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LWG
LOWER WILLAMETTE GROUP

Portland Harbor RI/FS

Draft Remedial Investigation Report

October 27, 2009

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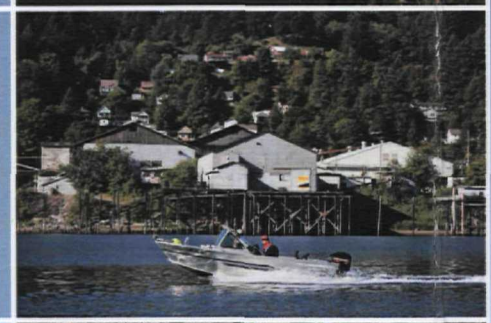
Section 4
Section 5 (Text)



Prepared for

The Lower Willamette Group

Prepared by

Integral Consulting Inc. • Windward Environmental LLC
Kennedy/Jenks Consultants • Anchor QEA, LLC

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LOWER WILLAMETTE GROUP

PORTLAND HARBOR RI/FS

REMEDIAL INVESTIGATION REPORT

DRAFT

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This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part.

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IC09-0003

RECOMMENDED FOR INCLUSION IN ADMINISTRATIVE RECORD

4.0 IDENTIFICATION OF SOURCES

As part of the Portland Harbor RI/FS, the LWG is required to identify sources that are contributing to contamination of the in-water portion of the Study Area. The SOW (EPA 2001a and amendments) states:

> Respondents will identify sources of contamination to the in-water portion of the Site, including those sources identified based on information obtained through DEQ summaries . . . (Section 7)
>
> Respondents will identify source areas that are contributing to contamination to the in-water portion of the Site. Although DEQ is primarily responsible for the control of upland contaminant sources to the Site, as part of the RI/FS, Respondents shall evaluate the distributions of sediment contaminants and, if appropriate (e.g., if the sediment data suggests the presence of an ongoing source), make recommendations to EPA and DEQ if the need for further investigation or control of sources is identified. EPA and DEQ will utilize this information in making source control adequacy determinations. Because upland sites represent many of the known contaminant sources, coordination with upland investigations and DEQ source control efforts will be required. (Section 7.4)

The primary focus of this section is the discussion, by pathway, of the historical and current sources that contributed to in-river contamination within the Study Area. The site summary process, which was initiated in 2004, and its role in identifying sources and pathways within the Study Area are described. Potential sources outside the Study Area from other reaches of the LWR and above Willamette Falls are also identified.

Although this section and its associated tables identify many specific sources of contamination, neither this section nor this RI report generally is intended by the LWG as an exhaustive list of current or historical sources of contamination. Identification and evaluation of potential sources is still ongoing. For example, EPA is still receiving and reviewing responses to information it requested in 2008 pursuant to CERCLA §104(e), and the LWG does not have access to the majority of this information. Rather, this section provides source information necessary for preparation of the FS.

This section first provides an overview of the general land use history within the Study Area beginning in 1936, the first year aerial photographs are available for this area. Land use, shoreline modifications, fill placement, and historical overwater activities are discussed by river mile to highlight those areas within the Study Area that have undergone significant change. The development of the municipal sewer system as far back as 1870 is also discussed to provide a historical perspective. This section is followed by a discussion of historical and current sources within the Study Area by migration pathway. Sources outside the Study Area are then discussed, followed by an overview and current status of source control efforts within the Study Area.

Sources are one component of the CSM for the Portland Harbor. Other components of the CSM are presented elsewhere in this RI:

- The distribution of select indicator chemicals in environmental media in the Study Area is presented in Section 5.
- The methods and information used to evaluate fate and transport of chemicals from potential sources is evaluated in Section 6.
- Human health and ecological risk evaluations are used to identify receptors potentially exposed to unacceptable risk in Sections 8 and 9.
- A description of the relationship between all of these elements (i.e., chemical distribution, sources, fate and transport, and risk) completes the CSM in Section 10.

4.1 HISTORICAL LAND USE

This section provides a summary of the major historical land use, fill placement, and shoreline and overwater operations. As part of the Conceptual Site Model Update (Integral and GSI 2005a,b,c) and the Round 2 Report, historical aerial photographs were reviewed to evaluate general trends in land use along the Willamette River waterfront. Mosaic TIFF (tagged image file format) images created by the Port of Portland from scanned historical aerial photographs of the river and waterfront were also reviewed, as were more recent aerial photographs (see Maps 4.1-1a–f). The oldest historical aerial photographs available for this harbor-wide review were taken in 1936. Based on the pace of land development observed during the preliminary review of all of the aerial photo mosaics, six of the photo mosaics (1936, 1948, 1961, 1974, 2000, and 2007) were selected for broader-scale depiction of changes in land usage (Maps 4.1-2 through 4.1-7). For most years selected, aerial photo images were available for the entire river waterfront from the Columbia River to Ross Island.

Shoreline changes are presented by decade on Maps 4.1-8a–e. The maps represent a series of historical snapshots of the shoreline starting in 1888. Specifically, the maps cover 1888, 1936, 1948, 1957, 1966, 1975, 1985, 1995, 2000, and 2007. Fill placement is shown on Maps 4.1-9a–f.

Detailed information on the fill placement activities can be found in Table 4.1-1. Information used to construct this table was obtained from the aerial photographs, site summaries prepared during the RI,[1] and the City of Portland. The descriptions of subsurface soils in site investigation reports suggest that much of the fill placed in these areas consists of river dredge material (from either the Willamette or Columbia rivers). The source of the fill, if known, is identified in Table 4.1-1.

Overwater structures, such as wharfs, piers, floating docks, and pilings, were built largely to accommodate or support shipping traffic and remain common. These structures along the shoreline are clearly visible in the aerial photographs provided in Maps 3.1-1a–t.

[1] Site summaries were presented in the draft Conceptual Site Model Updates (Integral and GSI 2005a,b,c) and in the Round 2 Report (Integral et al. 2007).

In summary, industrial and commercial development along the river began in the mid- to late-1800s in scattered areas such as downtown Portland, St. Johns, Linnton, and Macadam. Portland Harbor remained largely undeveloped through the late-1800s, but as urban development in the downtown area at the beginning of the 20th century pushed industrial development downriver, businesses began to relocate to the current industrial area of the harbor.

Significant physical modifications to the river coincided with the rapid development and industrialization of the harbor. Modifications included redirection and channelization of the main river, draining of seasonal and permanent wetlands in the lower floodplain, extensive filling along the shoreline, and periodic dredging to maintain the navigation channel

Commercial and industrial development in Portland Harbor accelerated in the 1920s and again during World War II, which reinvigorated industry following the Great Depression. Before the war years, industrial development included sawmills, manufactured gas production, bulk fuel terminals, and smaller industrial facilities. During the war years, a considerable number of Liberty ships, minesweepers, and T-2 tankers were built at military shipyards located in Portland Harbor (Map 4.1-10). Additional industrial operations during the shipyard years included oil gasification, wood-treatment, agricultural chemical production, battery processing, ship loading and unloading, ship maintenance and repair (e.g., sandblasting, scaling, repair, painting, refueling), and rail car manufacturing. Many of these operations are still current today.

4.1.1 Historical Land Use Changes by River Mile Segments

The most notable changes for the major reaches in the Study Area are described in the following subsections. These reach breaks are defined based on changes in the LWR's physical characteristics. General land use changes for the east and west banks of each reach are discussed, including historic riverbank fill placement and changes in overwater structures.

4.1.1.1 RM 9.5 to 11.8

In 1936 large areas of the waterfront in this river mile segment were undeveloped and showed evidence of only minor development of indeterminate nature (Map 4.1-1a). Railyards between RM 10 and 12 were present on both sides of the river in 1936 and were more fully developed by 1948 (Map 4.1-1a). By 1961, industrial development had expanded on both sides of the river and log storage areas were present along riverbanks (Map 4.1-1b). Relatively few changes occurred from 1961 to 2000, with the exception of the completion of Interstate 5 and Interstate 405 (Maps 4.1-1c–e). By 2007, dock structures were added along the west bank and a few parcels were converted from commercial to industrial or residential use (Map 4.1-1f).

The only obvious anthropogenic influences on the 1888 riverbank are from RM 11.1 and above on the east bank in the downtown Portland area. From approximately RM 9.5 to 10, the original shoreline on the east bank formed a cove. In the 1970s this

area was filled (Map 4.1-8c). Significant channel narrowing due to infill on the west bank is observed from 1888 to 1936 (Map 4.1-8a).

Beginning on the east side, the riverside area near RM 11.2 to 11.4 where Glacier NW is currently located (plus adjacent nonriparian properties) was the site of the former Albina Engine and Machine Works property, where ship construction and repair was conducted for the U.S. Navy and the War Shipping Administration (see Map 4.1-10). Albina Engine and Machine Works was founded in 1904 as a riverfront repair yard. During WWII, the shipyard facility was expanded to encompass 16.8 acres and included six shipways, welding and pipe shops, paint storage and shops, warehouses, two outfitting docks, plate storage yards, burning slabs, and a pickling plant. Thirteen shipbuilding contracts were undertaken for the Navy, including the construction of submarine chasers, landing craft and support ships, fuel oil and gasoline barges, and degaussing vessels. Operations in the general area since the 1970s have included a mix of industries, including transformer substations and electrical equipment manufacture, repair, and storage.

The shipways were filled beginning in the 1950s and completed by 1963. Most of the riverside buildings associated with the shipyard were demolished. The first new buildings on the former shipyard property appeared in the late 1970s. A portion of the former shipyard was used for expansion of the Pacific Power and Light Albina Substation beginning in the late 1940s.

Docks have been located in the area of the Glacier facility (RM 11.3) from 1936 to the present day. From the review of aerial photographs, it appears the existing docks at the Cargill facility (RM 11.5) were constructed sometime between 1957 and 1966 (Map 4.1-9f). A large overwater structure called the Irving Dock was present at this location prior to construction of the present-day Cargill dock, as shown in both the aerial photographs and 1924 Sanborn maps reviewed by Integral.

Along the west bank from RM 9.8 to 10.3, encompassing the present-day Terminal 2 and Sulzer Pumps properties, the Willamette Iron and Steel Company (WISCO) operated a shipyard for an unknown period up until 1949 (Map 4.1-10). In 1941-1942, the WISCO facility was expanded with public funds from the Defense Plant Corporation. The reconfigured facility was 79 acres in total area, with government ownership of approximately 36 acres. Combined, these facilities provided a complete shipyard for launching and outfitting steel ships. Many of the manufacturing operations associated with the shipyard were located on the current Sulzer property (RM 10.3), which included outfitting operations, a sheet metal fabrication shed, a cable storage building, a machine shop, a paint shop, a coppersmith shop, and the main industrial building. WISCO operations conducted on what is now Terminal 2 consisted of three shipways with four attendant craneways located at the southern (upstream) end of the property; these shipways were subsequently filled.

Significant changes occurred along the west bank with dredging of a slip at the WISCO shipyard in the mid-1940s (RM 10); the creation of the Albina Ferry slip (Slip No. 1) at Municipal Terminal 1 (RM 10) in 1914 and Slip No. 2 in 1923; filling of the western shoreline downstream of Terminal 2 (RM 10.6) in the 1950s and 1960s; filling of the Terminal 1 South slip in the early 1900s; and filling of the Terminal 2 upstream slip by 1987 (Map 4.1-1e).

Overwater features in this reach include the docks along the western shoreline at the former Municipal Terminal 1 and current Terminal 2 (RM 10 and 10.6), and an oil transfer pipeline (south of present-day Sulzer Pumps) at RM 10.4 (Map 4.1-9e). The oil transfer pipeline was used by Portland General Electric for transferring Bunker C oil from vessels to tanks at a nearby power plant. Some of these docks remain in place but are no longer in use. Most overwater activity associated with the docks in this reach appears to have occurred in the 1940s and 1950s, when the docks were used for loading lumber, paper products, grain, gravel, and coal. From the 1930s through the 1960s, log moorage rafts were present at approximately RM 9.2 and RM 10.

4.1.1.2 RM 8 to 9.5

This stretch of the river has undergone significant change through the years, as is shown in the six photo mosaics (Map 4.1-1a–f). Swan Island (RM 8.3 to 9.2 on the east bank) was originally a sandbar and marsh separated by two channels of the Willamette River. Prior to 1920, the eastern channel was the river's main channel. The eastern channel was deeper than the western channel, which was wide and shallow with a shoal that hindered boat passage. In the early to mid 1920s, the west channel was deepened and widened in places to facilitate navigation (the west channel was opened to navigation in 1926). In 1927, the diversion of the river's main channel from the east side to the west side of the island was completed through the construction of a causeway at the island's upstream end (creating a lagoon out of the east-side channel). The filling of Swan Island was mostly completed by the 1920s before construction began on the airport in 1926.

Mocks Bottom, once a swampy slough, was filled to build roads and facilitate industrial development. About half of Mocks Bottom had been filled by 1961 and filling was complete by 1974 (Map 4.1-9d). Although some industrial facilities had developed along the shoreline by 1961, less than half of the area had been developed by 1974. The area was fully developed by 2007 with industry related to truck manufacturing, shipping and transportation, marine salvage, and military uses.

The Swan Island peninsula has a long history of commercial and industrial operations that continue today. The Swan Island Municipal Airport functioned until operations moved in 1940 to a location that is now part of the Portland International Airport. Between 1942 and 1949, the U.S. Maritime Commission leased Swan Island from the Port of Portland and contracted with the Kaiser Company to construct a shipyard and associated facilities. The shipyard facilities were used to build T-2 tankers used during WWII. A Kaiser affiliate, Consolidated Builders, Inc., conducted ship dismantling

between 1947 and 1949. After the war, the area was redeveloped and used for ship repair purposes. The redeveloped facilities were used by various ship repair contractors and their subcontractors. In addition, facilities were leased to a number of industrial tenants who conducted a range of activities, including steel fabrication and storage, wood products manufacturing, equipment manufacturing, maritime supply sales, printing, chemical and soap storage, war surplus storage, fire extinguisher service and storage, paint storage, aluminum oil tank manufacturing, service station operation, sheet metal work, roofing supply storage, and general office storage. The eight shipways constructed during the military era were filled with dredged materials between 1950 and 1962. The current configuration of dry docks at the end of the peninsula and berths along Swan Island Lagoon and the Willamette River was largely completed by 1979. Some filling also occurred in the northwestern portion of the shipyard area in the late 1970s.

Up until the 1960s the west side of the river was mostly undeveloped and was used for log raft storage. The present-day Shell Equilon dock occupied the west bank at RM 8.8 in 1936. Operations at Gunderson (RM 8.7 to 9.2) began as early as 1942, and most of the present-day site was constructed by 1966 (Map 4.1-9d); activities have generally included barge and rail car manufacturing. Shipbuilding operations began at Gunderson in the 1960s and are still in operation today. During the 1960s and 1970s, a portion of the Gunderson facility was used by American Ship Dismantlers for ship scrapping. Overwater activities occurred at the barge launchways in Area 2 and the outfitting dock in Area 3. A dock structure and an oil transfer pipeline were located historically at the McCall Oil site (RM 8.2) prior to filling in the late 1960s. Fill was placed along the Gunderson shoreline beginning in the 1950s.

4.1.1.3 RM 5 to 8

The 1936 photo mosaic (Map 4.1-1a) shows that the east side of the river was largely undeveloped from RM 5 to approximately 5.7 until the period between the 1960s and 1970s. Early features include docks at Willamette Cove (RM 6.7) and downstream of Mar Com (RM 5.7). The eastern bank between RM 6.5 and 6.9 was primarily filled in the 1910s and 1920s to create the central and eastern parcels of the Willamette Cove upland facility. Upstream of RM 6.9, the eastern bank remained relatively unchanged until the 1970s, when the downstream end of the property presently known as Triangle Park (RM 7.4) was filled to create a dock and berth area. From 1888 to 1936, shoreline development is most notable from RM 5.9 to 6.4, due to the construction of the St. Johns Bridge at RM 5.9 and timber processing facilities on the eastern bank at RM 6.2 and on the western shore at RM 6 and 6.4. From 1888 to 1936 the eastern bank shows widening due to development in the vicinity of timber processing plants, including the M&B site (RM 7.1), and narrowing due to installation of the railroad crossing at RM 6.9 (Map 4.1-8a).

The Mar Com facility, which ceased operations in 2004, was situated on land that had been used for ship building and vessel repair since approximately 1905. The central parcel of the Willamette Cove facility was also used for ship repair on dry docks and

related ship maintenance between 1903 and 1953. Upland shops and structures and in-water dry docks were used by independent contractors working for various vessel owners. During wartime, U.S. Government contractors utilized the dry docks for military ship outfitting and repair. Several of these dry docks have since been removed from this stretch of the river (e.g., Mar Com, Willamette Cove). Dock structures at the former M&B facility were removed during the recent Superfund cleanup of this site.

The 1936 photograph of the west side of the river (Map 4.1-1a) shows the Willbridge (RM 7.7) and Gasco (RM 6.2) facilities with very little other development. Most of the shoreline change occurred on the west side of the river from the 1940s to the 1960s. Fill was placed along the eastern shoreline of RM 5 to 5.7 from the 1950s through the 1970s. By 1975, fill was also placed along the western shoreline and a larger low-lying area at what is present-day Siltronic (RM 6) and Gasco property. Fill materials for both sides of the river included quarry discards and dredge materials. At the Gasco and Siltronic properties, MGP materials were also included in the fill. At the Arkema site (RM 7.2), fill consisted of plant debris composed of asphalt, concrete, pipe, soil, and fill from other sources.

The western shore shows narrowing from RM 6.9 to 7.4 due to upland development and installation of the railroad crossing. Arkema maintained two dock structures for receipt of evaporated sea salt, which contained sodium chloride, and shipping of inorganic chemicals produced onsite. Operations ceased in 2001, and the facility has been dismantled, but the dock structures remain. Petroleum products have been loaded and unloaded at the Willbridge Terminal since the early 1900s.

4.1.1.4 RM 3 to 5

Major facilities on the east side of the river starting in the early 1920s and included cargo handling, a flour mill, warehousing, and bulk fuel storage. Tank farms were developed on the west bank in approximately 1918 (present-day Kinder Morgan Linnton Terminal) and were expanded in the 1960s to be the predominant land use. Other early west shore industries included lumber mills, toy manufacturers, a creosote plant, and lumber storage. Both sides of the river were fully industrial by the 1970s.

The most important shoreline changes in this reach occurred along the eastern shoreline from RM 4.2 to 4.6 (Map 4.1-9b). In the late 1910s and early 1920s, the mouth of Gatton Slough was filled, and three slips were dredged forming the Municipal Terminal No. 4 area (present-day Slips 1 and 3 and Wheeler Bay). Between approximately 1948 and 1958, the middle slip (Wheeler Bay) at Terminal 4 (which was never completed) was backfilled and Slip 3 was widened.

The Burgard Industrial Park (RM 4E) was the location of a large shipyard operated by the Oregon Shipbuilding Corporation. The deep-draft International Terminal Slip was created during the 1940s, and portions of the marshy, low-lying areas on the site were filled. Over 450 ships were built on this property from 1941 to late 1945. Ship breaking activities were reported in 1946 (*The Oregonian* 1946). The year in which

shipyard was dismantled has not been presented in documents reviewed, but the shipways were filled between the early 1960s and 1972. Post-shipyard industrial uses included metal fabrication, log rafting, and upland log storage. The property was converted for use in 1972 as a metals scrap yard. Automobile shredding operations began in 1980.

Conspicuous historical overwater features within this reach include docks associated with ship building and repair, lumber mills, petroleum product distribution, moorage, and cargo unloading. Port of Portland (POP) Terminal 4 tenants that currently (or historically) handle soda ash, new automobiles, and liquid bulk materials from their docks are located on the eastern shoreline. Metal scrap delivery occurs at docks in the International Terminal Slip (RM 3.7). Along the western shoreline, there are bulk petroleum distribution docks (ARCO; RM 4.9) and sand and gravel unloading/loading overwater activities (Columbia River Sand & Gravel; RM 4.5).

4.1.1.5 RM 1 to 3

Little change to the shoreline occurred in this vicinity of the river until fill materials were placed at the present-day Evraz Oregon Steel Mills (EOSM) site (RM 2.1E) from the early 1940s to the 1960s; additional filling of the riverbank occurred in the 1970s using EOSM slag materials, onsite soils, dredge material, and imported materials (Map 4.1-9a). A dredge/fill map compiled from USACE data shows dredge material from the Post Office Bar and the mouth of the Willamette being placed in the Rivergate Industrial area in the 1940s through 1970s (Port of Portland 1981, USACE 1973).

The primary overwater features along the eastern shore of this reach are docks for distribution of chemicals and petroleum products. From 1936 until the 1960s, the eastern shoreline was utilized for log raft storage. In the 1940s, a dock was constructed at what is now the EOSM site for the transport of oil and bilge water to an upland oil sump. The current dock at Ash Grove is first present in the 1966 aerial photograph (Map 4.1-1c). By 1975, new docks associated with EOSM, JR Simplot, and POP Terminal 5 are present along the RM 1 to 3 reach.

The only industrial feature on the western bank of the river in this area is Alder Creek Lumber Company (RM 2.9).

4.1.1.6 Multnomah Channel

Besides the Alder Creek lumber yard at the mouth of the Multnomah Channel, the only other conspicuous facilities in this stretch of the channel are Fred's Marina, the Multnomah Yacht Club, and the ESCO landfill.

Since 1959, floating logs have been delivered to the dock area at the Alder Creek Lumber property near the mouth of the channel. Houseboat and boat moorages and marinas line Multnomah Channel's southern bank, opposite the ESCO landfill, forming a continuous string that extends as far as one mile. Approximately 200 of these houseboats and sailboats are used as permanent residences (DEQ 2009e).

Fred's Marina has occupied its site since the 1940s (Parsons Brinckerhoff 2004). Presently, the marina contains a boat ramp, fuel dock, a boat trailer storage area, and over 200 slips. A designated dredged material disposal site is located upland directly east of the marina. This disposal site is for the containment of material dredged from the marina and vicinity that is deemed suitable for upland placement. The Multnomah Yacht Club has been in operation since 1961; prior uses of the property are unknown. The ESCO landfill does not have any operations on the shoreline. No further information on historical shoreline and fill placement activities was found.

4.1.2 Development of Municipal Sewer System

This section summarizes the publicly available historical and current information regarding the City of Portland (City) sewer system discharges to the Study Area. Potential COIs associated with historical and current sewer system discharges are discussed in Sections 4.3.1.2 and 4.4.1.3, respectively. Potential current and future loads from stormwater are discussed in Section 6.1.2.

4.1.2.1 Initial Sewer Systems: 1870–1947

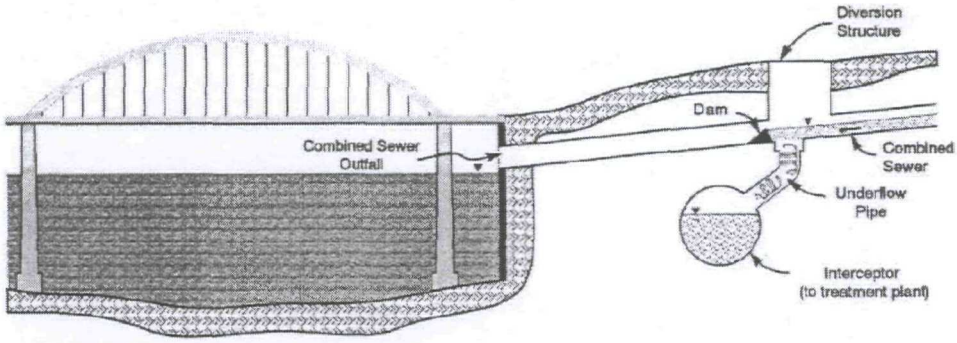
The City constructed its first municipal sewers in the 1870s. The City's combined sewers collected both surface drainage and sanitary wastes (including domestic and industrial discharges), and all private and public sewers discharged directly to the Willamette River or Columbia Slough (City of Portland 1966). At that time, the outfalls discharged directly to the river during dry and wet weather at all times.

In 1936, 48 sewers directly discharged to the Willamette River (City of Portland 1936), located between RM 17 and RM 4. Initial scoping of the Sewage Disposal Project included several interceptor sewers and a treatment plant discharging to the Columbia River (Smith 1936). Construction of this project began in 1947 (City of Portland 1952b).

4.1.2.2 Initiation of the Combined Sewer Overflow System: 1947–1955

In 1947 the City Sewage Disposal Project began the construction of two interceptor lines (the east side and the west side) and a treatment plant (Oregon State Sanitary Service Authority; OSSA 1964). Construction of the interceptor lines diverted most flows to the newly-constructed CBWTP and created the CSO system that exists today. The interceptor lines run south to north through the main trunk lines, paralleling the riverbanks. The interceptor system collects sanitary waste water, discharges from permitted connections (City of Portland 1969), and stormwater.[2] The capacity of this system could accommodate up to three times the dry weather flow. Diversion structures, essentially dams, direct flows that exceed the interceptor capacity to overflow to the river as illustrated below.

[2] City of Portland Charter, § 9-604(22) (1942) " ...the council is granted power and authority to enact legislation prohibiting industries, industrial plants or utilities or other enterprise ships, vessels, or other river craft from placing or draining deleterious matter into the waters of the Willamette river with the confines of the city, and to require all such to connect their properties with the sewage disposal system when physically possible..."



The overflow system was built to prevent the system from being overwhelmed during a storm event. This overflow system allows flows to breach the diversion dams and discharge the combined storm and sanitary sewage flows through an outfall to the Willamette River. Once the interceptors were put in place, the outfalls were referred to as CSO outfalls (CH2M Hill 1992; City of Portland 1952b, 2001b; Stevens & Thompson 1964). Table 3.1-3 identifies the locations of outfalls, including those constructed during this time period.

The interceptor system in Portland Harbor, as of 1952, is presented on Figure 4.1-1 (City of Portland 1952b); additional work that continued through 1954 is not shown in this figure. The first unit of the interceptor sewer system (serving northeast Portland) was completed in 1947. The CBWTP and the interceptor system on the east side of the Willamette River were both completed in 1952. The east side interceptor system extended from the southern limits of the city north to the treatment plant (City of Portland 1952a). Of the east side CSO outfalls, OF-43 through OF-53 discharged to the Portland Harbor Study Area.[3] Diversions from the combined system to the river (i.e., CSO events) occur before flows reach the interceptor. Once flows have entered the interceptor, these flows are directed to the treatment plant. During construction of the interceptor system, pump stations were added, some of which included emergency overflow lines that were connected to outfalls, which are known as SSOs. Thus, after the interceptor connections were made, any sewer connections made directly to the interceptor pipe could not overflow to the river unless there was an emergency failure at a pump station along the interceptor line. With respect to sewer connections to the trunk lines between the diversion structures in the river during this time period, the City instituted programs to compel customers to connect directly to the interceptor or to a separated sanitary line that was connected to the interceptor. With respect to sewer connections at points in the trunk lines above the diversion structures, these would

[3] OF-43 is at RM 11.4 and OF-53 is at RM 5.2.

overflow to the river only when rainfall caused an exceedance of the approximately three-times-dry-weather flow capacity of the system (City of Portland 1969).[4]

During construction of the interceptor system, the City separated the sewers serving most of the industrial areas near the riverfront by building separated sanitary and industrial wastewater sub-basins connected directly to the interceptor, and separated stormwater systems discharged directly to the river.

Some of these outfalls still had a combined system upgradient of the nearshore industrial separated area that served primarily residential areas. After the interceptors were installed, many properties that formerly discharged through private outfalls directly to the river connected to the City's sanitary system (either the new sanitary system installed or directly to the interceptor).

By September 1955, the City had completed construction of the west side interceptors incorporating outfalls designated OF-1 through OF-17 (OSSA 1953; 1954a,b; 1955). Of these west side outfalls, OF-11 through OF-17[5] discharge to the Portland Harbor Study Area. Portions of the industrial area that had been connected to the combined system were connected to a separate sanitary sewer that discharged directly to the interceptor.[6] The areas with no separate storm and sanitary systems continued to discharge to the combined system or discharged directly to the river. The interceptors and associated facilities reduced the volume of untreated sewage discharging to the Willamette from the City's system.

4.1.2.3 Completing the Combined Sewer Overflow System: 1964–1973

A 1964 study by Stevens & Thompson focused on the sewer systems in the Guild's Lake-Linnton area in northwest Portland and in the area served by the east side interceptor (Stevens & Thompson 1964).

Eight combined sewage/stormwater collection systems were identified in the Guild's Lake-Linnton area on the west side of the Willamette River, all within the current Study Area of the Portland Harbor Superfund Site. Most of the collection systems were noted to drain areas dominated by industrial and commercial activities and discharge directly to the Willamette River (Stevens & Thompson 1964). This area encompassed drainage to outfalls currently designated OF-17 through OF-24A. Stevens & Thompson also indicated that there were 12 private outfalls in this area discharging industrial wastes (several discharging only cooling water) directly to the Willamette (Stevens & Thompson 1964).

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[4] City of Portland Charter, § 9-604(22) (1942)
[5] OF-11 is at RM 11.4 and OF-17 is at RM 9.6.
[6] Based on City as-built drawings for the interceptor and other separation projects. As-built drawings are available on the City's website: http://PortlandMaps.com.

Although the east side interceptor was operational by 1952, studies performed by the OSSA in 1953 identified three outfalls upstream of Portland Harbor where bypass of sewage to the river occurred during dry weather periods (Stevens & Thompson 1964). For example, Stevens & Thompson estimated as much as 17 million gallons a day (dry weather flows) discharged from outfalls upstream of Portland Harbor (Stevens & Thompson 1964).

Stevens & Thompson estimated future volumes in the system to assess design parameters for the needed new diversion structures. The analysis compared the 1964 capacities for different interceptor lines/areas against population and flow projections for 1980. Stevens & Thompson determined that increased flows in the southeast and northwest sections, roughly comprising outfalls OF-11 through OF-17 (west side, in the Study Area) and OF-26 through OF-38 (east side, upstream of the Study Area), respectively, would exceed capacity of the interceptors during periods of maximum flow in the future. However, Stevens & Thompson determined that other sections of the system would be overloaded even if the volume of sewage allowed to bypass diversions in these outfalls were reduced (i.e., if more sewage was diverted to the treatment plant) (Stevens & Thompson 1964). Based on the results of this study, Stevens & Thompson recommended new and renovated facilities to alleviate overloading and meet the Sanitary Authority's capacity requirements (Stevens & Thompson 1964).

In 1968, the City initiated sewer projects to direct sanitary sewage discharges, including industrial wastewater discharges that were discharging directly to the river in the Guild's Lake-Linnton area, directly to the CBWTP (City of Portland 1969). The 1968 projects included construction of a pumping station and the Portsmouth Tunnel, which crossed under the river to the CBWTP (City of Portland 1969). Construction was completed the following year (City of Portland 1969).

4.1.2.4 Combined Sewer Overflow System Evaluations: 1974–1990

In 1972, the City estimated that the amount of combined sewage overflowing to the Willamette River and Columbia Slough was over 10 billion gallons per year (City of Portland 2001b).

In 1977, the Columbia Region Association of Governments (CRAG) undertook a study of the greater Portland area to evaluate municipal and industrial wastewater and urban stormwater, including the quality of the overflows from the City of Portland CSO system. The study provided a baseline for reevaluating Portland's CSO system. (Several of the reports cited below state different numbers of outfalls in the combined system; this most likely is due to the combination of two outfalls into one or the elimination of some outfalls during the time these reports were completed.) At the time of the CRAG study, there were 43 CSO outfalls in the City's entire Willamette River CSO system (25 on the east side and 18 on the west side), each draining a basin. Of the 43 outfalls discharging to the Willamette River, 16 discharged within the Study Area, and 27 were upstream of the Study Area up to RM 17.2. The resulting report contained descriptions of each outfall drainage basin, including acreage served, land-use type,

pipe size, interceptor, diversions, and details on specific diversions, where applicable. The report also distinguished, in acreage, the type of collection system for each drainage area/outfall. Table 4.1-2 summarizes that information (CRAG 1977).

The CRAG study calculated the average annual runoff of suspended solids, settleable solids, biological oxygen demand (BOD), ammonia, phosphorus, and bacteria from CSOs in the City's entire CSO system, based on historical rainfall data. The study area focused on municipal outfalls discharging to the Willamette River that were within the City of Portland's boundary, and provided discharge estimates for 1975 and projected land use and conditions for the year 2000. Table 4.1-3 lists the 1975 results for suspended solids from the lowest downstream location to the highest upstream location measured.

In 1985 the City issued a Sewer Outfall Report, the purpose of which was to gather information to design an abatement program to address CSO discharges to the river (City of Portland 1985). In the 1985 report, the City stated that the CSO system included 57 CSO outfalls, with 44 of the CSOs discharging to the Willamette River (16 of which were in the Portland Harbor Study Area), and 13 discharging to the Columbia Slough (City of Portland 1985). An outfall inspections program was instituted to include observations of the outfalls during the dry season to identify the condition of the outfall and to determine if the dry weather flow has any sanitary component. Dry weather flows could include groundwater infiltration, permitted and non-permitted process water (such as cooling water discharges and landscape irrigation), or illicit connections of sanitary discharges downstream of diversions. These dry weather flows were, and continue to be, analyzed for bacteria to determine if there is any sanitary contribution, and flow volumes are estimated where dry weather flows were evident (City of Portland 1985).

4.1.2.5 CSO Improvements: 1991–Present

In 1991 the City and State signed a Stipulation and Final Order (SFO) that would require the City to eliminate CSO discharges that violated applicable water quality standards. The following year, the federal government issued a CSO policy that was not as stringent as the SFO. The City and State entered into a collaborative process to study the environmental and socioeconomic impacts of the requirements of the SFO; the process also considered additional system characterization information not available in 1991 (CH2M Hill 1994). As a result of this process, DEQ and the City entered into an amended SFO (ASFO) in 1994 that adopted a standard of control more stringent than that required by the 1992 federal CSO Strategy (CH2M Hill 1994). The AFSO granted the City until 2011 to reduce the CSO events to the Willamette from about 100 events per year to four events per year in winter and one event every three summers (City of Portland 2001b). CSO discharges are organized into "events" based on the storm conditions that cause the overflows. Each statistically independent storm event causes one CSO event. A storm in Portland is considered a single statistically independent storm only if there has been a minimum of a preceding 24-hour period with no rain (CH2M Hill 1992, 1994).

At the time the AFSO was signed in 1994, it was estimated that the CSO system discharged an average of 4.8 billion gallons of stormwater (~80 percent) and untreated sewage and pretreated industrial waste (~20 percent) to the river between RM 4 and 17 (CH2M Hill 1994). The discharges occurred through 42 outfalls to the Willamette River, some of which overflowed nearly every time it rained (150 days), while others only overflowed 30 days per year (City of Portland 2001b). The City estimated an average of 50 CSO events (encompassing up to a total of 112 days) per year in the entire CSO system (City of Portland 1998).

