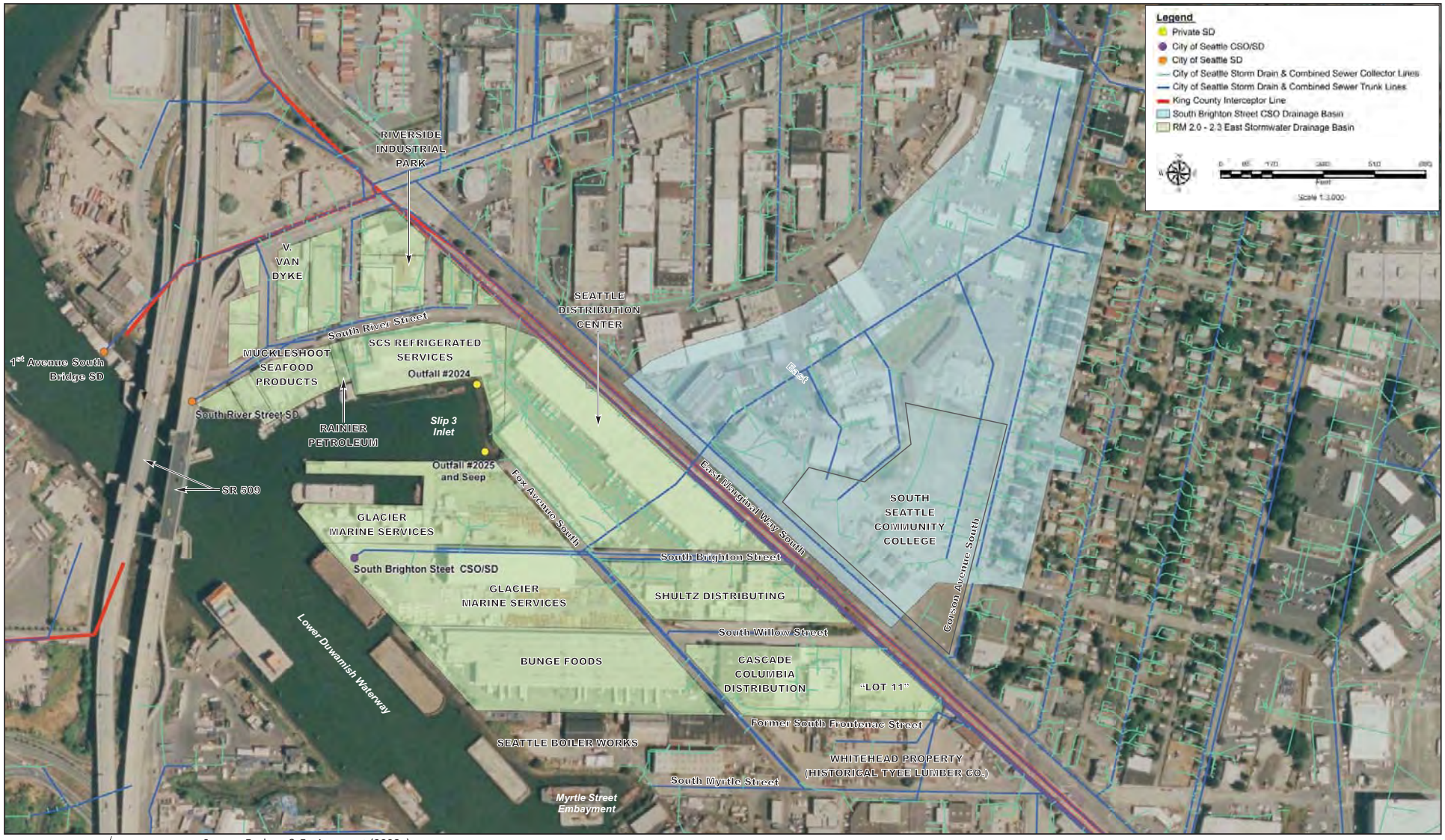

Source: Ecology & Environment (2008a)

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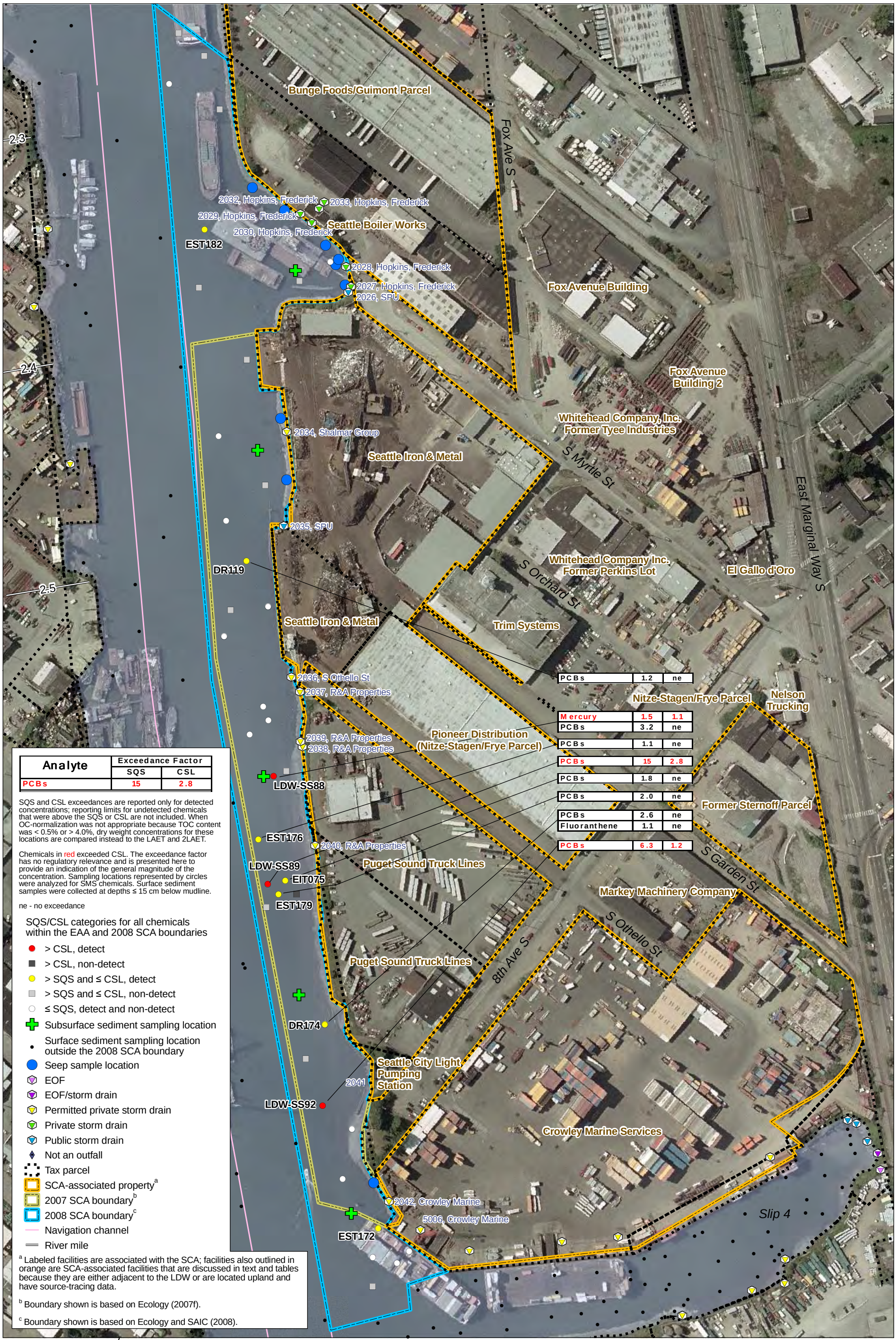
Map I-11. Stormwater basin and drainage features for the Slip 3 to Seattle Boiler Works SCA



Analyte	Exceedance Factor	
	SQS	CSL
PCBs	15	2.8

SQS and CSL exceedances are reported only for detected concentrations; reporting limits for undetected chemicals that were above the SQS or CSL are not included. When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

Chemicals in red exceeded CSL. The exceedance factor has no regulatory relevance and is presented here to provide an indication of the general magnitude of the concentration. Sampling locations represented by circles were analyzed for SMS chemicals. Surface sediment samples were collected at depths ≤ 15 cm below mudline.

ne - no exceedance

SQS/CSL categories for all chemicals within the EAA and 2008 SCA boundaries

- > CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Subsurface sediment sampling location
- Surface sediment sampling location outside the 2008 SCA boundary
- Seep sample location
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Not an outfall
- Tax parcel
- SCA-associated property[a]
- 2007 SCA boundary[b]
- 2008 SCA boundary[c]
- Navigation channel
- River mile

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] Boundary shown is based on Ecology (2007f).

[c] Boundary shown is based on Ecology and SAIC (2008).

Wind Ward LLC environmental

0 200 400 Feet

0 50 100 Meters

Map I-12. Surface sediment information for the Seattle Boiler Works to Slip 4 SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

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Data availability by media type for each facility associated with the Seattle Boiler Works to Slip 4 SCA

Facility[1]	Soil	Groundwater	Seep	Pore-water[2]	Storm-water[2]	Source-Tracing Data: Inline Sediment[3]
Crowley Marine Services			X			
Guimont Parcel (Dawn Food Products, Inc.)[4]						
Puget Sound Truck Lines[4]						
Seattle Boiler Works[4]						
Seattle City Light[4]						
Seattle Iron & Metals Corporation	X	X				
Sternoff Parcel (former)	X	X				X

An X indicates that source documents reported that data are available or the existence of data was implied for the identified media; however, the analytical data may not have been provided in the source documentation. Absence of an X does not necessarily indicate that facility-specific data for that media type do not exist.

[1] Facilities listed are those identified in the data gaps report (SAIC 2008) with relevent source control information.

[2] No porewater or stormwater data were identified in the source documents for any facility. Porewater data was collected for the GWI facility. The GWI facility is not presented in this table because it is not an adjacent property.

[3] Inline sediment samples included floor drain and storm drain solids. Sump water samples were also collected on the property.

[4] No soil, groundwater, seep, porewater, stormwater, or source-tracing data were identified in the source documents for this facility.

na - not applicable

Seattle Boiler Works: A stormwater compliance inspection was conducted by Ecology in 2007.

Seattle Iron & Metals: Soil investigations have been conducted. Soil and groundwater were remediated prior to 1998. A restrictive covenant was placed on the property, and an NFA was issued. Stormwater compliance inspections have taken place.

Former Sternoff Parcel: Groundwater and soil investigations have been conducted. In 1986, Ecology performed inspections related to concerns over a potential cement batch plant and a water treatment system on the property. An FS was conducted in 1986, and source-tracing investigations have been performed. SD lines have been cleaned, and onsite soils have been remediated. A trash pile and underlying soils were removed in 1999.SPU conducted a dye test on the property in 2006.

Puget Sound Truck Lines: Soil cleanup activities related to a LUST were conducted in 1995.

Crowley Marine Services: See Map I-16.

SQS/CSL categories for all chemicals within the EAA and 2008 SCA boundaries

- > CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Subsurface sediment sampling location
- Surface sediment sampling location outside the 2008 SCA boundary
- Seep sample location
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Not an outfall
- Tax parcel
- SCA-associated property[a]
- 2007 SCA boundary[b]
- 2008 SCA boundary[c]
- Navigation channel
- River mile

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] Boundary shown is based on Ecology (2007f).

[c] Boundary shown is based on Ecology and SAIC (2008).

Sources of additional information for facilities and outfalls: SAIC (2008a) and Windward (2004)

Wind Ward LLC environmental

0 200 400 Feet

0 50 100 Meters

Map I-13. Regulatory investigation and remediation status of the Seattle Boiler Works to Slip 4 SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

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Source: SAIC (2008a)

Wind Ward environmental LLC

0 125 250 500 750 1,000 Feet

1:2,700

Note: The shape of the S. Myrtle St. Embayment has changed due to filling and wharf construction.

Legend

- Water
- Building
- Parcel
- sewer lines

Outfall Type

- Public
- Private
- Unkown

Map I-14. Stormwater drainage features for the Seattle Boiler Works to Slip 4 SCA

BEHP	3.2	1.9
PCBs	17.0	3.1
Benzo(a)pyrene	1.0	ne
Benzo(g,h,i)perylene	2.0	ne
BBP	1.6	ne
Dibenzo(a,h)anthracene	1.7	ne
Indeno(1,2,3-cd)pyrene	2.0	ne
Mercury	1.1	ne
Total HPAH	1.0	ne

PCBs	17.0	3.1	SG03
PCBs	38.0	4.9	SG04
PCBs	11.0	2.0	R9
BEHP	1.4	ne	
PCBs	1.3	ne	SG07
PCBs	18.0	3.2	EST164
PCBs	7.2	1.3	R11
BEHP	1.4	ne	
PCBs	5.0	ne	EST165
PCBs	1.1	ne	SG09
PCBs	1.4	ne	SG12
PCBs	5.5	1.0	R13
PCBs	3.9	ne	EST168
PCBs	1.8	ne	DR177
PCBs	27.0	4.9	EST169
PCBs	4.7	ne	R15

SG01	PCBs	3.8	ne
EIT069	PCBs	8.3	1.5
	Benzo(a)pyrene	2.3	1.1
	Benzo(g,h,i)perylene	5.8	2.3
	BEHP	2.6	1.5
	Dibenzo(a,h)anthracene	5.9	2.2
	Indeno(1,2,3-cd)pyrene	5.9	2.3
C8	PCBs	13.0	2.5
	Acenaphthene	1.6	ne
	Benzo(a)anthracene	1.4	ne
	Benzofluoranthenes	1.7	ne
	BBP	2.0	ne
	Chrysene	1.5	ne
	Fluoranthene	1.6	ne
	Total HPAH	2.0	ne
SG02	PCBs	12.0	1.6
EIT070	PCBs	150.0	28.0
SG05	PCBs	3.4	ne
SG06	PCBs	10.0	1.8
	BEHP	2.1	1.3
	Mercury	2.7	1.9
DR179	PCBs	10.0	1.8
	Indeno(1,2,3-cd)pyrene	1.1	ne
EIT072	PCBs	7.2	1.3
C7-2	PCBs	4.1	ne
EST163	PCBs	28.0	5.1
SG08	PCBs	1.9	ne
	BEHP	2.1	1.3
R10	PCBs	12.0	2.2
	Indeno(1,2,3-cd)pyrene	1.1	ne
EIT063	PCBs	15.0	2.8
R12	PCBs	6.7	1.2
R14	PCBs	61.0	11.0
IC01	PCBs	13.0	2.5
EIT064	PCBs	10.0	1.8
C7-1	PCBs	5.4	ne

DR178
E Marginal Way S
North Boeing Field
Crowley Marine Services
Crowley Marine Services (former Parcel F)
2047 – GTSP Flume, SCL
2046 – I-5 SD, WSDOT
2048 – NBF SD, SPU
2049 – KCIA SD #3/PS44 SPU EOF, King County
East Marginal EOF (043), King County
5010, Crowley Marine
Crowley Marine Services (former Parcel D)
Slip 4
2050, First South Properties
2219, First South Properties
2217, First South Properties
First South Properties
5009, Crowley Marine
2051 & 2216, First South Properties
5008, Crowley Marine
5007, Crowley Marine
5006, Crowley Marine
2052, Boeing – Plant 2
2053, Boeing – Plant 2
Boeing Plant 2
Boeing Plant 2

Chemical	Exceedance Factor	
	SQS	CSL
PCBs	15	2.8

SQS and CSL exceedances are reported only for detected concentrations; reporting limits for undetected chemicals that were above the SQS or CSL are not included. When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

Chemicals in red exceeded CSL. The exceedance factor has no regulatory relevance and is presented here to provide an indication of the general magnitude of the concentration. Sampling locations represented by circles or squares were analyzed for SMS chemicals. Surface sediment samples were collected at depths ≤ 15 cm below mudline.

ne - no exceedance

SQS/CSL categories for all chemicals within the 2008 SCA boundary
- > CSL, detect
- > SQS and ≤ CSL, detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Subsurface sediment sampling location
- Seep sampling location

- CSO
- EOF
- EOF/storm drain
- Permitted private storm drain[a]
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Georgetown Steam Plant flume (approximate path)
- Tax parcel
- SCA-associated property[b]
- EAA boundary[c]
- 2008 SCA boundary[d]
- River mile
- Navigation channel

[a] Currently only one active private storm drain outfall remains on First South Properties (SAIC 2007a). The five outfalls formerly located on the property were replaced by a single outfall in 2006; however, the five former outfalls are shown as identified in the 2003 outfall survey (Herrera 2004) because this is the outfall information source used throughout the RI.

[b] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[c] The Slip 4 early action area boundary is based on the final sediment removal area delineated in the EE/CA (Integral 2006b).

[d] Boundary shown is based on Ecology and SAIC (2008).

Wind Ward environmental LLC

N

0 100 200 400 Feet

0 25 50 100 Meters

Map I-15. Surface sediment information for the Slip 4 SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

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Georgetown Steam Plant flume: Several historical soil and sediment sampling events have been conducted within the flume, and at industrial facilities that drain surface water runoff to the flume. Investigations have been conducted to identify illicit connections to the flume and potential sources of PCBs and to investigate spills into the flume. Soil and sediment in the flume have been cleaned out several times. Site characterization and design studies have been completed in preparation of the remediation and replacement of the flume. Construction related to the flume replacement has been initiated.

NBF SD: No source-tracing investigations have been reported.

KCIA SD No. 3 / Pump Station 44 EOF: Source tracing investigations involving onsite catch basin, manhole, sediment trap, and stormwater vault sampling have been conducted. Drain lines and other drainage structures (e.g., oil/water separators and catch basins) connected to the system have been cleaned out.

I-5 SD: Source-tracing investigations involving onsite and ROW catch basins, manhole, and sediment trap sampling have been conducted. Cleanout of catch basins and drain lines within the system is planned.

Crowley Marine Services

2047 – GTSP Flume, SCL

2048 – NBF SD, SPU

2049 – KCIA SD #3/PS44 SPU EOF, King County

East Marginal EOF (043), King County

2046 – I-5 SD, WSDOT

North Boeing Field

Crowley Marine Services (former Parcel F)

E Marginal Way EOF: No source-tracing investigations have been reported.

5010, Crowley Marine

E Marginal Way S

Crowley Marine Services (former Parcel D)

Slip 4

Crowley Marine Services: Several historical soil and groundwater investigations have been completed. No remedial activities have been conducted except for tank removals. Recent investigations related to source control, business inspections, and environmental characterization were conducted in preparation for the Slip 4 removal action. An RI/FS will be conducted at the property under a MTCA order. There are plans for a groundwater investigation, stormwater sampling, and inline solids sampling to be conducted on the property. Cleanout of onsite catch basins and SD lines is also planned.

2050, First South Properties

First South Properties

2219, First South Properties

2217, First South Properties

First South Properties: Several historical soil and groundwater investigations have been completed. The site was formerly listed as a Confirmed and Suspected Contaminated site but was granted No Further Action status after an interim remedial action in 1997. Recent investigations related to source tracing, business inspections, and environmental characterization were conducted in preparation for the Slip 4 removal action. A new stormwater system was installed in 2006 and all site drainage was routed to a single outfall. The other outfalls were abandoned and a former drainage swale area was excavated.

5009, Crowley Marine

5008, Crowley Marine

2051 & 2216, First South Properties

Slip 4: A non-time-critical removal action has been approved for Slip 4.

5007, Crowley Marine

Building 2-122

2052, Boeing – Plant 2

2053, Boeing – Plant 2

Boeing Plant 2: Soil and groundwater investigations and soil remediation activities were conducted in the 1990s during removal of Building 2-01 and construction of Building 2-122. A UST located in the vicinity of former Building 2-01 was removed. Ecology has plans to inspect Building 2-122 and sample storm drain solids on the northern portion of Boeing Plant 2.

Boeing Plant 2

Boeing Plant 2

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Seep sampling location
- CSO
- EOF
- EOF/storm drain
- Permitted private storm drain[a]
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- I-5 SD[b]
- Georgetown Steam Plant flume[b]
- NBF SD[b]
- KCIA SD No. 3 / Pump Station 44 EOF[b]
- Georgetown Steam Plant flume (approximate path)
- Tax parcel
- SCA-associated property[c]
- EAA boundary[d]
- 2008 SCA boundary[e]
- River mile
- Navigation channel

[a] Currently only one active permitted private storm drain outfall remains on First South Properties (SAIC 2007a). The five outfalls formerly located on the property were replaced by a single outfall in 2006; however, the five former outfalls are shown as identified in the 2003 outfall survey (Herrera 2004) because this is the outfall information source used throughout the RI.

[b] Major outfall text boxes are color-coded corresponding to the associated drainage basins on Map I-17.

[c] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[d] The Slip 4 early action area boundary is based on the final sediment removal area delineated in the EE/CA (Integral 2006b).

[e] Boundary shown is based on Ecology and SAIC (2008).

Sources of information for facilities and outfalls: Ecology (2006; 2007f), Ecology and SAIC (2008), Integral (2006b; 2007), SEA (2004), Parametrix (2005), RoseWater (2006), SAIC (2006a; 2006b; 2007a; 2007e), Schmoyer (2008d).

Data availability by media type for each facility and major outfall associated with the Slip 4 SCA

Facility[1]	Soil	Ground-water	Seep	Pore-water[2]	Storm-water[3]	Source Tracing Data: Onsite Catch Basin	ROW Catch Basin	Manhole	Sediment Trap	Oil-water Separator/ Stormwater Vault[4]	In-line Sediment[5]	Storm Drain Filter Bag Samples[6]	Joint Caulking
Boeing Plant 2 (northern portion of facility)[7]	X	X											
Crowley Marine Services	X	X	X			X							
First South Properties	X	X	X			X	X			X			
Georgetown Steam Plant	X	X				X							
KCIA (north drainage basin)	X	X				X			X	X			X
NBF[8]	X	X				X		X	X	X		X	X
Major Outfalls[9]													
E Marginal Way EOF[10]	na	na	na	na									
Georgetown Steam Plant Flume	na	na	na	na		X		X			X		
I-5 Storm Drain	na	na	na	na		X	X	X	X		X		
KCIA Storm Drain No. 3/Pump Station 44 EOF	na	na	na	na		X		X	X	X		X	X
NBF Storm Drain[10]	na	na	na	na									

An X indicates that source documents reported that data are available or the existence of data was implied for the identified media; however, the analytical data may not have been provided in the source documentation. Absence of an X does not necessarily indicate that facility-specific data for that media type do not exist.

[1] Facilities listed are those identified in the SCAP (Ecology 2006) with relevant source control information.

[2] A porewater sample was collected from approximately the center of Slip 4 by EPA in 1998. The sample is not associated with a particular facility in this table because of its location in the middle of the slip.

[3] No stormwater data were identified for any of the facilities or outfalls.

[4] Most stormwater vaults include oil/water separator infrastructure.

[5] In-line sediment samples indicated in this column are those collected from the flume; manhole solids, catch basin samples, and sediment trap solids can also be considered in-line sediment samples but are not included in this column.

[6] Storm drain filter bags are used to filter suspended solids from stormwater. The filter bags and their contents were analyzed together; the concentration on the retained solids was then back-calculated.

[7] Information included pertains to the 17.5 ac northwestern portion of Boeing Plant 2. The rest of the Boeing Plant 2 property will be discussed as part of the Boeing Plant 2/Jorgensen Forge SCA (Section I.4.5).

[8] Although NBF is part of KCIA, it is considered a separate facility for the purposes of this SCA summary.

[9] Major outfalls listed are those discussed as individual source control entities in the source documents.

[10] No stormwater, or source-tracing data were identified in the source documents for this outfall.

na - not applicable

WindWard LLC environmental

N

0 100 200 400 Feet

0 25 50 100 Meters

Map I-16. Regulatory investigation and remediation status of the Slip 4 SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

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Georgetown Steam Plant: Several historical soil and groundwater investigations have been completed. Tank removals and soil remediation have been conducted. The property is currently listed as a Confirmed and Suspected Contaminated site with a status of "ranked, awaiting remedial action." An interim remedial action was recently conducted that included soil and groundwater sampling along the property boundaries, and soil removal and erosion control measures at a low-lying drainage pond area. Source-tracing investigations have been conducted and additional site characterization is planned. The facility is being further assessed as part of the RI/FS for the NBF/GTSP site under a MTCA Order.

Georgetown Steam Plant/NBF Property Line: Environmental investigations, soil removal, and source tracing activities have recently been conducted along the GTSP/NBF fenceline. NBF storm drain utilities were repaired, replaced, and relined to prevent infiltration of PCB-contaminated soil into storm drainage systems.

NBF: Several historical soil and groundwater investigations and remedial activities have been completed related to site redevelopment, tank removals, other subsurface utilities, and to identify the source of PCB contamination on the northern portion of the property. Cleanup has also been conducted in response to spills and related to remediation of LNAPL from groundwater. Recent investigations have included source tracing and cleanout of site stormwater systems and removal of joint caulking material. Sections of the northern SD line were replaced or re-routed and soil sampling was conducted. Several catch basins and manholes were sealed or replaced. The facility is being further assessed as part of the RI/FS for the NBF/GTSP site under a MTCA Order.

KCIA (north drainage basin): Soil and groundwater investigations have been conducted to characterize a former fire-fighting training area, spills, and tank removal areas. Soil remediation was conducted at the former fire-fighting training area. Two site cleanups have been conducted at airport tenant properties. The storm drainage system is cleaned out on a regular basis, and an inspection of the drainage system was completed in 2001. Recent investigations have included source tracing in the stormwater system, joint sealant material testing, and business inspections.

S Albro Pl
I-5
Airport Way South
Georgetown Steam plant
King County International Airport
8th Ave S
Crowley Marine Services
First South Properties
North Boeing Field
Boeing Plant 2
14th Ave S
16th Ave S
East Marginal Way S
Boeing Plant 2
2.8
2.9
3.3
5

- Source-tracing sampling location[a]
- Private mainline
- Public mainline
- Public lateral line
- Permitted, private SD basins
- Discharge via private storm drains directly to Slip 4
- Georgetown Steam Plant flume basin
- I-5/WSDOT SD basin
- KCIA SD No. 3 / Pump Station 44 EOF basin
- NBF SD basin

Source: Schmoyer (2008a)

[a] Source tracing sampling locations were mapped when coordinates were available. Therefore, not all source tracing samples with chemical data are mapped.

- EOF
- EOF/storm drain
- Permitted private storm drain[a]
- Public storm drain
- Georgetown Steam Plant flume (approximate path)
- Tax parcel
- SCA-associated property[b]
- EAA boundary[c]
- 2008 SCA boundary[d]
- Navigation channel

[a] Currently only one active permitted private storm drain outfall remains on First South Properties (SAIC 2007a). The five outfalls formerly located on the property were replaced by a single outfall in 2006; however, the five former outfalls are shown as identified in the 2003 outfall survey (Herrera 2004) because this is the outfall information source used throughout the RI.

[b] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[c] The Slip 4 early action area boundary is based on the final sediment cleanup area delineated in the EE/CA (Integral 2006b).

[d] Boundary shown is based on Ecology and SAIC (2008).

Sources of information for facilities, drainage basins, and source tracing samples: Ecology (2006; 2007f), Ecology and SAIC (2008), Integral (2006b; 2007), SEA (2004), Parametrix (2005), RoseWater (2006), SAIC (2006a; 2006b; 2007a; 2007e), Schmoyer (2008a; 2008d)

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N

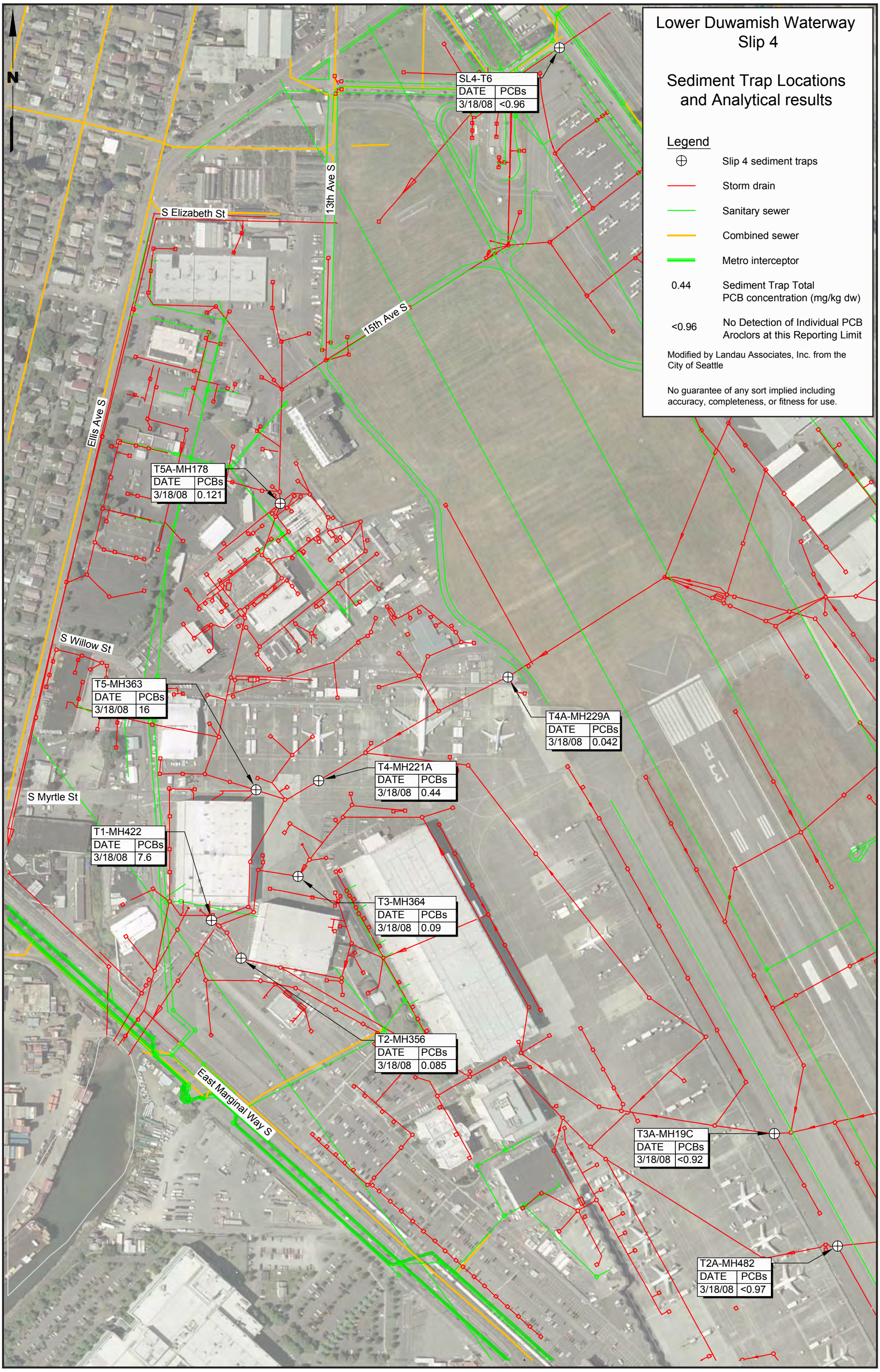
0 500 1,000 Feet

0 100 200 Meters

Map I-17. Regulatory investigation and remediation status of the Slip 4 SCA drainage basin

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/08/2010. MAP #3246: W:\Projects\00-08-06_Duwamish_R\data\gis\Phase2 RI\Source Control\Appendix I



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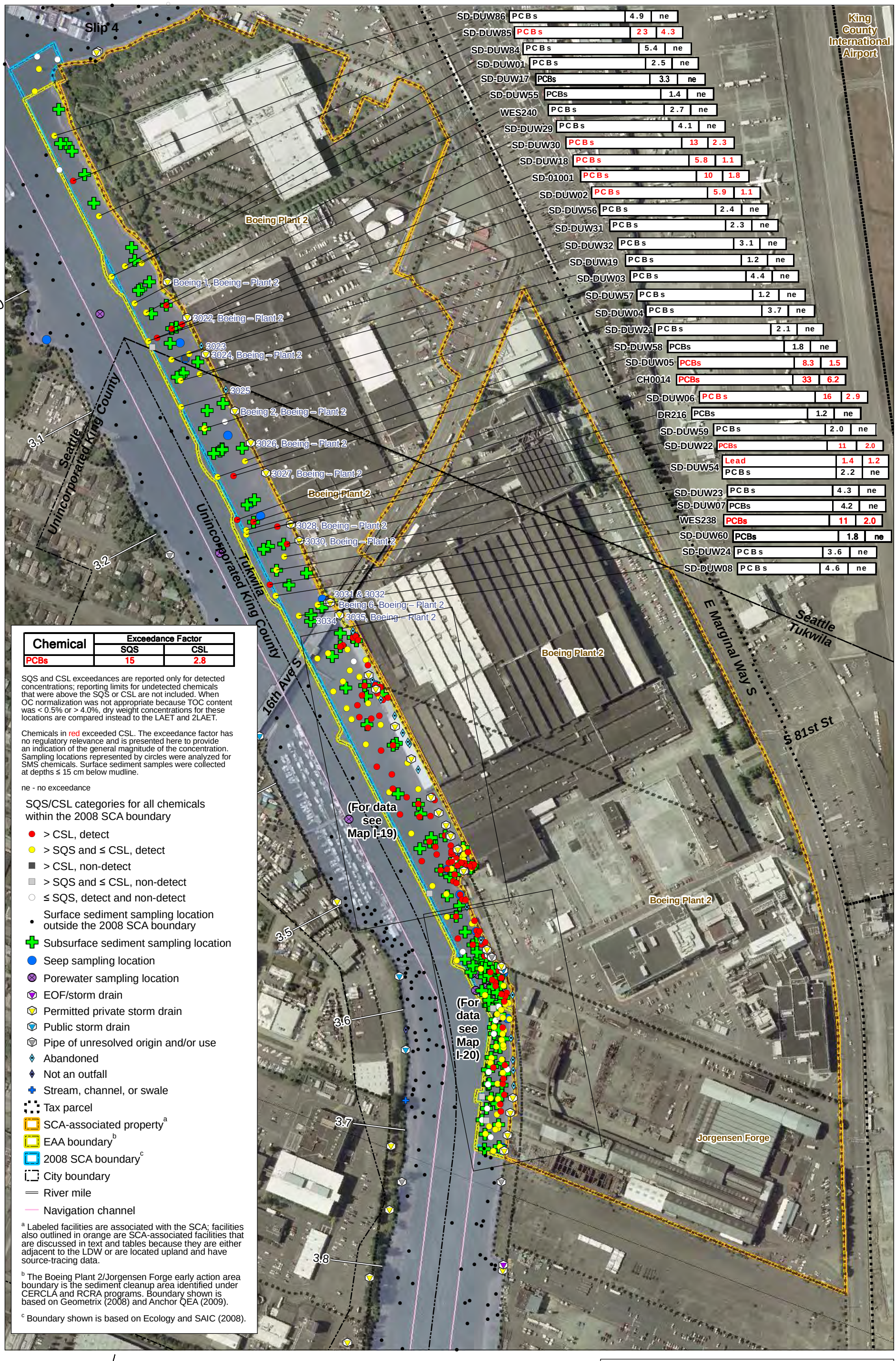
Source: City of Seattle, September 26, 2007 as modified by Landau Associates, Inc.

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Map I-18. Slip 4 sediment trap information for PCBs



Chemical	Exceedance Factor	
	SQS	CSL
PCBs	15	2.8

SQS and CSL exceedances are reported only for detected concentrations; reporting limits for undetected chemicals that were above the SQS or CSL are not included. When OC normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

Chemicals in red exceeded CSL. The exceedance factor has no regulatory relevance and is presented here to provide an indication of the general magnitude of the concentration. Sampling locations represented by circles were analyzed for SMS chemicals. Surface sediment samples were collected at depths ≤ 15 cm below mudline.

ne - no exceedance

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Subsurface sediment sampling location
- Seep sampling location
- Porewater sampling location
- EOF/storm drain
- Permitted private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale
- Tax parcel
- SCA-associated property[a]
- EAA boundary[b]
- 2008 SCA boundary[c]
- City boundary
- River mile
- Navigation channel

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] The Boeing Plant 2/Jorgensen Forge early action area boundary is the sediment cleanup area identified under CERCLA and RCRA programs. Boundary shown is based on Geometrix (2008) and Anchor QEA (2009).

[c] Boundary shown is based on Ecology and SAIC (2008).

WindWard environmental LLC

N

0 200 400 Feet

0 50 100 Meters

Map I-19. Surface sediment information for the Boeing Plant 2/Jorgensen Forge SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/08/2010; MAP 3013; W:\Projects\00-08-06_Duwamish_R\data\GIS\Phase2 R\\Source Control\Appendix I

PCBs	20	3.7

PCBs	27	4.9
PCBs	2.2	ne
PCBs	5.3	ne
PCBs	1.1	ne
PCBs	4.6	ne
PCBs	2.4	ne
PCBs	17	3.1
Acenaphthene	2.3	ne
PCBs	3.6	ne
PCBs	14	2.6
PCBs	1.7	ne
PCBs	4.1	ne
PCBs	18	3.2
PCBs	3.8	ne
PCBs	10	1.8
PCBs	21	3.8
BBP	2.4	ne
BEHP	1.3	ne
PCBs	1.3	ne
PCBs	22	4
PCBs	10	1.8
PCBs	3.6	ne
PCBs	1.6	ne
PCBs	52	9.5
PCBs	10	1.8
PCBs	1.7	ne
PCBs	6.3	1.2
PCBs	12	2.2
PCBs	5.0	ne
PCBs	51	9.4
PCBs	2.4	ne

BBP	37	2.8
BEHP	4.0	2.4
PCBs	28	5.1

PCBs	26	4.8
BBP	11	ne
BEHP	1.3	ne

PCBs	6.2	1.1
BEHP	1.2	ne

BBP	110	8.3
BEHP	3.8	2.3
PCBs	25	4.6
BEHP	1.1	ne
PCBs	2.8	ne

BEHP	6.6	4.0
Mercury	11	7.8
BBP	1.0	ne
PCBs	3.6	ne
PCBs	33	6.2
Mercury	1.0	ne
Mercury	5.1	3.6
PCBs	7.3	1.4
PCBs	8.3	1.5
PCBs	11	2.0
PCBs	7.7	1.4
PCBs	15	2.8
Phenol	6.7	2.3
Mercury	1.3	ne
PCBs	5.7	1.0
PCBs	59	11
PCBs	19	3.5
PCBs	1.3	ne
PCBs	13	2.3
PCBs	3.2	ne
PCBs	12	2.2

SD-DUW33
SD-DUW34
SD-DUW25
SD-DUW09
SD-DUW61
SD-DUW36
SD-DUW38
SD-DUW39
SD-DUW37
SD-DUW40
SD-DUW62
SD-DUW41
SD-DUW10
CH0016
SD-DUW42
DR217
SD-DUW63
WES237
SD-DUW43
SD-DUW44
SD-DUW64
SD-DUW26
SD-DUW11
SD-DUW46
SD-DUW65
SD-DUW45
SD-DUW27
WES236
SD-DUW66
SD-DUW12
SD-DUW47
SD-DUW67
SD-DUW48
SD-DUW68
SD-04408
SD-DUW50
SD-04407
SD-04403
SD-DUW69
SD-04406
B8a
SD-04401
SD-DUW51
SD-SWY01
SD-DUW70
SD-SWY08
SD-DUW14
SD-SWY02

3016
3015, Boeing – Plant 2
3014
Boeing 3, Boeing – Plant 2
3013
3012
3011, Boeing – Plant 2
3010
3009
3008
3007, Boeing – Plant 2
3006
3005, Boeing – Plant 2
Boeing 4, Boeing – Plant 2
3004, Boeing – Plant 2
3003, Boeing – Plant 2
Boeing 7, Boeing – Plant 2
3002
3001
3000, Boeing – Plant 2
3017
3018
SD-04905
Boeing 5, Boeing – Plant 2
3019
Boeing 8
2054
2055
2057
2058
9, Boeing – Plant 2
2059

Boeing Plant 2
Boeing Plant 2
Boeing Plant 2

3.4
3.5

Tukwila
Unincorporated King County

PCBs	29	5.4
Zinc	1.0	ne
PCBs	28	5.2
PCBs	66	12
Benzo(g,h,i)perylene	1.0	ne
Chrysene	1.2	ne
Dibenzo(a,h)anthracene	1.3	ne
Indeno(1,2,3-cd)pyrene	1.1	ne
Total HPAH	1.0	ne
PCBs	2.2	ne
PCBs	18	3.2
PCBs	82	15
Acenaphthene	1.7	ne
Dibenzofuran	1.3	ne
Fluorene	1.6	ne
Phenanthrene	1.1	ne
PCBs	32	4.1
Acenaphthene	1.3	ne
PCBs	12	1.6
PCBs	15	2.0
PCBs	13	2.5
PCBs	19	3.5
PCBs	6.8	1.2
Acenaphthene	1.6	ne
Cadmium	1.0	ne
Fluoranthene	1.1	ne
PCBs	3.3	ne
PCBs	10	1.8
BBP	18	1.4
BEHP	5.3	3.2
PCBs	16	2.9
Dibenzo(a,h)anthracene	1.1	ne
BBP	69	5.3
BEHP	7.0	4.2
PCBs	63	12
Zinc	1.8	ne
BBP	22	1.7
BEHP	3.2	1.9
Cadmium	2.2	1.6
Chromium	1.3	1.3
PCBs	15	2.8
Zinc	1.7	ne
PCBs	31	5.7
BBP	3.7	ne
PCBs	78	14
PCBs	38	7.1
Mercury	1.2	ne
PCBs	17	3.1
Mercury	2.3	1.6
PCBs	15	2.8
PCBs	2.8	ne
PCBs	1.3	ne
PCBs	4.3	ne
Fluoranthene	1.4	ne
PCBs	2.9	ne
PCBs	6.3	1.2
PCBs	2.8	ne
PCBs	5.3	ne
PCBs	38	7.1
BBP	1.0	ne
PCBs	25	4.6
PCBs	5.5	1.0
PCBs	20	3.7
BBP	3.1	ne
PCBs	39	7.2
PCBs	50	9.2
PCBs	2.2	ne
PCBs	23	4.3
BBP	2.0	ne
PCBs	4.5	ne
PCBs	70	13
BBP	8.6	ne
Zinc	2.0	ne
PCBs	52	9.5
Zinc	2.9	1.3
BBP	1.6	ne
PCBs	15	2.8
PCBs	5.0	ne
PCBs	7.1	1.3
Lead	5.1	4.3
Mercury	2.0	1.4
Cadmium	18	14
Chromium	3.5	3.4
PCBs	14	1.8
Zinc	2.1	ne
Lead	1.9	1.6
PCBs	10	1.8

SD-04108
SD-04107
SD-04109
SD-04121
SD-04122
SD-04102
SD-04104
SD-04103
SD-04105
SD-04101
SD-04113
SD-04110
SD-04112
SD-04111
SD-04117
SD-04116
SD-04115
SD-DUW49
SD-DUW13
SD-DUW28
WES235
SD-04409
SD-04404
SD-04405
SD-04910
SD-04912
SD-04914
SD-04909
SD-04918
SD-04904
SD-04906
SD-04911
SD-04902
SD-04901
SD-04917
SD-04903
SD-04908
SD-04907
SD-04905
SD-04915
SD-04922
SD-04921
SD-04920
SS-SWY04
SS-SWY05
SD-SWY09

SQS and CSL exceedances are reported only for detected concentrations; reporting limits for undetected chemicals that were above the SQS or CSL are not included. When OC normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

Chemical	Exceedance Factor	
	SQS	CSL
PCBs	15	2.8

Chemicals in red exceeded CSL. The exceedance factor has no regulatory relevance and is presented here to provide an indication of the general magnitude of the concentration. Sampling locations represented by circles were analyzed for SMS chemicals. Surface sediment samples were collected at depths ≤ 15 cm below mudline.

ne - no exceedance

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Subsurface sediment sampling location
- Seep sampling location
- Porewater sampling location

- Permitted private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Tax parcel
- SCA-associated property[a]
- EAA boundary[b]
- 2008 SCA boundary[c]
- City boundary
- River mile
- Navigation channel

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] The Boeing Plant 2/Jorgensen Forge early action area boundary is the sediment cleanup area identified under CERCLA and RCRA programs. Boundary shown is based on Geomatrix (2008).

[c] Boundary shown is based on Ecology and SAIC (2008).

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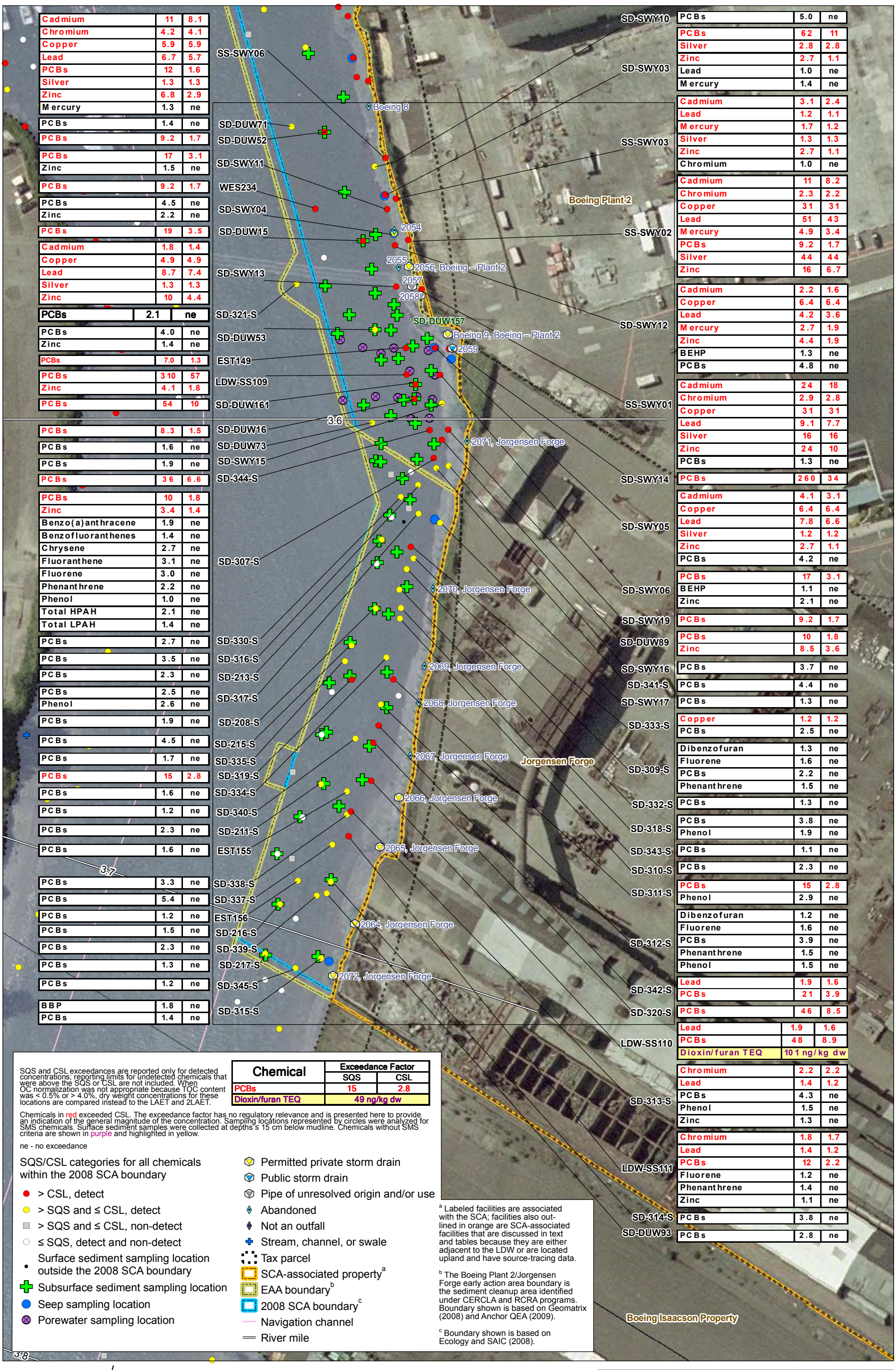
0 50 100 Feet
0 20 40 Meters

Map I-20. Surface sediment information for the Boeing Plant 2/Jorgensen Forge SCA, RM 3.3 to RM 3.5

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/08/2010: MAP 3013: W:\Projects\00-08-06_Duwamish_Rivdata\GIS\Phase2 RI\Source Control\Appendix I



Cadmium	11	8.1
Chromium	4.2	4.1
Copper	5.9	5.9
Lead	6.7	5.7
PCBs	12	1.6
Silver	1.3	1.3
Zinc	6.8	2.9
Mercury	1.3	ne

PCBs	1.4	ne

PCBs	9.2	1.7

PCBs	17	3.1
Zinc	1.5	ne

PCBs	9.2	1.7

PCBs	4.5	ne
Zinc	2.2	ne

PCBs	19	3.5

Cadmium	1.8	1.4
Copper	4.9	4.9
Lead	8.7	7.4
Silver	1.3	1.3
Zinc	10	4.4

PCBs	2.1	ne

PCBs	4.0	ne
Zinc	1.4	ne

PCBs	7.0	1.3

PCBs	310	57
Zinc	4.1	1.8

PCBs	54	10

PCBs	8.3	1.5

PCBs	1.6	ne

PCBs	1.9	ne

PCBs	36	6.6

PCBs	10	1.8
Zinc	3.4	1.4
Benzo(a)anthracene	1.9	ne
Benzofluoranthenes	1.4	ne
Chrysene	2.7	ne
Fluoranthene	3.1	ne
Fluorene	3.0	ne
Phenanthrene	2.2	ne
Phenol	1.0	ne
Total HPAH	2.1	ne
Total LPAH	1.4	ne

PCBs	2.7	ne

PCBs	3.5	ne

PCBs	2.3	ne

PCBs	2.5	ne
Phenol	2.6	ne

PCBs	1.9	ne

PCBs	4.5	ne

PCBs	1.7	ne

PCBs	15	2.8

PCBs	1.6	ne

PCBs	1.2	ne

PCBs	2.3	ne

PCBs	1.6	ne

PCBs	3.3	ne

PCBs	5.4	ne

PCBs	1.2	ne

PCBs	1.5	ne

PCBs	2.3	ne

PCBs	1.3	ne

PCBs	1.2	ne

BBP	1.8	ne
PCBs	1.4	ne

PCBs	5.0	ne

PCBs	62	11
Silver	2.8	2.8
Zinc	2.7	1.1
Lead	1.0	ne
Mercury	1.4	ne

Cadmium	3.1	2.4
Lead	1.2	1.1
Mercury	1.7	1.2
Silver	1.3	1.3
Zinc	2.7	1.1
Chromium	1.0	ne

Cadmium	11	8.2
Chromium	2.3	2.2
Copper	31	31
Lead	51	43
Mercury	4.9	3.4
PCBs	9.2	1.7
Silver	44	44
Zinc	16	6.7

Cadmium	2.2	1.6
Copper	6.4	6.4
Lead	4.2	3.6
Mercury	2.7	1.9
Zinc	4.4	1.9
BEHP	1.3	ne
PCBs	4.8	ne

Cadmium	24	18
Chromium	2.9	2.8
Copper	31	31
Lead	9.1	7.7
Silver	16	16
Zinc	24	10
PCBs	1.3	ne

PCBs	260	34

Cadmium	4.1	3.1
Copper	6.4	6.4
Lead	7.8	6.6
Silver	1.2	1.2
Zinc	2.7	1.1
PCBs	4.2	ne

PCBs	17	3.1
BEHP	1.1	ne
Zinc	2.1	ne

PCBs	9.2	1.7

PCBs	10	1.8
Zinc	8.5	3.6

PCBs	3.7	ne

PCBs	4.4	ne

PCBs	1.3	ne

Copper	1.2	1.2
PCBs	2.5	ne

Dibenzofuran	1.3	ne
Fluorene	1.6	ne
PCBs	2.2	ne
Phenanthrene	1.5	ne

PCBs	1.3	ne

PCBs	3.8	ne
Phenol	1.9	ne

PCBs	1.1	ne

PCBs	2.3	ne

PCBs	15	2.8
Phenol	2.9	ne

Dibenzofuran	1.2	ne
Fluorene	1.6	ne
PCBs	3.9	ne
Phenanthrene	1.5	ne
Phenol	1.5	ne

Lead	1.9	1.6
PCBs	21	3.9

PCBs	46	8.5

Lead	1.9	1.6
PCBs	48	8.9
Dioxin/furan TEQ	101 ng/kg dw	

Chromium	2.2	2.2
Lead	1.4	1.2
PCBs	4.3	ne
Phenol	1.5	ne
Zinc	1.3	ne

Chromium	1.8	1.7
Lead	1.4	1.2
PCBs	12	2.2
Fluorene	1.2	ne
Phenanthrene	1.4	ne
Zinc	1.1	ne

PCBs	3.8	ne

PCBs	2.8	ne

SQS and CSL exceedances are reported only for detected concentrations; reporting limits for undetected chemicals that were above the SQS or CSL are not included. When OC normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

Chemical	Exceedance Factor	
	SQS	CSL
PCBs	15	2.8
Dioxin/furan TEQ	49 ng/kg dw	

Chemicals in red exceeded CSL. The exceedance factor has no regulatory relevance and is presented here to provide an indication of the general magnitude of the concentration. Sampling locations represented by circles were analyzed for SMS chemicals. Surface sediment samples were collected at depths ≤ 15 cm below mudline. Chemicals without SMS criteria are shown in purple and highlighted in yellow.

ne - no exceedance

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Subsurface sediment sampling location
- Seep sampling location
- Porewater sampling location

- Permitted private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale
- Tax parcel
- SCA-associated property[a]
- EAA boundary[b]
- 2008 SCA boundary[c]
- Navigation channel
- River mile

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] The Boeing Plant 2/Jorgensen Forge early action area boundary is the sediment cleanup area identified under CERCLA and RCRA programs. Boundary shown is based on Geomatrix (2008) and Anchor QEA (2009).

[c] Boundary shown is based on Ecology and SAIC (2008).

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0 50 100 Feet

0 20 40 Meters

Map I-21. Surface sediment information for the Boeing Plant 2/Jorgensen Forge SCA, RM 3.5 to RM 3.7

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

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Data availability by media type for each facility associated with the Boeing Plant 2/Jorgensen Forge SCA

Facility[1]	Soil	Groundwater	Seep	Pore-water	Storm-water	Source-Tracing Data				
						Onsite Catch Basins	Manhole	Inline Sediment	Filter Bag[2]	Joint Caulking
Boeing Plant 2	X	X	X	X	X	X		X	X	X
Jorgensen Forge	X	X	X	X	X	X	X	X		
KCIA[3]						X		X		X

An X indicates that source documents reported that data are available or the existence of data was implied for the identified media; however, the analytical data may not have been provided in the source documentation. Absence of an X does not necessarily indicate that facility-specific data for that media type do not exist.

[1] Facilities listed are those identifed in the data gaps report (SAIC 2007) and the SCAP (Ecology 2007) with relevant source control information.

[2] Storm drain filter bags are used to filter suspended solids from stormwater.

[3] Small portions of KCIA drain to the Boeing Plant 2/Jorgensen Forge SCA.

2.4 2.5 2.6 2.7 2.8 2.9 3.0 3.1 3.2 3.3 3.5 3.6 3.7 3.8 3.9 4.0 4.1 4.2 4.3 4.4 4.8 4.9 5.0 7

See Map I-17 for information on North Boeing Field

See Map I-23 for the regulatory investigation and remediation status of the northern half of Boeing Plant 2.

See Map I-24 for the regulatory investigation and remediation status of the southern half of Boeing Plant 2 and Jorgensen Forge.

KCIA: A subsection of KCIA drains to this SCA. Two source tracing investigations were completed in 2001 and 2005. Flight lines and taxi ways are mechanically swept on a frequent basis.

Boeing Plant 2

North Boeing Field

KCIA

Jorgensen Forge

16th Ave S

E Marginal Way S

2215

Unincorporated King County

Seattle

Tukwila

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Seep sampling location
- Porewater sampling location
- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale
- Tax parcel
- SCA-associated property[a]
- EAA boundary[b]
- 2008 SCA boundary[c]
- City boundary
- River mile
- Navigation channel

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] The Boeing Plant 2/Jorgensen Forge early action area boundary is the sediment cleanup area identified under CERCLA and RCRA programs. Boundary shown is based on Geomatrix (2008) and Anchor QEA (2009).

[c] Boundary shown is based on Ecology and SAIC (2008).

Sources of information for facilities and outfalls: Ecology and Environment (2007b), Ecology (2007c), Windward (2003b), Windward (2004), Golder Associates (2007), Colligan (2008), Floyd|Snider (2005), Weston (1998), and Environmental Partners (2008).

WindWard environmental LLC

0 750 1,500 Feet

0 250 500 Meters

Map I-22. Regulatory investigation and remediation status of the Boeing Plant 2/ Jorgensen Forge SCA - overview

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

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Slip 4

Boeing Plant 2 General: Boeing conducted a RCRA Facility Investigation using a unit-by-unit approach. Boeing has also identified several CMS areas to investigate groundwater at the site. A two-phase stormwater survey was conducted in 2005. Paved surfaces are mechanically swept on a routine basis.

Data availability by media type for each facility associated with the Boeing Plant 2/Jorgensen Forge SCA

Facility[1]	Soil	Groundwater	Seep	Pore-water	Storm-water	Source-Tracing Data: Onsite Catch Basins	Manhole	Inline Sediment	Filter Bag[2]	Joint Caulking
Boeing Plant 2	X	X	X	X	X	X		X	X	X
Jorgensen Forge	X	X	X	X	X	X	X	X		
KCIA[3]						X		X		X

An X indicates that source documents reported that data are available or the existence of data was implied for the identified media; however, the analytical data may not have been provided in the source documentation. Absence of an X does not necessarily indicate that facility-specific data for that media type do not exist.

[1] Facilities listed are those identifed in the data gaps report (SAIC 2007) and the SCAP (Ecology 2007) with relevant source control information.

[2] Storm drain filter bags are used to filter suspended solids from stormwater.

[3] Small portions of KCIA drain to the Boeing Plant 2/Jorgensen Forge SCA.

2052, Boeing – Plant 2
2053, Boeing – Plant 2
North Area
E Marginal Way S
The DSOA area will require dredging with subsequent capping/ backfilling. This area was investigated under RCRA.
Boeing Plant 2
North Yard Area: Investigations of two RCRA units (SWMUs) have been completed.
Boeing 1, Boeing – Plant 2
3022, Boeing – Plant 2
3023
2-10 Area
3024, Boeing – Plant 2
2-10 Area: Investigations of 21 RCRA units (eight SWMUs, eight AOCs, and five OAs) have been conducted. NFAs have been approved by EPA for four RCRA units.
3025
Boeing 2, Boeing – Plant 2
3026, Boeing – Plant 2
Tukwila
Unincorporated King County
Seattle
Tukwila
3027, Boeing – Plant 2
Boeing Plant 2
3028, Boeing – Plant 2
3030, Boeing – Plant 2
16th Ave S
2-31 Area: Investigations of nine RCRA units (seven SWMUs, one AOC and one OA) have been conducted. NFAs have been approved by EPA for six RCRA units.
2-31 Area
3031 & 3032
Boeing 6, Boeing – Plant 2
3034

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Seep sampling location
- Porewater sampling location
- Permitted private storm drain
- Public storm drain
- Abandoned
- Not an outfall
- Tax parcel
- SCA-associated property[a]
- EAA boundary[b]
- Duwamish Sediment Other Area
- Duwamish Sediment Other Area western boundary extension area
- 2008 SCA boundary[c]
- City boundary
- River mile
- Navigation channel

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] The Boeing Plant 2/Jorgensen Forge early action area boundary is the sediment cleanup area identified under CERCLA and RCRA programs. Boundary shown is based on Geomatrix (2008).

[c] Boundary shown is based on Ecology and SAIC (2008).

Sources of information for facilities and outfalls: Ecology and Environment (2007b), Ecology (2007c), Windward (2003b), Windward (2004), Golder Associates (2007), Colligan (2008), Floyd|Snider (2005), Weston (1998), and Environmental Partners (2008)

WindWard environmental LLC

0 150 300 Feet
0 50 100 Meters

Map I-23. Regulatory investigation and remediation status of the Boeing Plant 2/ Jorgensen Forge SCA - northern half

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

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Boeing Plant 2 General: Boeing conducted a RCRA Facility Investigation using a unit-by-unit approach. Boeing has also identified several CMS areas to investigate groundwater at the site. A two-phase stormwater survey was conducted in 2005. Paved surfaces are mechanically swept on a routine basis.

Data availability by media type for each facility associated with the Boeing Plant 2/Jorgensen Forge SCA

Facility[1]	Soil	Groundwater	Seep	Pore-water	Storm-water	Source-Tracing Data: Onsite Catch Basins	Manhole	Inline Sediment	Filter Bag[2]	Joint Caulking
Boeing Plant 2	X	X	X	X	X	X		X	X	X
Jorgensen Forge	X	X	X	X	X	X	X	X		
KCIA[3]						X		X		X

An X indicates that source documents reported that data are available or the existence of data was implied for the identified media; however, the analytical data may not have been provided in the source documentation. Absence of an X does not necessarily indicate that facility-specific data for that media type do not exist.

[1] Facilities listed are those identifed in the data gaps report (SAIC 2007) and the SCAP (Ecology 2007) with relevant source control information.

[2] Storm drain filter bags are used to filter suspended solids from stormwater.

[3] Small portions of KCIA drain to the Boeing Plant 2/Jorgensen Forge SCA.

16th Ave S

3035, Boeing – Plant 2
3016
3015, Boeing – Plant 2
3014
Boeing 3, Boeing – Plant 2
3013
3012
3011, Boeing – Plant 2
3010
3009
3008
3007, Boeing – Plant 2
3006
3005, Boeing – Plant 2
Boeing 4, Boeing – Plant 2
3004, Boeing – Plant 2
3003, Boeing – Plant 2
Boeing 7, Boeing – Plant 2
3002
3000, Boeing – Plant 2
3017
Boeing 5, Boeing – Plant 2
Boeing 8
2054
2055
2056, Boeing – Plant 2
Boeing 9, Boeing – Plant 2
2059
2071, Jorgensen Forge
2070, Jorgensen Forge
2069, Jorgensen Forge
2068, Jorgensen Forge
2067, Jorgensen Forge
2066, Jorgensen Forge
2065, Jorgensen Forge
2064, Jorgensen Forge
2072, Jorgensen Forge
2063

Under Building Area
Southwest Bank
2-66 Area
2-40 Area
2-60 Area
South Yard Area
Jorgensen Forge
Boeing Plant 2
E Marginal Way S

The DSOA area will require dredging with subsequent capping/ backfilling. This area was investigated under RCRA.