Around this same time, it was determined that dry weather discharges of untreated sewage (including pretreated industrial wastewater discharges) were also still occurring in some portions of the City system due to periodic failure of the system to function properly, vandalism, illicit discharges, blockages caused by a variety of sources, and groundwater infiltration, which resulted in the discharge of untreated sanitary sewage through CSO outfalls directly to the Willamette River. These dry weather discharges involved relatively small volumes and are different than wet weather CSO events, which occur when the combined sanitary sewage and stormwater flows exceed the system's capacity during rain events. The City completed improvements to the CSO system between 1992 and 1996, and signed a SFO with DEQ in 1996 in which they agreed to eliminate the dry weather discharges (DEQ 1996).

To achieve the requirements of the 1994 ASFO, the City prepared a CSO Management Plan with recommendations to address wet weather overflow discharges, including the following:

- Implementation of "Cornerstone Projects" focused on reducing the volume of stormwater to the system
- Implementation of storage and treatment facilities to eliminate the CSO discharges to the Columbia Slough as required in the SFO
- Implementation of storage and treatment facilities along the Willamette River ("Big Pipe project") to control the CSO discharges as required by the ASFO.

The City is now 18 years into the completion of the 20-year project, with completion planned for 2011 (City of Portland 2008a). The current City outfall system is discussed in Section 3.1.4.1. As described in that section and in Table 3.1-3, the CSO abatement projects include one or more of the following for each outfall:

- Completely separating storm and sanitary to create stormwater-only outfalls with stormwater treatment prior to discharge, where possible
- Completely sealing and abandoning outfalls or diversions to prevent overflows
- Reducing stormwater flows to the CSO system to minimize flow through the system during a storm event, such that the system meets the AFSO standard

- Increasing the storage capacity for the CSO system to reduce the frequency of overflows to meet the AFSO standard.

The primary means for increasing the storage capacity is through construction of the West Side Tunnel (completed in 2006) and the East Side Tunnel (anticipated to be completed in 2011). The ASFO requires the City to control 16 CSO outfalls by 2006 and all remaining CSO outfalls by 2011. The City has met all requirements of the ASFO to date and is on schedule to complete the CSO abatement program in 2011. The goal of the abatement projects is to meet the AFSO design standard to control CSO discharges to an average of four events in the winter (November 1 to April 30) and one event in three summers (May 1 to October 31; City of Portland 2005). Since completion of the West Side CSO Tunnel Project in 2006 there have been three winter seasons and a total of five events for all Willamette River outfalls that were controlled by 2006—fewer than an average of two events per winter since completion of construction of the West Side tunnel. The overflow points in the Study Area were outfalls OF-11 and OF-47.

The abatement projects, including the West Side Tunnel and the final selected design for the East Side Tunnel, are projected to meet the CSO system demands and AFSO design standard (one event in three summers/four events in winter) by 2011 and continue through the year 2025. This projection is based on the assumption that other City programs will continue to implement mitigation measures to reduce stormwater flow to the overall CSO system by initiating projects not listed in the report (e.g., infiltration basins, green roofs, and other such stormwater reduction measures). The City noted that additional efforts would be required to control CSO demands beyond 2025 (City of Portland 2005). The configuration and dates of the abatement project for the separate and combined sewer systems is shown on Figure 4.1-2.

4.2 SITE SUMMARIES AND SOURCE TABLE

Site summaries are the primary vehicle for assembling information on upland sources for the Portland Harbor RI/FS. Summaries have been prepared for upland ECSI sites that were generally located within 0.5 mile of the LWR between RM 2 and 11. Map 4.2-1 depicts the locations of the ECSI sites within the Study Area.

It is important to note that site summaries have not been prepared for all ECSI sites. Not all ECSI sites that might be potential sources of contamination to the Study Area are included within the geographic boundaries described in the paragraph above. Also, potential sources of contamination may exist that have not been reported or included in the ECSI database. For example, ECSI sites have been newly identified based on DEQ stormwater investigations. The Portland Terminal Railroad (PTRR) Guilds Lake Yard located between RMs 8.6 and 9.5 (ECSI #100) and the City of Portland outfalls located in the Study Area between RM 2.7 and RM 9.8 (ECSI No. 2425) were not part of the site summary process described in this section. The City's CSOs are discussed in Section 4.1.2 above. Other ECSI sites, such as Hercules, the ESCO landfill, and

Brazil & Co., may be either connected to an outfall more than 0.5 mile from the river or located upriver or downriver of the original Study Area boundaries.

The site summaries are based on a review of information in the associated DEQ ECSI files and other readily available site information, including, in the case of LWG-member sites, information was provided by the site owner. It is important to note that the development of site summaries and the source information presented here is highly dependent on whether a site is involved in DEQ's cleanup program and the degree of investigation and data generation. As shown on Table 4.2-1, several sites adjacent to or near the Study Area are not in the cleanup program, and it is likely that many sites, particularly those that are the location of historical facilities that operated outside the boundaries of current sites, are not fully addressed in DEQ files. As a result, this section does not represent a complete inventory of sites and operations that contribute or have contributed to contamination in Portland Harbor. These limitations on source information primarily affect historical sources, and the understanding of current sources is adequate for the purposes of the FS.

Each site summary describes general ECSI site information (location, physical description); owner history; current and historical site uses; potential sources (overwater activities, recent and historical spills); the nature and extent of chemicals in soil, groundwater, surface water, and sediment; stormwater and wastewater permit information; and a summary of cleanup actions.

- Site summaries have been updated periodically, primarily from information on file with DEQ. Site summaries were originally published in 2004-2005, and a subset of the summaries was updated in 2007. The status of the ECSI sites within the Study Area is tabulated in Table 4.2-1. For each site listed in the table, the following information is shown:
- The site name and ECSI number
- The site status (e.g., remedial investigation, expanded preliminary assessment, not in DEQ cleanup program)
- The site summary documents prepared (e.g., site summary, site summary addendum, no site summary prepared) and dates of documents.

The summaries and addenda are the basis for the pathway information for upland sites provided in Table 4.2-2 (formerly Table 5.1-2 of the Round 2 Report), otherwise known as the Source Table. The following presents the site summary update iterations and the resultant modifications to Table 4.2-2:

- In 2003, summary descriptions focused on the groundwater pathway were prepared for the ECSI sites (GSI 2003a).
- Following discussions with EPA and its partners in early 2004, updated site summaries were prepared in 2004-2005 (Integral and GSI 2005a,b,c). This

iteration provided information on all pathways potentially contributing to in-river contamination.

- A second update of site summaries was prepared in 2006 (Integral 2007a). At the request of the LWG, DEQ (Anderson 2006a,b, pers. comm.) provided information concerning the status of cleanup actions and regulatory decisions at sites not owned by members of the LWG (i.e., non-member sites). New or completely revised site summaries were prepared for sites that had not previously been described, for sites where EPA-requested revisions had not previously been submitted, and for sites where significant new work warranted a complete revision. Addenda to existing summaries were prepared for sites where significant additional information was provided on one or two pathways.
- In 2007, based on recent sampling that indicated elevated PCBs in sediment and surface water, attention was focused on the east side of the river from RM 11 to 11.6 in the vicinity of the former Albina Shipyard and the current Glacier NW and Cargill facilities. A site summary was prepared for this stretch of the river and was added to Table 4.2-2.
- When the Study Area was expanded in 2008 to include RM 1.9 to 11.8, 20 additional ECSI sites were added to Table 4.2-2. Pathway information and COIs at these sites were obtained from the ECSI database; DEQ files were not reviewed and no site summaries were prepared.
- In January 2008, EPA commented on pathway information provided in Table 5.1-2 of the Round 2 Report. LWG responded to those comments and EPA commented on this response.
- In December 2008, Table 4.2-2 was further updated for LWG member sites and updated with minor revisions for non-member sites, as a result of the detailed review of the table for CSM indicator chemicals and development of Section 10 source tables. With a few exceptions, Table 4.2-2 reflects site conditions as of September 2008.
- In January 2009, the overwater release pathway for both historical (H) and current (C) impacts was modified based on the updated spill table (Table 4.3-1). The distinction between historical and current impacts is January 1, 2004, the approximate time in which the DEQ JSCS program was implemented.
- The completeness of the wastewater pathway on in-water media was not evaluated; however, sites with individual wastewater permits are identified in Table 4.2-2.
- Finally, in February 2009, DEQ's LUST database and other Internet records were searched for confirmed releases at sites with no groundwater data. If a release was confirmed, the COI box was entered as NS (x,y)—no sampling, confirmed releases include chemicals x and y—but the status remained current, insufficient data to make a determination (C-c).

In Table 4.2-2, a chemical is listed as a pathway COI if it was detected in sampled media, identified as having been released to site media, identified as a site COI, or documented to have been released directly to the river from site operations. LWG has not separately screened the results against DEQ's JSCS values or any other screening criteria. Note that LWG and non-LWG stormwater sampling data (as described in Section 4.4.1.1) was not reviewed or screened for the purposes of this table.

COIs for a pathway in Table 4.2-2 were assigned one of four categories (a–d), as defined below, for **both** historical (H) and current (C) impacts:

Category a. **Documented evidence of a complete transport pathway**—Data demonstrate that the pathway is complete; DEQ, the owner, or both concur that the pathway is complete.

Category b. **Likely a complete pathway**—Data suggest that the pathway is complete, but in the absence of confirming data (e.g., investigations are incomplete, nearshore wells are not yet installed, overwater operations are present and active). DEQ, the owner, or both have not concurred that pathway is complete. Although DEQ and owner evaluations are considered, LWG's analysis may support a different conclusion.

Category c. **Insufficient data to make determination**—Either a release has been documented but there has been no sampling of the potentially affected media, or a release has been documented but transport pathways have not been investigated, or no sampling has been conducted at the site or for a given pathway. Although DEQ and owner evaluations are considered, the LWG may have, for the purposes of the CSM, assumed that the pathway is complete.

Category d. **Not a complete pathway**—Information indicates with reasonable certainty that either of the following is likely for both current and historical pathways:

- The relevant media for a given pathway are not affected by site-related COIs (e.g., site-related COIs are not detected in groundwater)
- A current or historical complete pathway as defined above is not present (e.g., riverbank is not present at a site away from the river, COIs were not detected in downgradient groundwater).

The overall importance and relative contribution of the pathway is not evaluated in Table 4.2-2. DEQ's Milestone Reports (see Section 4.6) rank sites and pathways in terms of priority for investigation and cleanup, but the ranking is not chemical-specific.

For each potential migration pathway that is known or likely to be complete (categories a and b), Table 4.2-2 also shows whether the site's impact is current (C) or historical (H). The overwater pathway is designated H-a or C-a when a release has been

documented in the DEQ SPINS database, U.S. Coast Guard (USCG) records, or other similar documentation. If no spills have been reported for a facility that had or has active overwater operations, the pathway was modified to H-b or C-b.

For the groundwater pathway, Table 4.2-2 includes a column for the presence of non-aqueous phase liquid (NAPL). A "yes" is shown where the pathway is known or likely to be complete. A "no" is shown where the pathway is known to be incomplete. A question mark is shown if the presence or absence of NAPL cannot be evaluated because of insufficient data.

To help readers track the assessments tabulated in Table 4.2-2, Table 1 from DEQ's (2009b) Milestone Report is reproduced here as Appendix B. The table, which was considered in the development of Table 4.2-2, provides information on the status of DEQ's source control evaluations, decisions, and measures for ECSI sites within the original Study Area. The DEQ table does not list the new ECSI sites in the expanded Study Area (RM 11–11.8) or recently identified sites within the shared stormwater conveyance basins.

An important difference between DEQ's and LWG's evaluation of sources is that DEQ focuses on current and potential sources of pollution to the river, whereas LWG also considers historical inputs when information is readily available. As a result, DEQ may identify a source as "insignificant" based on the current condition, while LWG may characterize the same source as a known or potentially complete pathway because of historical conditions. Additionally, DEQ prioritizes pathways (high, medium, low) but does not identify COIs. The LWG identifies COIs for each pathway, but does not prioritize. LWG's evaluation may also differ where DEQ identifies a source as insignificant but there are no data (e.g., no groundwater sampling) supporting DEQ's conclusion.

4.3 HISTORICAL SOURCES WITHIN THE STUDY AREA

Historical sources likely contributed to the majority of the observed chemical distribution in sediments within the Study Area. Table 4.2-2 provides an assessment for the upland ECSI sites of whether the predominant impact for each of the pathways was historical or current. All the pathways have a historical component and many can be attributed entirely to historical operations or releases (e.g., historic discharge of waste to Doane Lake and historic tar disposal ponds). This section discusses by pathway the major historical operations that contributed to in-river contamination within the Study Area. Note that in this context, the term "pathway" refers only to the physical transport of a contaminant of interest to the Study Area. It does not include identification of exposure points, receptors, or exposure routes.

4.3.1 Direct Discharge – Stormwater, Sewage, and Industrial Wastewater

In the early 1900s, rivers in the United States were generally used as open sewers, which was also true for the Willamette (Carter 2006). The growing city's untreated

sewage, as well as process water from a variety of industries, including slaughterhouses, chemical plants, electroplaters, paper mills, and food processors, was discharged directly into the river. Stormwater runoff carried pollutants from nonpoint sources, including agricultural fields, outdoor industrial activities, oil spills, and rubber and oils from parking lots. By the 1930s, the water pollution was so severe that workers refused to work on riverside construction projects because of the foul odors and the risks to their health. Loggers even went on strike because they did not want to handle the scum accumulated on logs (Blalock 2008). Potential pollutants associated with these activities likely included volatile organic compounds (VOCs), SVOCs, PAHs, petroleum hydrocarbons, metals, pesticides, and herbicides. From 1926 to 1929, the U.S. Public Health Service collected samples from seven mid-river locations on the Willamette River. Although the studies focused on bacteria and oxygen levels from domestic waste, the sewage discharges also included municipal, industrial, and commercial waste products and stormwater runoff. Conclusions from the study indicated that although oxygen levels were sufficient to support fish life in all but two months of low water in late summer, the overall water quality probably was "not sufficiently pure" to justify recreational uses at any time (Laurgaard 1929, pers. comm.).

As noted in Section 4.1.2, the interceptors and associated facilities installed in the 1950s reduced the volume of untreated sewage discharging to the Willamette from the City of Portland. OSSA (1955) concluded that in spite of the fact considerably less raw sewage was being discharged in to the river by the City of Portland [than the year before], the degree of pollution in the harbor was "approximately the same" in 1954 in terms of dissolved oxygen (DO) and BOD levels. The OSSA noted, however, that DO levels at Willamette Falls were higher than at the SP Railroad Bridge (RM 6.9), indicating potential sources of pollution upstream of the City of Portland. Stevens & Thompson (1964) estimated that 6.3 million gallons per day of sewage, industrial waste, cooling water waste, stormwater, and groundwater was discharging through eight City outfalls and 12 private outfalls.

The outfalls and drainage basins for the WWII shipbuilding era have not been evaluated, but based on shipyards in the area (e.g., the Oregon Shipbuilding Corporation's shipyards) most likely there were separate stormwater drainage and sanitary sewer systems consisting of multiple outfalls that discharged directly to the Willamette (Bridgewater 2000). Other industries that lined the banks of the river most likely had direct sanitary and industrial discharges as well. Potential contaminants found in stormwater, sanitary sewer, and overland sheet runoff were likely associated with sandblasting, metal plating and surface finishing, painting, fiberglass construction, and machining and metal working activities at the shipyards. These contaminants likely included VOCs, SVOCs, PCBs, PAHs, petroleum hydrocarbons, metals, cyanide, and butyltins (EPA 1997b).

Also, in the early decades of the last century, it was routine practice for chemical plants to dump waste tars and sludges along or directly into the river. Petroleum terminals,

lumber and steel mills, and various other industrial operations within the harbor also directed untreated industrial wastewaters to the river. Pollutants potentially associated with these plants and other industries included herbicides, pesticides, PCDD/Fs, mercury and other metals, VOCs, SVOCs, PAHs, and PCBs.

Valuable insight into the magnitude of historical releases is provided by Glen D. Carter, an aquatic biologist employed between 1956 and 1988 by the OSSA, a forerunner to Oregon's DEQ. By the time he was hired in 1956, "fish kills were common in the river, massive rafts of decaying algae floated downstream, and a thick layer of bacterial slime covered much of the river bottom and shoreline. Rotting vegetation, bacterial slime, and countless dead fish produced highly unpleasant sights and odors. Large deposits of sewage sludge accumulated around sewage outfalls" (Carter 2006). In water quality tests performed during this period, fish often suffocated within minutes after being exposed to the water (Carter 2006).

Some of the releases resulted from combined stormwater/industrial wastewater discharges. Examples of industries with historically complete pathways in the harbor include the former M&B site, where wastewater and non-contact cooling water were discharged directly into the Willamette River between 1945 and 1969 (PTI 1992). The oil and tar disposal areas along the Gasco and Siltronic riverbank had drainage or overflow features leading to the river, which resulted in the former tar body in the river (HAI 1992a,b). At the former Rhone Poulenc facility, treated and untreated stormwater/wastewater was historically discharged to Doane Lake where it commingled with stormwater and releases from Gould/NL Industries, Schnitzer/Air Liquide, ESCO, and potentially Gasco wastes (AMEC 2002). Historical aerial photographs suggest that the former Doane Lake periodically discharged to the LWR through a historical drainage ditch. Another 37 sites have been identified as having likely complete historical pathways for stormwater but lack confirmatory data. Historical stormwater information does not exist for most of the historically and currently present sites discharging to the Portland Harbor. In addition, as discussed above, prior to the construction of the interceptor system beginning in the early 1950s, 48 sewers discharged sewage (including industrial waste) and stormwater directly to the Willamette River upstream and within the Study Area (City of Portland 1936). Private industries also had direct discharges to the river.

In addition to stormwater that was combined with known process wastes, historically and currently stormwater has run off to the river through outfalls and as sheet flow. As discussed in Section 6, based on LWG studies, it is clear such stormwater picks up COIs as it flows across industrial and commercial properties with outdoor process activities, across transportation corridors and residential neighborhoods that have vehicular traffic and parking, and even across open spaces that are subject to atmospheric deposition.

4.3.1.1 Stormwater, Sewage, and Industrial Wastewater Regulatory History

In the mid-20th century, cities and industries began efforts to improve the quality of wastewater discharged to the Willamette. Flood control reservoirs created by the federal government increased summer flow in the river, which contributed to the dilution of wastes.

4.3.1.1.1 Sewage and Industrial Wastewater

The State of Oregon and the City of Portland regulated wastewater discharges well before the enactment of the Clean Water Act (CWA) in 1972. At the state level, the Water Purification and Prevention of Pollution Law,[7] one of the first comprehensive state water pollution laws in the country,[8] was passed in 1938. The following year saw the creation of the OSSA, which began implementing wastewater treatment requirements. In 1967, the state legislature required a permit for sewage and wastewater discharges from any sewer system and imposed liability for pollution-related injury to fish and wildlife or their habitat.[9] In 1967, the OSSA issued water quality standards for the Willamette River. For the area including Portland Harbor, the water quality standard required that the daily average DO concentration could not be less than 5 mg/L. The standards included "not to exceed" concentrations for several metals and total dissolved solids, the latter of which could not exceed 100 mg/L (OSSA 1967). By 1968, the state was regulating all point-source discharges.[10]

The City of Portland's specific authority to prohibit discharges of contaminants to the Willamette River, the Columbia River, the Columbia Slough, and other waters in the City of Portland dates to at least 1942.[11] Revisions to the City Code in 1960 prohibited discharges to the public sewer of specific materials, including gasoline and other petroleum products, solvents, acids, and toxic wastes.[12] Restrictions on the discharge of commercial and industrial wastes were added and preliminary treatment was required for a number of contaminants before discharging wastewater to the municipal system.[13] Between 1969 and 2006, the City Code was amended ten more times to further limit discharges of untreated wastes to the City's storm and sanitary sewer systems.

Beginning in 1973, industrial and municipal point source dischargers were required under the CWA to obtain NPDES permits for their wastewater and process water discharges. NPDES permits for wastewater and process water are administered by the

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[7] Oregon Laws 1939, c. 3.
[8] Oregon Dept. of Environmental Quality, Administrative Overview, 2 (Mar. 2003), *available at* http://arcweb.sos.state.or.us/recmgmt/sched/special/state/overview/19970007deqadov.pdf (last visited May 6, 2009).
[9] Oregon Laws 1967, c. 426.
[10] Portland Bureau of Environmental Services. The Evolution of Wastewater Treatment in Portland, http://www.portlandonline.com/bes/index.cfm?a=41962&c=31031 (last visited May 6, 2009).
[11] City of Portland Charter, § 9-604(22) (1942)
[12] City of Portland Ordinance No. 111595 (1960).
[13] *Id.*

DEQ and set effluent limits, monitoring requirements and other conditions on the discharges. The requirements can be individual, written for a specific facility, or general, applicable to a group of dischargers having similar characteristics.[14]

The City of Portland combined sewage overflows that discharge to the Willamette River are regulated under an NPDES permit for the CBWTP.

4.3.1.1.2 Stormwater

Stormwater discharges had very little control and/or monitoring before the passage of the CWA. Industrial and municipal stormwater discharges were specifically addressed in the amendments to the Clean Water Act of 1987, and EPA stormwater rules became effective in 1990.[15] These rules ultimately required stormwater permits for industrial dischargers, discharges from construction activities, and discharges from municipal separate storm sewer systems serving urban areas.[16]

The NPDES permitting program was extended to require sources of point stormwater discharges to obtain an NPDES stormwater permits. DEQ administers several types of NPDES stormwater permits in Oregon, covering municipal, industrial, and construction-related operations. Municipal entities that discharge in the Study Area are regulated by MS4 NDPES stormwater permits; industrial dischargers that discharge into the Study Area are regulated by 1200-Z NPDES stormwater or individual NPDES permits; and discharges from construction activities are regulated under 1200-C or 1200-CA NPDES stormwater permits. Municipal and industrial permittees that discharge in the Study Area are listed in Table 4.4-5.

4.3.1.1.3 NPDES Municipal Stormwater Permits

Phase I of the NPDES Stormwater Program, developed in 1990, requires permits for stormwater discharges from medium and large MS4s serving populations of 100,000 or more.[17] In accordance with the regulatory requirements,[18] an MS4 must implement stormwater management programs to reduce the discharge of pollutants "to the maximum extent practicable."

4.3.1.1.4 NPDES Industrial Stormwater General Permits

Point source stormwater discharges from certain types of businesses and industries—such as manufacturers, hazardous waste treatment facilities, and publicly owned treatment works[19]—are regulated by NPDES Industrial General Stormwater Permits, which were first issued by DEQ in 1991. Industrial activities that are subject to permitting requirements are determined by Standard Industrial Classification codes

[14] http://www.epa.gov/npdes/pubs/101pape.pdf.
[15] 55 Federal Register 47,990 (November 16, 1990).
[16] *Id.*
[17] *Id.*
[18] 40 C.F.R. § 122.26(d) (1990).
[19] For the full list, see EPA, Categories of Industrial Activity that Require Permit Coverage, http://cfpub.epa.gov/npdes/stormwater/swcats.cfm (last visited May 5, 2009).

listed in the federal regulations 40 CFR 122.26(b)(14) and (15). These activities include:[20]

- Heavy manufacturing (such as paper mill, chemical plants, petroleum refineries and steel mills)
- Light manufacturing (such as food processing, printing and publishing, electronic manufacturing)
- Coal and mineral mining and oil and gas exploration and processing
- Hazardous waste treatment storage and disposal facilities
- Landfills, land application sites, and open dumps with industrial wastes
- Metals scrap yards, salvage yards, automobile junkyards, and battery reclaimers
- Steam electric power generating plants
- Transportation facilities that have vehicle maintenance, equipment cleaning, or airport deicing operations
- Treatment works treating domestic sewage with a design flow of 1 million gallons a day or more
- Other facilities subject to federal stormwater effluent discharge standards in the 40 CFR Parts 405-47.

However, some categories (e.g., mineral extraction industry, transportation and light industry) have special conditions or exceptions that may exclude a facility from the stormwater permitting requirements. Also, stormwater discharges associated with the wholesale, retail, commercial, or service industries are exempt.

The NPDES stormwater program requires a regulated facility to develop a stormwater pollution control plan that identifies pollutant sources and specifies best management practices (BMPs) to minimize impacts on stormwater quality.

In 1994, the City of Portland entered into a memorandum of agreement (MOA) with DEQ to administer industrial stormwater NPDES permits for discharges to the City's MS4. In 1999, the MOA was revised to cover all industrial NPDES stormwater permits in the City's urban services boundary. The City administers the general 1200-Z permits in the Portland Harbor and inspects sites for compliance; DEQ maintains responsibility for enforcing permit conditions.

4.3.1.1.5 NPDES Construction Stormwater Permits

DEQ's 1200-C and 1200-CA stormwater permits cover construction activities. NPDES 1200-C Stormwater Discharge Permits, first issued by DEQ in 1991, are required for any construction activities that disturb five or more acres of land to control erosion and

[20] http://cfpub.epa.gov/npdes/stormwater/swcats.cfm

reduce sedimentation in waterways. In 2002, the threshold for construction activities was lowered to include projects that disturb one or more acres of land.

While the development and implementation of stormwater regulations have resulted in significant reductions in uncontrolled releases to the river, both permitted exceedances and unpermitted releases continue to occur.

4.3.1.2 Historical Sewage System Chemicals of Interest

Historically, direct measurement of contaminants in CSO discharges focused on DO, TSS, bacteria, and BOD. Assumptions about COIs associated with historical discharges from the City sewer system (including direct discharges prior to construction of the interceptor system, wet-weather CSO events after construction of the interceptor system, and dry weather overflows through the CSO outfalls) can be made based on the types of industries and activities (e.g. transportation corridors, parking) that discharged to the system and whether those industries and activities discharged to the combined system at a location that could overflow a diversion structure, as well as from pretreatment records. As described below, potential COIs from industrial dischargers to the City system may have included solvents, petroleum hydrocarbons, PAHs, pesticides, herbicides, PCBs, PCDD/Fs, metals, and phenols.

4.3.1.2.1 Potential Chemicals of Interest Based on Industry Types

Detailed information on specific industries discharging industrial wastewater to the sewer system prior to the 1960s is limited. However, some historical documents provide information about the types of industries discharging to the system during this time. Untreated industrial and domestic wastewater, sewage, and surface runoff, along with other non-municipal sanitary and industrial discharges, were discharged to the sewer system, which, at that time, emptied into the Willamette River. COIs associated with these industrial wastewaters may have included pesticides (grain mills, plywood manufacturing), metals (shipbuilding, iron/steel manufacturing, electroplaters), phenols (plywood manufacturing after World War II), solvents (various manufacturing industries), PAHs (combustion emissions, road tar, paints, treated wood), PCBs (transformers, paints, rubber, and plasticizers after 1930), and PCDD/Fs (pentachlorophenol [PCP]-preserved wood). Construction of the interceptor system began in 1947 and was completed in approximately 1969. Although wastewaters from some areas of the city were discharged to the interceptor system after 1952, dry weather overflows and CSO discharge events could continue to allow untreated waste to reach the river, as discussed in Section 4.1.2.

4.3.1.2.2 Chemicals of Interest Based on Pretreatment Records

The City of Portland's NPDES pretreatment program for the CBWTP was approved in March 1983, "although the City had initiated an industrial waste control program in the early 1970s, prior to the promulgation of federal pretreatment regulations requiring POTWs [publicly owned treatment works] to establish pretreatment programs" (SAIC 1987). Portland City Code in 1960 required pretreatment of industrial wastes prior to discharge to the public sewer (Ordinance 111595, March 4, 1960). In 1983, 260

industrial users were discharging to the City's interceptor system throughout the city, including the system in Portland Harbor, and from six outlying areas (SAIC 1987). Some of the industries discharged to the sanitary system, some were located downstream of diversion structures in the combined system, and some were located upstream of diversion structures. Some discharged continuously and some in batch discharges (City of Portland 1992). Industrial discharges to the sanitary system and to the combined system downstream of diversion structures flowed directly to the POTW; industrial discharges located upstream of diversion structures could discharge to the river during wet weather in a combined sewer overflow (see Section 4.1.2.2). COIs discharged before the 1960 pretreatment requirements associated with categorical industrial discharges may have included solvents and metals (electroplating and metals finishing); pesticides and herbicides (pesticide manufacturing); and PCP, PCDD/Fs (PCP byproduct), copper, chromium, and arsenic (timber products; City of Portland 1967, 1992).

4.3.2 Overland Transport

Contaminated surface soils exposed in the upland areas can be carried directly to the river in stormwater sheet runoff. Overland transport was likely to have been more important historically, prior to the development of extensive stormwater conveyance systems within the Study Area. However, specific historical information on overland runoff is lacking for most sites. At the former shipyards, the upland site drainage patterns were conducive to the migration of contaminants to the river through stormwater sheet runoff (EPA 1997b).

Overland transport has been identified as a complete historical pathway for only three ECSI sites within the Study Area: Gasco, Gunderson, and M&B. The historical overland transport pathway has been identified as likely complete at nine other ECSI sites, but confirmatory data are lacking. As with other historical pathways, very little information is available on the details of operations and COIs, and it is more than likely that there were many more ECSI sites contributing COIs to this pathway.

4.3.3 Groundwater

Contaminated groundwater may have entered the river historically via discharge through sediments or bank seeps, or it may have infiltrated into storm drains/pipes, ditches, or creeks that discharge to the river. Contaminant migration may have occurred as NAPLs or as chemicals dissolved in the groundwater itself. Though insufficient data are available to evaluate the historical groundwater pathway at most sites reviewed (Table 4.2-2) significant contaminant migration via the historical groundwater pathway has been identified at a small number of upland ECSI sites within the Study Area. At a limited subset of these sites, the upland groundwater may have loaded upland chemicals to the local transition zone, including sediment and pore water. Because several of these sites are considered current sources of contamination as well, they are discussed in detail in Section 4.4.3. At three other sites—Schnitzer Steel/Calbag Metals, M&B, POP Terminal 4, Slip 3—the historical pathway was complete, but recent groundwater

source control efforts have been effective at reducing or eliminating the impacts from this pathway.

4.3.4 Riverbank Erosion

Surface soils can be eroded directly into the river (especially from unarmored or unprotected banks) by in-water forces due to fluctuations in river levels, currents, floods, boat wakes, and propeller wash from ship activities. Over the past 150 years, the Willamette River has experienced numerous floods. Most recently during the floods of 1964 and 1996, the river fully occupied its historical floodplain in the lower, narrower portion of the river and much of the mid-river portion as well.

In some locations, low-lying contaminated riverbank soils can be prone to erosion, and potentially contribute to sediment contamination in the river. These low-lying bank areas are particularly prone to erosion during periodic flooding events. The occurrence and relative importance of riverbank contamination is not well characterized for all parts of the Study Area, but is a focus of DEQ's Joint Source Control investigations. Contamination in riverbank soils can result from various sources, including use of contaminated fill or surface contamination of riverbank soils by site activities, such as spills or waste disposal practices. In some locations, contaminated dredged material from navigation dredging activities may have been placed in low-lying areas subject to erosion.

Because of the limited historical data, riverbank erosion has been identified on Table 4.2-2 as a "known" historical pathway for six ECSI properties within the Study Area: Alder Creek; Arkema; Gasco; M&B; POP Terminal 4; and EOSM.[21] This identification is based upon the detection of elevated concentrations of COIs in riverbank soils. Eighteen additional ECSI sites are likely complete historical pathways for riverbank erosion but lack confirmatory data, and 30 sites lack enough information as to determine the completeness of the pathway.

4.3.5 Atmospheric Deposition

Limited information is available on the historical contribution of atmospheric deposition in the Study Area. This pathway was likely more predominant before the advent of the Clean Air Act in 1970. Regional sources included automotive emissions, lead smelters, pesticide application, combustion sources, volcanoes, and energy generation. Chemicals commonly acknowledged to play an atmospheric source role in urban river settings within the broader geographic region of the Pacific Northwest include PCBs, PCDD/Fs, PAHs, and mercury. For example, extensive examination of the role of atmospheric deposition of such chemicals has been performed for the Columbia River Basin (EPA 2009a). From the study, it has been found that:

- Atmospheric deposition from sources inside and outside the region is thought to be a major pathway for mercury;

[21] See also Map 4.6-1a.

- Incineration and atmospheric deposition bring PCBs from distant sources and then contributed to the basin.

Global atmospheric transport and subsequent deposition has also been documented as a significant transport mechanism for PCDD/Fs (Commoner et al. 2000; Augusto et al. 2004).

Table 4.2-2 does not address atmospheric deposition. Information on the importance of this pathway is provided in Sections 6 and 10.

4.3.6 Overwater Releases

Historically, overwater releases were common occurrences for industries on the banks of the Willamette that relied on maritime shipping to get commodities to and from market. Overwater releases are important contributors to in-water contamination at sites that have long histories of overwater operations and product transfers. Historical overwater activities were discussed by river mile in Section 4.1.1.

Table 4.3-1 lists documented overwater spills for the ECSI sites within the Study Area based on information from DEQ, the USCG, and the National Response Center's (NRC) centralized federal database of oil and chemical spills. Records for 1995 to 2006 were available from DEQ, detailed reports of spills from 1990 to present were available from federal sources, and summary information for spills between 1982 and 1989 was obtained from the NRC online database.[22] Releases that did not meet reporting requirements in effect at the time of occurrence may not be included in these databases. Information on spill locations, particularly in the earliest reports, is often very general (e.g., only the river mile is provided). Spill information is also provided in the site summaries. Table 4.3-3 provides information on additional spills in the Study Area, primarily from vessels, that are not associated with known ECSI sites. Information on these spills was obtained from the NRC incident database, Oregon State Fire Marshal database, USCG pollution reports, and from Appendix F of the Portland Shipyard Supplemental Preliminary Assessment (Ash Creek and Newfields 2006).

The overwater release pathway is complete historically for approximately 28 ECSI facilities and is a likely complete pathway at 14 ECSI facilities within the Study Area. Dates of documented overwater releases are listed in Tables 4.3-1 and 4.3-3 and, as discussed in Section 4.2, any spills that occurred prior to January 1, 2004 are considered historical. (Spills that occurred after January 1, 2004 are considered current overwater releases and are discussed in Section 4.4.6.) Of these facilities, some of the largest spills have occurred at bulk fuel facilities (e.g., ARCO, Kinder Morgan Linnton, Willbridge), commodity shipping facilities (Goldendale Aluminum), and ship repair facilities (Schnitzer Steel, Cascade General). Types of spills include diesel, Bunker C fuel, asphalt, lube oil, hydraulic fluid, crude oil, sandblast grit, ballast/bilge water, waste oil, and generator fuel. For example, Table 4.3-3 describes a 50,000-gallon release of heavy oil from a U.S. Navy hull scrapped by Zidell Explorations Inc. in the Linnton

[22] National Response Center Database, http://www.nrc.uscg.mil/

area in 1973. It is important to note that historical industrial and commercial activities (e.g., prior to system permitting and release reporting requirements) are not well documented, and few records exist of spills prior to this time.

4.4 CURRENT SOURCES WITHIN THE STUDY AREA

Current sources of in-water contamination within the Study Area are discussed in this section. Information presented in the following subsections varies in detail because of differences in the level of understanding and quantitative investigation of the various pathways associated with the upland sites. The direct discharge pathway in Section 4.4.1 and groundwater pathway information in Section 4.4.3 represent the latest refinement of analyses that have been underway for several years. Information on overland runoff, riverbank erosion, atmospheric deposition, and overwater releases is limited, and these potential sources are described in general terms.