Under Building Area: An Underflow Flume IM and a Building 2-41 Debris Area IM were implemented.

2-40 Area: Investigations of 15 RCRA units (five TSD SWMUs, two non-TSD SWMUs, one AOC, seven OAs) have been completed. NFAs have been approved by EPA for three RCRA units. A VOC plume has been investigated; ongoing remedial actions have been occuring since 2002. The plume is located beneath the 2-40s area of the electrical manufacturing facility.

Southwest Bank: A Southwest bank corrective measure has been proposed.

2-66 Area: Investigations of ten RCRA units (four AOCs and six OAs) have been completed. No RCRA units have been closed. A sheet pile containment structure was installed in 1993. A density-driven convection system was installed in 2004. This system is monitored quarterly. A Phase I and II transformer investigation was conducted in 2001 to define PCB contam-ination. Beginning in 2001, the Shoreline Monitoring Program has collected and analyzed quarterly groundwater samples.

2-60 Area: Investigations of 14 RCRA units (ten SWMUs, two AOCs, and two OAs) have been completed. An NFA was approved by EPA for one RCRA unit. A Data Gap investigation was conducted in 2006, which included groundwater and soil analysis.

In 2005, an investigation of a PCB release was completed. As a result, manholes were plugged and Boeing plans to excavate soil in 2008.

South Yard Area: Investigations of 18 RCRA units (two TSD SWMUs, ten non-TSD SWMUs, three AOCs, and three OAs) have been conducted. Two TSD facilities have been partially closed. NFAs have been approved by EPA for vadose-zone soils in three RCRA units. Interim measures have been conducted at six RCRA units. A Data Gap Investigation was conducted by Boeing in 2005, which included groundwater and soil analysis.

Chemical analysis of fill material has been conducted.

Jorgensen Forge: Environmental investigations have been completed under RCRA. Three USTs were removed in 1991. Soil and groundwater have been investigated since the removal of the USTs. In 1993, Ecology conducted a Site Hazard Assessment. In 2003, EPA entered into an AOC with the Earle M. Jorgensen Company to investigate LDW sediments. A phased site investigation was conducted from 2003 to 2006. An additional source control investigation is in progress.

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Seep sampling location
- Porewater sampling location
- Permitted private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Tax parcel
- SCA-associated property[a]
- EAA boundary[b]
- Duwamish Sediment Other Area
- Duwamish Sediment Other Area southern boundary extension area
- Duwamish Sediment Other Area western boundary extension area
- 2008 SCA boundary[c]
- River mile
- Navigation channel

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] The Boeing Plant 2/Jorgensen Forge early action area boundary is the sediment cleanup area identified under CERCLA and RCRA programs. Boundary shown is based on Geomatrix (2008) and Anchor QEA (2009).

[c] Boundary shown is based on Ecology and SAIC (2008).

Sources of information for facilities and outfalls: Ecology and Environment (2007b), Ecology (2007c), Windward (2003b), Windward (2004), Golder Associates (2007), Colligan (2008), Floyd|Snider (2005), Weston (1998), and Environmental Partners (2008).

WindWard environmental LLC

0 150 300 Feet
0 50 100 Meters

Map I-24. Regulatory investigation and remediation status of the Boeing Plant 2/ Jorgensen Forge SCA - southern half

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

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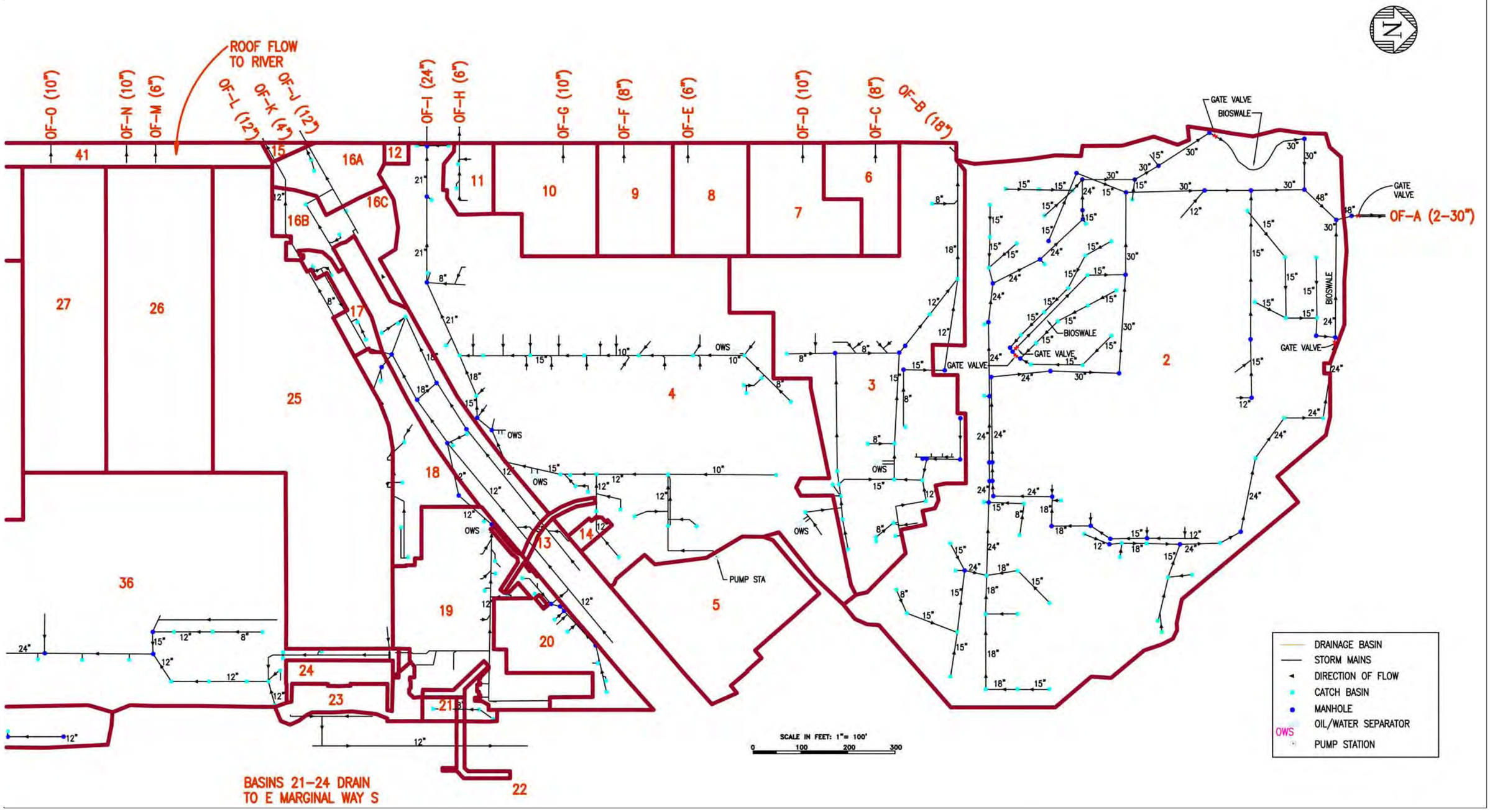

Source: Ecology and Environment (2007b)

Map I-25. Stormwater drainage lines on Boeing Plant 2 – northern portion

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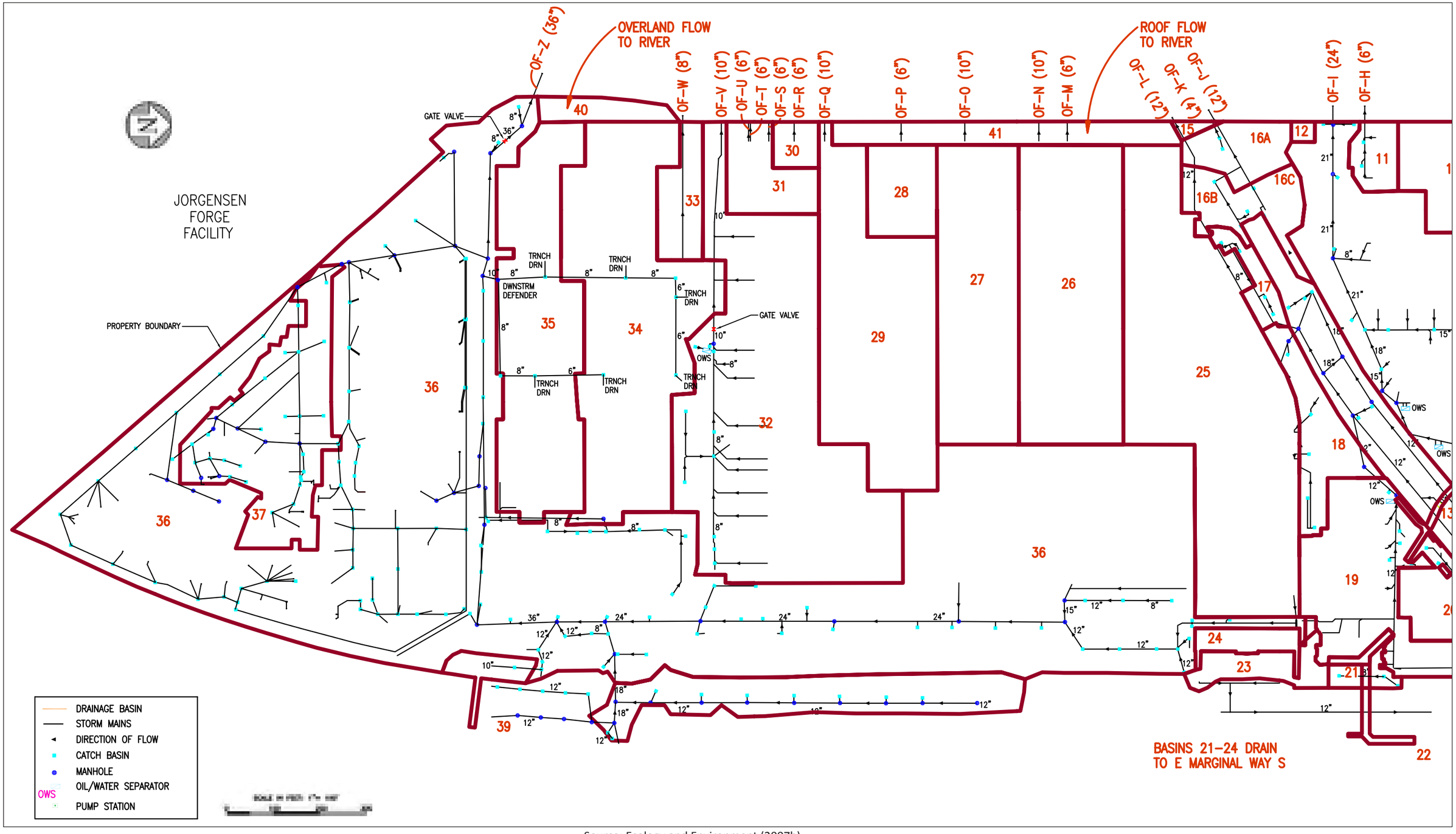

Source: Ecology and Environment (2007b)

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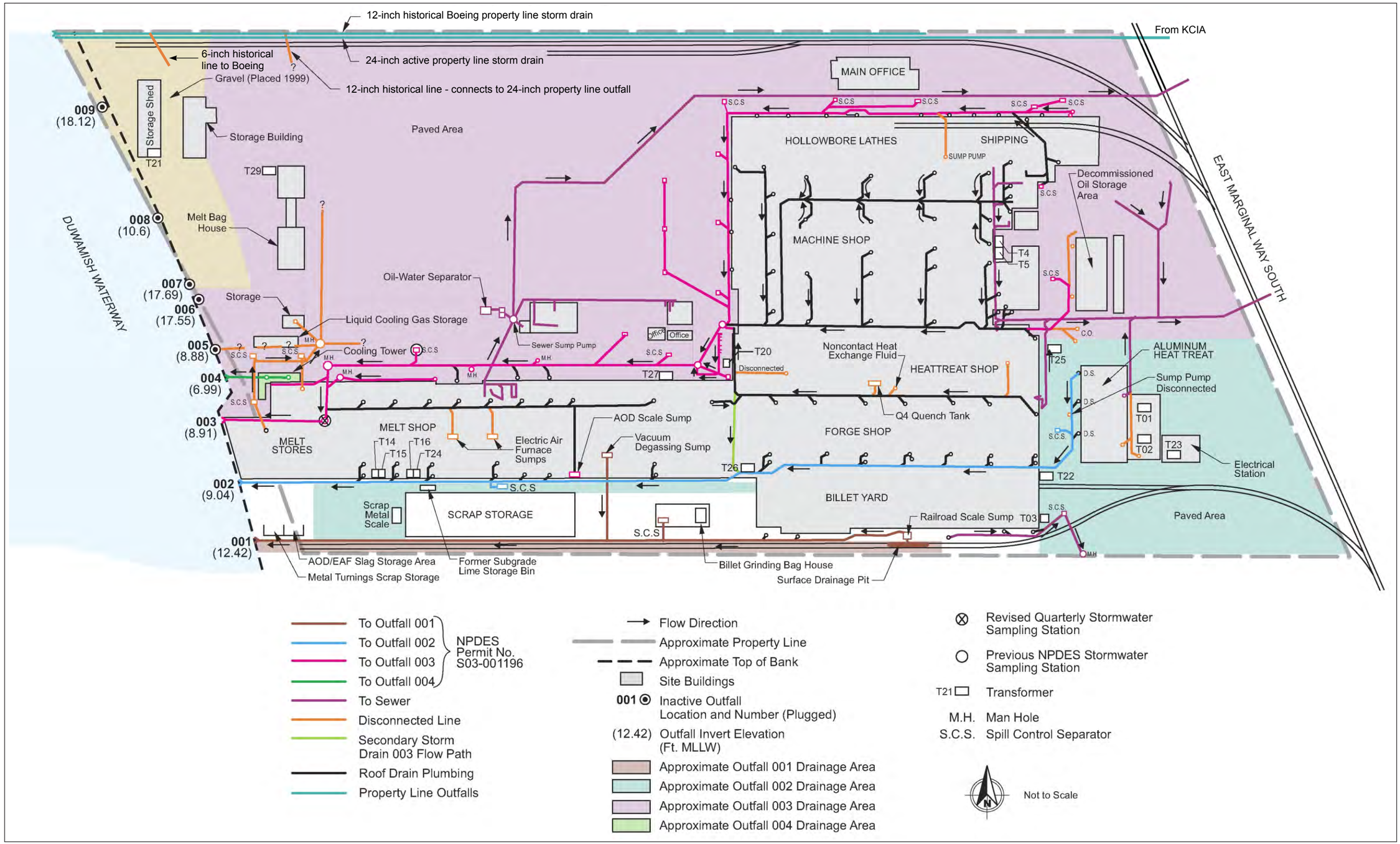
Map I-26. Stormwater drainage lines on Boeing Plant 2 – southern portion



Source: Ecology and Environment (2007b)

Map I-27. Stormwater drainage lines on the Jorgensen Forge facility and along the Boeing Plant 2/Jorgensen Forge boundary

Benzo(g,h,i)perylene	3.2	1.3
Indeno(1,2,3-cd)pyrene	3.2	1.3
Dibenzo(a,h)anthracene	3.0	1.1
Fluoranthene	2.5	ne
Phenanthrene	2.1	ne
Total HPAH	1.9	ne
Chrysene	1.8	ne
Benzo(a)pyrene	1.7	ne
Benzofluoranthenes	1.4	ne
Arsenic	1.4	ne
Benzo(a)anthracene	1.4	ne
PCBs	1.1	ne
BEHP	1.0	ne

PCBs	2.5	ne

Fluoranthene	1.7	ne
Phenanthrene	1.3	ne
Chrysene	1.2	ne
Dibenzo(a,h)anthracene	1.1	ne
Total HPAH	1.0	ne

Benzo(g,h,i)perylene	5.8	2.3
Dibenzo(a,h)anthracene	5.9	2.2
Indeno(1,2,3-cd)pyrene	5.6	2.2
Benzo(a)pyrene	2.6	1.2
Benzofluoranthenes	2.3	1.2
BEHP	1.7	1.1
PCBs	4.3	ne
Fluoranthene	4.1	ne
Phenanthrene	3.9	ne
Total HPAH	3.1	ne
Chrysene	2.8	ne
BBP	2.4	ne
Benzo(a)anthracene	2.1	ne
Acenaphthene	1.4	ne
Total LPAH	1.4	ne
Fluorene	1.3	ne
Dibenzofuran	1.2	ne

Benzoic acid	1.2	1.2
BBP	1.3	ne

PCBs	1.7	ne

BBP	2.0	ne
PCBs	1.3	ne

Chemical	Exceedance Factor	
	SQS	CSL
PCBs	15	2.8

SQS and CSL exceedances are reported only for detected concentrations; reporting limits for undetected chemicals that were above the SQS or CSL are not included. When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

Chemicals in red exceeded CSL. The exceedance factor has no regulatory relevance and is presented here to provide an indication of the general magnitude of the concentration. Sampling locations represented by circles were analyzed for SMS chemicals. Surface sediment samples were collected at depths ≤ 15 cm below mudline.

ne - no exceedance

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Subsurface sediment sampling location
- EOF/storm drain
- Permitted private storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Tax parcel
- SCA-associated property[a]
- EAA boundary[b]
- 2008 SCA boundary[c]
- River mile
- Navigation channel
- Former Slip 5 (1949)

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] The early action area boundary is preliminary and has not been finalized by EPA and Ecology.

[c] Boundary shown is based on Ecology and SAIC (2008).

KCIA SD No. 2 / PS78 EOF drainage basin
Source: Schmoyer (2008a)

0 250 500 1,000 Feet

N

0 200 400 Feet

0 50 100 Meters

Map I-28. Surface sediment and drainage basin information for the Boeing Isaacson/ Central KCIA SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

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Data availability by media type for each facility and major outfall associated with the Boeing Isaacson/Central KCIA SCA

Facility[1]	Soil	Ground-water	Seep	Pore-water[2]	Storm-water[3]	Source-Tracing Data	
						Onsite Catch Basin	ROW Catch Basins
Boeing Isaacson	X	X			X		
Boeing Thompson	X	X	X				
KCIA (central drainage basin)	X	X				X	X
Major Outfalls[4]							
KCIA SD No. 2/Pump Station 78 EOF	na	na	na	na		X	X

An X indicates that source documents reported that data are available or the existence of data was implied for the identified media; however, the analytical data may not have been provided in the source documentation. Absence of an X does not necessarily indicate that facility-specific data for that media type do not exist.

[1] Facilities listed are those identified in the data gaps report (SAIC 2008b) and draft SCAP (Ecology 2008a) with relevant source control information.

[2] No porewater data were identified in the source documents for any facility.

[3] The presence of stormwater data collected from the Boeing Isaacson facility was reported in the draft SCAP (Ecology 2008a); however, actual data were not presented in the source documents.

[4] Major outfalls listed are those discussed as individual source control entities in the source documentation.

na - not applicable

KCIA (Central Drainage Basin): Soil and groundwater investigations have been conducted, and USTs and contaminated soil have been removed at several tenant facilities. Groundwater remediation associated with a LUST was conducted at a former tenant facility. Source tracing samples have been collected within the central KCIA drainage basin, and catch basins located on some portions of the drainage basin have been cleaned out. Additional source tracing investigations, including sampling of joint caulking material, and SD system inspections are planned. Source control practices related to NPDES permit compliance are also in place at several of the tenant facilities.

Boeing Isaacson: Soil and groundwater investigations and remedial activities, including soil removal and onsite soil treatment and capping, were conducted throughout the 1980s and 1990s. Several groundwater monitoring events have been conducted since 1991. An RI/FS will be conducted at the property under a MTCA order. Additional source control investigations may be conducted as part of the RI/FS.

Boeing Thompson: Soil and groundwater investigations have been conducted since the 1990s, and three USTs have been decommissioned. Multiple site inspections have also been conducted on the property. Source control practices related to NPDES permit compliance are in place. An RI/FS will be conducted at the property under a MTCA order. Additional source control investigations may be conducted as part of the RI/FS.

KCIA SD No. 2 / Pump Station 78 EOF: Several business inspections have been conducted within the drainage basin, and source tracing samples have been collected. See the KCIA (Central Drainage Basin) text box for additional information.

King County International Airport
Jorgensen Forge
Boeing Isaacson Property
Boeing Thompson Property
Former Kenworth Truck Company/PACCAR
3.7
3.9
Duwamish Waterway

- Source-tracing sampling location
- Private mainline
- Public mainline
- Public lateral line
- KCIA SD No. 2 / PS78 EOF drainage basin Source: Schmoyer (2008a)

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Subsurface sediment sampling location
- EOF/storm drain
- Permitted private storm drain
- Pipe of unresolved origin and/or use
- Tax parcel
- SCA-associated property[a]
- EAA boundary[b]
- 2008 SCA boundary[c]
- River mile
- Navigation channel
- Former Slip 5 (1949)

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] The early action area boundary is preliminary and has not been finalized by the EPA and Ecology.

[c] Boundary shown is based on Ecology and SAIC (2008).

Sources of information for facilities, outfalls, the drainage basin and for source tracing samples: Ecology (2008a), SAIC (2008b), Schmoyer (2008a; 2008d).

Wind Ward LLC environmental

N

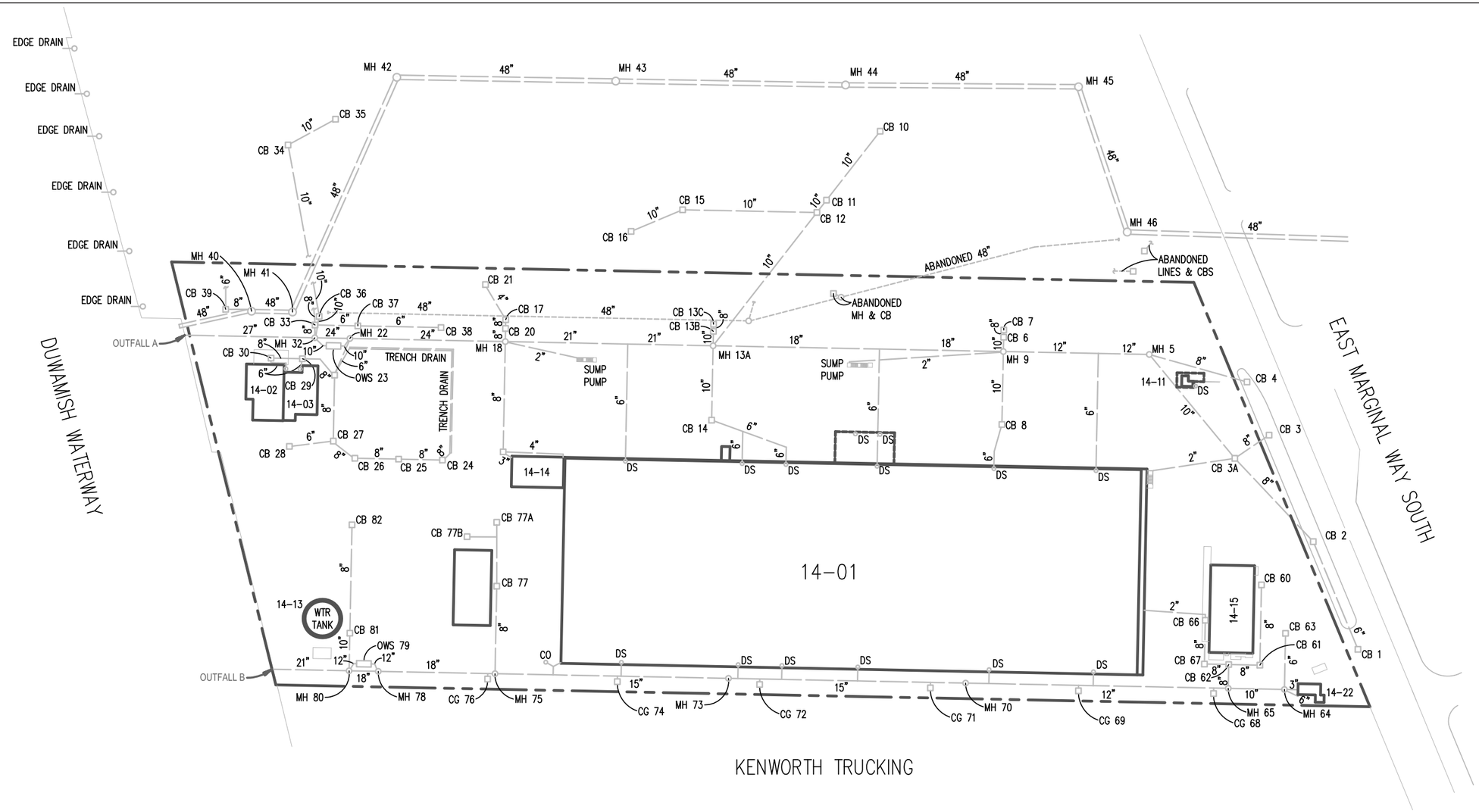
0 250 500 Feet

0 100 200 Meters

Map I-29. Regulatory investigation, remediation, and drainage basin information for the Boeing Isaacson/Central KCIA SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/13/2010, MAP 3443, W:\Projects\00-08-06 Duwamish Rl\data\gis\Phase2 RI\Source Control\Appendix I



DRAINAGE AREA TABLE

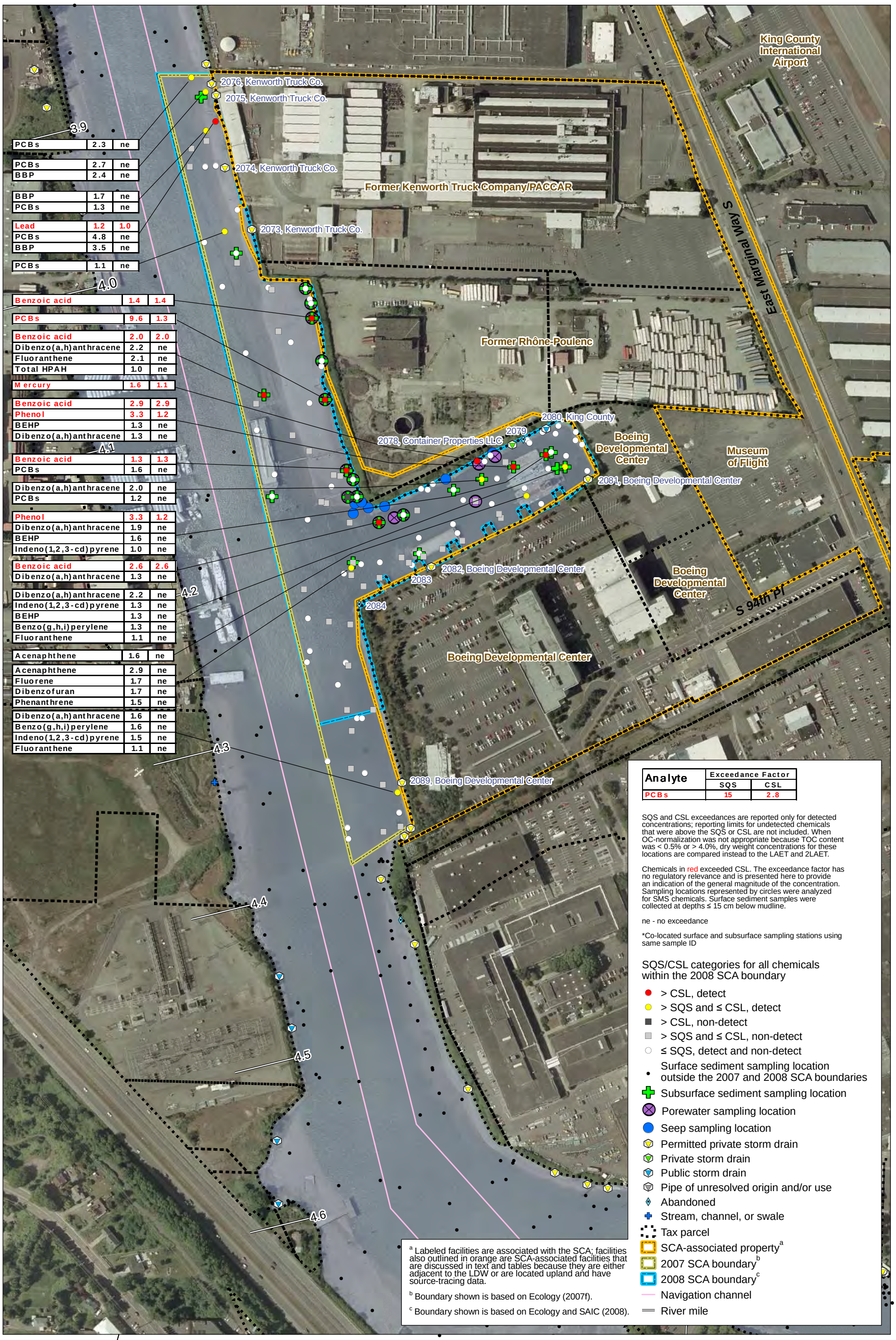
OUTFALL LETTER	BASIN NUMBER	BASIN AREA (ACRES)	REMARKS
A	1	13.06	
B	2	6.05	
TOTAL		19.11	

THOMPSON SITE
STORMWATER SITE MAP
SCALE: 1" = 100'

Source: Boeing (2008) as provided in SAIC (2008b)

Wind Ward environmental LLC

Map I-30. Stormwater drainage lines on the Boeing Thompson and Boeing Isaacson properties



Analyte	Exceedance Factor	
	SQS	CSL
PCBs	15	2.8

SQS and CSL exceedances are reported only for detected concentrations; reporting limits for undetected chemicals that were above the SQS or CSL are not included. When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

Chemicals in red exceeded CSL. The exceedance factor has no regulatory relevance and is presented here to provide an indication of the general magnitude of the concentration. Sampling locations represented by circles were analyzed for SMS chemicals. Surface sediment samples were collected at depths ≤ 15 cm below mudline.

ne - no exceedance

*Co-located surface and subsurface sampling stations using same sample ID

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2007 and 2008 SCA boundaries
- Subsurface sediment sampling location
- Porewater sampling location
- Seep sampling location
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Stream, channel, or swale
- Tax parcel
- SCA-associated property[a]
- 2007 SCA boundary[b]
- 2008 SCA boundary[c]
- Navigation channel
- River mile

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] Boundary shown is based on Ecology (2007f).

[c] Boundary shown is based on Ecology and SAIC (2008).

Wind Ward LLC environmental

N

0 250 500 Feet

0 100 200 Meters

Map I-31. Surface sediment information for the Slip 6 SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

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PACCAR: Environmental investigations involving groundwater, soil, sediment, source tracing, air, and seep sampling have been conducted. Remedial actions have included closure and removal of USTs, groundwater extraction, application of oxygen-releasing compound to soils and groundwater, excavation and removal of petroleum contaminated soils, and installation of an AS/SVE system to treat VOCs. The middle outfall (No. 2074) was closed and the complete stormwater system was cleaned. An investigation of the north storm drain was completed and the drain was repaired. Stormwater quality improvements were conducted in 2008 and monitoring is ongoing. Planned actions include a soil and groundwater investigation of the southern shoreline and northwest corner, additional sediment coring, and a review of the current O&M plan.

Rhône-Poulenc: Environmental investigations involving groundwater, soil, source tracing, sediment, and seep sampling have been conducted. Remedial actions have included PCB removal, SVE system operation, hydraulic control interim measure implementation, hazardous waste storage area cleanup, transformer area cleanup, east parcel voluntary interim measure, northwest corner soil removal, and west parcel redevelopment. The stormwater system was redeveloped in 2007. Quarterly groundwater monitoring is ongoing. Planned actions include an investigation of shoreline bank contamination, review of the stormwater system, and review of the O&M plan.

Boeing Developmental Center: No environmental investigations or remedial actions have been reported within the Slip 6 SCA drainage area. NPDES permit and SWPPP monitoring requirements have been established for this property. An evaluation of the drainage system and the current SWPPP is planned.

KCIA: One catch basin solids sample was collected in 2004. Airport catch basins have been cleaned semi-annually and airport O/W separators are cleaned annually. Evaluations of the drainage system are planned. An evaluation of joint caulk material for PCBs is also planned.

Data availability by media type for each facility associated with the Slip 6 SCA

Facility[1]	Soil	Groundwater	Seep	Porewater	Stormwater	Source-Tracing Data: Onsite Catch Basins
Boeing Developmental Center (northern drainage area)						
KCIA (southwest)			na	na		X
PACCAR (former)	X	X	X		X	X
Rhône-Poulenc (former)[2]	X	X	X	X		

An X indicates that source documents reported that data are available or the existence of data was implied for the identified medium; however, the analytical data may not have been provided in the source documentation. Absence of an X does not necessarily indicate that facility-specific data for that media type do not exist.

[1] Facilities listed are those identified in the data gaps report (Ecology and Environment 2008) and SCAP (Ecology and Ecology and Environment 2008) with relevant source control information.

[2] Includes east and west parcels

na - not applicable

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2007 and 2008 SCA boundaries
- Subsurface sediment sampling location
- Porewater sampling location
- Seep sampling location
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Stream, channel, or swale
- Tax parcel
- SCA-associated property[a]
- 2007 SCA boundary[b]
- 2008 SCA boundary[c]
- Navigation channel
- River mile

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] Boundary shown is based on Ecology (2007f).

[c] Boundary shown is based on Ecology and SAIC (2008).

Sources of information for facility, outfall, and drainage basin: Ecology and Ecology and Environment (2008), Ecology and Environment (2007b), Schmoyer (2008d).

Private mainline
Public mainline
Public lateral line
Portion of KCIA that drains to Slip 6

Wind Ward LLC environmental

N

0 250 500 Feet

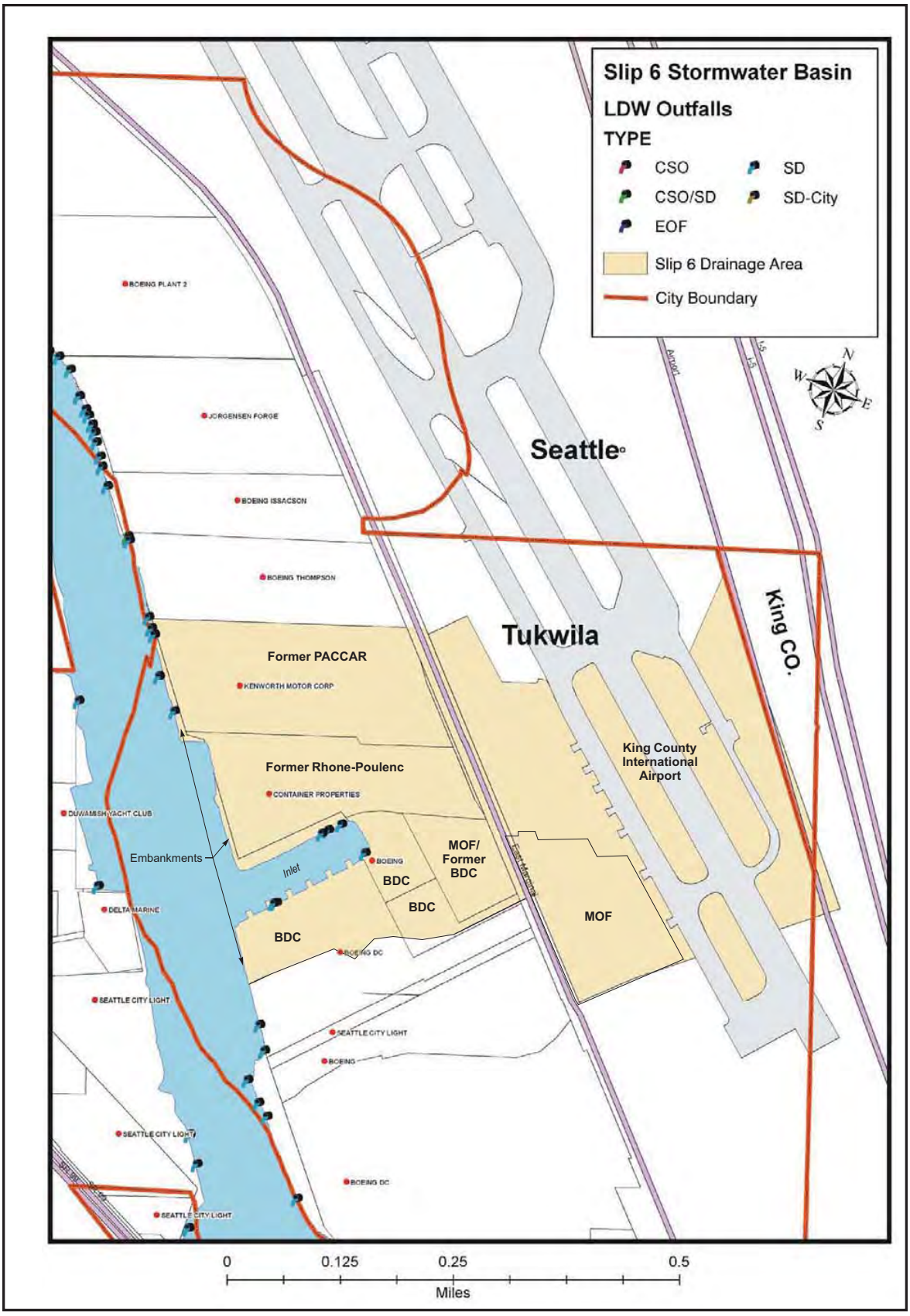
0 100 200 Meters

0 500 1,000 Feet

Map I-32. Regulatory investigation, remediation, and drainage basin information for the Slip 6 SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/13/2010, MAP #3444, W:\Projects\00-08-06_Duwamish_R\data\GIS\Phase2 RI\Source Control\Appendix I



Source: Ecology (2008). Base Map Reference: Department of Ecology.

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Map I-33. Drainage basin for the Slip 6 SCA

Analyte	Exceedance Factor	
	SQS	CSL
PCBs	15	2.8

SQS and CSL exceedances are reported only for detected concentrations; reporting limits for undetected chemicals that were above the SQS or CSL are not included. When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

Chemicals in red exceeded CSL. The exceedance factor has no regulatory relevance and is presented here to provide an indication of the general magnitude of the concentration. Sampling locations represented by circles were analyzed for SMS chemicals. Surface sediment samples were collected at depths ≤ 15 cm below mudline.

ne - no exceedance

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Subsurface sediment sampling location
- CSO/storm drain
- Permitted private storm drain
- Pipe of unresolved origin and/or use
- Tax parcel
- SCA-associated property[a]
- EAA boundary[b]
- 2008 SCA boundary[c]
- Norfolk SD drainage basin[d]
- River mile
- Navigation channel

[b] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO/SD removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain removal area in 2003. The Norfolk boundary represents the area of remediation actions that have been completed to date. Boundary shown is based on Ecology (2007f).

[c] Boundary shown is based on Ecology and SAIC (2008).

[d] Source: Schmoyer (2008a).

3.8
3.9
4.1
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4.9
5.0
5.1
5.2
5.3
5.4
5.5
5.6
Hwy 99
S 102nd St
East Marginal Way S
Airport Way S
Interstate 5
MLK Jr Way S
S Norfolk St
King County International Airport
Military Flight Center
Boeing Developmental Center
Boeing
Northwest Auto Wrecking
Associated Grocers
Affordable Auto Wrecking
Arco Gas Station

Boeing Developmental Center

BDC-5, Boeing Developmental Center

2096, Boeing Developmental Center

2093, Boeing Developmental Center

2094

2095 – Norfolk CSO/SD (044), KC/SPU/Boeing

Boeing

LDW-SS144	PCBs (total calc'd)	2.10	ne
5	PCBs (total calc'd)	1.80	ne
NFK507	BEHP	1.90	1.20
	PCBs (total calc'd)	33.0	6.00
	BBP	1.10	ne
7	PCBs (total calc'd)	16.0	2.90
NFK508	PCBs (total calc'd)	33.0	6.20
4	PCBs (total calc'd)	28.0	5.10
6	PCBs (total calc'd)	1.30	ne
11	PCBs (total calc'd)	1.50	ne
R88	1,4-Dichlorobenzene	21.0	7.20
	BEHP	2.00	1.40
NFK004A	BBP	2.20	ne
	Fluoranthene	1.30	ne
	PCBs (total calc'd)	2.90	ne
NFK005	BEHP	1.40	ne
NFK501 - Apr-01	BBP	1.40	ne
NFK503 - Apr-02	PCBs (total calc'd)	2.50	ne

Dredged and capped area
- Boeing Developmental Center south storm drain
- Norfolk CSO/SD

0 50 100 Feet

Wind Ward environmental LLC

N

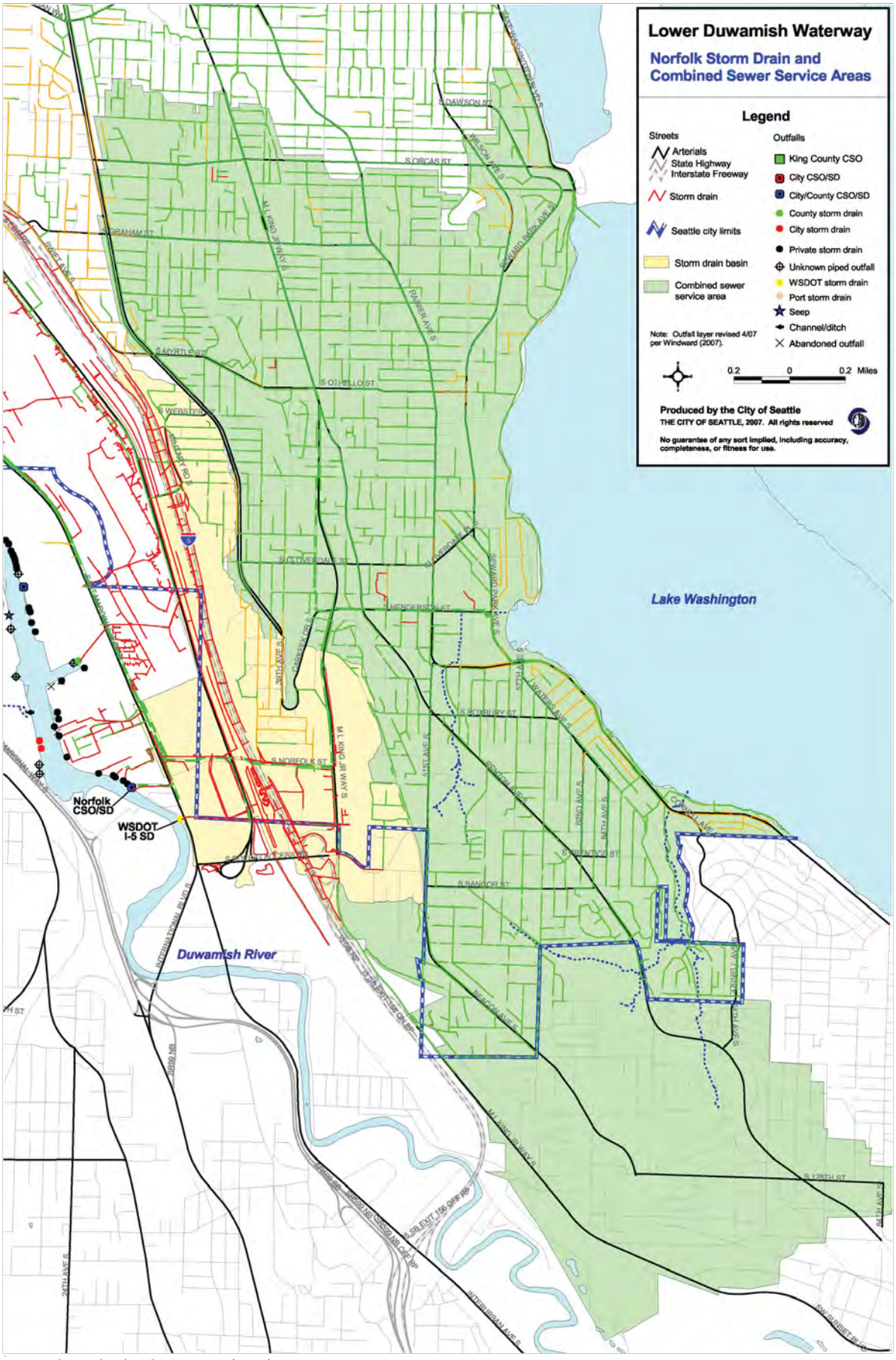
0 1,000 2,000 Feet

0 250 500 Meters

Map I-34. Surface sediment and drainage basin information for the Norfolk CSO/SD SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/13/2010; MAP 3017; W:\Projects\00-08-06_Duwamish_R\data\gis\Phase2 RI\Source Control\Appendix I


Lower Duwamish Waterway
Norfolk Storm Drain and Combined Sewer Service Areas
Legend
Streets
Arterials
State Highway
Interstate Freeway
Storm drain
Seattle city limits
Storm drain basin
Combined sewer service area
Outfalls
King County CSO
City CSO/SD
City/County CSO/SD
County storm drain
City storm drain
Private storm drain
Unknown piped outfall
WSDOT storm drain
Port storm drain
Seep
Channel/ditch
Abandoned outfall
Note: Outfall layer revised 4/07 per Windward (2007).
0.2 0 0.2 Miles
Produced by the City of Seattle
THE CITY OF SEATTLE, 2007. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
Lake Washington
Duwamish River
Norfolk CSO/SD
WSDOT I-5 SD
S DAWSON ST
S ORCAS ST
S GRAHAM ST
S MYRTLE ST
S OTHELLO ST
S WEBSTER ST
S CLOVERDALE ST
S HENDERSON ST
S BOEING ACCESS RD
S NORFOLK ST
S BOEHLER ST
S BRANDON ST
S BANGOR ST
S 112TH ST
S 120TH ST
M L KING JR WAY S
RAINIER AVE S
SEWARD PARK AVE S
MARGINAL WAY S
INTERNATIONAL BLVD S
I-5 SB EXIT 156 OFF RP
I-5 NB EXIT 158 ON RP

Data availability by media type for each facility and major outfall associated with the Norfolk CSO/SD SCA

Facility[1]	Soil	Groundwater	Seep[2]	Pore-water[2]	Storm-water	Source-Tracing Data					
						Onsite Catch Basins	ROW Catch Basins	Manhole	In-line Sediment	Outfall Discharge	Joint Caulking
Arco Gas Station	X	X							X		
BDC	X	X			X	X		X	X	X	X
Boeing Military Flight Center											X
KCIA[3, 4]											
Major Outfalls[5]											
Boeing South SD	na	na	na	na		X		X			X
Norfolk CSO/SD	na	na	na	na			X		X		

An X indicates that source documents reported that data are available or the existence of data was implied for the identified media; however, the analytical data may not have been provided in the source documentation. Absence of an X does not necessarily indicate that facility-specific data for that media type do not exist.

[1] Facilities listed are those identified in the data gaps report (Ecology and Environment 2007) and the SCAP (Ecology 2007) with relevent source control information.

[2] No seep or porewater data were identified in the source documents for any facility.

[3] KCIA information in this section pertains only to the area of KCIA that drains to the Norfolk SCA.

[4] No soil, groundwater, seep, porewater, stormwater, or source-tracing data were identified in the source documents for this facility.

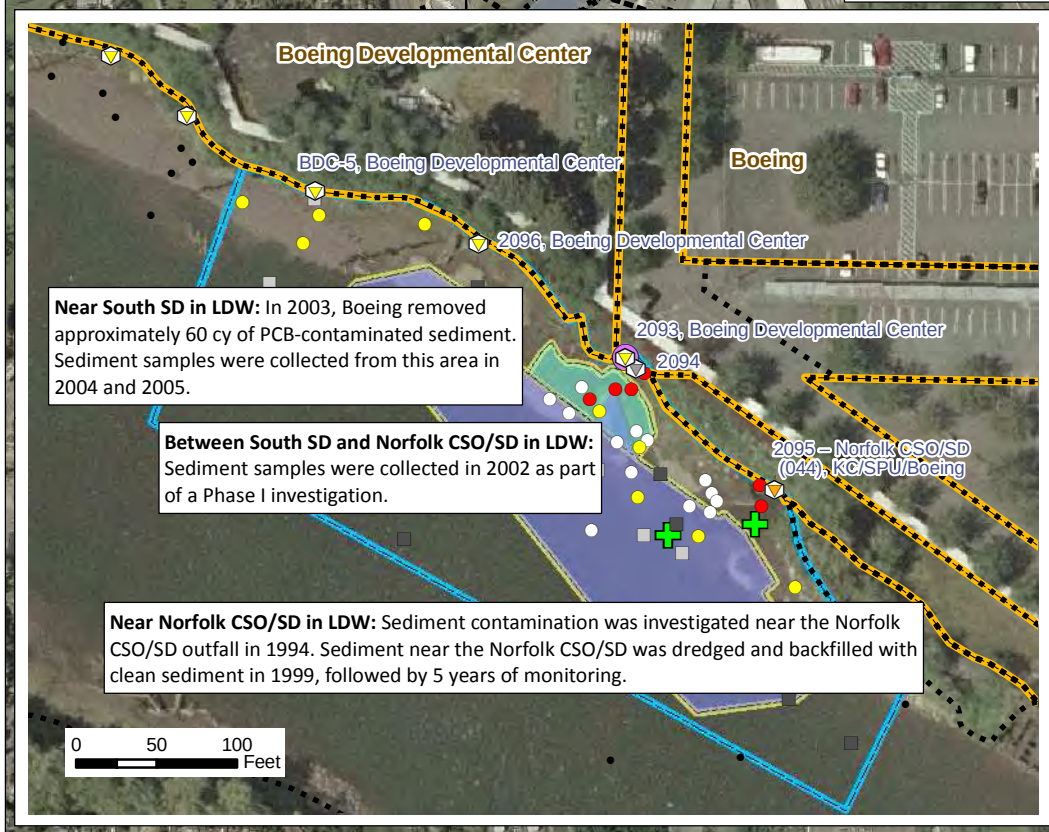
[5] Major outfalls listed are those discussed as individual source control entities in the source documentation.

na - not applicable

Boeing Developmental Center: A RCRA facility investigation was conducted in 1994, and corrective actions for soil and groundwater contamination have been conducted. In 2001, a Phase II ESA was conducted near the Museum of Flight. Subsequent groundwater monitoring was conducted. A four-phase source-tracing sampling event was conducted in and around the south SD line in 2001, and a segment of the south SD line was cleaned in 2002. Groundwater investigations were conducted following a gasoline leak. Soil near the south SD was remediated, and USTs have been removed.

Military Flight Center: Joint caulking materials containing PCBs were investigated and removed in 2005 and 2006.

Arco Gas Station: Groundwater sampling occurred between 2004 and 2006. Twenty-six USTs were removed, and onsite soils have been remediated. Inline Sediment samples were collected from within the Norfolk CSO/SD system between 2003 and 2005.



Near South SD in LDW: In 2003, Boeing removed approximately 60 cy of PCB-contaminated sediment. Sediment samples were collected from this area in 2004 and 2005.

Between South SD and Norfolk CSO/SD in LDW: Sediment samples were collected in 2002 as part of a Phase I investigation.

Near Norfolk CSO/SD in LDW: Sediment contamination was investigated near the Norfolk CSO/SD outfall in 1994. Sediment near the Norfolk CSO/SD was dredged and backfilled with clean sediment in 1999, followed by 5 years of monitoring.

King County International Airport
Boeing Developmental Center
Military Flight Center
Boeing
Northwest Auto Wrecking
Associated Grocers
Affordable Auto Wrecking
Arco Gas Station
Airport Way S
Interstate 5
S Norfolk St
S 102nd St
East Marginal Way S
Hwy 99

- Source-tracing sampling location[a]
- Private mainline
- Public mainline
- Public lateral line
- Norfolk SD drainage basin[b]

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Subsurface sediment sampling location
- CSO/storm drain
- Permitted private storm drain
- Pipe of unresolved origin and/or use
- Tax parcel
- SCA-associated property[c]
- EAA boundary[d]
- 2008 SCA boundary[e]

Dredged and capped area

- Boeing Developmental Center south storm drain
- Norfolk CSO/SD
- River mile
- Navigation channel

[a] Source-tracing sampling locations were mapped when coordinates were available. Therefore, not all source-tracing samples with chemical data are mapped.

[b] Source: Schmoyer (2008a).

[c] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[d] For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO/SD removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain removal area in 2003. The Norfolk boundary represents the area of remediation actions that have been completed to date. Boundary shown is based on Ecology (2007f).

[e] Boundary shown is based on Ecology and SAIC (2008).

Sources of information for facilities, outfalls, drainage basin, and source-tracing samples: Windward (2003b), Ecology and Environment (2007a), Ecology (2007c), and Schmoyer (2008d).

WindWard environmental LLC

N

0 1,000 2,000 Feet

0 250 500 Meters

Map I-36. Regulatory investigation and remediation status of the Norfolk CSO/SD SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

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Lower Duwamish Waterway

Legend

Streets
- Arterials
- State Highway
- Interstate Freeway

Parcel boundary

Building

Storm drain

Sanitary sewer

County interceptor

Pipe cleaned in 2005

Sediment sampling location

50 0 50 100 150 Feet

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THE CITY OF SEATTLE, 2005. All rights reserved

No guarantee of any sort implied, including accuracy, completeness, or fitness for use.

S NORFOLK ST

Norfolk20

Norfolk21

WSDOT Stormwater Treatment System

MH7

M L KING JR WAY S

MH5

AIRPORT WAY S

NP RR

Ditch

40TH AVE S

MH6

To Lower Duwamish Waterway

MH1

MH3

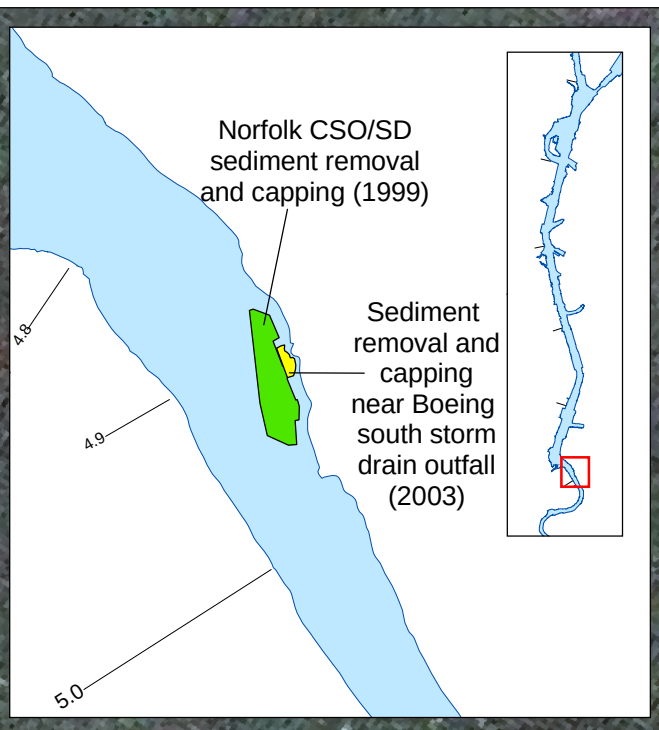
MH4

S 104TH PL

BN RR

Wind Ward environmental LLC

Map I-37. Norfolk CSO/SD in-line sediment sampling locations



Norfolk monitoring locations

- LDW RI 2006
- Apr-04
- Apr-03
- Apr-02
- Apr-01
- Apr-00
- Oct-99
- Apr-99

Boeing Developmental Center south storm drain monitoring location

Outfall classification

- CSO/storm drain
- Permitted private storm drain
- Pipe of unresolved origin and/or use

Boeing Developmental Center south storm drain removal area (2003)

Norfolk CSO/SD removal area (1999)

For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO/SD removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).

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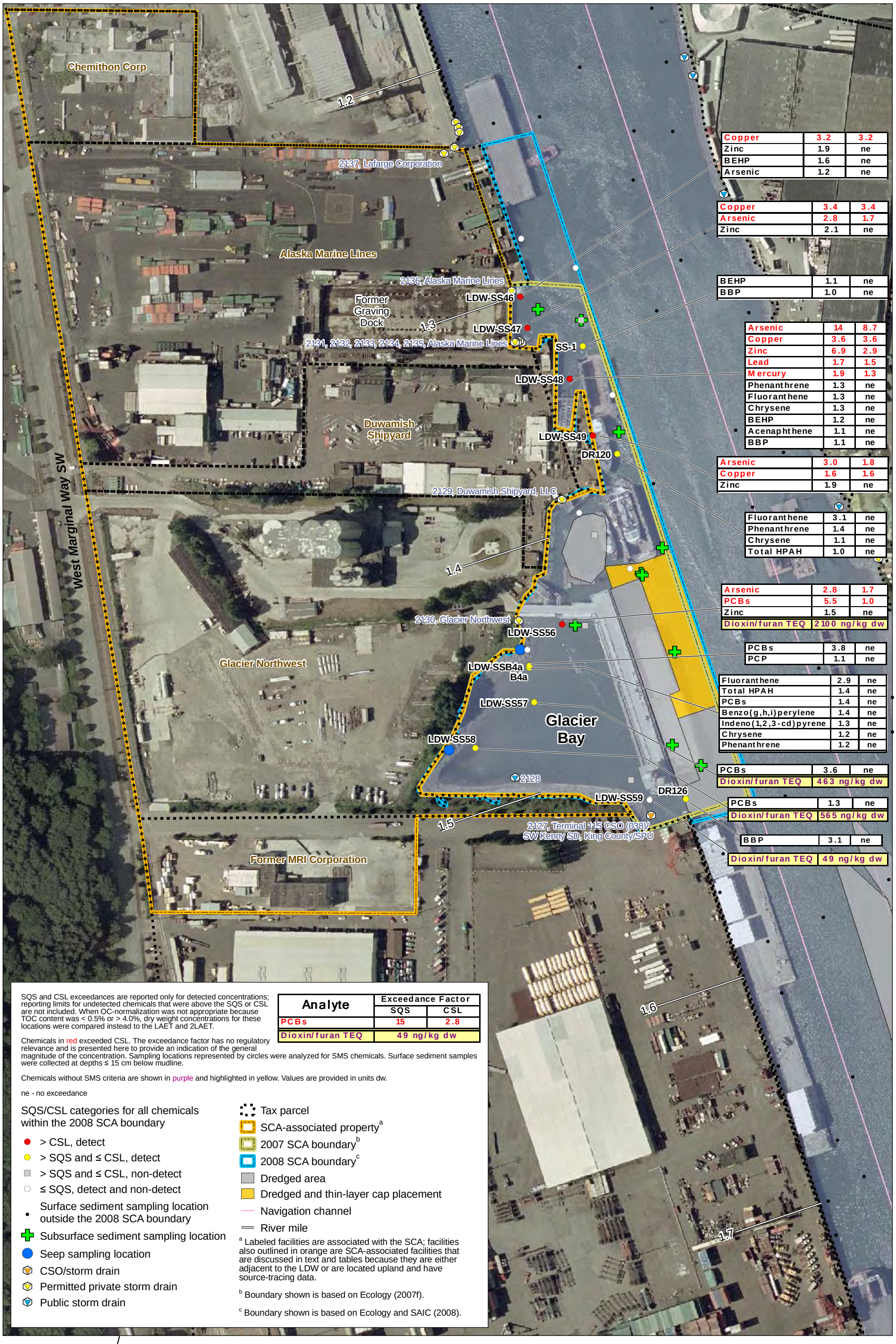
0 25 50 Feet

0 10 20 Meters

Map I-38. Surface sediment monitoring locations at Norfolk CSO/SD and Boeing Developmental Center South storm drain

Prepared by: CEH, 07/13/2010; MAP 2834; W:\Projects\00-08-06_Duwamish_R\data\GIS\Phase2 RI\Source Control\Appendix I



SQS and CSL exceedances are reported only for detected concentrations; reporting limits for undetected chemicals that were above the SQS or CSL are not included. When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

Analyte	Exceedance Factor	
	SQS	CSL
PCBs	15	2.8
Dioxin/furan TEQ	49 ng/kg dw	

Chemicals in red exceeded CSL. The exceedance factor has no regulatory relevance and is presented here to provide an indication of the general magnitude of the concentration. Sampling locations represented by circles were analyzed for SMS chemicals. Surface sediment samples were collected at depths ≤ 15 cm below mudline.

Chemicals without SMS criteria are shown in purple and highlighted in yellow. Values are provided in units dw.

ne - no exceedance

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Subsurface sediment sampling location
- Seep sampling location
- CSO/storm drain
- Permitted private storm drain
- Public storm drain
- Tax parcel
- SCA-associated property[a]
- 2007 SCA boundary[b]
- 2008 SCA boundary[c]
- Dredged area
- Dredged and thin-layer cap placement
- Navigation channel
- River mile

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] Boundary shown is based on Ecology (2007f).

[c] Boundary shown is based on Ecology and SAIC (2008).

Wind Ward LLC environmental

N

0 200 400 Feet

0 50 100 Meters

Map I-39. Surface sediment information for the Glacier Bay SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/13/2010, MAP #2985; W:\Projects\00-08-06_Duwamish_R\data\gis\Phase2 RI\Source Control\Appendix I

Chemithon Corporation: SPU completed site inspections and a source-tracing sampling investigation. An update to the SWPPP and follow-up inspections are planned for the near future. No remedial activities have been noted to date.

Alaska Marine Lines: Soil and groundwater sampling related to several USTs was completed; USTs and associated contaminated soil were removed from the property. Test pit sampling has been conducted in former storage area. Business inspections and NPDES compliance review are scheduled for the facility. Verification of graving dock remediation program is in progress.

Duwamish Shipyard: Numerous characterization investigations have been completed, including the investigation of spilled materials (e.g., sand blast grit, waste oil). Four USTs and associated contaminated soil have been removed from the property. Several NPDES discharge violations have been reported. Source-tracing investigations, including catch basin and stormwater sampling, are ongoing. Agreed order under MTCA will address further site characterization.

Glacier Northwest: Several environmental investigations involving soil and groundwater sampling of the former impoundment area and tank farm have been completed. No remedial activities have been identified to date. Additional site characterization efforts are scheduled, and source control inspections are ongoing.

Former MRI Corporation: Several characterization investigations involving areas of the former unlined settling/evaporation lagoons have been completed. No remedial activities have been identified to date. Additional source-tracing inspections and stormwater network mapping are in progress.

Chemithon Corp
1.2
2137, Lafarge Corporation
Alaska Marine Lines
2136, Alaska Marine Lines
Former Graving Dock
1.3
2131, 2132, 2133, 2134, 2135, Alaska Marine Lines
Duwamish Shipyard
2129, Duwamish Shipyard, LLC
1.4
2130, Glacier Northwest
Glacier Northwest
Glacier Bay
2128
1.5
2127, Terminal 115 CSO (038)/ SW Kenny SD, King County/SPU
Former MRI Corporation
West Marginal Way SW

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Subsurface sediment sampling location
- Seep sampling location
- CSO/storm drain
- Permitted private storm drain
- Public storm drain
- Tax parcel
- SCA-associated property[a]
- 2007 SCA boundary[b]
- 2008 SCA boundary[c]
- Dredged area
- Dredged and thin-layer cap placement
- Navigation channel
- River mile

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] Boundary shown is based on Ecology (2007f).

[c] Boundary shown is based on Ecology and SAIC (2008).

Sources of information for facilities and outfalls: Ecology (2007e), SAIC (2007d), Schmoyer (2008d).

Data availability by media type for each facility and major outfall associated with the Glacier Bay SCA

Facility[1]	Soil	Ground-water	Seep	Pore-water[2]	Storm-water	Source-Tracing Data: Onsite Catch Basins	Source-Tracing Data: ROW Catch Basins
Alaska Marine Lines	X	X					
Chemithon Corporation						X	
Duwamish Shipyard	X	X			X	X	
Glacier Northwest	X	X	X		X		
MRI Corporation (former)	X	X					
Outfall[3]							
No. 2127 Terminal 115 CSO (038)/SW Kenny SD, King County/SPU	na	na	na	na			X

An X indicates that source documents reported that data are available or the existence of data was implied for the identified media; however, the analytical data may not have been provided in the source documentation. Absence of an X does not necessarily indicate that facility-specific data for that media type do not exist.

[1] Facilities listed are those identified in the data gaps report (SAIC 2007d) and SCAP (Ecology 2007d) with relevant source control information.

[2] No porewater data were identified in the source documents for any facility.

[3] Major outfall listed is discussed as an individual source control entity in the source documents.

na - not applicable

Wind Ward LLC environmental

N

0 200 400 Feet

0 50 100 Meters

Map I-40. Regulatory investigation and remediation status for the Glacier Bay SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/13/2010; MAP #3441; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Appendix I

- Source-tracing sampling location[a]
- Private mainline
- Public mainline
- Public lateral line
- Glacier Bay-SW Kenny SD

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Subsurface sediment sampling location
- Seep sampling location
- CSO/storm drain
- Permitted private storm drain
- Public storm drain
- Tax parcel
- SCA-associated property[b]
- 2007 SCA boundary[c]
- 2008 SCA boundary[d]
- Dredged area
- Dredged and thin-layer placement
- Navigation channel
- River mile

[a] Source-tracing sampling locations were mapped when coordinates were available. Therefore, not all source-tracing samples with chemical data are mapped.

[b] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[c] Boundary shown is based on Ecology (2007f).

[d] Boundary shown is based on Ecology and SAIC (2008).

Sources of additional information for facilities and outfalls:
Ecology (2007e), SAIC (2007d), Schmoyer (2008d), Windward (2004).

Kellogg I.

0.8

0.9

1.0

Chemithon Corp

1.2

2137, Lafarge Corporation

Alaska Marine Lines

2136, Alaska Marine Lines

Former Graving Dock

1.3

2131, 2132, 2133, 2134, 2135, Alaska Marine Lines

Duwamish Shipyard

2129, Duwamish Shipyard, LLC

1.4

2130, Glacier Northwest

Glacier Northwest

Glacier Bay

2128

1.5

2127, Terminal 115 CSO (038)/ SW Kenny SD, King County/SPU

Former MRI Corporation

West Marginal Way SW

1.6

City of Seattle SD: ROW catch basin sampling within the drainage basin was completed in 2006. In-line sediment sampling is in progress.

1.7

1.8

WindWard LLC environmental

N

0 400 800 Feet

0 100 200 Meters

Map I-41. Stormwater basin and drainage features for Glacier Bay SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/13/2010; MAP #3442; W:\Projects\00-08-06 Duwamish RI\data\gis\Phase2 RI\Source Control\Appendix I

PCBs	180	23
Mercury	6	4.2
BEHP	3.2	2.2
Lead	1.4	1.2
Zinc	1	ne
Dioxin/furan TEQ	412 ng/kg dw	

PCBs	8.2	1.5
Mercury	2.0	1.4
BEHP	1.8	1.1

PCBs	10	1.8

PCBs	36	4.7
Mercury	3.9	2.7
BEHP	1.8	1.2
BBP	1.4	ne

PCBs	1.4	ne

Hwy 509/1st Ave Bridge
Douglas Management Company
2120
2118, SPU
Second Avenue S SD
Trotsky/former Northwest Cooperage
(presently Industrial Container Services)
2117, Boyer Logistics, Inc
Vacant
Boyer Towing
S Orchard St
22
Boyer Towing
Boyer Towing
Trotsky/former Northwest Cooperage
(presently Industrial Container Services)
23
W Marginal Way S
2nd Ave S
Wells Trucking & Leasing

SQS and CSL exceedances are reported only for detected concentrations; reporting limits for undetected chemicals that were above the SQS or CSL are not included. When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

Analyte	Exceedance	
	SQS	CSL
PCBs	15	2.8
Dioxin/furan TEQ	49 ng/kg dw	

Chemicals in red exceeded CSL. The exceedance factor has no regulatory relevance and is presented here to provide an indication of the general magnitude of the concentration. Sampling locations represented by circles were analyzed for SMS chemicals. Surface sediment samples were collected at depths ≤ 15 cm below mudline.

Chemicals without SMS criteria are shown in purple and highlighted in yellow.

ne - no exceedance

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Subsurface sediment sampling location
- Seep sampling location

- EOF
- Permitted private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Tax parcel
- SCA-associated property[a]
- EAA boundary[b]
- 2008 SCA boundary[c]
- Navigation channel
- River mile

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] The EAA boundary shown is based on Ecology (2007f); this boundary is preliminary and has not been finalized by EPA and Ecology.

[c] Boundary shown is based on Ecology and SAIC (2008).

Wind Ward LLC environmental

N

0 50 100 Feet

0 20 40 Meters

Map I-42. Surface sediment information for the Trotsky Inlet SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/13/2010; MAP #3011; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Appendix I

Data availability by media type for each facility and major outfall associated with the Trotsky SCA

Facility[1]	Soil	Groundwater	Seep	Pore-water[2]	Storm-water	Source-Tracing Data: Catch Basins	Source-Tracing Data: ROW Catch Basins	Source-Tracing Data: Inline Sediment
Boyer Towing, Inc (Parcels 7-9)[3]								
Douglas Management Company			X					
Trotsky	X	X	X					
Wells Trucking and Leasing						X		
Major outfalls[4]								
Second Avenue S SD	na	na	na	na	X		X	X

An X indicates that source documents reported that data are available or the existence of data was implied for the identified media; however, the analytical data may not have been provided in the source documentation. Absence of an X does not necessarily indicate that facility-specific data for that media type do not exist.

[1] Facilities listed are those identifed in the SCAP (Ecology 2007b), data gaps report (SAIC 2007b), or additional site characterization activities report (SAIC 2007a) with relavent source control information.

[2] No porewater data were identified in the source documents for any facility.

[3] No soil, groundwater, seep, porewater, stormwater, or source-tracing data were identified in the source documents for this facility.

[4] Major outfalls listed are those discussed as individual source control entities in the source documentation.

na - not applicable

Hwy 509/1st Ave Bridge

Douglas Management Company

Douglas Management Co.: A cleanup of a LUST was conducted in the 1990s. Additional site characterization will be conducted.

2120

2118, SPU Second Avenue S SD

Trotsky/former Northwest Cooperage (currently Industrial Container Services)

Second Avenue S SD: In-line sediment samples have been collected along the Second Avenue S SD line. SPU plans to conduct additional source tracing investigations in 2009.

2117, Boyer Logistics, Inc

Vacant

Boyer Towing

S Orchard St

Boyer Towing (Parcels 7 to 9): SPU conducted source control investigations in 2003. Sediment samples from an O/W separator were collected.

2.2

Boyer Towing

Boyer Towing

Trotsky/former Northwest Cooperage (currently Industrial Container Services)

Trotsky: A pretreatment facility was installed around 1970. In 1973, the site was bermed with concrete in response to a spill. A three-phase soil and groundwater assessment was conducted in 1986. A site hazard assessment (including the collection of soil samples and a source-tracing sample) was conducted in 1991. Additional groundwater sampling also was conducted in 1991. A site characterization study was conducted in 2007. Site inspections also have been conducted. An RI/FS will be conducted at the property under a MTCA order. Additional source control investigations may be conducted as part of the RI/FS.

2.3

W Marginal Way S

2nd Ave S

Wells Trucking and Leasing: SPU inspected the facility in 2002. Catch basins were cleaned in 2002, and catch basin samples were collected in 2003.

Wells Trucking & Leasing

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Subsurface sediment sampling location
- Seep sampling location

- EOF
- Permitted private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Tax parcel
- SCA-associated property[a]
- EAA boundary[b]
- 2008 SCA boundary[c]
- Navigation channel
- River mile

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] The EAA boundary shown is based on Ecology (2007f); this boundary is preliminary and has not been finalized by EPA and Ecology.

[c] Boundary shown is based on Ecology and SAIC (2008).

Sources of information for facilities and outfalls: SAIC (2007b, c), Ecology (2007b), Schmoyer (2008d), and Windward (2004).

Wind Ward environmental LLC

N

0 50 100 Feet

0 20 40 Meters

Map I-43. Regulatory investigation and remediation status of the Trotsky Inlet SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/13/2010; MAP #3446; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Section 10

Douglas Management Company
Hwy 509/1st Ave Bridge
2120
2118, SPU
Second Avenue S SD
2117, Boyer Logistics, Inc
Boyer Towing
S Orchard St
Boyer Towing
Boyer Towing
Trotsky/former Northwest Cooperage
(currently Industrial Container Services)
2nd Ave S
W Marginal Way S
Wells Trucking & Leasing
2.2
2.3
2.4
2.5
2.6

- Source-tracing sampling location[a]
- Public lateral line
- Public mainline
- 2nd Ave sub-basin
- > CSL, detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the 2008 SCA boundary
- Subsurface sediment sampling location
- Seep sampling location
- EOF
- Permitted private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Tax parcel
- SCA-associated property[b]
- EAA boundary[c]
- 2008 SCA boundary[d]
- Navigation channel
- River mile

[a] Source-tracing sampling locations were mapped when coordinates were available. Therefore, not all source-tracing samples with chemical data are mapped.

[b] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[c] The EAA boundary shown is based on Ecology (2007f); this boundary is preliminary and has not been finalized by EPA and Ecology.

[d] Boundary shown is based on Ecology and SAIC (2008).

Sources of information for drainage basin and source-tracing samples: Schmoyer (2008a, d).

Wind Ward environmental LLC

N

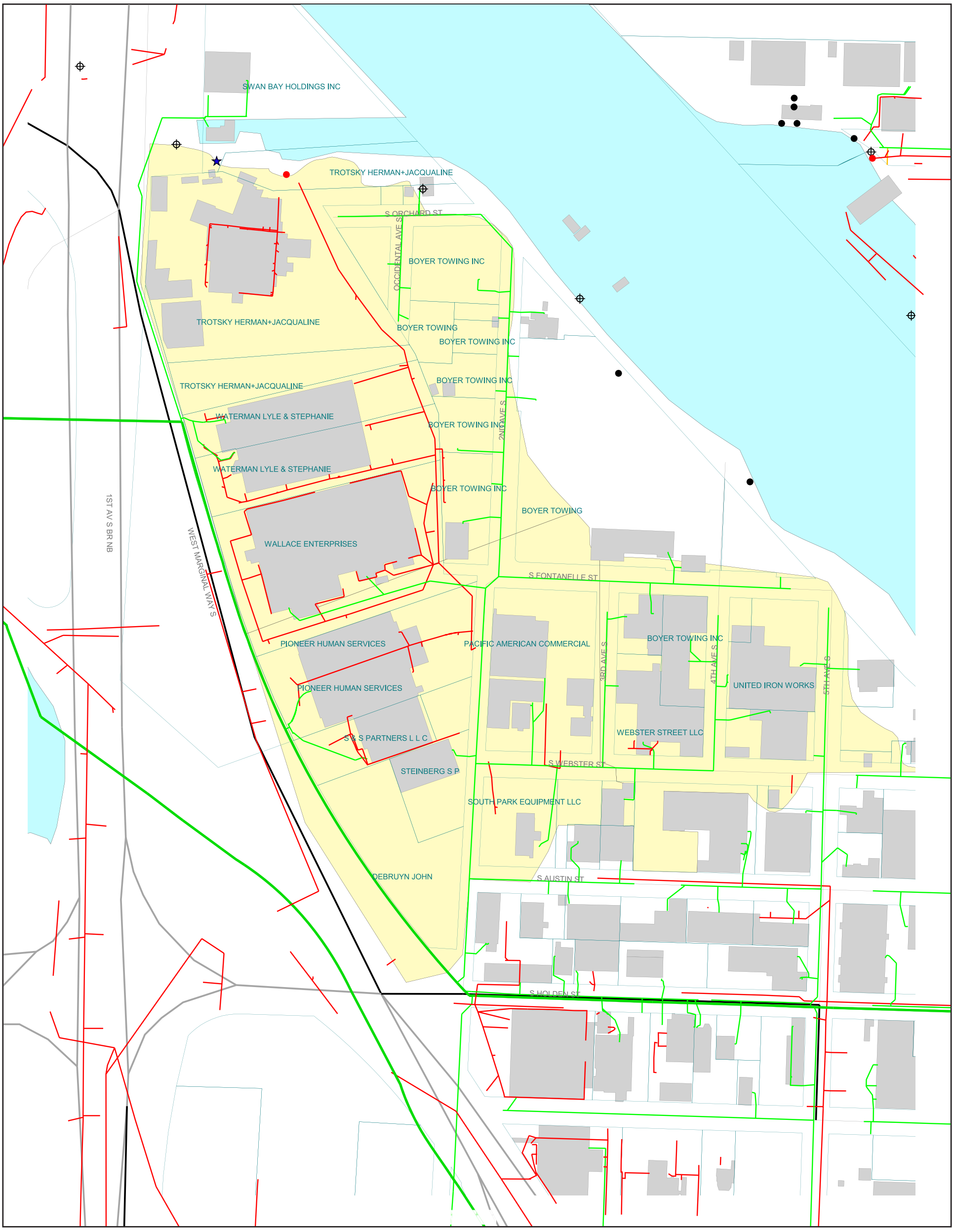
0 120 240 Feet

0 40 80 Meters

Map I-44. Drainage basin for the Trotsky Inlet SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/13/2010; MAP #3447; W:\Projects\00-08-06_Duwamish_Rfidata\gis\Phase2 RI\Source Control\Appendix I



Source: City of Seattle (2006) as provided in Ecology (2007b)

Legend:

Outfalls
- Abandoned pipe
- CSO-KC
- CSO/SD-City
- CSO/SD-SPU/KC
- Channel
- Private SD
- SD-City
- SD-KC
- SD-Port
- SD-WSDOT/C
- Seep
- Unk

Unlities
- Storm drain
- Sanitary sewer
- Combined sewer
- King County interceptor
- 2nd Ave S SD basin

100 0 100 200 Feet

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Wind Ward environmental LLC

Map I-45. Stormwater basin and drainage features for the Trotsky Inlet SCA

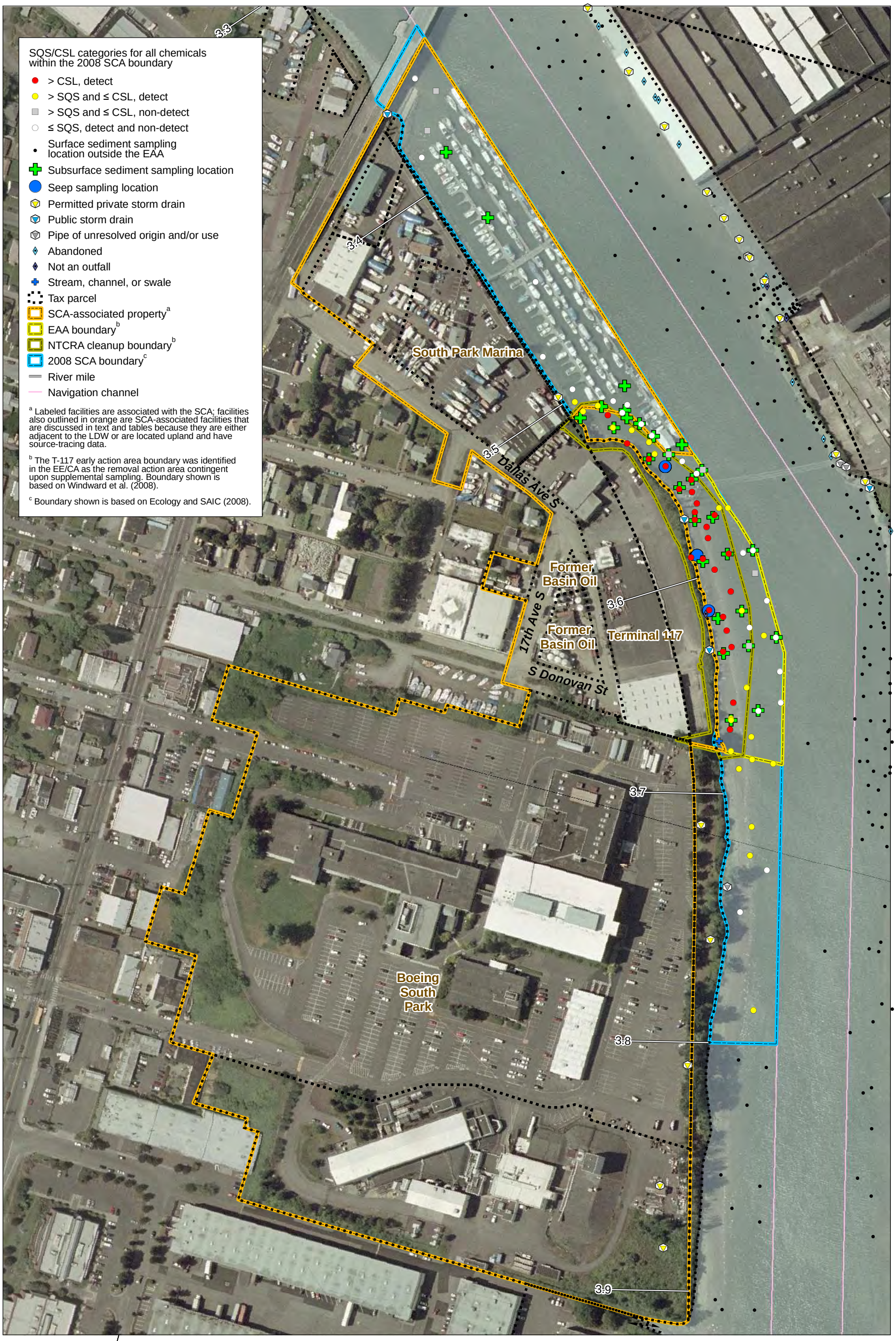
SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the EAA
- Subsurface sediment sampling location
- Seep sampling location
- Permitted private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale
- Tax parcel
- SCA-associated property[a]
- EAA boundary[b]
- NTCRA cleanup boundary[b]
- 2008 SCA boundary[c]
- River mile
- Navigation channel

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] The T-117 early action area boundary was identified in the EE/CA as the removal action area contingent upon supplemental sampling. Boundary shown is based on Windward et al. (2008).

[c] Boundary shown is based on Ecology and SAIC (2008).



N

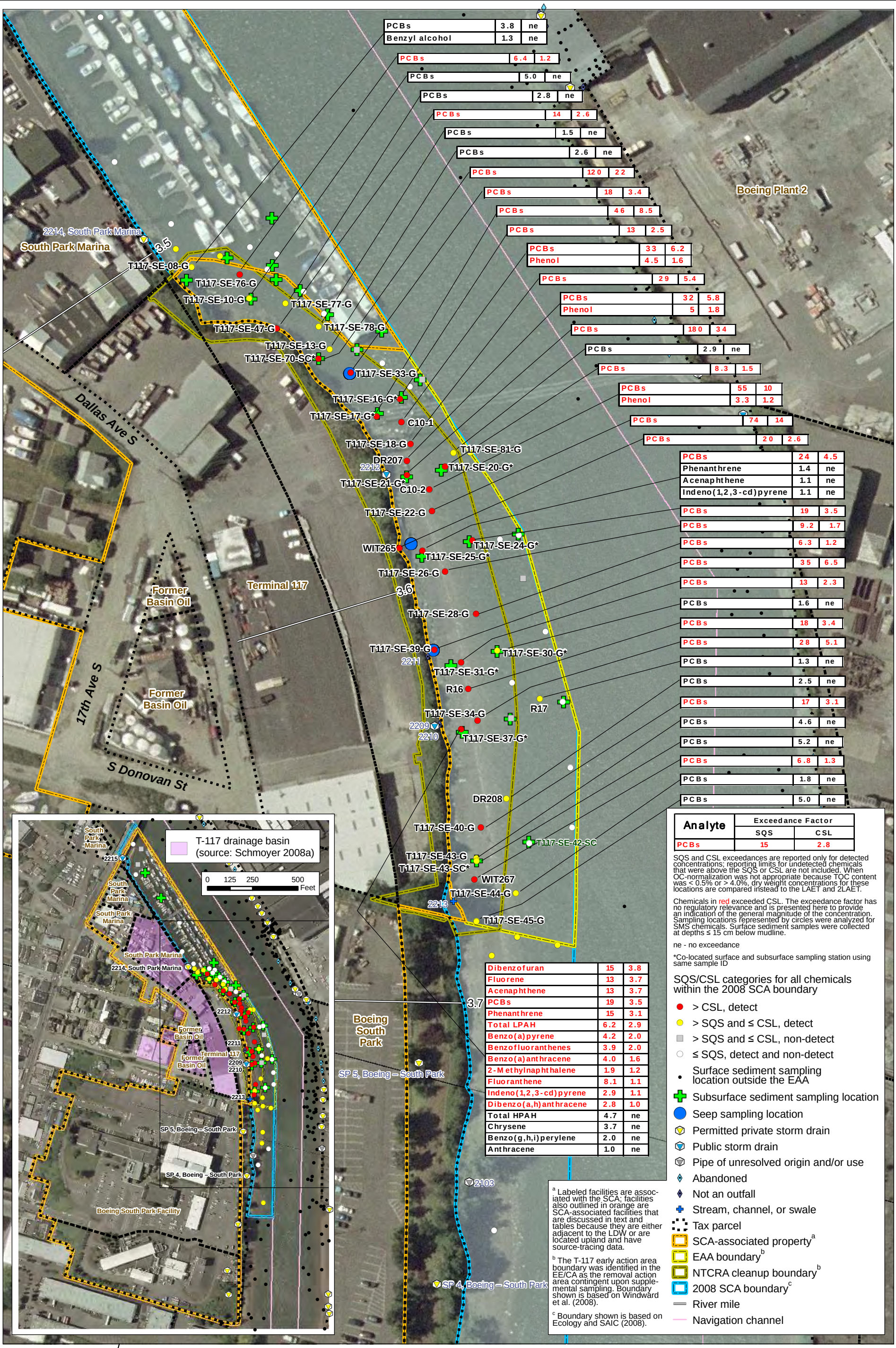
0 200 400 Feet

0 50 100 Meters

Map I-46. T-117 SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/13/2010, MAP #3436, W:\Projects\00-08-06_Duwamish_R\data\GIS\Phase2 RI\Source Control\Appendix I



Analyte	Exceedance Factor	
	SQS	CSL
PCBs	15	2.8

SQS and CSL exceedances are reported only for detected concentrations; reporting limits for undetected chemicals that were above the SQS or CSL are not included. When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

Chemicals in red exceeded CSL. The exceedance factor has no regulatory relevance and is presented here to provide an indication of the general magnitude of the concentration. Sampling locations represented by circles were analyzed for SMS chemicals. Surface sediment samples were collected at depths ≤ 15 cm below mudline.

ne - no exceedance

*Co-located surface and subsurface sampling station using same sample ID

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the EAA
- Subsurface sediment sampling location
- Seep sampling location
- Permitted private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale
- Tax parcel
- SCA-associated property[a]
- EAA boundary[b]
- NTCRA cleanup boundary[b]
- 2008 SCA boundary[c]
- River mile
- Navigation channel

[a] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[b] The T-117 early action area boundary was identified in the EE/CA as the removal action area contingent upon supplemental sampling. Boundary shown is based on Windward et al. (2008).

[c] Boundary shown is based on Ecology and SAIC (2008).

Wind Ward LLC environmental

N

0 50 100 Feet

0 20 40 Meters

Map I-47. Surface sediment and drainage basin information for the T-117 SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/13/2010; MAP #3007; W:\Projects\00-08-06_Duwamish_R\data\GIS\Phase2 R\\Source Control\Appendix I

Data availability by media type for each facility and major outfall associated with the T-117 SCA

Facility[1]	Soil	Ground-water	Seeps	Pore-water[2]	Storm-water	Source-Tracing Data: Onsite Catch Basins	Source-Tracing Data: ROW Catch Basins
Basin Oil	X	X					
Boeing South Park	X						
City of Seattle Street ROW (Dallas Ave Vicinity)	X				X		X
South Park Marina	X	X					
Terminal 117	X	X	X			X	
Major Outfalls[3]							
Port of Seattle SD (No. 2212)[4]	na	na	na	na			
Port of Seattle SD (No. 2209)[4]	na	na	na	na			
Public SD (No. 2215)[4]	na	na	na	na			
South Park Marina permitted private SD (No. 2214)[4]	na	na	na	na			
Boeing South Park permitted private SDs (Nos. SP-4 and SP-5)[4]	na	na	na	na			

An X indicates that source documents reported that data are available or the existence of data was implied for the identified medium; however, the analytical data may not have been provided in the source documentation. Absence of an X does not necessarily indicate that facility-specific data for that media type do not exist.

[1] Facilities are adjacent properties listed in the SCAP (Ecology 2005) and data gaps report (Windward et al. 2003) with relevant source control information.

[2] No porewater data were identified in the source documents for any facility.

[3] Major outfalls listed are those discussed as individual source control entities in the source documents.

[4] No stormwater or source-tracing data were identified for this outfall in the source documents.

na - not applicable

Public SD (No. 2215): No source-tracing investigations have been reported.

South Park Marina: Soil and catch basin sampling as well as water quality and stormwater compliance inspections have been conducted.

South Park Marina permitted private SD (No. 2214): No source-tracing investigations have been reported.

City of Seattle Street ROW (Dallas Avenue Vicinity): Soil and street dust samples were collected, leading to the performance of interim and cleanup actions. Stormwater and catch basin sediment monitoring has also been completed. Streets have been restored, contaminated soils have been removed from the streets and residential yards, and new SDs and catch basins have been installed.

Port of Seattle SD (No. 2212): No source-tracing investigations have been reported.

T-117: Several groundwater, soil, and sediment sampling events have been conducted within T-117. Investigations have been conducted to identify potential sources of recontamination. Soil has been removed from multiple areas around T-117, and a UST was removed. Site characterization and hazard assessments also have been completed in preparation of various removal actions.

Port of Seattle SD (No. 2209): No source-tracing investigations have been reported.

Basin Oil: Several environmental investigations related to dangerous waste compliance inspections and site visits have been conducted. Remedial actions conducted thus far have included adding gravel to disturbed areas, installing a silt fence, removing tanks.

Boeing South Park: An initial site characterization has been conducted.

Boeing South Park permitted private SDs (Nos. SP-4 and SP-5): No source-tracing investigations have been reported.

- Source-tracing sampling location[a]
- T-117 drainage basin

SQS/CSL categories for all chemicals within the 2008 SCA boundary

- > CSL, detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Surface sediment sampling location outside the EAA
- Subsurface sediment sampling location
- Seep sampling location
- EOF/storm drain
- Permitted private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale
- Tax parcel
- SCA-associated property[b]
- EAA boundary[c]
- NTCRA cleanup boundary[c]
- 2008 SCA boundary[d]
- River mile
- Navigation channel

[a] Source-tracing sampling locations were mapped when coordinates were available. Therefore, not all source-tracing samples with chemical data are mapped.

[b] Labeled facilities are associated with the SCA; facilities also outlined in orange are SCA-associated facilities that are discussed in text and tables because they are either adjacent to the LDW or are located upland and have source-tracing data.

[c] The T-117 early action area boundary was identified in the EE/CA as the removal action area contingent upon supplemental sampling. Boundary shown is based on Windward et al. (2008).

[d] Boundary shown is based on Ecology and SAIC (2008).

Sources of information for facilities and outfalls: Windward et al. (2003, 2004; 2008), City of Seattle (2004), SAIC (2008c), Schmoyer (2008d), and SECOR (1998), as cited in Windward et al. (2003)

Wind Ward LLC environmental

N

0 200 400 Feet

0 50 100 Meters

Map I-48. Regulatory investigation and remediation status of the T-117 SCA

Photo source: USGS High-Resolution Orthoimage, Seattle/Tacoma, WA, USGS, 2003. Distributed by King County GIS. Photo date 06/11/2002.
Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's NPDES permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003).
Tax parcel information was provided in 2008 by SPU and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property owner records was not conducted.

Prepared by CEH, 07/13/2010; MAP #3434; W:\Projects\00-08-06_Duwamish_R\data\GIS\Phase2 RI\Source Control\Appendix I

Appendix J. Boring Logs Used for the LDW Hydrostratigraphy Evaluation

Table J-1. Boring core IDs and references

Boring Core ID in WW Figures	Original ID/ Point name	Boring core ID	Reference	Notes
11457	SD-101	SD-101	Converse (1988)	
11458	SD-102	SD-102	Converse (1988)	
5656	84-2	84-2	Dames & Moore (1984)	
5657	84-3	84-3	Dames & Moore (1984)	
3727	88-3	88-3	Dames & Moore (1988)	
DR171		DR171	Weston (1999)	
DR220		DR220	Weston (1999)	
Sg11b		--		STC DR 2005 (WW and QEA) →have geochronology sediment core figure but not actual logs
Sg7		--		STC DR 2005 (WW and QEA) → have geochronology sediment core figure but not actual logs
58636	12329	12329	GeoEngineers (1988)	
16583	B-2	B-2	GeoEngineers (1995)	
56139	D-440	D-440	Geo/Resource Consultants (1984)	
11693	DB-1	DB-1	Golder Associates (1997)	
7459	B-2	B-2	Hart Crowser (1979)	
SC1 through SC55		SC1 through SC55	Windward and RETEC (2007)	SC44, 46, 52 →RI subsurface core 2006 on maps
SC4-96	4	4	SEA (1996)	
SC2-98	2	2	SEA (1998)	
SC3-98	3	3	SEA (1998)	
SC6-98	6	6	SEA (1998)	
SC7-98	7	7	SEA (1998)	
AV8-9-98		--	SEA (1998)	average of core 8 and 9 -- no log showing ave
SC1-99	1	1	SEA (1998)	
SC5-99	5	5	SEA (2000)	
SC6-99	6	6	SEA (2000)	
SC12-99	12	12	SEA (2000)	
SC13-99	13	13	SEA (2000)	
SC14-99	14	14	SEA (2000)	

Boring Core ID in WW Figures	Original ID/ Point name	Boring core ID	Reference	Notes
SC16-99	16	16	SEA (2000)	
SC17-99	17	17	SEA (2000)	
SC18-99	18	18	SEA (2000)	
58362	CPT-D77-01	CPT-D77-01	SEA (2000)	
11745	B-1	B-1	SPU (2003)	
11746	B-2	B-2	Terra Associates (1999)	
13867	B-1	B-1	Terra Associates (1999)	
13868	B-2	B-2	Twelker (1970)	
SD-217		--		
41218	B1	B1	Twelker (1970)	
41220	B3	B3	Yonemitsu Geological Services (1979)	

Note: Do not have actual log.

References

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Golder Associates. 1997. Geotechnical evaluation of proposed directional drill bore under the Duwamish River at 8th Avenue South, Seattle, Washington. Golder Associates Inc., Redmond, WA.

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SEA. 1996. PSDDA chemical characterization of Duwamish Waterway and upper turning basin. FY97 operations and maintenance dredging. Prepared for US Army Corps of Engineers, Seattle District. Striplin Environmental Associates, Inc., Olympia, WA.

SEA. 1998. PSDDA sediment characterization of Duwamish River navigation channel: FY99 operations and maintenance dredging data report. Prepared for US Army Corps of Engineers, Seattle District. Striplin Environmental Associates, Inc., Olympia, WA.

SEA. 2000. PSDDA sediment characterization of Duwamish River navigation channel: FY2000 operations and maintenance dredging data report. Prepared for US Army Corps of Engineers, Seattle District. Striplin Environmental Associates, Inc., Olympia, WA.

SPU. 2003. Geotechnical report, Duwamish substation, Bank 79 foundation retrofit, Seattle, Washington. Seattle Public Utilities Materials Laboratory, Seattle, WA.

Terra Associates. 1999. Geotechnical report: office/warehouse facility, 5030-1st Avenue South, Seattle, Washington. Terra Associates, Inc., Kirkland, WA.

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Weston. 1999. Site inspection report, Lower Duwamish River (RK 2.5-11.5), Seattle, Washington. Vol 1-Report and appendices. Prepared for US Environmental Protection Agency, Region 10. Roy F. Weston, Inc., Seattle, WA.

Windward, RETEC. 2007. Lower Duwamish Waterway remedial investigation. Data report: Subsurface sediment sampling for chemical analyses. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC and The RETEC Group, Inc., Seattle, WA.

Yonemitsu Geological Services. 1979. Proposed warehouse for C.D. Stimson Company. Yonemitsu Geological Services, Seattle, WA.

BORING CORE LOGS

DATE DRILLED: 3/18/88

SUMMARY: BORING NO. SD-101

ELEVATION: 3

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLE NO.*	SAMPLE	BLOWS/6"	OTHER TESTS**	FIELD MOISTURE % OF DRY WEIGHT	DRY DENSITY PCF	DESCRIPTION	SYMBOL	MOISTURE	CONSISTENCY
0							FILL 5" asphalt SAND; gray-brown, fine to coarse, trace silt	SP	moist	medium dense
	1C		10 11 9		4	96	RECENT ALLUVIUM SAND; gray-brown, fine to coarse, grades to fine to medium, trace silt	SP	moist	medium dense
5	2A		5 6 4	G			becomes wet		wet	
	3C		2 1 3		65	64	ORGANIC SILT; gray- brown, fine, trace peat and wood fragments, laminated with silty sand	OL	wet	very soft
10	4B		push							
	5C		2 2 4				SAND; gray, fine to medium, trace silt	SP	wet	loose
15	6A		5 10 10	G			grades to medium dense			medium dense
	7A		11 12 16				SAND; gray, fine to medium, trace silt	SP	wet	medium dense
20							(continued)			

* A. 2" split-spoon sampler
B. 3" O.D. thin-wall sampler C. 3-1/4" O.D. x 2-1/2" liner D. 3-1/2" O.D. split barrel sampler X. sample not recovered

** A - Atterberg, C - consolidation, DS - direct shear, G - grain size, T - triaxial, P - permeability

water level
impervious seal
piezometer tip

PROPOSED 7TH AVENUE STORM DRAIN
Seattle, Washington
for URS Consultants

Project No. 87-35192

Drawing No. A-14

Converse Consultants — Geotechnical Engineering and Applied Sciences

DATE DRILLED: 3/18/88

SUMMARY: BORING NO. SD-101 (Cont.)

ELEVATION:

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLE NO.*	SAMPLE	BLOWS/6"	OTHER TESTS**	FIELD MOISTURE % OF DRY WEIGHT	DRY DENSITY PCF	DESCRIPTION	SYMBOL	MOISTURE	CONSISTENCY
20	8A		5 6 7				**RECENT ALLUVIUM** SAND (continued) grades to trace coarse sand	SP	wet	medium dense
25	9C		12 29 19							
30	10A		12 18 16							
35	11C		12 16 20				grades with scattered pumice fragments and silt laminations			
40							Bottom of boring at depth 36.5 feet. 3" PVC monitoring well installed. Slotted screen from 25' to 35', backfilled to 7' with pea gravel, bentonite seal to the surface.			

* A. 2" split-spoon sampler
B. 3" O.D. thin-wall sampler C. 3-1/4" O.D. x 2-1/2" liner
D. 3-1/2" O.D. split barrel sampler X. sample not recovered

** A - Atterberg, C - consolidation, DS - direct shear, G - grain size, T - triaxial, P - permeability

water level
impervious seal
piezometer tip

PROPOSED 7TH AVENUE STORM DRAIN
Seattle, Washington
for URS Consultants

Project No. 87-35192

Drawing No. A-15

Converse Consultants Geotechnical Engineering and Applied Sciences

DATE DRILLED: 3/16/88

SUMMARY: BORING NO. SD-102

ELEVATION: 3

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLE NO.*	SAMPLE	BLOWS/6"	OTHER TESTS**	FIELD MOISTURE % OF DRY WEIGHT	DRY DENSITY PCF	DESCRIPTION	SYMBOL	MOISTURE	CONSISTENCY
0	1C		2 3 3				**FILL** SAND; gray-brown, fine, thinly bedded with sandy silt, trace wood debris and wire	SP	moist	loose
5	2C		1 1 1		58	61	**RECENT ALLUVIUM** CLAY, gray-brown mottled, trace organics and root holes, laminated with peat	CL	moist	very soft
	3B		push				SILTY SAND; gray-brown, fine to medium	SM	wet	very loose
10	4C		1 3 4				SAND; gray, fine to medium, trace to little silt, with laminations of wood debris	SP	wet	loose
	5A		2 4 6	G						
15	6C		6 9 12							
	7A		5 5 5							
20							SAND (description next page) (continued)			

* A. 2" split-spoon sampler
B. 3" O.D. thin-wall sampler C. 3-1/4" O.D. x 2-1/2" liner D. 3-1/2" O.D. split barrel sampler X. sample not recovered

** A - Atterberg, C - consolidation, DS - direct shear, G - grain size, T - triaxial, P - permeability

water level
impervious seal
piezometer tip

PROPOSED 7TH AVENUE STORM DRAIN
Seattle, Washington
for URS Consultants

Project No. 87-35192

Drawing No. A-16

Converse Consultants Geotechnical Engineering and Applied Sciences

DATE DRILLED: 3/16/88

SUMMARY: BORING NO. SD-102 (Cont.)

ELEVATION:

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLE NO.*	SAMPLE	BLOWS/6"	OTHER TESTS**	FIELD MOISTURE % OF DRY WEIGHT	DRY DENSITY PCF	DESCRIPTION	SYMBOL	MOISTURE	CONSISTENCY
20	8C		10 12 14				**RECENT ALLUVIUM** SAND; gray, fine to coarse, trace silt, scattered gravel	SW	wet	medium dense
25	9A		7 9 12	G			grades with scattered wood fragments			
30	10C		19 23 34							dense
35	11A		12 15 27							
							SAND (description next page)			
40							(continued)			

* A. 2" split-spoon sampler
B. 3" O.D. thin-wall sampler C. 3-1/4" O.D. x 2-1/2" liner
D. 3-1/2" O.D. split barrel sampler X. sample not recovered

** A - Atterberg, C - consolidation, DS - direct shear, G - grain size, T - triaxial, P - permeability

water level
impervious seal
piezometer tip

PROPOSED 7TH AVENUE STORM DRAIN
Seattle, Washington
for URS Consultants

Project No. 87-35192

Drawing No. A-17

Converse Consultants — Geotechnical Engineering and Applied Sciences

DATE DRILLED: 3/16/88

SUMMARY: BORING NO. SD-102 (Cont.)

ELEVATION:

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLE NO.*	SAMPLE	BLOWS/6"	OTHER TESTS**	FIELD MOISTURE % OF DRY WEIGHT	DRY DENSITY PCF	DESCRIPTION	SYMBOL	MOISTURE	CONSISTENCY
40	12C		17 22 27				**RECENT ALLUVIUM** SAND; gray, fine to medium, trace silt, and scattered pumice fragments, thinly bedded with laminations of silt, sandy silt with trace wood fragments and scattered gravel grades with scattered layers of low plasticity clay	SP	wet	medium dense to dense
45	13A		5 6 8							
							Bottom of boring at depth 46.5 feet. 3" PVC monitoring well installed. Slotted screen from 35' to 45', backfilled with pea gravel to 4' and bentonite seal to surface.			

* A. 2" split-spoon sampler
B. 3" O.D. thin-wall sampler C. 3-1/4" O.D. x 2-1/2" liner X. sample not recovered
D. 3-1/2" O.D. split barrel sampler

** A - Atterberg, C - consolidation, DS - direct shear, G - grain size, T - triaxial, P - permeability

water level
impervious seal
piezometer tip

PROPOSED 7TH AVENUE STORM DRAIN
Seattle, Washington
for URS Consultants

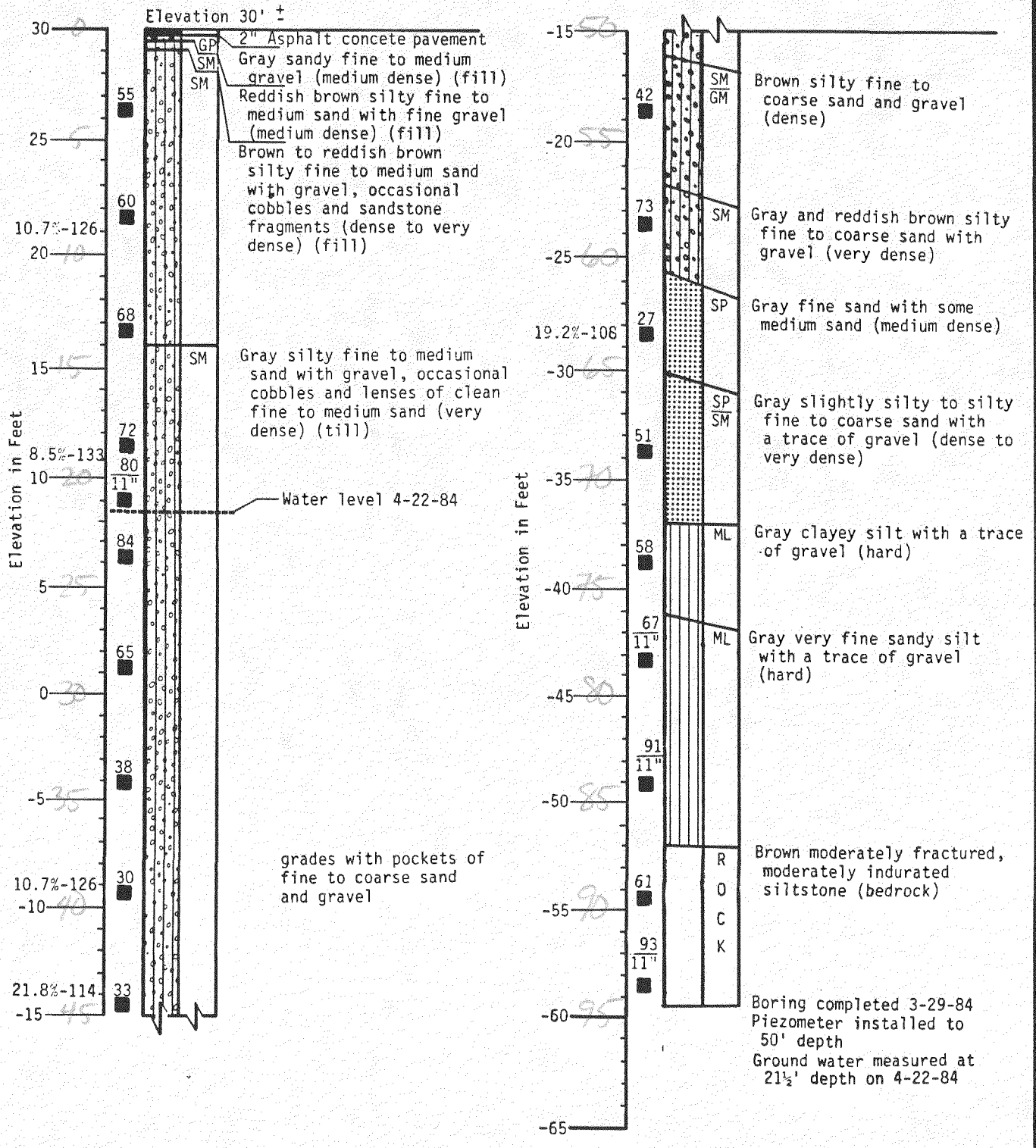
Project No. 87-35192

Drawing No. A-18

Converse Consultants Geotechnical Engineering and Applied Sciences

RECEIVED

Boring 84-2



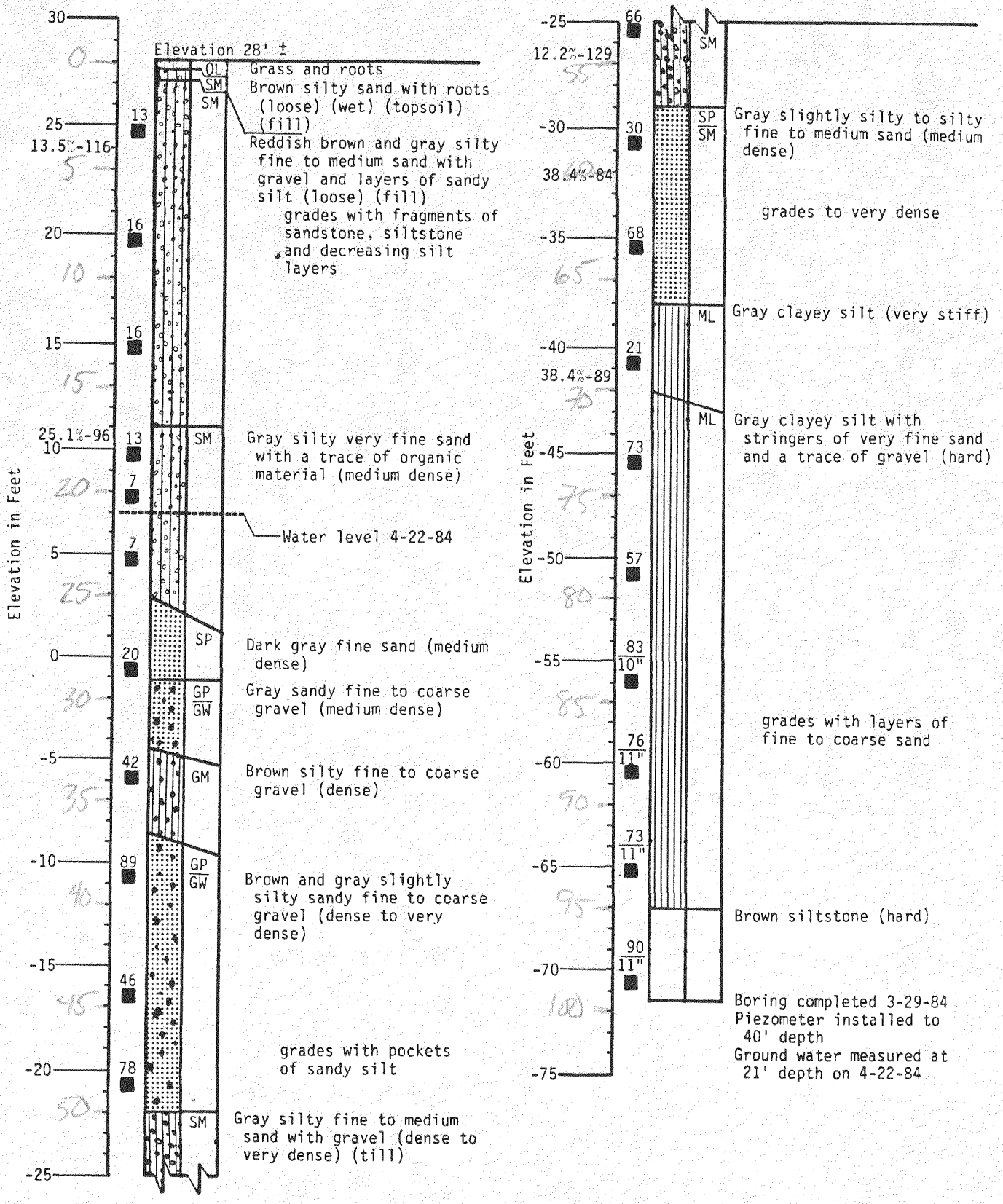
LOG OF BORINGS

Dames & Moore

Job No. 695-286

Plate A-2

Boring 84-3



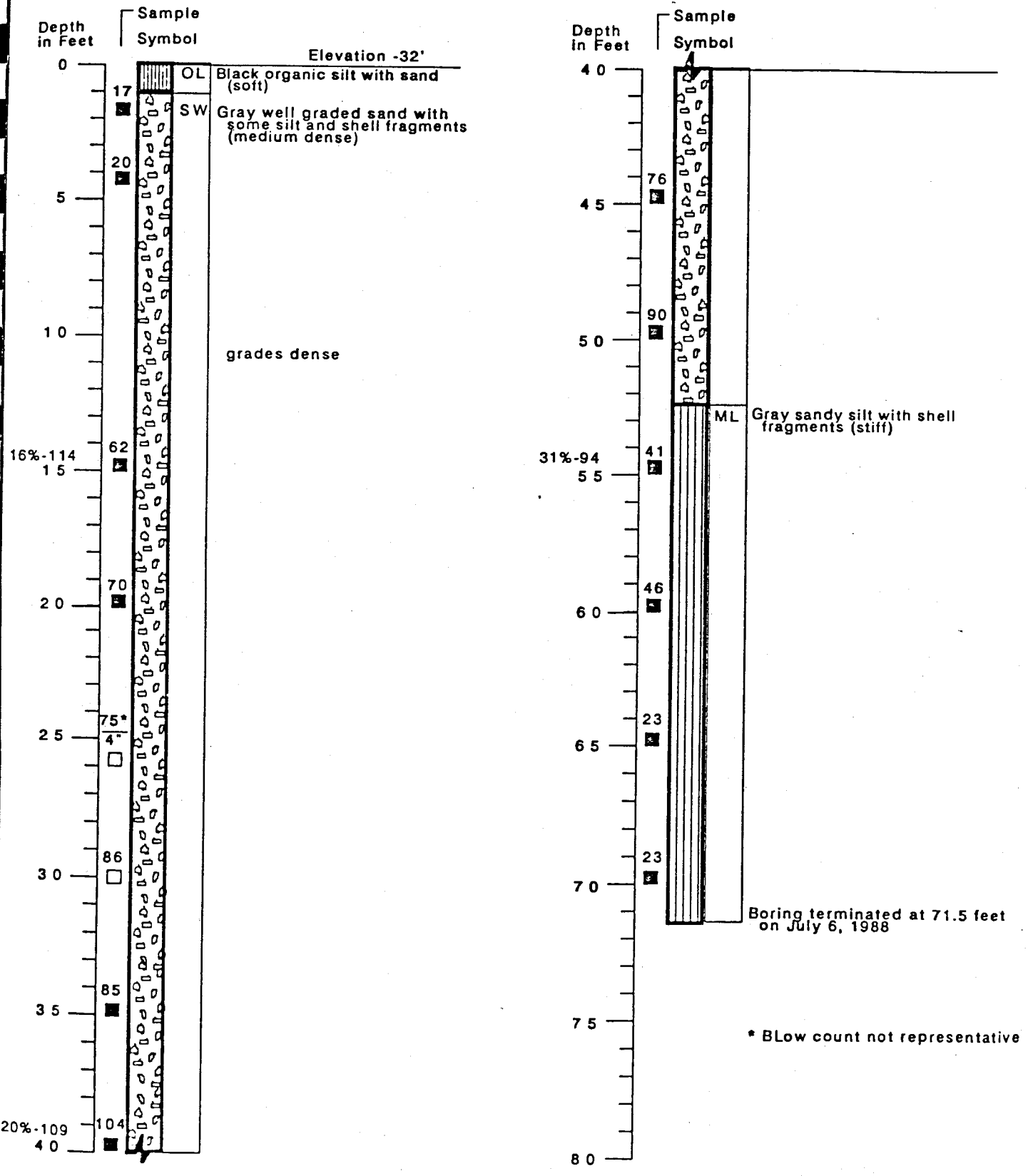
LOG OF BORINGS

Dames & Moore

Job No. 695-286

Plate A-3

Boring 88-3



Log of Borings

Dames & Moore

Job No. 17405-001-016

Plate A-3

REPLIC B
ALASKA BARGELINE

CORE DESCRIPTION

Project Name: Duwamish River SI
Project No.: 04000-019-038-5100-00
Project Location: Seattle WA
Core Method Gravity Corer (4")

Field Log by: S. Fernández	Lab Log by:	Field	Lab
Tide Level (MLLW)	Date	9/23/98	
Depth to Mud	S. Time	1230	
Mud Line Elev.	E. Time	1233	

Core Number	DR 171 (Replicate DR 171)
Drive Length, ft.	5' 3"
Recover Length, ft.	4', 7" 55"
Recovery Efficiency	87 %

DESCRIPTION OF CORE TUBES & TESTS (based on core tube lengths, feet)

Tube No. Ln, ft.	FIELD End Description	Spl No. & Test	LABORATORY Sample Description
_1	Silty CLAY, Bluish black, low plasticity, sat, no stain or odor, mottling in upper 6", wood fragments		
_2			
_3			
_4			
_5	TD 4', 7"		
_6			
_7			
_8			
_9			
_10			
_11			
_12			
_13			
_14			
_15			

(based on in-situ depths, feet)

Interpreted Summary Log (1)	Acquisition Data (2)	Blows/Ft. (3)
_1		
_2		
_3		
_4		
_5		
_6		
_7		
_8		
_9		
_10		
_11		
_12		
_13		
_14		
_15		

1. The summary log is an interpretation based on samples, blow counts, acquisition data, and interpolation. The recovery efficiency is a rough indication of the general confidence of the summary log. Variation between what is shown and actual conditions should be expected.
2. 11/9 (83%): Penetration Depth, ft./Corresponding Sample Recovery, ft. (Corresponding Total Recovery Efficiency, percent)
3. Blows/ft. are the number of hammer strikes required to drive the core tube 1 foot.

FIELD SAMPLING PLAN Expected Mudline Elev: Expected Thickness of Recent Sediment:

Tube Segment			Actual Recovery				Chain-of-Custody of Core Tube Sections Transfer Tube Sections from Field to Lab
No.	In Situ Depth	Ln.	Total % R	Core Tube Depth	Length	Segment % R	
A							Relinquished By:
B							Received By:
C							Date:
D							Time:
							Comments:

LAB: SAMPLES SELECTED FOR TESTING

SAMPLE		Sample Depth	
Number	Test	Tube	In-Situ
9839 4033	0-2		
9839 4034	2-4		

COMMENTS

95-1128.FRM

REACH C
ISAACSON CSC

CORE DESCRIPTION

Project Name: Duwamish River SI
Project No.: 04000-019-038-5100
Project Location: Seattle, WA
Core Method: Gravity Corer (4")

Field Log by: S. Fernández Lab Log by:

		Field	Lab
Tide Level (MLLW)	Date	9/23/98	
Depth to Mud	S. Time	1140	
Mud Line Elev.	E. Time	1143	

Core Number	DR 220 (replaced DR187)
Drive Length, ft.	5', 3"
Recover Length, ft.	4', 6" 54"
Recovery Efficiency	86%

DESCRIPTION OF CORE TUBES & TESTS (based on core tube lengths, feet)

Tube No. Ln, ft.	FIELD End Description	Spl No. & Test	LABORATORY Sample Description
_1	Silty Clay, bluish black, sat, no stain or odor, low plasticity, no things on top 6". wood frags.		
_2			
_3			
_4			
_5	TD - 4', 6"		
_6			
_7			
_8			
_9			
_10			
_11			
_12			
_13			
_14			
_15			

(based on in-situ depths, feet)

Interpreted Summary Log (1)	Acquisition Data (2)	Blows/FL (3)
_1		
_2		
_3		
_4		
_5		
_6		
_7		
_8		
_9		
_10		
_11		
_12		
_13		
_14		
_15		

1. The summary log is an interpretation based on samples, blow counts, acquisition data, and interpolation. The recovery efficiency is a rough indication of the general confidence of the summary log. Variation between what is shown and actual conditions should be expected.
2. 11/9 (83%): Penetration Depth, ft./Corresponding Sample Recovery, ft. (Corresponding Total Recovery Efficiency, percent)
3. Blows/ft. are the number of hammer strikes required to drive the core tube 1 foot.

FIELD SAMPLING PLAN

Expected Mudline Elev:

Expected Thickness of Recent Sediment:

Tube Segment No.	Tube Segment *In Situ* Depth	Tube Segment Ln.	Actual Recovery Total % R	Actual Recovery Core Tube Depth	Actual Recovery Length	Actual Recovery Segment % R	Chain-of-Custody of Core Tube Sections Transfer Tube Sections from Field to Lab
A							Relinquished By:
B							Received By:
C							Date:
D							Time:
							Comments:

LAB: SAMPLES SELECTED FOR TESTING

SAMPLE Number	SAMPLE Test	Sample Depth Tube	Sample Depth In-Situ
98394131	0-2		
98394032	2-4		

COMMENTS

95-1128.FRM

24/4E/33 F (10451)

RESOURCE PROTECTION WELL REPORT

KING CO.

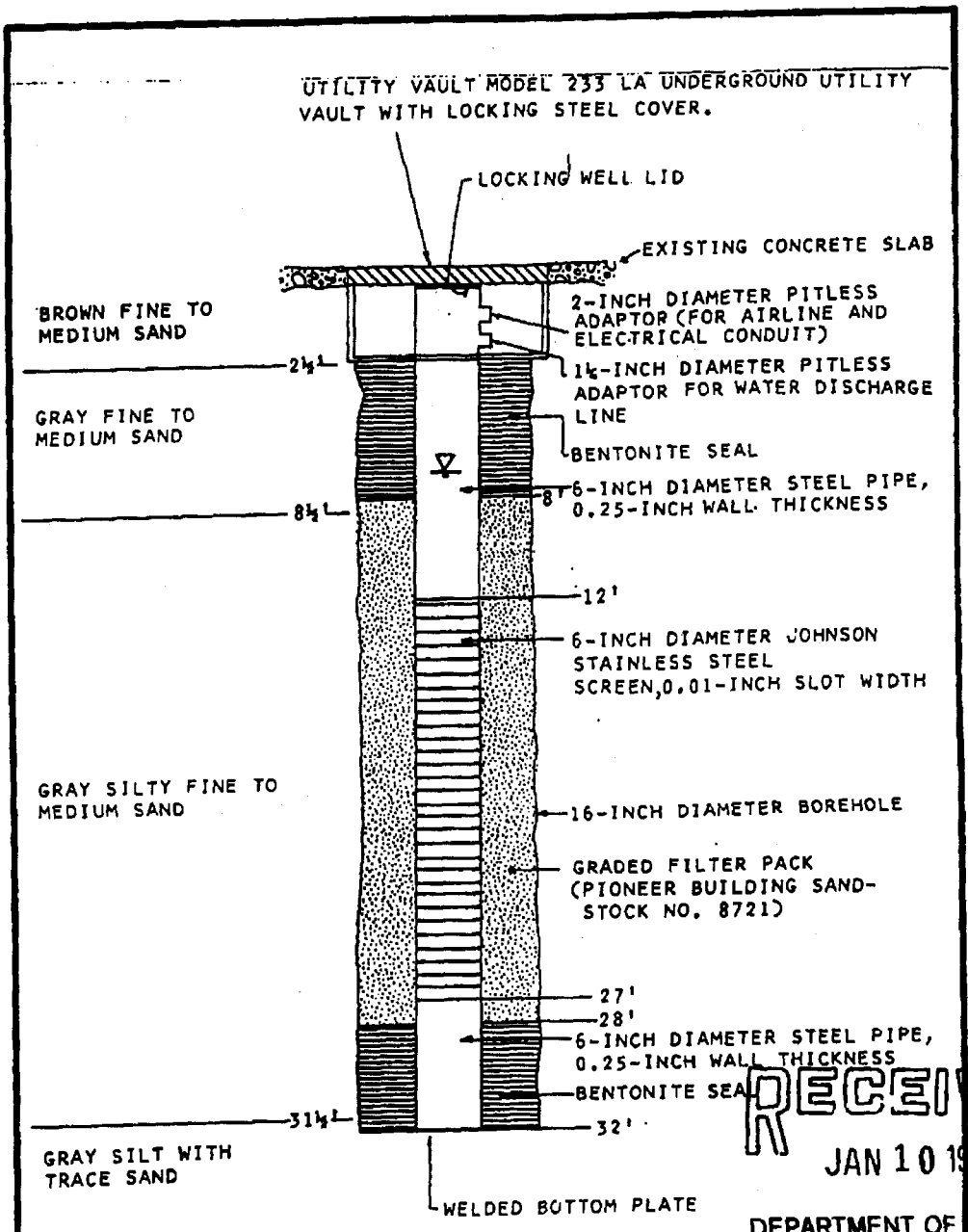
START CARD NO. 012329

PROJECT NAME: Kenworth TRUCK CO.
WELL INDENTIFICATION NO. RW-1
DRILLING METHOD: Cable Tool
DRILLER: Randy Holt
FIRM: Holt Drilling
SIGNATURE:
CONSULTING FIRM: GeoEngineers
REPRESENTATIVE: Scott Widness

LOCATION: T 24N, R 4E, SEC. 33 (E/4 SE NW) 9801 E. MARGINAL WAY SEATTLE, WA. 98108
DISTANCE: 2390 FT. (S/4) FROM N/S SECTION LINE
3280 FT. (W/4) FROM E/W SECTION LINE
DATUM: City of Seattle
WATER LEVEL ELEVATION: -3.5 ft
INSTALLED: 11/29 - 11/30/88
DEVELOPED: 12/1/88

Rev. 1-6-89 KKT
12-28-88 SEW:CJN
121-07-4

UTILITY VAULT MODEL 233 LA UNDERGROUND UTILITY VAULT WITH LOCKING STEEL COVER.