4.4.1 Direct Discharge – Stormwater, Sewage, and Industrial Wastewater

Pollutants from commercial, industrial, private, or municipal outfalls are being discharged directly to the Study Area. Many of these discharges are permitted under the CWA NPDES program. Permitted discharges include treated industrial wastes, stormwater runoff, and CSOs and sewer system overflows (SSOs, emergency overflows from sewage pump stations).

The following sections provide a brief description of the stormwater basins, the types of stormwater discharges, potential sources, currently available data, and a review of the current stormwater and wastewater permits within the Study Area.

Maps 4.4-1a–d present the following information:

- Stormwater and CSO and SSO outfalls
- Stormwater piping
- Streams discharging to the Study Area.

The maps also contain a characterization of the Study Area showing areas:

- With shared conveyances (e.g., City and Schnitzer-International Slip outfalls)
- With direct discharge (either through outfalls or sheet flow)
- Known to have no stormwater discharge, such as a site where there is specific information that the site/area only has infiltration and no ability to discharge stormwater (e.g., PGE-Harborton, which has a berm around it so no stormwater runoff occurs)
- With uncertain drainage.

4.4.1.1 Summary of Stormwater at ECSI Sites

DEQ began in approximately 2004 to include stormwater evaluations as part of source control evaluations under the DEQ/EPA JSCS program for Portland Harbor. Of the 89 facilities in the Study Area with permitted stormwater discharges (see Section 4.4.1.4), most have not yet conducted a stormwater source control evaluation or are recently in the process of conducting one. Of those ECSI sites for which stormwater source control evaluations have been completed, stormwater discharge has been determined to be a complete and current pathway at nine sites and a likely complete pathway at 24 sites. For a site to have a complete or likely complete stormwater pathway, COIs have been identified in site-reported stormwater data. No screening of stormwater COIs has been performed by LWG. However, as noted in Section 4.4.1.2.1, JSCS screening values for stormwater were exceeded in every land use sampled for at least some chemicals based on the LWG sampling program discussed below.

4.4.1.2 Summary of Stormwater Sampling

Stormwater sampling data are presented below from two sources. The LWG sampling program data are used in Section 6 to generate estimated stormwater loads to the Study Area for the purposes of fate and transport modeling and recontamination analysis. The non-LWG stormwater data were provided by DEQ in early 2008 for sites collecting data under the JSCS program and are presented for reference purposes in this section but will not be used in estimating stormwater loads, as directed by EPA.

4.4.1.2.1 LWG Sampling Program

In November 2006, EPA and LWG determined that stormwater data were needed to complete the RI/FS, and that such data would need to be collected in the 2006–2007 wet-weather season to fit within the overall RI/FS project schedule. They convened a Stormwater Technical Team, which included representatives from EPA, DEQ, and LWG, to develop the framework for a sampling plan. The sampling framework described in the FSP was developed by the Stormwater Technical Team and is based on an EPA memorandum dated December 13, 2006 (Koch et al. 2006). This framework was discussed and approved by Portland Harbor managers from EPA, DEQ, the Tribes, and LWG on December 20, 2006.

The Stormwater Technical Team evaluated a range of stormwater data collection technical approaches and selected those that are described in the framework and elaborated on in the Stormwater Sampling Rationale. Selection was based on 1) the ability to meet the objectives for data as agreed to by the Portland Harbor managers; and 2) practicability in terms of schedule, cost, and feasibility.

As also discussed in Section 6.1.2, representative samples from five general categories of land use (heavy industrial, light industrial, residential, major transportation, and parks/open space), as well as samples from non-representative locations, were included to obtain a practical and sufficient data set to estimate stormwater loading to the Study Area. Stormwater runoff and stormwater quality are affected by land use and the associated activities that occur within each drainage basin. Estimates of the

predominant land use classifications for the overall Study Area by drainage basin, per the City of Portland's GRID model (City of Portland 2008, pers. comm.; see RI Report Appendix E, Attachment E-2) are as follows:

- Parks and Open Space/Vacant—approximately 57 percent of total site drainage
- Light Industrial—approximately 8 percent
- Heavy Industrial—approximately 25 percent
- Residential/Commercial—approximately 8 percent
- Major Transportation—approximately 2 percent.

Maps 4.4-2a–d indicate the distribution of land uses through the Study Area. Further discussion on how various City zoning classifications were grouped into land uses is included in Section 6.1.2. Generally, areas adjacent to the river are dominated by industrial land uses. The largest combined areas of Heavy Industrial land use are on the east bank from RM 1 to 5 and on the west bank from RM 7 to 10. From RM 8 to 10 on the east bank of the river is the largest area of Light Industrial land use. Extensive areas of Parks and Open Space land use occur slightly away from the west bank from approximately RM 1 to 10. Similarly, much of the area east and away from the river from RM 5 to 12 is Residential/Commercial land use. Although Major Transportation thoroughfares extend throughout the Study Area, the largest areas tend to be at the upper reaches of the Study Area.

Stormwater composite water and sediment samples were collected from a subset of drainage basins/outfalls within each land use category in the Study Area. These locations were sampled by LWG during two sampling efforts in the spring/summer of 2007 (Round 3A) and the fall/winter of 2007–2008 (Round 3B), POP (Terminal 4 composite water and sediment trap samples at outfalls 52C and 53), and City of Portland (OF-53 composite water samples). One additional site (GE Decommissioning) was sampled by GE during the same time frame. Results from the GE investigation will also be used in the overall LWG stormwater data set. The stormwater composite water and sediment trap data were collected in accordance with the Round 3A Stormwater FSP and Addendum (Anchor and Integral 2007a,b) and its companion document, the Round 3A Stormwater Sampling Rationale (Anchor and Integral 2007c), and analyzed in accordance with the QAPP Addendum 8 (Integral 2007b).

Data were collected during a total of 15 storm events, with each outfall sampled an average of three times. Flow-weighted composite samples from each location were collected over the course of a storm event using ISCO automatic samplers to obtain event mean concentrations of chemicals. The objective was to get a composite sample that represents the water quality over the entire storm hydrograph. Sediment traps were left in place for 3 to 7 months during two separate sampling periods. These two measurements were collected to provide data to support two independent means of estimating stormwater chemical loads as explained further in Appendix E. Due to the

limited time span of sample collection and the known variability of stormwater, these data should be considered to represent a "snap shot" of stormwater entering the Study Area during the sampling period.

Table 4.4-1 provides summary statistics for nature and extent indicator chemicals for stormwater collected by the LWG. Appendix C1, Table C1-1, provides summary statistics for composite water and sediment traps for all stormwater chemicals analyzed during LWG stormwater investigations. Summary statistics for the LWG data include all LWG data, plus Terminal 4 catch basin and stormwater data (including City outfalls that are not part of Terminal 4), and GE Decommissioning stormwater data used for the stormwater loading analysis provided in Section 6. All data are Category 1. For purposes of showing summary statistics, representative and non-representative sampling locations were combined together. An analysis of representative land use locations versus non-representative locations was conducted as part of the estimation of actual stormwater loads (applying estimated concentration to estimated runoff volumes) to the Study Area and is detailed in Section 6.1.2.

Concentrations of indicator chemicals, such as total PCBs, total PAHs, DDx pesticides, non-DDx pesticides, bis(2-ethylhexyl)phthalate (BEHP), hexachlorobenzene, and metals, in the LWG stormwater sampling results were compared by land use. For the vast majority of indicator chemicals, including composite water and sediment data collected for total PCBs, total PAHs, DDx and non-DDx pesticides, and metals, samples taken from Heavy Industrial land use locations had the greatest concentrations. Exceptions include isolated metals (i.e., lead) in Light Industrial sediment trap data. Analyte concentrations collected from Open Space and Residential land uses were generally lower than other land uses. JSCS values for stormwater were exceeded in every land use sampled for at least some chemicals. The analysis of this data in terms of projected loads (which takes into account acreage of the various land use types) is contained in Section 6.

4.4.1.2.2 Non-LWG Sampling Program

In addition to the LWG stormwater data, at LWG's request, DEQ provided stormwater data in early 2008 for sites that had thus far collected data under the JSCS program. Table 4.4-2 provides a summary of the locations, sampling dates, data quality, and parameters analyzed. Table 4.4-3 provides summary statistics for nature and extent indicator chemicals for stormwater collected by non-LWG parties. Appendix C1, Table C1-2 provides summary statistics for all stormwater chemicals collected during non-LWG stormwater investigations. Summary statistics for the non-LWG stormwater data are limited to data collected after January 1, 2004, the approximate time in which the JSCS program began, and are Category 1 data.

Note that the methods and procedures used to collect non-LWG samples vary from the LWG stormwater sampling program and thus concentrations would be expected to vary. For example, some of the water samples contained in the non-LWG data set are grab

samples collected during one part of a storm event as opposed to flow-weighted composite samples collected by the LWG sampling program.

A comparison of the mean of the detected and non-detected non-LWG stormwater data and the LWG stormwater data indicated that analyte concentrations for non-LWG data were generally in the range of LWG data except for the instances mentioned below. For water data, non-LWG data were generally greater than LWG data for metals and non-DDx pesticides. For sediment trap data, non-LWG data were generally greater than LWG data for non-DDx pesticides and BEHP.

4.4.1.3 Potential Sources to Shared Conveyances Draining Stormwater from Multiple Properties

Just under half of the stormwater drainage to the Study Area is through storm shared conveyance systems, although open space is about 60 percent of those basins. The majority of these outfalls are not monitored nor were they sampled for the RI/FS. To qualitatively evaluate potential COIs from these systems, the LWG evaluated COIs from ECSI sites within the basins, public records, and, where available, from sampling data. Table 4.4-4 identifies 39 shared conveyance systems owned by the City, 8 outfalls for Burgard Industrial Park, 6 owned by the ODOT, 12 unknown multiparty outfalls, and 1 outfall that drains into Saltzman Creek from multiple properties. In addition to information on the outfall structure (e.g., location, owner, outfall size, outfall material, outfall status, basin area), ECSI sites within each basin and sites immediately upstream of the outfall on the main stem of the river were identified. For each of these sites, COIs were determined either through review of site summaries, public records, or DEQ's ECSI Web pages. The pathway designation for these COIs is classified as insufficient to make a determination as there are no known studies at these sites. However, the stormwater pathway at some sites has been independently investigated (e.g., DEQ's site discovery process), and these sites are also identified in Table 4.4-4. The pathway designation for COIs at these outfalls is classified as potentially complete because, while the sites have known stormwater COIs discharging to the City system, the COI components in the discharge at the outfalls are unknown. For the additional shared conveyance systems draining to the Study Area that are owned by other parties, basin areas for these systems are not defined so potential sources in these basins are unknown. As described in Section 4.4, Table 4.4-4 provides source information necessary for the preparation of the FS but is not an exhaustive list of current or historical sources of contamination. Identification and evaluation of potential sources is still ongoing.

COIs were identified through independent investigations at OF-16, OF-17, OF-18, and OF-19, and included PCBs, TPH, metals, VOCs, PAHs, phthalates, and DDx at one or more outfalls (see Table 4.4-4; DEQ 2009a; Anchor 2006a, 2008a; Anchor QEA 2009; GeoDesign 2008, pers. comm.; MWH 2009; City of Portland 2006a, 2009a; PES 2008; SES 2008; Evren Northwest 2007; CH2M Hill 2008; Consolidated Metco 2008, pers. comm.).

4.4.1.3.1 Portland Harbor Combined Sewer Overflow Volumes 1970 – 2011

In 1990 the City of Portland modeled approximate annual volumes for historical combined sewer overflows in preparation for development of a facilities plan for its Combined Sewer Overflow Plan. Estimated combined sewer overflow volumes in Portland Harbor are shown in Figure 4.4-1. Based on these modeled volumes, in 1970 approximately 1.6 billion gallons of combined stormwater and wastewater (sanitary sewage and some industrial wastewater) overflowed in the Portland Harbor Study Area. By 1990 the overflow volume had decreased to approximately 925 million gallons annually.

By 2001 the overflow volume was reduced to approximately 628 million gallons annually, as a result of the elimination of several outfalls, downspout disconnections, some sewer separation projects, and infiltration of stormwater to sumps in some areas served by combined sewers. In 2006 the West Side CSO Tunnel Project was completed and the annual CSO volume was reduced to approximately 195 million gallons. Upon completion of the East Side CSO Tunnel Project in 2011, the annual estimated CSO volume in the Portland Harbor area will be approximately 20 million gallons.

A CSO is composed of approximately 80 percent stormwater and 20 percent sanitary and pretreated industrial wastewater. As detailed in Table 4.3-2, available City records indicate that between 1994 and 2009, 16 industrial wastewater dischargers have been permitted through the City's NPDES pretreatment program to discharge pretreated industrial wastewater to a portion of the combined sewer system that can overflow in the Portland Harbor Study Area. Six of the 16 permitted industries are required by federal regulations to obtain permits, but they do not discharge to the City system. Three permittees are breweries with pH discharge limits only. All of the remaining seven industries have discharge limits for pH and oil and grease; several have limits for metals and cyanide, one has a limit for VOCs, and one has a limit for total toxic organics. Industrial dischargers are required to list all potential pollutants in their permits even if they do not pretreat and discharge those constituents.

Contaminants of interest in CSO discharges identified in a 1997 DEQ report for sampling are bacteria, copper, and lead (Willamette River Water Quality Data Analysis Report, [DEQ 1997]; see also Table 4.4-4).

4.4.1.4 Stormwater and Wastewater Discharge Permits

Many types of stormwater and industrial wastewater permits are issued within the Study Area uplands. Stormwater permits include discharges of industrial and municipal stormwater and stormwater runoff from construction activities. Wastewater includes permits for process water, oil/water separator discharge, petroleum hydrocarbon cleanup wastewater (tank cleanup and groundwater treatment), vehicle and equipment washwater, boiler blowdown, filter backwash, cooling water, heat pump wastewater, log pond drainage, noncontact geothermal exchange water, and rinsewater of various types, and CSO and SSO discharges. Permitted wastewater discharges are generally required to be treated before discharge.

As discussed in Section 3.1.4, stormwater and wastewater enter surface waters via pipes, culverts, ditches, catch basins, and other types of channels. In the Study Area, both stormwater and treated wastewater generally enter the river via constructed conveyance systems and outfalls. All wastewater discharges and stormwater discharges from certain types of facilities require a NPDES permit.

DEQ issues two types of NPDES permits: general and individual. General permits are issued to dischargers with similar operations and type of waste. Individual permits are issued to facilities whose processes or wastewater/stormwater flows merit unique monitoring requirements. There are 12 individual industrial wastewater permit holders discharging to the Study Area. There are no municipal wastewater treatment plant discharges in the Study Area. However, the 2002 NPDES permit for the CBWTP permitted the City of Portland to discharge CSO and pump station overflows (SSOs) into the Study Area from designated outfalls. The 2002 permit is currently in effect. The POP, ODOT, Multnomah County, and the City of Portland discharge stormwater under MS4 permits, which include discharges to the Study Area.

As of May 2009, there were approximately 89 general NPDES stormwater (not including construction permits) and 15 general NPDES wastewater permitted discharges to the Study Area, as listed in Table 4.4-5. Note that multiple permits may be associated with a single outfall. The number of NPDES-permitted discharges by type of permit is shown below:

NPDES Permit Type	Number of 5/2009 Permits
General Permits for cooling water/heat pumps **(GEN01)**	10
General Permits for boiler blowdown **(GEN05)**	2
General Permits for treatment of groundwater **(GEN15A)**	4
General Permits for stormwater **(GEN12A,C,Z)**	96
Individual Permits for facilities not elsewhere classified that dispose of primary smelting/refining of metals not elsewhere classified **(NPDES-IW-B08)**	1
Individual Permits for facilities not elsewhere classified that dispose of process wastewater (includes remediated groundwater) **(NPDES-IW-B014)**	1
Individual Permits for facilities not elsewhere classified that dispose of process wastewater **(NPDES-IW-B15)**	5
Individual Permits for facilities not elsewhere classified that dispose of non-process wastewater **(NPDES-IW-B16)**	5
Municipal Separate Storm Sewer System Discharge Permit **(NPDES-DOM-MS4-1)** including CBWTP	3

Individual permit limits may be based on either effluent concentrations or total loadings, incorporating factors such as mixing zones or available technologies. Thirteen facilities within the Study Area have individual permits and are denoted with a footnote in Table 4.2-2. Discharge monitoring requirements for these 13 individual permits are

listed in Table 4.4-6. The vast majority of permitted discharges to the Study Area (by number of permits) are for industrial stormwater discharges under general permits (NPDES GEN12Z). Instead of flow or chemical limits, these permits specify benchmark concentrations to help permittees evaluate the effectiveness of their stormwater management practices. Table 4.4-7 lists the permit discharge requirements for each type of general permit. Monitoring parameters for NPDES GEN12Z are limited to pH, oil and grease, TSS, copper, lead, zinc, and sometimes *E. coli*. The monitoring data generated under these permits provide some data regarding metals and TSS but are otherwise are of limited value in identifying sources.

Other tools that have been used to control active discharges include industrial process changes, pollution prevention practices, and technology-based effluent controls. These tools, in addition to the development and implementation of stormwater regulations, have resulted in significant reductions in uncontrolled releases to the river. However, not all industrial operations and many other operations near the Study Area (wholesale, retail, commercial or service industries) are not currently regulated.

4.4.2 Overland Transport

Overland transport has been identified as a complete and current pathway at only the Gunderson facility. This pathway is likely complete at the following additional sites: Crawford Street, Mar Com South, Premier Edible Oils, and Triangle Park. Several of these sites lack stormwater conveyance systems, and stormwater either infiltrates the ground or discharges to the river via sheet runoff.

4.4.3 Groundwater

Based on the conceptual understanding of the regional hydrogeology (see Section 3.2), groundwater discharge to the river is expected to occur over most of the Study Area. However, this does not mean that all upland areas represent sources of contamination to the river via the groundwater pathway. Understanding the groundwater pathway as a source of contamination to the river requires an understanding of the distribution of upland plumes in relation to the river and the hydrogeologic factors affecting the migration and discharge of groundwater and groundwater contaminants to the river. In cooperation with the EPA and DEQ, the LWG initiated the groundwater pathway assessment (GWPA) for the Study Area in 2003.

The LWG conducted a review of data available from DEQ ECSI files for all chemicals analyzed in groundwater for sites between RM 2 and 11, including sites bordering the river and sites with documented groundwater plumes in certain areas up to approximately 0.5 mile inland from the river (GSI 2003a). This review identified 113 sites that were initially categorized according to their likelihood to represent a potential source of COIs to Portland Harbor via the groundwater transport pathway. The initial site categorization was presented in GSI (2003a) and was updated in the draft GWPA Technical Memorandum (GSI et al. 2004).

This initial GWPA classified 21 ECSI sites as high priority or Category A, having met the following three criteria (GSI et al. 2004):

- An upland source of COIs is present.
- COIs have been detected in upland groundwater.
- A groundwater pathway from the upland site to the river is complete or is reasonably likely to be complete. This criterion is met when COIs present in upland groundwater are either confirmed or, based on professional judgment, believed to have a reasonable potential to discharge to the river (via sediments, the transition zone, surface water, or a combination thereof).

Working in collaboration with EPA and DEQ, the LWG identified 12 out of the 21 Category A sites to be considered in the scoping process for the Round 2 GWPA field investigation, which was designed to map groundwater discharges and to characterize TZW within groundwater discharge zones. Based on a detailed review of available data for each of the sites, the LWG selected nine Category A sites for inclusion in the Round 2 GWPA investigation. The remaining three sites were excluded because the available data suggested the groundwater pathway was incomplete or there was insufficient upland data to develop an appropriate investigation of the groundwater pathway. As described in the site selection process (Appendix C2), 83 sites lacked sufficient data to determine the completeness of the groundwater pathway. The criteria and individual sites are discussed in detail in the Round 2 Groundwater Pathway Assessment SAP (Integral et al. 2005). Appendix C2 updates the 2005 site selection evaluation—specifically to consider additional data collected at the three excluded sites since 2005.

The Round 2 GWPA field investigation was completed at the sites in 2006. Results of the Round 2 GWPA were used to ascertain the status of the groundwater pathway using combined lines of evidence:

- Approximate zones of groundwater discharge offshore of the sites, identified from groundwater discharge mapping (site stratigraphy, upland groundwater contours and concentrations, sediment texture, Trident temperature data, and seepage meter results) and from analytical chemistry data for TZW and sediment
- Major ion signatures for upland groundwater, surface water, and TZW, evaluated using Piper diagrams
- Chemical concentrations in zones of groundwater discharge relative to zones of low or no groundwater discharge (concentration graphs by flow zone).

This analysis is presented in Appendix C2 and is supplemented by data collected during site-specific investigations conducted by the site responsible party to further characterize the groundwater pathway at a given site. In addition, at the request of EPA, a follow-up investigation was conducted offshore of Gunderson's Area 1 during

Round 3 to evaluate possible in-river discharge of a suspected chlorinated solvent remnant plume. The stratigraphic coring indicated that a complete flow pathway was not present, and LWG and EPA agreed that additional TZW sampling was not necessary.

At the nine sites selected for the GWPA, a complete groundwater pathway was confirmed at four sites, and migration of groundwater was found to have no significant influence on TZW and sediment chemistry at five other sites (Appendix C2):

- **Arkema.** The pathway for transport of upland groundwater COIs to the transition zone within the nearshore and intermediate zones is complete.
- **Gunderson.** Chlorinated solvents measured in nearshore TZW off Area 1 are likely the result of migration of upland groundwater COIs prior to installation of the remediation system extraction wells.
- **Rhone Poulenc.** A complete pathway for transport of upland groundwater COIs to the transition zone is present.
- **Siltronic.** The pathways for chlorinated volatile organic compounds (CVOCs) in the offshore zone and PAHs, benzene, toluene, ethylbenzene, xylenes (BTEX), and TPH in the nearshore zone are complete.
- **ARCO.** Migration of chemicals in upland groundwater to the transition zone does not appear to significantly influence TZW and sediment chemistry.
- **ExxonMobil Oil Terminal.** Migration of chemicals in upland groundwater to the transition zone does not appear to significantly influence TZW and sediment chemistry.
- **Kinder Morgan Linnton Terminal (GATX).** Migration of chemicals in upland groundwater to the transition zone does not appear to significantly influence TZW and sediment chemistry.
- **Willbridge Terminal.** Based on concentrations and spatial patterns in TZW, a complete groundwater transport pathway from the upland to the transition zone does not appear to be present.
- **Gasco.** The findings of the Round 2 GWPA and NW Natural's in-water investigation at the Gasco site indicate a complete groundwater pathway for VOCs and PAHs to the transition zone. However, the relative contribution of the groundwater transport pathway to COI concentrations observed in the TZW is uncertain due to the masking effects of existing in-water sediment chemical sources.

Table 4.2-2 presents LWG's current Study Area-wide understanding of the groundwater pathway at DEQ ECSI sites based on the findings of the GWPA (Appendix C2). The groundwater pathway has been reasonably well-characterized at relatively few of the sites listed in Table 4.2-2, as summarized by category below:

- Documented evidence of a complete current pathway (a): 9 sites
- Likely a complete current pathway (b): 1 site
- Insufficient data to make determination (c): 61 sites[1]
- Not a complete current pathway (d): 33 sites[2].

DEQ's evaluation of pathways, which has been reproduced in Appendix B (DEQ 2009b, Table 1), reaches similar conclusions with respect to the groundwater evaluation of the current status of the sites, with a few areas of potential disagreement:

- DEQ determined that the groundwater pathway was "insignificant" at several sites based on "screening" (footnote at the end of Table 1, DEQ 2009b); however, in Table 4.2-2, sites without groundwater investigations are classified as category c (insufficient data to make determination). These sites include Alder Creek, Babcock Land Company, Chase Bag, Ryerson & Son, McWhorter Technologies, Olympic Pipeline, RK Storage, Schnitzer – Doane Lake, and Transloader International.
- DEQ determined that the groundwater pathway was "insignificant" at several sites where no groundwater investigations had been completed, investigations were incomplete, or no downgradient information was available, specifically, Jefferson Smurfit, RoMar Transportation, GP Linnton, Linnton Oil Fire Training Grounds, POP Terminal 4 Auto Storage, Linnton Plywood, Marine Finance, Schnitzer Investment-Kittridge, Shaver Transportation, and Goldendale Aluminum. These sites are classified in Table 4.2-2 as category c (insufficient data to make determination).
- Conclusions about complete pathways reached with the GWPA differ from the designations shown the Milestone Report (DEQ 2009b). Specifically, the GWPA did not identify complete pathways for ARCO, ExxonMobil, Kinder Morgan, and Willbridge, whereas the Milestone Report identifies complete pathways for these sites.

The overall findings of the GWPA are summarized in Maps 4.4-3a–h, which provide a river-mile-scale view of groundwater areas known to be affected by upland COIs in the vicinity of the Portland Harbor and the identified zones of in-river groundwater plume discharge, both interpreted and potential, based on the findings of the GWPA.

4.4.4 Riverbank Erosion

Currently about 75 percent of the riverbanks within the Study Area are stabilized and armored with various engineered materials, including seawalls, riprap, structures, and engineered soil. Riverbank erosion from unstabilized bank areas may represent an ongoing release mechanism in the Study Area. Riverbank erosion is identified on Table

[1] Reflects EOSM's C-c pathway for metals only, see Table 4.2-2.
[2] Reflects EOSM's C-d pathway for TPH only, see Table 4.2-2.

4.2-2 as a "known" current pathway at five ECSI sites: Alder Creek, Arkema, Gasco, EOSM, and Terminal 4 (Wheeler Bay).[23] This identification is based upon the detection of elevated concentrations of COIs in riverbank soils. An additional five ECSI sites—Crawford Street, Gunderson, Mar Com South, Premier Edible Oils, and Triangle Park—are likely complete but no confirmed data exist for these sites. Many other ECSI sites have not been evaluated as to the completeness of this pathway.

Today, riverbank stabilization and remediation plans are underway at several of these facilities.

4.4.5 Atmospheric Deposition

Similar to historical sources, current regional sources include automotive emissions, pesticide applications, and energy generation. Chemicals commonly acknowledged to play an atmospheric source role in urban river settings within the broader geographic region of the Pacific Northwest include PCBs, PCDD/Fs, PAHs, and mercury (see Section 4.3.5). Air pollution (e.g., vehicle and industrial emissions, other combustion products, fugitive dust, etc.) can enter the river directly through the processes of dry and wet deposition. Atmospheric deposition is known to be a source of contamination globally, and its relative importance in the Study Area in terms of atmospheric loading to the Study Area is evaluated in Section 6.

4.4.6 Overwater Releases

Overwater spills are unpermitted releases that occur directly into the waterway. As discussed in Section 4.2, current overwater spills are those that have occurred since January 1, 2004, the date the JSCS program was initiated. As shown in Table 4.3-1, documented spills have occurred since January 1, 2004 at approximately 12 facilities. The nature of reported spills ranges widely, from dropped bottles to sheens of unknown origin to a 100-gallon spill of lubricating oil in April 2007, as a result of equipment failure at the Cascade General facility.

The activities most commonly associated with spills in the Study Area are product handling, overwater activities such as refueling, and vessel leaks:

- **Product handling**. Many facilities are now required to maintain spill prevention plans and have instituted practices to reduce spills.
- **Overwater activities.** Overwater activities, including ship repair or vessel refueling, are potential sources to surface water and sediment contamination. Regulations and BMPs have reduced such contributions in recent years. Spills during refueling are the most common type of overwater spill, but incidents during transfer of other materials (e.g., paint, hydraulic fluid, coal tar pitch) have also been reported. Furthermore, the operation of boat motors may contribute to surface water and sediment contamination.

[23] See also Map 4.6-1a.

- **Vessel leaks.** On average, 20 spills from vessels directly into the LWR are reported to the USCG each year (NRC 2002), nearly all of which are diesel fuel, gasoline, hydraulic oil, lubricating oil, or waste oil. Bilge and ballast water from vessels has also been released.

Utility crossings are a potential source of spills in the Study Area. One petroleum pipeline crosses the Willamette River within the Study Area. It is located between the Willbridge bulk fuel terminal and south end of Triangle Park (approximately RM 7.7). Gasoline lines cross the river at RM 2.8 and near the Sauvie Island Bridge in the Multnomah Channel. Two sewer lines cross the river, one at RM 7 and the other near RM 10. There are no records of spills or leaks from these crossings.

4.5 HISTORICAL AND CURRENT SOURCES OUTSIDE THE STUDY AREA

Point and nonpoint discharges within the Willamette River Basin are potential sources of contamination in sediment, surface water, and biota in the Study Area. Chemicals in discharges and runoff from diverse land uses in the basin eventually make their way to the river by the time it flows into the Study Area. Contaminant loading from sediment transport and water from upstream areas throughout the last century also contributed to the conditions currently observed in the Study Area.

4.5.1 Non-Study-Area Sources in the Lower Willamette River

Sources in the LWR, both downstream and upstream of the Study Area, may contribute to chemical deposition within the Study Area. The Study Area is at the downstream end of a large basin with a long history of industrial, municipal, and agricultural inputs. Significant agricultural runoff persists upriver, and together with inputs from other industries and cities upstream, as well as atmospheric deposition in the watershed, the river's chemical burden is already elevated before entering the Study Area.

These upstream and downstream areas are prone to flooding, as evidenced during the major flood events of the past century. Flooding contributes to in-water contamination by eroding contaminated riverbank areas and other surface soils, and potentially breaching historical wastewater containment ponds proximal to the river. Today, many riverbanks have been armored with seawalls, riprap, and other engineered materials. The 32-ft-tall seawall that extends approximately one mile from the Hawthorne Bridge to the Steel Bridge was constructed by the City from 1923 to 1929 as a bulwark against floods (Blalock 2008).

The downtown reach immediately upstream from the Study Area is described below (GSI 2009):

> The downtown reach of the Willamette River has been used and modified for more than 150 years. Various industrial activities have occurred on the banks of the river, including ship building and ship breaking, heavy manufacturing, pesticide formulating, manufactured gas production, power generation and distribution, lumber processing, and commodities importing and exporting. The river banks have been significantly modified and used for automotive transportation, particularly in the lower half of the

downtown reach. Waterfront and upland facilities and roadways may have contributed contaminants to the Willamette River via direct discharges (e.g., stormwater and non-stormwater flows), groundwater discharges, overwater activities, overland runoff, or bank erosion.

Shoreline facilities upstream of the Study Area that are included in DEQ's ECSI database are listed in Table 4.5-1, with locations shown in Map 4.5-1a–d. This map also shows outfalls upstream of the Study Area. The outfalls shown are generally limited to known City of Portland outfalls, including CSO outfalls; there are likely a number of private outfalls within this map view, but information on these outfalls is not currently available. Table 4.5-2 lists currently available data on NPDES-permitted discharges from facilities upstream (to Willamette Falls) and downstream of the Study Area (Anderson 2006a,b pers. comm.).

As described in Section 3, under certain river stages, flows, and tidal conditions, the influence of the Columbia River estuary causes periodic flow reversals in the Willamette River near its mouth and within Multnomah Channel. These flow reversals could transport sediment-bound chemicals from downstream reaches of the river into the Study Area.

The list of impaired waters in Oregon prepared under Section 303(d) of the federal CWA and its amendments includes the main stem and tributaries of the Willamette River. The 303(d) listings in the LWR (RM 0 to 24.8 as defined by DEQ)[24] include aldrin, DDT, DDE, dieldrin, iron, manganese, mercury, PCBs, PCP, PAHs, temperature, and bacteria. Johnson Creek, a tributary that enters at RM 18, is listed for toxic chemicals, including dieldrin, DDT, PAHs, and PCBs. DEQ has developed total maximum daily loads (TMDLs) for temperature, bacteria, dieldrin, and DDT in Johnson Creek to reduce these watershed contaminants.

4.5.2 Sources above Willamette Falls (Upper Willamette River)

Both point sources and nonpoint sources of contamination are present above Willamette Falls. Agriculture, forestry, urban land use, geologic features, and atmospheric deposition can contribute to conditions in Portland Harbor.

More than 750 permitted discharges enter the Willamette River upstream of Willamette Falls, including 10 municipal sewage treatment plants and several pulp, paper, lumber, and fiberboard manufacturers. Hundreds of facilities also have general permits for discharge of noncontact cooling water and filter backwash, gravel mining waste streams, and tank cleaning fluids. Industrial stormwater discharge permits are held by facilities that handle paint, steel, metal plating, semiconductors, adhesives, and food products, as well as by landfills and transportation companies.

Most of the agricultural and forested land in the Willamette River Basin can generate nonpoint sources of pollution. The primary nonpoint source problem associated with

[24] http://www.deq.state.or.us/wq/assessment/rpt0406/results.asp

forestry is accelerated sediment transport, but nutrients, fertilizers, and herbicides are also found in forest runoff. Erosion from agricultural lands in the Willamette Valley is the most commonly cited nonpoint source of pollutants in the upper reaches of the Willamette River Basin (Tetra Tech and E&S 1993), especially fertilizers, pesticides, and herbicides. In USGS studies of pesticides in the Willamette Basin (Wentz et al. 1998), the highest concentrations of organochlorine pesticides and PCBs were reported for three mostly agricultural sites.

Nonpoint pollutants from the upper Willamette Basin (e.g., pesticides, PAHs, metals) also enter via runoff from residential, industrial, and commercial areas that do not require stormwater permits. Municipal stormwater permits are also held by cities in the upper Willamette Basin.

A fish advisory for mercury is in effect throughout the entire main stem of the Willamette River, due in part to runoff from natural volcanic sources, past mining activities, and atmospheric deposition in the upstream reaches of the Willamette River Basin.

DEQ's 303(d) list of impaired waters above Willamette Falls includes numerous tributaries of the Willamette River. The 303(d) listings in the main stem above Willamette Falls include aldrin, arsenic, DDT, DDE, dieldrin, iron, manganese, mercury, PCBs, DO, temperature, and bacteria. Most of the 303(d) listings for the upper Willamette River tributaries are for temperature and bacteria; other listings relate to nutrients, DO, turbidity, and pH. In addition, smaller creeks in the middle and upper Willamette sub-basins are listed for dieldrin, heptachlor, dichloroethylene, PCE, TCE, arsenic, copper, iron, lead, manganese, mercury, or zinc.

Based on the 303(d) list, DEQ has developed TMDLs for 11 of the 12 Willamette River sub-basins (Table 4.5-3; DEQ 2006). TMDLs are expected to be developed for the Yamhill sub-basin in 2009. Temperature and mercury TMDLs have been issued for all Willamette River sub-basins (and the main stem); bacteria TMDLs have been issued for 8 of the 12. A PCDD/F TMDL was developed by EPA in 1991 for the Willamette and Columbia rivers. Further reduction in watershed contaminants will likely occur as a result of TMDL implementation and other future watershed toxic reduction efforts.

4.6 SOURCE CONTROL MEASURES

Under the 2001 MOU, DEQ is the lead agency responsible for identifying and controlling upland sources of contamination. EPA is the lead agency for overseeing the investigation and cleanup of the in-water portion of the Study Area. Together, these two agencies developed the Portland Harbor JSCS in 2004 with the goals of identifying, evaluating, and controlling sources of contamination that may affect the LWR.