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JAN 10 1989
DEPARTMENT OF ECOLOGY
NORTHWEST REGION

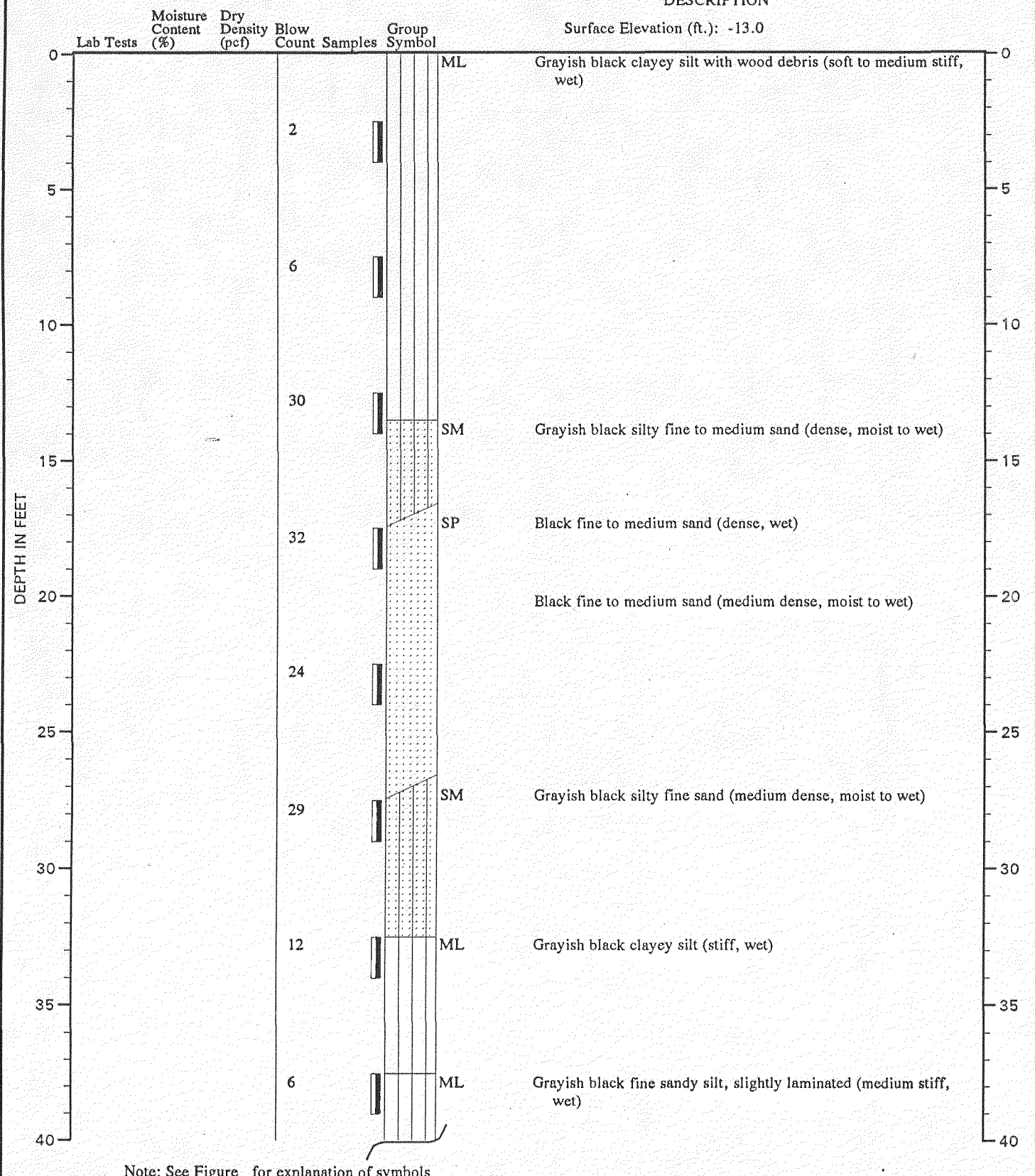
GeoEngineers

RECOVERY WELL AS BUILT

FIGURE

TEST DATA

BORING B-2



Note: See Figure for explanation of symbols

JEB:GWH:vc: 6/1/95

1092-006-T03

NB40

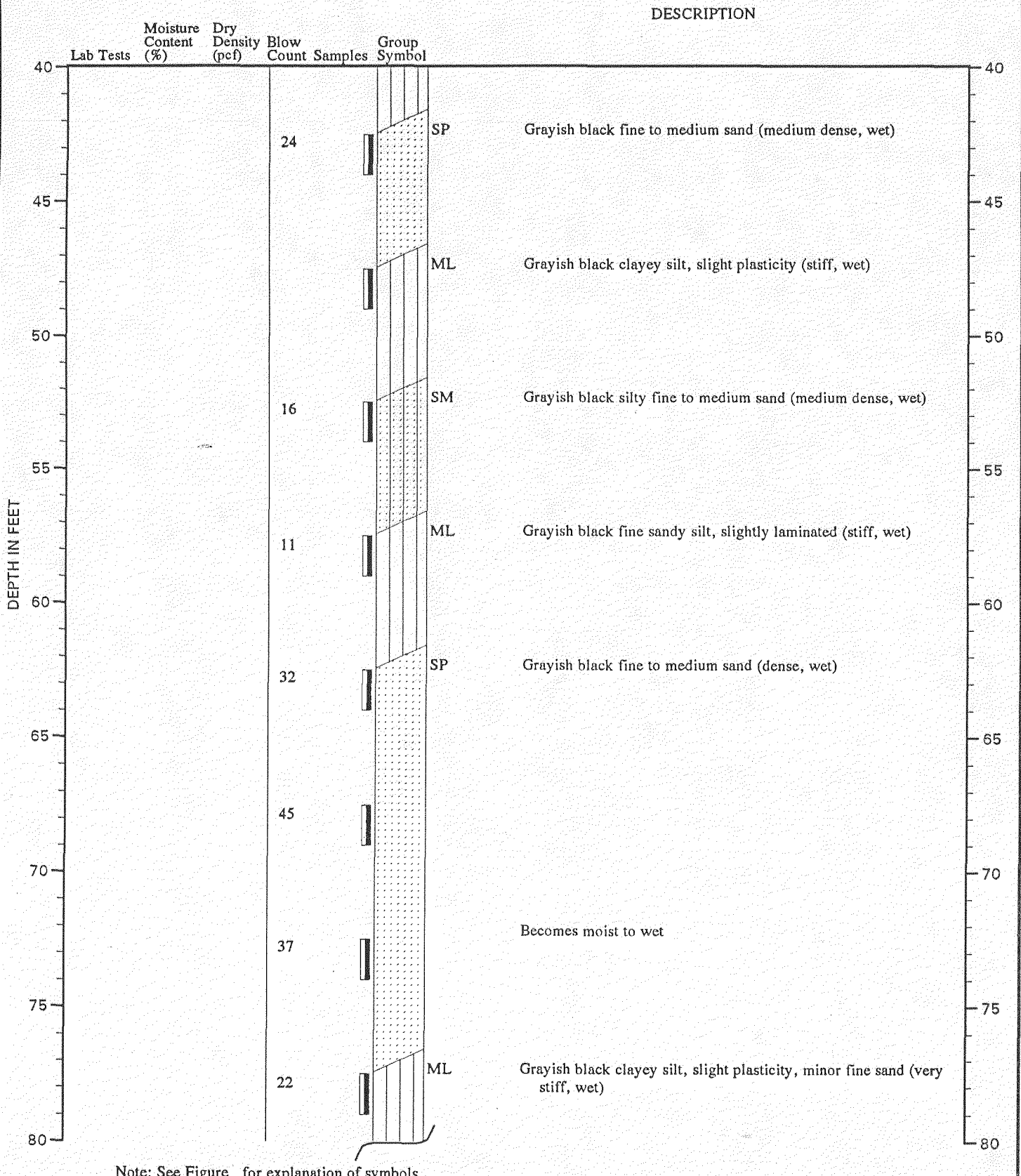
Geo Engineers

LOG OF BORING

FIGURE 4

TEST DATA

BORING B-2
(Continued)



Note: See Figure for explanation of symbols

JEB:GWH:vc: 6/1/95

1092-006-T03

NB40

GeoEngineers

LOG OF BORING

FIGURE 4

TEST DATA

BORING B-2
(Continued)

Lab Tests	Moisture Content (%)	Dry Density (pcf)	Blow Count	Samples	Group Symbol	DESCRIPTION
			38		SP	Grayish black fine to medium sand (dense, moist to wet)
						Boring completed at a depth of 84.0 feet on 05/03/95
						Ground water encountered at a depth of approximately 12.5 feet during drilling

DEPTH IN FEET

80 85 90 95 100 105 110 115 120

Note: See Figure for explanation of symbols

JEB:GWH:vc: 6/1/95

1092-006-T03

NB40

Geo Engineers

LOG OF BORING

FIGURE 4

SUMMARY: BORING NO. D-438

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED ARE A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DATE DRILLED: 1/30/85

APPROX. ELEV. (MSL)	DEPTH (FT.)	SAMPLE TYPE	SAMPLE NO.	GRAPHIC SYMBOL	PIEZOMETER	BLOWS/6 IN	LAB TESTS	DRY DENSITY	MOISTURE	ATTERBERG LIMITS
40		SPT	12		GLACIAL LACUSTRINE DEPOSITS CLAYEY SILT		100			
					TOTAL DEPTH, 40.5 FEET.					
					PIEZOMETER: THREE QUARTER INCH DIAMETER PVC. SCREEN DEPTH: 5 TO 20 FEET. SEAL DEPTH: 1 TO 5 FEET.					
45										
-30										

SAMPLE TYPES

- B GRAB SAMPLE - HAND COLLECTED FROM AUGER OR BIT
- M BARGER SAMPLE - MIXED AND HAND COLLECTED
- C CUTTING SAMPLE - HAND COLLECTED FROM DRILL FLUID RETURN
- RD 3"O.D. SPLIT BARREL RING SAMPLER - DRIVEN WITH 300 LB. DOWN HOLE SLIP-JAR HAMMER
- SPT 2"O.D. SPLIT SPOON SAMPLER - DRIVEN WITH 140 LB. SURFACE HAMMER WITH 30" DROP
- BS SPT, EXCEPT DRIVEN WITH 300 LB. DOWN HOLE SLIP-JAR HAMMER WITH 18" DROP
- P PITCHER SAMPLER - 3"O.D. THIN WALLED SHELBY TUBE PUSHED WITH ROTATING CUTTING BARREL
- SH 3"O.D. THIN WALLED SHELBY TUBE - PUSHED WITH HYDRAULICS

MOISTURE CONTENT - PERCENT OF DRY WEIGHT
DRY DENSITY - POUNDS PER CUBIC FOOT

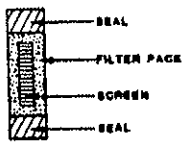
LABORATORY TESTS

- G GRAIN SIZE DISTRIBUTION
- A ATTERBERG LIMITS
- V MINI VANE SHEAR
- C CONSOLIDATION
- UU UNCONSOLIDATED-UNDRAINED TRIAXIAL
- CU CONSOLIDATED-UNDRAINED TRIAXIAL
- PP POCKET PENETROMETER
- T PETROGRAPHIC THIN SECTION

ATTERBERG LIMITS

- LL LIQUID LIMIT
- PL PLASTIC LIMIT
- PI PLASTICITY INDEX

PIEZOMETER DETAIL



SAMPLE DETAIL

RENTON EFFLUENT TRANSFER SYSTEM DUWAMISH ALIGNMENT
King County, Washington
for METRO

Project No. 275-05G

Drawing No. A-24

GEO/RESOURCE CONSULTANTS, INC.
Geologists/Geophysicists/Geotechnical Engineers

1116

SUMMARY: BORING NO. D-440

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED ARE A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DATE DRILLED: 3/11/85

APPROX. ELEV. (MSL)	DEPTH (FT.)	SAMPLE TYPE	SAMPLE NO.	GRAPHIC SYMBOL		PIEZOMETER	BLOWS/6 IN	LAB TESTS	MOISTURE DRY DENSITY	ATTERBERG LIMITS
18	0									
		B	1		FILL SILTY SAND (LOOSE)			G	6%	
					LIGHT GRAY; FINE TO COARSE; LITTLE TO SOME FINE GRAVEL, ANGULAR; NO BEDDING EVIDENT; MOIST; (SM).					
					SCATTERED WOOD DEBRIS.					
	5	RD	2		CLAYEY SILT (FIRM)		7 11 12			
					OLIVE GRAY; TRACE TO LITTLE FINE SAND; SCATTERED WOOD FIBERS; NO BEDDING EVIDENT; (ML).					
		SPT	3				4 3 3	G	27%	
	10				SOME FINE TO MEDIUM SAND.	4/18/85				
		RD	4		ALLUVIUM SAND (LOOSE)	7/1/85	2 3 5			
					DARK BROWN; FINE TO MEDIUM; LITTLE SILT; SCATTERED WOOD FIBERS AND PIECES; NO BEDDING EVIDENT; WET; (SM).					
		SPT	5				21 14 14			
					SAMPLE 5; DRIVEN ON WOOD PIECE.					
	15	RD	6		ESTUARINE DEPOSITS SAND AND SILT (LOOSE)		3 3 3		22% 99	
					GRAY; FINE SAND; SCATTERED FINE TO COARSE GRAVEL, ROUNDED; SCATTERED SHELL FRAGMENTS AND BRANCHES; NO BEDDING EVIDENT; (SP–ML).					
		SPT	7		SILT AND SAND (LOOSE)		2 3 3	G	30%	
0					GRAY; FINE SAND, TRACE MEDIUM TO COARSE; TRACE FINE GRAVEL; SCATTERED SHELL FRAGMENTS; NO BEDDING EVIDENT; (ML–SP).					
	20				(CONTINUED)					

SAMPLE TYPES

- S GRAB SAMPLE – HAND COLLECTED FROM AUGER OR BIT
- M SAMPLER SAMPLE – MIXED AND HAND COLLECTED
- C CUTTING SAMPLE – HAND COLLECTED FROM DRILL FLUID RETURN
- RD 4"O.D. SPLIT BARREL RING SAMPLER – DRIVEN WITH 300 LB. DOWN HOLE SLIP-JAR HAMMER WITH 30" DROP
- SPT 2"O.D. SPLIT SPOON SAMPLER – DRIVEN WITH 140 LB. SURFACE HAMMER WITH 30" DROP
- SS SPT, EXCEPT DRIVEN WITH 300 LB. DOWN HOLE SLIP-JAR HAMMER WITH 18" DROP
- P PITCHER SAMPLER – 3"O.D. THIN WALLED SHELBY TUBE PUSHED WITH ROTATING CUTTING BARREL
- SH 3"O.D. THIN WALLED SHELBY TUBE – PUSHED WITH HYDRAULICS

MOISTURE CONTENT – PERCENT OF DRY WEIGHT
DRY DENSITY – POUNDS PER CUBIC FOOT

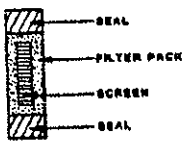
LABORATORY TESTS

- G GRAIN SIZE DISTRIBUTION
- A ATTERBERG LIMITS
- V MINI VANE SHEAR
- C CONSOLIDATION
- UU UNCONSOLIDATED-UNDRAINED TRIAXIAL
- CU CONSOLIDATED-UNDRAINED TRIAXIAL
- PP POCKET PENETROMETER
- T PETROGRAPHIC THIN SECTION

ATTERBERG LIMITS

- LL LIQUID LIMIT
- PL PLASTIC LIMIT
- PI PLASTICITY INDEX

PIEZOMETER DETAIL



SAMPLE DETAIL

RENTON EFFLUENT TRANSFER SYSTEM DUWAMISH ALIGNMENT
King County, Washington
for METRO

Project No. 275-05G

Drawing No. A-25

GEO/RESOURCE CONSULTANTS, INC.
Geologists/Geophysicists/Geotechnical Engineers

1126

SUMMARY: BORING NO. D-440

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED ARE A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DATE DRILLED: 3/11/85

APPROX. ELEV. (MSL)	DEPTH (FT.)	SAMPLE TYPE	SAMPLE NO.	GRAPHIC SYMBOL	PIEZOMETER	BLOWS/6 IN	LAB TESTS	DRY DENSITY	MOISTURE	ATTERBERG LIMITS
20		RD	8			4 82				
				ESTUARINE DEPOSITS SILT AND SAND (LOOSE) — SCATTERED SHELL FRAGMENTS AND BRANCHES.						
				GLACIAL LACUSTRINE DEPOSITS CLAYEY SILT (VERY HARD) — GRAY; TRACE FINE SAND; SCATTERED FINE TO COARSE GRAVEL, ROUNDED; NO BEDDING EVIDENT; (CL).						
		RD	9			45 30 50		109	21%	LL 34 PL 20 PI 14
25				TRACE FINE TO COARSE GRAVEL, ROUNDED.						
						50				
-10		SPT	10	SCATTERED FINE TO COARSE GRAVEL, ROUNDED.		50/5"				
30										
		RD	11	TRACE FINE TO COARSE SAND; SCATTERED FINE GRAVEL, ROUNDED.		27 45				
-20										
				(CONTINUED)						
40										

SAMPLE TYPES

- G — GRAB SAMPLE - HAND COLLECTED FROM AUGER OR SIT
- M — BAILER SAMPLE - MIXED AND HAND COLLECTED
- C — CUTTING SAMPLE - HAND COLLECTED FROM DRILL FLUID RETURN
- RD — 3"O.D. SPLIT BARREL RING SAMPLER - DRIVEN WITH 300 LB. DOWN HOLE SLIP-JAR HAMMER
- SPT — 2"O.D. SPLIT SPOON SAMPLER - DRIVEN WITH 140 LB. SURFACE HAMMER WITH 30" DROP
- SS — SPT, EXCEPT DRIVEN WITH 300 LB. DOWN HOLE SLIP-JAR HAMMER WITH 18" DROP
- P — PITCHER SAMPLER - 3"O.D. THIN WALLED SHELBY TUBE PUSHED WITH ROTATING CUTTING BARREL
- SH — 3"O.D. THIN WALLED SHELBY TUBE - PUSHED WITH HYDRAULICS

MOISTURE CONTENT - PERCENT OF DRY WEIGHT
DRY DENSITY - POUNDS PER CUBIC FOOT

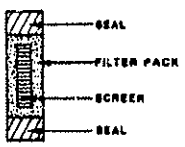
LABORATORY TESTS

- G — GRAIN SIZE DISTRIBUTION
- A — ATTERBERG LIMITS
- V — MINI VANE SHEAR
- C — CONSOLIDATION
- UU — UNCONSOLIDATED-UNDRAINED TRIAXIAL
- CU — CONSOLIDATED-UNDRAINED TRIAXIAL
- PP — POCKET PENETROMETER
- T — PETROGRAPHIC THIN SECTION

ATTERBERG LIMITS

- LL — LIQUID LIMIT
- PL — PLASTIC LIMIT
- PI — PLASTICITY INDEX

PIEZOMETER DETAIL



SAMPLE DETAIL

RENTON EFFLUENT TRANSFER SYSTEM DUWAMISH ALIGNMENT
King County, Washington
for METRO

Project No. 275-05G

GEO/RESOURCE CONSULTANTS, INC.
Geologists/Geophysicists/Geotechnical Engineers

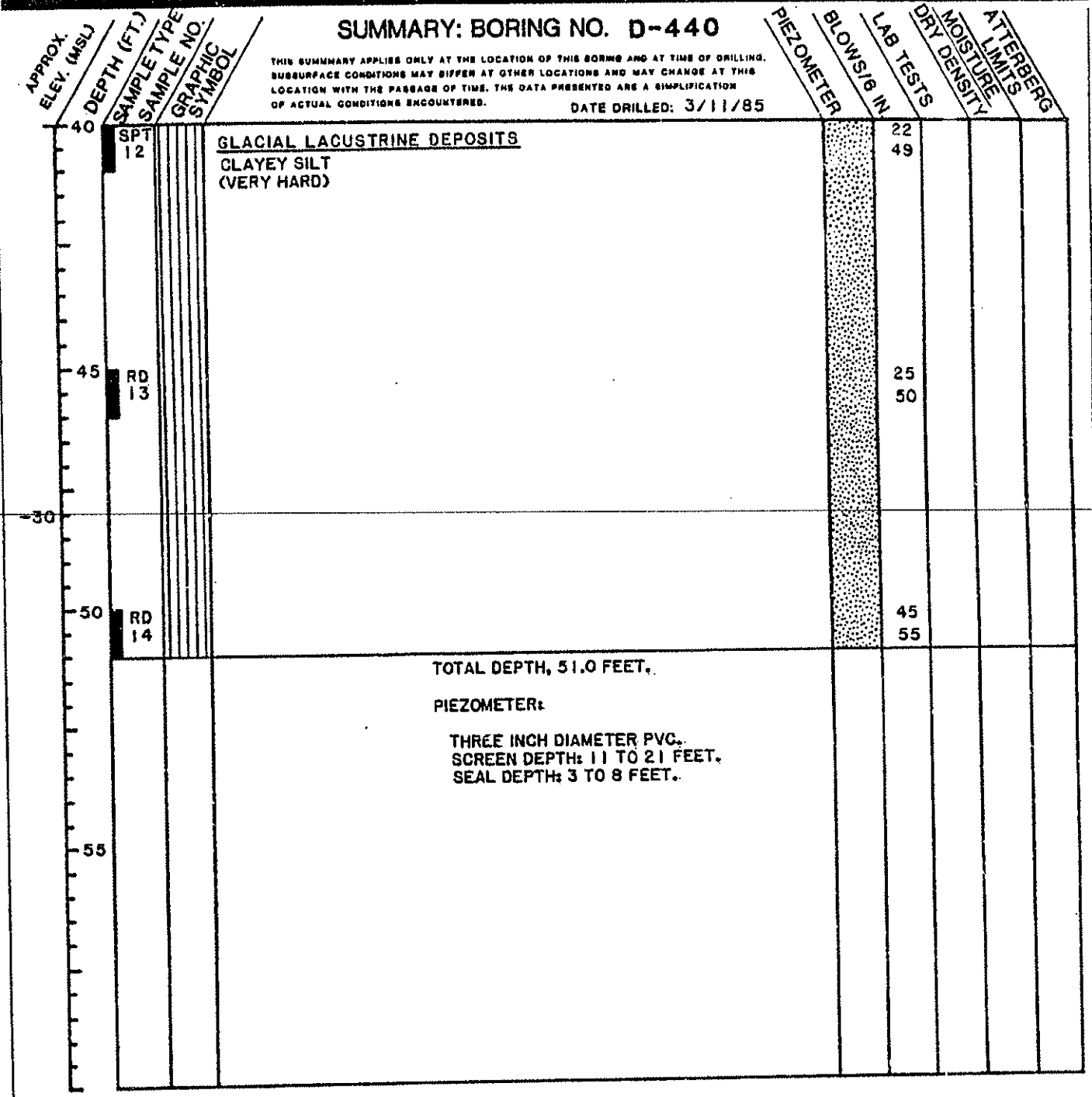
11117

Drawing No. A-26

SUMMARY: BORING NO. D-440

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED ARE A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DATE DRILLED: 3/11/85



SAMPLE TYPES

B	GRAB SAMPLE - HAND COLLECTED FROM AUGER OR BIT
M	BAILER SAMPLE - MIXED AND HAND COLLECTED
C	CUTTING SAMPLE - HAND COLLECTED FROM DRILL FLUID RETURN
RD	3"O.D. SPLIT BARREL RING SAMPLER - DRIVEN WITH 300 LB. DOWN HOLE SLIP-JAR HAMMER
SPT	2"O.D. SPLIT SPOON SAMPLER - DRIVEN WITH 140 LB. SURFACE HAMMER WITH 30" DROP
SS	SPT, EXCEPT DRIVEN WITH 300 LB. DOWN HOLE SLIP-JAR HAMMER WITH 18" DROP
P	PITCHER SAMPLER - 3"O.D. THIN WALLED SHELBY TUBE PUSHED WITH ROTATING CUTTING BARREL
SH	3"O.D. THIN WALLED SHELBY TUBE - PUSHED WITH HYDRAULICS

MOISTURE CONTENT - PERCENT OF DRY WEIGHT
DRY DENSITY - POUNDS PER CUBIC FOOT

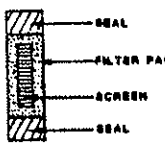
LABORATORY TESTS

G	GRAIN SIZE DISTRIBUTION
A	ATTERBERG LIMITS
V	MINI VANE SHEAR
C	CONSOLIDATION
UU	UNCONSOLIDATED-UNDRAINED TRIAXIAL
CU	CONSOLIDATED-UNDRAINED TRIAXIAL
PP	POCKET PENETROMETER
T	PETROGRAPHIC THIN SECTION

ATTERBERG LIMITS

LL	LIQUID LIMIT
PL	PLASTIC LIMIT
PI	PLASTICITY INDEX

PIEZOMETER DETAIL



SAMPLE DETAIL

RENTON EFFLUENT TRANSFER SYSTEM DUWAMISH ALIGNMENT
King County, Washington
for METRO

Project No.
275-05G

Drawing No.
A-27

GEO/RESOURCE CONSULTANTS, INC.
Geologists/Geophysicists/Geotechnical Engineers

PROJECT: ECLIPSE/DUWAMISH CROSSING/WA

RECORD OF BOREHOLE: DB-1

SHEET 1 OF 3

DATUM: MSL

PROJECT NUMBER: 973-1047.100

BORING LOCATION: North Side of the Duwamish

BORING DATE: 2 / 28 / 97

DEPTH FEET	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH	SAMPLES NUMBER	TYPE	BLOWS / 6 IN. 140 lb. hammer 30 inch drop	N	REC/ATT	PENETRATION RESISTANCE BLOWS/FT. ■ 0 10 20 30 40 50	WATER CONTENT, PERCENT Wp W Wl	PIEZOMETER GRAPHIC / WATER LEVEL
0					10.0								
		Loose to very loose, dark brown to grayish brown, non-stratified, mottled, fine to coarse SAND trace to some silt, damp to moist (FILL)	SW		0.0								
					6.5								
			SW		3.5	1	SS	2-1-3	4	1/1.5	■		
5					5.0								
					5.0								
		Very loose, medium gray to brownish gray, stratified, silty, fine SAND and fine sandy SILT, slight FeOx staining, grades down to grayish brown, massive, SAND, trace silt (ALLUVIUM)			1.5								
			SM ~ ML		8.5		SS	1-1-2	3	0	■		▼ ATD
					0.0								
10					10.0	2	SS	1-2-1	3	1.5 / 1.5	■		
					-1.5								
					11.5								
					-3.5								
			SW		13.5	3	SS	1-1-1	2	1.5 / 1.5	■	G ○	
					-5.0								
15		Very loose, dark brown, fine to medium SAND and ORGANICS (woody detrius) little silt, moist (ALLUVIUM)			15.0								
			SP-SM										
					-8.5								
			SP		18.5	4	SS	6-15-42	57	1.5 / 1.5			■+
					-10.0								
20		Compact to dense, brownish gray to dark grayish brown, massive to faintly bedded, fine to medium SAND, trace to little silt in lenses, trace organics, wet, trace silt lens (ALLUVIUM)	SW		20.0								
					-13.5								
					23.5	5	SS	3-8-7	13	1.1 / 1.5		■	
					-15.0								
25					25.0								
					-18.5								
					28.5	6	SS	4-6-9	15	1.0 / 1.5		■ G ○	
					-20.0								
30					30.0								

Log continued on next page

DRILL RIG: Mobile B-59

DRILLING CONTRACTOR: Holt

DRILLER: F. Bennett

LOGGED: Mocker

CHECKED: JDC

DATE: 3/4/97

Golder Associates

PROJECT: ECLIPSE/DUWAMISH CROSSING/WA

RECORD OF BOREHOLE: DB-1

SHEET 2 OF 3

DATUM: MSL

PROJECT NUMBER: 973-1047.100

BORING LOCATION: North side of the Duwamish

BORING DATE: 2 / 28 / 97

DEPTH FEET	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH	SAMPLES NUMBER	TYPE	BLOWS / 6 IN. 140 lb. hammer 30 inch drop	N	REC/ATT	PENETRATION RESISTANCE BLOWS/FT ■ (0, 10, 20, 30, 40, 50) / WATER CONTENT, PERCENT (Wp — W — Wl)	PIEZOMETER GRAPHIC / WATER LEVEL
30					-20.0							
		Compact to dense, brownish gray to dark grayish brown, massive to faintly bedded, fine to medium SAND, trace to little silt in lenses, trace organics, wet, trace silt lens (ALLUVIUM)	SW		30.0							
					-23.5							
					33.5	7	SS	4-8-11	19	1.3 / 1.5	■	
35					-25.0							
					35.0							
					-28.5							
					38.5	8	SS	2-18-23	41	1.3 / 1.5	■	
					-30.0							
40					40.0							
					-33.5							
					43.5	9	SS	11-15-17	32	1.2 / 1.5	■	
					-35.0							
45					45.0							
					-38.5							
					48.5	10	SS	3-2-11	13	1.3 / 1.5	■	
					-40.0							
50					50.0							
					-43.5							
					53.5	11	SS	6-10-13	23	1.5 / 1.5	■	
					-45.0							
55					55.0							
					-48.5							
					58.5	12	SS	12-14-16	30	1.5 / 1.5	■	
					-50.0							
60		Log continued on next page			60.0							

DRILL RIG: Mobile B-59

DRILLING CONTRACTOR: Holt

DRILLER: F. Bennett

LOGGED: Mocker

CHECKED: JDC

DATE: 3/4/97

Golder Associates

PROJECT: ECLIPSE/DUWAMISH CROSSING/WA

RECORD OF BOREHOLE: DB-1

SHEET 3 OF 3

DATUM: MSL

PROJECT NUMBER: 973-1047.100

BORING LOCATION: North side of the Duwamish

BORING DATE: 2 / 28 / 97

DEPTH FEET	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH	SAMPLES NUMBER	TYPE	BLOWS / 6 IN. 140 lb. hammer 30 inch drop	N	REC/ATT	PENETRATION RESISTANCE BLOWS/FT. ■ (0, 10, 20, 30, 40, 50) / WATER CONTENT, PERCENT Wp, W, Wl	PIEZOMETER GRAPHIC / WATER LEVEL
					-50.0							
60		Compact to dense, brownish gray to dark grayish brown, massive to faintly bedded, fine to medium SAND, trace to little SILT, trace organics, wet, trace silt lens (ALLUVIUM)	SW		60.0							
					-53.5							
					63.5	13	SS	9-14-17	31	1.3 / 1.5		
65					-55.0							
					65.0							
					-58.5							
					68.5	14	SS	15-19-22	41	1.2 / 1.5		
					-60.0							
70					70.0							
					-63.5							
		blow count overstated			73.5	15	SS	15-28-26	54	1.2 / 1.5		
					-65.0							
75					75.0							
					-68.5							
					78.5	16	SS	11-8-20	28	1.2 / 1.5		
					-70.0							
80		Total Depth 80' below ground surface			80.0							
85												
90												

DRILL RIG: Mobile B-59

DRILLING CONTRACTOR: Holt

DRILLER: F. Bennett

LOGGED: Mocker

CHECKED: JDC

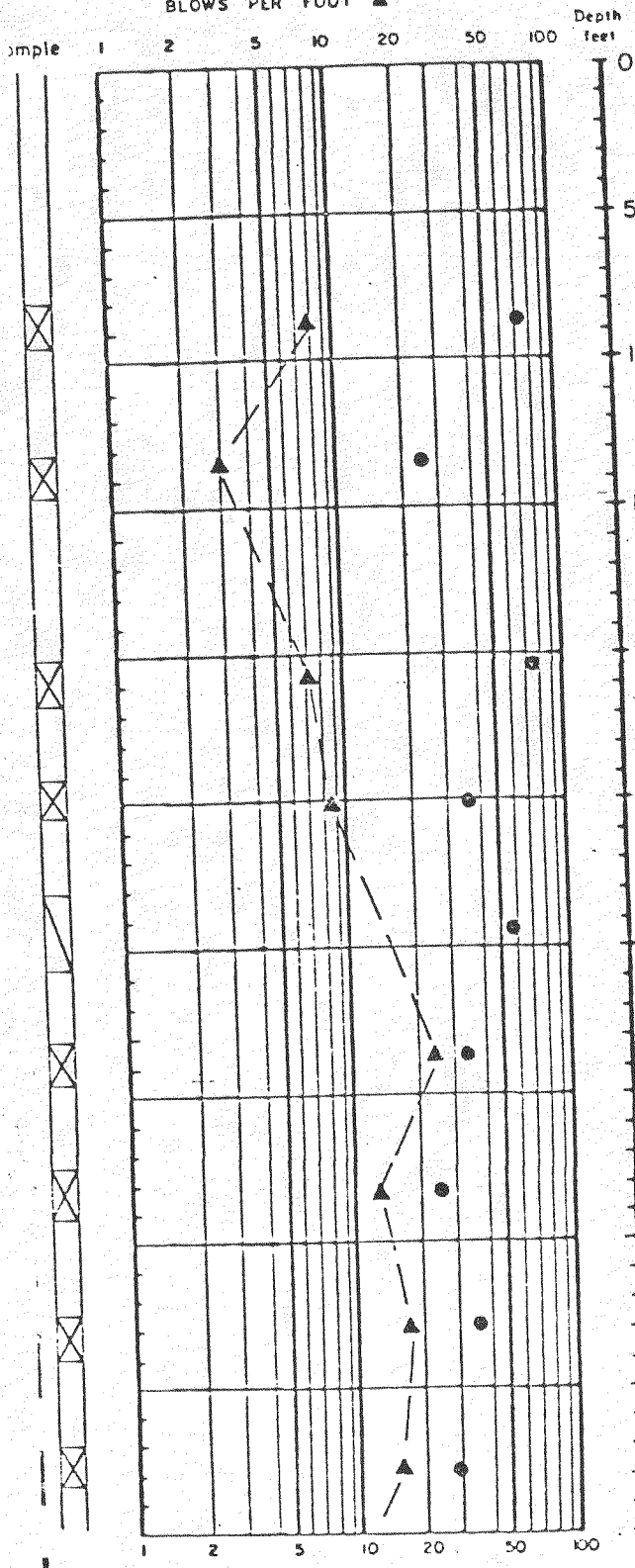
DATE: 3/4/97

Golder Associates

STANDARD PENETRATION RESISTANCE B-2

(140 pound weight, 30 inch drop)

BLOWS PER FOOT ▲



WATER CONTENT

PERCENT ●

SOIL INTERPRETATION

MUDLINE 29.4 FEET BELOW WATER SURFACE

SOFT SATURATED BLACK CLAYEY SILT TO SILTY CLAY WITH TRACE OF ORGANICS.

SOFT TO MEDIUM STIFF, SATURATED GRAYISH-BLACK SLIGHTLY CLAYEY FINE SANDY SILT TO SILTY FINE SAND WITH OCCASIONAL THIN SILT LAYERS AND TRACES OF ORGANICS.

INTERBEDDED LAYERS OF BLACK ORGANIC SILT.

MEDIUM DENSE TO DENSE SATURATED GRAYISH-BLACK TO BLACKISH-GRAY SILTY FINE SAND TO FINE SANDY SILT WITH FEW THIN SILT AND FINE SAND LAYERS.

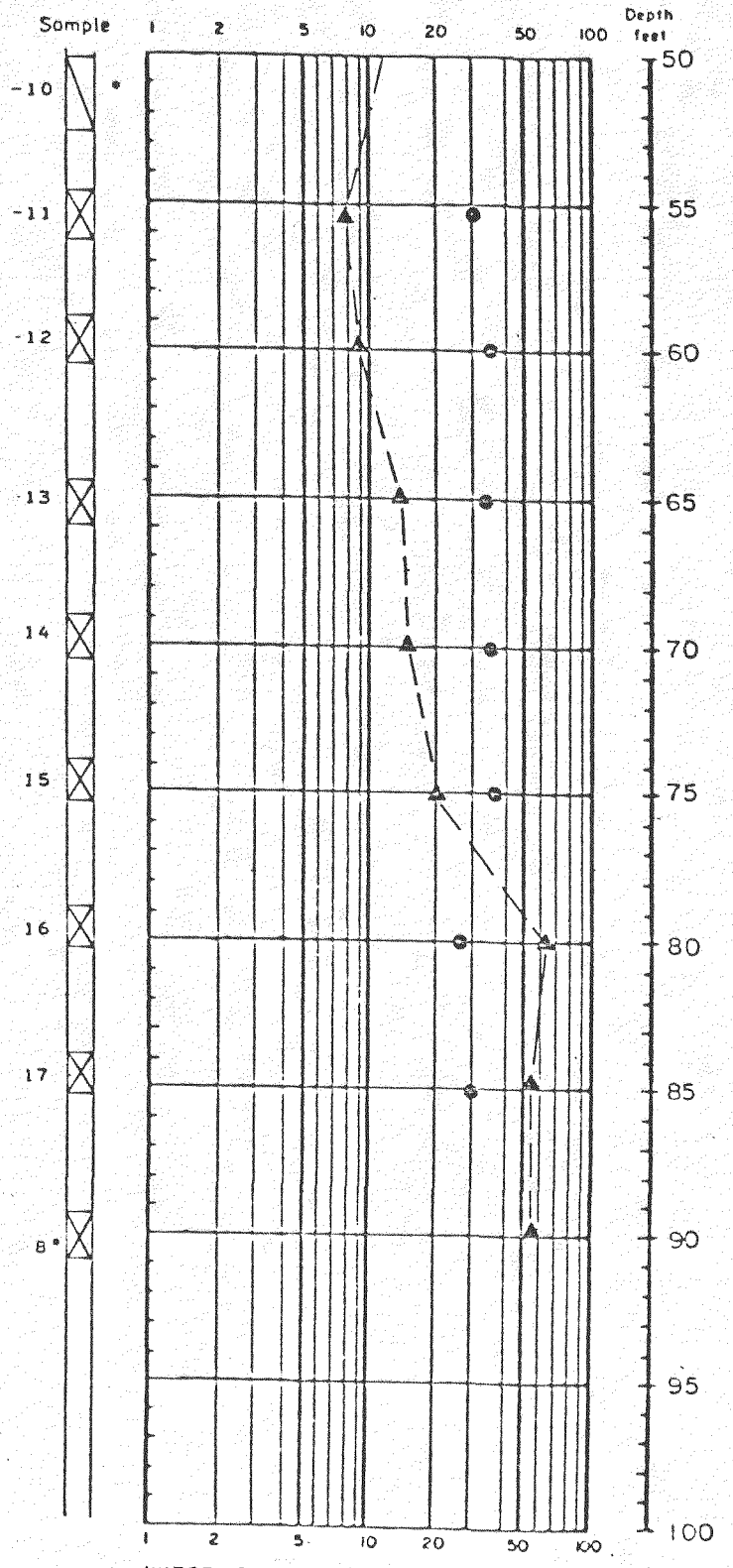
LEGEND

- 2" O.D. Split Spoon Sample
- 3" O.D. Shelby Sample
- ★ No Sample Recovery
- ▽ Water Level
- Observation Well

NOTE: Soil descriptions are interpretive and actual changes may be gradual.

B-2 (cont)

STANDARD PENETRATION RESISTANCE
(140 pound weight, 30 inch drop)
BLOWS PER FOOT ▲



SOIL INTERPRETATION

SAME

VERY DENSE, MOIST TO WET BLACKISH GRAY SLIGHTLY SILTY FINE SAND.

BOTTOM AT 90.9 FEET BELOW MUDLINE.
COMPLETED 3/11/79

LEGEND

- 2" OD Split Spoon Sample
- 3" OD Shelby Sample
- ★ No Sample Recovery
- Water Level
- Observation Well

NOTE: Soil descriptions are interpretive and actual changes may be gradual

J-788 April 1979
HART-CROWSER & associates inc.
Figure A-14

Boring

Sediment Core Log

LDW-SC-1 (R2)

Sheet 1 of 1

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **8.1**	Penetration Depth (ft): **6.6**
Client: **LDWG**	Water Depth (ft): **25.3**	Sample Quality: **Good**
Collection Date: **2/8/06**	Mudline Elevation (ft): **-15.7**	Recovery in ft (%): **6.0 (91)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **211282** E./LONG: **1266316**	Process Date: **2/9/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC1-0-2		PCB SVOC Metals TBT Hg	0	ML: (0.0-0.2) wet, soft, greenish gray (GLEY 1, 5/10 Y), SILT, little sand, moderate shell fragments, and trace twigs and rootlets.	@ 0.2' TV = 0.6 kg/cm2	recent
1					MH: (0.2-1.3) moist, medium soft, black (GLEY1 2.5N) SILT, few sand, trace wood, and rootlets. Very slight H2S-like odor. @ 0.6' 1/2" gray CLAY seam @ 0.7' piece of bark 3" x 1.5" L @ 0.9-1.1' Layer of wet, medium dense, gray (GLEY1 4/N) fine SAND, few silt. Sand grains are multicolored (black and white).	Transitional Contact GT @ 1.6'	
2	LDW-SC1-2-4	97% (0-3)	PCB SVOC Metals TBT Hg	0	MH: (1.3-2.8) moist, medium stiff, black (GLEY1 2.5/N) SILT and scattered wood fragments. Moderate H2S-like odor. @ 1.6' trace shells	@1.9' TV = 0.5 kg/cm2	upper alluvium
3					SM: (2.8-6.6) moist, medium dense, very dark gray (GLEY1 3/N) fine to medium SAND, few silt. Sand grains are multicolored (orange, red, white) and grade to medium to coarse @ 4.9'.	Sharp Contact GT @ 3.1'	
4	LDW-SC1-4-6	100% (3-5)			@ 3.4' 1/2" round clay pocket @ 3.8' grades to trace silt	@ 3.6' TV = 0.7 kg/cm2	lower alluvium
5		89% (5-6.6)	PCB	0		Below 4.6' core is slightly winnowed (~5%) from edge of tube @ 5.1' TV = 0.5 kg/cm2	
6					End of core at 6.0' . Driven to refusal.		

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Remarks: **Drive Notes: slowed (6.2-3.4'), refusal (6.6').**
Two drive attempts made at station.

Calculated Recovery
Sample Length/Penetration Length:
6.0 / 6.6 = 91 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-2 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **7.4**	Penetration Depth (ft): **13.1**
Client: **LDWG**	Water Depth (ft): **31.4**	Sample Quality: **Good**
Collection Date: **2/9/06**	Mudline Elevation (ft): **-23.7**	Recovery in ft (%): **13.1 (100)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **211196** E./LONG: **1267032**	Process Date: **2/9/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher, A. Fitzpatrick**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC2-0-2	47% (0-1)	PCB SVOC Metals Hg Pesticides	0	SM: (0.0-1.2) wet, loose, black (GLEY 1, 2.5/N) SAND, little silt.		recent
1					@ 0.7-0.9' wood fragments and subrounded gravel up to 1" L	Transitional Contact PID bag @ 0.9' = 0.0 Sheen Test @ 1.0: 50% rainbow w/ scattered 1/2" florets @ 1.5' TV = 0.3 kg/cm2	
2	LDW-SC2-2-4	100% (1-2)			OL: (1.2-2.4) wet, soft to medium stiff, light gray (2.5Y, 7/1), ORGANIC SILT, few sand and clay. Trace scattered shell fragments, moderate H2S-like odor that decreases with depth, and trace sheen. Horizontal banding of black and gray clay seams in 1/2" bands. Clay has some plasticity.	Transitional Contact	
3		100% (2-5)	PCB SVOC Metals Hg Pesticides	0	OL: (2.4-4.1) wet, medium stiff, light gray (2.5Y, 7/1), ORGANIC SILT, few clay. Silt texture is homogenous and of medium plasticity. Slight H2S-like odor and trace HC-like sheen.	GT @ 2.9' @ 3.2' TV = 0.4 kg/cm2	
4	LDW-SC2-4-6				OL: (4.1-4.3) wet, stiff, light gray (2.5Y, 7/1) CLAYEY ORGANIC SILT.	Sharp Contact	
5			PCB SVOC Metals	0	ML: (4.3-10.5) wet to moist, stiff, light gray (2.5Y, 7/1) to dark gray (2.5Y, 4/1) seams of SILT and rock flour and chunky balls of hard SILT (80% anthropogenic). Trace wood and minor sand seams with wood up to 3". Trace sheen and black streaks associated with hard silt.	Transitional Contact @ 4.3' TV =0.5 kg/cm2 GT @ 4.7' Wet test @ 5.0' = gray silt melts away when wetted- no integrity, flour/ash-like @ 5.7' TV =1.8 kg/cm2	
6	LDW-	100% (5-8)			@ 6.0' 5" L wood fragment		
				0			

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Remarks: **Drive Notes: freefall (0.5'), easy (2.2'), moderate (4.9'), hard (13.1'), penetration goal reached. One drive attempt made at station. Core catcher was intact.**

Calculated Recovery
Sample Length/Penetration Length:
13.1/ 13.1 = 100 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-2 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **7.4**	Penetration Depth (ft): **13.1**
Client: **LDWG**	Water Depth (ft): **31.4**	Sample Quality: **Good**
Collection Date: **2/9/06**	Mudline Elevation (ft): **-23.7**	Recovery in ft (%): **13.1 (100)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **211196** E./LONG: **1267032**	Process Date: **2/9/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83** N Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher, A. Fitzpatrick**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth; (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	SC2-6-8					@ 7.4' TV = 0.5 kg/cm2	non-native
8	LDW-SC2-8-10	100% (8-9)		0	@ 8.4' 1" layer of black SILT and shell fragments	Sharp Moisture Contact Core catcher is wedged @ 8.4 to 9.0'	8
9					@ 9.0' Grades to damp, medium stiff SILT and hard SILT chunks banded in 1 to 3" layers. Trace HC-like sheen in softer SILT.	@ 9.5' TV =3.5 kg/cm2	9
10	10-10.7	92% (9-10.6)		0		@ 10.5' TV =2.0 kg/cm2	10
11	LDW-SC2-10.7-12	80% (10.6-11.6)	PCB SVOC Metals	0	SM: (10.5-12.0) damp, dense, very dark greenish gray (GLEY 1, 3/5GY), medium to fine SAND, trace multicolored grains (orange, red, gray, white).	Sharp Contact @ 11.5' TV =1.0 kg/cm2	lower alluvium 11
12	LDW-SC2-12-13.1	75% (11.6-12)		0	SM: (12-13.1) damp, dense, very dark greenish gray (GLEY 1, 3/5GY), fine SAND with 1/2" brown SILT seams. Distinct horizontal layers, scattered rootlets, and 1/2"L wood fragment.	Transitional Contact	12
13		100% (12-13)			Bottom 6" is very fine SAND, few silt in core shoe.		13
					End of core at 13.1'.		

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Remarks: **Drive Notes: freefall (0.5'), easy (2.2'), moderate (4.9'), hard (13.1'), penetration goal reached. One drive attempt made at station. Core catcher was intact.**

Calculated Recovery
Sample Length/Penetration Length:
13.1/ 13.1 = 100 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-3 (R1)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **7.9**	Penetration Depth (ft): **8.5**
Client: **LDWG**	Water Depth (ft): **57.0**	Sample Quality: **Good**
Collection Date: **2/9/06**	Mudline Elevation (ft): **-49.3**	Recovery in ft (%): **8.5 (83)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **210648** E./LONG: **1266431**	Process Date: **2/9/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher, A. Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC3-0-2	93% (0-1)	PCB SVOC Metals Hg TBT	0	SM: (0.0-1.6) moist, medium dense, very dark gray (10YR, 3/1) fine SAND, few silt, and scattered wood fragments. Sand is multicolored (orange, red, white).	GT @ 0.7'	upper alluvium
1					@ 0.9' 1" thick SILT lens	@ 0.9' TV = 0.2 kg/cm2	
2	LDW-SC3-2-4	130% (1-2)			SP- SM: (1.6-5.1) moist to wet, medium dense, very dark gray (2.5Y, 3/1) fine to medium SAND interbedded with 1/2" to 3" thick SILT layers. Sand grains are multicolored and coarsen downward. Scattered wood fragments up to 1"L. Moderate H2S-like odor to 4.0'.	Sharp Contact GT @ 1.8'	
					@ 1.6' 1" thick SILT lens		
3		83% (2-5)	PCB SVOC Metals Hg TBT	0	@ 2.4' 1.5" thick SILT lens	@ 3.0' TV = 0.4 kg/cm2	
					@ 2.7' 3"L x 1"W thin wood fragment		
4	LDW-SC3-4-6				@ 3.1' 3" thick SILT lens		
					@ 4.0' Slight H2S-like odor to 4.6'		
5				0	@ 4.2' 1/2" thick SILT lens	Gradational Contact: less water	lower alluvium
					@ 4.6' Scattered twigs	@ 4.9' TV = 0.2 kg/cm2	
6	LDW	81% (5-7)			SP- SM: (5.1-10.2) damp, dense, greenish black (GLEY 1, 4/10Y), medium SAND interbedded with SILT. Silt interbeds are frequent, horizontal, range from 1/2" to 2" thick and are spaced every 0.3'. Small, scattered wood fragments at bottom of core (7.0' to 8.0').		
				0			

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Remarks: **Drive Notes: easy (5.0'), moderate (7.0'), hard (7.8'), refusal (8.7'). One drive attempt made at station.**

Calculated Recovery
Sample Length/Penetration Length:
8.5 / 10.2 = 83 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-3 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **7.9**	Penetration Depth (ft): **8.5**
Client: **LDWG**	Water Depth (ft): **57.0**	Sample Quality: **Good**
Collection Date: **2/9/06**	Mudline Elevation (ft): **-49.3**	Recovery in ft (%): **8.5 (83)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **210648** E./LONG: **1266431**	Process Date: **2/9/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83** N Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher, A. Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	SC3-8-9	70% (7-8)			@ 7.0' wood fragments, elongated @ 7.2' 1.5" thick SILT lens	@ 7.3' TV = 0.6 kg/cm2	7
8		80% (8-9)			@ 7.9' 1" thick SILT lens @ 8.1' small wood fragment	Not sampled below 8.0'.	8
9		83% (9-10.2)			End of core at 8.5'. Driven to refusal.		9
10							10

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Remarks: **Drive Notes: easy (5.0'), moderate (7.0'), hard (7.8'), refusal (8.7'). One drive attempt made at station.**

Calculated Recovery
Sample Length/Penetration Length:
8.5 / 10.2 = 83 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-4 (R2)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **7.9**	Penetration Depth (ft): **9.0**
Client: **LDWG**	Water Depth (ft): **41.9**	Sample Quality: **Not indicated**
Collection Date: **2/9/06**	Mudline Elevation (ft): **-34.0**	Recovery in ft (%): **7.7 (85)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **210597** E./LONG: **1266933**	Process Date: **2/9/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth; (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC4-0-1	92% (0-2)	PCB SVOC Metals Hg TBT	0	SM: (0.0-0.3) wet, very loose, dark greenish gray (GLEY 1, 4/10Y) SILTY SAND, trace subrounded gravel up to 1/2", trace shells and rootlets.	Sharp Contact GT @ 0.4' @ 0.6' TV = 0.4 kg/cm2	recent
1	LDW-SC3-1-2				OL: (0.3-1.4) moist, medium stiff, black (GLEY 1, 2.5/N) ORGANIC SILT, little sand, trace angular gravel up to 1/2", and trace rootlets and twigs. Silt has medium plasticity.	Sharp Contact	
2	LDW-SC3-2-4	115% (2-4)	PCB SVOC Metals Hg TBT	0	GP: (1.4-1.8) wet, medium dense, dark greenish gray (GLEY 1, 4/5G) GRAVEL, little silt and sand. Gravel is subangular and up to 2.5" in diameter. Trace HC-like odor and sheen.	Sharp Contact	upper alluvium
					OL: (1.8-2.5) moist, medium soft, black (GLEY 1, 2.5/N) ORGANIC SILT, trace sand. Slight to moderate H2S-like odor and trace HC-like sheen.	@ 2.1' TV = 0.4 kg/cm2	
3			PCB SVOC Metals Hg TBT	0	SP- SM: (2.5-3.3) moist, medium dense, very dark brown (10YR, 2/2) fine SAND interbedded with lenses of gray CLAYEY SILT. Lenses are irregular and up to 3" thick. Moderate wood fragments, twigs, and rootlets increase toward basal contact.	Sharp Contact	
4	LDW-SC3-4-6				SP-SC: (3.3-7.2) moist, medium dense, very dark greenish gray (GLEY 1, 3/10GY) fine to medium SAND with scattered 1/2" pockets of clay and 1" lenses of gray silt, and scattered wood fragments. Sand is multicolored (orange, red, white) and grades to medium grained below 5.5'. @ 4.7' 1/4" clay pocket	@ 4.5' TV = 0.5 kg/cm2	
5		92% (4-6)	PCB	0	@ 5.0' 1/2" clay pocket		
6	LDW-SC	85% (6-7)			@ 5.4' 1/2" gray silt lens		lower alluvium
					@ 6.4' 1" clay pocket		

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Remarks: **Drive Notes: moderate (7.5'), hard (9.0'), refusal (9.0'). Two drive attempts made at station. Core catcher was intact.**

Calculated Recovery
Sample Length/Penetration Length:
7.7 /9.0 = 85 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-4 (R2)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **7.9**	Penetration Depth (ft): **9.0**
Client: **LDWG**	Water Depth (ft): **41.9**	Sample Quality: **Not indicated**
Collection Date: **2/9/06**	Mudline Elevation (ft): **-34.0**	Recovery in ft (%): **7.7 (85)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **210597** E./LONG: **1266933**	Process Date: **2/9/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	3-6.7'	60% (7-8)		0	SP- SM: (7.2-9.0) moist, dense, gray fine SAND interbedded with SILT. Interbeds are 1/8" thick, spaced 1/4" apart from 6.9' to 7.2', and scattered lenses 1/4" thick.	Transitional Contact @ 7.2' TV = 0.6 kg/cm2	7
8		60% (8-9)			End of core at 7.7'. Driven to refusal.		8
9							9

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Remarks: Drive Notes: moderate (7.5'), hard (9.0'), refusal (9.0'). Two drive attempts made at station. Core catcher was intact.

Calculated Recovery
Sample Length/Penetration Length:
7.7 / 9.0 = 85 %

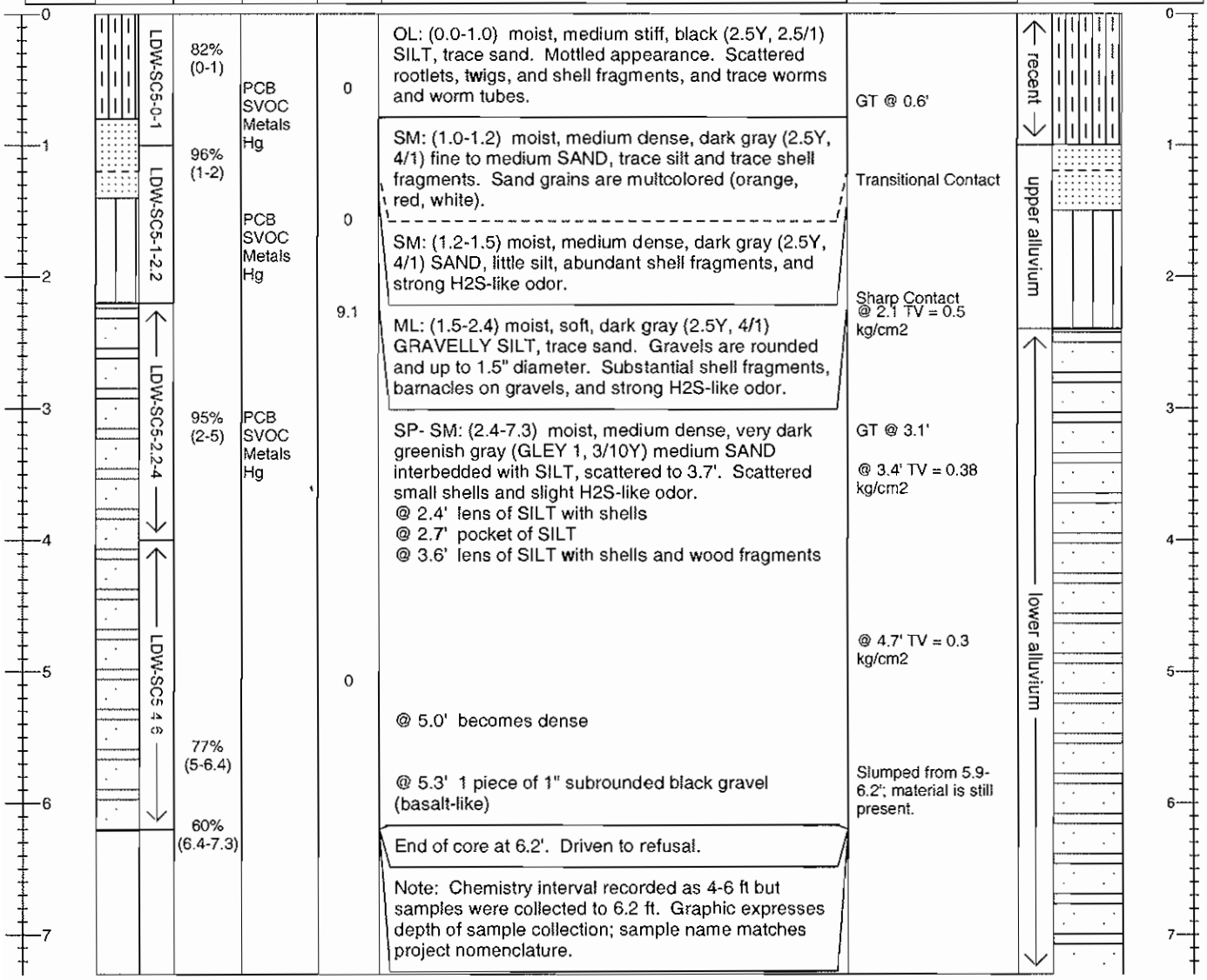
Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-5 (R2)

Sheet 1 of 1

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **7.7**	Penetration Depth (ft): **7.3**
Client: **LDWG**	Water Depth (ft): **19.7**	Sample Quality: **Good**
Collection Date: **2/9/06**	Mudline Elevation (ft): **-10.4**	Recovery in ft (%): **6.2 (85)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **210543** E./LONG: **1266048**	Process Date: **2/10/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher, A. Fitzpatrick**



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Remarks: **Drive Notes: freefall (0.5'), easy (5.0'), moderate (6.3'), hard (7.3'), refusal (7.3'). Two drive attempts made at station. Core catcher was intact. EPA oversight approved processing as Method A.**

Calculated Recovery
Sample Length/Penetration Length:
6.2 / 7.3 = 85 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-6 (R1)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **11.0**
Client: **LDWG**	Water Depth (ft): **8.6**	Sample Quality: **Good**
Collection Date: **2/9/06**	Mudline Elevation (ft): **-33.0**	Recovery in ft (%): **8.6 (77)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **209838** E./LONG: **1266285**	Process Date: **2/10/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher, A. Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC6-0-2				OL: (0.0-0.4) wet, very soft, olive (5Y, 4/3) ORGANIC SILT. Scattered twigs and trace worm tubes.	Transitional Contact	recent
1			PCB SVOC Metals Hg	0	OL: (0.4-4.8) wet, soft to medium stiff, greenish black (GLEY 1, 2.5/5G) ORGANIC SILT, little sand and scattered wood fragments. Silt texture is homogenous, of moderate plasticity, increases in stiffness with depth, and decreases in sand content with depth. Slight H2S-like odor.	@ 0.7 TV = 0.5 kg/cm2 GT @ 1.1'	
2	LDW-SC6-2-4.5	100% (0-2.6)				@ 1.7' TV = 0.8 kg/cm2	
3		100% (2.6-4.7)	PCB SVOC Metals Hg	0		GT @ 3.2' @ 3.5' TV = 0.7 kg/cm2	
4					@ 3.4' 2" pocket of soft, stiff, gray SILT SM: (4.8-8.8) moist, medium dense, very dark gray (10YR, 3/1) SAND, trace silt. Sand is multicolored (orange, red, white) with fining upward sequences; silt is non-layered with stiff clasts and abrupt edges (xenoclasts). Scattered debris (brick fragments). @ 4.5' grades to fine sand	Sharp Contact	
5	LDW-SC6-4.5-6	71% (4.7-6.8)		0		@ 4.9' TV = 1.2 kg/cm2	upper all
6	LDW				@ 5.4' grades to coarse to medium sand @ 6.0' grades to medium sand @ 6.4' grades to medium to fine sand	Bag @ 5.7' (debris) Bag @ 6.0' (sand clast with odor) @ 6.5' TV = 0.5 kg/cm2	

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Remarks: **Drive Notes: easy (2.6'), moderate (8.8'), hard (10.0'), refusal (11.0'). One drive attempt made at station.**

Core catcher was intact.

Calculated Recovery
Sample Length/Penetration Length:
8.6 / 11.0 = 78 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-6 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **11.0**
Client: **LDWG**	Water Depth (ft): **8.6**	Sample Quality: **Good**
Collection Date: **2/9/06**	Mudline Elevation (ft): **-33.0**	Recovery in ft (%): **8.6 (77)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **209838** E./LONG: **1266285**	Process Date: **2/10/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Verl. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher, A. Fitzpatrick**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth; (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	SC6-8-8	65% (6.8-8.8)	PCB SVOC Metals Hg	0	@ 7.1' grades to coarse to medium sand	Bag @ 7.0' (brick fragment, 1/2" shell)	7
8	SC6-8-8.6			0	@ 7.4' grades to medium sand @ 7.5' scattered brick fragments to 1/8" L, coarse quartz sand present	Gradational Contact	8
9		67% (8.8-10)			SM: (8.8-11.0) Grading to moist, dense, medium SAND. No layers or hard silt clasts; more rounded coarse quartz grains than above. One intact half shell 1" L.	Last 0.1' of core is slightly winnowed	9
10		30% (10-11)			End of core at 8.6'. Driven to refusal.		10
11							11

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Remarks: **Drive Notes: easy (2.6'), moderate (8.8'), hard (10.0'), refusal (11.0'). One drive attempt made at station.**

Core catcher was intact.