Upland source control is necessary to allow cleanup of the river to proceed without the risk of recontamination. Source control measures are implemented at a given site to address ongoing sources of contamination whether or not the source is a result of a

historical or current release. Currently, DEQ is investigating or directing source control work at over 80 upland sites in Portland Harbor (DEQ 2009b).

For DEQ, upland source control is an iterative process, where conclusions determined earlier may be refined by information gathered later in the process. The 2009 Milestone Report lists the following combination of tools that DEQ uses to control a source(s):

- Technical assistance.
- Cleaning up contaminated upland areas by removing highly contaminated soil areas, stabilizing or capping contaminated bank areas, treating or containing contaminated groundwater, and extracting contaminated sediment from storm sewer systems.
- Source control of active discharges using BMPs, industrial process changes, pollution prevention practices, and technology-based effluent controls. Compliance is achieved voluntarily or through administrative actions, including permits or enforcement.
- Source control of stormwater.
- Administrative actions and enforcement, such as licenses, permits, deed restrictions, requirements for site development plans, and enforcement actions, which may be necessary when administrative actions are violated.

Table 1 of the 2009 Milestone Report (reproduced as Appendix B) summarizes, for a given site, the status and type of source control activities, the basis for determining if source control is needed, and the schedule for implementing source control measures. Sites listed in the table are only those sites for which DEQ is actively overseeing upland investigations or source control activities (also including sites for which source control decisions have been made). Several ECSI sites are not included in the table because DEQ does not believe these sites are contributors to Willamette River contamination, because there is insufficient information to determine if the site is a contributor but the site has not entered DEQ's cleanup program, or because DEQ had not amended the Milestone Report to align with the expanded Study Area (e.g., ECSI sites in the RM 11 to 11.8 reach).

Information from Table 1 has been graphically displayed in Maps 4.6-1a–e for each of the major pathways of a particular site: riverbank erosion, groundwater, overland transport, overwater activities, and stormwater/wastewater. Sites on the maps are shaded different colors to correspond with the status of the following DEQ source control activities:

- Red – Source control evaluation is ongoing
- Blue – Source control evaluation has not started yet
- Green – The source control evaluation is complete or under EPA review

- Yellow – A "No Further Action" determination has been made for the site
- Gray – The pathway does not exist for a site
- Black – Site is not included in Table 1 of the Milestone Report.

For each ECSI site on Maps 4.6-1a–e, a symbol is included that corresponds with DEQ's interpretation of the potential for that pathway to impact in-water media. The priority levels for sites and pathways, as described in the footnotes to DEQ's Table 1, are provided below:

> High = High priority pathways and sites are those where a complete migration pathway exists and the upland source is significantly impacting the river or poses a significant and imminent threat to the river based on initial evaluation of key source control prioritization factors (see p. 4-3 of the JSCS). A primary consideration is that one or more media (soil, water, air) significantly exceed applicable Screening Level Values (SLVs) at the point of discharge to the river (e.g., water at the end of a discharge pipe, or soil or material at the riverbank) or the most reliable and cost-effective data point (e.g., groundwater measured at the shoreline), or where a bioaccumulative chemical is detected at concentrations significantly above the SLV. In addition, if an upland source is violating DEQ narrative water quality criteria for the Willamette River, the site may be considered a high priority. High priority sites are expected to move forward with aggressive source control measures without delay or be subject to enforcement action.
>
> Medium = Medium priority pathways and sites are those where a complete contaminant migration pathway exists and the upland source is impacting the river or poses a significant and/or imminent threat to the river based on an initial evaluation of key source control prioritization factors (see p. 4-3 JSCS). A primary consideration is that one or more media exceed applicable SLVs, but not significantly, at the point of discharge to the river, or where a bioaccumulative chemical is detected at concentrations above the SLV. Although exceedance of SLVs does not necessarily indicate a site poses a significant and/or imminent threat or needs to immediately implement source control measures, it does indicate that the site may pose a threat to human health or the environment and that additional evaluation may be needed to determine if source control measures are required to prevent, minimize or mitigate the migration of hazardous substances to the river. If the site exceeds one or more SLVs, the need for further characterization or for implementation of source control measures will be based on a site-specific weight-of-evidence determination. Medium priority sites are expected to perform a weight-of-evidence evaluation to determine if source control measures are required.
>
> Low = Low priority pathways and sites are those where upland data indicate, based on an initial evaluation of key source control prioritization factors (listed on p. 4-3 JSCS), that the site likely poses a low threat to the river (e.g., concentrations are near or below SLVs) or where DEQ, in consultation with EPA, may issue an upland "No Further Action" (NFA) determination or lower the State's priority of the site for further upland investigation or remedial action under DEQ's cleanup authority. Source control measures will not be required at low priority sites unless determined necessary by the results of the Portland Harbor RIFS or ROD.

As of April 2009, the ECSI sites were categorized, according to DEQ's source control efforts, into the following categories:

- High-priority sites – 8
- Preliminary high-priority sites – 8
- Medium-priority sites – 13
- Low-priority sites – 22
- Priority to be determined – 11
- Sites with source control decisions – 22.

Additionally, DEQ and the City (under an Intergovernmental Agreement) are jointly working together to identify and control upland sources draining to the Study Area through City outfalls.

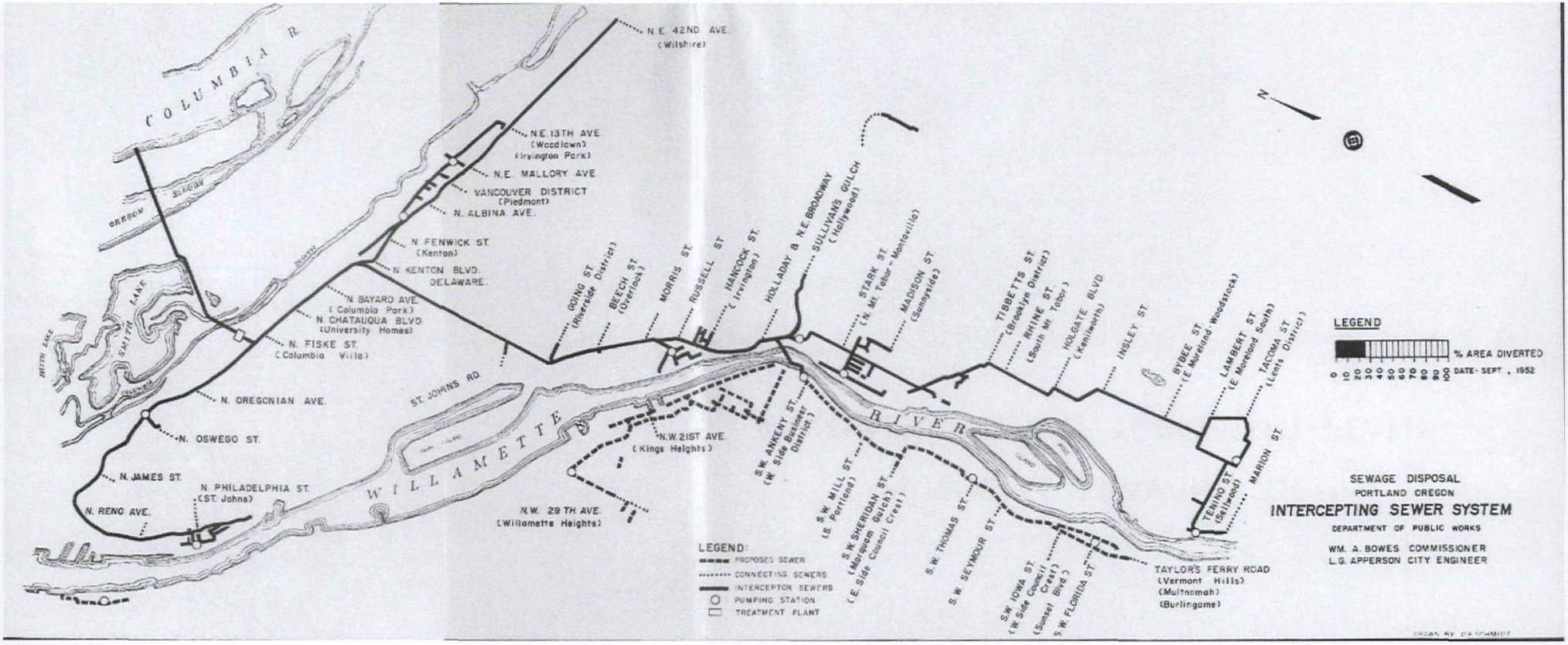

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Figure 4.1-1
Portland Harbor RI/FS
Draft Remedial Investigation Report
Intercepting Sewer System - 1952

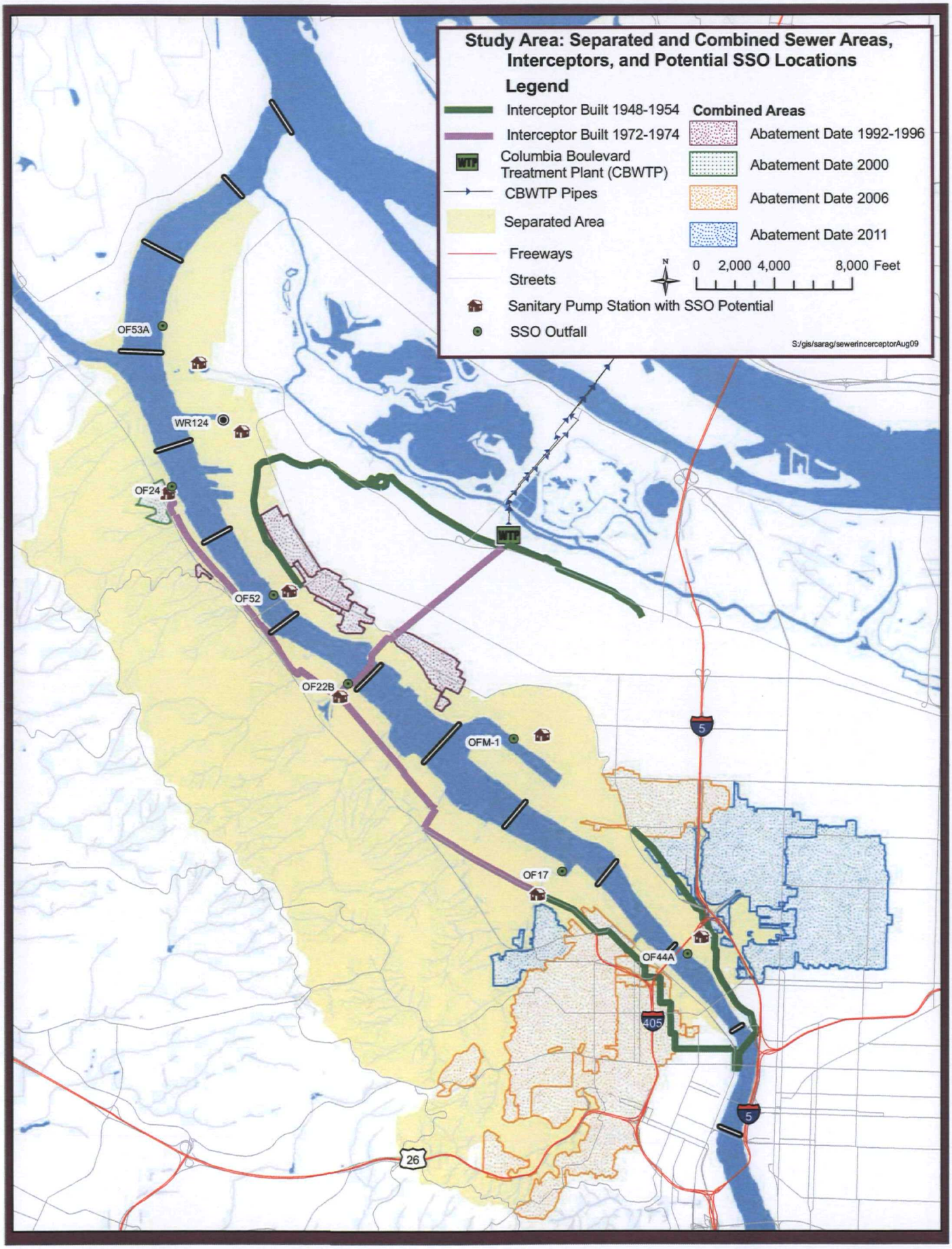

Figure 4.1-2
Portland Harbor RI/FS
Draft Remedial Investigation Report
Separate and Combined Sewer Systems
and Interceptor Facilities

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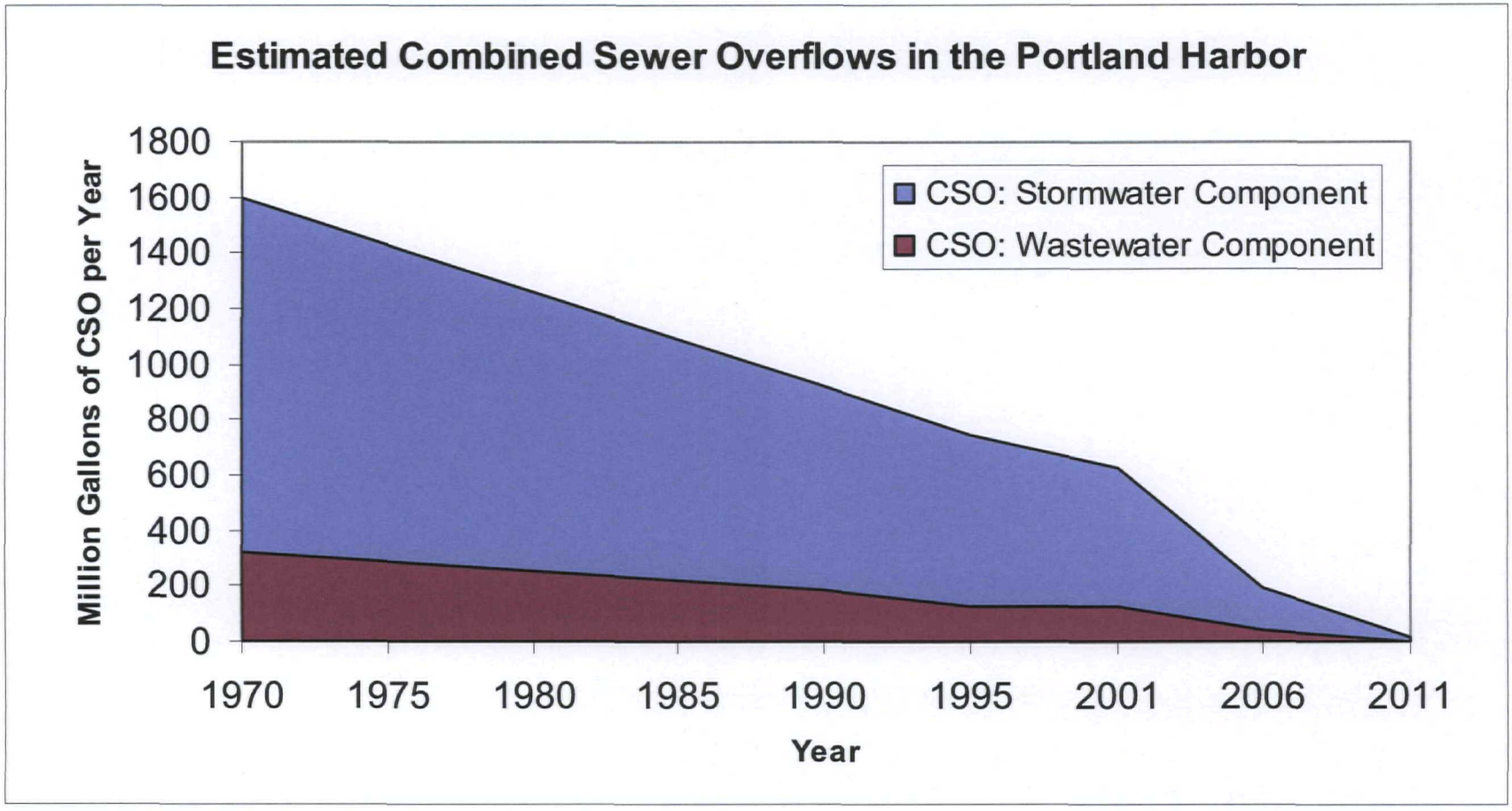

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Figure 4.4-1
Portland Harbor RI/FS
Draft Remedial Investigation Report
Estimated Combined Sewer Overflows
in the Portland Harbor

Table 4.1-1. Historical Overwater Features and Fill Placement.

Site Name and ECSI Number	River Mile	River Bank	Major Industrial Operations[a]	Overwater Activities [a,b,c] Historical	Overwater Activities [a,b,c] Current	Fill [a,c]
Evraz Oregon Steel Mills #141	2.2	E	Current: manufacturing of carbon steel coils, plates and pipe.	Prior to current ownership, pipe mounted on a trestle was used by the War Shipping Administration, and possible later operators, to convey bilge water from river barges, tied up to prior dock, to the former sump. Current dock added by current owner in 1969. Leased dock for temporary moorage, unloaded ore slurry (via piping).	None	Fill soils (hydraulically placed dredged material) were placed in the area over an extended time from the 1940s through the 1960s. In the 1970s, EOSM did some filling of the riverbank area of the property, using soil from the site, imported soil, dredge material and slag generated from its processes. Three artificial fill units are present in near-surface soils: 1) soils (sand and silt) used to construct the berm at the top of the shoreline riverbank, 2) a surficial layer of slag-soil fill, and 3) older dredge-fill (predominantly sand and silty sand) used to achieve development grades for the site prior to industrial manufacturing operations. The slag-soil deposits cover a majority of the upland EOSM plant area and are typically 2 to 6 ft thick; however, along the riverbank area, the slag-soil unit appears to be wedge-shaped, with a maximum thickness of approximately 12 ft that forms the cliff bank along the shoreline. The wedge configuration appears to be the result of historical placement of the slag-soil along the former shoreline bank.
Private Residences	2.2	W	NA	Dock added in 1957.	NA	NA
South Rivergate Industrial Park #2980	2.5	E	Current: JR Simplot - storage and distribution of urea and anhydrous ammonia; Union Chemical - manufacturer of adhesives and glues; Ash Grove Cement - manufacturer of calcium oxide; POP/Ft James - distribution of paper products; Douglas Walters/T&G Trucking/Online Roofing - container hauling, com'l/resid roofing; PGE - utility power line tower.	JR Simplot - Anhydrous ammonia, urea, and diesel fuel are transferred overwater; Ash Grove - overwater conveyor belt system for loading barges with lime products. One large dock added in 1966 off of present day Ash Grove Cement, one dock added in 1969 off of present day JR Simplot, and one dock added in 1969 off of present day Ft James/NW Service Center.		Ash Grove: from 1936 until 1956, the parcel was undeveloped and covered with dredged fill. From the 1950s to 1970s, dredge material was placed here from Post Office Bar and mouth of Willamette River.
Alder Creek Lumber Company #2446	2.9	Southern end of Sauvie Island	Lumber related activities (log storage, sawmill, lumber, planing).	Floating logs delivered to docks (1959 to present day).		In 1971, dredged material, obtained from the Multnomah Channel about 1,500 ft west of the southern tip of Sauvie Island, was placed on the bank of the Alder Creek property. In 1972, dredged material from the Georgia Pacific Linnton Fiber Terminal was also placed on the property, approximately 500 ft from Multnomah Channel.
PGE Harborton #2353	3.2	W	Electrical switchyard, easement of oil/gas pipelines, radio communication station, turbine power plant, two distillate fuel tanks, and storage of new and surplus equipment.	None.	None. Floating logs visible offshore on aerial photo (2000).	Sand and silt fill were hydraulically placed at the site in the early 1970s to depths ranging from 4 to 10 ft bgs. Perimeter dike constructed of silt fill materials. Fill source unknown.
Time Oil #170	3.4	E	Current: petroleum products handling and storage. Historical: petroleum products handling and storage, wood treatment products storage and formulation, waste oil storage.	Dock added in 1939. Dock used for the mooring of tanker ships while transferring petroleum products to pipelines located on the dock.	Dock still present, not used. Operations ceased in 2001.	Gravel fill covers portions of site within former terminal operations. It is assumed that dredged fill material was placed into this area around the turn of the 20th century, based on the similar practices along the river, but there is no documentation of the specific dates of this activity. In 1989 an excavated area in the former wood treatment area was backfilled with clean soil (fill source unknown).

Table 4.1-1. Historical Overwater Features and Fill Placement.

Site Name and ECSI Number	River Mile	River Bank	Major Industrial Operations[a]	Overwater Activities [a,b,c] Historical	Overwater Activities [a,b,c] Current	Fill [a,c]
Premier Edible Oils #2013	3.6	E	Current: none. Historical: aboveground oil storage, manufacturing, packaging, and distribution of chemicals, metals, and metal products, edible oil processing and storage facility.	Three docks associated with operations at the PEO site since the early 1950s (dock added in 1957). A wooden dock and pilings were located in the slip from the 1950s until the early 1990s. A terminal associated with the Northwest Oil tank farm was also present on the Willamette, south of the existing terminal, until the early 1970s. A pipeline from the dock at PEO ran to the adjacent Time Oil Bell Terminal until 1973, when it was torn out by Schnitzer Investment Corp. during construction, resulting in a documented release. By 1977, a large dock was built on the Willamette frontage, which was retrofitted and reconstructed through the years to accommodate operational needs of the facilities. PEO received edible oils for refining by ship.	None. Dock still present on Willamette River frontage, but not used.	The site was a marsh prior to 1941. The bottomlands were filled soon thereafter. The fill material (20-25 ft) has been described as medium-grained sand, most likely a combination of native sands and river dredge material.
Portland Container Repair (Burgard Industrial Park) #2375	3.6	E	Current: storage and repair of intermodal containers; Historical: WWII shipyard (1940s-1945, Oregon Shipbuilding Corp.), scrap metal storage	Site is upland only. Ship building (assembly) was conducted in the shipways at the adjacent Schnitzer property. Ship-related equipment and parts were fabricated upland then transported by rail to shipways on the river (International Terminals Slip - Schnitzer Burgard Industrial Park).	None	During the WWII years, this property was likely part of the shipyard owned by the Oregon Shipbuilding Corporation. The International Terminals Slip was built during this time, and much of the Burgard Industrial Park's low-lying property was filled. From the 1960s into the early 1970s, shipways associated with the former shipyard were filled.
Noncontiguous Burgard Industrial Park Properties	3.7	E	Current: Boydstun Metal Works - automotive trailer manufacturing and automotive parts storage; Morgan CFS - container unloading (lumber and building materials); Northwest Pipe - storage; Schnitzer Steel Remnant- storage. Historical: WWII shipbuilding.	Site is upland only. Ship building (assembly) was conducted in the shipways at the adjacent Schnitzer property. Ship-related equipment and parts were fabricated upland then transported by rail to shipways on the river (International Terminals Slip - Schnitzer Burgard Industrial Park).	None	During WWII, the general site area was the location of a large shipyard owned by the Oregon Shipbuilding Corporation. The deep draft International Terminals Slip was created during this period, and much of the site was filled to address marshy, low-lying areas present on the site. In 1970, dredged sand was placed as fill at present day Boydstun property.
Owens Corning #1036	3.8	W	Current: asphalt product production. Historical: wood product operations and wood treatment, solvent, lubricant, and fuel storage.	Dock added in 1985. Vessels delivered asphalt products to the site at the facility's dock from 1982 to 1987. Vessel activity and product transfer occurred on southern portion of site at location of former dock (removed in 1975).	One dock remains on site but no longer in use.	The fill material was identified as consisting mostly of sand with clay, silt, and gravel. The thickness of the fill ranges from 8 ft to at least 24 ft. Fill source unknown.
Northwest Pipe Company #138	4	E	Current: pipe manufacturing. Historical: pipe manufacturing and ship building (1937-1950, WWII years) at Oregon Shipbuilding Corp.	Site is upland only. Ship building (assembly) was conducted in the shipways at the adjacent Schnitzer property. Ship-related equipment and parts were fabricated upland then transported by rail to shipways on the river (International Terminals Slip - Schnitzer Burgard Industrial Park).	None	Dredge fill was placed during 1960s and early 1970s. The depth of the dredge fill ranges from 2 ft to approximately 20 ft bgs.
Schnitzer-Calbag #2355	4	E	Current: metals recycling, truck maintenance and repair, warehousing; Historical: ship construction/shipyard activities (1941-1945, Oregon Shipbuilding Corp.), metals recycling, truck maintenance and repair, warehousing; upland log storage and log rafting; filling of shipways; grain storage, steel pipe and tank manufacturing.	From 1941 to 1945, ships were assembled in the shipways and moored along the southern edge of the slip for outfitting. Interior mechanical and electrical features were installed and the deck painted. In 1945, a fire destroyed the dock and shops along the south side of the dock. Several ships were damaged, and cranes fell into the slip as the dock collapsed. In 1948 boat rails were added, and removed in 1969, as shown on historical photos. Between 1945 and 1972, industrial use was limited to the dismantling of the shipyard, filling of shipways associated with the former shipyard, and log rafting. Historical photos indicate that on river side, in 1978 and 1985, docks were added.	Scrap metal sometimes arrives at the SSI dock in the International Terminals Slip by barge. Bulk materials are loaded and off-loaded by using three dock-mounted cranes.	Prior to 1941, the property was largely undeveloped except for bulk petroleum storage in six aboveground storage tanks near the river. During WWII (1941-1945), the site was the location of a large shipyard owned by the Oregon Shipbuilding Corporation. The deep draft International Terminals Slip was created during this period, and portions of the marshy, low-lying areas on the site were filled. The shipways were filled in the later 1960s and early 1970s with dredged material. Thickness varies from 25 to 35 ft along the river to 15 ft on the eastern edge of the site.

Table 4.1-1. Historical Overwater Features and Fill Placement.

Site Name and ECSI Number	River Mile	River Bank	Major Industrial Operations[a]	Overwater Activities [a,b,c] Historical	Overwater Activities [a,b,c] Current	Fill [a,c]
Port of Portland - Terminal 4, Slip 1 #2356	4.3	E	Current: grain mill, liquid bulk storage, storage and maintenance of equipment for loading and unloading ships, loading soda ash to ships, unloading from rail. Historical: marine terminal, bulk storage facilities (grain and liquid).	A dock existed as early as 1920. At Pier 1, grain was transported to and from berth using conveyor (1920-2003). Tri-calcium phosphate was also handled at Pier 1. Ore and other bulk raw products were handled at Pier 2 (1921-1996). Berth 409 was removed in 1962. In June 1996, during the Pier 2 dismantling project, the dock structure at Berths 406 and 407 collapsed. The dock structure and berths were subsequently removed.	No current activitites at Pier 1 (Berths 401 and 405). Currently, IRM handles urea ammonium nitrate (UAN, a fertilizer), at Berth 408.	In 1917, dredged fill material was deposited across the low-lying ground. Most of lower Gatton Slough was filled at that time. Fill was also placed into the offshore shallows to extend the riverbank out into the channel. In 1950s Slip 1 was dredged. A Slip 2 was planned and excavated but later filled. Fill materials typically consist of silty sand and sandy dredge material, with pockets of gravel, silt, clay, concrete, and wood debris.
Babcock #2361	4.4	W	Current: site leased to steel railroad materials storage. Historical: lumber storage and loading.	Historical loading and dock operations (dates unknown). No docks appear on current aerial photograph.	Docks not present in current aerial photograph. No known activities.	Varying thicknesses of fill up to approximately 25 ft. Fill consists of medium-grained sand and silt, source unknown.
Kinder Morgan Liquids Terminal - Linnton #1096	4.4	W	Refined petroleum products storage since 1918.	A dock existed as of 1936. The dock is infrequently used for loading and unloading of petroleum fuels through above-grade conveyance pipelines connecting the site dock to the ASTs. No petroleum storage occurs at or near the riverfront outside of the AST containment area.		Soils are composed of fill material from 1 to 35 ft bgs. The source of the fill (silt and sand) is likely from dredging activities on the Willamette and Columbia rivers.
RK Storage and Warehousing #2376 (Includes West Coast Adhesives #333)	4.5	W	Current: lumber storage and log loading. Historical: lumber storage and log loading, manufactured phenol-formaldehyde glues, and storage of railroad materials.	Dock associated with lumber handling demolished in 1957.	None	Mostly composed of fill. Between 1961 and 1980, aerial photographs show dumping and fill activities south of the West Coast Adhesives facility. Debris present in the fill consists of concrete, metal, fiberglass, and asphalt to a depth of 5 ft bgs. Fill source unknown.
Port of Portland Terminal 4, Slip 3 # 272	4.6	E	Current: loading soda ash at docks. Historical: oil supply docks for locomotives, loading soda ash, unloading pencil pitch, storage and unloading of bulk oil, import and export of ore and concentrate, unloading diesel, No. 6 fuel, and Bunker C oil and transferring via pipeline.	Oil dock in place by 1906. Other site docks existed as early as 1920. Bulk materials (including pencil pitch) and petroleum products unloaded and/or loaded at ships. Petroleum pipeline traversed Terminal 4. Pencil pitch (1978-1998), ammonium sulfate (1970), sodium sulfate, soybean meal, sulfur (1961-1967), lead and zinc concentrates (1961-1971), soda ash (1988-present), and alumina/bauxite and chromite (1963) were handled at Pier 4.	None at Slip 3 Upland Facility. Berths 410 and 411 along north side of Slip 3 used by Kinder Morgan Bulk Terminals. Ship loading of soda ash at Pier 4.	Approximately 10 to 30 ft of sandy fill was placed on the lowland area along the Willamette River circa 1920 to create Terminal 4. Site filled between 1917 and 1920 with material dredged from the river adjacent to the site and with material excavated to create the facility slips. Soil removed from the east bank of Slip 3 during cleanup activity in the 1990s was re-used to fill the excavation (non-impacted soils). Slip 3 was dredged in the teens to 1920s and widened in 1958.
Linnton Plywood Association #2373	4.7	W	Linnton Plywood: sawmill and lumber company, plywood manufacturing, and warehousing in plywood building. CRSG: sand barging and distribution.	Dock existed as of 1936. Raw logs stored along waterfront pilings until processing operations began at dock (cutting logs and loading onto conveyor).	Operations ceased at Linnton in 2001. Sand is delivered to the CRSG site by tug and barge.	The area leased to CRSG was once used for dredge material disposal from dredging the historic log processing area. The historic wigwam burner was also located on the CRSG site in the area used for dredge material placement. CRSG has since placed 10 ft of clean fill in this area. The air treatment system on the CRSG site captured solids from the sander dust burner, which were spread on the ground to dry and used as fill on this parcel. CRSG has since placed 10 ft of clean fill in this area. Currently, CRSG mixes the dust with the sand. Boring logs indicate fill material at least 24 ft thick in the above areas consisting primarily of silt and fine-to-medium-grained sand. The fill also includes burner ash, angular gravel, wood chips, and brick. Fill source unknown.
ARCO #1528	4.9	W	Current: petroleum storage and distribution. Historical: petroleum storage and distribution, foamite plant, toy manufacturing, lumber company.	Dock existed as of 1936. Fuel transfer activities conducted at site.	Fuel transfer facilities.	Recent fill (consisting of sand, sandy gravel and cobbles, and/or gravelly sand and containing some debris), source of material unknown.

Table 4.1-1. Historical Overwater Features and Fill Placement.

Site Name and ECSI Number	River Mile	River Bank	Major Industrial Operations[a]	Overwater Activities [a,b,c] Historical	Overwater Activities [a,b,c] Current	Fill [a,c]
Port of Portland - Terminal 4 (Auto Storage Facility) #172 #2642	5	E	Current: unloading, storing, and processing of new automobiles. Historical: unloading, storing, and processing of new automobiles; unloading of steel and export of lumber products on the northern third of the facility. The upper portion of Toyota Logistics Services' leasehold (their processing facility) is not included in the ESCI facility, but is located northeast of the facility along North Lombard Street.	In 1971 and 1974, docks were constructed. Unloading new automobiles and steel from ships. Throughout the 1990s lumber was loaded from the yard to ships.	Unloading new automobiles from ships.	In the 1950s, 1960s, and possibly the early 1970s, sand fill was used to bring the facility up to an elevation above the flood level. Fill is about 5 ft thick at the base of the bluff east of the facility and thickens to about 40 ft at the riverbank.
Exxon Mobil #137	5.1	W	Petroleum storage and distribution.	Dock existed as of 1936. Fuel transfer activities conducted at site.		None
ST Services/Shore Terminals #1989	5.3	W	Bulk petroleum storage and marine terminal.	A dock (constructed in 1978) extends approximately 90 ft into the Willamette River from the site. The dock is used for the mooring of tanker ships while transferring petroleum products to pipelines located on the dock.		Fill placed upland in 1948. Fill material, consisting of sand and silt, was historically placed in the site vicinity on alluvial floodplain materials. Fill source unknown. Petroleum-hydrocarbon-impacted soils, resulting from the release of gasoline in 1988 and 1992, were excavated, aerated onsite, and ultimately used as fill in the excavations.
Foss Maritime/Brix Marine #2364	5.5	W	Current: marine vessel transportation services and maintenance. Historical: above and tugboat service and fueling.	Maintenance activities performed at the covered barge permanently moored at the facility dock.		Some infilling of the northeastern portion of the property occurred in 1948. Fill material was fine to medium sand (dredge fill).
Transloader International #2367	5.6	W	Current: unknown. Historical: store, sort and reship logs by land.	Aerial photographs from the early to mid-1960s show log rafts in the river adjacent to the site, but the source and duration of this activity cannot be determined. Offshore there are four dolphins and a 3-ft wide floating walkway. It is not known if these structures are completed.		The site was constructed on varying thicknesses of recent fill composed of fine to medium sands and silts.
Mar Com North (Brix DeArmond)	5.6	E	Current: unknown. Historical: mostly vacant, storage of abandoned ship repair equipment and excess parts (bone yard). Quonset hut on site used for storing ship repair material and timber. Stored, manufactured, and distributed timber and lumber products.	While Mar Com was in operation from ~1905 to 2004, a floating dry dock located at the adjacent Mar Com South Facility was used to conduct ship repairs, hull overhauls, and maintenance services (e.g., mechanical/electrical retrofits). Barges acted as support platforms relative to operations.	None	Filling activities have occurred at the North Parcel from as far back as 1917 to at least 1983-1984. Fill encountered in test pits in 1986 included organics, silts and sands with variable amounts of concrete, wood and wood products, asphalt, plastic and glass. The fill material at the Mar Com and DSL sites originated from various sources. A substantial amount of fill (greater than 10,000 cubic yards) originating from excavation materials from the Veterans Hospital is documented to have been placed at the Mar Com and DSL sites. During the 1970s, sediments dredged from the river as part of maintenance operations were placed on the southern half of the North Parcel.
Mar Com South (Langley St. Johns)	5.7	E	Current: unknown. Historical: from ~1905 to 2004 site operated as a shipway, ship repair operations (maintenance, fabrication, electrical/mechanical repairs, storage). A sawmill occupied a portion of the site between the late 1940s and ~1990. For years (dates unknown), a portion of the property was leased for sandblasting and painting services during ship construction and repair.	Two marine ways for pulling ships up to 1,000 tons out of the water to the upland shipyard facilities. An offshore floating dry dock was also present and designed to sink down to allow ships as heavy as 4,000 tons to navigate into position prior to performing maintenance activities.	Unknown. Facilty structures and equipment remain onsite, but all shipbuilding and repair activites have ceased.	Fill materials had been placed on the South Parcel since approximately 1945. In 1987, the "knoll" at the south corner of the South Parcel was constructed using dredged sediment from the marine way area.
Marine Finance (Hendren Tow Boats) #2352	5.8	W	Current: tugboat business, houseboat/sailboat construction. Historical: above and metal salvage, moorage.	Overwater structures include a home builder's dock and a gangway and floating facilities owned by a tow boat company. Overwater activities have been prevalent at this site since the early 1920s when there was a ferry slip located here.		Between 1936 and 1948 the area was filled; the fill was likely obtained from private dredging operations. In 1961 material was excavated at the site. Artificial fill material was placed at the site during the 1930s and 1960s. The excavations and soil borings completed at the site indicate that the fill material underlying the site is approximately 9 to 30 ft thick. The fill material consists of road base material, brownish-gray, poorly graded, fine to medium sand and silty sand, and organic and construction debris.

Table 4.1-1. Historical Overwater Features and Fill Placement.

Site Name and ECSI Number	River Mile	River Bank	Major Industrial Operations[a]	Overwater Activities [a,b,c] Historical	Overwater Activities [a,b,c] Current	Fill [a,c]
U.S. Moorings #1641	6	W	Government port, supply, repair facilities for dredge and other support vessels, warehousing facilities, fuel storage, motor pool garage and parking.	In 1963 a dock and floating structure were removed from the site. On the south end of the property a dock was constructed in 1936. Fueling of dredges, sandblasting, and vehicle maintenance occur at the site.	Docking facilities, maintenance, and overhaul to support the dredge fleet and the hydrographic survey vessels.	Dredge material from river used as fill upland (1914), and partial filling of new parcel in 1945.
City of Portland BES Water Pollution Control Laboratory #2452	6.1	E	Current: analytical lab. Historical: lumber mill operations, fruit box manufacturer, and original site of Terminal 3.	Lumber mill operations when dock present. Dock removed in 1979.	None	Pre-1970s fill that brought the site to the grade of the pavement for the Portland Lumber Mill. Early 1970s fill in the foundation of the Coast Veneer facility and along the bank of the river. Limited placement of "black sand" fill in the Coast Veneer area and in isolated piles on the southern portion of the site. From 1988 to 1989, construction and other debris were disposed of in the southern and northwestern portions of the site. Black sand and debris were removed from the property during site development in the mid-1990s.
Crawford Street Corporation #2363	6.1	W	Current: metal forging, steel recycling and distribution. Historical: above activities and lumber and sawmill.	None/Unknown	None/Unknown	Up to approximately 6 ft of black sand fill material was placed by previous property owners during the demolition of the former lumber mill building in 1977-1978. The sand had reportedly been obtained from a local sandblasting company and previously had been used to clean land- and ship-based oil tanks. Reported to have been transported to the beach fronting the property and into the Willamette River by riverbank erosion.
Gasco #84	6.2	W	Current: liquefied natural gas storage and distribution, solid and liquid coal tar pitch storage and distribution; northern portion - bulk fuel storage and distribution. Historical: oil manufactured gas plant, coal tar formulation, storage and distribution, electrode grade pitch manufacture and distribution.	A dock existed as of 1936 and a second dock was removed in 1957 (on the south end of the property). Fuel and Marine Marketing Inc. conducts overwater transfer of bulk petroleum from barge to their bulk storage facility. Koppers Industries (now Beazer East) conducts overwater transfer of heated liquid coal tar pitch from barge to their bulk storage facility.		Much of the Gasco property has been extensively filled through time, beginning with initial MGP site development activities between 1905 and 1913. Low-lying areas, primarily to the southeast (lampblack storage and tar pond area) received MGP by-product placement through time (1940, 1952 aerial photographs), and likely received soils from the excavation of the LNG tank containment basin at the central portion of the site in 1967 and 1968 (1968 aerial photograph). By 1975, the southern portion of the property was predominantly filled. Retention ponds were filled in 1981. The thickness of the surficial fill ranges from approximately 2 ft along the western portion of the site near the Tualatin Mountains, to a maximum of approximately 30 ft in the northern and eastern portions of the site, near the Willamette River. Much of the fill at the site, especially in the northwestern and central areas, was found to consist of poorly graded sands and silty sands that were likely hydraulically placed river-dredge material. Other areas of fill at the site were found to contain lampblack and/or pencil pitch material, solidified tars, oil, quarry reject rock, and building debris, which were incorporated into the fill when these areas were brought to current grade.
Siltronic #183	6.2	W	Current: manufactures silicon wafers from silicon crystal ingots. Historical: waste disposal area (waste effluent pond, 11-acre lagoon, disposal pit, spent oxide/lampblack disposal pile).	Tugboat refueling by former Western Transportation facility. In 1957 two docks were removed from the upstream end of the site.	None	By 1975, the site was covered with fill up to 30 ft thick in places. The fill consisted of former MGP process wastes, dredged material from Willamette River dredging operations, quarry rock, and potentially materials and wastes from other onsite and offsite sources. The southern portion of the site was filled to about 30 ft above MSL (current grade) between 1971 and 1977. The fill included quarry rock, Willamette River dredge material (which may or may not have included sediments impacted by direct discharge of wastes), and MGP waste from the PG&C facility.

Table 4.1-1. Historical Overwater Features and Fill Placement.

Site Name and ECSI Number	River Mile	River Bank	Major Industrial Operations[a]	Overwater Activities [a,b,c] Historical	Overwater Activities [a,b,c] Current	Fill [a,c]
Willamette Cove #2066	6.7	E	Current: vacant. Historical: plywood manufacturing plant (west parcel), structures to support ship repair on dry docks (central parcel) - U.S. Government facilitated during Great Depression and wars (WWI, WWII, and the Korean War), cooperage plant-manufactured wood vats, kegs, barrels, shingles (east parcel).	The central parcel of the Willamette Cove facility was used for ship repair on dry docks between 1903 and 1953. During wartime, U.S. Government contractors utilized the dry docks for military ship outfitting and repair. Dry docks were relocated in 1953. The plywood facility (West Parcel) and cooperage facility (East Parcel) were used for a variety of overwater activities associated with wood processing. The dock structure was removed between 1965 and 1969.	None	Sandy fill was placed on a strip of lowland adjacent to the bluff and outward into the Willamette River prior to and concurrent with facility development (completed by 1930). In early 1970s, filled the former log pond on the West Parcel. Fill source unknown. Debris in fill (bricks, metal, wood). Fill was placed on the upstream end of the site (in the head of the cove) in 1985.
McCormick and Baxter #74	7	E	Current: none. Historical: manufactured fir lumber and wood products treatment.	Historically, creosote was unloaded at a dock and transported to a large tank by pipeline. The facility was operational from 1944 to 1991. Unloading at the creosote dock was gradually phased out throughout the 1980s. A pier was removed in 1980 and the dock removed in 2000.	None	The site is located in an area that was filled in the early 1900s.
Arkema #398	7	W	NA	Dock removed in 1957.		Fill added in 1957.
Arkema #398	7.3	W	Current: none. Historical: inorganic chemical manufacturing company from 1941 to 2001. Produced sodium chlorate and potassium chlorate, chlorine, sodium hydroxide, hydrogen gas, hydrochloric acid, and DDT.	Dock 1 was most likely constructed in 1941 and Dock 2 was constructed sometime between 1954 and 1959. The Salt Dock was under construction in 1962. Shipments of sodium chloride (salt) were historically delivered by ship to either the Salt Dock or Dock 1. Sodium hydroxide, sodium chlorate solution, and chlorine were loaded onto barges for shipment from Dock 2.	None. Dock structures still remain.	The eastern portion of the site generally between Docks 1 and 2 has been filled with plant debris consisting of asphalt, concrete, pipe, and clean soil, in addition to fill from the City of Portland and excavation contractors. The majority of the fill material between Docks 1 and 2 was placed between 1948 and the mid-1960s.
Triangle Park LLC - North Portland Yard #277	7.4	E	Current: vacant. Historical: wharf, shipbuilding (1921-1946), lumber manufacturing, sawmill, concrete, marine towing, construction and heavy equipment (Riedel International). Riedel also responded to chemical, industrial, and accidental spills of contaminants on the ground or in waterways. Equipment was stored and cleaned onsite. Between 1980 and 1984, the site included a regulated hazardous waste storage area.	Dock existed as of 1936. Docks associated with ship building, repair, and product transfer. In 1966 a dock and floating structure was removed.	A dock and dolphins are still present at the site, but the site is vacant. There is temporary barge moorage along the shoreline.	Fill was place on the downstream end of the property in 1974 and upstream in 1966. The fill blanketing the site extends to a depth of approximately 15 ft bgs and is composed predominantly of sand. Fill was used to create the dock and berth area.
Willbridge Terminals #1549	7.5	W	Bulk petroleum storage since early 1900s.	Dock existed as of 1936. Each of the three terminals, which compose the Willbridge Terminals site, have a marine dock for the loading and unloading of petroleum products to or from tankers, barges and tug boats.		Fill material of gravel, silt and sand was deposited over most of the site. The former Holbrook Slough that connected Kittridge Lake with the Willamette River was filled in the early 1900s. The source of the fill is primarily Willamette River dredging. There is relatively little fill in the KMLT terminal's south tank yard, while there are significant fill areas on the rest of the site.
Willbridge Terminals (WMCSR-NWR-94-06) #2355	7.7	W	Current: distribution of refined petroleum products (gasoline, diesel fuel, lubricating oil), fuel storage.	Petroleum products have been loaded and unloaded at the terminal since the early 1900s.	Current marine docks (one at each facility - constructed by 1936) for loading and unloading petroleum products to or from tankers, barges, and tug boats.	Fill material of gravel, silt and sand has been deposited over most of the site. The source of the fill is primarily Willamette River dredging. The thickness of the fill material ranges from nonexistent to greater than 30 ft. There is relatively little fill in the KMLT terminal's south tank yard, while there are significant fill areas on the rest of the site. The former Holbrook Slough that connected Kittridge Lake with the Willamette River was filled in the early 1900s. Fill material placed on downstream end of site from 1948-1957.

Table 4.1-1. Historical Overwater Features and Fill Placement.

Site Name and ECSI Number	River Mile	River Bank	Major Industrial Operations[a]	Overwater Activities [a,b,c] Historical	Overwater Activities [a,b,c] Current	Fill [a,c]
McCall Oil #134	7.9	W	Asphalt manufacturing and chemical manufacturing, storage and distribution.	A dock structure and an oil transfer pipeline historically were located at the McCall Oil site prior to filling in the late 1960s. Douglas Oil operated a marine dock at the northeastern portion of the site. This dock was added in 1975 and was used to transfer asphalt from moored barges to the asphalt facility via pipeline. The dock was later replaced by the existing dock located northeast of the terminal.	Petroleum products are received and dispensed at the marine dock.	In 1966, dredge materials from the Willamette River were added to the shoreline to create additional land.
US Coast Guard - Marine Safety Station #1338	8	E	Current: USCG marine safety and marine inspection offices. Historical: roofing shingle manufacturer, lumber company.	A dock was constructed in 1974. Activities unknown.	A fixed pier is located in the southwest corner of the property and is used as a dock and fueling platform for the buoy tender CGC Bluebell. Support activities include minor onboard ship repair and storage of ship equipment. A floating dock is located east of the fixed pier and is used for servicing and launching the smaller vessels.	The property was created by filling marshy lowlands in Mocks Bottom beginning in the late 1930s. Filling of Mocks Bottom was completed in 1974.
Fred Devine Diving and Salvage #2365	8.2	E	Current: moorage. Historical: moorage and waterfront structures (1940s), cleaner and solvent storage.	A dock was constructed in 1979 where fueling and loading/unloading activities occur.		None/not reported in CSM
Front Avenue LP Properties #1239	8.2	W	Lumber facility/storage, concrete plant, pipe fittings manufacturing.	A dock was constructed in 1991. Ships deliver raw materials to facilities at the site (e.g., sand and aggregate to Glacier NW on Parcel 1).		Large portions of the site were formed by filling the riverbed and lake bed from 1887 through 1980. A large volume of fill was placed on Parcels 1 and 3 between the 1940s and the 1970s. The fill was made up of slag from a steel mill which began operating at the property in approximately 1942 (predecessor to Oregon Steel Mills), dredged material from the Willamette River, and construction debris. Fill is estimated to range from 15 to 45 ft thick on all but the northeastern third of the property.
Cascade General #271	8.4	E	Current: Cascade General - Ship repair yard and other industrial operations, POP - parking lot/undeveloped property. Historical: airport (1927-1941); shipbuilding facility (1942-1945); ship repair/industrial operations (1949-present). Between 1942 and 1949, the U.S. Maritime Commission leased Swan Island from the POP and contracted with the Kaiser Company to construct a shipyard and associated facilities. The shipyard facilities were used to build WWII T2 tanker ships. A Kaiser affiliate, Consolidated Builders, Inc., conducted ship dismantling between 1947 and 1949. After the war, the area was redeveloped and used for ship repair purposes by various ship repair contractors and their subcontractors. In addition, facilities were leased to a number of industrial tenants who conducted a range of activities, including steel fabrication and storage, wood products manufacturing, equipment manufacturing, maritime supply sales, printing, chemical and soap storage, war surplus storage, fire extinguisher service and storage, paint storage, aluminum oil tank manufacturing, service station operation, sheet meta work, roofing supply storage, and general office storage.	Shipways were constructed in the early 1940s and removed or abandoned in the late 1940s through 1962 for the installation of dry docks. Dry docks were installed on the downstream end of the site in 1945, 1953, 1962, and 1978. Boat rails were added in three areas (one added in 1948, the other two removed in 1957 and 1963 where docks were placed). Activities at the dry docks have included: ship dismantling, ship repair, ship hull washing, abrasive blasting and painting.	Activities at the dry docks include ship dismantling, ship repair, ship hull washing, abrasive blasting and painting.	From 1923 to 1927, the main navigational channel was relocated from the east side of Swan Island to the west side. Dredged materials were placed on Swan Island to raise its elevation and used to construct a causeway that connected the upstream end of the island to the east shore of the mainland. Between 1950 and 1962, the eight military-era shipways were abandoned in place by filling with dredged materials.

Table 4.1-1. Historical Overwater Features and Fill Placement.

Site Name and ECSI Number	River Mile	River Bank	Major Industrial Operations[a]	Overwater Activities [a,b,c] Historical	Overwater Activities [a,b,c] Current	Fill [a,c]
Shaver Transportation #2377	8.4	W	Current: general towing and lightering. Historical: mobile telephone service and marine transportation.	Overwater activities include a fleet of 11 tugboats and 16 barges, a main dock including ramp and 3-finger piers, 200-ft shop barge including ramp and fuel dispensers (unknown type and capacity), and a 200-ft floating shed.		From 1923 to 1927, the main navigational channel was relocated from the east side of Swan Island to the west side. Dredged materials were placed on Swan Island to raise its elevation and used to construct a causeway that connected the upstream end of the island to the east shore of the mainland. Between 1950 and 1962, the military-era shipways were abandoned in place by filling with dredged materials.
Kittridge Distribution Center - Schnitzer Investment Corp #2442	8.6	W	Current: storage, mixing, and distribution of oil-based inks; storage of trailer-mounted generators and large spools of cables and supplies for maintenance of telecommunication cables; newspaper machines, limited bearing cleaning with lube oil; distribution of household decorative tiles and tile installation supplies. Historical: activities above and acetylene production and lime recovery operations, scrap metal handling, and diesel truck refueling.	None - upland location		The small portion (~10%) of the site that is not paved is covered with imported clean landscape fill.
Lakeside Industries #2372	8.6	W	Current: asphalt manufacturing. Historical: asphalt manufacturing and moorage.	Dock added in 1948. Since 1995, raw aggregate is delivered to the site by tug and barge, and after being unloaded with a conveyor system, the aggregate is stockpiled along the edge of the river.		The fill predominantly consists of sand extending to approximately 10 feet bgs.
Christianson Oil #2426	8.7	E	Petroleum/lubricant storage, blending, and distribution.	None - upland location		None
Gunderson LLC #1155	8.8	W	Current: Manufacturing rail cars and marine barges. Historical: rail car and marine vessel manufacturing, ship dismantling and auto salvage.	Dock was present 1936 and launchways in 1957. The application of marine primers and paints onto the marine barges is conducted on the launchways. This work is considered overwater activity. Completed railcars are temporarily staged on outfitting dock (gantry) for rework of welds, touch-up painting, and using a transit to make sure cars are level. Prior to the 1960s, the area offshore of Gunderson was used for mooring of log rafts.		Gunderson site adjacent to the Willamette River was raised above the river level beginning in the 1930s using dredged fill material. The man-made fills were placed over much of the site. Therefore, most of the sand and silt found in the subsurface of the Gunderson site are fill materials obtained from the dredging of the Willamette River channel. A gully onsite was filled in the 1970s, fill source unknown. Fill was also placed in 1957.
Equilon Property (Pipeline Containment) #2117	8.8	W	Current: storage/distribution of gasoline, diesel, and ethanol. Historical: Beginning in 1928, storage/distribution of petroleum, bunker fuel, jet fuel, and lubrication oil.	The Equilon facility includes a dock on the Willamette where petroleum products are transferred from vessels to an underground pipeline corridor that extends upgradient beneath the Gunderson property to the main bulk petroleum facility. The dock has existed since at least 1936.		The riverbank in the vicinity of the dock is composed of fill materials deposited there sometime after 1936. The fill is believed to be dredged sand material.
Trumbull Asphalt #1160	9.1	W	Asphalt and roofing manufacturing plant.	None - upland location		The industrial area surrounding the site is known as the Guilds Lake area because of a shallow lake that formerly occupied the area until it was filled to provide industrial land in the early 1900s. Fill consists of asphalt, crushed rock subgrade, silt and sand. Fill source unknown.
Van Waters and Rogers #330	9	W	Bulk chemical packaging, storage and distribution.	None - upland location		Between 1910 and 1930, the lake and surrounding area were filled with dredged sediment from the Willamette River and upland fill material.
Columbia Plating #29	9.1	E	Electroplating, plating, polishing, anodizing, and coloring (all after 1975).	None - upland location		None
City of Portland	9.5-10.0	E	NA	Kerr-Gifford grain dock removed in 1939 (based on 1935 Commission of Public Docks Industrial Map).	NA	Original shoreline formed cove. In 1969, area was filled (corresponding with filling of lagoon).
Goldendale Aluminum #2440	10	E	Current: storage of lubricating and hydraulic oils. Historical: alumina and electrode binder pitch unloading facility, grain shipment facility.	Two docks constructed in 1936. Activities began in 1957 and included ship refueling, alumina and pitch unloading. Prior to this time, the site was a grain shipment facility.	None	A small area in the northeast section of the site was filled beginning in 1969.

Table 4.1-1. Historical Overwater Features and Fill Placement.

Site Name and ECSI Number	River Mile	River Bank	Major Industrial Operations[a]	Overwater Activities [a,b,c] Historical	Overwater Activities [a,b,c] Current	Fill [a,c]
Port of Portland - Terminal 2 #2769	10	W	Current: marine terminal. Historical: marine terminal, shipyard-ship construction during WWII (unknown to 1949), exporter of agricultural and manufactured wood products.	Overwater activities associated with the historical sawmill and shipyard operations were performed in areas that were subsequently filled to create the current facility. Thus, none of these operations were conducted in areas that are currently within the Willamette River. A dock was removed from the site in 1966 and then in 1987 two docks were added. Activities at site included loading and unloading by SSA of break-bulk lumber, plywood, pulp, and products on vessels, railcars, trucks, including agricultural and manufactured wood products.	Infrequent loading and unloading by SSA of break-bulk lumber, plywood, pulp and products on vessels, railcars, and trucks.	The facility is built largely on filled riverbed. In 1927, fill was placed east of the old sawmill operations. In 1966, a dock was removed and the area filled. Backfilling occurred downstream of Terminal 2 in the late 1960s. Backfilling of the Terminal 2 upstream slip occurred by 1987. In 1981 the dredge berth was filled after it was relocated. Fill source not identified.
Sulzer Bingham Pumps #1235	10.3	W	Current: Equipment pump manufacturer. Historical: part of WISCO shipyard where conversion, maintenance, and repair of government ships was conducted. WISCO also constructed minesweepers, minelayers, escort vessels, and patrol vessels, and repaired various operating vessels.	Several large pieces of metal slag are located along the Willamette River bank, at and above the surface water level. Information regarding the lease of submerged lands and/or overwater structures was not found in Oregon DSL files. Historical: ship repair activities		By 1947 the site was filled with layers of sand and layers of silt and sand mixed with brick and wood debris up to 22.5 ft bgs.
UPRR Albina Rail Yard #178	10.4	E	Switching yard.	There were several former docks located along the shoreline between RM 10 and 11 originating from 1936. Two docks are still visible on 2005 aerial photo. There is no information regarding the types of activities associated with the former docks.	None	The Albina Rail Yard is situated over both hydraulic fill and fine-grained alluvium. The hydraulic fill may be 10 ft to 20 ft in thickness and most likely originated from sediments previously dredged from the river.
Port of Portland-Terminal 1 North #3377	10.6	W	Current: lumber company operations (Emerson hardwood), combined sewer overflow shaft and tunneling operations (City of Portland). Historical: sawmill, planing mill, steam plant/drying kilns, and lumber storage yard, retail coal and wood dealer, edible oil refiners, finished wood products, retail fuel wood dealer and wholesale dried fruit.	In 1908, a coal and gravel dock was located along the river. In 1946, a single-berth dock was used as a lumber terminal. Loading and unloading of items such as lumber, logs, paper products, steel, containers, and bagged grain.	None, dock berth structures still present.	Filled submersible and submerged lands. Filling was occurring in 1957. Fill source not identified. The fill consists of sandy gravel, sand, silty sand with traces of clayey silt and wood debris.
Port of Portland - Terminal 1 South (Riverscape) #2642	10.9	W	Current: mixed commercial and residential. Historical: marine terminal, Emerson Hardwood dock, Willamette Iron and Steel dock. Prior to and during WWII, WISCO periodically used T1 South for temporary equipment storage.	Docks were constructed in the early 1900s. Activities included loading and unloading of items such as lumber, logs, paper products, steel, containers, and bagged grain. All overwater activities ceased in 1986 and most dock/pier structures have been removed.	None, some dock structures still remain.	Filled submersible and submerged lands in early 1900s. Fill source not identified. Albina Ferry Slip (Slip 1) created in 1914 and Slip 2 in 1923. Filling ocurred at the downstream end of former Terminal 1 in 1922, upstream end in 1936, and the former Terminal 1, Slip No. 1, in the early 1970s.

Table 4.1-1. Historical Overwater Features and Fill Placement.

Site Name and ECSI Number	River Mile	River Bank	Major Industrial Operations[a]	Overwater Activities [a,b,c] Historical	Overwater Activities [a,b,c] Current	Fill [a,c]
Former Albina Engine and Machine Works Shipyard (and immediate surrounding areas) Tucker Building (#3036)	11 to 11.6	E	Current: cement handling (Glacier NW), grain storage and distribution (Cargill), misc. warehouses, fabrication shops, parking strips, garages, light industry. Historical: former shipyard and machine works, former electrical operations (Tucker Bldg, PP&L, Western Electric, and Westinghouse).	Albina Engine and Machine Works was founded in 1904 as a repair yard and included both riverfront and non-riverfront property. Overwater features consisted of 6 shipways and attendant dock structures. After ships were assembled in the Albina shipways, they were moored at the Albina dock for outfitting, which included installing interior mechanical and electrical features and deck painting. Incidental spills of paint residue and fuels into the slip were possible during this time. Bilge water (often containing oily residue) was likely discharged from the grain ships, as well as other ships that moored in this area in the early 1900s. Other historical riverfront activities included sand and gravel storage, asphalt manufacturing, general cargo handling, grain shipping, and cement manufacturing. Docks have been present in the area of the Glacier faciltiy from 1936 to present day. Present-day docks at the Cargill facility were constructed sometime between 1957 and 1966. A large overwater structure called the Irvine Dock was present at this location prior to construction of the present-day Cargill dock. The dock appears to have been present since 1906 or earlier according to information obtained from the City of Portland.	Docks associated with Glacier NW and Cargill for loading and unloading. Glacier's dock has been in existence since 1936. Two additions to Cargill's docks occurred in 1966.	Infilling of the former shipways associated with the Albina shipyard began in the 1950s and was completed by 1963. The source of the fill material is unknown.
Albers Mill	11.6	W	Current: commercial office building and pay parking lot. Historical: grain and cereal mill.	At least as far back as 1889, the site was occupied by docks and grain storage warehouses that were constructed on pilings.	None	The warehousing was demolished in 1965-1966. Addition of 5-30 ft of fill to the northwest end of the site was begun in 1966. The fill may have included concrete-steel bow sections of scrapped Liberty ships. Aerial photographs indicate that additional fill may have been placed along the river and northwest property line sometime after 1980.

Notes:

[a] Information obtained from CSM site summaries (2005) and site summary addenda (2006).

[b] Known or documented spills at the sites were obtained from DEQ ERIS database for the period of 1995 to 2008.

[c] Additional information obtained from Map 4.1-9a-f.

AST - aboveground storage tank
BES - City of Portland Bureau of Environmental Services
bgs - below ground surface
CRSG - Columbia River Sand and Gravel
CSM - conceptual site model
DEQ - Oregon Department of Environmental Quality
DSL - Oregon Division of State Lands
ECSI - Oregon Environmental Cleanup Site Inventory
EOSM - Evraz Oregon Steel Mills
ERIS - Emergency Response Information System
KMLT - Kinder Morgan Linnton Terminal
LNG - liquified natural gas
MGP - manufactured gas plant
MSL - mean sea level
NA - not applicable
PEO - Premier Edible Oils
PG&C - Portland Gas & Coke
PGE - Portland General Electric
POP - Port of Portland
SSA - Stevedore Services of America
SSI - Schnitzer Steel Industries
UPRR - Union Pacific Rail Road
USCG - U.S. Coast Guard
WISCO - Willamette Iron and Steel Company

Table 4.1-2. Outfall Status 1977.[a]

Outfall(s) ID	Diverted Area[b] (Acres)	Combined (Acres)	Sanitary-Only (Acres)	Storm-Only (Acres)
OF1, OF1B, OF2	1424	220	1175	29
OF3	1007	977	--	30
OF4	6	6	--	--
OF5	39	39	--	--
OF6	285	285	--	--
OF7	696	696	--	--
OF8A	39	39	--	--
OF8	101	2	100	36
OF9	389	389	--	--
OF11	1500	1500	--	--
OF12	46	46	--	--
OF13	33	33	--	--
OF15	1335	1320	15	--
OF17	423	293	70	60
OF23	43	43	--	--
OF24	78	78	--	--
OF26A	45	45	--	--
OF26	28	28	--	--
OF27	3107	2317	790	--
OF28	1820	1820	--	--
OF29	12	12	--	--
OF30	3934	3934	--	--
OF31	61	61	--	--
OF32	26	26	--	--
OF33	30	30	--	--
OF34	10	10	--	--
OF35	14	14	--	--
OF36	900	894	6	--
OF37	2589	2589	--	--
OF38	298	298	--	--
OF40	1905	1905	--	--
OF41	280	271	--	9
OF43	1076	1076	--	--
OF44A	159	81	78	--
OF46	670	658	--	12
OF47	297	297	--	--
OF48	102	102	--	--
OF49	46	46	--	--
OF50	35	35	--	--
OF52	33	33	--	--
OF53	94	94	--	--

Notes:

[a] CRAG 1977.

[b] Diverted Area is the total area of the diversion basins within each combined sewer basin.

Table 4.1-3. Average Annual Pollutant Loads Resulting from CSOs in 1975.[a]

Outfall(s) ID	River Mile	Suspended Solids (10^3 lbs.)	Suspended Solids (mg/L)
OF12-15	10.5	87	33.5
OF43	11.4	233.9	70.4
OF11	11.4	70.2	24.5
OF40	12.2	464.6	81.5
OF8-10	12.5	0.4	74.5
OF37	12.6	355.6	60.9
OF38	12.6	354.4	116.2
OF36	12.7	97.1	55.6
OF5-7	13.6, 14.0	30.7	31.2
OF30	14	446.8	70.5
OF30	14	216.3	60.3
OF28	15.3	180.1	57.0
OF3, OF4	15.5	46.5	30.2
OF1, OF1A, OF2	15.8	14.1	52.0
OF27	16.8	416.9	72.0

Notes:

[a] CRAG 1977.

CSO - combined sewer overflow

Table 4.2-1. Site Summary Status.

ECSI	Site	Site Status[a]	Site Summary (and Addendum)	Date of Site Summary (and Addendum)[b]
794	ACF Industries	CNFA	Site Summary Addendum	4/26/2005 2/28/2007
2446	Alder Creek Lumber Company	CNFA	Site Summary	4/26/2005
970	Anderson Brothers Property	ICP	Site Summary	5/31/2005
1528	ARCO Bulk Terminal	RI complete, removal underway	Site Summary Addendum	9/17/2004 2/28/2007
398	Arkema	Consent Decree	Site Summary	2/28/2007
2361	Babcock Land Company	Not in DEQ CUP	Site Summary	3/8/2005
3395	BNSF (Willbridge Railyard, Kleenblast)	XPA	Site Summary	2/28/2007
2362	Burgard Industrial Park - Boydstun Metals	RI	Site Summary	3/8/2005
	Burgard Industrial Park - Noncontiguous	RI	Site Summary	3/8/2005
2375	Burgard Industrial Park - Portland Container Repair	RI	Site Summary	3/8/2005
2355	Burgard Industrial Park - Schnitzer Steel	RI	Site Summary	3/8/2005
138	Burgard Industrial Park (NW Pipe)	RI	Site Summary	3/8/2005
2454	Calbag Metals - Front Avenue	NFA	Site Summary Addendum	3/8/2005 2/28/2007
271	Cascade General (Portland Shipyard)	RI	Site Summary	2/28/2007
2424	Chase Bag	Not in DEQ CUP	Site Summary	3/8/2005
1281	Chevron Asphalt Refinery	XPA	Site Summary	2/28/2007
2426	Christenson Oil	XPA	Site Summary	4/26/2005
2452	City of Portland - BES Water Pollution Control Lab	PA	Site Summary	5/31/2005
2425	City of Portland Outfalls (RM 2.7 to 9.8)	SE	No Site Summary	NA
29	Columbia American Plating	PPA negotiations	Site Summary	4/26/2005
3295	Consolidated Metco	XPA	Site Summary	3/8/2005
2363	Crawford Street Corp	XPA	Site Summary	3/8/2005
141	Evraz Oregon Steel Mills	RI	Site Summary	2/28/2007
137	ExxonMobil Oil Terminal	RD/RA	Site Summary Addendum	10/10/2005 2/28/2007
2364	Foss Maritime/Brix Marine	Source control decision	Site Summary	10/10/2005
2365	Fred Devine Diving and Salvage	Source control decision	Site Summary	4/26/2005
2366	Freightliner TMP	RI	Site Summary	5/31/2005
115	Freightliner TMP2 (Parts Plant)	RI	Site Summary	4/26/2005
1239	Front Avenue LP Properties	XPA	Site Summary Addendum	9/1/2005 2/28/2007
84	Gasco (NW Natural, Koppers, Pacific Northern Oil)	RI	Site Summary	2/28/2007
4003	GE Decommisioning	XPA	Site Summary	2/28/2007
2370	Georgia Pacific - Linnton (Morse Bros.)	Closeout, source control not needed	Site Summary	3/8/2005
2440	Goldendale Aluminum	NFA	Site Summary	2/28/2007
49	Gould Electronics, Inc./ NL Industries	Remedy Implemented	Site Summary	9/1/2005
117	GS Roofing Products (Genstar)	XPA	Site Summary	4/26/2005
1155	Gunderson	RI	Site Summary Addendum	10/10/2005 2/28/2007
2371	Jefferson-Smurfit	XPA	Site Summary	3/8/2005
2441	Joseph T. Ryerson & Son	Not in DEQ CUP	Site Summary	5/31/2005
1096	Kinder Morgan Linnton Terminal (GATX)	RI complete, remedial action	Site Summary	9/17/2004
2372	Lakeside Industries	XPA	Site Summary	4/26/2005
1189	Linnton Oil Fire Training Grounds	NFA	Site Summary	9/1/2005
2373	Linnton Plywood	NFA proposed	Site Summary	3/8/2005
4797	Mar Com North	RD/RA	Site Summary Addendum	10/10/05 2/28/2007
2350	Mar Com South	RI	Site Summary Addendum	10/10/2005 2/28/2007
2352	Marine Finance Corporation (Hendren Tow Boats)	CNFA	Site Summary Addendum	9/15/2004 2/28/2007
134	McCall Oil	Source control decision	Site Summary	9/15/2004
74	McCormick & Baxter Creosoting	Remedy Implemented	Site Summary	9/15/2004
135	McWhorter Technologies	NFA	Site Summary	4/26/2005
2374	Olympic Pipeline Co.	Not in DEQ CUP	Site Summary	5/31/2005
1036	Owens Corning - Linnton	Source control decision	Site Summary	3/8/2005
3377	Port of Portland - Terminal 1 North	RI	Site Summary	2/28/2007
2642	Port of Portland - Terminal 1 South	PNFA	Site Summary	2/28/2007

Table 4.2-1. Site Summary Status.