Calculated Recovery
Sample Length/Penetration Length:
8.6 / 11.0 = 78 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-7 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **6.7**	Penetration Depth (ft): **11.0**
Client: **LDWG**	Water Depth (ft): **34.8**	Sample Quality: **Good**
Collection Date: **2/10/06**	Mudline Elevation (ft): **-27.1**	Recovery in ft (%): **8.7 (79)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **209605** E./LONG: **1266850**	Process Date: **2/10/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **A. Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC7-0-1	100% (0-0.6)	PCB SVOC Metals Hg Pesticides TBT	0	ML: (0.0-0.5) wet, very soft, black (GLEY 1, 2.5/N) ORGANIC SILT, trace clay. Scattered wood fragments, trace worms and rootlets.		recent
1	SC7-1-1.7	92% (0.6-1)	PCB SVOC Metals Hg Pesticides TBT	0	OL: (0.5-1.8) very wet, very soft, very dark greenish gray (GLEY 1, 3/10Y) SANDY ORGANIC SILT. Scattered 1/2" rounded gravel.	Transitional Contact @ 0.5' TV = 0.2 kg/cm2 GT @ 0.9'	upper alluvium
2	LDW-SC7-1.7-4	56% (1-4)	PCB SVOC Metals Hg Pesticides TBT	0	SP: (1.8-3.5) moist, loose to medium dense, dark greenish gray (GLEY 1, 4/5GY) very fine to fine SAND. Sand grains are uniform, multicolored (orange, red, white), and grade to coarse with depth.	Sharp Contact GT @ 2.6'	
3					SP-SM: (3.5-7.1) moist, dense, dark greenish gray (GLEY 1, 4/5GY) medium SAND, trace gravel, and trace scattered greenish-gray (GLEY1, 5/5GY) silt pockets at top 1/2" of unit and increasing in size and abundance (up to 4" L) toward basal contact. Gravel is scattered, well rounded, and 1 to 4" in diameter.	@ 3.2' TV = 0.3 kg/cm2 @ 3.5' TV = 0.7 kg/cm2	
4	LDW-SC7-4-6.5	119% (4-6)			@ 4.0' Gravel ends and silt pockets increase to substantial. Silt pockets are subrounded, hard, and up to 4" in diameter.	Bag @ 4.0 to 6.0' (silt clasts)	lower alluvium
5				0		@ 5.3' TV = 0.4 kg/cm2	

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Remarks: **Drive Notes: freefall (0.6'), moderate (9.4'), hard (10.7'), refusal (11'). One drive attempt made at station. Core shoe was 50% full of sand.**

Calculated Recovery
Sample Length/Penetration Length:
8.7 / 11.0 = 79 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-7 (R1)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **6.7**	Penetration Depth (ft): **11.0**
Client: **LDWG**	Water Depth (ft): **34.8**	Sample Quality: **Good**
Collection Date: **2/10/06**	Mudline Elevation (ft): **-27.1**	Recovery in ft (%): **8.7 (79)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **209605** E./LONG: **1266850**	Process Date: **2/10/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **A. Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
6							6
7	LDW-SC7-6.5-8	89% (6-9)		0	SM: (7.1-11.0) moist, dense, dark greenish gray (GLEY 1, 4/5GY) medium SAND interbedded with fine SAND, trace silt (fluvial-looking).	Transitional Contact @ 7.1' TV = 0.5 kg/cm2	7
8	SC7-8-8.7			0	End of core at 8.7'. Driven to refusal.	@ 8.7 to 8.9' Core is winnowed and was not sampled. Shoe is 50% of same material as above.	8
9							9
10		38% (9-10)					10
11		33% (10-11)					11

fluvial

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Remarks: **Drive Notes: freefall (0.6'), moderate (9.4'), hard (10.7'), refusal (11'). One drive attempt made at station. Core shoe was 50% full of sand.**

Calculated Recovery
Sample Length/Penetration Length:
8.7 / 11.0 = 79 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-8 (R1)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **7.3**	Penetration Depth (ft): **14.6**
Client: **LDWG**	Water Depth (ft): **46.5**	Sample Quality: **Good**
Collection Date: **2/10/06**	Mudline Elevation (ft): **-39.1**	Recovery in ft (%): **10.0 (68)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **209589** E./LONG: **1266614**	Process Date: **2/10/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83** N Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **A. Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC8-0-1	73% (0-1)	PCB SVOC Metals Hg Pesticides	0	ML: (0-0.4) very wet, soft, olive gray (5Y, 4/2) SILT.		0
					OL: (0.4-1.1) wet, soft, mottled black (2.5Y, 2.5/1) ORGANIC SILT, moderate wood fragments up to 4" L, and scattered shell fragments.	Transitional Contact	
1	LDW-SC8-1-2		PCB SVOC Metals Hg Pesticides	0	OL: (1.1-4.8) wet, medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT, little clay interbedded with fine-medium black SAND. Silt texture is uniform, slightly compressible and of medium plasticity. Scattered rootlets and moderate to strong H2S-like odor.	GT @ 0.9'	1
						Bag @ 1.2' (orange agglomerate) @ 1.5' TV = 0.6 kg/cm2	
2	LDW-SC8-2-4	100% (1-5)					2
						@ 2.5' TV = 0.34 kg/cm2	
3			PCB SVOC Metals Hg Pesticides	0		GT @ 3'	3
4	LDW-SC8-4-6				OL: (4.8-11.8) Grades to moist, medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT, little clay interbedded with fine-medium black SAND. Silt texture is stiffer than above due to decreased water content.	Gradational Contact: less water	4
5		100% (5-7)	PCB SVOC Metals Hg	0	@ 4.8 to 5.0' 2" layer of wet, black (2.5Y, 4/2) SAND	Bag @ 4.8' (black chunk) @ 5' TV = 0.56 kg/cm2	5
6					@ 5.6' 2" layer of black SAND, moderate wood fragments, trace sheen florets, faint HC-like odor	@ 5.8' PID Bag = 0	6
						@ 6.6' TV = 0.84 kg/cm2	
7	LDW-SC8-6-8	81% (7-10)	PCB SVOC Metals Hg	0	@ 6.4' end of sand interbeds		7
8					@ 7 .0 to 8.0' possible HC-like odor		8

recent

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Remarks: **Drive Notes: freefall (0.8'), easy-moderate (4.8'), easy (9.6'), moderate (14.6'), penetration goal reached. One drive attempt made at station. Core catcher was intact but inverted.**

Calculated Recovery
Sample Length/Penetration Length:
10.0/ 14.6 = 68 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-8 (R1)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **7.3**	Penetration Depth (ft): **14.6**
Client: **LDWG**	Water Depth (ft): **46.5**	Sample Quality: **Good**
Collection Date: **2/10/06**	Mudline Elevation (ft): **-39.1**	Recovery in ft (%): **10.0 (68)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **209589** E./LONG: **1266614**	Process Date: **2/10/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **A. Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth; (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
8					CL: (11.4-11.8) wet, stiff, greenish gray (GLEY 1, 6/1) CLAY.	@ 8.4' TV = 0.4 kg/cm2	8
9	LDW-SC8-8-10		PCB SVOC Metals Hg	0	ML: (11.8-14.6) wet, stiff, black(2.5Y, 2.5/1) SILT.		9
10					End of core at 10.0'.		10
11		73% (10-13)					11
12							12
13							13
14		62% (13-14.6)					14

upper alluvium

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Remarks: Drive Notes: freefall (0.8'), easy-moderate (4.8'), easy (9.6'), moderate (14.6'), penetration goal reached. One drive attempt made at station. Core catcher was intact but inverted.

Calculated Recovery
Sample Length/Penetration Length:
10.0/ 14.6 = 68 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-9 (R1)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **-1.6**	Penetration Depth (ft): **12.9**
Client: **LDWG**	Water Depth (ft): **30.0**	Sample Quality: **Good**
Collection Date: **2/13/06**	Mudline Elevation (ft): **-31.6**	Recovery in ft (%): **8.5 (66)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **208919** E./LONG: **1266863**	Process Date: **2/13/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher, A. Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC9-0-1	78% (0-2)	PCB SVOC Metals Hg Pesticides	0	SM: (0.0-0.6') wet, loose, greenish black (GLEY 1, 2.5/10GY) fine to medium SAND, few silt grading to black SANDY SILT. Scattered wood fragments and rootlets, moderate H2S-like odor.	@ 0.4' TV = 0.6 kg/cm2	recent
1	LDW-SC9-1-2.6		PCB SVOC Metals Hg Pesticides	0	OL: (0.6-1.3) wet, medium stiff, black (GLEY 1, 2.5/N) ORGANIC SILT. Scattered wood fragments and strong H2S-like odor.	GT @ 0.9' Transitional Contact	
2		100% (2-4)			OL: (1.3-2.6) wet, medium stiff, black (GLEY 1 , 2.5/N) ORGANIC SILT. Silt texture is uniform, compressible, and of low plasticity. Moderate scattered rootlets and trace HC-like odor from 1.5' to 2.6'.	@ 1.4' TV = 0.4 kg/cm2	
3	LDW-SC9-2.6-4		PCB SVOC Metals Hg Pesticides	0	SM: (2.6-7.7) damp, loose to medium dense, very dark brown (10YR, 2/2) fine to medium SAND, little silt interbedded with SAND and substantial (40-60%) WOOD layers. Uniform, alternating layers of sand and wood about 2" thick. Scattered wet, soft, fresh wood fragments up to 1"L and rootlets.	GT @ 2.5'	upper alluvium
4		70% (4-6)				@ 3.8' TV = 0.4 kg/cm2	
5	LDW-SC9-4-6.4			0		@ 4.6' TV = 0.5 kg/cm2	
6		30% (6-8)					
7	LDW			0	CL: (7.7-12.9) moist, stiff, bluish gray (GLEY 2, 6/1) SILTY CLAY. 1" black colored convex layers of clay uniformly spaced, homogenous, highly plastic, no textural difference between clay unit and layers.	Sharp Contact @ 6.9' TV = 0.2 kg/cm2	

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Remarks: **Drive Notes: freefall (1.9'), easy (7.9'), moderate (12.9'), no refusal. One drive attempt made at station. Core was intact but shoe was empty. Water elevation and mudline values were adjusted based on bathymetry.**

Calculated Recovery
Sample Length/Penetration Length:
8.5 / 12.9 = 66 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-9 (R1)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **-1.6**	Penetration Depth (ft): **12.9**
Client: **LDWG**	Water Depth (ft): **30.0**	Sample Quality: **Good**
Collection Date: **2/13/06**	Mudline Elevation (ft): **-31.6**	Recovery in ft (%): **8.5 (66)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **208919** E./LONG: **1266863**	Process Date: **2/13/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher, A. Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
8	LSC9-6.4-8.4	29% (8-10)			End of core at 8.5'		8
9					Note: Chemistry interval recorded as 6.4-8.4 ft but sample was collected to bottom of core at 8.5 ft. Graphic expresses depth of sample collection; sample name matches project nomenclature.		9
10		58% (10-12)					10
11							11
12		80% (12-12.9)					12

lower alluvium ?

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Remarks: **Drive Notes: freefall (1.9'), easy (7.9'), moderate (12.9'), no refusal. One drive attempt made at station. Core was intact but shoe was empty. Water elevation and mudline values were adjusted based on bathymetry.**

Calculated Recovery
Sample Length/Penetration Length:
8.5 / 12.9 = 66 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-10 (R1)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **6.8**	Penetration Depth (ft): **10.6**
Client: **LDWG**	Water Depth (ft): **24.6**	Sample Quality: **Good**
Collection Date: **2/10/06**	Mudline Elevation (ft): **-17.3**	Recovery in ft (%): **8.9 (83)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **208776** E./LONG: **1267167**	Process Date: **2/10/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **A. Fitzpatrick**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC10-0-1	82% (0-0.6)	PCB SVOC Metals Hg Pesticides	0	MH: (0.0-0.05) very wet, very soft, brown SILT.		0
					GP: (0.05-0.7) wet, loose, greenish gray (GLEY 1, 4/5GY) GRAVEL, few sand and silt. Gravel is 1/2", subrounded, pea gravel-like; sand grains are white and black. Moderate scattered wood and very small shell fragments.	GT @ 0.9'	
1	LDW-SC10-1-2		PCB SVOC Metals Hg Pesticides	0	OL: (0.7-4.1) wet, medium stiff, black (GLEY 1, 2.5/N) ORGANIC SILT, little sand and clay. Scattered rootlets, moderate H2S-like odor, trace shell fragments and hairlets. Silt texture uniform, slightly compressible, of high plasticity, and with less water with depth.	@ 1.2' TV = 0.5 kg/cm2	1
2	LDW-SC10-2-4	100% (0.6-5.8)				@ 2.3' TV = 0.4 kg/cm2	2
3			PCB SVOC Metals Hg Pesticides	0	@ 3.4' one mussell shell fragment	GT @ 2.9'	3
4	LDW-SC10-4-5		PCB SVOC Hg	0	OH: (4.1-5) wet, stiff, greenish gray (GLEY 1, 5/5GY) CLAY, little silt. Clay texture is uniform, massive, and of high plasticity.	Sharp Contact @ 4.5' TV = 0.4 kg/cm2	4
5	LDW-SC10-5-6			0	OL: (5-6) moist to wet, stiff, very dark greenish gray (GLEY 1, 3/10Y) SILT, few clay interbedded with fine SAND layers ~1.5" thick. Moderate wood fragments, plant material, and scattered peat pockets about 1" diameter decreasing with depth.	Sharp Contact @ 5.4' TV = 0.5 kg/cm2	5
6	LDW-	80% (5.8-7.8)			SP- SM: (6-10.6) moist, dense, very dark greenish gray (GLEY 1, 3/10Y) medium SAND interbedded with 1/8" thick gray SILT seams (fluvial-looking). Sand coarsens with depth. Scattered wood fragments.	Sharp Contact @ 6.3' TV = 0.8 kg/cm2	6

recent

upper alluvium

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Remarks: **Drive Notes: freefall (0.6'), easy (7.8'), moderate (9.8'), hard (10.6'), refusal (10.6'). One drive attempt made at station. Core catcher was 50% full with partial winnowing. Core tube was intact.**

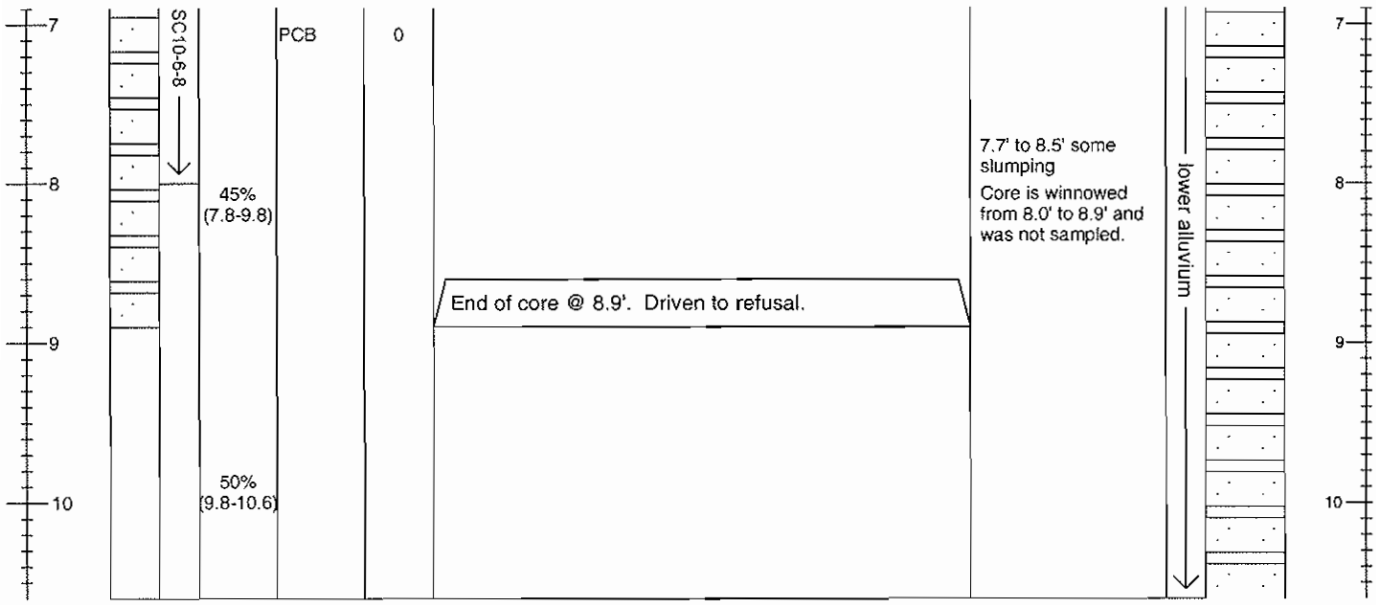
Calculated Recovery
Sample Length/Penetration Length:
8.8 / 10.6 = 83 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-10 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **6.8**	Penetration Depth (ft): **10.6**
Client: **LDWG**	Water Depth (ft): **24.6**	Sample Quality: **Good**
Collection Date: **2/10/06**	Mudline Elevation (ft): **-17.3**	Recovery in ft (%): **8.9 (83)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **208776** E./LONG: **1267167**	Process Date: **2/10/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **A. Fitzpatrick**



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Remarks: **Drive Notes: freefall (0.6'), easy (7.8'), moderate (9.8'), hard (10.6'), refusal (10.6'). One drive attempt made at station. Core catcher was 50% full with partial winnowing. Core tube was intact.**

Calculated Recovery
Sample Length/Penetration Length:
8.8 / 10.6 = 83 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

Sheet 1 of 1

LDW-SC-11 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **5.3**	Penetration Depth (ft): **5.9**
Client: **LDWG**	Water Depth (ft): **8.6**	Sample Quality: **Good**
Collection Date: **2/13/06**	Mudline Elevation (ft): **-5.1**	Recovery in ft (%): **5.0 (85)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **208291** E./LONG: **1265908**	Process Date: **2/13/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher, A. Fitzpatrick**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth; (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	SC11-0-0.8		PCB SVOC Metals Hg	0	ML: (0.0-0.9) wet, soft, black (2.5 YR, 2.5/N) SILT, little sand. Texture is non-homogenous (jumbled) with substantial wood fragments and debris. Debris includes red chips (possibly paint), plastic, leather, glass shards, and wood chips with strong H2S-like odor.	Core catcher found at 0.8' Bag @ 0.7' (red chips, debris)	recent
1	LDW-SC11-0.8-2	85% (0-3)	PCB SVOC Metals Hg	0	SM: (0.9-4.1) moist to wet, medium dense, very dark gray (10YR, 3/1) SILTY FINE SAND. Silt decreases with depth. Texture is homogenous.	GT @ 0.9' @ 1.2' TV = 0.8 kg/cm2	upper alluvium
2	LDW-SC11-2-3.4	79% (3-5)	PCB SVOC Metals Hg	0			
3	SC11-3.4-4.1		PCB SVOC Metals Hg		GP: (4.1-4.9) wet, loose, dark gray (10YR, 4/1) GRAVEL, little silt and sand. Gravel is 2" in diameter and subrounded and percentage decreases with depth. Moderate small shell fragments.	Transitional Contact	
4	LDW-SC11-4.1-5				CL: (4.9-5.9) damp, very hard, olive yellow (5Y, 6/4), mottled CLAY (possible glacial sequence), little silt. Massive, no layering, low plasticity.	Transitional Contact @ 4.5' TV = 12.0 kg/cm2	
5		100% (5-5.6) 67% (5.6-5.9)		0	End of core at 5.0'. Driven to refusal.		lower alluvium ?

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Remarks: **Drive Notes: moderate (4.6), moderate to hard (5.6') hard (5.9'), refusal (5.9'). One drive attempt made at station. Core catcher was intact and 100% full. Difficult extraction.**

Calculated Recovery
Sample Length/Penetration Length:
5.0 / 5.9 = 85 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-12 (R1)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **2.8**	Penetration Depth (ft): **9.6**
Client: **LDWG**	Water Depth (ft): **13.7**	Sample Quality: **Good**
Collection Date: **2/16/06**	Mudline Elevation (ft): **-7.5**	Recovery in ft (%): **8.7 (91)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **208217** E./LONG: **1266577**	Process Date: **2/16/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC12-0-2				ML: (0.0-0.1) wet, very soft, olive brown (2.5Y, 4/3) SILT.	Transitional Contact	recent
1			PCB SVOC Metals Hg TBT	0	OL: (0.1-2.6) wet, medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT, few sand. Silt texture is uniform, slightly compressible, massive, blocky, and of low plasticity. Abundant rootlets and wood fragments, scattered shell fragments up to 1/2" and plant matter. Moderate H2S-like odor. @ 1.0' wood fragments up to 0.5'L	GT @ 0.9' @ 1.3' TV = 0.5 kg/cm2	
2		100% (0-4)			@ 2.0' strong H2S-like odor		
3	LDW-SC12-2-4		PCB SVOC Metals Hg TBT	0	OL: (2.6-6.0) moist, stiff, gray (2.5Y, 5/1) CLAYEY ORGANIC SILT interbedded with moist, medium stiff, black (2.5, 2.5/1) SILT, few sand. Scattered wood fragments and strong H2S-like odor. Grades to stiff with depth.	Transitional Contact GT @ 2.9' @ 3.4' TV = 0.2 kg/cm2	upper alluvium
4		89% (4-5)					
5	LDW-SC12-4-6.7		PCB Hg	0	@ 5.0' wood fragments up to 3" L	@ 5.4' TV = 0.6 kg/cm2	
6		93% (5-7)			ML: (6.0-6.9) moist, medium stiff, dark greenish gray (GLEY 1, 4/10Y) SILT interbedded with up to 3" thick layers of sandy SILT, wood fragments up to 2" L, and mild H2S-like odor.	Transitional Contact	

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Remarks: **Drive Notes: easy (6.9'), moderate (7.6'), hard (9.6'), refusal (9.6'). One drive attempt made at station. Core catcher was intact and 83% full.**

Calculated Recovery
Sample Length/Penetration Length:
8.7 / 9.6 = 91 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-12 (R1)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **2.8**	Penetration Depth (ft): **9.6**
Client: **LDWG**	Water Depth (ft): **13.7**	Sample Quality: **Good**
Collection Date: **2/16/06**	Mudline Elevation (ft): **-7.5**	Recovery in ft (%): **8.7 (91)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **208217** E./LONG: **1266577**	Process Date: **2/16/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83** N Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth; (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	LDW-SC12-6.7-8.7	83% (7-8)	PCB Hg	0	SP-SC: (6.9-9.6) moist, medium stiff, very dark greenish gray (GLEY 1, 3/1) SAND with clasts and layers of olive gray SILT up to 1/2" L. Sand grains are multicolored; silt is moist, slightly compressible, and rolls easily. Pockets of subrounded 1/2" peat at 8.0' to basal contact.	Sharp Contact @ 7.0' TV = 0.7 kg/cm2	7
8		70% (8-9)				@ 8.2' TV = 0.8 kg/cm2	8
9		80% (9-9.6)			End of core at 8.7'. Driven to refusal. Note: Chemistry interval recorded as 6.7-8.7 ft but was collected at top of sand at 6.6 ft. Graphic expresses depth of sample collection; sample name matches project nomenclature.		lower alluvium 9

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Remarks: **Drive Notes: easy (6.9'), moderate (7.6'), hard (9.6'), refusal (9.6'). One drive attempt made at station. Core catcher was intact and 83% full.**

Calculated Recovery
Sample Length/Penetration Length:
8.7 / 9.6 = 91 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-13 (R1)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **4.8**	Penetration Depth (ft): **12.5**
Client: **LDWG**	Water Depth (ft): **16.5**	Sample Quality: **Good**
Collection Date: **2/13/06**	Mudline Elevation (ft): **-10.7**	Recovery in ft (%): **9.9 (79)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **207096** E./LONG: **1267585**	Process Date: **2/13/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher, A. Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth; (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC13-0-2	115% (0-1)	PCB SVOC Metals Hg	0	SW: (0.0-0.2) wet, loose, greenish black (GLEY 1, 2.5/10GY) medium to coarse SAND, trace silt and gravel. Scattered shell fragments.	Sharp Contact	0
1					SM: (0.2-1.3) moist, medium dense, very dark greenish gray (GLEY 1, 3/1) SAND, little silt, and moderate wood, twigs, and rootlets. Moderate to strong H2S-like odor.	GT @ 0.9' @ 1.0' TV = 0.3 kg/cm2	1
2	LDW-SC13-2-4	94% (1-3)	PCB SVOC Metals Hg	0	OL: (1.3-3.1) moist, medium stiff, very dark greenish grey (GLEY 1, 3/1) ORGANIC SILT, few sand and moderate wood, twigs, and rootlets. Trace H2S-like odor and very slight HC-like odor from 2.5' to 3.0'.	@ 2.4' TV = 0.4 kg/cm2	2
3		71% (3-5)		0	SM: (3.1-5.9) moist, medium dense, very dark greenish gray (GLEY 1, 3/1) fine to medium SAND, trace silt. SAND grains are multicolored (orange, red, white). Scattered thin silt layers/pockets, and rootlets. From 4.1' to 4.5', a layer of SILTY SAND with substantial wood fragments and slight H2S-like odor.	Sharp Contact	3
4	LDW-SC13-4-6						4
5						@ 4.9' TV = 0.4 kg/cm2	5
6	LDW-	67% (5-7)		0	SP- SM: (5.9-12.5) moist, medium dense, very dark grayish brown (10YR, 3/2) fine SAND interbedded with 1" to 2" thick, moist, medium stiff, very dark greenish gray SILT, few sand. Sand grains are multicolored (orange, red, white). Trace scattered rootlets. @ 5.5' to 6.0' layer of shredded wood with fibrous, peaty material, and slight H2S-like odor	Transitional Contact @ 6.4' TV = 0.6 kg/cm2	6

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Remarks: **Drive Notes: easy (5.2'), moderate (10.4'), hard (12.5'), penetration goal reached. One drive attempt made at station. Core catcher was intact.**

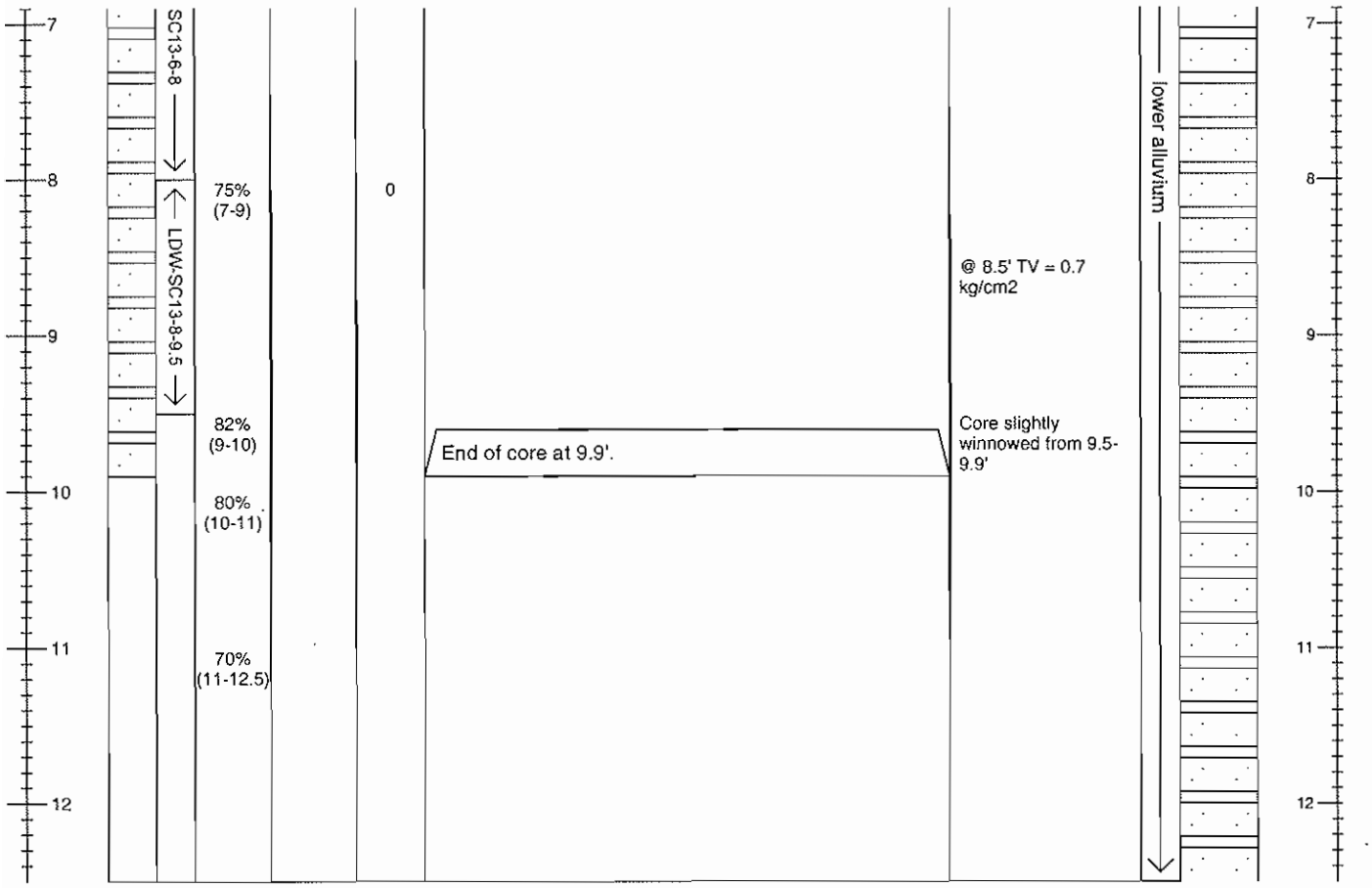
Calculated Recovery
Sample Length/Penetration Length:
9.9 / 12.5 = 79 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-13 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **4.8**	Penetration Depth (ft): **12.5**
Client: **LDWG**	Water Depth (ft): **16.5**	Sample Quality: **Good**
Collection Date: **2/13/06**	Mudline Elevation (ft): **-10.7**	Recovery in ft (%): **9.9 (79)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **207096** E./LONG: **1267585**	Process Date: **2/13/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher, A. Fitzpatrick**



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Remarks: **Drive Notes: easy (5.2'), moderate (10.4'), hard (12.5'), penetration goal reached. One drive attempt made at station. Core catcher was intact.**

Calculated Recovery
Sample Length/Penetration Length:
9.9 / 12.5 = 79 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-14 (R1)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **6.7**	Penetration Depth (ft): **12.6**
Client: **LDWG**	Water Depth (ft): **46.0**	Sample Quality: **Good**
Collection Date: **2/13/06**	Mudline Elevation (ft): **-36.8**	Recovery in ft (%): **11.6 (92)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **207055** E./LONG: **1267397**	Process Date: **2/13/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83** N Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC14-0-1.4	100% (0-2)	PCB SVOC Metals Hg Pesticides TBT	0	SM: (0.0-0.3) wet, loose, dark greenish gray (GLEY 1, 4/10Y) SAND, few silt. Scattered shell fragments and intact shells.	@ 0.6' TV = 0.1 kg/cm2	0
1					OL: (0.3-3.7) wet, medium soft, black (GLEY 1, 2.5/N) ORGANIC SILT. Grades to more competent with a blocky texture with depth. Trace organics, twigs, rootlets, wood fragments, 1/16" sheen florets, and very trace HC-like odor.	GT @ 1.0'	1
	1.4-2.0		PCB SVOC Metals Hg Pesticides TBT	0	@ 0.5' 1" thick lens of moist, medium dense, brown fine SAND		
2	LDW-SC14-2-4.1	100% (2-2.4)			@ 1.4' color changes to mottled, grayish black, trace sheen noted below this depth		2
3		100% (2.4-4)	PCB SVOC Metals Hg Pesticides TBT	0		GT @ 3.0'	3
						@ 3.4' TV = 0.3 kg/cm2	
4					ML: (3.7-4.1) moist, soft, dark gray (2.5Y, 4/1) SILT, little clay. Trace horizontal black mottling.	Transitional Contact	4
	LDW-SC14-4.1-6				ML: (4.1-8.7) moist, medium stiff, black (GLEY 1, 2.5N) SILT with scattered 1/2" brown sand pockets and discontinuous mottled gray silt lenses to 8.0'. Silt has blocky texture. Scattered organics, twigs, rootlets, and wood fibers. Trace 1/16" sheen florets and very trace HC-like odor to 6.0'.	Transitional Contact	
5		100% (4-7)	PCB SVOC Hg	0			5
6							6

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Remarks: **Drive Notes: freefall (1.8'), easy (9.0'), moderate (12.7'), penetration goal reached. One drive attempt made at station. Core catcher was intact.**

Calculated Recovery
Sample Length/Penetration Length:
11.6/12.6 = 92 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-14 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **6.7**	Penetration Depth (ft): **12.6**
Client: **LDWG**	Water Depth (ft): **46.0**	Sample Quality: **Good**
Collection Date: **2/13/06**	Mudline Elevation (ft): **-36.8**	Recovery in ft (%): **11.6 (92)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **207055** E./LONG: **1267397**	Process Date: **2/13/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	DW-SC14-6-8.7	82% (7-9)	PCB Hg	0	@ 7.0' 1.5" thick layer of grayish brown SILT, few sand @ 7.7' 1" thick layer of brown fine SAND	@ 7.0' TV = 0.7 kg/cm2	7
8							8
9	LDW-SC14-8.7-10	74% (9-11)			SP- SM: (8.7- 9.5) moist, [medium dense], very dark grayish brown (2.5Y, 3/2) fine SAND interbedded with grayish olive SILT, few clay. Color is mottled. Trace organics, rootlets, and wood fragments up to 4" L (transitional unit). SP: (9.5-12.6) moist, medium dense, very dark grayish brown (2.5Y, 3/2) fine SAND, trace silt. Sand grains are multicolored (orange, red, white) and grade to medium at 11.0'. Scattered organics, twigs, and rootlets.	Transitional Contact Slight winnowing in sand below 10.3'	9
10	LDW-SC14-10-11		PCB Hg				10
11		67% (11-12.6)			End of core at 11.6'.	@ 11.0' TV = 0.4 kg/cm2	11
12					Note: Chemistry interval recorded as 8.7 ft but samples were collected above and below lithology transition at 8.6 ft. Graphic expresses depth of sample collection; sample name matches project nomenclature.		12

In-situ Depth (ft) & Graphic Log: alluvium; lower alluvium

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Remarks: **Drive Notes: freefall (1.8'), easy (9.0'), moderate (12.7'), penetration goal reached. One drive attempt made at station. Core catcher was intact.**

Calculated Recovery
Sample Length/Penetration Length:
11.6/12.6 = 92 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-15 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **6.6**	Penetration Depth (ft): **12.7**
Client: **LDWG**	Water Depth (ft): **37.8**	Sample Quality: **Good**
Collection Date: **2/16/06**	Mudline Elevation (ft): **-27.9**	Recovery in ft (%): **10.1 (80)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **206821** E./LONG: **1267821**	Process Date: **2/17/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth; (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC15-0-1	80% (0-1)	PCB SVOC Metals Hg TBT	0	ML: (0.0-0.4) wet, very soft, olive brown (2.5Y, 4/3) SILT, few sand.	Transitional Contact	recent
1	LDW-SC15-1-2		PCB SVOC Metals Hg TBT	0	OL: (0.4-2.0) moist to wet, (medium stiff), black (2.5Y, 2.5/1) ORGANIC SILT. Silt texture is uniform, slightly compressible, massive, and blocky. Scattered rootlets, wood fragments up to 0.4' L, and worms and worm tubes in top 0.8'. @ 1.2' to 2.0' trace HC-like florets up to 1/2" L	GT @ 0.9' Sheen Test @ 1.0': no sheen @ 1.5' TV = 0.3 kg/cm2	
2	LDW-SC15-2-4	100% (1-3)	PCB SVOC Metals Hg TBT	0	OL: (2.0-8.2) moist, medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT interbedded with 0.1' thick pockets and 0.5' thick layers of mottled, dark greenish gray (GLEY 1, 4/10Y) SILT, little clay and scattered wood fragments. Interbedded silt texture is uniform, slightly compressible, and rolls easily. Scattered 1/2" L sheen florets from 2.0' to 6.7'.	Transitional Contact @ 2.5' TV = 0.5 kg/cm2 GT @ 2.9'	
3		86% (3-5)					
4	LDW-SC15-4-6		PCB TBT			Sheen Test @ 4.0': no sheen @ 4.7' TV = 0.1 kg/cm2	upper alluvium
5		57% (5-7)		0	@ 5.1' 6" L wood fragment		
6	LDW-						

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Remarks: **Drive Notes: freefall (1.0'), moderate (7.0'), hard (12.7'), refusal (12.7'). One drive attempt made at station.**

Core catcher was intact but slightly winnowed.

Calculated Recovery
Sample Length/Penetration Length:
10.1/ 12.7 = 80 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-15 (R1)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **6.6**	Penetration Depth (ft): **12.7**
Client: **LDWG**	Water Depth (ft): **37.8**	Sample Quality: **Good**
Collection Date: **2/16/06**	Mudline Elevation (ft): **-27.9**	Recovery in ft (%): **10.1 (80)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **206821** E./LONG: **1267821**	Process Date: **2/17/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83** N Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	SC15-8-8	87% (7-8)		0	SM: (8.2-8.7) Alternating 1" thick layers of very fine SAND and SILT, little clay (transitional unit).	Transitional Contact @ 7.0' TV = 0.8 kg/cm2	7
					SP: (8.7-12.7) moist, medium dense, very dark greenish gray SAND with convex layers. SAND is multicolored (orange, red, white) and coarsens downward.	Sharp Contact	
8							8
	LDW-SC15-8-10	80% (8-9)	PCB			@ 8.8' TV = 0.8 kg/cm2	
9		70% (9-10)			@ 9.7' 1/2", subrounded, green-gray SILT pockets (xenoclasts)		9
10					End of core at 10.1'. Driven to refusal.		10
11		60% (10-12)					11
12		73% (12-12.7)					12

lower alluvium

The RETEC Group, Inc.
1011 SW Klickitat Way, Suite 207
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Fax: (206) 624-2839

Remarks: **Drive Notes: freefall (1.0'), moderate (7.0'), hard (12.7'), refusal (12.7'). One drive attempt made at station.**

Core catcher was intact but slightly winnowed.

Calculated Recovery
Sample Length/Penetration Length:
10.1/12.7 = 80 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-16 (R1)

RETEC

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **8.3**	Penetration Depth (ft): **13.5**
Client: **LDWG**	Water Depth (ft): **32.3**	Sample Quality: **Good**
Collection Date: **2/13/06**	Mudline Elevation (ft): **-24.6**	Recovery in ft (%): **10.8 (80)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **206669** E./LONG: **1267959**	Process Date: **2/14/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher, L.McKee**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC16-0-2	76% (0-1)	PCB SVOC Metals Hg	0	ML: (0.0-0.3) wet, very soft, olive gray, SILT, few sand and trace shell fragments.	Transitional Contact	0
1					MH: (0.3-2.2) moist to wet, medium soft, black (GLEY 1, 2.5/N) SILT. Scattered twigs, rootlets, and worm tubes from 0.8' to 2.0'. @ 0.5' 3/4" piece of thin, white plastic (garbage bag) @ 1.3' to 2.0' trace 1/16" sheen florets	GT @ 0.8'	1
2	LDW-SC16-2-4	100% (1-4)			MH: (2.2-3.2) moist, soft, dark greenish gray (GLEY 2, 4/10G) SILT, little clay. Scattered horizontal, thin, black seams of SILT, little clay.	Sharp Contact GT @ 2.5'	2
3			PCB SVOC Metals Hg	0	ML: (3.2-7.4) moist, medium stiff, black (GLEY 1 2.5/N) SILT, few clay. Trace gravel from 3.3' to 3.4'. Grading to silt below 4.0'. Silt texture is blocky. Scattered wood fragments, twigs, and rootlets. Slightly mottled SILT, few clay and 1/4" to 1/2" silt inclusions from 5.0' to basal contact.	Sharp Contact @ 3.0' TV = 1.5 kg/cm2	3
4	LDW-SC16-4-6	100% (4-6)			@ 4.0' to 7.4' trace HC-like odor and sheen		4
5			PCB SVOC Metals Hg	0		@ 5.0' TV = 0.8 kg/cm2	5
6	LDW-						6

recent

upper alluvium

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1011 SW Klickitat Way, Suite 207
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Fax: (206) 624-2839

Remarks: **Drive Notes: freefall (3.8'), easy (8.1'), easy to moderate, (13.5'), penetration goal reached. One drive attempt made at station. Core catcher was intact and 100% full with a silty plug.**

Calculated Recovery
Sample Length/Penetration Length:
10.8/ 13.5 = 80 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-16 (R1)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **8.3**	Penetration Depth (ft): **13.5**
Client: **LDWG**	Water Depth (ft): **32.3**	Sample Quality: **Good**
Collection Date: **2/13/06**	Mudline Elevation (ft): **-24.6**	Recovery in ft (%): **10.8 (80)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **206669** E./LONG: **1267959**	Process Date: **2/14/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher, L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	SC16-9-8	80% (6-8)		0	SP-SC: (7.4-13.5) moist, medium dense, very dark gray (10YR, 3,1) fine SAND mottled with pockets of SILT, few sand. Sand grains are multicolored (orange, red, white) and coarsen with depth. Scattered wood fragments.	Sharp Contact	7
8	LDW-SC16-8-10				@ 8.5' medium SAND with moderate wood fragments		8
9		85% (8-10)	PCB SVOC Metals Hg	0		@ 9.0' TV = 0.8 kg/cm2	9
10	SC16-10-10.8				@ 9.5' Unit grades to alternating 1/8" to 1/4" thick interbeds of very dark gray fine SAND and gray SILT.		10
				0	End of core at 10.8'.		
11		62% (10-12)					11
12		36% (12-13.5)					12
13							13

lower alluvium

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Remarks: **Drive Notes: freefall (3.8'), easy (8.1'), easy to moderate, (13.5'), penetration goal reached. One drive attempt made at station. Core catcher was intact and 100% full with a silty plug.**

Calculated Recovery
Sample Length/Penetration Length:
10.8/ 13.5 = 80 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-17 (R5)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **14.0**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **13.0**
Client: **LDWG**	Water Depth (ft): **20.0**	Sample Quality: **Good**
Collection Date: **2/23/06**	Mudline Elevation (ft): **-15.1**	Recovery in ft (%): **8.6 (66)**
Contractor: **MSS**	N./LAT: **47 33.3761** E./LONG: **122 20.3911**	Process Date: **2/24/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3.5" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth; (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC17-0-1	66% (0-13)	PCB SVOC Metals Hg	0	ML: (0.0-0.9) wet, soft, olive brown (2.5Y, 4/3) SILT, little sand.	Winnowing @ 0.2' (70%)	0
1	LDW-SC17-1-2		PCB SVOC Metals Hg	0	OL: (0.9-12.3) damp to wet, medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT, few sand and scattered layers of moist, medium stiff, dark grayish brown (2.5Y, 4/2) ORGANIC SILT, little clay. Silt texture is uniform, slightly compressible, massive, blocky, and of low plasticity. Trace pockets of peat and subrounded gravel with HC-like odor. Scattered shell fragments, rootlets, layers of wood and abundant debris with HC-like odor.	Transitional Contact @ 0.9' TV = 0.02 kg/cm2 GT @ 1.2'	1
2	LDW-SC17-2-4		PCB SVOC Metals Hg	0	@ 1.4' to 1.8' A layer of shell fragments, rootlets, and wood fragments up to 1" L with a 2" piece of red, crumbly conglomerate, slight HC-like odor and rainbow sheen.	@ 1.8' TV = 0.1 kg/cm2 GT @ 2.3'	2
3			PCB SVOC Metals Hg	0	@ 2.4' A 0.2' thick layer of shell fragments, rootlets, and wood fragments up to 1" L, 1-1/4" x 1/8" anthropogenic conglomerate with strong HC-like odor and sheen, 7" piece of plastic (tape), and a piece of subrounded multicolored glass 1/2" L.	Bag @ 2.6' (1/2" subrounded glass) Bag @ 3.2' (2" foliated red chip)	3
4	LDW-SC17-4-6				@ 3.2' to 4.5' A 2" piece of foliated red chip (possibly paint), 0.6' piece of plastic (tape), and wood fragment 0.5 x 0.2'. Slight to strong HC-like odor, rainbow streaks and florets up to 1/4" in diameter.		4
5				0		@ 4.6' TV = 0.02 kg/cm2	5
6					@ 5.2' to 5.7' A 0.1' layer of wood, 2" pocket of peat, and 0.2' x 0.1' pieces of cloth with slight to moderate HC-like odor.		6

recent

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Remarks: **Drive Notes: freefall (7.0'), moderate (10.0'), easy to moderate (14.0'), penetration goal reached. Five drive attempts made at station. Station re-occupied with vibracore. Rainbow sheen and strong HC-like odor on sidewalls from 2.0' to 6.0'. ua = upper alluvium**

Calculated Recovery
Sample Length/Penetration Length:
8.6 / 13.0 = 66 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-17 (R5)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **14.0**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **13.0**
Client: **LDWG**	Water Depth (ft): **20.0**	Sample Quality: **Good**
Collection Date: **2/23/06**	Mudline Elevation (ft): **-15.1**	Recovery in ft (%): **8.6 (66)**
Contractor: **MSS**	N./LAT: **47 33.3761** E./LONG: **122 20.3911**	Process Date: **2/24/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3.5" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	DW-SC17-6.8-8.2		PCB SVOC Metals Hg	0	@ 7.0' to 8.1' Wood fragments, 1 piece of 0.1' L subrounded gravel, 1" peat pocket, and foliated red chips (possibly paint) with slight to moderate HC-like odor.		7
8						Transitional Contact	8
9					SM: (12.3-13.0) damp, medium dense, dark gray (GLEY 1, 3/N) fine SAND and layers of black SILT. SAND grains are multicolored (orange, red, white). SILT has slight HC-like odor. Trace debris at basal contact (foliated red chips; transitional unit).		9
10					End of core @ 8.6'.		10
11					Note: Chemistry interval recorded as 8.2 ft but sample was collected to the bottom of the core at 8.6 ft. Graphic expresses depth of sample collection; sample name matches project nomenclature.		11
12							12
13							13

ua

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Remarks: **Drive Notes: freefall (7.0'), moderate (10.0'), easy to moderate (14.0'), penetration goal reached. Five drive attempts made at station. Station re-occupied with vibracore. Rainbow sheen and strong HC-like odor on sidewalls from 2.0' to 6.0'. ua = upper alluvium**

Calculated Recovery
Sample Length/Penetration Length:
8.6 / 13.0 = 66 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-18 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **4.6**	Penetration Depth (ft): **11.8**
Client: **LDWG**	Water Depth (ft): **27.6**	Sample Quality: **Good**
Collection Date: **2/16/06**	Mudline Elevation (ft): **-19.4**	Recovery in ft (%): **10.7 (91)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **206336** E./LONG: **1267929**	Process Date: **2/17/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC18-0-1	65% (0-1)	PCB SVOC Metals Hg	0	ML: (0.0-0.1) wet, soft, olive brown (2.5Y, 4/3) SILT, few sand.	Sharp Contact	0
1	LDW-SC18-1-2	89% (1-3)	PCB SVOC Metals Hg	0	SP- SM: (0.1-3.8) damp to moist, [medium dense], black (2.5Y, 2.5/1) fine SAND interbedded with distinct layers of moist, soft, dark greenish gray (GLEY 1, 4/10Y) SILT up to 0.2' thick. SAND grains are well sorted and multicolored (orange, red, white). Scattered trace debris (glass). @ 0.8' glass shard 0.2' L	Bag @ 0.8' (glass shard)	1
2	LDW-SC18-2-4				@ 1.5' subangular rock 0.3' L	GT @ 1.2'	2
3		100% (3-4)	PCB SVOC Metals Hg	0		GT @ 3.2'	3
4	LDW-SC18-4-6				ML: (3.8-6.2) damp, soft, dark greenish gray (GLEY 1, 4/10Y) SILT, few sand interbedded with 0.05' thick layers of damp, medium dense, black (2.5Y, 2.5/1) very fine to fine SAND. SILT texture is slightly compressible and of low plasticity.	Transitional Contact	4
5		91% (4-7)		0	@ 5.5' scattered shell fragments		5
6	LDW-				SP- SM: (6.2-9.6) wet, medium dense, black (2.5Y, 2.5/1) very fine SAND alternating with layers of dark greenish gray (GLEY 1, 4/10Y) SILT, little clay.	Transitional Contact	6

upper alluvium

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Remarks: **Drive Notes: freefall (0.8'), moderate (9.8'), moderate to hard (10.8'), hard (11.8'), refusal (11.8'). One drive attempt made at station. Core catcher was intact and 100% full. No torvane measurements recorded. r = recent**

Calculated Recovery
Sample Length/Penetration Length:
10.7/ 11.8 = 91 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-18 (R1)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **4.6**	Penetration Depth (ft): **11.8**
Client: **LDWG**	Water Depth (ft): **27.6**	Sample Quality: **Good**
Collection Date: **2/16/06**	Mudline Elevation (ft): **-19.4**	Recovery in ft (%): **10.7 (91)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **206336** E./LONG: **1267929**	Process Date: **2/17/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	SC18-8-8	100% (6-9)		0			lower alluvium
8					@ 8.6' 1" thick layer of wood fragments up to 3/4" L		
9	LDW-SC18-8-10.7	91% (9-10)		0	SP- SM: (9.6-11.8) moist, dense, black (2.5Y, 2.5/1) fine SAND, few silt and layers of dark greenish gray (GLEY 1, 4/10Y) SILT, few sand. Layers alternate every 0.1', are tightly spaced, and are convex in shape from 9.9' to 10.7'.		
10		90% (10-11)					
					End of core at 10.7'. Driven to refusal.		
11		60% (11-11.8)					

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Remarks: **Drive Notes: freefall (0.8'), moderate (9.8'), moderate to hard (10.8'), hard (11.8'), refusal (11.8'). One drive attempt made at station. Core catcher was intact and 100% full. No torvane measurements recorded. r = recent**

Calculated Recovery
Sample Length/Penetration Length:
10.7/ 11.8 = 91 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-19 (R5)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **14.0**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **13.0**
Client: **LDWG**	Water Depth (ft): **34.6**	Sample Quality: **Good**
Collection Date: **2/24/06**	Mudline Elevation (ft): **-25.3**	Recovery in ft (%): **11.9 (92)**
Contractor: **MSS**	N./LAT: **47 33.3172** E./LONG: **122 20.7486**	Process Date: **2/24/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83** N Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3.5" round Alum**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0–1	LDW-SC19-0-1	93% (0-13)	PCB, SVOC, Metals, Hg, Dioxins/Furans	0	OL: (0.0-7.5') moist to damp, medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT, few sand with mottled olive-brown ORGANIC SILT, little clay. SILT texture is slightly compressible and of low plasticity. Scattered wood fragments up to 3" L, rootlets and shell fragments, trace worms and worm tubes in top 0.7', and slight H2S-like odor.	@ 0.9' TV = 0.1 kg/cm2	recent
1–2	LDW-SC19-1-2		PCB, SVOC, Metals, Hg, Dioxins/Furans	0	@ 1.9' rainbow sheen florets up to 1/4" and wood fragments up to 1" L	GT @ 2.2'	
2–3	LDW-SC19-2-4					@ 2.6' TV = 0.2 kg/cm2	
3–4			PCB, SVOC, Metals, Hg, Dioxins/Furans	0		GT @ 3.1'	
4–5	LDW-SC19-4-6					@ 3.7' TV = 0.2 kg/cm2	
5–6			PCB	0			
6	LDW-SC19-6-7		PCB	0			

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Remarks: **Drive Notes: freefall (6.0'), moderate (6.5'), easy (13.0'), penetration goal reached. Five drive attempts made at station. Station re-occupied with vibracore. Core catcher was intact intact but empty. Rainbow sheen on sidewalls from 0.8' to 7.0'.**

Calculated Recovery
Sample Length/Penetration Length:
11.9/ 13.0 = 92 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-19 (R5)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **14.0**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **13.0**
Client: **LDWG**	Water Depth (ft): **34.6**	Sample Quality: **Good**
Collection Date: **2/24/06**	Mudline Elevation (ft): **-25.3**	Recovery in ft (%): **11.9 (92)**
Contractor: **MSS**	N./LAT: **47 33.3172** E./LONG: **122 20.7486**	Process Date: **2/24/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3.5" round Alum**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth; (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7					SW: (7.5-8.1) [wet, dense] black (2.5Y, 2.5/1) SAND, little gravel. Gravel is subrounded to subangular up to 1" diameter. Slight H2S-like odor.	Transitional Contact	7
8	LDW-SC19-7.5-9			0	ML: (8.1-9.2) [moist to damp, medium stiff,] black (2.5Y, 2.5/1) SILT interbedded with gray-brown very fine SAND.	Transitional Contact	8
9					ML: (9.2-9.7) [damp, medium stiff,] very dark greenish gray (GLEY 1, 3/1) SILT, little clay and 1/2" diameter peat pocket. Silt texture is slightly compressible and of low plasticity.		9
10	LDW-SC19-9.1-11.9		PCB	0	SW: (9.7-13.0) moist, medium dense, medium grading to fine SAND, little gravel. Sand grains are multicolored (orange, red, white). Gravel is subrounded up to 1/4" in diameter.	Sharp Contact	10
11							11
12					End of core at 11.9'.		12
13							13

upper alluvium

lower alluvium

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Remarks: **Drive Notes: freefall (6.0'), moderate (6.5'), easy (13.0'), penetration goal reached. Five drive attempts made at station. Station re-occupied with vibracore. Core catcher was intact intact but empty. Rainbow sheen on sidewalls from 0.8' to 7.0'.**

Calculated Recovery
Sample Length/Penetration Length:
11.9/ 13.0 = 92 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-20 (R1)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **7.4**	Penetration Depth (ft): **12.6**
Client: **LDWG**	Water Depth (ft): **43.5**	Sample Quality: **Good**
Collection Date: **2/15/06**	Mudline Elevation (ft): **-33.9**	Recovery in ft (%): **10.0 (79)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **206177** E./LONG: **1267735**	Process Date: **2/15/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (Interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC20-0-2	100% (0-4)	PCB SVOC Metals Hg Pesticides TBT Dioxins/ Furans	0	ML: (0.0-0.1) moist, soft, olive brown (2.5Y, 4/3) SILT, few sand.	Transitional Contact	recent
1					OL: (0.1-2.1) moist, [medium stiff], black (2.5Y, 2.5/1) ORGANIC SILT with trace subrounded gravel up to 0.6" diameter. Scattered rootlets, leaf and wood fragments up to 2" L. Slight HC-like sheen and moderate HC-like odor.	GT @ 0.9' @ 1.1' TV = 0.2 kg/cm2	
2	LDW-SC20-2-4				OL: (2.1-3.7) moist, [medium stiff,] black (2.5Y, 2.5/1) ORGANIC SILT, few sand interbedded with 0.6" thick seams of convex, moist, stiff, gray (2.5Y, 5/1) SILT, little clay. Slight rainbow sheen and HC-like odor to 3.5 feet.	Transitional Contact	
3			PCB SVOC Metals Hg Pesticides TBT Dioxins/ Furans	0	@ 2.5' layer of moist, dense, black, fine SAND	GT @ 2.9'	
4					OL: (3.7-4.1) moist, medium stiff, very dark greenish gray (GLEY 1, 3/1), SILT, little clay. Slight H2S-like odor.	@ 3.9' TV = 0.2 kg/cm2	
5	LDW-SC20-4-6	95% (4-8)	PCB Dioxins/ Furans	0	ML: (4.1-12.6) moist, [stiff,] black (2.5Y, 2.5/1) SILT, few fine sand. Silt texture is uniform, slightly compressible, massive, blocky, low plasticity, and rolls easily. Trace small shell fragments up to 0.6" in diameter.		
6	LDW-						

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Remarks: **Drive Notes: freefall (0.2'), moderate (12.6'), penetration goal reached. One drive attempt made at station.**

Core catcher was 50% full.

Calculated Recovery
Sample Length/Penetration Length:
10.0/ 12.6 = 79 %

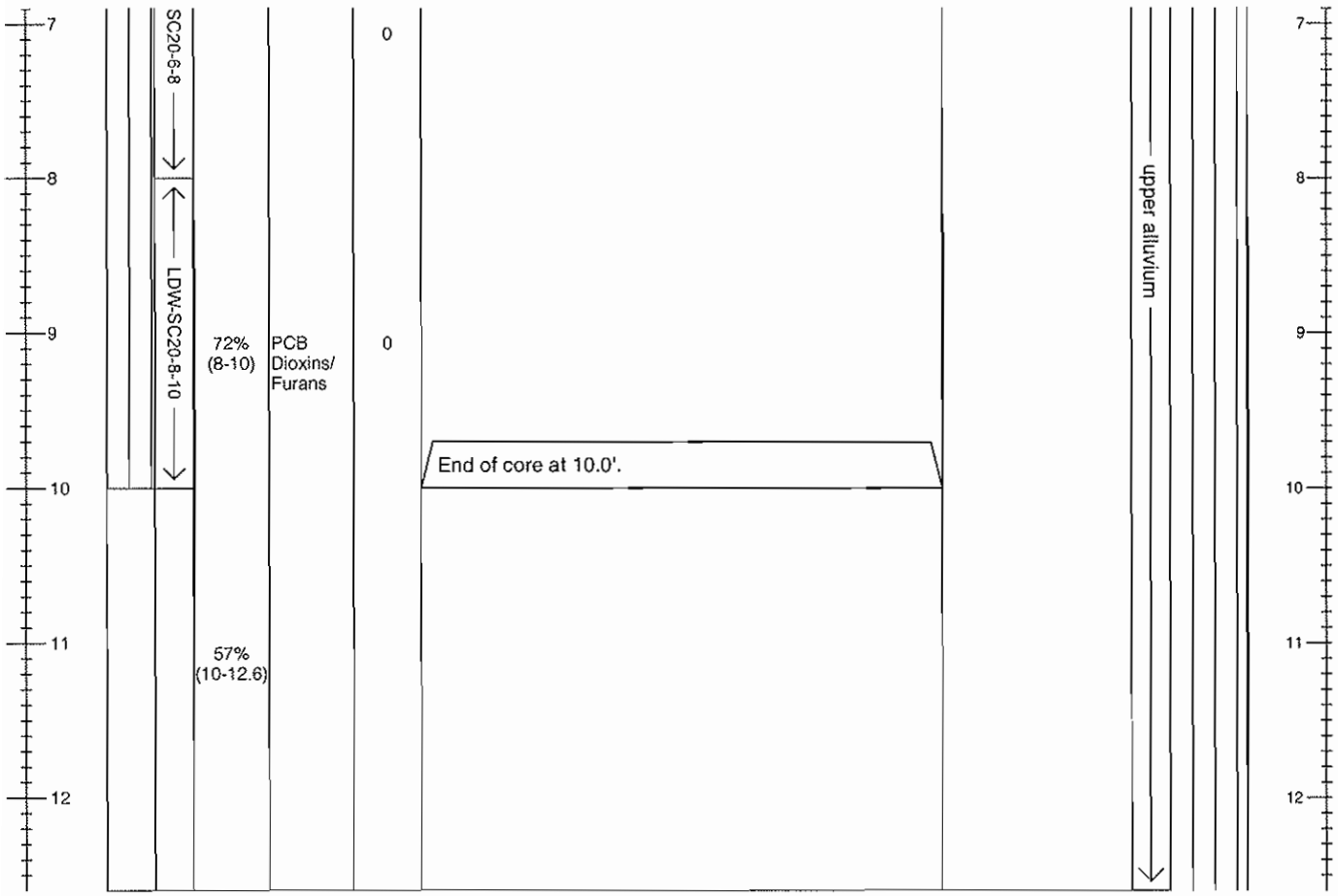
Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-20 (R1)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **7.4**	Penetration Depth (ft): **12.6**
Client: **LDWG**	Water Depth (ft): **43.5**	Sample Quality: **Good**
Collection Date: **2/15/06**	Mudline Elevation (ft): **-33.9**	Recovery in ft (%): **10.0 (79)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **206177** E./LONG: **1267735**	Process Date: **2/15/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83** N Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**



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Remarks: **Drive Notes: freefall (0.2'), moderate (12.6'), penetration goal reached. One drive attempt made at station. Core catcher was 50% full.**

Calculated Recovery
Sample Length/Penetration Length:
10.0/ 12.6 = 79 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-21 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **5.9**	Penetration Depth (ft): **12.7**
Client: **LDWG**	Water Depth (ft): **34.1**	Sample Quality: **Good**
Collection Date: **2/14/06**	Mudline Elevation (ft): **-28.5**	Recovery in ft (%): **11.3 (89)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **206167** E./LONG: **1267486**	Process Date: **2/15/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **A. Fitzpatrick, L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC21-0-1	100% (0-0.5)	PCB SVOC Metals Hg	0	ML: (0.0-0.5) moist, medium stiff, olive brown (2.5Y, 4/3) fine SANDY SILT.		0
1	LDW-SC21-1-2	100% (0.5-3)			OL: (0.5-5.1) moist, medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT, trace fine sand. Silt texture is uniform, slightly compressible, massive, and of low plasticity. Scattered wood fragments and slight H2S-like odor.	Transitional Contact @ 0.8' TV = 0.4 kg/cm2 GT @ 1.1'	1
2	LDW-SC21-2-4		PCB SVOC Metals Hg			GT @ 2.2'	2
3			PCB SVOC Metals Hg	0			3
4	LDW-SC21-4-6.2	100% (3-6)			@ 3.6' 2" layer of fine sand @ 4.5' moderate H2S-like odor		4
5			PCB	0	ML: (5.1-6.5) moist, medium stiff, black (2.5Y, 2.5/1) SILT, few sand with clasts and layers of moist, stiff, gray (2.5Y, 5/1) medium SILT, little clay up to 0.1' L. Scattered layers of moist, black fine sand (transitional unit).	Transitional Contact @ 5.6' TV = 0.6 kg/cm2	5
6	LDW				SP- SM: (6.5-10.1) moist, dense, grayish brown (2.5Y, 5/2) medium to fine SAND interbedded with layers of black SANDY SILT. Scattered wood fragments up to 4" L and scattered wood layers up to	Sharp Contact	6

recent

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Remarks: **Drive Notes: freefall (0.5'), easy to moderate (8.0'), moderate, (10.0'), hard (12.7'), penetration goal reached. One drive attempt made at station. Core catcher was empty with 0.2' lost from bottom.**

Calculated Recovery
Sample Length/Penetration Length:
11.3/12.7 = 89 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-21 (R1)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **5.9**	Penetration Depth (ft): **12.7**
Client: **LDWG**	Water Depth (ft): **34.1**	Sample Quality: **Good**
Collection Date: **2/14/06**	Mudline Elevation (ft): **-28.5**	Recovery in ft (%): **11.3 (89)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **206167** E./LONG: **1267486**	Process Date: **2/15/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **A. Fitzpatrick, L.McKee**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	LDW-SC21-6.2-8	96% (6-8)		0	2" thick. Grades to coarse SAND and trace wood at basal contact.		upper alluvium
8							
9	LDW-SC21-8-10	81% (8-10)		0	SP: (10.1-12.7) moist, dense, very dark greenish gray (GLEY 1, 3/1) medium SAND with multicolored grains (white, red, orange). Scattered wood layers up to 0.1' thick with orange-brown shredded wood fragments.	@ 9.5' TV = 0.9 kg/cm2 Transitional Contact	
10					@ 11.0' non-lumbered wood piece		
11	LDW-SC21-10-11.3	57% (10-12.7)	PCB		End of core at 11.3'.	Lost 0.2 feet of unit.	lower alluvium
12							

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Remarks: **Drive Notes: freefall (0.5'), easy to moderate (8.0'), moderate, (10.0'), hard (12.7'), penetration goal reached. One drive attempt made at station. Core catcher was empty with 0.2' lost from bottom.**

Calculated Recovery
Sample Length/Penetration Length:
11.3/12.7 = 89 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-22 (R1)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **9.1**	Penetration Depth (ft): **9.3**
Client: **LDWG**	Water Depth (ft): **12**	Sample Quality: **Good**
Collection Date: **2/13/06**	Mudline Elevation (ft): **-3.4**	Recovery in ft (%): **7.7 (83)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **205908** E./LONG: **1268174**	Process Date: **2/14/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher, L.McKee**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC22-0-1.1	100% (0-3)	PCB SVOC Metals Hg	0	SM: (0.0-1.3) wet, loose, dark yellowish brown (10/YR, 4/4) medium SAND, few silt. Sand grains are multicolored (orange, red, white). Trace debris (brick fragments) and 1" diameter pocket of brown woody SILT (possibly peat).	GT @ 0.7'	recent
1	LDW-SC22-1.1-2		PCB SVOC Metals Hg	0	SM: (1.3-2.0) moist, medium dense, greenish black (GLEY 1, 2.5/10Y) medium SAND, few silt and moderate wood fragments up to 1.5" L. Sand grains are multicolored (orange, red, white). Moderate creosote-like sheen from 0.9' to 1.1' and moderate HC-like staining and odor to 1.1'.	Transitional Contact Transitional Contact GT @ 1.9'	
2	LDW-SC22-2-4				SP-SM: (2.0-9.3) moist, medium dense, black (GLEY 1, 2.5/N) fine SAND with pockets and lenses of gray SILT, few sand up to 1/2" L. Sand grains are multicolored (red, orange, white) and grade to medium below 6.5'. Trace scattered debris (brick fragment) and trace wood fragments up to 2" L. Trace pockets of brown peaty silt up to 1/2" diameter.		upper alluvium
3			PCB SVOC Metals Hg	0		@ 3.0' TV = 0.6 kg/cm2	
4	LDW-SC22-4-6	95% (3-7)			@ 3.6' one 3" L red brick fragment		
5				0	@ 5.1' trace 1/4" diameter pocket of brown peaty material	@ 5.0' TV = 0.7 kg/cm2	
6	LDW-SC2					Winnowing from 5.7' to 6.9'.	