ECSI	Site	Site Status[a]	Site Summary (and Addendum)	Date of Site Summary (and Addendum)[b]
2769	Port of Portland - Terminal 2	XPA	Site Summary	2/28/2007
2356	Port of Portland - Terminal 4, Slip 1	RI	Site Summary	2/28/2007
272	Port of Portland - Terminal 4, Slip 3	RD/RA	Site Summary	2/28/2007
172	Port of Portland - Terminal 4, Toyota Auto Storage	NFA	Site Summary	2/28/2007
100	Portland Terminal Railroad	RD/RA	No Site Summary	NA
2353	Portland General Electric - Harborton	Source control decision	Site Summary	5/31/2005
2013	Premier Edible Oils (Schnitzer Investment)	RI	Site Summary	9/15/2004
155	Rhone Poulenc (SLLI)	RI	Site Summary	2/28/2007
2376	RK Storage and Warehousing	Not in DEQ CUP	Site Summary	9/1/2005
2437	RoMar Transportation Systems	NFA	Site Summary	5/31/2005
2104	Santa Fe Pacific Pipeline	Not in DEQ CUP	Site Summary	9/1/2005
395	Schnitzer Investment - Doane Lake (Air Liquide America Corp.)	NFA under CERCLIS, not in DEQ CUP	Site Summary	5/31/2005
2442	Schnitzer Investment - Kittridge	XPA	Site Summary	9/1/2005
2377	Shaver Transportation	NFA	Site Summary	9/1/2005
183	Siltronics	RI	Site Summary	2/28/2007
2980	South Rivergate Industrial Park	Other remedial action recommended	Site Summary	5/31/2005
1989	ST Services/Shore Terminal	Source control decision	Site Summary	9/1/2005
1235	Sulzer Bingham Pumps	XPA	Site Summary Addendum	5/31/2005 2/28/2007
2117	Texaco/Equilon Enterprises - Pipeline	RI	Site Summary	3/8/2005
169	Texaco/Equilon Enterprises - Bulk Terminal	RI	Site Summary	3/8/2005
170	Time Oil	BRA	Site Summary	2/28/2007
2367	Transloader International (General Construction)	Not in DEQ CUP	Site Summary	9/1/2005
277	Triangle Park (Riedel Environmental)	RI	Site Summary	10/10/2005
1160	Trumbull Asphalt Plant	DEQ SE	Site Summary	4/26/2005
176	Union Carbide	Partial ROD	No Site Summary	
178	UPRR Albina Railyard	RI	Site Summary	2/28/2007
1641	USACE - Portland Moorings	FFA	Site Summary	3/8/2005
1338	US Coast Guard - Marine Safety Station	RI	Site Summary	4/26/2005
330	Van Waters and Rogers	RCRA Corrective Action Implemented	Site Summary	5/31/2005
2066	Willamette Cove	RI	Site Summary	2/28/2007
1549	Willbridge Bulk Fuel Terminal	RI/FS	Site Summary Addendum	9/17/2004 2/28/2007
RM 11 to 11.8				
No ECSI #	Former Albina Engine and Machine Works Shipyard	See # 3036, #5117, and Westinghouse below	Site Summary	11/20/2007
3036	Tucker Building	CNFA	Site Summary	11/20/2007, with Albina site summary
TSCA site, no ECSI #	Westinghouse	Cleanup occurring under TSCA	Site Summary	11/20/2007, with Albina site summary
5117	PacifiCorp Properties	DEQ SE	Site Summary	11/20/2007, with Albina site summary
2761	Vermiculite Northwest, Inc (former)	CERCLIS-led	No Site Summary	NA
4775	Boxer NW Building	Not in DEQ CUP	No Site Summary	NA
4590	Albers Mill	RI recommended	No Site Summary	NA
4535	Waterfront Pearl Condominiums Construction Site	NFA	No Site Summary	NA
1080 1624 4960	Hoyt Street Railroad (former) Hoyt Steet Railroad - Pearl Court Pearl Building	RD/RA	No Site Summary	NA
2183	US Postal Service Processing & Distribution Center	ROD	No Site Summary	NA
1414	Union Station - Track #5	CNFA	No Site Summary	NA
1962	Union Station Agricultural Marketing Center Site	RD/RA	No Site Summary	NA
1885	Union Station - Parcel B South	RD/RA	No Site Summary	NA
2407	Union Station Horse Barn	PNFA	No Site Summary	NA
2313	Gender Machine Works, Inc.	CNFA	No Site Summary	NA
1019	Cascade Brake Products	Not in DEQ CUP	No Site Summary	NA
1302	Master Chemical Inc.	NFA	No Site Summary	NA
3215	Valvoline	NFA	No Site Summary	NA

Table 4.2-1. Site Summary Status.

ECSI	Site	Site Status[a]	Site Summary (and Addendum)	Date of Site Summary (and Addendum)[b]
776	Williamson & Bleid	Not in DEQ CUP	No Site Summary	NA
1331	Wilbur-Ellis Co. - Portland	NFA	No Site Summary	NA
1301	Mammal Survey & Control Service	Not in DEQ CUP	No Site Summary	NA
1139	Tarr Inc.	RI	No Site Summary	NA
3067	RiverTec Property	Not in DEQ CUP	No Site Summary	NA
2500	Courtyard Hotel	NFA	No Site Summary	NA
ECSI Sites within Shared Conveyance Systems[c]				
1820	ANRFS	RI recommended	No Site Summary	NA
1076	Ashland Chemical	XPA recommended	No Site Summary	NA
5059	Calbag-Nicolai	SE	No Site Summary	NA
1405	Carson Oil	RI recommended	No Site Summary	NA
4784	Container Management	Source control decision	No Site Summary	NA
4015	Container Recovery	CNFA	No Site Summary	NA
4008	Front Avenue MP	NFA	No Site Summary	NA
TSCA site, no ECSI #	GE - NW 28th	Cleanup occurring under TSCA	No Site Summary	NA
4655	Greenway Recycling	CNFA	No Site Summary	NA
2406	PGE - Forest Park	PPA negotiations	No Site Summary	NA
5103	SFI	Letter agreement	No Site Summary	NA
1196	Galvanizers	Source control decision	No Site Summary	NA
146	Paco Pumps	NFA	No Site Summary	NA
69	Magnus/Wilhelm	Source control decision	No Site Summary	NA

Notes:

[a] Obtained from http://www.oregondeq.com/lq/ECSI/ecsiquery.asp?listtype=lis&listtitle=Environmental+Cleanup+Site%20Information+Database

[b] Information on sites with site summaires was updated on the basis of EPA/DEQ comments on the Round 2 Report (EPA 2008d) in November 2008. Information on sites with no site summary was obtained from the above website between December 2008 and June 2009.

[c] Based on independent investigations performed in 2007-2008, as documented in Table 4.4-4.

BRA - baseline risk assessment
CERCLIS - Comprehensive Environmental Response, Compensation and Liability Act
CNFA - Conditional No Further Action
CUP - Cleanup Program
DEQ - Oregon Department of Environmental Quality
ECSI - Oregon Environmental Cleanup Site Inventory
FFA - Federal Facilities Agreement
FS - feasibility study
ICP - Independent Cleanup Program
NA - not applicable
NFA - No Further Action
PA - preliminary assessment
PNFA - Partial No Further Action
PPA - Prospective Purchaser Agreement
RCRA - Resource Conservation and Recovery Act
RD/RA - Record of Decision/Remedial Action
RI - remedial investigation
ROD - Record of Decision
SE - site evalutation
TSCA - Toxic Substances Control Act
XPA - expanded preliminary assessment

Table 4.2-2. Upland Site Pathway Assessment Summary.[a]

Site Name	ECSI #	River Mile	River Bank	Potential Upland and Overwater Sources	Pathway Summary										
					Groundwater			Direct Discharge				Overland Transport		Riverbank Erosion	
								Stormwater		Overwater					
					COIs	Pathway Status	NAPL	COIs	Pathway Status	COIs	Pathway Status	COIs	Pathway Status	COIs	Pathway Status
ECSI Sites within Study Area															
ACF Industries	794	4	West	Former UST area, sandblasting, painting, adjacent rail tracks	4,7	H-c, C-d	?	1,4,7 (Stormwater Ditch)	H-a, C-d		N/A		H-d, C-d		N/A
Alder Creek Lumber Co.	2446	2.7	West	Wood waste leachate, private outfalls, overwater dock, potentially contaminated dredge material	NS	H-c, C-c	?	11	H-c, C-c		H-b, C-b	11	H-c, C-c	11	H-a, C-a
Anderson Brothers	970	8	West	Former UST, paint spill area, historic waste disposal system		H-d, C-d	?	1,3,4,7	H-c, C-c		N/A		N/A		N/A
ARCO	1528	4.9	West	Truck-loading rack area, remanufacturing warehouse, tank farms, historic spill areas, groundwater plume, seepage from interceptor well and seawall, dock operations	1,3,4,7	H-a, C-a	Y	1,3,4,7	H-b, C-b	3,4,7	H-a, C-a		N/A		N/A
Arkema	398	7.3	West	Former unlined MPR pond and trench, historic discharge through pipe, unpaved areas with contamined soils, historic spill areas, stormwater outfalls, contaminated groundwater plume	1,2,5,7,10	H-a, C-a	Y	5	H-a, C[b]-a	4,10	H-a, C-d	NS	H-c, C-c	5,10	H-a, C-a
Babcock Land Co.	2361	4.4	West	Foundry sand, historic dock operations	NS	H-c, C-c	?	NS	H-c, C-c	NS	H-c, C-d	NS	H-c, C-c	NS	H-c, C-c
BNSF	3395	8	West	DTL fueling and switching operation, former AST, historic track switch lubrication, diesel spill area	NS	H-c, C-c	N?	7	H-c, C-c		N/A		N/A		N/A
Burgard Ind. Park - Boydstun Metals, Portland Blast Media	2362	4.1	East	Oil storage area, contaminated soils, stormwater outfall, unknown source	1	H-c, C-c	N	3,6,7	H-c, C-c		N/A		N/A		H-d, C-d
Burgard Ind. Park - Noncontiguous Properties	N/A	4.1	East	Former shipyard sewer and stormwater discharges, groundwater contamination on NW Pipe leased property (2)	1,2,4	H-c, C-c	Y	11	H-c, C-c		N/A	NS	H-c, C-c	NS	H-c, C-c
Burgard Ind. Park - NW Pipe	138	4	East	ASTs and 55-gallon drums, pipe lining and coating building, transformer storage area, asphalt dipper tank, industrial well, dust suppressant use, alleged solvent and petroleum dumping areas, catch basins and storm drains	1,3,4	H-c, C-c	Y	1,3,4,6,7	H-b, C-c[c]		N/A		N/A		N/A
Burgard Ind. Park - Portland Container Repair	2375	4	East	PCE groundwater contamination (source unknown), PCB-contaminated soil (since removed), fuel truck parking area, wash pad area	1	H-c, C-c	N	4(?)	H-c, C-c		N/A		N/A		N/A
Burgard Ind. Park - Schnitzer Steel, Calbag Metals	2355	4	East	Former NW Oil Co. tanks, former sanitary sewer and stormwater discharges, former shipyard shipways, ASR on ground surface, storm drains and outfalls, over-water activities	1,4,7	H-a, C-c	N	1,4,6,7	H-a, C-a[c]	1,3,4,7	H-a, C-a	NS	H-c, C-c	3,4,6,7	H-c, C-c
Calbag Metals - Front Ave.	2454	8.5	West	Metal recycling operations, incinerator ash, stormwater runoff to Outfall 19		H-d, C-d	N	6,7,9	H-a, C-b[c]		N/A		N/A		N/A
Cascade General (Portland Shipyard)	271	8.5	East	Paint shed and blast booth area; BWTP; Buildings 43,50, and 80 areas; Building 73, 4, and 58; WSI storage area; substations; USTs; N. Channel Ave. fabrication site; drydocks and berths	1,7	H-c, C-c	N	1,3,4,6,7,8,9	H-b, C[b,c]-b	3,4,7,8,9	H-a, C-a	NS	H-c, C-c	NS	H-c, C-c
Chase Bag	2424	9.2	West	Subsurface groundwater VOC plume, former UST, observed leaking drums along east and south boundaries, observed pool of petroleum substance	1	H-c, C-c	?	NS	H-c, C-c		N/A		N/A		N/A
Chevron Asphalt Refinery	1281	8	West	Historic spills and boilovers	1,3,4,7	H-c, C-c	Y	1,3,4,7	H-a, C-c[c]		N/A		N/A		N/A
Christenson Oil	2426	8.8	West	Historic spills, stormwater conveyance, unnamed creek	NS (1)[d]	H-c, C-c	?	1,3,4,7	H-a, C-c[c]		N/A		N/A		N/A

Table 4.2-2. Upland Site Pathway Assessment Summary.[a]

Site Name	ECSI #	River Mile	River Bank	Potential Upland and Overwater Sources	Pathway Summary										
					Groundwater			Direct Discharge				Overland Transport		Riverbank Erosion	
								Stormwater		Overwater					
					COIs	Pathway Status	NAPL	COIs	Pathway Status	COIs	Pathway Status	COIs	Pathway Status	COIs	Pathway Status
City of Portland - BES	2452	6.1	East	Historic operations (lumber mill, fruit box manufacturing), fill and debris material, subsurface electrical conduit, historic lumber mill deck, WPCL	11	H-c, C-c	N	11	H-c, C-d	NS	H-c, C-d	4,7	H-c, C-d	NS	H-c, C-c
City of Portland Outfalls	2425	2.7 to 9.8	East/West	Stormwater and/or combined sewer outfalls draining multiple properties				Detailed Information provided for Specific Outfalls in Table 4.4-4	H-a[j], C-a[j]						
Columbia American Plating	29	9.5	West	Metal plating operations, spills and releases	1,2,7,10	H-c, C-c	N	1,2,6,7,10	H-a, C-d		N/A		N/A		N/A
Consolidated Metco	3295	2.8	East	PAH-contaminated fill material, cutting fluid spills, catch basins and storm drains	3,4	H-c, C-c	Y	3,4,6,7,9	H-b, C-b[c]		N/A		N/A		N/A
Crawford Street Corp.	2363	6.5	East	Historic and current manufacturing operations, historic and current site runoff, sandblast fill material, former UST, electrical transformer, railroad right-of-way, historic dock operations, historic private outfalls, beach metal debris	11	H-c, C-c	N	1,3,4,6,7	H-b, C-a	1,3,4,7	H-b, C-d	1,3,4,6,7	H-b, C-b	1,3,4,6,7,9	H-b, C-b
Evraz Oregon Steel Mills	141	2.4	East	Former Ramsey Lake sump, riverbank fill area, stormwater collection system, historic overwater spills from oil sump transfers	4	H-c, C-d	Y, H	3,4,6,7	H-a, C[b,c,g]-c	1,2,4	H-a, C-d		N/A	6,7	H-a, C-a
					7	H-c, C-c	N								
ExxonMobil Oil Terminal	137	5	West	North and Center tank farms, fuel loading rack, over-water fuel transfer spills	1,3,4,7	H-a, C-a	Y	1,3,4,7	H-b, C-b[c]	1,3,4	H-a, C-a		H-d, C-d		H-c, C-c
Foss Maritime/Brix Marine	2364	5.7	West	Former gasoline and lube oil UST and pipelines, former gasoline dispenser area, former 30-weight oil pipeline area, current lube oil and diesel UST and pipelines, catch basins, transformers, overwater activities (vessel servicing and emissions)	1,3,4,7	H-b, C-b	Y	1,3,4	H-c, C-c	1,2,3,4,7	H-a, C-a	NS	H-c, C-c	NS	H-c, C-c
Fred Devine Diving and Salvage	2365	8	East	Maintenance operations, former USTs, ASTs, PGE transformers, catch basins, overwater spills, vessel emisions, storage area NE of warehouse	NS	H-c, C-c	?	2,3,4,7,9	H-b, C-b	4	H-a, C-b	4,7,8,9	H-c, C-c	NS	H-c, C-c
Freightliner TMP	2366	8.5	East	Former USTs, former wheel paint booth, stormwater discharges	1,2,4	H-c, C-c	Y?	3,6,7	H-b, C-b[c]		N/A		N/A		N/A
Freightliner TMP2 (Parts Plant)	115	9.3	East	Former UST, former wet filter paint booths, stormwater discharges	1,2,4	H-c, C-c	Y?	7	H-b, C-b[c]		N/A		N/A		N/A
Front Avenue LP Properties (CMI NW, Hampton, Lonestar NW/Glacier NW, Tube Forging)	1239	8.3	West	Slag fill material, Parcels 1, 2, and 3 former and current operations, caustic-lube oil and graphic lube oil discharges to storm drain, overwater activities	1,2,3,4,6,7	H-c, C-c	Y	1,2,3,4,6,7,9	H-b, C-c[c]	4	H-b, C-b	1,2,3,4,7	H-c, C-c	7	H-c C-c
Gasco (NW Natural, Koppers, Pacific Northern Oil)	84	6	West	Former retort area, former tar processing area, former light oil plant Kopper Co. Plan/Current KI tank farm, former naphthalene plant, former coke oven area, former pitch plant/tar loading area, former tar settling ponds, former Kopper Co./Current KI pencil pitch storage area	1[e],2[f],3,4,7,10	H-a, C-a	Y	1[e],2[f],3,4,7, 10	H-a, C[b]-a	3,4	H-a, C-b	1[e],2[f],3,4,7,10	H-a, C-c	1[e],2[f],3,4,7	H-a, C-a
GE Decommissioning	4003	9.5	West	Former equipment handling and pressure washing areas, report of subsurface oil in storage yard, former transformer pit outlet drain, catch basins and storm drains	4,6,7	H-c, C-c	N	3,4,6,7	H-a, C-a		N/A		N/A		N/A
Georgia Pacific - Linnton	2370	3.6	West	Gasoline UST and soil remediation pile, ASTs, former ACF site, former wood-treating plant, former Linnton Oil fire training grounds, dock and former overwater fueling	1,3	H-c, C-c	N	1,3,4	H-c, C-c	NS	H-b, C-b		H-d, C-d	NS	H-c, C-c
Goldendale Aluminum	2440	10	East	Former alumina and pitch handling operations, ASTs, former USTs, storage buildings, transformers, outfalls, overland runoff areas, historic grain shipment facility, dock operations and spills		H-d, C-d	N	3,4,7	H-b, C-c[c]	3,4,7	H-a, C-b	1,2,3,4,7	H-c, C-d	NS	H-c, C-c

Table 4.2-2. Upland Site Pathway Assessment Summary.[a]

Site Name	ECSI #	River Mile	River Bank	Potential Upland and Overwater Sources	Pathway Summary										
					Groundwater			Direct Discharge				Overland Transport		Riverbank Erosion	
								Stormwater		Overwater					
					COIs	Pathway Status	NAPL	COIs	Pathway Status	COIs	Pathway Status	COIs	Pathway Status	COIs	Pathway Status
Gould Electronics/NL Industries	49	7.2	West	Former smelter and other site operations, historical landfilling operations, surface and subsurface soil contamination, former East Doane Lake sediment, current onsite containment facility		H-d, C-d	N	1,5,7,10 3,7	H-a, C-d H-c, C-c		N/A		N/A		N/A
GS Roofing	117	7.5	West	Facility operations, former USTs, storm sewer catch basins/drains, and overwater separators, former wastewater discharge, landfilled materials, railroad spur, finished products storage area	1,2,4,7	H-c, C-c	Y(H)	1,3,4,7	H-b, C-c[b]		N/A	NS	H-c, C-c	NS	H-c, C-c
Gunderson	1155	8.8	West	Former TCA tank, marine paint and blast areas, launchways, former salvage yard, hazardous materials storage areas, marine barge launchways, railcar storage on outfitting dock, fill material in Area 3	1,3,4,7	H-a, C-a	N	4,6,7,8,9	H-a, C-a	1,7	H-a, C-b	1,3,6,7	H-a, C-a	1,3,6,7	H-b, C-b
Jefferson Smurfit	2371	4	East	Former fuel ASTs and USTs, stormwater outfalls		H-d, C-d	?	4,7	H-c, C-c[c]		N/A	NS	H-c, C-c	NS	H-c, C-c
Kinder Morgan Linnton Terminal (GATX)	1096	4.1	West	Petroleum fuel storage areas, dock operations	1,3,4,7	H-a, C-a	Y	1,3,4,7	H-c, C[b]-c	1,2,4	H-a, C-b		H-d, C-d	NS	H-c, C-c
Lakeside Industries	2372	8.5	West	Former dry wells, Gunderson VOC groundwater plume, dock operations	1	H-c, C-c	N	NS	H-c, C-c		H-a, C-b	NS	H-c, C-c	NS	H-c, C-c
Linnton Oil Fire Training Grounds	1189	3.5	West	Residual contaminated soil pockets (remaining after remediation), historic main training area, upper and lower ponds, historic north drainage system (direct discharge to river)		H-d, C-d	N	3,10	H-a, C-d		N/A		H-d, C-d		N/A
Linnton Plywood (Columbia River Sand and Gravel)	2373, 2351	4.7	West	Eroded bank at maintenace shop area; private outfalls, tug and barge operations at CRSG and historic log operations	4,7,9	H-c, C-c	N	1,2,3,4,6,7,9	H-b, C[b,c]-d	4,7	H-a, C-b	3,4,6,7	H-b, C-d	4,7	H-c, C-c
Mar Com - North Parcel	4797	5.6	East	Stained soils, sandblast grit piles, contaminated riverbank soil		H-d, C-d	N		H-d, C-d		N/A	4,6,7	H-b, C-d	1,2,3,4,7,8,9	H-c, C-c
Mar Com - South Parcel	2350	5.6	East	Former sawmill, Building C, steel fabrication building, former warehouse, machine shop, compressor shed, paint booth, contaminated soil in knoll and SW corner	1,2,3,4,7,8,10	H-c, C-c	N	1,2,3,4,6,7,8,9	H-b, C-c[c]	1,2,3,4,7,8,9	H-a, C-a	1,2,3,4,6,7,8,9	H-b, C-b	1,2,3,4,7,8,9	H-b, C-b
Marine Finance (Hendren Tow Boats)	2352	5.8	West	Former metal salvage operation, former USTs, former drum storage area, former warehouse, pooled water below storm drain, overwater dock, stormwater pipe, barge/tug moorage		H-d, C-d	N	1,3,4,7,8	H-b, C-d	1,2,3,4,7	H-a, C-b	1,3,4,7,8	H-b, C-d	1,2,3,4,7,8,10	H-b, C-d
McCall Oil	134	7.9	West	Bulk fuel storage, marine fuel transfers, rail fuel transfers, former CCA and solvent storage, drum storage, underground pipeline corridor, catch basins, upgradient facilities (Chevron, TFA), dock operations	1,2,3,4,7	H-c, C-c	Y	1,2,3,4,6,7,9	H-b, C-b	1,2,3,4	H-a, C-a		H-d, C-d	2,3,7	H-c, C-c
McCormick & Baxter Creosoting	74	7	East	Former onsite waste disposal area, former central processing area, former tank farm area, former small waste disposal areas and trench, former dock operations	3,7,10	H-a, C-c	Y	3,7,10	H-a, C-d	3,7,10	H-a, C-d	3,7,10	H-a, C-d	3,7,10	H-a, C-d
McWhorter Technologies	135	8.8	West	Historic spills or releases from tanks and pipelines, former creek	NS (1,3,4)[d]	H-c, C-c	?	1,2,3,4,9	H-a, C-d		N/A		N/A		N/A
Olympic Pipeline	2374	3.5-7.9	West	Pipeline pump station (area of 1995 spill), AST farm, soil stockpile area, injection pump area	1,3,4,7	H-c, C-c	N	11	H-c, C-c		N/A		N/A		N/A
Owens Corning - Linnton	1036	3.8	West	Historic releases in pole barn storage area, former wood-processing area, former UST, process area releases in northern portion, historic releases during product unloading at dock		H-d, C-d	N	11	H-c, C-c[c]	3,4	H-b, C-d	3,4	H-c, C-c	3,4	H-c, C-c

Table 4.2-2. Upland Site Pathway Assessment Summary.[a]

Site Name	ECSI #	River Mile	River Bank	Potential Upland and Overwater Sources	Pathway Summary										
					Groundwater			Direct Discharge				Overland Transport		Riverbank Erosion	
								Stormwater		Overwater					
					COIs	Pathway Status	NAPL	COIs	Pathway Status	COIs	Pathway Status	COIs	Pathway Status	COIs	Pathway Status
POP - Terminal 1 South	2642	11	West	B-5 area, B-37 (dry well area), B-38 area, B-102 area, B-3, B-11, B-97, berths		H-c, C-d	N	11	H-c, C-c	NS	H-b, C-d		N/A	NS	H-c, C-c
POP - Terminal 1 North	3377	10.6	West	Suspected former UST, former wood-filled ravine, soil beneath Warehouse No. 101	1,3,4,7	H-c, C-d	N	11	H-c, C-c	NS	H-b, C-d		N/A		H-d, C-d
POP - Terminal 2	2769	10	West	Gearlocker, former Buildings 3060 and 3070, former USTs, berths 201, 202, and 203		H-d, C-d	N	3,4	H-c, C-c	NS	H-a, C-b		N/A	NS	H-c, C-c
POP - Terminal 4, Auto Storage	172	4.8 to 5.6	East	Completely paved storage yard		H-d, C-d	N	11	H-c, C-c[c]		H-d, C-b		N/A		H-d, C-d
POP - Terminal 4, Slip 1	2356	4.3	East	Railroad tracks in western portion of OU1, former paint storage area in OU2, riverbank of Wheeler Bay		H-d, C-d	N	3,4,5,6,7,9	H-b, C-d	3,10	H-c, C-b		H-d, C-d	3,7	H-a, C-d
POP - Terminal 4, Slip 3	272	4.7	East	East end of Slip 3, pencil pitch in limited area of riverbank and Slip 3 bank	3,4	H-a, C-d	Y	3,5,7,9	H-a, C-a	3,4	H-a, C-d		H-d, C-d	3	H-a, C-a
Portland General Electric - Harborton	2353	3.3	West	Pockets of subsurface contaminated soils near monitoring wells		H-d, C-d	N		H-d, C-d		N/A		N/A	?	H-d, C-d
Portland Terminal Railroad	100	9.5	West	Railroad switching yard	1,2,3,4,6,7,9	H-c, C-c	?	1,2,3,4,6,7,9	H-c, C-c		NA		NA		NA
Premier Edible Oils	2013	4	East	Near-surface and smear zone contaminanted soil in the following areas: 1) former NW Oil Company tank farm, 2) southern shoreline, 3) vicinity of former PEO diesel USTs, 4) WWTP, 5) former process buildings and truck-loading area; historic outfalls	1,2,3,4,6,7,9	H-c, C-c	Y	1,3,4,7	H-a, C-d	4,7	H-a, C-d	1,3,4	H-b, C-b	1,3,4	H-b, C-b
Rhone Poulenc	155	7.2	West	Former insecticide and herbicide areas, former lake area, former East Doane Lake	1,2,4,5,7,10	H-a, C-a	Y	1,5,6,7,9,10	H-a, C[b]-b		N/A		N/A		N/A
RK Storage and Warehousing	2376	4.5	West	Former UST, former stockpiled oily sludge, former stockpiled sandblast grit		H-d, C-d	N	NS	H-c, C-c	NS	H-a, C-d	NS	H-c, C-c	NS	H-c, C-c
RoMar Transportation Syst.	2437	3.8	East	Historic releases from stored scrap metal equipment and parts		H-d, C-d	N	4,6,7	H-c, C-c		N/A		N/A		N/A
Ryerson and Son	2441	4.1	East	Historic stormwater trench to slip, USTs	NS	H-c, C-c	N	NS	H-c, C-c		N/A		N/A		N/A
Santa Fe Pacific Pipeline	2104	7	West	Containment area at the SFPP site		H-d, C-d	Y		H-d, C-d		N/A		N/A		N/A
Schnitzer Investment - Doane Lake (Air Liquide)	395	7.3	West	Former discharge of calcium hydroxide into Doane Lake, former acetone UST, unknown source of subsurface contamination, compressor oil spill	6,7,10	H-c, C-c	N	1,6,7,10	H-a, C-c		N/A		N/A		N/A
Schnitzer Investment - Kittridge	2442	8.4	West	Historic acetylene plant and lime recovery		H-d, C-d	N	1,4,6,7,10	H-c, C-c		N/A		N/A		N/A
Shaver Transportation	2377	8.4	West	Diesel fuel AST, former diesel fuel USTs, storage building, overwater activities		H-d, C-d	N		H-d, C-d	4	H-a, C-a		H-d, C-d		H-d, C-d
Siltronic	183, 84, 155	6.6	West	Gasco disposal ponds and adjacent lowland areas, Gasco disposal piles, potential Gasco waste product fill (WWTP area and Fab 1 and parking lot), potential disposal area, Koppers via north drainage ditch and City Outfall 22C, former Western Transportation tanks, Olympic pipeline	1,2,3,4,7,10	H-a, C-a	Y	1,2,3,4,7,10	H-b, C[b,c]-c	3,4	H-b, C-d	1[h],2,3,4,7, 10	H-b, C-c	2,3,4,7,10	H-b, C-d

Table 4.2-2. Upland Site Pathway Assessment Summary.[a]

Site Name	ECSI #	River Mile	River Bank	Potential Upland and Overwater Sources	Pathway Summary										
					Groundwater			Direct Discharge				Overland Transport		Riverbank Erosion	
								Stormwater		Overwater					
					COIs	Pathway Status	NAPL	COIs	Pathway Status	COIs	Pathway Status	COIs	Pathway Status	COIs	Pathway Status
South Rivergate Ind. Park	2980	2.5 to 3.4	East	**JR Simplot:** warehouse storage and transfer of urea, truck storage and transfer of anhydrous ammonia, tank storage and transfer of diesel fuel, overwater transfer of urea, anhydrous ammonia, and diesel fuel. **Ash Grove Cement**: storage tanks and manufacturing	NS	H-c, C-c	N	10	H-c, C[b]-c	10	H-a, C-a	NS	H-c, C-c	NS	H-c, C-c
ST Services/Shore Terminal	1989	5.4	West	Terminal tank farm, dock operations	1,4	H-c, C-c	N	11	H-c, C-c	NS	H-a, C-b	NS	H-c, C-c	NS	H-c, C-c
Sulzer Bingham Pumps	1235	10.3	West	Former and existing USTs, historic sandblasting areas, hazardous waste storage area (including radioisotopes), electrical substations, historic welding and machine operations on piers, metal slag along riverbank	1,3,4,7,9,10	H-c, C-c	?	3,4,7	H-a, C-c	7	H-b, C-b	6	H-c, C-c	7	H-b, C-c
Texaco/Equilon - Bulk Terminal	169	8.8	West	Pipe containment, ASTs, foundary sand, historic wooden flume and utilities (possibly a preferential GW pathway)	1,3,4	H-c, C-c	Y	1,3,4	H-c, C-c		N/A		N/A		N/A
Texaco/Equilon - Pipeline	2117	8.8	West	Dock and overwater fueling activities	1,3,4	H-c, C-c	Y	1,3,4	H-c, C-c	1,3,4	H-a, C-b	NS	H-c, C-c	NS	H-c, C-c
Time Oil	170	3.5	East	Former wood treatment formulation and storage area, former Main Terminal tank farm, former Bell Terminal tank farm, dock operations	1,2,3,4,7,10	H-c, C-d	Y	3,4,7,10	H-a, C-c[c]	NS	H-b, C-d	1,3,4,7,10	H-c, C-c	3,7	H-c, C-c
Transloader International	2367	5.6	West	Dolphin and floating walkway, outfall (ownership unknown)	NS (3,4)[d]	H-c, C-c	?	NS	H-c, C-c	NS	N/A	NS	H-c, C-c	NS	H-c, C-c
Triangle Park (Riedel Env.)	277	7.4	East	Former lumber mills, wood processing, rail car servicing, oil and fuel storage, former concrete plant, former sludge disposal pond, former ASTs and USTs, former power plant, possible underground fuel storage vault, former chemical storage areas, oil spill	1,2,3,4,5,6,7,9, 10	H-c, C-c	N	1,2,3,4,5,6,7,10	H-b, C-b	3,4	H-b, C-d	1,2,3,4,5,6,7,10	H-b, C-b	1,2,3,4,5,6,7,10	H-b, C-b
Trumbull Asphalt Plant	1160	9.1	West	Asphalt tank farm, roofing production line (historic wastewater discharge to Outfall 18), boiler lines and fuel tank, fume line	1,4	H-c, C-c	Y	3,6,7,9	H-b, C-b		N/A		N/A		N/A
Union Carbide	176	4	East	Former calcium carbide and ferroalloy processing facility, electrical substation, portion of stormwater runoff directed to Willamette		N/A		1,3,4,5,6,7,9,10	H-c, C-c		N/A		N/A		N/A
UPRR Albina Railroad	178	10 to 11	East	Existing and former fueling areas, locomotive washing area, wastewater treatment plant, freight car repair shop (former paint stripper area, former UST)	2,3,4,7,9	H-c, C-c	N	2,3,4,6,7	H-a, C-a	NS	H-b, C-d		H-d, C-d	6	H-b, C-d
US Coast Guard - Marine Safety Station	1338	8	East	Dock and overwater maintenance operations, fuel storage and buried product lines, garage, buoy storage yard, former drum storage area, Mt. Jefferson building, catch basins		H-d, C-d	N	3,7	H-b, C-b[c]	1,2,3,4,7	H-b, C-a	NS	H-c, C-c	NS	H-c, C-c
USACE - Portland Moorings	1641	6	West	Former sandblasting area, oil-stained soil at west end of property, historic sunken barge	1,3,7,10	H-c, C-c	?	3,4,7,8	H-c, C-c	4	H-a, C-a	3,4,7,8	H-c, C-c	NS	H-c, C-c
Van Waters and Rogers	330	8.9	West	Former recycling area, loading dock area, spill areas		H-d, C-d	Y	1,4,5,7	H-c, C[b]-c		N/A		N/A		N/A

Table 4.2-2. Upland Site Pathway Assessment Summary.[a]

Site Name	ECSI #	River Mile	River Bank	Potential Upland and Overwater Sources	Pathway Summary										
					Groundwater			Direct Discharge				Overland Transport		Riverbank Erosion	
								Stormwater		Overwater					
					COIs	Pathway Status	NAPL	COIs	Pathway Status	COIs	Pathway Status	COIs	Pathway Status	COIs	Pathway Status
Willamette Cove	2066	6.8	East	Spills and historic waste disposal practices on the west, central, and east parcels, slag and beach debris, contaminated groundwater and seeps, riverbank soil, historic drydock activities	1,2,3,4,7	H-c, C-c	N	NS	H-b, C-d	NS	H-b, C-d	NS	H-c, C-c	3,7	H-b, C-c
Willbridge Bulk Fuel Facility	1549	7.5	West	ConocoPhillips, Chevron, and Kinder Morgan bulk terminals and dock operations	1,3,4,7,9	H-a, C-a	Y	1,3,4,5,7,9	H-b, C-c[c]	1,3,4,7	H-a, C-a	NS	H-c, C-c	3,5,7	H-b, C-c
ECSI Sites between RM 11-11.8															
Tucker Building	3036	11.3	East	Former electrical transformer and other equipment repair facility. Served as PP&L's district office, storage, and warehouse space	1,3,4,7	H-c, C-c	N	3,4,6,7	H-b, C-d		N/A		N/A		N/A
Westinghouse	No ECSI #, TSCA site	11.5	East	Former electrical transformer repair facility		H-c, C-c	?	6	H-b, C-b		N/A		N/A		N/A
PacifiCorp Albina Properties	5117	11.3 to 11.5	East	Former shipyard and machine works property, former electrical transformer storage		H-c, C-c	?	4,6	H-b, C-b		N/A		N/A		N/A
Vermiculite Northwest, Inc. (former)	2761	11.2	East	Former vermiculite processing/handling area, possibly containing asbestos	NS	H-c, C-c	?	NS	H-c, C-c		N/A		N/A		N/A
Boxer NW Building	4775	11.8	West	Former heating oil tank (now filled), diesel soil contamination	NS (4)[d]	H-c, C-c	?		H-d, C-d		N/A		N/A		N/A
Albers Mill	4590	11.6	West	Possible contaminated fill material (Liberty Ship debris); former fuel oil storage tank (now filled) and associated contaminated soil; six former USTs (removed) and associated soil contamination, historic docks	3,4,7	H-c, C-c	?	3,4,7	H-c, C-c	3,4,7	H-c, C-d	7	H-c, C-c	7	H-c, C-c
Waterfront Pearl Condominiums Construction Site	4535	11.7	West	Historic flour mill, contaminated fill material (Liberty Ship debris), contaminated subsurface soil (74,000 tons removed), former overwater actvities	7	H-c, C-c	?	3,4,7	H-c, C-c	3,4,7	H-c, C-d	7	H-b, C-c	7	H-b, C-c
Hoyt Street Railroad (former) **Hoyt Steet Railroad - Pearl Court** **Pearl Building**	1080 1624 4960	11.6	West	Former railyard and fueling facilities, former ASTs and USTs		H-d, C-d	Y(H)		H-d, C-d		N/A		N/A		N/A
US Postal Service Processing & Distribution Center	2183	11.7	West	Former railyard and fueling facilities, former ASTs and USTs	1,3,4,7	H-c, C-c	?	1,3,4,7	H-c, C-c		N/A		N/A		N/A
Union Station - Track #5	1414	11.6	West	Former train diesel refueling area		H-d, C-d	N	3,4	H-c, C-c		N/A		N/A		N/A
Union Station Agricultural Marketing Center Site	1962	11.6	West	Former rail yard, contaminated dredge fill		H-d, C-d	N	3,4,7	H-c, C-c		N/A		N/A		N/A
Union Station - Parcel B South	1885	11.6	West	Rail yard and rail station, contaminated dredge fill		H-d, C-d	N	3,4,7	H-c, C-c		N/A		N/A		N/A
Union Station Horse Barn	2407	11.6	West	Former rail yard, manufactured gas plant (south)	1,3,4	H-c, C-d	N	3,4,7	H-c, C-c		N/A		N/A		N/A
Gender Machine Works, Inc.	2313	11.4	West	Former foundry and machine shop, soil contamination		H-d, C-d	N	3,4,7	H-c, C-c		N/A		N/A		N/A
Cascade Brake Products	1019	11.3	East	Potential improper disposal of solvent and waste brake fluid	NS	H-c, C-c	?	NS	H-c, C-c		N/A		N/A		N/A
Master Chemical Inc.	1302	11.5	East	Chemical manufacturing facility		H-d, C-d	N		H-d, C-d		N/A		N/A		N/A
Valvoline	3215	11.2	East	Former foundry, bulk fuel tank spills and associated contaminated soil (removed)	NS	H-c, C-c	?	1,3,4,7	H-c, C-c		N/A		N/A		N/A
Williamson & Bleid	776	11.5	East	Hazardous waste generator, improper storage and disposal	NS (1,4)[d]	H-c, C-c	?	NS	H-c, C-c		N/A		N/A		N/A

Table 4.2-2. Upland Site Pathway Assessment Summary.[a]

Site Name	ECSI #	River Mile	River Bank	Potential Upland and Overwater Sources	Pathway Summary										
					Groundwater			Direct Discharge				Overland Transport		Riverbank Erosion	
								Stormwater		Overwater					
					COIs	Pathway Status	NAPL	COIs	Pathway Status	COIs	Pathway Status	COIs	Pathway Status	COIs	Pathway Status
Wilbur-Ellis Co. - Portland	1331	11.6	West	Former warehouse and distribution center for agricultural chemicals and fertilizer, some pesticide formulation	NS (4)[d]	H-c, C-c	?	1,2,3,4,5,6,7	H-c, C-d		N/A		N/A		N/A
Mammal Survey & Control Service	1301	11.6	East	Former pesticide manufacturing facility	NS	H-c, C-c	?	NS	H-c, C-c		N/A		N/A		N/A
Tarr Inc.	1139	11.3	East	Bulk fuel and chemical storage, former USTs (decommissioned) and associated soil contamination (4,000 yd^3 removed), oil spill on nearby gravel lot, possible dry well	1,3,4	H-c, C-c	?	1,3,4	H-c, C-c		N/A		N/A		N/A
RiverTec Property	3067	11.6	West	Former lead-smelting operations	NS	H-c, C-c	?	NS	H-c, C-c		N/A		N/A		N/A
Courtyard Hotel	2500	11.8	East	Contaminated soil from unknown source (removed)	NS	H-c, C-c	?		H-d, C-d		N/A		N/A		N/A
ECSI Sites within Shared Conveyance Systems[i]															
ANRFS (aka AFB)	1820	9.5	West	No information was found regarding site activities				3,6,7,9	H-b, C-b						
Ashland Chemical	1076	9.5	West	Former food processing facility, currently a chemical storage facility, stormwater discharges to COP storm sewer pipe				3,6,7,9	H-b, C-b						
Calbag-Nicolai	5059	10.3	West	No information was found regarding site activities				4,6,7,9	H-b, C-b						
Carson Oil	1405	9.7	West	Historic pipe leaks and spills, LUSTs, vehicle maintenance activities involving fuels, oil & grease, petroleum-based solvents, surface water discharges to COP storm sewer				1,3,4,6,7,9	H-b, C-b						
Container Management	4784	9.5	West	Container reconditioning facility, water from oil/water separator discharged to COP storm sewer				3,4,6,7,9	H-b, C-b						
Container Recovery	4015	9.3	West	Truck fabricating activities, furnace manufacturing, sheet metal fabrication, stormwater discharges to COP storm sewer				3,6,7,9	H-b, C-b						
Front Avenue MP	4008	9.9	West	Former truck, crane, and rigging operations center; historic releases to soil, catch basins and sump				1,3,4,6,7	H-b, C-c						
GE - NW 28th	No ECSI#	10	West	Former commerical PCB storage facility				6	H-b, C-b						
Greenway Recycling	4655	8.4	West	Former automobile wrecking yard, vehicle towing and storage, garbage hauling, current construction debris transfer station				1,4,6,7	H-b, C-d						
Galvanizers	1196	9.4	West	Zinc galvanizing operation since 1940s; some storage of process chemicals, and hazardous and non-hazardous wastes				3,4,7,9	H-b, C-b						
PGE - Forest Park	2406	8.3	West	Electrical equipment storage				6	H-c, C-d						
Paco Pumps	146	9.1	West	Pump manufacturing and refurbishing facility				4,6	H-c, C-c						
Magnus/Wilhelm	69	9.6	West	Former lead bearing rehabilitation plant				7	H-c, C-d						
SFI	5103	10	West	Former metal working and forge hammering operations				1,3,4,6,7	H-b, C-b						

Table 4.2-2. Upland Site Pathway Assessment Summary.[a]

Site Name	ECSI #	River Mile	River Bank	Potential Upland and Overwater Sources	Pathway Summary										
					Groundwater			Direct Discharge				Overland Transport		Riverbank Erosion	
								Stormwater		Overwater					
					COIs	Pathway Status	NAPL	COIs	Pathway Status	COIs	Pathway Status	COIs	Pathway Status	COIs	Pathway Status

Notes:

[a] The information contained in this table is based on information obtained by LWG from DEQ files as of July 2006 and correspondence with EPA reflecting conditions as of September 2008. Some modifications have been made at sites with information provided by LWG through March 2009. Information on sites upriver of RM 11 is limited to LWG review of ECSI.

[b] This site has an active NPDES permit with a direct discharge to the river. See Table 4.4-6 for additional information.

[c] Sites for which SWPCP plans are on file with LWG, obtained from DEQ files in 2005.

[d] COIs identified based on review of LUST files and confirmed release records on the ECSI database.

[e] VOC COIs include only BTEX for the Gasco site.

[f] Non-PAH SVOCs include only carbazole, dibenzofuran, 2,4-dimethylphenol, 1- and 2-methylnaphthalene, 2- and 4-methylphenol, and phenol for the Gasco site.

[g] EOSM's permitted discharge from their wastewater plant was not a complete pathway.

[h] VOCs characteristic of Gasco are likely to have been transported overland.

[i] Stormwater COIs at these ECSI sites were identified based on independent investigations, see Table 4.4-4.

[j] DEQ identified the COP outfalls as a group. Not all outfalls are known current or historical sources.

ECSI number: DEQ Environmental Cleanup Site Inventory number

COI: A chemical is listed as a pathway COI if it was detected in sampled media, identified as having been released to site media, or documented to have been released directly to the river from site operations.

1: VOCs
2: SVOCs
3: PAHs
4: TPHs
5: Pesticides/Herbicides (e.g., DDT, chlordanes, aldrin)
6: PCB Aroclors and congeners
7: Metals
8: Butyltins
9: Phthalates
10: Other (e.g., PCDD/Fs, cyanide)
11: None reported

Pathway: The potential for impacting in-water media rated as follows:

a: The pathway is known to be a contaminant migration pathway - the pathway discharges to the river and there are contaminants of interest (COIs) associated with the pathway.
b: Likely a complete pathway.
c: Insufficient data to make determination.
d: Not a complete pathway.
N/A: Pathway does not exist at site.

Historical/Current: Available information indicates if the predominant impact to in-water media is historical (H) or current (C).

NAPL: Available information indicates the presence of historic or current NAPL (Y/N).

N/A = Not applicable, pathway is not present at site (e.g., riverbank at an inland site).

NS = No sampling of upland COIs reported. For stormwater/wastewater, no sampling beyond permit requirements reported.

? = Unknown, typically due to lack of sampling information.

ASR - automobile shredder residue
AST - aboveground storage tank
BTEX - benzene, toluene, ethylbenzene, and xylenes
BWTP - ballast water treatment plant
CCA - chromium copper arsenate
COI - contaminant of interest
COP - City of Portland
CRSG - Columbia River Sand and Gravel
DEQ - Oregon Department of Environmental Quality
DSL - Oregon Division of State Lands
DTL - direct to locomotive
ECSI - Environmental Cleanup Site Inventory
EOSM - Evraz Oregon Steel Mills
EPA - U.S. Environmental Protection Agency
GW - groundwater
KI - Koppers International
LUST - leaking underground storage tank
LWG - Lower Willamette Group
MPR - manufacturing process residue
NAPL - non-aqueous phase liquid
NPDES - National Pollutant Discharge Elimination System
PAH - polycyclic aromatic hydrocarbon
PCE - tetrachloroethene
PCB - polychlorinated biphenyl
PEO - Premier Edible Oils
PGE - Portland General Electric
RM - river mile
SFPP - Santa Fe Pacific Pipeline
SWPCP - stormwater pollution control plan
SVOC - semivolatile organic compound
TCA - trichloroethylene
TFA - tank farm area
TPH - total petroleum hydrocarbon
UST - underground storage tank
VOC - volatile organic compound
WPCL - Water Pollution Control Laboratory
WWTP - wastewater treatment plant

Table 4.3-1. Overwater Releases from ECSI Sites within the Study Area.

Site Name and ECSI#	River Mile	River Bank	Major Industrial Operations	Documented In-River Date	Materials Released	Volume Spilled	Spill Surface	Comments
Evraz Oregon Steel Mills #141	2.2	E	Current: Manufacturing of carbon steel coils and plates. Pipe production capabilities are currently being added.	2/4/2000	Hydraulic fluid	1-2 gal	Storm drain, then to river	
				12/22/1997	Hydraulic fluid	Some of (~15 gal) 40-70 gal	Catch basin/river	
				4/29/1945	Oil	Unknown	River	Transfer pipe from vessels to sump was observed to be leaking badly (prior to EOSM ownership).
South Rivergate Industrial Park #2980	2.5	E	Current: JR Simplot - storage and distribution of urea and anhydrous ammonia; Union Chemical - manufacturer of adhesives and glues; Ash Grove Cement - manufacturer of calcium oxide; POP/Ft James - distribution of paper products; Douglas Walters/T&G Trucking.	4/10/2006	Unknown	Unknown	River	All reported from JR Simplot.
				1/12/2006	Hydraulic oil	1 quart	River	
				4/18/2004	Tar	Unknown	River	
				9/28/2002	Anhydrous ammonia	Unknown	River	
				5/29/2001	Granular urea	500 lbs	Dock, ship deck, river	
				1/15/2001	Conveyor residual lube oil into river	Unknown	River	
				5/5/1998	500- by 50-ft sheen	Unknown	River	
				11/16/1999	Sheen on river	Not available	River	
				4/13/1998	Urea	1,000-1,600 lbs	River	
Premier Edible Oils #2013	3.6	E	Current: None; Historical: Aboveground oil storage, manufacturing, packaging, and distribution of chemicals, metals, and metal products, edible oil processing and storage facility.	1988	Edible oil	20-50 gal	GAL	No spills indicated in DEQ ERIS database, spill reported in CSM.
Noncontiguous Burgard Industrial Park Properties #none	3.7	E	Current: Boydstun Metal Works - automotive trailer manufacturing and automotive parts storage; Morgan CFS - container unloaded (lumber and building materials); Northwest Pipe - no manufacturing, storage; Schnitzer Steel Remnant - storage; Historical: WWII shipyard.	9/2/2003	Diesel	10 gal	Barge deck and river	
				11/18/2003	Hydraulic fluid	<1 gal	International Slip Waterway	
				3/29/2001	Oily water	Unknown	International Slip Waterway	
				5/1/1981	Transformer fluids containing PCBs	Unknown	Upper and lower decks and bilge of ship	
Schnitzer-Calbag #2355	4	E	Current: Metals recycling, truck maintenance and repair, warehousing; Historical: Ship construction/shipyard activities (1945-1972, Oregon Shipbuilding), metals recycling, truck maintenance and repair, warehousing; upland log storage and log rafting.	11/11/2007	Oil	1 gal	International Slip Waterway	Discharged from crushed automobile mistakenly dropped in Slip.
				11/18/2003	Hydraulic oil	<1 gal	River	
				9/2/2003	Diesel	10 gal	River	
				12/28/2002	Hydraulic oil	10-15 gal	River	Spill traced to Schnitzer facility, cause not indicated.
				3/29/2001	Oily water	Unknown	International Slip Waterway	
				5/9/2000	Fuel oil	2 gal	River	Spill due to open valve on facility crane barge.
				10/14/1998	Hydraulic oil	Unknown	River	Hydraulic hose broke on dock.
				7/9/1997	Oil/water mixture	Unknown	River	Released via storm drain during fire fighting activities to extinguish automobile bodies which caught fire.
				5/1/1981	Transformer fluids containing PCBs	Unknown	Upper and lower decks and bilge of ship	
Kinder Morgan Liquids Terminal - Linnton #1096	4.4	W	Bulk petroleum facility since installation of fuel ASTs in 1918	6/14/1999	Potash	5-7 tons	River	
				10/3/1998	Fuel?	200 gal	River	Dock line broke.
Port of Portland Terminal 4, Slip 3 # 272	4.6	E	Current: Loading soda ash at docks; Historical: Loading soda ash, unloading pencil pitch, storage and unloading of bulk oil, import and export of ore and concentrate, unloading diesel, No. 6 fuel, and Bunker C oil and transferring via pipeline.	6/18/1997	Pitch	Small amount	River	
				1971	Oil seep	Unknown	River	
				9/25/1993	Hydraulic oil	0.5 gal	River	Hydraulic hose failure originating at Cargill facility. Cargill and Riedel Environmental conducted cleanup.

Table 4.3-1. Overwater Releases from ECSI Sites within the Study Area.

Site Name and ECSI#	River Mile	River Bank	Major Industrial Operations	Documented In-River				Comments
				Date	Materials Released	Volume Spilled	Spill Surface	
Linnton Plywood Association #2373	4.7	W	Linnton Plywood - sawmill and lumber company, plywood manufacturing, and warehousing in plywood building. CRSG - sand barging and distribution.	2/17/1995	Pale oil	20-55 gal	Storm drain, sheen on river	
ARCO #1528	4.9	W	Current: Petroleum storage and distribution; Historical: Petroleum storage and distribution, foamite plant, toy manufacturing lumber company.	1/16/2006	Unknown	Unknown	River	Orphan sheen discovered around docks of BP ARCO, 900-ft containment boom deployed to contain sheen.
				10/31/2005	Diesel	15,000 spilled (at least 1,000 gal to river)	Ground/river	
				1995, 2003, 2004	Reported sheen on water inside boomed area (multiple separate incidences)			
				5/14/2000	Crude oil	Sheen	Released from ship, created sheen on river	
				6/9/2000	Hydraulic oil	1 barrel	Release from ship to river	
				8/13/1997	#2 Diesel	25,000 gal, unknown total amount to river	Ground/river	
				5/4/1995	Automotive gasoline	Unknown (up to 20 gal)	Released from leaking gasket onto soil then flowed to river	
				8/9/1995	Gasoline	2 gal	Discharge to river (equipment failure on dock)	
				4/23/1986	Crude oil	1 cup from ballast pipeline	From ballast pipeline to river	
POP - Terminal 4 (Auto Storage Facility) #172 #2642	5	E	Current: Unloading, storing and processing of new automobiles; Historical: Unloading, storing and processing of new automobiles, unloading of steel and export of lumber products on the northern third of the facility.	3/18/1985	Unknown oil	Unknown	Unknown	
Exxon Mobil #137	5.1	W	Petroleum storage and distribution.	1/20/2004	Oil residue	4 gal	River via outfall	25 ft out into the river spanning 50 ft on either side of the outfall. Cleanup conducted.
				5/4/2004	Oil	Not reported	River	
				8/11/2003	Jet fuel	50-100 gal	River	
				3/20/1999	Gasoline	2 gal	River	Occurred from loading arm at Mobil dock.
ST Services/Shore Terminals #1989	5.3	W	Bulk petroleum storage and marine terminal.	8/11/2003	JP8 fuel	50-100 gal	River	

Table 4.3-1. Overwater Releases from ECSI Sites within the Study Area.

Site Name and ECSI#	River Mile	River Bank	Major Industrial Operations	Documented In-River				
				Date	Materials Released	Volume Spilled	Spill Surface	Comments
Foss Maritime/Brix Marine #2364	5.5	W	Current: Marine vessel transportation services and maintenance; Historical: Above and tugboat service and fueling.	9/9/2004	Lube oil	Unknown	River	
				1995 - 2004	Fuel	<25 gal at a time	River	Small amounts of fuel (<25 gallons at a time) released into Willamette from maintenance activities, periodically from 1995 - 2004.
				4/21/2003	Hydraulic oil	Unknown	River	Pump failure at Foss facility.
				7/8/2002	No.2 Diesel fuel	5 gal	River	During refueling, glass valve not open all the way.
				7/8/2002	Fuel	5 gal	River	
				5/29/2000	Gear oil	2-3 cups	River	Discharged from tug JOSEPH T's bilge pump.
				12/15/1999	Fuel oil	17 gal	River	During refueling.
				11/11/1999	Diesel fuel	15-20 gal	River	During refueling.
				11/2/1999	Diesel fuel	1 gal	River	During refueling - result of improperly aligned valve.
				1/23/1999	Diesel fuel	1 gal	River	Discharged from tug SARA BRIX.
				12/23/1998	Bilge slop	5 gal	River	
				9/18/1998	Residual oil	Unknown	River	Released from Foss Barge 208 - washed overboard as result of heavy rains and clogged scuppers.
				5/31/1998	Oil	35 gal	River	Released from tug HOWARD OLSEN.
				3/21/1998	Oil	5 gal	River	Released from tug FAIR WIND.
				1/12/1998	Oil	25 gal	River	Vessel bilge.
				1/12/1998	Diesel oil	5 gal	River	Separator line broke on a marine vessel.
				9/2/1996	Diesel oil sheen	Unknown	River	Observed sheen around tug JIM MOORE.
				4/23/1996	Cable lube grease	Unknown	Storm drain	Released from dumpster. Two 5-gal drums thrown into dumpster, rain washed material from dumpster into nearby storm drain then to river.
				3/27/1996	Fuel oil	1 gal	River	Released from ship due to overfilling.
				1/24/1996	Oily waste	2.5 gal	River	Released from two separate incidents.
				7/15/1995	Oil	7 gal	River	
				6/19/1995	Oil	7 gal	River	
				8/8/1994	Oil	3 gal	River	Released at Pacific Northern Terminal.
				2/19/1994	Oil	Unknown	River	Released at Union Dock.
				12/30/1993	Oil	Unknown	River	Sheen observed around tug.
				9/23/1993	Waste oil	1 gal	River	Tugboat leak while offloading.
				2/19/1993	Diesel	1 gal	River	
				2/18/1993	Black oil	1.5 gal	River	
				10/30/1992	Oil	Unknown	Not given	Willamette River - Columbia River. Sheen 75 ft x 10 ft.
				7/10/1992	Diesel	1 gal	Not given	
				5/10/1992	Oil	50 gal	River	Released from hole in vessel.
				9/12/1991	Waste lubricating oil	3 gal	River	Released from tug to river.

Table 4.3-1. Overwater Releases from ECSI Sites within the Study Area.

Site Name and ECSI#	River Mile	River Bank	Major Industrial Operations	Documented In-River Date	Materials Released	Volume Spilled	Spill Surface	Comments
Mar Com #2350	5.6	E	Current: None; Historical: shipbuilding and repair, sandblasting and painting, moorage.	2/23/2006	Unknown oil - air compressor	1 gal	River	
				2/23/2006	Discharge from pipe onto ground and subsequently to river	Unknown	River	
				7/11/2000	Diesel fuel	10-15 gal	River	Hose rupture.
				6/6/2000	Lanolite	Unknown, 50 x 100 ft sheen	River	
				10/15/1997	Oily/water materials	50 gal	River	Release from vessel.
				4/2/1997	Sandblasting paint/dust	Unknown	River	
				4/1/1997	Oil-contaminated bilge water	20 gal	River	
				~1970s	Barge in shipway tipped over releasing fuel oil	Unknown	In shipway	The barge/fuel oil release was addressed at the time by excavating the saturated soils/material and placing it on the top of the bank adjacent to the spillway.
Marine Finance (Hendren Tow Boats) #2352	5.8	W	Current: Tugboat business, houseboat/sailboat construction; Historical: Above and metal salvage, moorage.	2003	Oily bilge water	1 gal	River	
U.S. Moorings #1641	6	W	Government port, supply, repair facilities for dredge and other support vessels, warehousing facilities, fuel storage, motor pool garage and parking.	1/15/2004	Hydraulic oil	10 gal	River	50-ft by 300-ft sheen. Also trace amounts of hydraulic oil in 2004 and 2003.
				11/24/1996	Oil slick of black fuel oil	Unknown	River	
				3/9/1996	Unknown oil	Unknown	River	
				12/29/1990	Sinking of anchor barge Raggy at its moorings - diesel / motor oil	350 gal (diesel)/ unknown (motor oil)	River	
USACE #1641	6.2	W	Maintenance port for USACE vessels.	9/26/2007	Unknown	Unknown	River	USACE advising of a large sheen which appears to be coming from a tugboat near their facility on the Willamette.
				3/10/2006	Gear Oil	Unknown	River	A bow thruster on a dredge ship was being tested when some oil was noticed leaking out of the tunnel.
				12/19/2000	Hydraulic oil	2 gal	River	Released from ESSAYON.
				9/30/1999	Lube oil	Unknown	River	150 sq ft sheen caused by spill from bow thruster on ESSAYON.
				2/19/1997	Hydraulic oil	20 gal	River	Released from bow thruster value on vessel YAQUIMA.
				9/23/1990	Hydraulic oil	10 gal	River	Released from ESSAYON.
				12/28/1989	Motor oil	1 gal	River	Released from ESSAYON while refueling.
Gasco #84	6.2	W	Current: Liquefied natural gas storage and distribution, solid and liquid coal tar pitch storage and distribution; northern portion - bulk fuel storage and distribution; Historic: Oil manufactured gas plant, coal tar formulation, storage and distribution.	10/22/2003	Coal tar pitch	2 gal	River	KI operations.
				3/2000	Oily water	<25 gal at a time	River	NW Natural operations.
				1998	Fuel oil (PNO)	Few gallons	River	NW Natural operations
Willamette Cove #2066	6.7	E	Current: Vacant; Historical: Plywood manufacturing plant (west parcel), ship repair and maintenanced (central parcel) - US Government facilitated during Great Depression and wars (WWI, WWII, and the Korean War), cooperage plant-manufactured wood vats.	None				8/16/01: 30-ft cabin cruiser partly submerged in Willamette River. Sheen noted when discovered.

Table 4.3-1. Overwater Releases from ECSI Sites within the Study Area.

Site Name and ECSI#	River Mile	River Bank	Major Industrial Operations	Documented In-River Date	Materials Released	Volume Spilled	Spill Surface	Comments
Arkema	7.3	W	Current: None; Historical: Inorganic chemical manufacturing company from 1941 to 2001. Produced sodium chlorate and potassium chlorate, chlorine, sodium hydroxide, hydrogen gas, hydrochloric acid and DDT.	3/9/1995	Fuel oil	1 gal	Overwater dock	
Willbridge Terminals (Kinder Morgan, Shell, Conoco Phillips) #1549	7.5	W	Bulk petroleum storage since early 1900s.	4/18/2007	Diesel	Unknown	River	Fuel line broke causing discharge to river. Release originated on Kinder Morgan portion of the facility.
				2/9/2007	Unknown	Unknown	River	50' x 100' sheen reported near Kinder Mogran, Chevron Conoco. Release originated on Kinder Morgan portion of the facility.
				9/20/2006	Unknown	Unknown	River	Hose ruptured while loading a barge resulting in discharge to river. Release originated on Kinder Morgan portion of the facility.
				7/23/2006	Hydraulic Oil	Unknown	River	A ship loader fell onto the ship, hydraulic fluid was noticed dripping onto the dock, sheen was also noticed in the river. Release originated on Kinder Morgan portion of the facility.
				7/6/2006	Hydraulic Oil	Unknown	River	Hydraulic line broke on a ship loader which resulted in the release of material into the river. Release originated on Kinder Morgan portion of the facility.
				11/1/1989	Oil	10 gal	River	
				9/9/1984	Heavy hydrocarbon	NA	River	Seepage from docking facility.
				9/4/1984	Heavy hydrocarbon	NA	River	Seepage from docking facility.
				8/1/1984	Black oil	NA	River	Seepage from docking facility.
				12/1/1982	Petroleum product	90 gal	Saltzman Creek	
				3/1/1982	Oily water	NA	Saltzman Creek	Leak from weephole in flume wall.
				12/1/1981	Diesel	NA	Saltzman Creek	Leak from drum on pick up.
				4/1/1981	Undocumented solvent	NA	Saltzman Creek	
				4/1/1980	Lube oil	2 gal	River	
				10/1/1979	Aviation gasoline	70 gal	River	
				3/7/1979	Bunker oil	2 - 5 gal	Overwater dock	100% recovered.
				6/1/1978	Gasoline	NA	River	
				6/1/1976	Gasoline	NA	River	
				12/1/1975	Asphalt	100 gal	Saltzman Creek	Tank overflow
				1/1/1971	Gasoline	Several hundred gallons	River	Cleaned up
				8/19/1956	Oil	Unknown	River	Portland Harbor Patrol observed oil in the River possibly coming from "old pipes" under the Shell Oil dock.
				8/18/1956	Oil	Unknown	River	Portland Harbor Patrol observed oil in the River possibly coming from "old pipes" under the Shell Oil dock.
				3/10/1956	Gasoline	1,000 gal	Dock	Occurred at Shell Oil dock while loading a barge.
				1/21/1956	Bunker oil	20 gal	Dock to river	Occurred at Shell Oil dock.
Freightliner	7-8	E	Truck parts and manufacturer.	11/29/2006	Pure gear oil	450-500 gal	River	Discharge from City Outfall M-1. Rupture of oil line (synthetic 50 weight lube oil) at facility.
				11/29/2006	Oil water mixture	1,000 gal	River	Discharge from City Outfall M-1. Rupture of oil line (synthetic 50 weight lube oil) at facility.
				4/9/2002	Diesel sheen	Unknown	Sheen at storm water outlet	Fuel line rupture on truck.
				7/25/1995	Untreated wastewater	3,000 gal	Storm drain to river	Released to river due to an open valve.

Table 4.3-1. Overwater Releases from ECSI Sites within the Study Area.

Site Name and ECSI#	River Mile	River Bank	Major Industrial Operations	Documented In-River				Comments
				Date	Materials Released	Volume Spilled	Spill Surface	
Shaver Transportation #2377	8.4	W	Current: General towing and lightering; Historical: Mobile telephone service and marine transportation.	3/3/2005	Diesel	10-30 gal	river	Spill contained and cleaned up.
				9/29/2001	Diesel oil	1 gal	River	Tug SANDY sank at Shaver dock.
				8/19/1998	Oil	Unknown	River	Released when tug picked up section of bunker hose with it's propeller that contained oil.
				7/21/1996	Diesel oil	Unknown	River	Released when floating shop facility partially sunk.
Willbridge Terminals (WMCSR-NWR-94-06) #2355	7.7	W	Current: Distribution of refined petroleum products (gasoline, diesel fuel, lubricating oil), fuel storage.	1989	Asphalt	6,300 gal	River	Multiple instances of sheen was observed on water (1998-2004), no spills >1 gallon.
McCall Oil #134	7.9	W	Asphalt manufacturing and chemical manufacturing, storage and distribution.	8/7/2006	Diesel	Unknown	River	Material release from a tank barge due to operator error
				10/13/1998	Oil	2 gal	River	Oil/water separator outflow was clogged and oil released to river
				12/10/1996	Unknown	<1 gal	Parking lot - storm drain	Material washed onto parking lot.
				6/1/1994	Oil	1 quart	River	
				1991 and mid-1970s	Asphalt	Unknown	River	
				Mid-1970s	Oil and water	Unknown	River	
US Coast Guard - Marine Safety Station #1338	8	E	Current: USCG marine safety and marine inspection offices; Historical: Roofing shingle manufacturer, lumber company.	6/9/2007	Gasoline	Unknown	River	Overflow during vessel fueling.
				9/11/2007	Motor oil	1 quart	River	Discharge during engine vessel maintenance.
				12/7/2004	Petroleum	Sheen	River	
				8/18/2002	Diesel - bilge from tug	Unknown	River	400-by 100-ft sheen.
				9/9/1999	ZEP paint and varnish remover	1 gal	River	Hose rupture.
				11/28/1998	Diesel	~30 gal	River	
				10/8/1996	Fuel	Unknown	River	
				1991	Hydraulic oil	1 gal	River	Released from POLAR SEA.
Fred Devine Diving and Salvage #2365	8.2	E	Current: Moorage; Historical: Moorage and waterfront structures (1940s), cleaner and solvent storage.	2000	Paint	5 gal	River	1 pint of hydraulic oil spilled into Willamette - date unknown. Crews cleaned up spill.

Table 4.3-1. Overwater Releases from ECSI Sites within the Study Area.

Site Name and ECSI#	River Mile	River Bank	Major Industrial Operations	Documented In-River Date	Materials Released	Volume Spilled	Spill Surface	Comments
Cascade General #271	8.4	E	Current: Cascade General - Ship repair yard and other industrial operations, POP - parking lot/undeveloped property; Historical: Military shipyard and military ship dismantling (1942-1949), POP - leased out to ship repair/industrial operators (1950-1996), Cascade General - ship repair/industrial operations (1996-present).	6/30/2008	Residual oil	~ 2 tbsp.	River	Chevron reported ~2 tablespoons of residual oil washed off deck of tanker at 5555 N Channel Ave.
				6/28/2007	Lubricating oil	Unknown	River	Leak from vessel.
				4/13/2007	Lubricating oil	100 gal	River	Discharge during transfer due to equiptment failure.
				12/4/2006	Other oil	Unknown	River	Release into river from leaky pipe.
				9/23/2006	Oil, misc: lubricating	Unknown	River	Check valve failure.
				9/23/2006	Lube oil	~ 5 gal	River	Check valve failed at Dry Dock One, spilled 5 Gal lube oil to Willamette River.
				9/13/2006	Diesel	5 gal	River	Diesel discharged from a work vessel.
				4/18/2006	Sandblasting dust	Unknown	River	
				5/13/2004	Hydraulic oil	<5 gal	River	Small amount of hydraulic oil spilled on dock, when dock is submerged, a sheen is seen in the water.
				11/25/2003	Lube oil	15 gal	River	Released during transfer of the USNS JOHN OLMSTEAD.
				5/29/2003	Lube oil	55 gal	River	Released from vessel, UNIVERSE EXPLORER, due to broken lube line.
				4/11/2002	Oil	2 L	River	Release of 2 liters of oil into the Willamette.
				12/6/2000	Oil	0.5 gal	River	Residual oil spilled from equipment while loading onto barge.
				6/9/2000	Hydraulic oil	1 barrel	River	Materials released while testing emergency fire pump. No known reason for release.
				5/22/2000	Diesel	3 gal	River	3 gal fuel can of diesel fell in river.
				3/21/2000	Diesel	~ 5 gal	River	5 gal diesel into river, after check ball valve failed.
				2/23/2000	Generator fuel	~1 gal	River	10 gal spilled during generator testing, ~1 gal reached river.
				1/29/1999	Hydraulic oil	5 gal	River	
				10/20/1998	Generator fuel	5 gal	River	
				12/23/1997	Diesel	25-50 gal	River	
				11/13/1997	Crude oil	100 gal	River	
				9/27/1997	Diesel	22 gal	River	
				8/28/1997	Unknown oil	25-40 gal	River	~25 gal of black waste oil released from an outfall into Swan Island Lagoon.
				4/9/1996	Unknown oil	~25 gal	River	Oil released into the river when a stern line broke on the USS HIGGINS.
				7/20/1993	Hydraulic oil	~50 gal	River	
				1/8/1992	2-D Fuel oil	3 barrels	River	Oil released from F/V PACIFIC EXPLORER into river during fuel bunkering operations.
				9/16/1991	Waste oil/lubricants	~35 gal	River	
				4/17/1991	Lube oil	150-200 gal	River	Discharged oil into storm drain that discharged into River from Exxon's vessel EXXON BENICIA.
				6/11/1987	Diesel	~25 gal	River	
				4/11/1982	Ballast water	900 bbls	River	
Gunderson LLC #1155	8.8	W	Current: Manufacturing rail cars and marine barges; Historical: Rail car and marine vessel manufacturing, ship dismantling and auto salvage.	2/26/2001	gtea-415 & toluene	1.5 gal	River	

Table 4.3-1. Overwater Releases from ECSI Sites within the Study Area.

Site Name and ECSI#	River Mile	River Bank	Major Industrial Operations	Documented In-River Date	Materials Released	Volume Spilled	Spill Surface	Comments
Equilon Property (Pipeline Containment) #2117	8.8	W	Current: Storage/distribution of gasoline, diesel and ethanol; Historical: Beginning in 1928 -Storage/distribution of petroleum, bunker fuel, jet fuel, and lubrication oil.	1994, 1992, 1989, 1988	Diesel	~250 gal	River	Action was taken.
Goldendale Aluminum #2440	10	E	Current: Storage of lubricating and hydraulic oils; Historical: Alumina and electrode binder pitch unloading facility, grain shipment facility.	1991	Bunker C fuel	8,000 gal	River	
POP - Terminal 2 #2769	10	W	Current: Marine terminal; Historical: Marine terminal, shipyard-ship construction during WWII (unknown to 1949), exporter of agricultural and manufactured wood products.	10/25/2000	Hydraulic oil	1 gal	River	
				10/9/1998	Hydraulic Oil	2 gal	River	1-inch pipe on deck of vessel ("packing"/pipe) cracked during hatch coveroperation releasing ~1 liter to the water.
				1/15/1995	Paint spilled from vessel into river	Unknown	River	M/V PAC PRINCE spilled pallet load of paint (silver paint, green paint and thinner)into river. NRC Incident #276445.
				1/15/1995	Pallet load of paint spilled from ships crane	Unknown	River	M/V PAC PRINCE spilled pallet load of paint (grey, green, and orange colored paint, and thinner). Incident occurred at Terminal 2, Berth 4. NRC Incident #276446.
				6/17/1978	Oil and bilge water	Unknown	River	
Glacier Northwest	11-12	E	Cement manufacturer.	8/26/2004	Oil	1 gal	River	Hydraulic line failure on dock.