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Remarks: **Drive Notes: no freefall, easy (7.0'), moderate (8.0'), hard (9.0'), refusal (9.3'). One drive attempt made at station.**

Calculated Recovery
Sample Length/Penetration Length:
7.7 / 9.3 = 83 %

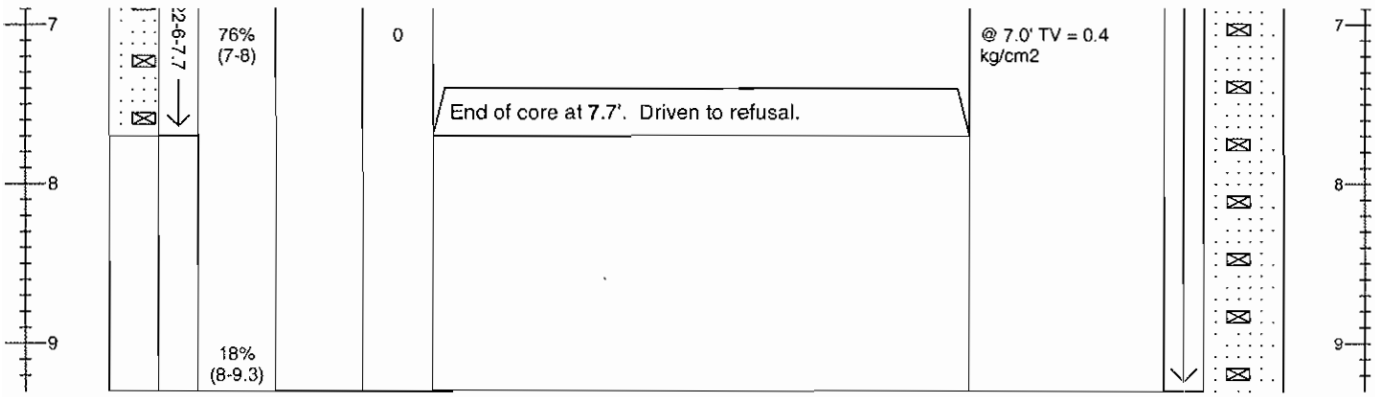
Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-22 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **9.1**	Penetration Depth (ft): **9.3**
Client: **LDWG**	Water Depth (ft): **12**	Sample Quality: **Good**
Collection Date: **2/13/06**	Mudline Elevation (ft): **-3.4**	Recovery in ft (%): **7.7 (83)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **205908** E./LONG: **1268174**	Process Date: **2/14/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83** N Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher, L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	2.6-7.7	76% (7-8)		0		@ 7.0' TV = 0.4 kg/cm2	7
					End of core at 7.7'. Driven to refusal.		
8							8
9		18% (8-9.3)					9



The RETEC Group, Inc. 1011 SW Klickitat Way, Suite 207 Seattle, WA 98134-1162 Phone: (206) 624-9349 Fax: (206) 624-2839	**Remarks:** **Drive Notes: no freefall, easy (7.0'), moderate (8.0'), hard (9.0'), refusal (9.3'). One drive attempt made at station.**	**Calculated Recovery** Sample Length/Penetration Length: **7.7 / 9.3 = 83 %**

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-23 (R1)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **2.1**	Penetration Depth (ft): **12.4**
Client: **LDWG**	Water Depth (ft): **23.2**	Sample Quality: **Good**
Collection Date: **2/16/06**	Mudline Elevation (ft): **-18.7**	Recovery in ft (%): **10.7 (86)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **205418** E./LONG: **1268229**	Process Date: **2/17/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC23-0-2	94% (0-1)	PCB SVOC Metals Hg Pesticides TBT	0	ML: (0.0-0.5) wet, very soft, olive brown (2.5Y, 4/3) SILT and trace debris (piece of concrete).	@ 0.0 to 1.0' Sheen Test: no sheen	recent
1					OL: (0.5-5.3) moist, medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT with trace shell and wood fragments. Silt texture is uniform, slightly compressible, massive, blocky, and of low plasticity. Slight H2S-like odor. Scattered layers of very dark greenish gray (GLEY 1, 3/1) SILT, little clay up to 3" thick.	Transitional Contact GT @ 0.9' @ 0.9' TV = 0.6 kg/cm2	
2	LDW-SC23-2-4	100% (1-3)	PCB SVOC Metals Hg Pesticides TBT	0	@ 1.8' 4" thick layer of stiff, black SILT, little sand and few gravel up to 1/2" in diameter	@ 1.0 to 2.0' Sheen Test: no sheen	
3						GT @ 2.9' @ 2.9' TV = 0.6 kg/cm2	
4	LDW-SC23-4-6	100% (3-5)	PCB SVOC TBT	0		@ 4.4' TV = 0.3 kg/cm2	
5					ML: (5.3 -6.4) moist, [medium stiff,] very dark greenish gray (GLEY 1, 3/5GY) SILT, few clay. Silt texture is slightly compressible and rolls easily. Slight H2S-like odor.		
6	LDW-	100% (5-7)	PCB	0	OL: (6.4-9.6) [moist, medium stiff] very dark greenish gray (GLEY 1, 3/5GY) ORGANIC SILT, trace clay. Silt texture is slightly compressible, rolls well. Slight H2S-like odor.		

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Remarks: **Drive Notes: freefall (1.6'), easy (10.4'), moderate (12.4'), penetration goal reached. One drive attempt made at station. Torvane had restricted maneuverability due to freezing.**

Calculated Recovery
Sample Length/Penetration Length:
10.7/ 12.4 = 86 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-23 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **2.1**	Penetration Depth (ft): **12.4**
Client: **LDWG**	Water Depth (ft): **23.2**	Sample Quality: **Good**
Collection Date: **2/16/06**	Mudline Elevation (ft): **-18.7**	Recovery in ft (%): **10.7 (86)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **205418** E./LONG: **1268229**	Process Date: **2/17/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83** N Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	SC23-6-8					@ 7.0' TV = 0.8 kg/cm2	7
8		85% (7-9)	PCB	0			8
9	LDW-SC23-6-10.2	85% (9-10)			ML: (9.6-12.4) moist, medium stiff, gray (2.5Y, 5/1) SILT, few clay and chunky clay balls. Scattered wood and shell fragments up to 1" L and [slight] H2S-like odor.	Transitional Contact	9
10		65% (10-10.7)			End of core at 10.7'. Driven to refusal.	Not sampled below 10.2'.	10
11							11
12							12

upper alluvium

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Remarks: **Drive Notes: freefall (1.6'), easy (10.4'), moderate (12.4'), penetration goal reached. One drive attempt made at station. Torvane had restricted maneuverability due to freezing.**

Calculated Recovery
Sample Length/Penetration Length:
10.7/ 12.4 = 86 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-24 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **6.1**	Penetration Depth (ft): **12.2**
Client: **LDWG**	Water Depth (ft): **26.3**	Sample Quality: **Good**
Collection Date: **2/17/06**	Mudline Elevation (ft): **-20.4**	Recovery in ft (%): **11.8 (97)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **205130** E./LONG: **1267860**	Process Date: **2/17/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC24-0-1	65% (0-1)	PCB SVOC Metals Hg	0	OL: (0.0-1.3) wet, soft, black (2.5Y, 2.5/1) ORGANIC SILT, little sand and few wood fragments less than 1/2". Abundant worms.		recent
1	LDW-SC24-1-2		PCB SVOC Metals Hg	0	SP-SM: (1.1-3.4) damp, [medium dense], black (2.5Y, 2.5/1) fine SAND interbedded with 1" thick layers and pockets of wet, medium stiff, dark greenish gray (GLEY 1, 4/10Y) SILT, few sand. Sand grains are multicolored (orange, red, white).	GT @ 0.9' Gradational Contact @1.3' TV = 0.2 kg/cm2	upper alluvium
2	LDW-SC24-2-4	100% (1-2)					
3			PCB SVOC Metals Hg	0		GT @ 2.8'	
4	LDW-SC24-4-6	100% (2-5)			SM: (3.3-9.4) damp, dense, black (2.5Y, 2.5/1) medium SAND with scattered thin layers up to 1/4" thick of dark greenish gray (GLEY 1 4/10Y) SILT, few clay that decrease with depth. Scattered wood fragments up to 0.2" L. Grades to lower unit.	Sharp Contact @ 3.6' TV = 0.4 kg/cm2	
5				0	@ 6.0' to 7.0' slight H2S-like odor	@ 5.4' TV = 0.6 kg/cm2	
6	LDW-	100% (5-7)					lower alluvium

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Remarks: **Drive Notes: freefall (1.0'), easy (7.0'), moderate (11.0'), hard (12.2'), penetration goal reached. One drive attempt made at station. Core catcher was 100 % full.**

Calculated Recovery
Sample Length/Penetration Length:
11.8/ 12.2 = 97 %

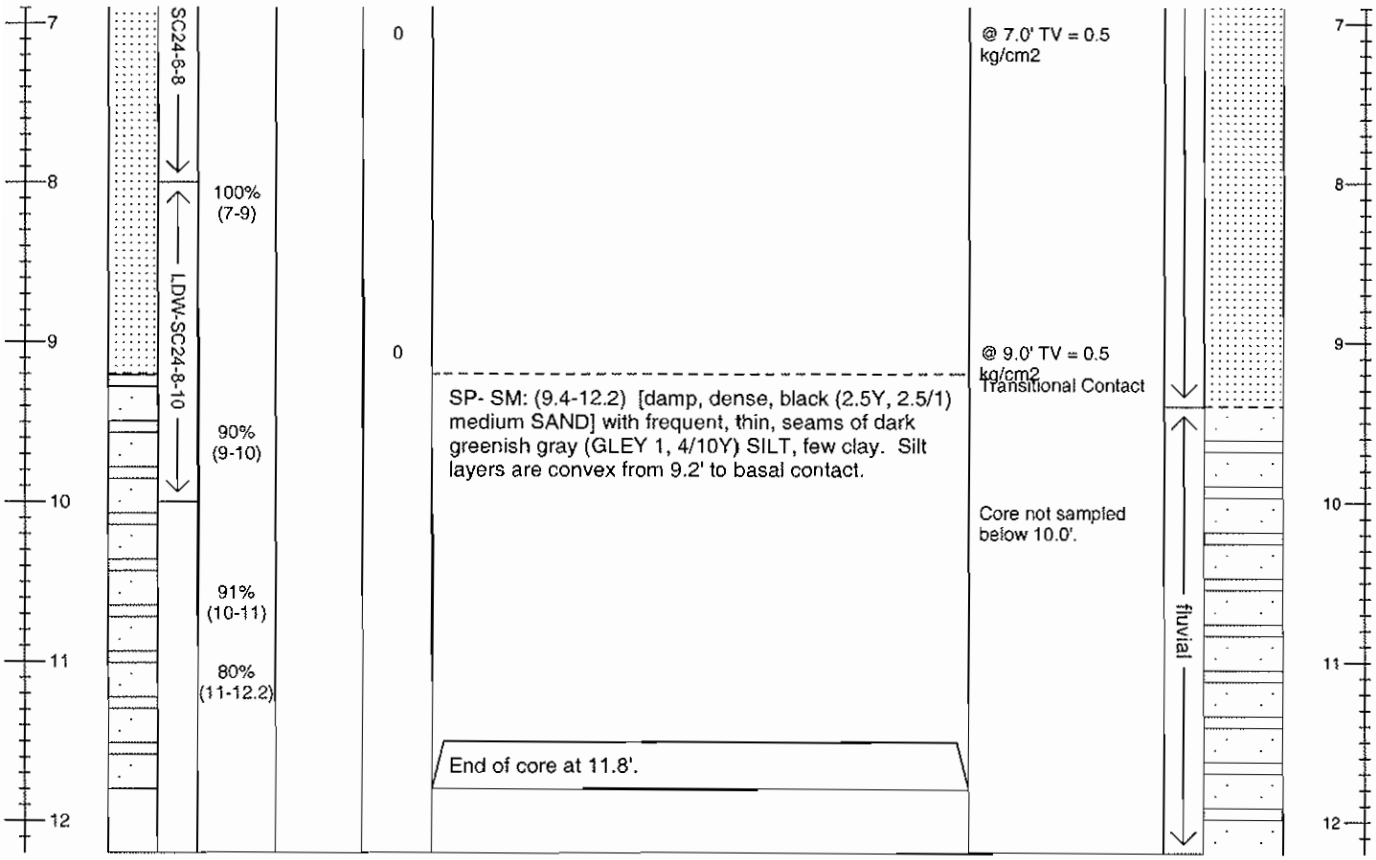
Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-24 (R1)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **6.1**	Penetration Depth (ft): **12.2**
Client: **LDWG**	Water Depth (ft): **26.3**	Sample Quality: **Good**
Collection Date: **2/17/06**	Mudline Elevation (ft): **-20.4**	Recovery in ft (%): **11.8 (97)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **205130** E./LONG: **1267860**	Process Date: **2/17/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**



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Remarks: **Drive Notes: freefall (1.0'), easy (7.0'), moderate (11.0'), hard (12.2'), penetration goal reached. One drive attempt made at station. Core catcher was 100 % full.**

Calculated Recovery
Sample Length/Penetration Length:
11.8/ 12.2 = 97 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-25 (R2)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **18.7**	Penetration Depth (ft): **10.3**
Client: **LDWG**	Water Depth (ft): **18.7**	Sample Quality: **Good**
Collection Date: **2/17/06**	Mudline Elevation (ft): **-15.2**	Recovery in ft (%): **9.1 (88)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **204751** E./LONG: **1267980**	Process Date: **2/18/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC25-0-1	67% (0-1)	PCB SVOC Metals Hg TBT	0	ML: (0.0-0.4) very wet, very soft, black (2.5Y, 2.5/1) SILT, few sand and trace wood fragments up to 4" L. Trace leaf stems and worms.		0
1	LDW-SC25-1-2		PCB SVOC Metals Hg TBT	0	OL: (0.4-5.5) wet, soft to medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT with substantial wood fragments up to 1.2" L. Silt texture is uniform, compressible, blocky, and of low plasticity. Substantial 4" L layers of shredded wood fragments. Wood matter increases from 4.0' to basal contact.	GT @ 1.4'	1
2	LDW-SC25-2-4	100% (1-3)			@ 1.8' clear glass shard and black clast 1" in diameter @ 2.0' slight H2S-like odor	@1.8' TV = 0.2 kg/cm2 Bag @ 1.8' (black clast)	2
3			PCB SVOC Metals Hg TBT	0		GT @ 3.2'	3
4		100% (3-5)				@ 3.6' TV = 0.4 kg/cm2	4
5	LDW-SC25-4-6		SVOC Metals TBT	0	ML: (5.5-6.6) moist, medium stiff, black (2.5Y, 2.5/1) SILT with scattered small, stiff, gray SILT clasts up to 1/2" diameter and trace medium SAND pockets 1" in diameter. Moderate rootlets, twigs, and organics.		5
6	LDW-	90% (5-7)			SP-SM: (6.6-8.6) moist to wet, medium dense, black (2.5Y, 2.5/1) medium SAND, few silt with scattered pockets of soft, gray CLAY, little silt up to 2" diameter.	Transitional Contact @ 6.6' TV = 0.3 kg/cm2	6

recent

upper

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Remarks: **Drive Notes: freefall (1.5'), easy (7.0'), moderate (9.0'), hard (10.3'), refusal (10.3'). Two drive attempts made at station. Core catcher was 80% full. Slight slumping below 8.3'.**

Calculated Recovery
Sample Length/Penetration Length:
9.1 / 10.3 = 88 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-25 (R2)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **18.7**	Penetration Depth (ft): **10.3**
Client: **LDWG**	Water Depth (ft): **18.7**	Sample Quality: **Good**
Collection Date: **2/17/06**	Mudline Elevation (ft): **-15.2**	Recovery in ft (%): **9.1 (88)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **204751** E./LONG: **1267980**	Process Date: **2/18/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	SC25-8-8			0			upper alluvium
8	LDW-SC25-8-9.1	69% (7-9)	PCB Metals TBT	0	SP: (8.6-10.3) moist to wet, medium dense, black (2.5, 2.5/1) grading to greenish black (GLEY 1, 2.5/1) medium SAND. Sand grains are multicolored (orange, red, white) and well sorted.	@ 7.9' TV = 0.2 kg/cm2	
9		80% (9-10)			End of core at 9.1'. Driven to refusal.		lower alluvium
10		88% (10-10.3)					

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Remarks: **Drive Notes: freefall (1.5'), easy (7.0'), moderate (9.0'), hard (10.3'), refusal (10.3'). Two drive attempts made at station. Core catcher was 80% full. Slight slumping below 8.3'.**

Calculated Recovery
Sample Length/Penetration Length:
9.1 / 10.3 = 88 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-26 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **18.7**	Penetration Depth (ft): **14.6**
Client: **LDWG**	Water Depth (ft): **35.4**	Sample Quality: **Good**
Collection Date: **2/22/06**	Mudline Elevation (ft): **-26**	Recovery in ft (%): **12.3 (84)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **204479** E./LONG: **1268157**	Process Date: **2/22/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC26-0-1	81% (0-1)	PCB SVOC Metals Hg TBT Dioxins/ Furans	0	OL: (0.0-0.6) wet, soft, olive brown (2.5Y, 4/3) ORGANIC SILT, few sand and trace worms.		0
1	LDW-SC26-1-2		PCB SVOC Metals Hg TBT Dioxins/ Furans	0	OL: (0.6-5.3) wet, soft, black (2.5YR, 2.5/1) ORGANIC SILT, few sand and little olive-gray mottled SILT, little clay. Silt texture is slightly compressible and of low plasticity. Trace rootlets, shell fragments, and wood fragments up to 1.2" L.	Transitional Contact @ 0.9' TV = 0.8 kg/cm2 GT @ 1.5'	1
2	LDW-SC26-2-4	93% (1-3)				@ 1.9' TV = 0.3 kg/cm2	2
3			PCB SVOC Metals Hg TBT Dioxins/ Furans	0		@ 3.0' TV = 0.4 kg/cm2	3
4	LDW-SC26-4-6	100% (3-5)			@ 4.5' wood fragments with 1 mm rainbow sheen florets	GT @ 3.9'	4
5				0	SM: (5.3-6.6) wet, medium dense, black (2.5Y, 2.5/1), medium SAND, few silt.	Sharp Contact @ 5.0' TV = 0.2 kg/cm2	5

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Remarks: **Drive Notes: freefall (1.0'), easy (5.0'), moderate (14.6'), penetration goal reached. One drive attempt made at station. Core catcher was 50% full. Rainbow HC-like sheen on sidewalls at 4.6'. Sampled 58' off station around barge.**

Calculated Recovery
Sample Length/Penetration Length:
12.3/14.6 = 84 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-26 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **18.7**	Penetration Depth (ft): **14.6**
Client: **LDWG**	Water Depth (ft): **35.4**	Sample Quality: **Good**
Collection Date: **2/22/06**	Mudline Elevation (ft): **-26**	Recovery in ft (%): **12.3 (84)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **204479** E./LONG: **1268157**	Process Date: **2/22/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
6	LDW-SC26-6-8	75% (5-7)			SW: (6.6-7.7) [moist, dense,] black (2.5Y, 2.5/1) SAND, few gravel. [Sand is medium and multicolored (orange, red, white)]. Gravel is subangular and 1/4" diameter. Few seams of black SILT with wood fragments and rootlets. Strong HC-like odor and sheen on sand and gravel.	Transitional Contact @ 6.5' TV = 0.0 kg/cm2	upper alluvium
7			PCB SVOC Metals Hg TBT Dioxins/ Furans	0	GP: (7.7-9.1) moist, dense, black (2.5Y, 2.5/1) SANDY GRAVEL. Gravel is mostly subangular conglomerate with scattered 1/2 mm orange flecks (anthropogenic) attached. Large gravels have HC-like sheen. Scattered debris. @ 7.6' 1" L foliated chips (possibly paint) @ 7.8' 1" L amber glass	Bag @ 7.6' (1" chips)	
8	LDW-SC26-8-11.1	90% (7-9)			SP-SC: (9.1-13.1) [moist, medium dense,] black (2.5Y, 2.5/1) medium SAND interbedded with layers of [medium stiff,] black SILT and scattered pockets of olive-gray SILT, little clay. Few 2" thick layers of black SILT. Scattered debris.	Sharp Contact	non-native
9				0	@ 9.4' bronze/brass 3/8" nut	@ 9.0' TV = 0.7 kg/cm2	
10		75% (9-11)			@ 10.6' 6" x 1" plastic strips and metal clamp, slight HC-like odor, and 1/4" rainbow sheen florets	Bag @ 10.6' (1" plastic strips and metal clamp)	
11	LDW-	75% (10-13)	PCB Metals		SP-SM: (13.1-14.6) moist, medium dense, very dark greenish gray (GLEY1, 3/1) fine SAND with pockets	Transitional Contact	

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Remarks: **Drive Notes: freefall (1.0'), easy (5.0'), moderate (14.6'), penetration goal reached. One drive attempt made at station. Core catcher was 50% full. Rainbow HC-like sheen on sidewalls at 4.6'. Sampled 58' off station around barge.**

Calculated Recovery
Sample Length/Penetration Length:
12.3/14.6 = 84 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-26 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **18.7**	Penetration Depth (ft): **14.6**
Client: **LDWG**	Water Depth (ft): **35.4**	Sample Quality: **Good**
Collection Date: **2/22/06**	Mudline Elevation (ft): **-26**	Recovery in ft (%): **12.3 (84)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **204479** E./LONG: **1268157**	Process Date: **2/22/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
12	SC26-11.1-12.1	75% (13-14.6)			of olive- gray SILT, little clay. SAND grades to very coarse with multicolored grains (orange, red, white) toward basal contact. Pockets of silt are up to 4" diameter with scattered wood and shell fragments. Strong H2S-like odor.	@ 11.6' TV = 0.2 kg/cm2	upper alluvium
13					End of core at 12.3'.	Bottom 0.3' winnowed.	
14					Note: Chemistry interval recorded as 11.1-12.1 ft. but sample was collected to bottom of core at 12.3 ft. Graphic expresses depth of sample collection; sample name matches project nomenclature.		

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Remarks: **Drive Notes: freefall (1.0'), easy (5.0'), moderate (14.6'), penetration goal reached. One drive attempt made at station. Core catcher was 50% full. Rainbow HC-like sheen on sidewalls at 4.6'. Sampled 58' off station around barge.**

Calculated Recovery
Sample Length/Penetration Length:
12.3/ 14.6 = 84 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-27 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **6.8**	Penetration Depth (ft): **11.2**
Client: **LDWG**	Water Depth (ft): **20.0**	Sample Quality: **Good**
Collection Date: **2/14/06**	Mudline Elevation (ft): **-10.5**	Recovery in ft (%): **9.5 (85)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **204441** E./LONG: **1268518**	Process Date: **2/14/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee, N. Bacher**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC27-0-2	85% (0-0.5)			OL: (0.0-4.6) wet, soft to medium stiff, black (GLEY 1, 2.5/N) grading to very dark greenish gray (GLEY 1, 3/5GY) ORGANIC SILT, few sand. Scattered shells, rootlets, and wood fragments up to 3" L and trace wood layers up to 5" thick. Moderate H2S-like odor. Silt becomes stiffer with depth.		0
1		100% (0.5-2)	PCB SVOC Metals Hg	0		GT @ 0.9' @ 1.0' TV = 0.3 kg/cm2	1
2	LDW-SC27-2-4.5						2
3		96% (2-5)	PCB SVOC Metals Hg	0		GT @ 2.5' @ 3.0' TV = 0.6 kg/cm2	3
4							4
5	LDW-SC27-4.5-6			0	SP- SM: (4.6-9.1) moist, medium dense, very dark gray (10YR, 3/1) fine SAND, few silt interbedded with scattered convex layers of very dark grayish brown (2.5Y, 3/2) SILT, few sand, trace silt pockets, and trace subrounded gravel. SAND is multicolored (orange, red, white). Scattered wood fragments.	@ 5.5' TV = 0.7 kg/cm2	5
6	LDW-SC	67% (5-7)				@ 6.5' TV = 0.6 kg/cm2	6

recent

upper al

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Remarks: **Drive Notes: freefall (1.0'), moderate (5.0'), hard (11.2'), refusal (11.2'). One drive attempt made at station.**

Calculated Recovery
Sample Length/Penetration Length:
9.5 / 11.2 = 85 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-27 (R1)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **6.8**	Penetration Depth (ft): **11.2**
Client: **LDWG**	Water Depth (ft): **20.0**	Sample Quality: **Good**
Collection Date: **2/14/06**	Mudline Elevation (ft): **-10.5**	Recovery in ft (%): **9.5 (85)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **204441** E./LONG: **1268518**	Process Date: **2/14/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee, N. Bacher**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	LDW-SC27-7.8-9.5 (27-6-7.8)	73% (7-10)		0	@ 7.5' 1" wood layer with substantial wood	Core catcher found @ 6.5'.	Iuvium
8				0	SP: (9.1-11.2) moist, dense, very dark grayish brown (2.5Y, 3/2) medium SAND with trace wood fragments. Sand grains are multicolored (orange, red, white).	Depositional Contact @ 8.5' TV = 0.6 kg/cm2	
9					End of core at 9.5'. Driven to refusal.	@ 9.0' TV = 0.8 kg/cm2	lower alluvium
10		100% (10-11.2)					
11							

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Remarks: **Drive Notes: freefall (1.0'), moderate (5.0'), hard (11.2'), refusal (11.2'). One drive attempt made at station.**

Calculated Recovery
Sample Length/Penetration Length:
9.5 / 11.2 = 85 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-28 (R5)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **14.0**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **13.0**
Client: **LDWG**	Water Depth (ft): **38.5**	Sample Quality: **Good**
Collection Date: **2/24/06**	Mudline Elevation (ft): **-30.6**	Recovery in ft (%): **12.6 (92)**
Contractor: **MSS**	N./LAT: **47 32.933** E./LONG: **122 20.4721**	Process Date: **2/25/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3.5" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC28-0-1		PCB SVOC Metals Hg TBT Dioxins/ Furans	0	OL: (0.0-0.6) wet, soft, brown (7.5YR, 4/3) ORGANIC SILT, few sand.		0
1	LDW-SC28-1-2		PCB SVOC Metals Hg TBT Dioxins/ Furans	0	OL: (0.6-5.8) moist, medium stiff, mottled black and very dark greenish gray (GLEY 1, 3/1) SILT, few sand and clay. Scattered rootlets, wood, worms, and shell fragments up to 3" L. Silt grades to stiff; texture is slightly compressible, uniform, massive, blocky, and of low plasticity.	Tranistional Contact @ 1.0' TV = 0.1 kg/cm2 @ 1.6' TV = 0.3 kg/cm2 GT @ 2.0'	1
2							2
3	LDW-SC28-2-4		PCB SVOC Metals Hg TBT Dioxins/ Furans	0		@ 3.1' TV = 0.4 kg/cm2 GT @ 3.9'	3
4							4
5	LDW-SC28-4-5.5			0	@ 5.1' subrounded gravel 1.5' L	@ 5.0' TV = 1.2 kg/cm2	5
6	LDW-SC28-5.5-7		PCB SVOC Metals Hg TBT	0	SAND BLAST GRIT: (5.8-12.8) wet, loose, black with metallic, shiny surface. Sand blast grit (80%) interbedded with 2" to 3" thick layers of wet, medium stiff, black (2.5Y, 2.5/1) SILT grading to very dark greenish gray (GLEY 1, 3/1) SILT, little clay. Sand blast grit is well sorted, coarse-grained, and has a metallic surface color and a moderate to strong HC-like odor. Scattered debris associated with sand blast grit.	Sharp Contact Bag @ 6.5' (2" chips)	6

recent

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Remarks: **Drive Notes: freefall (5.0'), easy (6.0'), very easy (9.0'), hard (11.0'), easy (13.0'), penetration goal reached. Five drive attempts made at station. Core catcher was intact and 100% full.**

Rainbow sheen on sidewalls from 4.0' to 11.3'. ua= upper alluvium

Calculated Recovery
Sample Length/Penetration Length:
11.9/ 13.0 = 92 %

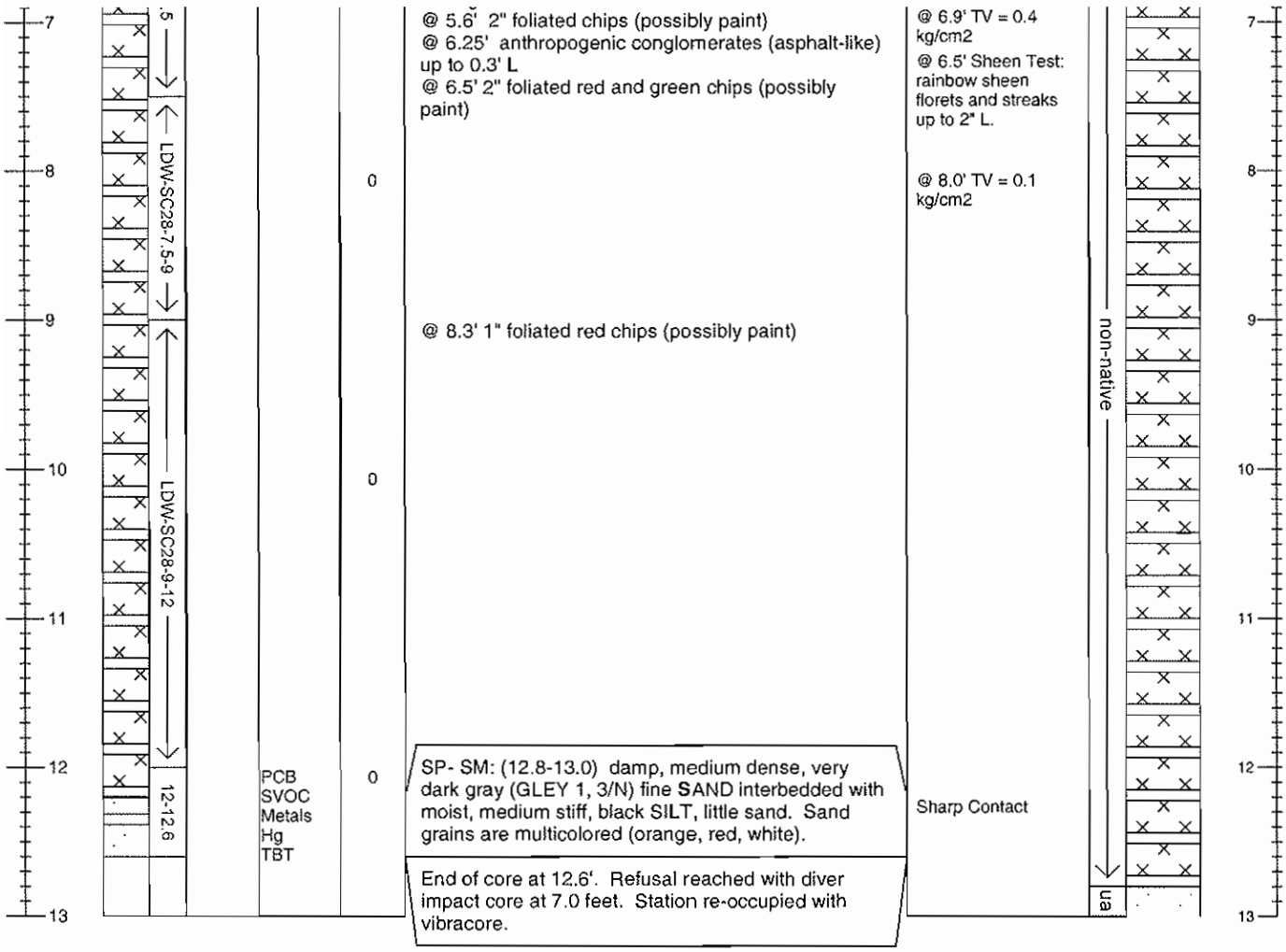
Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-28 (R5)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **14.0**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **13.0**
Client: **LDWG**	Water Depth (ft): **38.5**	Sample Quality: **Good**
Collection Date: **2/24/06**	Mudline Elevation (ft): **-30.6**	Recovery in ft (%): **12.6 (92)**
Contractor: **MSS**	N./LAT: **47 32.933** E./LONG: **122 20.4721**	Process Date: **2/25/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3.5" round Al**	Logged By: **L.McKee, C.Brackett**



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Remarks: **Drive Notes: freefall (5.0'), easy (6.0'), very easy (9.0'), hard (11.0'), easy (13.0'), penetration goal reached. Five drive attempts made at station. Core catcher was intact and 100% full.**

Rainbow sheen on sidewalls from 4.0' to 11.3'. ua= upper alluvium

Calculated Recovery
Sample Length/Penetration Length:
11.9/13.0 = 92 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log
LDW-SC-29 (R2)

Sheet 1 of 1

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **9.9**	Penetration Depth (ft): **6.1**
Client: **LDWG**	Water Depth (ft): **14.1**	Sample Quality: **Poor**
Collection Date: **2/21/06**	Mudline Elevation (ft): **-4.2**	Recovery in ft (%): **3.6 (59)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **204054** E./LONG: **1268061**	Process Date: **2/21/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC29-0-1	97% (0-3)	PCB SVOC Metals Hg Dioxins/ Furans	0	OL: (0.0-0.6) wet to moist, soft, black (2.5Y, 2.5/1) ORGANIC SILT, few sand.		recent
1	LDW-SC29-1-2		PCB SVOC Metals Hg Dioxins/ Furans	0	ML: (0.6-1.8) moist, soft, black (2.5Y, 2.5/1) SILT interbedded with 2" thick layers of moist, dense, black, medium SAND and pockets of very dark greenish gray (GLEY 1, 3/1) SILT, little clay up to 1/2" diameter. Sand grains are multicolored (orange, red, white).	Sharp Contact GT @ 0.7' GT @ 0.9'	upper alluvium
2	LDW-SC29-2-3.6	32% (3-5)	PCB SVOC Metals Hg Dioxins/ Furans	0	SP: (1.8-6.1) moist, dense, black (2.5Y, 2.5/1) medium SAND. Sand grains are multicolored (orange, red, white). @ 2.6' pockets of olive-gray clayey silt up to 1/2" in diameter	Transitional Contact Winnowing @ 1.2' to 2.0' (70%), 2.0' to 2.8' (30%), 2.8' to 3.3' (10%)	lower alluvium
3					End of core at 3.6'. Driven to refusal.		
4							
5		33% (5-6.1)					
6							

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Remarks: **Drive Notes: freefall (3.0'), hard (6.1'), refusal (6.1').**
Two drive attempts made at station. Core catcher was 60% full.
No torvane measurements taken. Difficult intertidal access.

Calculated Recovery
Sample Length/Penetration Length:
3.6 / 6.1 = 59 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-30 (R2)

Sheet 1 of 1

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **3.5**	Penetration Depth (ft): **6.9**
Client: **LDWG**	Water Depth (ft): **18**	Sample Quality: **Good**
Collection Date: **2/14/06**	Mudline Elevation (ft): **-12.2**	Recovery in ft (%): **5.9 (86)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **203576** E./LONG: **1268785**	Process Date: **2/14/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee, N.Bacher**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC30-0-2.5	86% (0-1)	PCB SVOC Metals Hg	0	SM: (0.0-0.2) wet, dense, very dark greenish gray (GLEY 1, 4/10Y) fine SAND, few silt.	Transitional Contact	recent
1					SP: (0.2-2.7) moist, dense, black (2.5Y, 2.5/1) fine to medium SAND, few gravel, grading to fine to medium sand below 1.2 feet. Gravel is subrounded and up to 3.5" in diameter with barnacle scars. Trace wood fragments up to 2" L.	GT @ 1.4' @ 1.5' TV = 0.4 kg/cm2	
2		97% (1-3)		0			
3	LDW-SC30-2.5-4		PCB SVOC Metals Hg		SP-SM: (2.7-3.4) moist, dense, dark gray (2.5Y, 4/1) fine to medium SAND with angular 3" diameter pockets of moist, stiff, [very dark greenish gray (GLEY 1, 4/10Y)] SILT. Sand grains are multicolored (orange, red, white, transitional unit).	Sharp Contact @ 3.0' TV = 1.1 kg/cm2	upper alluvium ?
4	LDW-SC30-4-5.9	100% (3-5)		0	SP- SM: (3.4-6.9) moist, dense, black (2.5Y, 2/1) very fine SAND interbedded with layers of moist, stiff, dark grey (2.5Y, 4/1) SILT, few sand. Sand is well sorted. Trace wood fragments less than 1" L.	Transitional Contact GT @ 3.4'	
5		55% (5-6)		0	End of core at 5.9'. Driven to refusal.	Core catcher @ 4.7'. @ 5.0' TV = 0.9 kg/cm2	
6		100% (6-6.9)		0			

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Remarks: **Drive Notes: freefall (0.7'), easy (5.0'), moderate-hard (6.0'), hard (6.9'), refusal (6.9'). Two drive attempts made at station.**

Calculated Recovery
Sample Length/Penetration Length:
5.9 / 6.9 = 86 %

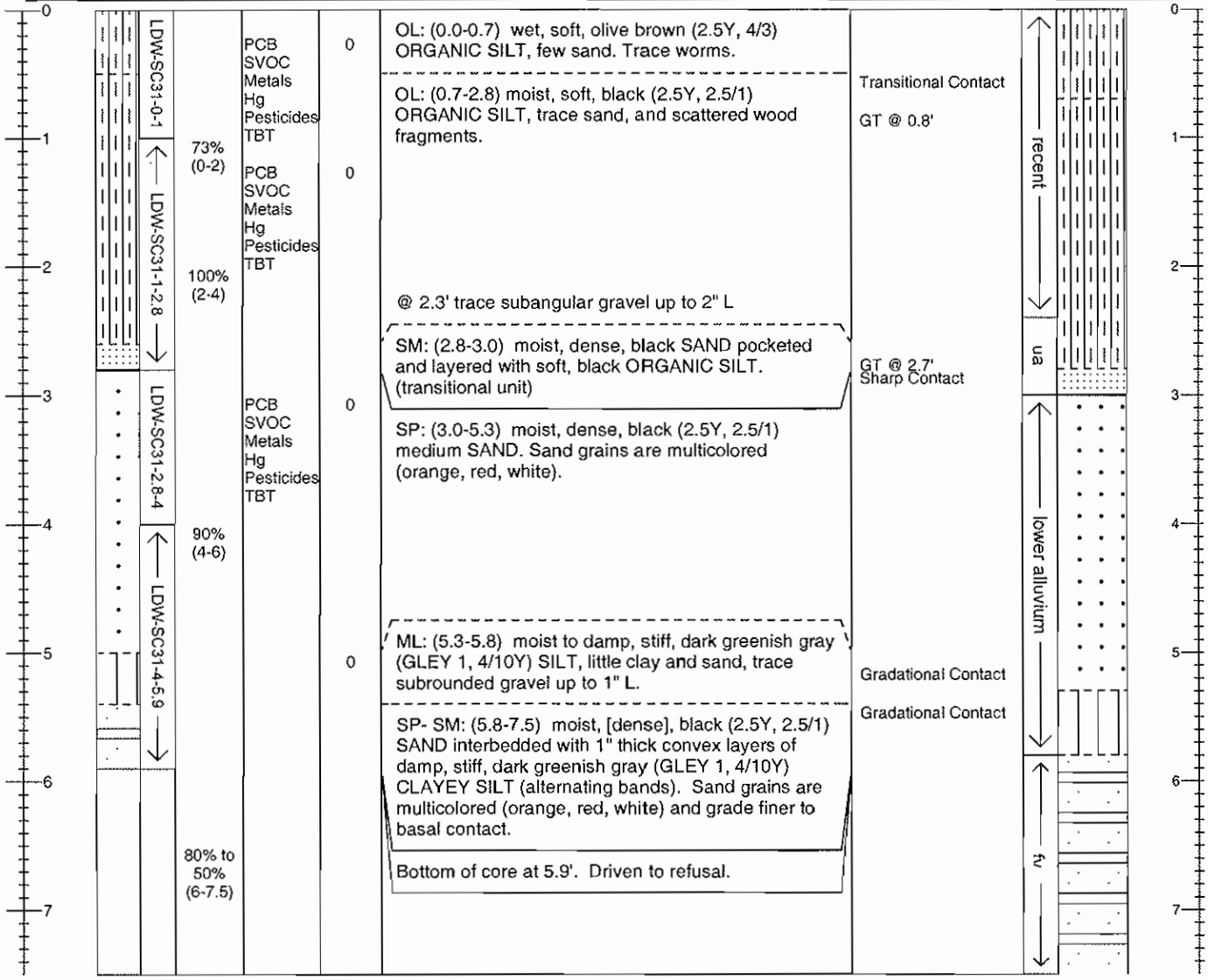
Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-31 (R1)

Sheet 1 of 1

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **7.5**
Client: **LDWG**	Water Depth (ft): **35.3**	Sample Quality: **Good**
Collection Date: **2/16/06**	Mudline Elevation (ft): **-31.7**	Recovery in ft (%): **5.9 (79)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **203092** E./LONG: **1268934**	Process Date: **2/17/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**



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Remarks: **Drive Notes: freefall (2.0'), easy (6.0'), moderate (7.0'), hard (7.5'), refusal (7.5'). One drive attempt made at station. Core catcher was empty. Difficult core extraction.**

ua = upper alluvium, fv = fluvial

Calculated Recovery
Sample Length/Penetration Length:
5.9 / 7.5 = 79 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-32 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **8.6**	Penetration Depth (ft): **12.7**
Client: **LDWG**	Water Depth (ft): **25.6**	Sample Quality: **Good**
Collection Date: **2/10/06**	Mudline Elevation (ft): **-17.2**	Recovery in ft (%): **11.2 (88)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **202959** E./LONG: **1269344**	Process Date: **2/11/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N.Bacher, A.Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (in-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC32-0-1		PCB SVOC Metals Hg	0	OL: (0.0-0.4) wet, very soft, dark olive brown (2.5Y, 3/3) ORGANIC SILT, little sand.	Transitional Contact @ 0.4' TV = 0.4 kg/cm2	recent
1	LDW-SC32-1-2	84% (0-3)	PCB SVOC Metals Hg	0	OL: (0.4-0.9) moist, medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT, few sand. Trace twigs, rootlets, and worms. GP: (0.9-1.2) wet, loose, black (2.5Y, 2.5/1) GRAVEL, little silt and sand. Slight HC-like odor.	Sharp Contact GT @ 1.1'	
2	LDW-SC32-2-4				MH: (1.2-3.1) wet, medium stiff, dark gray (2.5Y, 4/4) SILT, few to little clay, trace 1/2" diameter pockets of SAND. Sand pockets are slightly mottled and have thin black streaks. Trace twigs and rootlets. Trace to slight HC-like sheen florets up to 1/8" and moderate HC-like odor. @ 2.5' 1" diameter piece of gravel	@ 2.5' TV = 0.1 kg/cm2	
3			PCB SVOC Metals Hg	0	SM: (3.1-5.1) wet, medium dense, black (2.5Y, 2.5/1) medium SAND interbedded with dark olive brown (2.5Y, 3/3) SILT. Sand is multicolored (orange, red, white). Trace wood fragments up to 4" L. Slight HC-like sheen florets up to 1/8" and moderate HC-like odor.	Transitional Contact GT @ 3.3'	
4	LDW-SC32-4-5.2	100% (3-5)		0	@ 4.8' end of sheen	@ 4.5' TV = 0.4 kg/cm2	upper alluvium
5		100% (5-7)			SP- SM: (5.1-7.2) moist, medium dense, very dark greenish gray (GLEY 1, 3/5GY) alternating 2" thick layers of SILT, SAND and silty SAND (banded). Trace rootlets and wood up to 2" L.	Transitional Contact	
6	LDW-SC32-5.2			0	@ 6.4' 2" diameter clast of hard, light gray clay	@ 5.7' TV = 1.1 kg/cm2	

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Remarks: **Drive Notes: freefall (2.0'), easy (8.0'), moderate (10.0'), hard (12.7'), refusal (12.7'). One drive attempt made at station.**

Calculated Recovery
Sample Length/Penetration Length:
11.2/ 12.7 = 88 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-32 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **8.6**	Penetration Depth (ft): **12.7**
Client: **LDWG**	Water Depth (ft): **25.6**	Sample Quality: **Good**
Collection Date: **2/10/06**	Mudline Elevation (ft): **-17.2**	Recovery in ft (%): **11.2 (88)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **202959** E./LONG: **1269344**	Process Date: **2/11/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N.Bacher, A.Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	LDW-SC32-8-10	100% (7-9)	PCB SVOC	0	SP-SM: (7.2-12.7) moist, medium dense, very dark greenish gray (GLEY 1, 3/5GY) medium to coarse SAND, abundant silt clasts (rip-up clasts), trace sand, and silt interbeds. Sand is multicolored (orange, red, white). Grading coarser with depth.	@ 6.9' TV = 0.9 kg/cm2 Transitional Contact	7
8							8
9		89% (9-11)			@ 9.1-10.0' fresh wood	@ 9.2' TV = 0.6 kg/cm2	9
10	LDW-SC32-10-11			0	@ 10.0' 1/8" diameter quartz grains to basal contact		10
11		87% (11-11.8)			End of core at 11.2' Driven to refusal.	Slumping @ 11.2' to end of core.	11
12		73% (11.8-12.7)					12

lower alluvium

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Remarks: **Drive Notes: freefall (2.0'), easy (8.0'), moderate (10.0'), hard (12.7'), refusal (12.7'). One drive attempt made at station.**

Calculated Recovery
Sample Length/Penetration Length:
11.2/12.7 = 88 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-33 (R2)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **8.4**	Penetration Depth (ft): **13.1**
Client: **LDWG**	Water Depth (ft): **24.1**	Sample Quality: **Good**
Collection Date: **2/10/06**	Mudline Elevation (ft): **-14.7**	Recovery in ft (%): **10.2 (78)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **202056** E./LONG: **1269267**	Process Date: **2/11/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N.Bacher, A.Fitzpatrick**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth; (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC33-0-2	100% (0-0.6)	PCB SVOC Metals Hg	0	OL: (0.0-0.3) wet, soft, dark greenish gray (GLEY 1, 4/1) ORGANIC SILT, little sand, trace clay and rootlets.	Transitional Contact	0
1		100% (0.6-3)			OH: (0.3-1.8) moist, medium stiff, black (GLEY 1, 2.5/N) ORGANIC SILT, little sand, trace worms. @1.3': 5" layer of wet, medium dense, black, coarse SAND, little silt, trace gravel. Trace to moderate H2S-like odor and trace black sheen.	@ 0.9' TV = 0.6 kg/cm2 GT @ 1.0'	1
2	LDW-SC33-2-4		PCB SVOC Metals Hg	0	OL: (1.8-2.8) moist, medium stiff, very dark greenish gray (GLEY 1, 3/1) ORGANIC SILT, little clay and sand. Trace rootlets. Moderate H2S-like odor. @ 1.4' pale yellow (5Y, 7/4) fibrous clast with strong H2S-like odor - clast disintegrates when rolled	Transitional Contact Bag @ 1.9' (twine)	2
3		87% (3-5)			ML/OH: (2.8-10.0) moist, medium stiff, black (2.5Y, 2.5/1) SILT to ORGANIC SILT, trace clay, sand, gravel, wood, and shell fragments. Trace 5" thick layers of silt, trace sand. Slight H2S-like odor. Trace debris (glass, metal).	@ 2.5' TV = 0.5 kg/cm2 GT @ 3.0' Bag @ 3.2' (possible shell)	3
4	LDW-SC33-4-6		PCB SVOC Metals	0	@ 4.4-5.0' shiny layer of SAND with wood, abundant shell fragments, 1/2" angular debris (1/4" silvery, shiny, metal chunk) and slight HC-like odor to 7.7'	@ 5.0' TV = 0.6 kg/cm2 Bag @ 5.5' (chunks) Bag @ 5.6' (silver chunk)	4
5		76% (5-7)			@5.7': glass shard (top of soda bottle)	Bag @ 5.7' (glass shard)	5
6	LDW-			0	@6.0': no debris observed below 6.0'.		6

recent

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Remarks: **Drive Notes: freefall (0.6'), easy (9.0'), moderate (13.1'), penetration goal reached. Two drive attempts made at station. Core catcher was empty. Core tip smashed and side walls scored. Field replicate is SC-201.**

Calculated Recovery
Sample Length/Penetration Length:
10.2/13.1 = 78 %

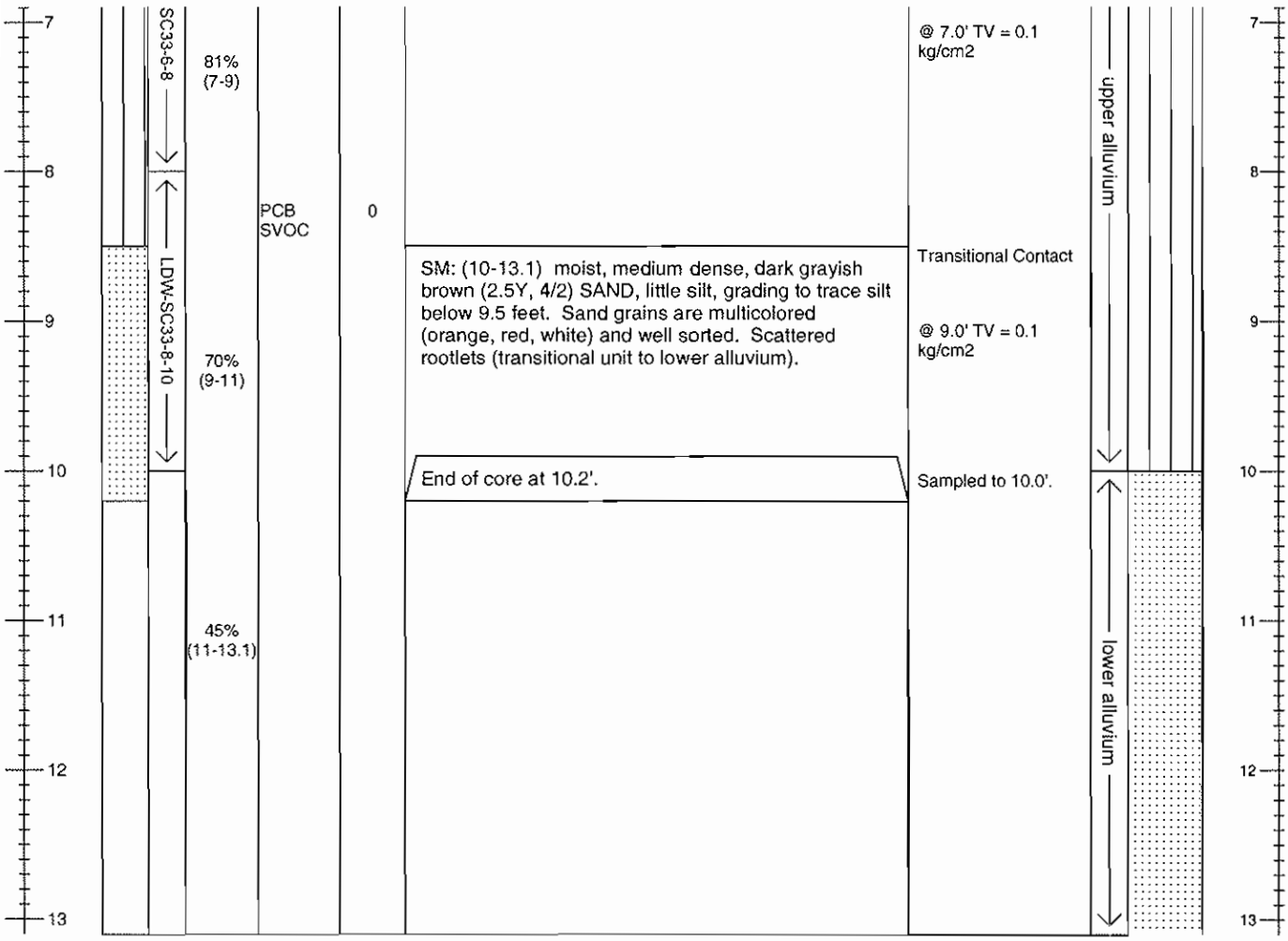
Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-33 (R2)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **8.4**	Penetration Depth (ft): **13.1**
Client: **LDWG**	Water Depth (ft): **24.1**	Sample Quality: **Good**
Collection Date: **2/10/06**	Mudline Elevation (ft): **-14.7**	Recovery in ft (%): **10.2 (78)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **202056** E./LONG: **1269267**	Process Date: **2/11/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N.Bacher, A.Fitzpatrick**



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Remarks: **Drive Notes: freefall (0.6'), easy (9.0'), moderate (13.1'), penetration goal reached. Two drive attempts made at station. Core catcher was empty. Core tip smashed and side walls scored. Field replicate is SC-201.**

Calculated Recovery
Sample Length/Penetration Length:
10.2/ 13.1 = 78 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-34 (R2)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **9.1**	Penetration Depth (ft): **12.2**
Client: **LDWG**	Water Depth (ft): **23.7**	Sample Quality: **Good**
Collection Date: **2/17/06**	Mudline Elevation (ft): **-14.5**	Recovery in ft (%): **9.3 (76)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **202014** E./LONG: **1268831**	Process Date: **2/18/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **A.Fitzpatrick, C.Brackett**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC34-0-1	72% (0-1)	PCB SVOC Metals Hg Pesticides	0	ML: (0.0-0.7) wet, medium stiff, dark olive brown (2.5Y, 3/3) SILT, little gravel, trace sand. Substantial wood fragments.		
						Transitional Contact	
1	LDW-SC34-1-2	91% (1-5)	PCB SVOC Metals Hg Pesticides	0	OL: (0.7-3.8) moist, medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT with substantial organic matter (twigs, leaves, stems, pine needles, shredded wood, wood fragments). Silt texture is slightly compressible, uniform, with moderate to low plasticity, and grading to unit below. Trace debris.		
2	LDW-SC34-2-4		PCB SVOC Metals Hg Pesticides	0	@ 1.3' plastic zip-tie		recent
3							
					ML: (3.8-7.2) moist, medium stiff, black (2.5Y, 2.5/1) SILT with scattered organic matter interbedded in 8" thick layers with very dark grayish brown (2.5Y, 3/2) fine SAND with moderate small shell fragments. Sand layers grade coarser (medium) with depth below 5.0'. Trace debris (glass)	Transitional Contact	
4				0	@ 3.4' glass shard	Bag @ 3.4' (glass shard)	
5	LDW-SC34-4-6	100% (5-7)					
6	LDW-			0			
					SM: (7.2-11.3) damp, dense, very dark greenish gray (GLEY 1, 3/1) slightly mottled medium SAND, trace gravel, silt, and 1-2" thick layers of dark brown	Sharp Contact	

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Remarks: **Drive Notes: freefall (1.5'), easy (12.2'), penetration goal reached. Two drive attempts made at station. Core catcher was 100% full. No torvane or geotechnical samples taken due to frozen core. Field replicate of SC-203.**

Calculated Recovery
Sample Length/Penetration Length:
9.3 / 12.2 = 76 %

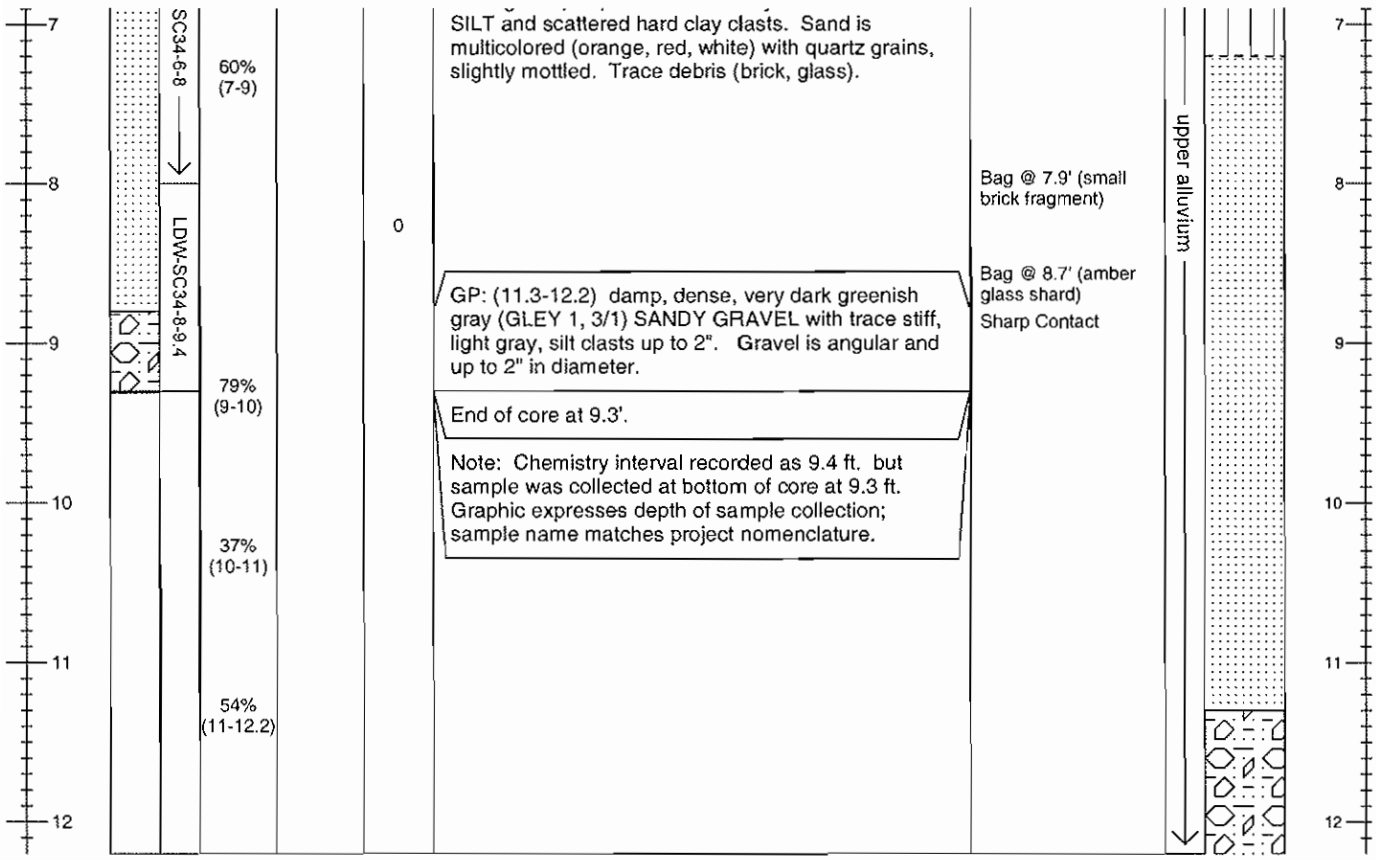
Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-34 (R2)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **9.1**	Penetration Depth (ft): **12.2**
Client: **LDWG**	Water Depth (ft): **23.7**	Sample Quality: **Good**
Collection Date: **2/17/06**	Mudline Elevation (ft): **-14.5**	Recovery in ft (%): **9.3 (76)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **202014** E./LONG: **1268831**	Process Date: **2/18/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **A.Fitzpatrick, C.Brackett**



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Remarks: **Drive Notes: freefall (1.5'), easy (12.2'), penetration goal reached. Two drive attempts made at station. Core catcher was 100% full. No torvane or geotechnical samples taken due to frozen core. Field replicate of SC-203.**

Calculated Recovery
Sample Length/Penetration Length:
9.3 / 12.2 = 76 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-35 (R2)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **6.7**	Penetration Depth (ft): **10.2**
Client: **LDWG**	Water Depth (ft): **21.2**	Sample Quality: **Good**
Collection Date: **2/14/06**	Mudline Elevation (ft): **-13.8**	Recovery in ft (%): **8.3 (81)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **201602** E./LONG: **1269260**	Process Date: **2/15/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee, A.Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC35-0-2	100% (0-1)	PCB SVOC Metals Hg	0	OL: (0.0-0.7) wet, soft, olive brown (2.5Y, 4/3) ORGANIC SILT, few sand.		recent
1		100% (1-4)			OL: (0.7-4.2) moist, soft, black (2.5Y, 2.5/1) ORGANIC SILT, little clay, trace pockets of SILT. Silt texture is slightly compressible, blocky, uniform, and of low plasticity. Scattered worms, rootlets, and wood fragments up to 2" L. Slight H2S-like odor toward basal contact.	Transitional Contact GT @ 0.9' @ 0.9' TV = 0.2 kg/cm2	
2	LDW-SC35-2-4		PCB SVOC Metals Hg	0			
3						GT @ 2.9' @ 2.9' TV = 0.4 kg/cm2	
4	LDW-SC35-4-4.9	76% (4-6)		0	ML: (4.2-5.5) moist, medium stiff, black (2.5Y, 2.5/1) SILT, few sand, 1/2" layers and pockets of gray (2.5Y, 5/1) SILT, little clay. Slight H2S-like odor.	Transitional Contact	upper alluvium
5	LDW-SC35-4.9-6			0	SP: (5.5-10.2) [moist, dense], very dark greenish gray (GLEY 1, 3/1) fine SAND, trace gravel and 2" thick convex layers of olive gray silt. Sand grains are multicolored (orange, red, white); gravel is subrounded to subangular and is up to 2" L. Trace debris (concrete). @ 5.3' to 5.9' concrete fragments	Sharp Contact Bag @ 5.3' (4" piece concrete)	
6	LDW-	73% (6-8)		0		@ 5.9 TV = 0.5 kg/cm2	

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Remarks: **Drive Notes: freefall (0.8'), easy (3.7)', moderate (8.0'), hard (10.2'), refusal (10.2'). Two drive attempts made at this station. Core tip crushed, but full.**

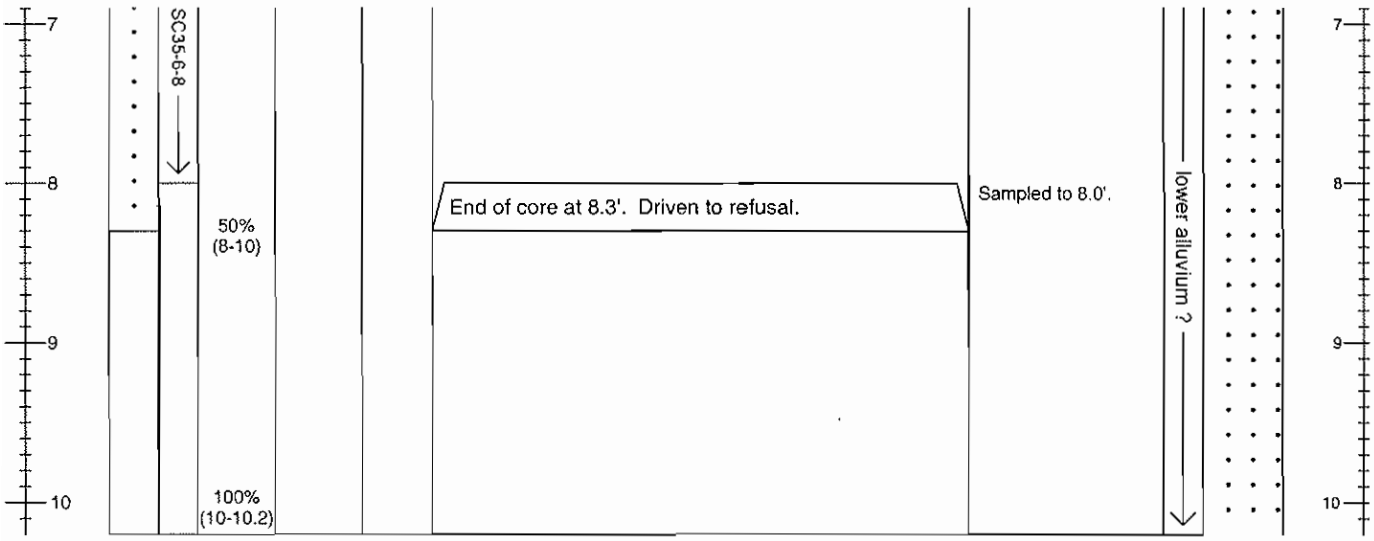
Calculated Recovery
Sample Length/Penetration Length:
8.3 / 10.2 = 81 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-35 (R2)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **6.7**	Penetration Depth (ft): **10.2**
Client: **LDWG**	Water Depth (ft): **21.2**	Sample Quality: **Good**
Collection Date: **2/14/06**	Mudline Elevation (ft): **-13.8**	Recovery in ft (%): **8.3 (81)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **201602** E./LONG: **1269260**	Process Date: **2/15/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee, A.Fitzpatrick**



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Remarks: **Drive Notes: freefall (0.8'), easy (3.7)', moderate (8.0'), hard (10.2'), refusal (10.2'). Two drive attempts made at this station. Core tip crushed, but full.**

Calculated Recovery
Sample Length/Penetration Length:
8.3 / 10.2 = 81 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-36 (R1)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **2.9**	Penetration Depth (ft): **12.3**
Client: **LDWG**	Water Depth (ft): **17.4**	Sample Quality: **Good**
Collection Date: **2/15/06**	Mudline Elevation (ft): **-12.3**	Recovery in ft (%): **10.2 (83)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **201490** E./LONG: **1269988**	Process Date: **2/16/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee, A.Fitzpatrick**

Recovered Depth (ft)	Recov. interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC36-0-1	100% (0-1)	PCB SVOC Metals Hg TBT	0	OL: (0.0-0.4) wet, soft, olive brown (2.5Y, 4/3) ORGANIC SILT, few sand, trace worms.	Transitional Contact	recent
1	LDW-SC36-1-2	85% (1-2)	PCB SVOC Metals Hg TBT	0	OL: (0.4-3.6) wet, medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT. Scattered wood fragments up to 2" L, small shell fragments, and rootlets decreasing with depth. Silt texture is slightly compressible, blocky, massive, and of low plasticity. Slight H2S-like odor.	@ 0.9' TV = 1.4 kg/cm2	
2	LDW-SC36-2-4	84% (2-5)	PCB SVOC Metals Hg TBT	0	@ 2.0' 1/2" thick layer of medium sand	GT @2.1'	
3					ML: (3.6-6.2) wet, medium stiff, dark greenish gray (GLEY 1, 4/10Y) SILT, little sand, interbedded with 3" thick layers of greenish black (GLEY 1, 4/10Y) ORGANIC SILT (banded), scattered rootlets and twigs. (transitional unit)	Transitional Contact @ 3.9' TV = 1.1 kg/cm2	
4					@ 4.9' whole clam shell 1" L		
5	LDW-SC36-4-6	83% (5-8)		0			
6	LDW-				MH: (6.2-9.8) moist to wet, medium stiff, dark greenish gray (GLEY 1, 4/10Y), SILT. Silt texture is homogenous. Scattered rootlets.	Transitional Contact @ 5.9' TV = 1 kg/cm2	upper alluv

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Remarks: **Drive Notes: freefall (0.4'), easy (3.0'), moderate (11.0'), hard (12.3'), refusal (12.3'). One drive attempt made at station. Core catcher was 50% full. Feild replicate of SC-202.**

Calculated Recovery
Sample Length/Penetration Length:
10.2/ 12.3 = 83 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-36 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **2.9**	Penetration Depth (ft): **12.3**
Client: **LDWG**	Water Depth (ft): **17.4**	Sample Quality: **Good**
Collection Date: **2/15/06**	Mudline Elevation (ft): **-12.3**	Recovery in ft (%): **10.2 (83)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **201490** E./LONG: **1269988**	Process Date: **2/16/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee, A.Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	SC36-8-9			0	@ 7.4' 5" thick layer of black SILT, few clay	@ 7.8' TV = 0.9 kg/cm2	upper alluvium
8	LDW-SC36-8-10	85% (8-10)			SP- SM: (9.8-12.3) moist to damp, [dense], very dark greenish gray (GLEY 1, 3/1) fine SAND with uniform 1" thick layers of alternating very fine SAND, little silt and SILT. Banded layers are slightly convex. Sand grains are multi-colored (red, white, orange) and grade to medium sand at basal contact. Trace wood fragments up to 3".	Transitional Contact	8
9						@ 9.0' TV = 0.9 kg/cm2	9
10		69% (10-11)			End of core at 10.2'. Driven to refusal.	Slight winnowing from 10.0-10.2' Sampled to 10.0'.	10
11		75% (11-12.3)					lower alluvium 11
12							12

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Remarks: **Drive Notes: freefall (0.4'), easy (3.0'), moderate (11.0'), hard (12.3'), refusal (12.3'). One drive attempt made at station. Core catcher was 50% full. Feild replicate of SC-202.**

Calculated Recovery
Sample Length/Penetration Length:
10.2/ 12.3 = 83 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-37 (R1)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **8.2**	Penetration Depth (ft): **8.6**
Client: **LDWG**	Water Depth (ft): **19.8**	Sample Quality: **Good**
Collection Date: **2/22/06**	Mudline Elevation (ft): **-11.4**	Recovery in ft (%): **6.9 (80)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **201435** E./LONG: **1270690**	Process Date: **2/22/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC37-0-1	48% (0-1)	PCB SVOC Metals Hg	0	OL: (0.0-0.3) wet, soft, olive brown (2.5Y, 4/3) ORGANIC SILT, few sand.		
					OL: (0.3-3.2) moist, medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT, few layers of olive gray silt, little clay and black fine to medium sand, little silt. Silt texture is slightly compressible, [massive, blocky], and of low plasticity. Trace debris and scattered wood fragments.	Transitional Contact @ 0.4' TV = 0.2 kg/cm2 GT @ 0.9'	
1	LDW-SC37-1-2	100% (1-3)	PCB SVOC Metals Hg	0		Bag @ 1.5' (copper wire) @ 1.9' TV = 0.1 kg/cm2	recent
2			PCB SVOC Metals Hg	0		GT @ 2.2'	
	LDW-SC37-2-4	100% (3-4)			ML: (3.2-6.3) moist, medium stiff, black (2.5Y, 2.5/1) SILT, layers of moist, dense, black, fine sand and trace 2" L clasts of SILT, little clay. Abundant black conglomerates up to 2" L (anthropogenic, asphalt-like; 35%). Moderate metallic and rainbow sheen florets up to 1" L and moderate HC-like odor associated with sand from 3.0' to 5.3'. Trace wood fragments up to 3" L (10%).	Transitional Contact	
3						@ 3.6' TV = 0.5 kg/cm2	
4	LDW-SC37-4-5.3	80% (4-6)		0		Bag @ 3.9' (1/2-vesicular, 1/2-metallic, shiny, fused conglomerate)	upper alluvium
5	L					@ 5.0' TV = 1.3 kg/cm2	
					SP: (6.3-8.6) moist, medium dense, black (2.5Y, 2.5/1) SAND, few 1" L green-gray silt clasts. Sand grains are multicolored (red, white, orange).	Slumping in sand below 5.2'	

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Remarks: **Drive Notes: freefall (1.4'), easy (3.0'), moderate (6.5'), hard (8.6'), refusal (8.6'). One drive attempt made at station. Core catcher was 100% full. Steep slope and pier pilings in area. Scattered rainbow sheen florets along sidewalls from 0.5' to 4.0' up to 1/2" diameter.**

Calculated Recovery
Sample Length/Penetration Length:
6.9 / 8.6 = 80 %

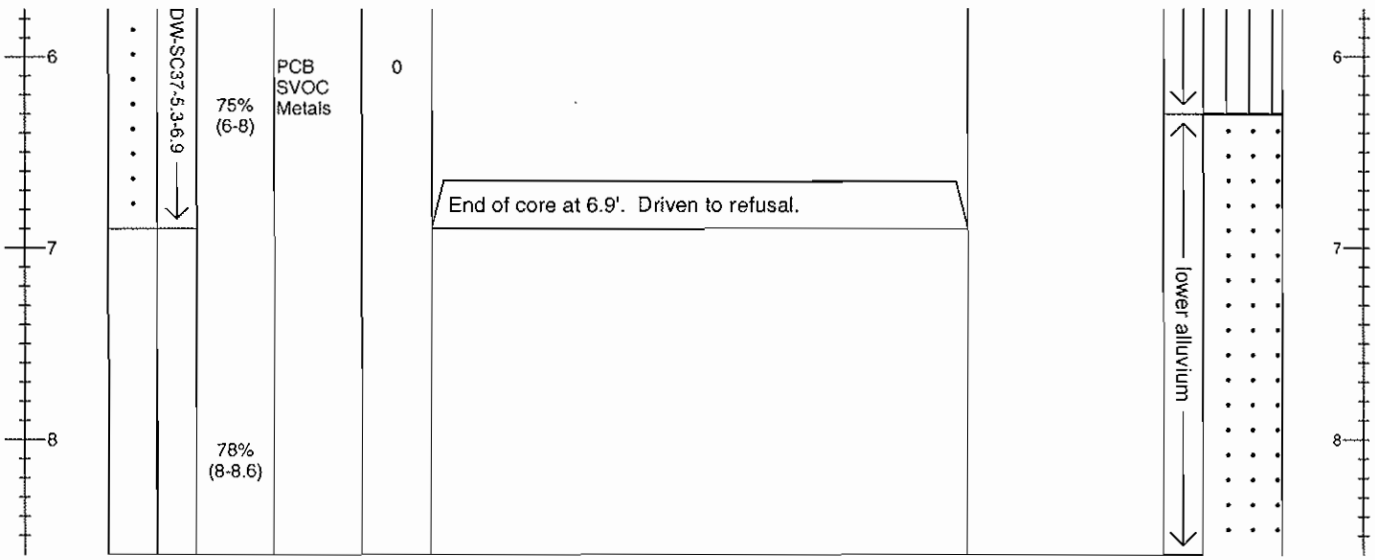
Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-37 (R1)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **8.2**	Penetration Depth (ft): **8.6**
Client: **LDWG**	Water Depth (ft): **19.8**	Sample Quality: **Good**
Collection Date: **2/22/06**	Mudline Elevation (ft): **-11.4**	Recovery in ft (%): **6.9 (80)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **201435** E./LONG: **1270690**	Process Date: **2/22/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**



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Remarks: Drive Notes: freefall (1.4'), easy (3.0'), moderate (6.5'), hard (8.6'), refusal (8.6'). One drive attempt made at station. Core catcher was 100% full. Steep slope and pier pilings in area. Scattered rainbow sheen florets along sidewalls from 0.5' to 4.0' up to 1/2" diameter.

Calculated Recovery
Sample Length/Penetration Length:
6.9 / 8.6 = 80 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-38 (R1/R2)

Sheet 1 of 1

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **9.8**	Penetration Depth (ft): **5.6**
Client: **LDWG**	Water Depth (ft): **6.6**	Sample Quality: **Good**
Collection Date: **2/20/06**	Mudline Elevation (ft): **+3.4**	Recovery in ft (%): **3.8 (68)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **200959** E./LONG: **1269745**	Process Date: **2/21/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee, A.Fitzpatrick**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC38-0-1		PCB SVOC Metals Hg	0	OL: (0.0-1.2) wet, medium stiff, mottled black (2.5Y, 2.5/1) SILT. Trace wood fragments up to 4" L. Silt texture is slightly compressible and of low plasticity. Slight H2S-like odor.	GT @ 0.3' @ 0.5' TV = 0.1 kg/cm2	recent
1	LDW-SC38-1-2	81% (0-3)	PCB SVOC Metals Hg	0	ML: (1.2-2.5) wet, medium stiff, dark brown (7.5Y, 3/2) SILT, 1" thick layer of fine sand. Silt is slightly jumbled and grades to black. Trace wood fragments and rootlets up to 1.5" L.	Transitional Contact @ 1.5' TV = 1.1 kg/cm2	upper alluvium
2	LDW-SC38-2-3		PCB SVOC Metals Hg	0	ML: (2.5-3.8) wet, medium stiff, black (2.5Y, 2.5/1) SILT, scattered seams of medium sand from 1/8" to 1/2" thick. Moderate to heavy HC-like rainbow sheen and odor concentrated in sand seams. Greasy texture.	@ 2.0' to 3.0' Sheen Test = heavy rainbow sheen (100%) @ 2.5' TV = 0.7 kg/cm2	
3	3-3.3	75% (3-4)	PCB SVOC Metals Hg		SP: (3.8-5.6) wet, loose, very dark greenish gray (GLEY 1, 3/1) medium SAND, trace 1/2" diameter silt pockets and scattered wood fragments up to 1" L. Sand is well sorted.	Sharp Contact	
4		63% (4-5)			End of R1 core at 3.1'. Driven to refusal at 4.5'. End of R2 core at 3.8'. Driven to refusal at 5.6'. Sample 3-3.3' collected from R2. Other samples from R1, collected closer to shore.	Core 20% winnowed below 3.3'. Not sampled below 3.3'.	lower alluvium
5		75% R2 (5-5.6)					

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Remarks: **Drive Notes: no freefall, easy (3'), moderate (4'), hard (5.6'), refusal (5.6'). Two drive attempts made at station. Core tip crushed. Core is combined: 0-3' (R1) and 3-3.8' (R2). Header notes are from R2. R1 is from 1st Ave Bridge and R2 from 20' further downslope; tagged sand unit.**

Calculated Recovery
Sample Length/Penetration Length:
3.8 / 5.6 = 68 %

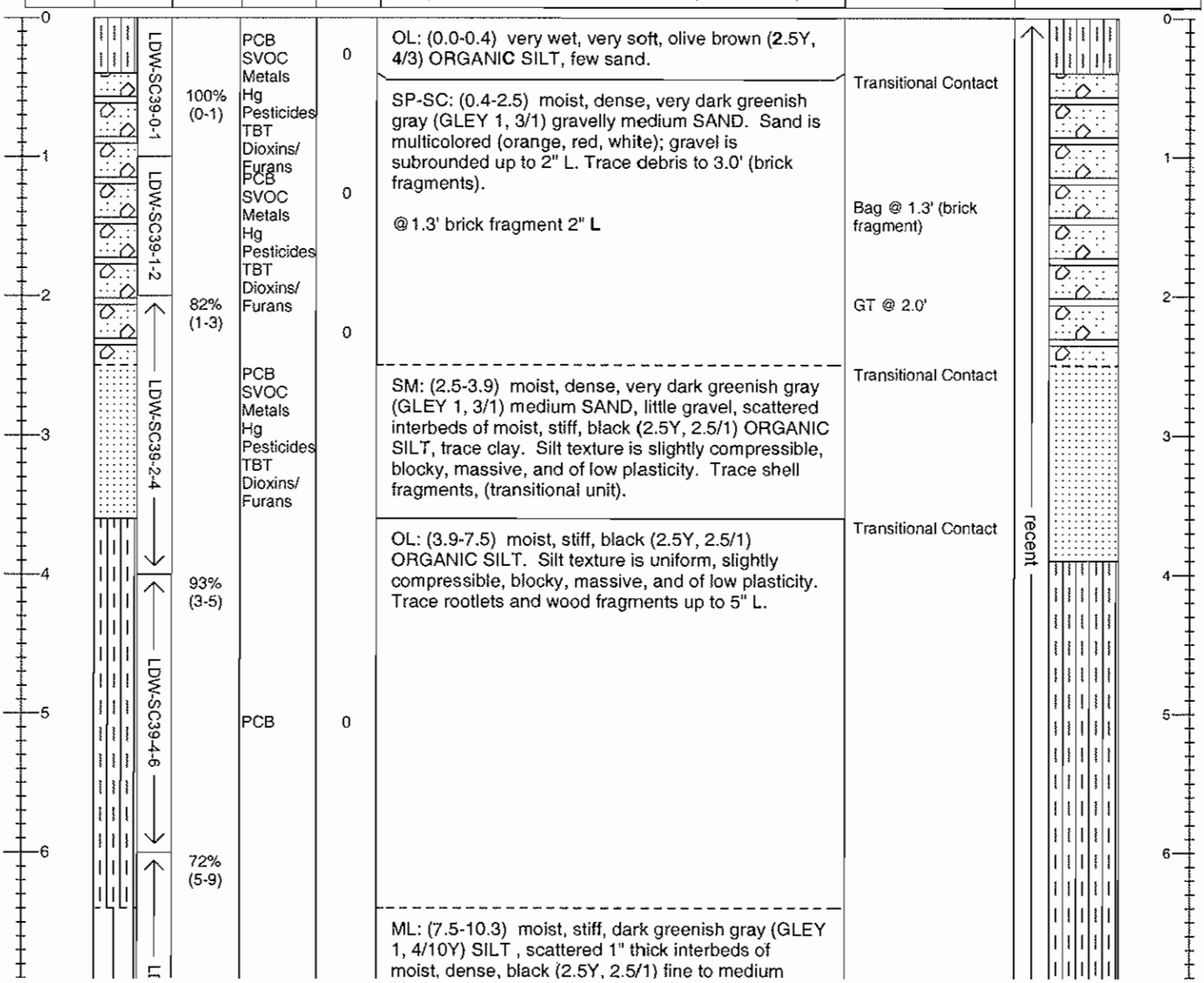
Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-39 (R1)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **5.3**	Penetration Depth (ft): **12.4**
Client: **LDWG**	Water Depth (ft): **9.8**	Sample Quality: **Good**
Collection Date: **2/15/06**	Mudline Elevation (ft): **-5**	Recovery in ft (%): **9.2 (74)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **200657** E./LONG: **1270056**	Process Date: **2/16/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**



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Remarks: **Drive Notes: no freefall, easy (1.0'), moderate (9.0'), hard (12.4'), penetration goal reached. One drive attempt made at station. Core catcher was 100% full. Difficult core extraction. No torvane measurements taken.**

Calculated Recovery
Sample Length/Penetration Length:
9.2 / 12.4 = 74 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-39 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **5.3**	Penetration Depth (ft): **12.4**
Client: **LDWG**	Water Depth (ft): **9.8**	Sample Quality: **Good**
Collection Date: **2/15/06**	Mudline Elevation (ft): **-5**	Recovery in ft (%): **9.2 (74)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **200657** E./LONG: **1270056**	Process Date: **2/16/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth; (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	JW-SC39-8.5			0	SAND. Trace wood fragments up to 7" L.		7
8							8
					SP- SM: (10.3-12.4) moist, dense, very dark greenish gray (GLEY 1, 43/1) fine to medium SAND with alternating (banded) layers of very fine SAND, few silt and SILT.	Transitional Contact	upper alluvium
9	8.5-9.2	71% (9-10)		0			9
					End of core at 9.2'.	Winnowing @ 9.2 to 9.3'	
10		74% (10-12.4)					10
11							lower alluvium 11
12							12

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Remarks: **Drive Notes: no freefall, easy (1.0'), moderate (9.0'), hard (12.4'), penetration goal reached. One drive attempt made at station. Core catcher was 100% full. Difficult core extraction. No torvane measurements taken.**

Calculated Recovery
Sample Length/Penetration Length:
9.2 / 12.4 = 74 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-40 (R3)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **14.0**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **13.0**
Client: **LDWG**	Water Depth (ft): **10.4**	Sample Quality: **Good**
Collection Date: **2/23/06**	Mudline Elevation (ft): **-1.0**	Recovery in ft (%): **10.0 (77)**
Contractor: **MSS**	N./LAT: **200339** E./LONG: **1270298**	Process Date: **2/24/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracore/3.5" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0–1	LDW-SC40-0-1.3	77% (0-13)	PCB SVOC Metals Hg Pesticides Dioxins/ Furans	0	SP: (0.0-0.5) damp, medium dense, brown (7.5YR, 4/2) medium SAND. Sand grains are multicolored (orange, red, white).	@ 0.2' TV = 0 kg/cm2 Tranistional Contact	upper alluvium
1–2	1.3-2		PCB SVOC Metals Hg Pesticides Dioxins/ Furans	0	OL: (0.5-1.7) moist, soft, black (2.5YR, 2.5/1) ORGANIC SILT, little sand layers (2") alternating with layers (3") of moist, medium stiff, dark gray (GLEY 1, 4/N) SILT, few sand. Organic silt has scattered shell and wood fragments up to 1/2" L. Grades to sand at basal contact.	@ 0.7' TV = 0.3 kg/cm2 GT @ 1.2' Sharp Contact	
2–3	LDW-SC40-2-4				SW: (1.7-13.0) moist, medium dense, brown (7.5Y,R, 4/2) medium to coarse SAND. Sand grains are multicolored (orange, red, white) and coarsen towards basal contact (from 6.0' to 10.0'). Slight H2S-like odor from 4' to 8'. @ 1.5' to 1.9': layer of SAND, little subrounded gravel up to 1" L. Scattered brick fragments up to 1" L.	@ 2.2' TV = 0 kg/cm2 GT @ 2.5'	
3–4			PCB SVOC Metals Hg Pesticides Dioxins/ Furans	0		@ 3.0' TV = 0.1 kg/cm2 Oxidation @ 0.0' to 4.0'.	
4–5	LDW-SC40-4-6			0	@ 4.4' color changes to very dark gray sand		
5–6	LDW-						

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Remarks: **Drive Notes: no freefall , easy (13.0'), penetration goal reached. Three drive attempts made at station. Station re-occupied with vibracore after MCS drives. Core catcher was empty (0.5' sediment loss).**

Calculated Recovery
Sample Length/Penetration Length:
10.0/13.0 = 77 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-40 (R3)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **14.0**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **13.0**
Client: **LDWG**	Water Depth (ft): **10.4**	Sample Quality: **Good**
Collection Date: **2/23/06**	Mudline Elevation (ft): **-1.0**	Recovery in ft (%): **10.0 (77)**
Contractor: **MSS**	N./LAT: **200339** E./LONG: **1270298**	Process Date: **2/24/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracore/3.5" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7–13	SC40-8-8 / LDW-SC40-8-10			0 / 0 / 0	End of core at 10.0'.		lower alluvium

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Remarks: Drive Notes: no freefall , easy (13.0'), penetration goal reached. Three drive attempts made at station. Station re-occupied with vibracore after MCS drives. Core catcher was empty (0.5' sediment loss).

Calculated Recovery
Sample Length/Penetration Length:
10.0/ 13.0 = 77 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-41 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **8.9**	Penetration Depth (ft): **11.6**
Client: **LDWG**	Water Depth (ft): **15.6**	Sample Quality: **Good**
Collection Date: **2/20/06**	Mudline Elevation (ft): **-6.5**	Recovery in ft (%): **7.9 (66)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **200294** E./LONG: **1271170**	Process Date: **2/21/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC41-0-1	83% (0-1)	PCB SVOC Metals Hg Dioxins/ Furans	0	OL: (0.0-0.6) very wet, very soft, olive brown (2.5Y, 4/3) ORGANIC SILT, few sand.	@ 0.0' to 0.5' Sheen Test = no sheen	recent
1	LDW-SC41-1-2		PCB SVOC Metals Hg Dioxins/ Furans	0	OL: (0.6-7.9) moist, soft to medium stiff, black (2.5Y, 2./1) ORGANIC SILT, few sand, interbedded with trace 1" to 3" thick layers of moist, soft, very dark greenish gray (GLEY 1, 3/1) SILT, little clay. Organic silt texture is uniform, slightly compressible, massive, blocky, and of low plasticity. Scattered rootlets, wood fragments up to 4" L, and trace shell fragments up to 1/2" L. Scattered 1/2" L sheen florets at depth.	Transitional Contact GT @ 1.2' @ 1.2' TV = 0.4 kg/cm2	
2	LDW-SC41-2-4	100% (1-3)	PCB SVOC Metals Hg Dioxins/ Furans	0		GT @ 3.2' @ 3.5' TV = 0.2 kg/cm2	
3							
4	LDW-SC41-4-6	100% (3-5)				Slight winnowing @ 3.9' to 4.2'	
5			PCB SVOC	0		@ 5.3' TV = 0.4 kg/cm2	
6		68% (5-8)					

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Remarks: **Drive Notes: freefall (2.0'), easy (11.6'), penetration goal reached. One drive attempt made at station. Scattered HC-like sheen florets along sidewalls from 4.0' to 5.4'.**

la = lower alluvium

Calculated Recovery
Sample Length/Penetration Length:
7.7 / 11.6 = 66 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-41 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **8.9**	Penetration Depth (ft): **11.6**
Client: **LDWG**	Water Depth (ft): **15.6**	Sample Quality: **Good**
Collection Date: **2/20/06**	Mudline Elevation (ft): **-6.5**	Recovery in ft (%): **7.9 (66)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **200294** E./LONG: **1271170**	Process Date: **2/21/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
	LDW-SC41-7.9		PCB	0	ML: (7.9-8.3) moist, soft, very dark greenish gray (GLEY 1 3/1) SILT, little clay.	@ 6.6' TV = 0.5 kg/cm2 Transitional Contacts	7
					SP- SM: (8.3-10.9) damp, medium stiff, bluish gray (GLEY 2, 5/10B) SILT, few sand layers grading to fine SAND layers interbedded with black SILT (transitional unit).	Sharp Contact	8
		70% (8-10)			SP: (10.9-11.6) damp, medium dense, bluish gray (GLEY 2, 5/10B) fine SAND. Lost 0.2' of sand.		9
		60% (10-11.6)			End of core at 7.9'.		10
							11

upper alluvium

la

The RETEC Group, Inc. 1011 SW Klickitat Way, Suite 207 Seattle, WA 98134-1162 Phone: (206) 624-9349 Fax: (206) 624-2839	**Remarks:** Drive Notes: freefall (2.0'), easy (11.6'), penetration goal reached. One drive attempt made at station. Scattered HC-like sheen florets along sidewalls from 4.0' to 5.4'. la = lower alluvium
	Calculated Recovery Sample Length/Penetration Length: 7.7 / 11.6 = 66 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-42 (R2)

Sheet 1 of 3

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **8.8**	Penetration Depth (ft): **15.9**
Client: **LDWG**	Water Depth (ft): **20.2**	Sample Quality: **Good**
Collection Date: **2/8/06**	Mudline Elevation (ft): **-11.9**	Recovery in ft (%): **12.8 (79)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **199898** E./LONG: **1271361**	Process Date: **2/8/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth; (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC42-0-1	100% (0-5)	PCB SVOC Metals Hg	0	OL: (0.0-0.2) very wet, very soft, very dark greenish gray (GLEY 1, 3/10Y) ORGANIC SILT, few sand and trace twigs.	Transitional Contact	0
1	LDW-SC42-1-2		PCB SVOC Metals Hg	0	OL: (0.2-4.0) moist, medium stiff, black (GLEY 1, 2.5/N) ORGANIC SILT, few sand and clay. Scattered rootlets, shredded wood, and wood fibers. Less sand with depth. Trace H2S-like odor.	@ 0.7' TV = 0.3 kg/cm2 GT @ 0.9' @ 1.3' TV = 0.5 kg/cm2	1
2	LDW-SC42-2-4		PCB SVOC Metals Hg	0	@3.4' a distinct 3" thick layer of moist, soft, dark greenish gray SILT with scattered rootlets, fibers, shells, and black sheen	GT @ 2.2'	2
3							3
4	LDW-SC42-4-6				ML: (4-5.6) moist, medium stiff, black (GLEY 1, 2.5/N) SILT, few clay, grading to SILT; trace sand at basal contact. Trace rootlets and wood fibers. Sand grains are multicolored (orange, red, white).	Transitional Contact @ 4.3' TV = 0.5 kg/cm2	4
5				0			5

recent

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Remarks: **Drive Notes: freefall (0.0'), easy (2.4'), moderate (15.9'), penetration goal reached. Two drive attempts made at station. Core catcher was empty, but natural plug as described by boat crew. Fine sand in shoe.**

Calculated Recovery
Sample Length/Penetration Length:
12.8/15.9 = 81 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-42 (R2)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **8.8**	Penetration Depth (ft): **15.9**
Client: **LDWG**	Water Depth (ft): **20.2**	Sample Quality: **Good**
Collection Date: **2/8/06**	Mudline Elevation (ft): **-11.9**	Recovery in ft (%): **12.8 (79)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **199898** E./LONG: **1271361**	Process Date: **2/8/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
6	LDW-SC42-6-8	85% (5-8)		0	SM: (5.6-7.5) moist to wet, medium dense, dark greenish gray (GLEY 2, 4/10G) medium SAND, little gravel and silt. Sand grains are multicolored (orange, red, white). Gravel is rounded and up to 2" diameter.	Sharp Contact @ 5.7' TV = 0.5 kg/cm2	6
7					ML: (7.5-11.8) moist, medium stiff, black (GLEY 1, 2.5/N) SILT, little clay, grading to SILT, few gravel. Black sheen from 8' to to basal contact.	@ 7.5' TV = 1 kg/cm2	7
8	LDW-SC42-8-10	70% (8-13)		0			8
9						@ 9.5' TV = 0.9 kg/cm2	9
10	LDW-S				ML: (11.8-13.8) moist, medium stiff, dark greenish gray (GLEY 1, 4/10Y) SILT with 1/8" to 1/4" thick seams of pale olive gray CLAY spaced every half foot. Trace debris. @ 11.0' piece of thin plastic (resting ontop of core; location qualified)		upper alluvium 10

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Remarks: **Drive Notes: freefall (0.0'), easy (2.4'), moderate (15.9'), penetration goal reached. Two drive attempts made at station. Core catcher was empty, but natural plug as described by boat crew. Fine sand in shoe.**

Calculated Recovery
Sample Length/Penetration Length:
12.8/15.9 = 81 %

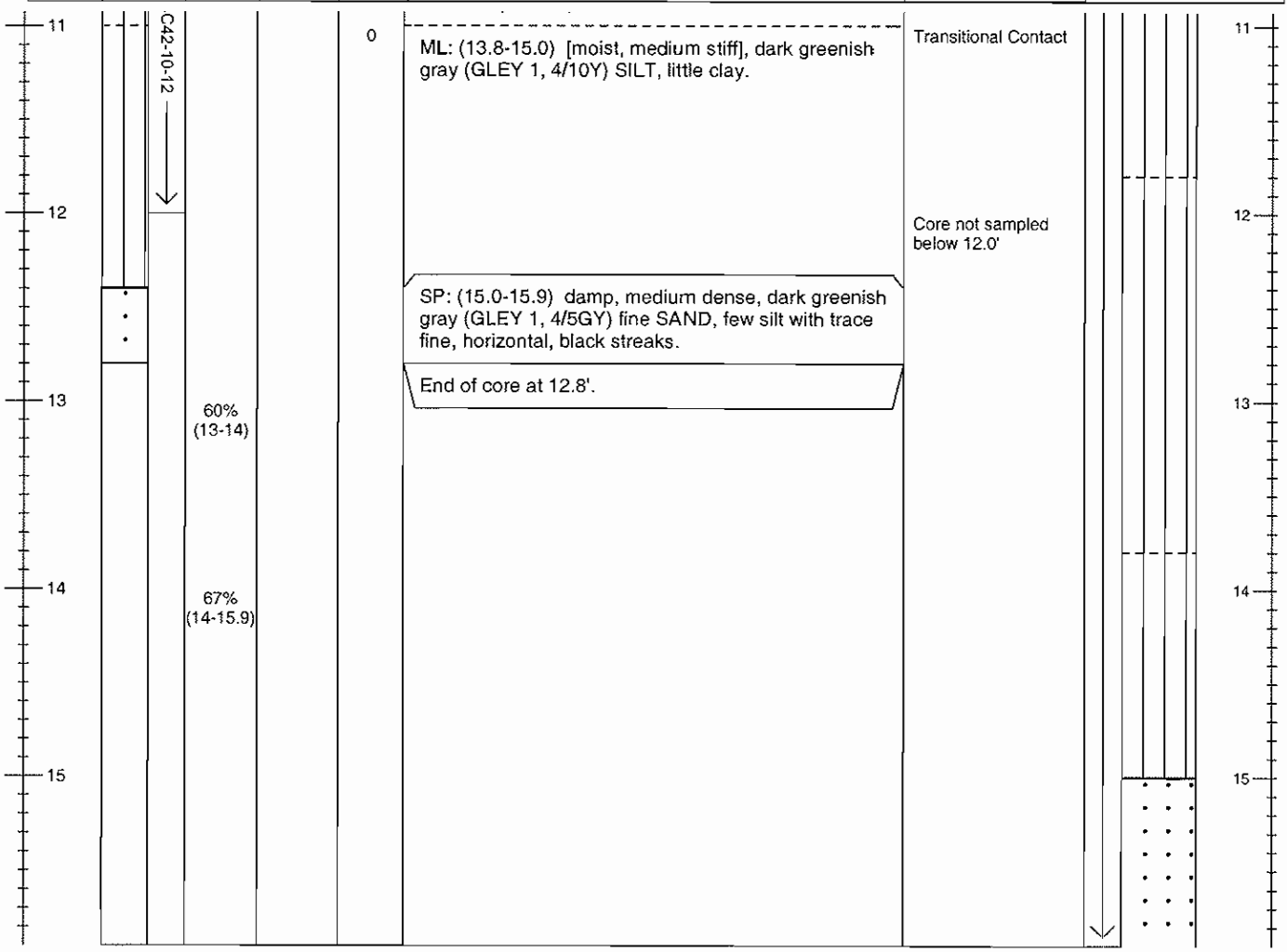
Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-42 (R2)

Sheet 3 of 3

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **8.8**	Penetration Depth (ft): **15.9**
Client: **LDWG**	Water Depth (ft): **20.2**	Sample Quality: **Good**
Collection Date: **2/8/06**	Mudline Elevation (ft): **-11.9**	Recovery in ft (%): **12.8 (79)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **199898** E./LONG: **1271361**	Process Date: **2/8/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N. Bacher**



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Remarks: **Drive Notes: freefall (0.0'), easy (2.4'), moderate (15.9'), penetration goal reached. Two drive attempts made at station. Core catcher was empty, but natural plug as described by boat crew. Fine sand in shoe.**

Calculated Recovery
Sample Length/Penetration Length:
12.8/ 15.9 = 81 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-43 (R3)

Sheet 1 of 3

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **3.9**	Penetration Depth (ft): **15.9**
Client: **LDWG**	Water Depth (ft): **11.1**	Sample Quality: **Good**
Collection Date: **2/22/06**	Mudline Elevation (ft): **-6.8**	Recovery in ft (%): **9.8 (62)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **199287** E./LONG: **1271846**	Process Date: **2/23/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC43-0-2	100% (0-0.5)	PCB SVOC Metals Hg	0	OL: (0.0-0.1) very wet, very soft, yellowish red (5YR, 4/6) ORGANIC SILT, little sand.	Transitional Contact	recent
1		69% (0.5-3)			OL: (0.1-0.7) moist, medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT, little sand. Silt texture is uniform, slightly compressible, blocky, massive, and of low plasticity.	Transitional Contact GT @ 0.9' @ 0.9' TV = 1.04 kg/cm2	
2	LDW-SC43-2-4		PCB SVOC Metals Hg	0	ML: (0.7-3.8) moist, soft to medium stiff, gray (2.5Y, 5/1) SILT, little clay , interbedded with 1" thick, moist, medium dense, black (2.5Y, 2.5/1) fine to medium SAND. Silt texture is slightly compressible, of low plasticity, and rolls easily. Sand grains are multicolored (orange, red, white). Trace gray (7.5YR, 5/1) pockets of SILT, little clay up to 1/2" L.		
3		78% (3-7)			SP- SM: (3.8-11.9) moist, medium dense, gray (7.5YR, 5/1) fine to medium SAND, grading to medium sand below 4.0', interbedded with 1" thick, moist, soft to medium stiff, gray (2.5Y, 5/1) SILT. Trace layers of moist, dense, dark gray brown, well sorted, fine sand.	GT @ 3.1'	
4							
5	LDW-SC43-4-6			0			

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Remarks: **Drive Notes: freefall (0.5'), easy (7.0'), moderate (13.0'), hard (14.0'), penetration goal reached. Core catcher was half full. Torvane measurments taken from R2. 1/2" HC-like sheen sheen florets on sidewalls from 8.5' to 8.9'.**

Calculated Recovery
Sample Length/Penetration Length:
9.8 / 15.9 = 62 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-43 (R3)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **3.9**	Penetration Depth (ft): **15.9**
Client: **LDWG**	Water Depth (ft): **11.1**	Sample Quality: **Good**
Collection Date: **2/22/06**	Mudline Elevation (ft): **-6.8**	Recovery in ft (%): **9.8 (62)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **199287** E./LONG: **1271846**	Process Date: **2/23/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
6	LDW-SC43-6.9	80% (7-9)		0	@ 8' 1" thick layer of coarse SAND	Winnowing @ 8.5' to 8.9'.	upper alluvium
7							
8							
9	8.9-9.8	75% (9-11)		0	SW: (11.9-15.9) damp, stiff, black (2.5Y, 2.5/1), medium to coarse SAND, grading to coarse sand at basal contact.	Sharp Contact	
10					End of core at 9.8'.		
11		45% (11-13)					

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Remarks: **Drive Notes: freefall (0.5'), easy (7.0'), moderate (13.0'), hard (14.0'), penetration goal reached. Core catcher was half full. Torvane measurments taken from R2. 1/2" HC-like sheen sheen florets on sidewalls from 8.5' to 8.9'.**

Calculated Recovery
Sample Length/Penetration Length:
9.8 / 15.9 = 62 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-43 (R3)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **3.9**	Penetration Depth (ft): **15.9**
Client: **LDWG**	Water Depth (ft): **11.1**	Sample Quality: **Good**
Collection Date: **2/22/06**	Mudline Elevation (ft): **-6.8**	Recovery in ft (%): **9.8 (62)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **199287** E./LONG: **1271846**	Process Date: **2/23/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
12							12
13		26% (13-15.9)					13
14							14
15							15

lower alluvium

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Remarks: Drive Notes: freefall (0.5'), easy (7.0'), moderate (13.0'), hard (14.0'), penetration goal reached. Core catcher was half full. Torvane measurments taken from R2. 1/2" HC-like sheen sheen florets on sidewalls from 8.5' to 8.9'.

Calculated Recovery
Sample Length/Penetration Length:
9.8 / 15.9 = 62 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-44 (R2)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **10.0**	Penetration Depth (ft): **11.7**
Client: **LDWG**	Water Depth (ft): **12.0**	Sample Quality: **Good**
Collection Date: **2/21/06**	Mudline Elevation (ft): **-2.1**	Recovery in ft (%): **5.8 (50)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **198925** E./LONG: **1272230**	Process Date: **2/21/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Driver Impact Core/4" sq Al**	Logged By: **L.McKee, A.Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0–1	LDW-SC44-0-2	70% (0-3)	PCB SVOC Metals Hg	0	OL: (0.0-0.4) wet to moist, soft, black (2.5Y, 2.5/1) ORGANIC SILT, few sand. Silt texture is uniform, massive, blocky, and slightly mottled.	Transitional Contact	recent
1–2		61% (3-5)			OL: (0.4-4.8) moist, soft, black (2.5Y, 2.5/1) ORGANIC SILT with 1" thick layers of fine SAND, medium SAND, and SILT, little clay. Trace rootlets, wood and shell fragments.	GT @ 0.9' @ 1.2' TV = 0.9 kg/cm2	
2–3	LDW-SC44-2-3.2		PCB SVOC Metals Hg	0	@ 2.4' abundant 1" L glass shards	@ 2.6' TV = 0.6 kg/cm2	
3–4	3.2-4.0	41% (5-7)	PCB SVOC Metals Hg	0	SP- SM: (4.8-6.2) moist, dense, brown (7.5YR, 4/2) medium SAND, little gravel, interbedded with SILT. Gravel is subangular; sand grains are multicolored (orange, red, white) (transitional unit). @ 3.3' 6" L subangular concrete conglomerate (anthropogenic)	Sharp Contact @ 3.2' TV = 0.6 kg/cm2 Bag @ 3.3' (piece of conglomerate)	
4–5	LDW-SC44-4-5.8			0	SP: (6.2-11.7) damp, dense, brown (7.5YR, 4/2) medium to coarse SAND. Sand grains are multicolored (orange, red, white) and well sorted. Grades to gray (2.5Y, 5/1) coarse SAND, few subangular gravel at basal contact. Sand coarsens downward.	Transitional Contact GT @ 3.9'	
5–6					End of core at 5.8'. Driven to refusal.		

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Remarks: **Drive Notes: freefall (3.0'), moderate (7.0'), hard (11.7'), refusal (11.7'). Two drive attempts made at station.**

Core catcher was 66% full.

Calculated Recovery
Sample Length/Penetration Length:
5.8 /11.7 = 50 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-44 (R2)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **10.0**	Penetration Depth (ft): **11.7**
Client: **LDWG**	Water Depth (ft): **12.0**	Sample Quality: **Good**
Collection Date: **2/21/06**	Mudline Elevation (ft): **-2.1**	Recovery in ft (%): **5.8 (50)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **198925** E./LONG: **1272230**	Process Date: **2/21/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Driver Impact Core/4" sq Al**	Logged By: **L.McKee, A.Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7		56% (7-9)					upper alluvium
8							
9		23% (9-11)					
10							
11		40% (11-11.7)					

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Remarks: **Drive Notes: freefall (3.0'), moderate (7.0'), hard (11.7'), refusal (11.7'). Two drive attempts made at station.**

Core catcher was 66% full.

Calculated Recovery
Sample Length/Penetration Length:
5.8 / 11.7 = 50 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-45 (R3)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **9.2**	Penetration Depth (ft): **7.7**
Client: **LDWG**	Water Depth (ft): **22.7**	Sample Quality: **Good**
Collection Date: **2/21/06**	Mudline Elevation (ft): **-13.5**	Recovery in ft (%): **6.5 (84)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **198588** E./LONG: **1272647**	Process Date: **2/21/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Driver Impact Core/4" sq Al**	Logged By: **L.McKee, A.Fitzpatrick**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth; (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC45-0-1	100% (0-1)	PCB SVOC Metals Hg	0	ML: (0.0-0.3) very wet, very soft, olive brown (2.5Y, 4/3) SILT.	Transitional Contact	0
					ML: (0.3-4.1) moist, medium stiff, black (2.5Y, 2.5/1) SILT, few sand, trace rootlets, wood and shell fragments.		
1	LDW-SC45-1-2	91% (1-5)	PCB SVOC Metals Hg	0		GT @ 1.1'	1
2	LDW-SC45-2-4		PCB SVOC Metals Hg	0	@ 2.2' scattered rainbow sheen florets to basal contact	@ 1.9' TV = 0.6 kg/cm2	2
3					@ 3' 1" thick layer of damp, black SAND with multicolored grains oriented transversely		3
						Transitional Contact	
4	LDW-SC45-4-5			0	ML: (4.1-4.5) moist, medium stiff, gray (2.5Y, 5/1) SILT, little clay.	@ 3.8' TV = 0.6 kg/cm2 GT @ 3.8'	4
					MH: (4.5-5.2) moist, medium stiff, black (2.5Y, 2.5/1) SILT, few sand, trace rootlets. Trace debris.	Transitional Contact	
5	LDW-SC45-5-6				@ 4.8' 2" L piece of subrounded anthropogenic conglomerate (concrete)	Bag @ 4.8' (concrete conglomerate)	5
			PCB	0	SW: (5.2-7.7) moist, medium dense, black (2.5Y, 2.5/1) medium SAND, few silt and gravel. SAND grains are multicolored (orange, red, white) and grade to coarse near basal contact. Gravel is subrounded up to 1" L.	Sharp Contact	
6		71% (5-7.7)				@ 5.6' TV = 0.7 kg/cm2	6

upper alluvium

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Remarks: **Drive Notes: freefall (0.8'), easy (5.0'), moderate (7.5'), hard (7.7'), refusal (7.7'). Three drive attempts made at station. Core catcher was 50% full. HC-like rainbow sheen on sidewalls and parting seams from 1.8' to 4.2'. r = recent**

Calculated Recovery
Sample Length/Penetration Length:
6.5 / 7.7 = 84 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-45 (R3)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **9.2**	Penetration Depth (ft): **7.7**
Client: **LDWG**	Water Depth (ft): **22.7**	Sample Quality: **Good**
Collection Date: **2/21/06**	Mudline Elevation (ft): **-13.5**	Recovery in ft (%): **6.5 (84)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **198588** E./LONG: **1272647**	Process Date: **2/21/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Driver Impact Core/4" sq Al**	Logged By: **L.McKee, A.Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7					End of core at 6.5'. Driven to refusal. Note: R1 core driven closer to shore (-7.2' MLLW) and to refusal at 9.5'; end of recovered core at 5.3'. A heavy petroleum-like sheen and odor observed from 4.5' to 5.3' in a gravel layer and throughout matrix (bottom of core). Trace staining on sidewalls and free phase blebs. A discrete sample collected of this unit at 5.0'.	Sheen test: heavy rainbow sheen and free phase product blebs.	7

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Remarks: **Drive Notes: freefall (0.8'), easy (5.0'), moderate (7.5'), hard (7.7'), refusal (7.7'). Three drive attempts made at station. Core catcher was 50% full. HC-like rainbow sheen on sidewalls and parting seams from 1.8' to 4.2'. r = recent**

Calculated Recovery
Sample Length/Penetration Length:
6.5 / 7.7 = 84 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-46 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **14.0**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **13.0**
Client: **LDWG**	Water Depth (ft): **16.8**	Sample Quality: **Good**
Collection Date: **2/24/06**	Mudline Elevation (ft): **-7.6**	Recovery in ft (%): **11.2 (86)**
Contractor: **MSS**	N./LAT: **198577** E./LONG: **1272117**	Process Date: **2/24/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3.5" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC46-0-1		PCB SVOC Metals Hg	0	OL: (0.0-2.3) wet to moist, medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT, few sand, mottled with medium stiff, very dark greenish gray (GLEY 1, 3/1) SILT, little clay. Trace subrounded gravel, wood and shell fragments, rootlets, and worms. Silt texture is slightly compressible, of low plasticity, and increases in competency towards basal contact.	GT @ 1.1'	recent
1	LDW-SC46-1-2	86% (0-13)	PCB SVOC Metals Hg	0	OL: (2.3-7.9) moist, medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT, little clay, with scattered 1" thick layers of black, fine to medium SAND with multicolored grains (orange, red, white). Silt texture is compressible and blocky. Scattered wood fragments up to 1/2" L and shell fragments up to 2" L. Slight HC-like odor and sheen in upper portion of unit. Trace debris. @ 2.8' 1" shell layer with shells up to 1/2" L and slight HC-like odor and metallic sheen	@ 1.8' TV = 0.3 kg/cm2 Transitional Contact GT @ 2.1'	
2	LDW-SC46-2-4		PCB SVOC Metals Hg	0		@ 3.2' TV = 0.3 kg/cm2	
3							
4	LDW-SC46-4-6.8		PCB	0	@ 3.9' shell layer with shells up to 2" L and slight HC-like odor and rainbow sheen	@ 3.9' TV = 0.2 kg/cm2	upper alluvium
5							
6							

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Remarks: **Drive Notes: freefall (3.5'), easy (13.0'), penetration goal reached. One drive attempt made at station. Core catcher was empty (0.5' sediment loss).**

Calculated Recovery
Sample Length/Penetration Length:
11.2/ 13.0 = 86 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-46 (R1)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **14.0**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **13.0**
Client: **LDWG**	Water Depth (ft): **16.8**	Sample Quality: **Good**
Collection Date: **2/24/06**	Mudline Elevation (ft): **-7.6**	Recovery in ft (%): **11.2 (86)**
Contractor: **MSS**	N./LAT: **198577** E./LONG: **1272117**	Process Date: **2/24/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3.5" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7	LDW-SC46-6.8-8			0	@ 6.9' 2" L piece of plastic SP: (7.9-13.0) damp, medium dense, brown (7.5YR, 4/2) medium SAND with trace 1-2" pockets of olive gray (GLEY 1, 3/1) SILT, little clay. Trace subrounded gravel up to 2". Grades to very dark greenish gray (GLEY 1, 3/1) medium SAND.	Sharp Contact	lower alluvium
8	LDW-SC46-8-10			0			
9							
10	LDW-SC46-10-11.2			0			
11					End of core at 11.2'.		
12							
13							

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Remarks: Drive Notes: freefall (3.5'), easy (13.0'), penetration goal reached. One drive attempt made at station. Core catcher was empty (0.5' sediment loss).

Calculated Recovery
Sample Length/Penetration Length:
11.2/ 13.0 = 86 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-47 (R3)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **14.0**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **13.0**
Client: **LDWG**	Water Depth (ft): **10**	Sample Quality: **Good**
Collection Date: **2/23/06**	Mudline Elevation (ft): **-0.4**	Recovery in ft (%): **10.3 (79)**
Contractor: **MSS**	N./LAT: **197422** E./LONG: **1273340**	Process Date: **2/23/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3.5" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC47-0-1	79% (0-13)	PCB SVOC Metals Hg	0	ML: (0.0-0.1) very wet, very soft, olive brown (2.5Y, 4/3) SILT, few sand.		recent
1	LDW-SC47-1-2		PCB SVOC Metals Hg	0	SW: (0.1-0.7) moist, medium dense, brown (7.5YR, 4/2) medium to coarse SAND. Sand grains are multicolored (orange, red, white) and poorly sorted. Scattered rootlets.		
2	LDW-SC47-2-3		PCB SVOC Metals Hg	0	OL: (0.7-2.9) moist, medium stiff, black (2.5Y, 2.5/1) ORGANIC SILT, little sand, trace layers of black, coarse SAND. Scattered shell and wood fragments up to 1" L and trace debris. Strong to mild H2S-like odor.	GT @ 1.4'	upper alluvium
3	LDW-SC47-3-4		PCB SVOC Metals Hg	0	@ 1' piece of 2" L anthropogenic conglomerate (concrete)	@ 1.8' TV = 0.2 kg/cm2	
4	LDW-SC47-4-6			0	SP- SM: (2.9-3.8) damp, medium dense, black (2.5Y, 2.5/1) medium SAND interbedded with black ORGANIC SILT, few sand.	Sharp Contact	
5				0	SP: (3.8-13.0) damp to moist, dense, brown (7.5YR, 4/2) [medium] SAND, trace 1" thick layers of coarse sand and fine sand. Sand grains are multicolored (orange, red, white), uniform, and well sorted. Grades to very dark greenish gray (GLEY 1, 3/1) fine sand at basal contact. Trace wood fragments up to 1/2" L.	@ 2.6' TV = 0.2 kg/cm2 GT @ 2.8'	
6				0		Sharp Contact	
						Oxidation @ 5.0' to 7.6'	
						@ 5.5 TV = 0.1 kg/cm2	

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Remarks: **Drive Notes: moderate (8.0'), hard (10.0'), refusal (13.0'). Core catcher was 50% full. Instrument not reading correctly during early part of the drive. Three drive attempts made at station; station re-occupied with vibracore.**

Calculated Recovery
Sample Length/Penetration Length:
10.3/ 13.0 = 79 %

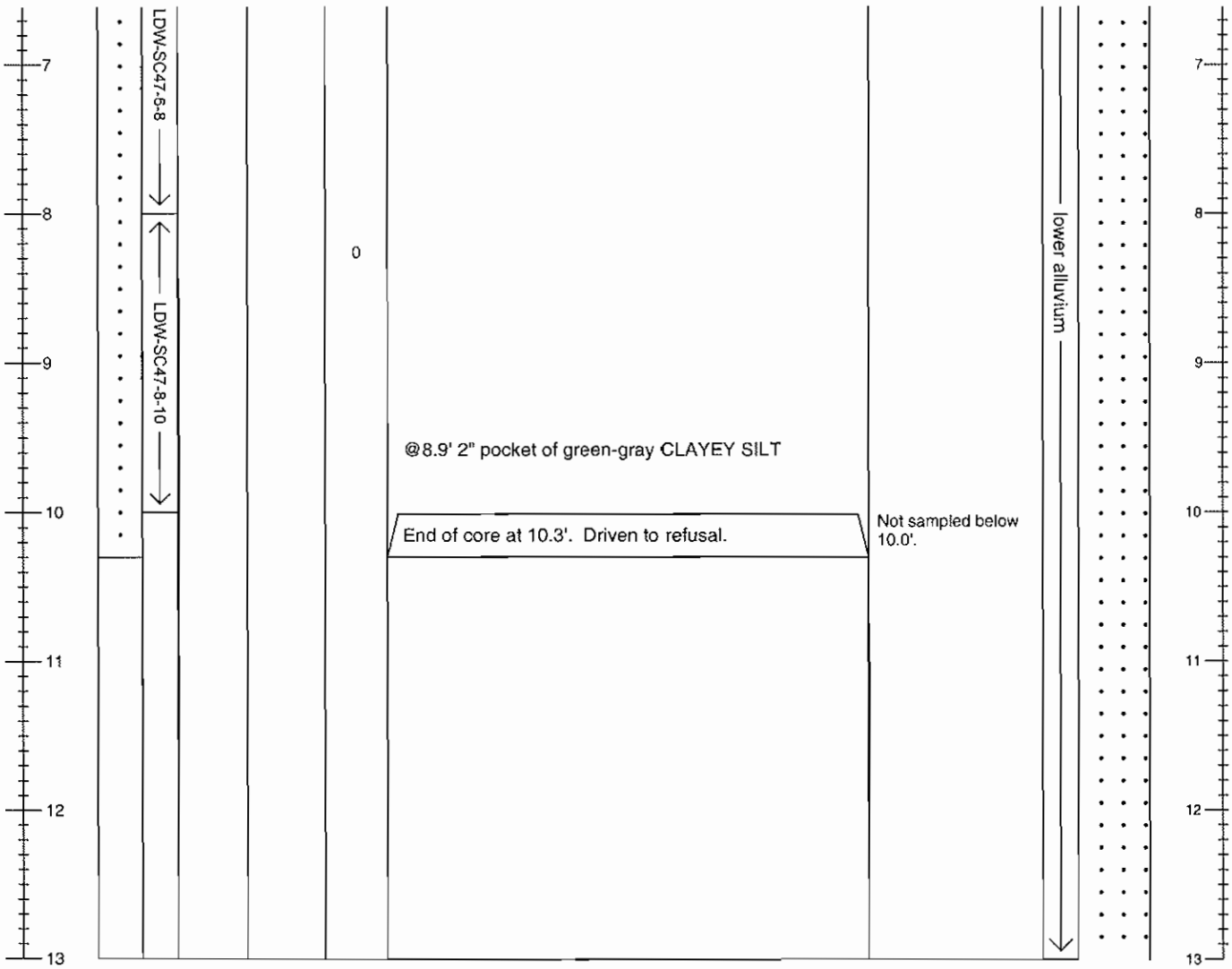
Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-47 (R3)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **14.0**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **13.0**
Client: **LDWG**	Water Depth (ft): **10**	Sample Quality: **Good**
Collection Date: **2/23/06**	Mudline Elevation (ft): **-0.4**	Recovery in ft (%): **10.3 (79)**
Contractor: **MSS**	N./LAT: **197422** E./LONG: **1273340**	Process Date: **2/23/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3.5" round Al**	Logged By: **L.McKee, C.Brackett**



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Remarks: **Drive Notes: moderate (8.0'), hard (10.0'), refusal (13.0'). Core catcher was 50% full. Instrument not reading correctly during early part of the drive. Three drive attempts made at station; station re-occupied with vibracore.**

Calculated Recovery
Sample Length/Penetration Length:
10.3/ 13.0 = 79 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-48 (R2)

Sheet 1 of 1

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **9.4**	Penetration Depth (ft): **6.7**
Client: **LDWG**	Water Depth (ft): **37.4**	Sample Quality: **Good**
Collection Date: **2/8/06**	Mudline Elevation (ft): **-22.3**	Recovery in ft (%): **5.8 (86)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **196658** E./LONG: **127453**	Process Date: **2/8/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N.Bacher**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC48-0-1	100% (0-4)	PCB SVOC Metals Hg	0	ML: (0.0-0.2) very wet, very soft, dark olive gray (5Y, 3/2) SILT, few sand, trace wood fragments, and worms.	Sharp Contact	r
1	LDW-SC48-1-2		PCB SVOC Metals Hg	0	SW: (0.2-4.5) moist, medium dense, very dark greenish gray (GLEY 1, 3/5GY) fine to medium SAND, few silt. Sand grains are multicolored (orange, red, white).	@ 0.6' TV = 0.1 kg/cm2 GT @ 0.9' (R1)	
2	LDW-SC48-2-4		PCB SVOC Metals Hg	0		@ 1.5' TV = 0.1 kg/cm2 GT @ 2.0' (R1)	
3						@ 3.0' TV = 0.1 kg/cm2	lower alluvium
4	LDW-SC48-4-5.6	85% (4-6)		0	SP- SM: (4.5-5.5) [moist, medium dense], dark greenish gray (GLEY 1, 4/5GY) fine SAND, little silt to SILT, little sand, thinly interbedded with 1/8" thick seams of moist, [medium stiff], dark grayish brown (10YR, 4/2) SILT, little clay. @5.0' 0.2' thick layer of medium stiff gray SILT, little clay, trace horizontal black streaks	Transitional Contact @ 4.7' TV = 0.4 kg/cm2	
5					SM: (5.5-6.7) moist, medium dense, dark greenish gray (GLEY 1, 4/5GY) fine SAND, little silt. Sand grains are multicolored (orange, red, white).		
6		66% (6-6.3) 0% (6.3-6.6)			End of core at 5.8'. Driven to refusal.	50% winnowing below 5.8'.	

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Remarks: **Drive Notes: freefall (0.2'), easy (6.0'), hard (6.6'), refusal (6.7'). Two drive attempts made at station. Core catcher was 50% full. r = recent**

Calculated Recovery
Sample Length/Penetration Length:
5.8 / 6.7 = 86 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-49 (R1)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **5.5**	Penetration Depth (ft): **14.0**
Client: **LDWG**	Water Depth (ft): **28.9**	Sample Quality: **Good**
Collection Date: **2/6/06**	Mudline Elevation (ft): **-19.8**	Recovery in ft (%): **11.4 (81)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **195851** E./LONG: **1275477**	Process Date: **2/6/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N.Bacher, A.Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC49-0-1	62% (0-1)	PCB SVOC Metals Hg	1.1	OL: (0.0-1.1) very wet, soft, greenish black (GLEY 2, 2.5/10GY) ORGANIC SILT, little clay. Trace rootlets and worms. Moderate H2S-like odor. @ 0.7' 3" thick layer of wet, soft, black, silty, WOOD FRAGMENTS (60%), shredded, natural	@ 0.7' TV = 0.6 kg/cm2 GT @ 0.9'	recent
1	LDW-SC49-1-2	93% (1-8)	PCB SVOC Metals Hg		OL: (1.1-4.1) moist to wet, medium stiff, greenish black (GLEY 2, 2.5/10GY) ORGANIC SILT, little clay. Silt texture is homogenous, uniform, slightly compressible, and blocky; trace shell fragments up to 1/2" diameter and rootlets.	Transitional Contact @ 1.5' TV = 0.6 kg/cm2 GT @ 1.9'	
2	LDW-SC49-2-4		PCB SVOC Metals Hg	2.9			
3					SP: (4.1-4.4) damp, medium dense, very dark greenish gray (GLEY 1, 3/10GY) fine SAND. Sand grains are multicolored (orange, red, white). Moderate H2S-like odor.	@ 3.0' TV = 0.4 kg/cm2 Sharp Contact	
4	LDW-SC49-4-6		PCB	3.1	MH: (4.4-14.0) moist, medium stiff, greenish black (GLEY 1, 2.5/10Y) grading to black (GLEY 1, 2.5/N) SILT, few clay, with trace 1" thick layers of wood fragments and 1/2" to 6" thick layers of dark greenish gray (GLEY 1, 4/10Y) fine sand. Silt texture is slightly compressible and has a slight H2S-like odor that increases with depth; scattered wood fragments. Increasing stiffness with depth.	Sharp Contact @ 5.0' TV = 0.4 kg/cm2	
5							
6	LDW-SC49-6-		PCB				
7						@ 7.0' TV = 0.6 kg/cm2	

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Remarks: **Drive Notes: none taken. One drive attempt made at station. Core shoe was 100% full.**

Calculated Recovery
Sample Length/Penetration Length:
11.4/14.0 = 81 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-49 (R1)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **5.5**	Penetration Depth (ft): **14.0**
Client: **LDWG**	Water Depth (ft): **28.9**	Sample Quality: **Good**
Collection Date: **2/6/06**	Mudline Elevation (ft): **-19.8**	Recovery in ft (%): **11.4 (81)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **195851** E./LONG: **1275477**	Process Date: **2/6/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N.Bacher, A.Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
8	LDW-SC49-8-10	88% (8-10)	PCB	5		@ 9.0' TV = 0.5 kg/cm2	upper alluvium
9							
10	LDW-SC49-10-11	65% (10-12)		500		@ 10.5' TV = 0.5 kg/cm2	
11					End of core at 11.4'.	Sheen test @ 10.6' = very slight sheen with green irridescence (two 1/16" florets). Not sampled below 11.0'.	
12		70% (12-14)					
13							
14							

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Remarks: Drive Notes: none taken. One drive attempt made at station. Core shoe was 100% full.

Calculated Recovery
Sample Length/Penetration Length:
11.4/14.0 = 81 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-50 (R3)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **14.0**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **13.0**
Client: **LDWG**	Water Depth (ft): **11.6**	Sample Quality: **Good**
Collection Date: **2/24/06**	Mudline Elevation (ft): **-4.0**	Recovery in ft (%): **9.8 (75)**
Contractor: **MSS**	N./LAT: **194871** E./LONG: **1276045**	Process Date: **2/24/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3.5" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC50-0-1	75% (0-13)	PCB SVOC Metals Hg	0	ML: (0.0-1.2) wet, soft, black (2.5Y, 2.5/1) SANDY SILT grading to SILTY SAND at basal contact. @ 0.9' 2" thick layer of wet, [dense], black (2.5Y, 2.5/1) GRAVEL, subangular, up to 1" diameter with possible 1/4" paint chip.	Transitional Contact @ 0.8' TV = 0.0 kg/cm2	upper alluvium
1	LDW-SC50-1-2		PCB SVOC Metals Hg	0	MH: (1.2-2.7) [wet, soft], black (2.5Y, 2.5/1) SILT with some sand and few gravel interbedded and pocketed with very dark greenish gray (GLEY 1, 3/1) SILT, little clay. Scattered subangular gravel. Trace fibrous wood fragments up to 1/4" L. Slight HC-like odor.	GT @ 1.2' @ 1.5' TV = 0.2 kg/cm2	
2	2-2.8		PCB SVOC Metals Hg	0	SM: (2.7-3.7) moist, [medium dense], very dark gray (GLEY 1, 3/N) fine SAND with moderate 1" diameter pockets of moist, medium stiff, black (2.5Y, 2.5/1) SILT, few sand. Trace rootlets, wood fragments, and 1" diameter subangular gravel. Slight H2S-like odor.	Transitional Contact	
3	LDW-SC50-2.8-4		PCB SVOC Metals Hg	0	SP: (3.7-13.0) moist, medium dense, very dark greenish gray (GLEY 1, 3/N) medium SAND with few 1" thick layers of coarse sand, trace 2" to 3" diameter pockets of very dark greenish gray (GLEY 1, 3/1) SILT, little clay or black SILT, few sand from 2.8' to 5.5'. Grades to coarse sand at basal contact.	Sharp Contact @ 3.2' TV = 0.0 kg/cm2 Salinity collected at 2.0' intervals from 2.8' to 9.8'.	
4	LDW-SC50-4-6			0			
5							
6				0			

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Remarks: **Drive Notes: freefall (4.0'), easy (10.0'), hard (13.0'), penetration goal reached. Three drive attempts made at station; station reoccupied with vibracore. Core catcher was 100% full.**

Calculated Recovery
Sample Length/Penetration Length:
9.8 / 13.0 = 75 %

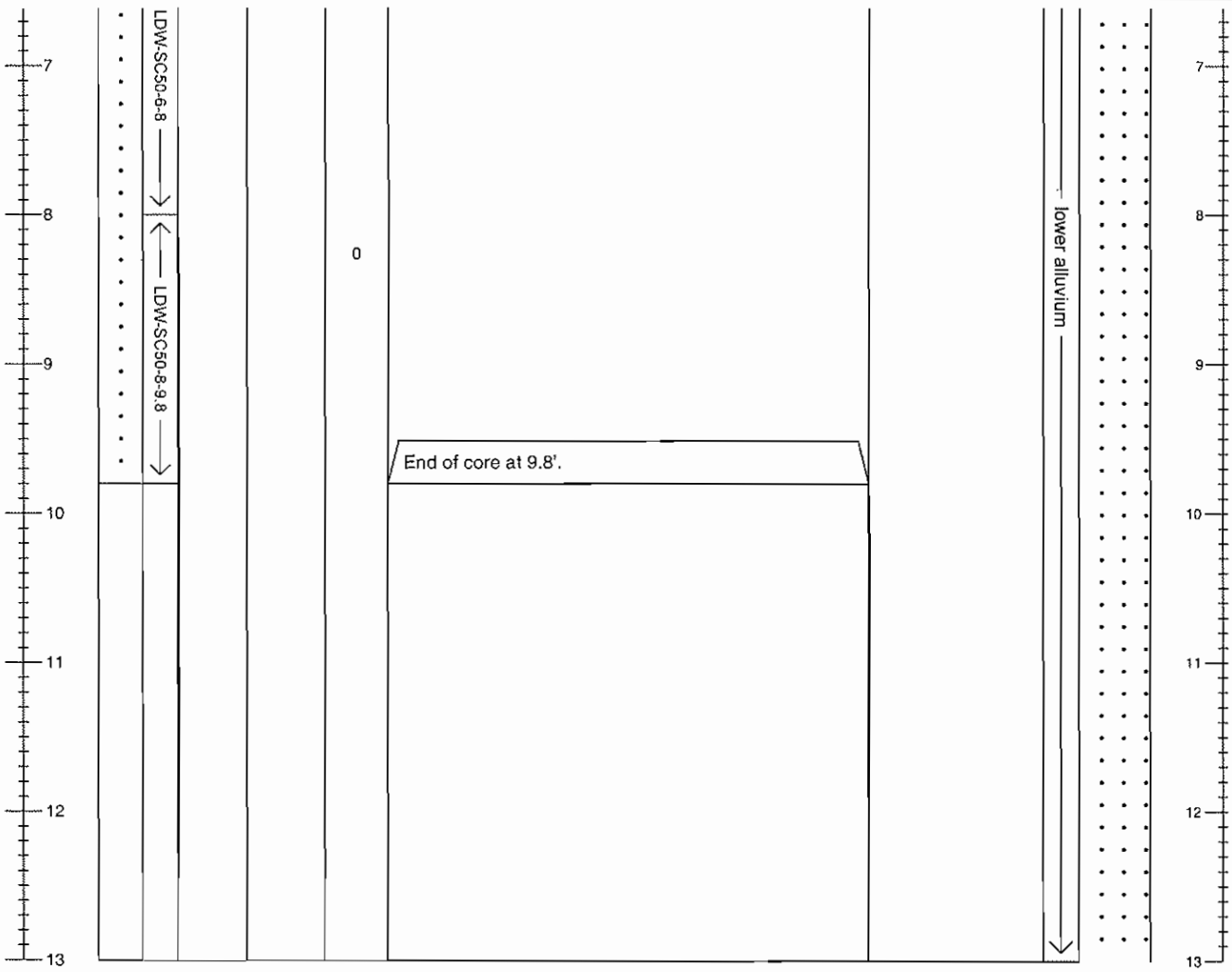
Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-50 (R3)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **14.0**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **13.0**
Client: **LDWG**	Water Depth (ft): **11.6**	Sample Quality: **Good**
Collection Date: **2/24/06**	Mudline Elevation (ft): **-4.0**	Recovery in ft (%): **9.8 (75)**
Contractor: **MSS**	N./LAT: **194871** E./LONG: **1276045**	Process Date: **2/24/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3.5" round Al**	Logged By: **L.McKee, C.Brackett**



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Remarks: **Drive Notes: freefall (4.0'), easy (10.0'), hard (13.0'), penetration goal reached. Three drive attempts made at station; station reoccupied with vibracore. Core catcher was 100% full.**

Calculated Recovery
Sample Length/Penetration Length:
9.8 / 13.0 = 75 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-51 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **9.2**	Penetration Depth (ft): **10.6**
Client: **LDWG**	Water Depth (ft): **8.5**	Sample Quality: **fair**
Collection Date: **2/22/06**	Mudline Elevation (ft): **0.8**	Recovery in ft (%): **6.1 (58)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **194728** E./LONG: **1276135**	Process Date: **2/22/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth. (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC51-0-2	78% (0-1)	PCB SVOC Metals Hg	0	ML: (0.0-0.4) very wet, very soft, dark reddish brown (2.5YR, 3/3) SILT, little sand. Scattered HC-like sheen florets and streaks up to 1" L.		recent
1					SW: (0.4-1.7) damp to moist, dense, black (2.5YR, 2.5/1) SAND, little gravel. Gravel is subangular and ranges in size from 1/4" to 1" L. Trace 1" layer of SILT, few sand.	Sheen Test = trace HC-like sheen GT @ 1.0' @ 1.1' TV = 0.8 kg/cm2 Transitional Contact	
2	LDW-SC51-2-3.8	69% (1-3)	PCB SVOC Metals Hg	0	SM: (1.7-5.0) damp, medium dense, dark greenish gray (GLEY 1, 4/1) SAND with scattered pockets and 1/2" L seams of black (2.5YR, 2.5/1) SILT, few sand. Scattered 1" to 2" thick layers of GRAVEL or coarse SAND, few gravel. Scattered debris. Slight HC-like sheen associated with gravel and debris. Moderate HC-like odor. @ 1.8' brick fragment @ 2.0' rock fragment (marble) 0.2' L @ 2.6' 2" thick layer of coarse SAND, few gravel	Sheen Test = moderate HC-like sheen Bag @ 2.0' (marble) @ 2.4' TV = 0.2 kg/cm2 GT @ 2.5'	upper alluvium
3		85% (3-4)			@ 3.5' 1" thick layer of GRAVEL and moderate amounts of blue-metallic, flat, angular, sharp anthropogenic material.	Sheen Test = trace HC-like sheen Bag @ 3.5' (anthropogenic)	
4	LDW-SC51-3.8-5.8		PCB	0	SP: (5.0-10.6) moist, dense, black (2.5YR, 2.5/1) medium SAND with trace 1" thick layers of coarse sand. Sand grains are multicolored (orange, red, white). Trace wood fragments up to 1" L.	Sharp Contact @ 4.5' TV = 0.2 kg/cm2	
5		34% (5-9)					

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Remarks: **Drive Notes: freefall (1.4'), moderate (5.6'), hard (10.6'), refusal (10.6'). One drive attempt made at station. Core catcher was 50% full.**

Calculated Recovery
Sample Length/Penetration Length:
6.1 / 10.6 = 58 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-51 (R1)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **9.2**	Penetration Depth (ft): **10.6**
Client: **LDWG**	Water Depth (ft): **8.5**	Sample Quality: **fair**
Collection Date: **2/22/06**	Mudline Elevation (ft): **0.8**	Recovery in ft (%): **6.1 (58)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **194728** E./LONG: **1276135**	Process Date: **2/22/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **L.McKee**

Recovered Depth (ft)	Recov. interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
					End of core at 6.1'. Driven to refusal.	Not sampled below 5.8' due to winnowing	lower alluvium
		44% (9-10.6)					

6 7 8 9 10

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Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-52 (R3)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **4**	Penetration Depth (ft): **10.3**
Client: **LDWG**	Water Depth (ft): **5.8**	Sample Quality: **fair**
Collection Date: **2/7/06**	Mudline Elevation (ft): **1.3**	Recovery in ft (%): **5.9 (57)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **194160** E./LONG: **1276279**	Process Date: **2/8/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83** N Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N.Bacher**

Recovered Depth (ft)	Recov. Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC52-0-1	68% (0-3)	PCB SVOC Metals Hg	0	ML: (0.0-0.3) very wet, very soft, dark grayish brown (2.5Y, 3/2) SILT, few sand. Trace shredded wood fragments and twigs.	Transitional Contact	0
1	LDW-SC52-1-2		PCB SVOC Metals Hg	0	OL: (0.3-0.9) moist, medium stiff, dark greenish gray (GLEY 1, 4/10GY) ORGANIC SILT, trace sand. Trace shredded wood fragments. Slight to moderate H2S-like odor.	Transitional Contact @ 0.8' TV = 2.3 kg/cm2	1
2	LDW-SC52-2-4	71% (3-4)	PCB SVOC Metals Hg	0	OL: (0.9-3.2) moist, medium stiff, black (GLEY 1, 2.5N) ORGANIC SILT with trace lenses of CLAY, few silt. Trace shredded wood fragments throughout and 1" thick layer of wood fragments at basal contact. Slight H2S-like odor.	GT @ 1.2' @ 1.6' TV = 1.9 kg/cm2	2
3			PCB SVOC Metals Hg	0	SP: (3.2-10.3) moist, medium dense, greenish black (GLEY 1, 2.5/5GY) fine SAND, little silt, grading to coarse sand towards basal contact. Sand grains are muticolored (orange, red, white). Trace wood fragments.	Sharp Contact @ 3.4' TV = 0.5 kg/cm2 GT @ 3.7'	3
4	LDW-SC52-4-4.9	57% (4-6)		0		End of sediment at 4.9'. One foot void (48% recovery)	4
5							5
6					End of core at 5.9'. Driven to refusal.		6

recent

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Remarks: **Drive Notes: moderate (4'), hard (10.3'), refusal (10.3'). Three drive attempts made at station. One foot of void space between 2.0' and 3.0' at silt/sand contact; logged continuously. EPA oversight.**

Calculated Recovery
Sample Length/Penetration Length:
5.9 / 10.3 = 57 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-52 (R3)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **4**	Penetration Depth (ft): **10.3**
Client: **LDWG**	Water Depth (ft): **5.8**	Sample Quality: **fair**
Collection Date: **2/7/06**	Mudline Elevation (ft): **1.3**	Recovery in ft (%): **5.9 (57)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **194160** E./LONG: **1276279**	Process Date: **2/8/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N.Bacher**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
6		64% (6-7)					lower alluvium
7		46% (7-9)					
8							
9		31% (9-10.3)					
10							

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Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-53 (R1)

Sheet 1 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **0.8**	Penetration Depth (ft): **13.6**
Client: **LDWG**	Water Depth (ft): **16.3**	Sample Quality: **NA**
Collection Date: **2/6/06**	Mudline Elevation (ft): **-12.6**	Recovery in ft (%): **11.1(82)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **192927** E./LONG: **1277458**	Process Date: **2/7/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83** N Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N.Bacher, A.Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS. Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC53-0-2	64% (0-2)	PCB SVOC Metals Hg Pesticides	0	OL: (0.0-0.5) very wet, very soft, black (GLEY 1, 2.5/N) ORGANIC SILT, little sand. Trace rootlets, wood fragments, and worms.	Transitional Contact	0
1					OL: (0.5-6.3) wet to moist, soft to medium stiff, black (GLEY 1, 2.5/N) ORGANIC SILT, few clay decreasing downsection (<15%). Trace rootlets and shell fragments. Moderate H2S-like odor.	GT @ 1.0' @ 1.0' TV = 1.0 kg/cm2	1
2	LDW-SC53-2-4	95% (2-4)	PCB SVOC Metals Hg Pesticides	0		Sheen Test @ 2.0' = no sheen	2
3						@ 1.0' TV = 1.2 kg/cm2 GT @ 3.0'	3
4	LDW-SC53-4-6	79% (4-6)		0		@ 4.2' TV = 1.5 kg/cm2	4
5					SP- SM: (6.3-7.0) moist, medium dense, dark greenish gray (GLEY 1, 4/5GY) fine to medium SAND interbedded with 1/2" thick moist, [medium stiff], greenish gray (GLEY 1, 5/5GY) SILT, [few clay] (transitional unit). @ 5.2' trace possible anthropogenic fibers	Transitional Contact @ 5.2' TV = 1.0 kg/cm2	5
6	LDW-	85% (6-8)		0	SP: (7.0-7.9) moist, medium dense to dense, dark greenish gray (GLEY 1, 4/5GY) medium SAND. Sand grains are multicolored (orange, red, white). Trace small wood, shells, and rootlets.	Transitional Contact	6
					ML: (7.9-9.2) moist, stiff, dark brown (7.5YR, 3/2) SILT, trace sand and clay. Trace small wood fragments at basal contact.	Top of unit has angled contact from 6.3' to 7.0'	

recent

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Remarks: **Drive Notes: none taken. One drive attempt made at station. Core catcher was 100% full.**

Calculated Recovery
Sample Length/Penetration Length:
11.1/13.6 = 82 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-53 (R1)

Sheet 2 of 2

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **0.8**	Penetration Depth (ft): **13.6**
Client: **LDWG**	Water Depth (ft): **16.3**	Sample Quality: **NA**
Collection Date: **2/6/06**	Mudline Elevation (ft): **-12.6**	Recovery in ft (%): **11.1(82)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **192927** E./LONG: **1277458**	Process Date: **2/7/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N.Bacher, A.Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth; (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
	SC53-8-8					@ 7.0' TV = 1.4 kg/cm2	upper alluvium
		82% (8-9)		0	SP: (9.2-10.6) moist, dense to medium dense, dark brown (7.5YR, 3/2) fine to medium SAND. Sand grains are multicolored (orange, red, white). Trace small wood fragments at basal contact.	@ 8.2' TV = 0.5 kg/cm2	
	LDW-SC53-8-10				ML: (10.6-11.1) moist, medium stiff, dark brown (7.5YR, 3/2) SILT, few sand.		
		80% (9-10)			SP- SM: (11.1-13.6) moist, medium dense to dense, dark brown (7.5YR, 3/2) fine SAND interbedded with 1" to 4" thick layers of SILT.	Transitional Contact @ 9.5' TV = 0.8 kg/cm2	
		100% (10-11)				@ 10.4' TV = 0.5 kg/cm2	
					End of core at 11.1'.		lower alluvium
		83% (11-13.6)					

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Remarks: **Drive Notes: none taken. One drive attempt made at station. Core catcher was 100% full.**

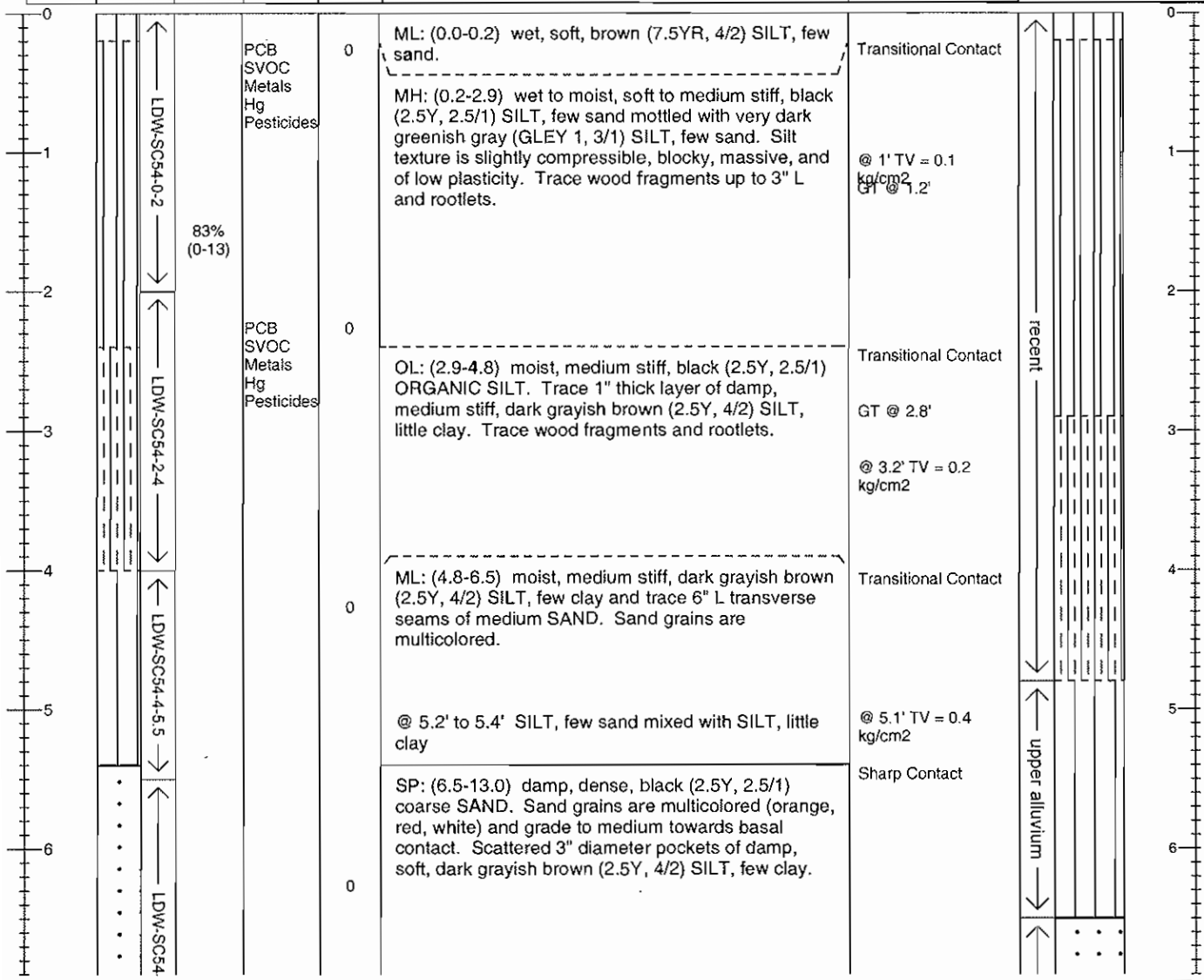
Calculated Recovery
Sample Length/Penetration Length:
11.1/ 13.6 = 82 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-54 (R3)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **14.0**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **13.0**
Client: **LDWG**	Water Depth (ft): **9.4**	Sample Quality: **Good**
Collection Date: **2/23/06**	Mudline Elevation (ft): **-0.2**	Recovery in ft (%): **10.2 (78)**
Contractor: **MSS**	N./LAT: **192179** E./LONG: **1276342**	Process Date: **2/23/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3.5" round Al**	Logged By: **L.McKee, N.Bacher**



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Remarks: **Drive Notes: easy to moderate (10.0'), hard (11.0'), moderate (13.0'), penetration goal reached. Three drive attempts made at station. Core catcher was 50% full. Station re-occupied with vibracore.**

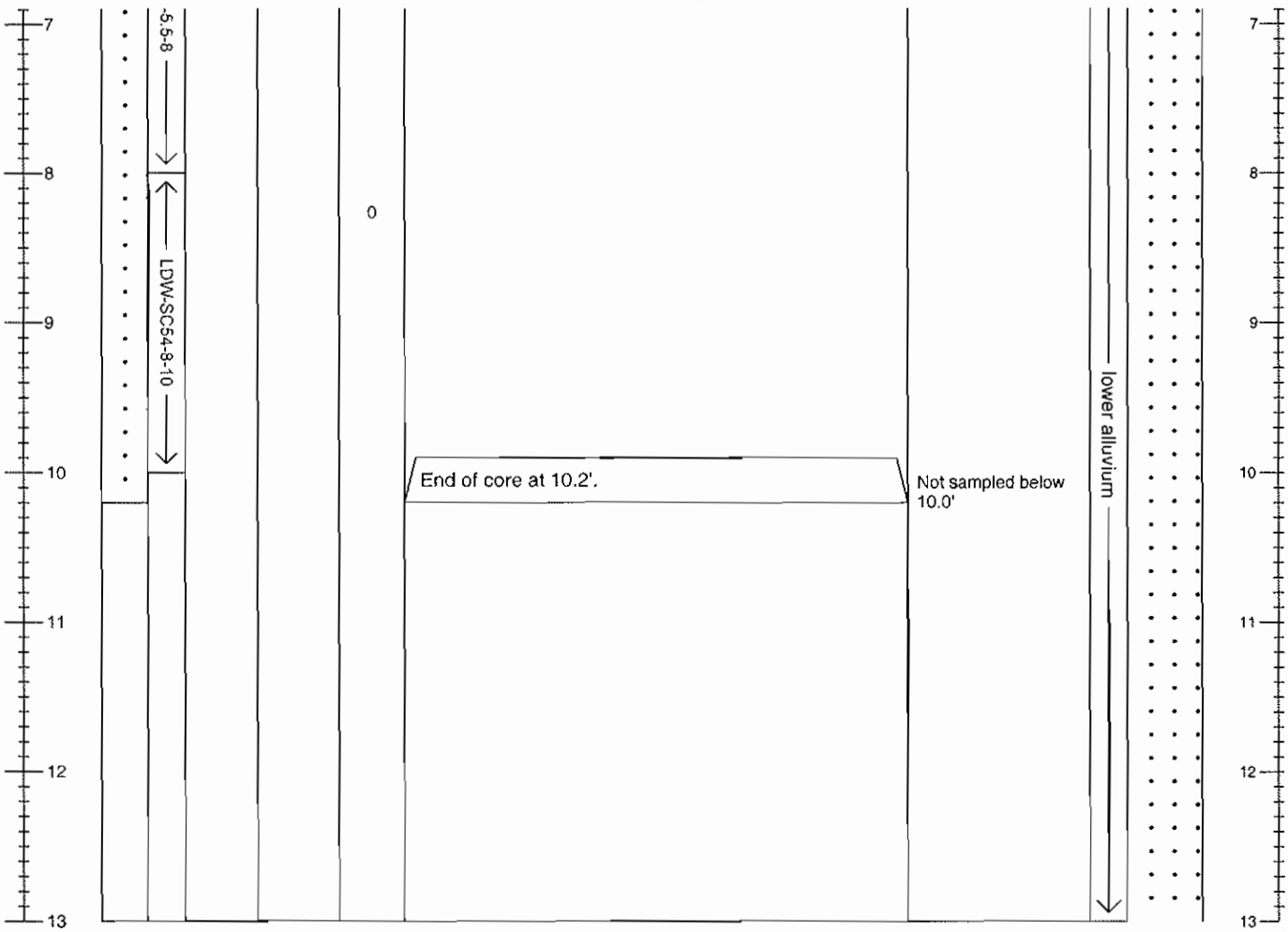
Calculated Recovery
Sample Length/Penetration Length:
10.2/13.0 = 78 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-54 (R3)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **14.0**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **NA**	Penetration Depth (ft): **13.0**
Client: **LDWG**	Water Depth (ft): **9.4**	Sample Quality: **Good**
Collection Date: **2/23/06**	Mudline Elevation (ft): **-0.2**	Recovery in ft (%): **10.2 (78)**
Contractor: **MSS**	N./LAT: **192179** E./LONG: **1276342**	Process Date: **2/23/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3.5" round Al**	Logged By: **L.McKee, N.Bacher**



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Remarks: Drive Notes: easy to moderate (10.0'), hard (11.0'), moderate (13.0'), penetration goal reached. Three drive attempts made at station. Core catcher was 50% full. Station re-occupied with vibracore.

Calculated Recovery
Sample Length/Penetration Length:
10.2/13.0 = 78 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-55 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **10.4**	Penetration Depth (ft): **11.3**
Client: **LDWG**	Water Depth (ft): **8.5**	Sample Quality: **NA**
Collection Date: **2/6/06**	Mudline Elevation (ft): **1.6**	Recovery in ft (%): **6.2 (55)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **190389** E./LONG: **1278266**	Process Date: **2/6/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N.Bacher, A.Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	Sediment Description (Classification Scheme: USCS; Contacts are recovered depth; (In-situ depth interval in feet with parentheses))	Comments for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
0	LDW-SC55-0-1	85% (0-1)	PCB SVOC Metals Hg	0	ML: (0.0-0.7) very wet, very soft, greenish black (GLEY 1, 2.5/2.510Y) SILT, trace clay. Trace sheen/black organic streaks and moderate H2S-like odor.		recent
1					SP: (0.7-1.5) wet, loose, greenish black (GLEY 1, 2.5/10Y) fine SAND. Sand is homogenous.	GT @ 0.9' @ 0.7' TV = 0.0 kg/cm2	
	LDW-SC55-1-2	72% (1-3)	PCB SVOC Metals Hg	0	OL: (1.5-1.8) moist, soft, greenish black (GLEY 1, 2.5/10Y) ORGANIC SILT, trace sand.	@ 1.5' TV = 0.8 kg/cm2	
2					SP: (1.8-2.6) moist, medium dense, greenish black (GLEY 2, 2.5/10BG) fine to medium SAND, trace gravel. Sand grains are multicolored (orange, red, white). Trace H2S-like odor.	GT @ 1.8' GT @ 2.1'	upper alluvium
	LDW-SC55-2-3		PCB SVOC Metals Hg	0	SP- SM: (2.6-4.0) moist, medium dense, dark greenish gray (GLEY 1, 4/5GY) fine SAND interbedded with 1/4" thick, convex layers of SILT. Sand grains are multicolored (orange, red, white).	@ 2.5' TV = 2.0 kg/cm2	
3	LDW-SC55-3-4	68% (3-6)		0	SP: (4.0-11.3) moist, medium dense, greenish black (GLEY 2, 10BG) medium to coarse SAND, trace gravel. Sand grains are multicolored (orange, red, white) and grade to fine sand near basal contact.. Trace 1" thick layers of greenish black (GLEY 2, 10BG) SILT. Trace wood fragments and rootlets.	Sharp Contact @ 3.3' TV = 1.2 kg/cm2	
4				0	@ 4.6' grades to medium sand	@ 4.3' TV = 1.0 kg/cm2	
	LDW-SC55-4-6				@ 4.9' abundant wood fragments to 5.6' (75%)	GT @ 4.8'	
5					@ 5.6' grades to fine sand		
6		45% (6-8)			End of core at 6.2'. Driven to refusal.	@ 5.7' TV = 0.8 kg/cm2 Slightly winnowed below 6.0'	

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Remarks: **Drive Notes: refusal (11.3). Three drive attempts made at station. Abundant logs/wood observed in vicinity. Wood found in core catcher.**

Calculated Recovery
Sample Length/Penetration Length:
6.2 / 11.3 = 55 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Sediment Core Log

LDW-SC-55 (R1)

Project: **LDW RI/FS**	Water Body Type: **Lower Duwamish Waterway**	Tube Length (ft): **16.1**
Project #: **PORS5-18220-511**	Water Elevation (ft)/Tide: **10.4**	Penetration Depth (ft): **11.3**
Client: **LDWG**	Water Depth (ft): **8.5**	Sample Quality: **NA**
Collection Date: **2/6/06**	Mudline Elevation (ft): **1.6**	Recovery in ft (%): **6.2 (55)**
Contractor: **MCS Environmental, Inc.**	N./LAT: **190389** E./LONG: **1278266**	Process Date: **2/6/06**
Vessel: **MCS barge**	Horiz. Datum: **NAD 83 N** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Gary Maxwell**	Method/Tube ID: **Diver Impact Core/4" sq Al**	Logged By: **N.Bacher, A.Fitzpatrick**

Recovered Depth (ft)	Recov.Interval & Sample	% Recovery (interval)	Chemical Analysis	PID Measurement	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth (In-situ depth interval in feet with parentheses)	**Comments** for Recovered Depths	*In-situ* Depth (ft) & Graphic Log
7							7
8		50% (8-10)					8
9						lower alluvium	9
10		50% (10-11.3)					10
11							11

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Remarks: **Drive Notes: refusal (11.3). Three drive attempts made at station. Abundant logs/wood observed in vicinity. Wood found in core catcher.**

Calculated Recovery
Sample Length/Penetration Length:
6.2 / 11.3 = 55 %

Note: Stratigraphic interpretations are preliminary and subject to change during the Remedial Investigation.

Striplin Environmental Associates, Inc.

Core Description and Sample Information

STATION: 4
REPLICATE: 1

Field Log by: Sandy Browning	Processing by:	Coring by: USACE
Tide Level from MLLW: Depth to Mudline: Mudline Elev.:	Date: 9/6/96 Time: 1055	Total Drive Length: Recovered Length: ≈8 FT Recovery Efficiency:

Note: All elevations, depths, and distances in feet.

Core Description - Core Tube Lengths

Tube Length	Sample No.	Visual Description
1		sand
2	chip	sand
3		black, cohesive clayey silt
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

In-Situ Summary Log

	Interpreted Summary	Sample No.	Acquisition Notes
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length
31		0-4

Sample Test Information

Sample No./Tests	In-Situ Depth Int.
PSDDA/VOAs	

Notes:

000007

Striplin Environmental Associates, Inc.

Core Description and Sample Information

STATION: 4
REPLICATE: 2

Field Log by: Sandy Browning	Processing by:	Coring by: USACE
Tide Level from MLLW:	Date: 9/6/96	Total Drive Length:
Depth to Mudline:	Time: 1105	Recovered Length: 9 FT
Mudline Elev.:		Recovery Efficiency:

Note: All elevations, depths, and distances in feet.

Core Description - Core Tube Lengths

Tube Length	Sample No.	Visual Description
1		Oxidized surface Black cohesive clayey silt with thin alternating bands of fine to med. sand
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

In-Situ Summary Log

Interpreted Summary	Sample No.	Acquisition Notes
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length
51		0-4

Sample Test Information

Sample No./Tests	In-Situ Depth Int.
PSDDA	

Notes:

000008

STATION: 4
REPLICATE: 3

Field Log by: Sandy Browning	Processing by:	Coring by: USACE
Tide Level from MLLW: Depth to Mudline: Mudline Elev.:	Date: 9/6/96 Time: 1130	Total Drive Length: Recovered Length: 9 FT Recovery Efficiency:

Note: All elevations, depths, and distances in feet.

Core Description - Core Tube Lengths

Tube Length	Sample No.	Visual Description
1		Black, moist silt
2		
3		fine - med. sand
4		Black silt w/ clay (very cohesive) alternating w/ thin sand layers
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

In-Situ Summary Log

Interpreted Summary	Sample No.	Acquisition Notes
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length
S1		0-4

Sample Test Information

Sample No./Tests	In-Situ Depth Int.
PSDDA/sulfides	

Notes:

000003

Striplin Environmental Associates, Inc.

Core Description and Sample Information

STATION: 2
REPLICATE:

Field Log by: SB	Processing by: SD, DT	Coring by: Puget
Tide Level from MLLW:	Date: 5 oct 98	Total Drive Length:
Depth to Mudline:	Time: 1000 - 1205	Recovered Length:
Mudline Elev.:		Recovery Efficiency:

Note: All elevations, depths, and distances in feet.

Core Description - Core Tube Lengths

Tube Length	Sample No.	1	2 Visual Description	3
1		uniform DK gray to black Silt w/ Clay — mod. Sulfides odor	DK gray to black clayey silt	DK gray to black clayey silt
2				
3				
4			thin layers >1C riverine org.	
5			Dense, Cohesive Clay+Silt	Dense, Cohesive Clay+silt
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				

#1 → 6
#2 → 8
#3 → 9

In-Situ Summary Log

	Interpreted Summary	Sample No.	Acquisition Notes
1	* Soft shell clam		
2			
3			
4			
5			
6			
7			
8			
9	Bioassay — 4.5 l		
10	TBT — 3 l		
11	No composite archive		
12			
13			
14			
15			
16			
17			
18			

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length

Sample Test Information

Sample No./Tests	In-Situ Depth Int.

Notes:

Core #2 Sulfides
in #3 VOAs

Vibracore driven 15' to retain 6-8' of sediment.
4 bad cores

Striplin Environmental Associates, Inc.

Core Description and Sample Information

STATION: 3

REPLICATE:

Field Log by: SB	Processing by: SB/TS	Coring by: Pusher
Tide Level from MLLW:	Date: 10.5.98	Total Drive Length:
Depth to Mudline:	Time: 1230 - 13	Recovered Length:
Mudline Elev.:		Recovery Efficiency:

Note: All elevations, depths, and distances in feet.

Core Description - Core Tube Lengths

Tube Length	Sample No.	1	2 Visual Description	3
		DK gray	DK gray	DK gray
1		silt w/	to black	to black
		clay	silt w/	silt w/
2			clay	clay
3				
			SAND w/ sheen ★	
4		F. grained	Black	F. grained
		sand w/silt ★	clayey	sand
5		Dense	silt	Black
		clayey		clayey
6		silt		silt
7				
8				
		F. grained	SAND	F. grained
9		sand		sand
10				
11				
12				
13				
14				
15				
16				
17				
18				

In-Situ Summary Log

Interpreted Summary	Sample No.	Acquisition Notes
1		
2		
3		
4		
5		(★) mod. sulfides, oder in sand
6		(★★) oily sheen 3'5"-3'9"
7		
8		
9		
10		TBT - 3 Liters
11		Bioassay - 5 liters
12		
13		
14		
15		
16		
17		
18		

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length

Sample Test Information

Sample No./Tests	In-Situ Depth Int.

Notes:

Core #1 Sulfides

" #2 VOAs

11/23/98 11:13 [illegible] STRIPLIN ENVL 949 STRIPLIN 008/018

Striplin Environmental Associates, Inc.

Core Description and Sample Information

STATION: CO

REPLICATE:

Field Log by: TS	Processing by: TS/FP	Coring by: Puget
Tide Level from MLLW: Depth to Mudline: Mudline Elev.:	Date: 6 Oct 98 Time:	Total Drive Length: Recovered Length: Recovery Efficiency:

Note: All elevations, depths, and distances in feet.

Core Description - Core Tube Lengths

Tube Length	Sample No.	1	Visual Description 2	3
1		dark gray silty clay	sand	sand
2				
3		sandy		
4				
5				
#1 → 6			sandy ↓	sandy
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				

In-Situ Summary Log

	Interpreted Summary	Sample No.	Acquisition Notes
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length

Sample Test Information

Sample No./Tests	In-Situ Depth Int.

Notes:

Striplin Environmental Associates, Inc.

Core Description and Sample Information

STATION: 7

REPLICATE:

Field Log by: TS	Processing by: TS/TP	Coring by: Puget
Tide Level from MLLW:	Date: 0850	Total Drive Length: 0
Depth to Mudline:	Time: 6 Oct 98	Recovered Length:
Mudline Elev.:		Recovery Efficiency:

Note: All elevations, depths, and distances in feet.

Core Description - Core Tube Lengths

Tube Length	Sample No.	1	2	3
		Visual Description		
1		dark gray Sandy Silt	Sample	
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				

In-Situ Summary Log

	Interpreted Summary	Sample No.	Acquisition Notes
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length

Sample Test Information

Sample No./Tests	In-Situ Depth Int.

Notes:

voa / sulfide from #1

Striplin Environmental Associates, Inc. **Core Description and Sample Information**

PROJECT: DR FY2006

STATION: 7 REPLICATE: 1

Field Log by: TS	Processing by: TS / PS	Coring by: Puget
Tide Level from MLLW:	Date: 23 Aug 99	Total Drive Length:
Depth to Mudline:	Time: 850	Recovered Length:
Mudline Elev.:		Recovery Efficiency:

Core Description - Core Tube Lengths (ft)

Tube Length	Sample No.	Visual Description
		black, stiff silt/clay
1		
2		dark gray clay
3		black, organic clay/silt
4		
5		
6		
7		
8		
9		

In-Situ Summary Log

Interpreted Summary	Sample No.	Acquisition Notes
1		
2		
3		
4		
5		
6		
7		
8		
9		

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length

Sample Test Information

Sample No./Tests	In-Situ Depth Int.

Notes:

took sulfides + VOAs

Striplin Environmental Associates, Inc. **Core Description and Sample Information**

PROJECT: DR FY2000

STATION: 5 REPLICATE: 1

Field Log by: FS	Processing by: TS/PS	Coring by: Purgatory
Tide Level from MLLW:	Date: 23 Aug 99	Total Drive Length:
Depth to Mudline:	Time: 1040	Recovered Length:
Mudline Elev.:		Recovery Efficiency:

Core Description - Core Tube Lengths (ft)

Tube Length	Sample No.	Visual Description
		black clay/silt
1		
2		dark gray v. fine sandy/clay
		black clay/silt
3		organic black clay/silt
4		
5		
6		
7		
8		
9		

In-Situ Summary Log

Interpreted Summary	Sample No.	Acquisition Notes
1		
2		
3		
4		
5		
6		
7		
8		
9		

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length

Sample Test Information

Sample No./Tests	In-Situ Depth Int.

Notes:

Striplin Environmental Associates, Inc. **Core Description and Sample Information**

PROJECT: DRFV 2000

STATION: C0 REPLICATE: 1

Field Log by: TS	Processing by: TS/BS	Coring by: Pinnacle
Tide Level from MLLW:	Date: 23 Aug 99	Total Drive Length:
Depth to Mudline:	Time: 1100	Recovered Length:
Mudline Elev.:		Recovery Efficiency:

Core Description - Core Tube Lengths (ft)

Tube Length	Sample No.	Visual Description
		dark gray clay/silt
1		
		black organic clay/silt
2		
		black silt/clay
3		
		organic, soft black clay/silt
4		
5		
6		
7		
8		
9		

In-Situ Summary Log

Interpreted Summary	Sample No.	Acquisition Notes
1		
2		
3		
4		
5		
6		
7		
8		
9		

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length

Sample Test Information

Sample No./Tests	In-Situ Depth Int.

Notes:

took sulfides + VOAs

Striplin Environmental Associates, Inc. **Core Description and Sample Information**

PROJECT: DR FY2000

STATION: 12 REPLICATE: 1

Field Log by: TS	Processing by: TS/PS	Coring by: Purgatory
Tide Level from MLLW:	Date: 23Aug99	Total Drive Length:
Depth to Mudline:	Time: 1500	Recovered Length:
Mudline Elev.:		Recovery Efficiency:

Core Description - Core Tube Lengths (ft)

Tube Length	Sample No.	Visual Description
		dark gray/olive
		v fine sand/silt
1		
2		
		black organic
		clay/silt
3		
4		
5		
6		
7		
8		
9		

In-Situ Summary Log

Interpreted Summary	Sample No.	Acquisition Notes
1		
2		
3		
4		
5		
6		
7		
8		
9		

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length

Sample Test Information

Sample No./Tests	In-Situ Depth Int.

Notes:

dark sulfides

+ VOAs

Striplin Environmental Associates, Inc. **Core Description and Sample Information**

PROJECT: DR FY2000

STATION: 13 REPLICATE: 1

Field Log by: TS	Processing by: TS / LR	Coring by: Puget
Tide Level from MLLW:	Date: 25 Aug 99	Total Drive Length:
Depth to Mudline:	Time: 0800	Recovered Length:
Mudline Elev.:		Recovery Efficiency:

Core Description - Core Tube Lengths (ft)

Tube Length	Sample No.	Visual Description
		dark gray fine sand/silt
		organic detritus
1		
2		dark gray clay/silt
3		
4		
5		
6		
7		
8		
9		

In-Situ Summary Log

Interpreted Summary	Sample No.	Acquisition Notes
1		
2		
3		
4		
5		
6		
7		
8		
9		

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length

Sample Test Information

Sample No./Tests	In-Situ Depth Int.

Notes:

Striplin Environmental Associates, Inc. **Core Description and Sample Information**

PROJECT: OR FY2000

STATION: 14 REPLICATE: 1

Field Log by: TC	Processing by: TS/GR	Coring by: Puget
Tide Level from MLLW:	Date: 25 Aug 99	Total Drive Length:
Depth to Mudline:	Time: 0810	Recovered Length:
Mudline Elev.:		Recovery Efficiency:

Core Description - Core Tube Lengths (ft)

Tube Length	Sample No.	Visual Description
		dark gray-black clay/silt
1		
2		
3		
4		black med sand
5		black organic clay/silt
6		gray silt/clay
		black silt/clay
7		
8		
9		

In-Situ Summary Log

Interpreted Summary	Sample No.	Acquisition Notes
1		
2		
3		
4		
5		
6		
7		
8		
9		

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length

Sample Test Information

Sample No./Tests	In-Situ Depth Int.

Notes:

Striplin Environmental Associates, Inc. **Core Description and Sample Information**

PROJECT: DR FY 2000

STATION: 16 REPLICATE: 1

Field Log by: TS	Processing by: TS/GR	Coring by: Pinnacle
Tide Level from MLLW:	Date: 25 Aug 99	Total Drive Length:
Depth to Mudline:	Time: 835	Recovered Length:
Mudline Elev.:		Recovery Efficiency:

Core Description - Core Tube Lengths (ft)

Tube Length	Sample No.	Visual Description
		dark gray-olive fine sand/silt
1		
		black clay/silt
2		
3		black organic clay/silt
4		
5		
6		
7		
8		
9		

In-Situ Summary Log

Interpreted Summary	Sample No.	Acquisition Notes
1		
2		
3		
4		
5		
6		
7		
8		
9		

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length

Sample Test Information

Sample No./Tests	In-Situ Depth Int.

Notes:

Striplin Environmental Associates, Inc. **Core Description and Sample Information**

PROJECT: DR FY2000

STATION: 17 REPLICATE: 1

Field Log by: TS	Processing by: TS/GR	Coring by: Puget
Tide Level from MLLW:	Date: 25 Aug 99	Total Drive Length:
Depth to Mudline:	Time: 933	Recovered Length:
Mudline Elev.:		Recovery Efficiency:

Core Description - Core Tube Lengths (ft)

Tube Length	Sample No.	Visual Description
		dark gray silt/clay
1		
		black organic clay/silt
2		
3		
4		
5		
6		
7		
8		
9		

In-Situ Summary Log

Interpreted Summary	Sample No.	Acquisition Notes
1		
2		
3		
4		
5		
6		
7		
8		
9		

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length

Sample Test Information

Sample No./Tests	In-Situ Depth Int.

Notes:

Striplin Environmental Associates, Inc. **Core Description and Sample Information**

PROJECT: DR FY2000

STATION: 18 REPLICATE: 1

Field Log by: TS	Processing by: TS/GR	Coring by: Puget
Tide Level from MLLW:	Date: 25 Aug 99	Total Drive Length:
Depth to Mudline:	Time: 940	Recovered Length:
Mudline Elev.:		Recovery Efficiency:

Core Description - Core Tube Lengths (ft)

Tube Length	Sample No.	Visual Description
		dark gray - black silt/clay
1		
2		black organic clay/silt
3		
4		dark gray - black stiff silt/clay
5		
6		black fine-med sand
7		
8		
9		

In-Situ Summary Log

Interpreted Summary	Sample No.	Acquisition Notes
1		
2		
3		
4		
5		
6		
7		
8		
9		

Core Tube Field Cut Information

Sample No.	Tube Length Interval	Segment Length

Sample Test Information

Sample No./Tests	In-Situ Depth Int.

Notes:

took sulfids & VOAs for both SC & BP

PROJECT NAME : SEATTLE CITY LIGHT-DUWAMISH
PROJECT NO. : 86-140-04
PROBE : CPT-D77-01
INSTRUMENT NO. : F15CKE084
DATE : 09/25/85

DEPTH FT	CONE TSF	FRICTION TSF	FRIC RATIO	SOIL BEHAVIOR TYPES	EQUIV RELATIVE DENSITY	EQUIV FRIC ANGLE	EQUIV N1	EQUIV N1'
1.0	0.0	0.00	0.03	SILTY CLAY TO CLAY	UNDEF	UNDEF	1-2	1-5
2.0	75.5	0.27	0.37	SAND TO SILTY SAND	40-50	40-42	25-30	20-25
3.0	76.3	0.30	0.41	SAND TO SILTY SAND	40-50	40-42	30-35	20-25
4.0	46.1	0.21	0.46	SAND TO SILTY SAND	30-40	35-40	15-20	15-20
5.0	27.9	0.21	0.77	SAND TO SILTY SAND	30-40	35-40	7-10	10-15
6.0	12.0	0.15	1.78	CLAYEY SILT-SILTY CLAY	30-40	27-31	3-5	10-15
7.0	19.8	0.10	0.76	SILTY SAND-SANDY SILT	20-30	31-35	5-7	5-10
8.0	54.0	0.21	0.38	SAND TO SILTY SAND	30-40	35-40	12-15	10-15
9.0	62.2	0.29	0.46	SAND TO SILTY SAND	30-40	40-42	15-20	15-20
10.0	51.9	0.26	0.49	SAND TO SILTY SAND	30-40	35-40	12-15	10-15
11.0	35.5	0.17	0.48	SAND TO SILTY SAND	20-30	35-40	7-10	10-15
12.0	26.7	0.13	0.50	SAND TO SILTY SAND	20-30	31-35	5-7	5-10
13.0	22.6	0.13	0.57	SILTY SAND-SANDY SILT	20-30	31-35	3-5	5-10
14.0	22.6	0.13	0.59	SILTY SAND-SANDY SILT	20-30	31-35	3-5	5-10
15.0	28.9	0.15	0.54	SAND TO SILTY SAND	20-30	35-40	5-7	5-10
16.0	23.5	0.20	0.81	SILTY SAND-SANDY SILT	20-30	31-35	5-7	10-15
17.0	22.2	0.20	0.89	SILTY SAND-SANDY SILT	20-30	31-35	3-5	5-10
18.0	46.7	0.33	0.73	SAND TO SILTY SAND	30-40	35-40	10-12	15-20
19.0	53.6	0.45	0.81	SAND TO SILTY SAND	30-40	35-40	15-20	15-20
20.0	98.4	0.45	0.45	SAND TO SILTY SAND	40-50	40-42	25-30	15-20
21.0	102.2	0.45	0.44	SAND TO SILTY SAND	40-50	40-42	25-30	15-20
22.0	70.8	0.28	0.38	SAND TO SILTY SAND	30-40	35-40	12-15	10-15
23.0	43.0	0.25	0.56	SAND TO SILTY SAND	20-30	35-40	7-10	10-15
24.0	48.0	0.16	0.38	SAND TO SILTY SAND	20-30	35-40	7-10	5-10
25.0	68.0	0.21	0.33	SAND TO SILTY SAND	30-40	35-40	12-15	10-15
26.0	42.5	0.21	0.54	SAND TO SILTY SAND	20-30	35-40	7-10	10-15
27.0	60.2	0.18	0.29	SAND TO SILTY SAND	30-40	35-40	10-12	5-10
28.0	83.4	0.27	0.32	SAND TO SILTY SAND	30-40	40-42	15-20	10-15
29.0	43.6	0.29	0.67	SAND TO SILTY SAND	20-30	35-40	7-10	10-15
30.0	155.4	0.34	0.23	GRAVELLY SAND TO SAND	40-50	40-42	35-40	20-25

FIGURE 2B

Boring No. B-1

Logged by: KPR

Date: 3/22/99

Approximate Elev.

Soil Description	Consistency/ Relative Density.	Depth (ft.)	Sample	(N) Blows/ ft.	Moisture Content (%)	Notes
FILL; Brown silty, fine to medium sand, moist. (Cuttings: SM)						
FILL; Brown fine to medium sand, moist. (SP)	Loose to Medium Dense			10	6.1	Boulder at 4.5 feet.
FILL; Dark brown mottled, silty, fine to medium sand, moist. (SM)	Loose	5		6	14.4	
Dark gray medium SAND with silt, water-bearing. (SP-SM)	Loose	10		8	22.9	
Dark gray medium SAND, water-bearing. (SP)	Medium Dense	15		13	26.9	Augers sinking into ground under own weight.
No recovery.	Medium Dense	20		12		Drilled to 20 feet. 4.5 feet of sand heave into auguer. Heave flushed out of hole. Drilling with column of water.
Dark gray to black, fine to medium SAND, water-bearing. (SP)	Dense	25		30	24.2	
Black fine to medium SAND with silt, 3-inch layer of sandy silt at 31 feet, water-bearing. (SP-SM)	Medium Dense	30		17	31.4	
Black fine to medium SAND with silt, water-bearing. (SP-SM)	Loose to Medium Dense	35		10	27.4	
	Medium Dense	40		26	28.4	

Boring terminated at 41.5 feet.
Groundwater encountered at 8.5 feet.

TERRA ASSOCIATES
Geotechnical Consultants

BORING LOG
OFFICE/WAREHOUSE FACILITY
SEATTLE, WASHINGTON

Proj. No. T-4343 | Date APR 1999 | Figure A-2

Boring No. B-2

Logged by: KPR

Date: 3/23/99

Approximate Elev.

Soil Description	Consistency/ Relative Density	Depth (ft.)	Sample	(N) Blows/ ft.	Moisture Content (%)	Notes
FILL; Brown sandy silt with some gravel, moist. (Cuttings; ML)						
FILL; Dark brown-gray, fine to medium SAND with silt, moist. (SP-SM)	Medium Dense			11	15.0	
No recovery. Rock in sampler shoe.	Loose	5		7		
Dark gray-brown, medium SAND, water-bearing. (SP)	Loose	10 ▼		9	26.2	Two feet of water shown on sampler and rods. Water added to hole to control heave.
Black medium SAND, water-bearing. (SP)	Medium Dense	15		18	26.4	
Black, fine to medium SAND, water-bearing. (SP)		20		16	29.1	
As above. (SP)	Medium Dense	25		18	28.0	
Black, sandy SILT, very fine to fine sand, saturated, non-plastic. (ML)	Loose	30		7	36.7	
Black, fine to medium SAND with silt, water-bearing. (SP-SM)	Medium Dense	35		21	29.5	
Black, fine to medium SAND, water-bearing. (SP)	Medium Dense	40		26	29.5	

Boring terminated at 41.5 feet.
Groundwater encountered at 9.5 feet.

TERRA ASSOCIATES
Geotechnical Consultants

BORING LOG
OFFICE/WAREHOUSE FACILITY
SEATTLE, WASHINGTON

Proj. No. T-4343 | Date APR 1999 | Figure A-3

TERMINAL 107
PORT OF SEATTLE
SUBSURFACE EXPLORATION
GEOLOGIC SECTION AA'
NEIL H. TWELKER & ASSOC.
7-16-70

B-2

B-1

A

A'

block u. soft SILT

bl. soft sandy SILT

gr. loose silty SAND

gr. mod. stiff fine sandy SILT

gr. mod. den. silty mod. SAND w/shells, O.M. & GRAV.

gr. maden. silty SAND & GRAVEL

gray hard silty CLAY w/scattered GRAVEL

SILT

LOOSE-TO-MOD. DENSE SAND

SILT LAYERS

SAND

SILT

SAND

CLAY

(ALLUVIUM)

bl. u. soft fine silty SILT

gr. m. d. silty fine SAND

gr. m. den. fine SAND w/GRAVEL

gray mod. den. silty fine mod. SAND w/layers of silt

gray moderately dense fine SAND

gr. stiff to v. stiff SILT w/SAND layers

gray loose to m. den. silty fine mod. SAND with scattered GRAVEL

gr. hard gravelly sandy silty CLAY

SCALE:
1" = 60'
1" = 20'

LOG OF BORING NO. 1

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED ARE A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

STANDARD PENETRATION
▲ BLOWS PER FOOT**

ELEVATION	DEPTH IN FEET	SAMPLE*	SYMBOL		DRY DENSITY LB./CU.FT.	BLOW COUNTS/ 140LB. HAMME 30" DROP
16±				BROWN SAND AND GRAVEL WITH DEBRIS - FILL.		
11	5	1-A		BROWN SILTY FINE SAND TO SANDY FINE SILT, WITH SOME ORGANICS, TRACE COARSE SAND, AND FINE GRAVEL - LOOSE, WET.		3 3 4
6	10	2-A		BROWNISH-GRAY FINE TO MEDIUM SAND WITH LITTLE SILT - LOOSE TO MEDIUM COMPACT, WET.		3 5 9
1	15	3-A		SLIGHTLY SILTIER.		5 4 7
-4	20	4-A		GRADES DARK GRAY WITH TRACE SILT-MEDIUM COMPACT. TRACE OF FINE GRAVEL.		7 13 12
-9	25	5-A				8 12 12
-14	30	6-A		DECAYED WOOD CHIPS AND TRACE ORGANIC MATERIAL.		7 11 12
				FINE TO MEDIUM ROUNDED GRAVEL IN MATRIX OF GREEN SILT.		
-19	35	7-A		DARK GRAY FINE TO MEDIUM SAND, TRACE OF SILT-COMPACT.		9 15 17
-24	40	8-A		CONTAINS OCCASIONAL THIN SILTY VERY FINE SAND LAYERS-VERY COMPACT.		25 35 49
-29	45	9-A		DARK GRAY FINE TO MEDIUM SAND WITH THIN 1/4" LAYERS OF BROWN SILT-COMPACT.		10 14 18
-34	50	10-A				19 20 24
-39	55	11-A		DARK GRAY FINE SAND WITH SOME SILT, TRACE FINE GRAVEL AND ORGANICS-COMPACT.		13 16 15
-44	60	12-A		WITH WOOD CHIPS.		13 23 25
-49	65	13-A		GRADES FINER TO VERY FINE TO FINE.		12 14 16
-54	70	14-A		OCCASIONAL BROWN SILT LAYERS TO 3/4" THICK.		11 16 18
-59	75	15-A		DARK GRAY VERY FINE TO FINE SILTY SAND WITH BROWN SILT LAYERS TO 2" THICK-LOOSE, WET.		8 8 9
-64	80	20-A		DARK GRAY FINE SAND WITH TRACE OF SILT AND FINE GRAVEL - OCCASIONAL THIN (1/2") BROWN SILT LAYERS - COMPACT.		13 15 16
				BOTTOM OF BORING AT 81.5'.		

0 50 100

0 25 50

WATER CONTENT - % dry weight

plastic limit — liquid limit

natural water content

PROPOSED WAREHOUSE FACILITIES
Seattle, Washington
for C.D. Stimson Company

ConverseWardDavisDixon Geotechnical Consultants

Project No.
79-5154

Drawing No.
A-1

DATE DRILLED: 11/10/79

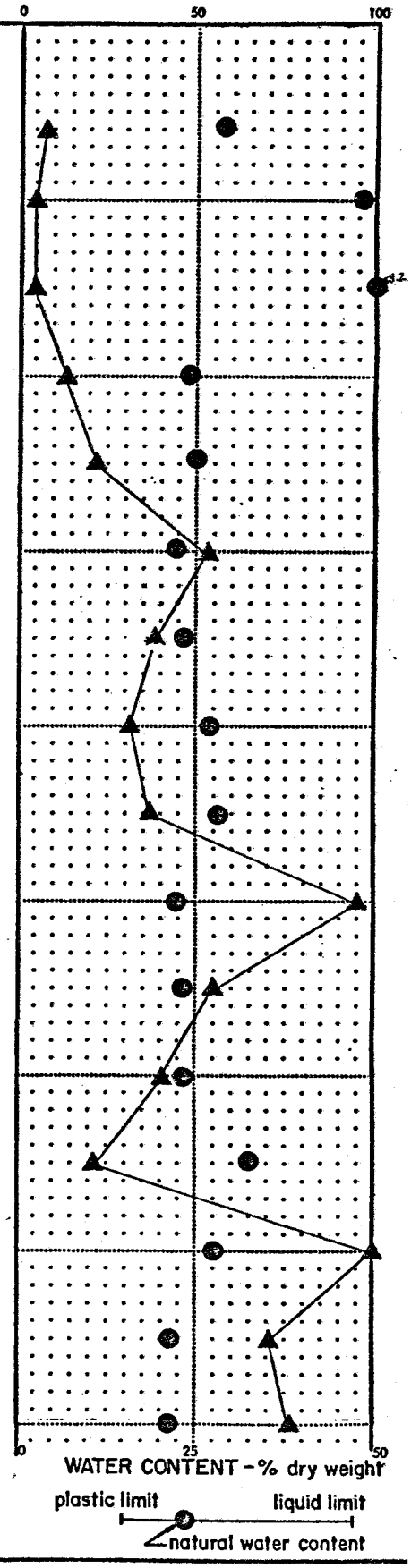
LOG OF BORING NO. 3

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED ARE A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

STANDARD PENETRATION ▲ BLOWS PER FOOT**

ELEVATION	DEPTH IN FEET	SAMPLE*	SYMBOL		DRY DENSITY LB./CU.FT.	BLOW COUNTS/6 140LB. HAMMER 30" DROP
15±				CONCRETE FRAGMENTS, WOOD DEBRIS, SOME GRAVEL - UNSORTED FILL.		
10	5	1-A		BROWNISH-GRAY VERY FINE TO FINE SANDY SILT AND SILT WITH TRACE FINE GRAVEL AND COARSE SAND, TRACE ORGANICS - MOIST, SOFT.		1 3 5
5	10	2-A		WOOD CHIPS. FEW THIN LAYERS OF SILTY CLAY.		1 2 3
0	15	3-A		NUMEROUS WOOD FRAGMENTS.		3 2 3
-5	20	4-A		DARK GRAY VERY FINE TO FINE SILTY SAND, WITH TRACE ORGANICS - LOOSE, WET.		6 6 7
-10	25	5-A		BLACK FINE TO MEDIUM SAND WITH TRACE SILT AND FINE GRAVEL - LOOSE. MEDIUM COMPACT.		7 10 12
-15	30	6-A		COMPACT TO VERY COMPACT.		11 17 36
-20	35	7-A		DARK GRAY FINE SAND WITH TRACE OF SILT - COMPACT, WET.		13 20 19
-25	40	8-A		TRACE MEDIUM TO COARSE SAND, ORGANICS AND WOOD FRAGMENTS - OCCASIONAL SOFT GRAY-BROWN VERY FINE SANDY SILT LAYERS (TO 1/4").		10 16 16
-30	45	9-A		WITH INCREASED VERY FINE SANDY SILT LAYERS (UP TO 25%).		12 17 20
-35	50	10-A		DARK GRAY FINE TO MEDIUM SAND WITH TRACE TO LITTLE SILT - VERY COMPACT.		24 43 52
-40	55	11-A		GRADES FINER - COMPACT.		16 24 31
-45	60	12-A				10 17 24
-50	65	13-A		DARK GRAY SILT WITH TRACE VERY FINE SAND - MEDIUM STIFF, WET. WITH INTERBEDS OF VERY FINE TO FINE SILTY SAND (TO 1/2" THICK).		3 10 12
-55	70	14-A		DARK GRAY SILTY VERY FINE TO FINE SAND WITH 1/4" LAYERS OF SILT TO VERY FINE SANDY SILT - VERY COMPACT.		40 54/6"
-60	75	15-A		DARK GRAY VERY FINE TO FINE SILTY SAND WITH TRACE MEDIUM SAND - COMPACT.		24 33 38
-65	80	16-A		SLIGHTLY LESS SILTY WITH OCCASIONAL LAYERS OF GRAY-BROWN VERY FINE SANDY SILT.		22 34 43

BOTTOM OF BORING AT 81.5'.



PROPOSED WAREHOUSE FACILITIES
Seattle, Washington
for C.D. Stimson Company

ConverseWardDavisDixon Geotechnical Consultants

Project No.
79-5154

Drawing No.
A-3