Notes:

Spills information obtained from National Response Center Online Database (www.nrc.uscg.mil) and Supplemental Preliminary Assessment, Swan Island Upland Facility (Ash Creek and Newfields 2006).

AST - aboveground storage tank
CRSG - Columbia River Sand and Gravel
CSM - conceptual site model
DEQ - Oregon Department of Environmental Quality
ECSI - Environmental Cleanup Site Inventory
EOSM - Evraz Oregon Steel Mills
ERIS - Emergency Response Information System
KI - Koppers International
NA - not available
NRC - National Response Center
POP - Port of Portland
UACE - U.S. Army Corps of Engineers
USCG - U.S. Coast Guard

Table 4.3-2. Pretreatment Permittees where Industrial Wastewater Could Overflow to River through Control Structures— Status as of February 2009.

Permittee	Address	Outfall[a]	Permit Period	Basis of Permit Limits	COIs[b]
Aramark Uniform Services	1848 NW 23rd Ave.	15	1994-current	Local	pH, oil & grease, metals, volatile organics
Blackline Inc.	2424 NW St Helens Rd.	17	1994-current	Categorical	pH, oil & grease, metals, cyanide, TTOs
Bridgeport Brewing Co.[c]	1313 NW Marshall St.	11	1990-current	Local	pH
Burlington Northern RR	1105 NW 9th Ave.	11	1993-1997	Remediation Site	pH, oil & grease, metals
Hospital Linen Svc.	1804 NW Northrup St.	11	1993-1998	Local	pH, oil & grease, BOD, metals
Portland Brewing Co.	2730 NW 31st Ave.	17	1990-2004	Local	pH
Pyramid Brewing Inc.	2730 NW 31st Ave.	17	2005-current	Local	pH
Portland Hospital Svc.	1804 NW Northrup St.	11	1999-2000	Local	pH, oil & grease
Rejuvenation Inc.	2550 NW Nicolai St.	15	2000-current	Categorical	pH, oil & grease, metals, cyanide
Terra Vac	330 NW 23rd Ave.	15	1996-1998	Remediation Site	pH, oil & grease, BTEX, lead
Wade Manuf. Co. Foundry	2420 NW 31st Ave.	NA	1992-2002	Non-Discharger[d]	Process wastewater discharges are prohibited except for air compressor condensate
Drew Paints	1525 NW 23rd Ave.	NA	1998-current	Non-Discharger[e]	NA - industrial wastewater discharges are prohibited
Galvanizers	2406 NW 30th Ave.	NA	<1988-current	Non-Discharger[d]	NA - industrial wastewater discharges are prohibited
King Cycle Group	2801 NW Nela St.	NA	2006-current	Non-Discharger[d]	NA - industrial wastewater discharges are prohibited
Oregon Retinners	2712 N Mississipi Ave.	NA	1993-2007	Non-Discharger[d]	NA - industrial wastewater discharges are prohibited
Portland Bolt and Mfg.	3441 NW Guam St.	NA	1996-current	Non-Discharger[d]	NA - industrial wastewater discharges are prohibited

Source: City of Portland Annual Pretreatment Reports from 1995 - 2007. Additional pretreatment records consulted to identify permit period and COIs.

Notes:

[a] Outfall where potential diversion could discharge to river.

[b] COIs identified as those chemicals for which pretreatment permit limits were established.

[c] Location of connection to City system uncertain, may not discharge to pipe with a downstream diversion structure.

[d] Permitted based on procedures contained in the COP's approved pretreatment program. NOTE: these facilities elect not to discharge.

[e] Federal mandate to permit this facility based on its regulated process and zero-discharge limitation (i.e., mandated not to discharge wastewater from its process).

BOD - biological oxygen demand
BTEX - benzene, toluene, ethylbenzene, and total xylene
COI - contaminant of interest
COP - City of Portland
NA - not applicable
TTO - total toxic organics

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This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part.

Table 4.3-3. Overwater Releases from Vessels and Other Spills in the Study Area.

Party	River Mile	Type of Operation (s)	Date of Release	Summary of Release	Pathway to River	Reference
Alaska Sea Cloud	2-3	Barge	11/13/2001, 4/10/2006 and 4/12/2006; 9/21/2006	On November 13, 2001, a report to the NRC stated that an unknown amount of residual oil was released from a barge and a sheen was noted on the river. A similar report occurred on April 10, 2006 discussing a release from a barge with a sheen on the river. No volume estimate of substance was noted in the NRC report. Another release occurred from the same barge on April 12, 2006 when approximately three ounces of oil was released from the deck of a barge into the river. On September 21, 2006, the SEA CLOUD was moored at an undisclosed location in Portland Harbor at which time it was reported to the NRC that an overboard discharge line released approximately two tablespoons of oily bilge water into the river due to a defective check value.	Direct discharge to the river	NRC Incident Reports[a]
Blue Water Shipping Company	2-3	Transportation	6/1/2001	On June 1, 2001 M/V MED INTEGRITY discharged an unknown amount of oil to the Willamette River while located at JR Simplot.	Direct discharge to the river	NRC Incident Report #568009, NRC Incident database
Steinfields Products	2-3	Food processing plant, including a pickling plant	12/4/1997	A report to the NRC stated that approximately 400 gallons of diesel oil was released from a boiler backup storage tank overflow. Approximately 100 gallons of oil reached a nearby storm drain and was discharged into the Willamette River.	Discharge of material to river via storm drain	NRC Incident database
Sunshine Maritime, Ltd	2-3	Transportation	1/12/2006	A discharge of approximately 1 quart of hydraulic oil from vessel M/V SEA LADY occurred due to unknown causes.	Direct discharge to river	NRC Incident Report #784964
James River/Western Transportation	2-3, 4-5	Marine transportation including oil bunkering	8/10/1994, 10/24/1994, 10/3/1995	An Aug. 1994 report to the NRC stated that approximately of 10 gallons of diesel oil was released from M/V WESTERN STAR into the Willamette River during fueling. Oct. 1994 and Nov. 1994 reports to the NRC stated that approximately 1 pint of lubricating oil and 2 gallons of hydraulic oil were released into the Willamette River, respectively. In 1995, a lube oil spill to river occurred, but the location was not identified. No additional information available.	Direct discharge to river	NRC Incident database, Notice of Federal Interest for an Oil Pollution Incident
Fritz Maritime Agencies	2-3, 4-5	Marine transportation company	3/18/1994, 1/22/1998	In 1994, an unknown amount of petroleum product at Terminal 4 directly to the Willamette River. In January 1998, approximately one pint of hydraulic oil was reportedly released into the river.	Direct discharge to river	NRC Incident Reports
West Coast Marine Cleaning	2-3, 7-8	Cleanup contractor	12/23/1999, 5/2000 and 11/2000	In December 1999 a 3-gallon spill of waste oil from a vacuum hose occurred during tank cleaning of a barge when a hose connection came loose. In May 2000, a spill from diesel can of no more than 2 gallons occurred. In November 2000, a discharge of approximately 1/2 gallon of waste oil occurred due to a transfer hose rupture.	Direct discharge to river	USCG Pollution Reports; NRC Incident Report #547979
M/V BIG BLUE	3-4	Cargo vessel	3/29/2001	In March 2001 at the International Terminals Slip, the ship discharged approximately 15 gallons of hydraulic and bunker oil during deballasting.	Direct discharge to river	NRC Incident Reports #561131 & 56143
M/V C. MEHMET	3-4	Merchant vessel	3/5/2001	A discharge of less than 1 gallon of IFO 380 oil occurred from this vessel due to a holed flange.	Direct discharge to river	USCG Pollution Report
M/V SP5 ERIC GIBSON	3-4	Product transfer	11/18/2003	A report to the NRC stated that approximately 1 gallon of hydraulic oil was released into the Willamette River from a container/roll-on or roll-off vessel due to a broken hydraulic fitting on a cargo crane.	Direct discharge to river	NRC Incident Reports
Mark Marine Service, Inc.	3-4	Marine towing company	1/8/1999 and 9/2000	A January 1999 report to the NRC stated that an approximately 1 bucket of lube oil was released from a tugboat into the Willamette River. In 2000, OSFM incident report stated that two tugs sank in Multnomah Channel near Alder Creek Lumber Company. An oil slick and debris were observed in the vicinity of Fred's Marina and Lucky Landing.	Direct discharge to river	NRC Incident Reports; Oregon State Fire Marshal database
Pan Ocean Shipping Co., Ltd.	3-4	Transportation	11/14/2006	M/V OCEAN JADE discharged 45 liters of hydraulic oil to the deck of the vessel, with at least 1 liter reaching the river. Discharge the result of a broken pipe.	Direct discharge to river	NRC Incident Reports
M/V AOMORI WILLOW	4-5	Unknown at this time	5/30/2001	A report to the NRC stated that an approximately 1 gallon of diesel oil was released onto the deck of a vessel then into the Willamette River due to tank overflow during an internal fuel transfer.	Direct discharge to river	NRC Incident Report #567788
M/V CENTURY LEADER	4-5	Freight vessel	4/6/2000	Vessel discharged approximately 1 liter of hydraulic oil to river due to the bursting of a hydraulic seal.	Direct discharge to river	USCG Pollution Report
SS BATTLE CREEK VICTORY	4-5	Marine vessel	2/5/1957	In February 1957, an oil spill was observed by the Portland Police Bureau as water and oil were pumped from the SS BATTLE CREEK VICTORY. The vessel was docked at Terminal 4, Pier No. 2. The vessel's agent, Pope & Talbot, informed the police that the spill would be cleaned up.	Direct discharge to river	NARA historical USCG records
Trident Shipping Limited	4-5	Tank leak	4/8/2001	A leak of approximately 50 gallons of IFO 180 occurred on the M/V ASTYPALEA. Leak was a result of cracks in the forward starboard fuel tank of the vessel.	Direct discharge to river	NRC Incident Report and Transmittal, Fed. Proj S01035
Tidewater-Shaver Barge Lines	4-5	Marine transportation company	8/8/1947	In 1947, a release of oil into the Willamette River was observed coming from an unidentified barge operated by Tidewater-Shaver Barge Lines.	Direct discharge to river	Portland Fire Marshal records

Table 4.3-3. Overwater Releases from Vessels and Other Spills in the Study Area.

Party	River Mile	Type of Operation (s)	Date of Release	Summary of Release	Pathway to River	Reference
Tidewater Barge Lines	4-5, 5-6, 7-8, 8-9, 9-10	Marine transportation company	2/1991, 4/1991, 6/22/1993, 7/16/1993, 6/22/1994, 8/1994, 6/30/1995, 2/10/1999, 3/26/2001, 9/28/2001 and 1/28/2004	Two 1991 NRC database reports involved Tidewater Barge vessels. The first incident involved, M/V LEIRA which released approximately 1 gallon of lubricating oil directly into the Willamette River at an unidentified location. Tank Barge TW 704 released approximately 15 gallons of gasoline into the Willamette River at River Mile 10. In 1993, approximately 10 gallons of gasoline and 2 gallon of fuel oil were released into the river during two separate incidents. A 1994 report stated that approximately 1 gallon of gasoline was released into the Willamette River. A 1995 report to the NRC stated that approximately 5 gallons of oil was released into the Willamette River due to operator error while refueling. A Feb. 1999 report to the NRC stated that approximately 3 gallons of diesel oil was released into the Willamette River from the vessel, DEFIANCE. In March 2001, less than 1 cup of diesel fuel oil was released into the Willamette River during the fueling of a tug due to a leaky hatch on the vessel. In September 2001, a 1-gallon leak of No. 2 diesel from the right collision bulkhead of Barge No. 1 was discovered at the Tosco dock. In January 2004, a report to the NRC stated that an unknown amount of jet fuel (JP-8) was released into the Willamette River from a barge due to an unknown cause.	Direct discharge to river	NRC Incident Reports # 560738, 581299
Transversal Shipping Company	4-5, 5-6	Shipping company	3/10/1997, April 2001	A March 1997 report to the NRC stated that an unknown amount of oil from M/V SEMENA washed off the deck during a rain storm into the Willamette River. An April 2001 OSFM incident report stated that a Bunker C fuel oil slick had drifted towards the mouth of Terminal 4, Berth 408. The spill was traced to Transversal Shipping across the river. Another incident occurred in April 2001, when a vessel docked at Transversal caught fire. The City's Fire Boat responded and pumped water for five hours. Transversal was identified as an agent for the vessel.	Direct discharge of hazardous substance.	NRC Incident database; Oregon State Fire Marshal database
Advanced American Diving	5-6	Diving and salvage operations	7/29/1998	A report to the NRC stated that a barge disturbed "some kind of contamination" in the bottom of the Willamette River.	In-water disturbance	NRC Incident Report #448107
Gelco Construction	5-6	Road construction	7/13/2005	Discharge occurred during re-lining of a storm drain. Approximately 1 quart of asphalt liner was released through the line and into the river.	Discharge to river via storm sewer	NRC Incident Report #765482
M Cutter	5-6	Towing and mooring	2/5/1996	A report to the NRC stated that an unknown amount of diesel oil was released from the D/B PAUL BUNYUN into the Willamette River due to a previously frozen fuel line.	Direct discharge to river	NRC Incident Reports
M/V ZANIS GRIVA	5-6	Transportation	10/17/2001	A report to the NRC stated that approximately 2 barrels of hydraulic oil were released from the vessel into the Willamette River due to equipment failure.	Direct discharge to river	NRC Incident Report #583407
Keystone Shipping Co.	5-6, 7-8, 8-9	Marine transportation company	8/13/1991, 6/6/1992, 10/17/1995, 3/3/1997, 3/16/1998	A 1991 report stated that approximately 2 gallons of waste oil/lubricating was released into the river when a contractor error opened a bilge valve on the T/S DELAWARE TRADER. In June 1992, the State Fire Marshal reported a ship fire on Keystone's "bulk oil ship," the ATIGUN PASS. The fire was caused when welding torches igniting "paraffin/oil" on the bulkheads. It is not clear from the report whether fire fighting activities flushed contaminated water into the river. A 1995 report to the NRC stated that approximately 1 gallon of oil was released from the tanker KEYSTONE CANYON into the Willamette River due to equipment failure. A 1997 report to the NRC stated that an unknown amount of soot was released from M/V FREDERICKSBURG into the Willamette River when the engines were "fired up" and shot out of the exhaust pipe. In 1998, the Portland Harbor Master responded to a pumproom fire aboard Keystone's vessel, S/S FREDERICKSBURG. The vessel was moored at MarCom's dock and being repaired. An operator cutting a bolt from a flange with a blow torch and dropped the bolt into the bilge. The bolt ignited gasoline which was in the bilges. It is not clear from the report what impact the vessel's fire had on the river.	Direct discharge to river	National Response Center; Portland Harbor Master records, PSY Suppl. PA App. F (2006)[b]
Olympic Tug & Barge	6-7, 7-8	Marine transportation company	8/5/1995, 6/29/1997, 11/3/1999, 1/28/2002	A 1995 report to the NRC stated that approximately 5-8 gallons of oil was released into the Willamette River. A June 1997 report to the NRC stated that approximately 50 gallons of diesel oil was released from the tug LELA JOY into the Willamette River due to a tank overflow. A Nov. 1999 report to the NRC stated that approximately 1 gallon of oil was released from M/V PACIFIC FALCON into the Willamette River during refueling. In 2002, approximately 2 gallons of waste oil discharged to Willamette River after a half-full drum was knocked over when Olympic was moving a heavy winch by crane.	Direct discharge to river	NRC Incident Reports
OSPREY ARROW	6-7	Product transfer	10/22/2003	A report to the NRC stated that approximately 2 gallons of pitch was released from the vessel into the Willamette River due to an equipment failure or malfunction.	Direct discharge to river	NRC Incident Reports
Pacific Northern Oil	6-7	Bulk storage terminal	8/19/1999	A report to the NRC stated that approximately 200 gallons of oil (blend of diesel and bunker oil) was released onto the soil and concrete from an overloaded oil/water separator. It was reported that oil was discharged into the Willamette River.	Direct discharge to river	NRC Incident Reports

Table 4.3-3. Overwater Releases from Vessels and Other Spills in the Study Area.

Party	River Mile	Type of Operation (s)	Date of Release	Summary of Release	Pathway to River	Reference
Portland General Electric Company	6-7, 7-8, 12-13	Power barge Pole transformer	12/17/1992, 10/12/1993, 5/20/1999, 10/1/2000, 10/26/2004; 10/30/1999	A 1992 report to the NRC stated that approximately 22 gallons of hydraulic oil was spilled with an unknown amount released into the Willamette River via a storm drain. A 1993 report to the NRC stated that a 5-gallon spill of PCB transformer oil occurred when a transformer exploded. An unknown amount of oil was released into a storm drain discharging into the Willamette River. A May 1999 report to the NRC stated that approximately 15 gallons of transformer oil was released into a nearby storm drain and into the Willamette River. The NRC database reported that it is not known whether the release reached the Willamette River. In November 1999, the NRC reported that approximately 3 gallons of oil was released onto the ground from a ruptured truck reservoir line. The spill reached a nearby storm drain and was released into the Willamette River. In October 2000 the sump on Power Barge Rio DaLuz overflowed during heavy rains, discharging approximately 2 gallons of lubricating oil to the river. In October 2004, approximately 30 gallons spilled from a pole transformer containing fluid with 31 ppm PCB, based on September 30, 1986 sampling. Oil initially discharged to ground and subsequently to the catch basin.	Discharge of material to river via storm drain	NRC Incident Reports; NRC Incident Report #739571
Sause Brothers	6-7, 7-8, 9-10	Hydraulic line failure	7/2/1992, 8/18/1993, 12/13/1996, 4/2/2006	A 1992 report to the NRC stated that an unknown amount of "hot" oil was release into the Willamette River. A 1993 report to the NRC stated that approximately 1 cup of oil was released from a pinhole leak in a tank on the tank barge NESTUCCA NO. 569658 into the Willamette River. A 1996 report to the NRC stated that approximately 5 gallons was released from the tug TITAN into the Willamette River due to overfueling. In 2006, a 1-gallon release of hydraulic oil at facility dock from shore crane was due to a broken line. "Old age" of hydraulic line cited as cause of release.	Direct discharge to river	NRC Incident Reports; NRC Incident Report #792758
Alaska Tanker Company	7-8	Transportation	6/5/1999	It was reported that a release of an unknown amount of oil was observed coming from the vessel M/V DENALI at Berth 314 on the river side.	Direct discharge to the river	PSY Suppl. PA (2006) [a]
American Trading Transportation	7-8	Transportation company	8/13/1991	In 1991, approximately 2 gallons of waste oil/lubricatnts was released to the river from the T/S DELAWARE TRADER, owned at the time by American Trading Transportation Co.	Direct discharge to the river	PSY Suppl. PA, App. F (2006)
Ballard Diving & Salvage Inc.	7-8	Ship repair	8/22/2003	A report to the NRC stated that approximately 10 gallons of hydraulic oil was released into the Willamette River from a hydraulic line that was cut during the polishing of propellers on a military vessel (the USNS SISLER Navy vessel).	Direct discharge to the river	NRC Incident Reports
Central Gulf	7-8	Transportation company	7/8/1996	In 1996, an unknown amount of oil leaked out the stern tube of the vessel GREEN HARBOUR into the river.	Direct discharge to the river	PSY Suppl. PA, App. F (2006)
Dynea Overlays Inc.	7-8	Provider of bonding and surface solutions	4/23/2002	A report to the NRC stated that approximately 2 liters of unknown oil type was released into the Willamette River from a vessel due to unknown causes.	Direct discharge to the river	NRC Incident Reports
LONG BEACH and EXXON BENICIA	7-8	Petroleum product distribution company	8/24/1988, 4/17/1991, 3/15/1993	Exxon is the owner of the vessel LONG BEACH which was being repaired at PSY. In 1988, a contractor released sandblast grit and paint chips into the river. An April 1991 report stated that NMIW illegally discharged approximately 150-200 gallons of lubricating oil into a storm drain that discharged into the river from Exxon's vessel EXXON BENICIA. In 1993, a release of approximately 0.01 gallon of Bunker C oil was released into the river from the T/S EXXON BENICIA.	Direct discharge to the river	PSY Suppl. PA App. F
Foss Environmental	7-8, 8-9	Emergency response contactor including cleaning catch basins and oil/water separators	3/9/1995,1/26/1998, 7/13/2001	A 1995 report to the NRC stated that less than 1 gallon of hydraulic oil was released onto asphalt then into the Willamette River from a power steering hose on a vehicle. A January 1998, NRC report stated that approximately one-half gallon of "bilge slop" was released into the river from a vacuum truck vent. The 2001 incident discharged approximately 5 gallons of slop oil due to clogged vacuum line.	Direct discharge to river; indirect discharge to river through separator.	NRC Incident Reports, NRC Incident Report 572917
Garwood Oil	7-8	Petroleum product distribution company	12/30/2003	A report to the NRC stated that approximately 20 gallons of fuel oil was released from a fuel tank on a tractor trailer due to a transport accident. It is not known whether the release reached the Willamette River.	Possible indirect discharge to stormwater system.	NRC Incident Reports
General Steamship Corp.	7-8 8-9 9-10	Marine construction and transportation	7/7/1992, 3/14/1994, 9/16/1996, 6/15/2000	A 1992 report to the NRC stated that an unknown amount of oil was released from M/V BELFOREST into the Willamette River. A 1994 report to the NRC stated that approximately 0.5 cup of motor oil was released from M/V AMERICAN DYNASTY into the Willamette River from a 5-gallon bucket that was knocked over. A 1996 report to the NRC stated that an unknown amount of oil was released from the bulk carrier TAI SHING into the Willamette River due to a leaking bilge or cargo tank. The same day, the vessel ALASKAN JEWEL discharged 1 barrel of hydraulic oil while testing the emergency fire pump. On June 15, 2000, a spill of approximately 10 gallons of lubricating oil was released from the M/V TALL [PAUL] BUCK into the river as reported to the NRC. Also, on June 15, there was a discharge of less than 1 gallon of lube oil caused by crew members of the M/V TALL BUCK over-pressurizing the stern tube. This was discharged to the Swan Island Lagoon.	Direct discharge to river	NRC Incident Reports; NRC Incident Reports # 531544, TALL BUCK Incident Report # 532237, Tall Buck: ERNS Database/NRC Incident No. 532225, PSY Suppl. PA, App. F (2006)
Hickey Marine	7-8	Vessel repair	8/29/1996	A report to the NRC stated that approximately 2 gallons of oil was released from the crane barge SEA LION into the Willamette River due to a broken air compressor hose.	Direct discharge to river	PSY Suppl. PA, App. F (2006)

Table 4.3-3. Overwater Releases from Vessels and Other Spills in the Study Area.

Party	River Mile	Type of Operation (s)	Date of Release	Summary of Release	Pathway to River	Reference
Industrial Marine, Inc.	7-8	Ship repair	10/17/2006	A report to the NRC stated that during spray painting operations on the bridge wing of M/V CHEMICAL EXPLORER, the over sprayer landed in the Willamette River due to operator error. Approximately one-half cup of "International Paint (called 99)" was released into the Willamette River.	Direct discharge to river	NRC Incident Reports
K-Sea Transportation	7-8	Tank overflow	11/10/2007	Approximately 2 gallons of fuel discharged to the river due to valve misalignment on the Tug SCORPIUS.	Direct discharge to river	NRC Incident Report 854198
Lindblad Expeditions	7-8	Unknown at this time	4/25/2003 and 5/10/2006	An April 2003 NRC report stated that approximately 1 pint of oil was released from a bilge manifold as a result of flushing a leaking hot water heater discharge overboard from the vessel, LAZETTE. In May 2006, an NRC report stated that a fitting broke on a hydraulic crane which resulted in the release of approximately 1 pint of hydraulic oil into the Willamette River.	Direct discharge to river	NRC Incident Reports #643271, 796683
Linden Farms	7-8	Operated a poultry processing facility	5/3/1998	A 1998 report stated that guts and grease were observed discharging from a storm drain at the chicken farm processing facility.	Direct discharge to river	LWG Programmatic Work Plan (referenced as OERS 98-1032)
Marine Vacuum Service, Inc.	7-8	Tank, bilge and boiler cleanup	Potential releases during occupancy from 1993 to 1995	Marine Vacuum leased Bay 1 including two office spaces, a shop, and an adjacent parking lot at the PSY. Also Marine Vacuum conducted overwater activities as part of its operations. Environmental inspections performed in 1995 and 1996 determined the following: (1) floor and walls of the shop were contaminated with oil and it was noted that the shop had two floor drains; (2) parking lot was stained with oil; and (3) three drums of unknown substance were abandoned in Bay 1.	Possible indirect discharge to stormwater system.	PSY Suppl. PA (2006)
Military Sealift Command	7-8	Military transportation	12/1/2004	Approximately 5 gallons of oil was released into the river when a Doppler speed log was replaced on the USNS HENRY K. KAISER.	Direct discharge to river	PSY Suppl. PA, App. F (2006)
O'Briens Oil Pollution	7-8		9/10/2005	A report to the NRC stated that approximately 1 quart of No. 2 diesel oil was released into the Willamette River from a pipeline due to unknown causes.	Direct discharge to river	
Northwest Marine Iron Works	7-8	Vessel construction and repair	5/13/1982, 8/25/1988, 10/19/1988, 12/12/1990, 5/23/1991	A 1982 release of approximately 2 gallons of lube oil into the river. In August 1988, NMIW staff were observed dumping sandblast sand and wastewater into the river from a vessel. In October 1988, NMIW staff reported disposed of sandblast sand into river at night. In 1990, sandblast grit was released into the river. A May 1991 report to the NRC stated that approximately 300 gallons of lubricating oil was released from the facility, with 200 gallons spilling into the Willamette River.	Direct discharge to river	NRC Incident Reports
Rainier Petroleum	7-8	Transportation	8/7/2006	An approximate 15-gallon oil spill occurred at the McCall facility involving Brix Maritime Barge #4. Spill caused by operator error (flow "kicked back" causing an overfill). Brix Maritime is identified as operator of the vessel, while Rainier Petroleum is listed as the "managing owner" and Marine Equipment Leasing is identified as the owner.	Direct discharge to river	NRC Incident Report #807033
Roadway Express	7-8	Freight transfer and delivery	2/20/1990	A report to the NRC stated that during a rain storm an unknown amount of oil was being washed into storm drains discharging into the Willamette River. The report stated that a leak developed in a tractor trailer fuel line.	Discharge of material to river via storm drain	NRC Incident Reports
Salmon Bay Barge Line, Inc.	7-8	Fuel transfer	6/29/2000	A 2-gallon discharge of diesel fuel occurred due to overfilling of fuel tank on tug JESSE.	Direct discharge to river	NRC Incident Report #533913
Sea Coast Towing	7-8	Transportation	3/19/2000, 5/8/2001, 8/10/2003 and 10/10/2005	In March 2000, approximately 1 gallon of diesel fuel was released into the Willamette River from the tug vessel JOHN BRIX, which had a leak from its fuel vent. In May 2001, a report to the NRC stated that approximately 3 gallons of diesel fuel was released into the Willamette River during a tank to barge overfill. In August 2003, a report to the NRC stated that approximately 100 gallons of jet fuel (JP-8) was released into the Willamette River during a tank to barge overfill. An October 2005 report to the NRC stated that approximately 1 tablespoon of hydraulic oil was released into the Willamette River from a barge due to an equipment failure.	Direct discharge to river	USCG Pollution Report; NRC Incident Reports #565304, 653457; NRC Incident Reports
Sea-Land Service, Inc./ Sea-Land Transport Co. and SEA-LAND NAVIGATOR, SEA-LAND HAWAII	7-8	Transportation	Potential releases during occupancy from 1963 to 1974; in-water spill on 10/7/1990 and 12/23/1990	Sea-Land Service leased Bay 10 in Building 4 for several years. Building 4 had a series of floor drains which collected wastewater then discharged through a private outfall into the river downstream of Berth 314; also stormwater and wastewater discharged through private outfall in Dry Dock #3. Several vessels owned by Sea-Land have been brought to the PSY dry docks for repair. Both Building 4 and the dry docks are subjects of environmental investigations for contamination from various hazardous substances. In October 1990, while cleaning the aft of the SEA-LAND HAWAII, a contractor released oil, dust, and paint into the river causing a sheen on the surface. In December 1990, an unknown amount of foam was released into the river during the repair of the vessel NAVIGATOR, owned by Sea-Land.	Possible indirect discharge to stormwater system; also direct discharge from spill.	PSY Suppl. PA App. F (2006); Sewer map at PUB0006726
Sound Freight Lines, Inc.	7-8	Fuel transfer/tug operator	11/6/2007	The tug BLACK HAWK discharged approximately 50 gallons of diesel to the river due to a leaky valve.	Direct discharge to river	NRC Incident Report #853814
M/V SEA RIVER NORTH SLOPE; S/R GALENA BAY	7-8	Transportation	7/6/1994, 10/19/2001	SeaRiver Maritime is the owner of the vessel, M/V SEA RIVER NORTH SLOPE. It was reported that a stern tube on the vessel released approximately 2 gallons of turbine oil into the river. In 2001, a release of approximately 1 pint into the river causing a sheen from a leak in a lube oil cooler on SeaRiver's vessel S/R GALENA.	Direct discharge to river	PSY Suppl. PA (2006)

Table 4.3-3. Overwater Releases from Vessels and Other Spills in the Study Area.

Party	River Mile	Type of Operation (s)	Date of Release	Summary of Release	Pathway to River	Reference
SS BARBARA	7-8	Marine vessel	6/21/1957	On June 21, 1957, a "large amount of bunker fuel" was released from the dry dock into the river due to operator error by an employee of WISCO while repairing the SS BARBARA. Olympic Steamship Co. was identified as the vessel local agent by the U.S. Coast Guard.	Direct discharge to river	NARA historical USCG records
Tanker Pacific Management	7-8	Transportation	6/9/2000, 7/9/2000	Two separate releases occurred of an unknown amount of oil into the river during the testing of fire equipment aboard the M/V ALASKAN JEWEL.	Direct discharge to river	PSY Suppl. PA, App. F (2006)
Trans Marine Navigation Corporation	7-8	Marine transportation	6/25/2001	A release was reported of approximately 1 gallon or 5 liters of marine oil gasoline from a faulty cap of a sounding pipe on the vessel M/V DANSUS.	Direct discharge to river	PSY Suppl. PA, App. F (2006), USCG Pollution Report
Transoceanic Shipping Company	7-8	Provider of bonding and surface solutions	1/19/2001, 4/13/2002	A report to the NRC stated that approximately 0.5 gallon of hydraulic oil was released into the Willamette River due to a ruptured hose in the blower thruster on the cable laying ship GLOBAL SENTINAL. In 2002, approximately 2 liters of unknown oil was released into the river from the vessel TYCOM RELIANCE.	Direct discharge to river	NRC Incident Report #554151
Tyco Telecommunications	7-8	Oceanic cable vessel	4/13/2002	M/V TYCOM RELIANCE discharged approximately 2 liters of scar oil to the river due to suspected seal slippage.	Direct discharge to river	USCG Pollution Report
U.S. Army	7-8	Transportation	1/26/1993	Based on Internet research it appears that the U.S. Army was the vessel owner in 1986. In 1993, a release of oil was reported from the SS AUSTRAL LIGHTNING onto the pier at Berth 312. It is not clear whether the oil was discharged into the river.	Possible direct discharge to river	PSY Suppl. PA App. F (2006)
United Parcel Service	7-8	Package delivery depot and equipment maintenance facility	4/28/1993	A report to the NRC stated that approximately 35 gallons of hydraulic oil was released onto the ground when a garbage compactor's hydraulic fitting broke. An unknown amount of oil was released into the Willamette River.	Direct discharge to river	NRC Incident Reports
M/V COLUMBIA	8-9	Passenger ferry	4/27/2005	In 2005, a release of unknown materials caused a sheen on the river from the outboard area of the M/V COLUMBIA, a vessel owned by the Alaska Department of Transportation.	Direct discharge to river	PSY Suppl. PA, App. F (2006)
M/V CSO CONSTRUCTOR	8-9	Marine pipe laying vessel	9/15/1998	In 1998, a release of unknown oil from the vessel created a 10 m^2 sheen on the river.	Direct discharge to river	PSY Suppl. PA, App. F (2006)
Northwest Aggregates Co.	8-9	Transportation	3/3/2004	A report to the NRC stated that approximately 14 quarts of gear oil was released from a gear box on a conveyor belt when the conveyor belt broke and the gear box fell into the Willamette River.	Direct discharge to river	NRC Incident Reports
OVERSEAS GALENA BAY	8-9	Transportation	10/19/2001	A report to the NRC stated that approximately 1 pint of lubricating oil was released from the vessel into the Willamette River from a leak in the lube oil cooler in the engine room.	Direct discharge to river	NRC Incident Reports
Peninsula Truck Lines, Inc.	8-9	Transportation company	4/19991	OSFM incident report stated that an employee washing the bed of a 40-ft trailer spilled approximately 2 gallons of blue dye pigment into the storm sewer. The storm sewer is situated in the City of Portland's stormwater basin No. 18 which discharges to the Willamette River.	The intersection is situated in the City of Portland's OF 18 stormwater basin.	Oregon State Fire Marshal database
Portland Truck and Diesel	8-9	Transportation	1/9/2003	A report to the NRC stated that approximately 160 gallons of oil were released from an oil/water separator to the surrounding soil due to equipment failure. The NRC database reported that it is not known whether the release reached the Willamette River.	Possible release to City's storm water conveyance system to either Outfall 18 or 19.	NRC Incident Reports
U. S. Navy	8-9, 10-11	Defense agency	4/22/1946, 1/25/1987, 9/29/1989, 7/18/1991, 7/24/1991, 10/9/1991, 7/12/1994, 9/24/1994, 6/13/1995, 6/19/1995, 1/7/1996, 5/12/1997, 1/12/2001, 4/18/2002, 6/29/2003	A 1946 release of bilge oil into Swan Island Lagoon at Berthing Area B from pumping out bilges of an LST. Navy was owner of vessel USNS WILKES, which released approximately 1 gallon of lubricating oil in bilge into river in 1987. In 1989, Navy BARGE 60 was in repair at the PSY when a contractor released sandblast grit into the river. A July 1991, two incidents were reported, including the release of approximately 1 gallon of hydraulic oil and 3 gallons of waste oil/lubricants from the USS WILLIAM H. STANDLEY into the river. In October 1991, two reports to the NRC stated that approximately 5 gallons of aviation fuel and 1 gallon of waste lubricating oil were released from USNS HASSAYAMPA and the USNS TITAN into the Willamette River, respectively. In 1994, a report stated that approximately 1 pint of jet fuel was released into the river when a contractor removed a cargo hose from the USNS GUADALUPE. A Sept. 1994 report stated that approximately 1 ounce of hydraulic oil was released into the river from the M/V SEALIFT ANTARCTIC. In June 1995, two NRC reports stated that approximately 6 gallons of waste oil was released from the USNS TIPPECANOE into the Willamette River during two separate incidents. An April 1996 report stated that approximately 25 gallons of unknown oil was released into the river when a stern line broke on the USS HIGGINS. A 1997 report to the NRC stated that approximately of 3 gallons of "bilge slops" or oily waste was released from USNS JOHN ERICSSON into the Willamette River when a tank truck in the process of shutting down lost material. In 2001, an oil sheen was observed in the dry dock following repairs to the Navy ship TIPPECANOE. In 2002, a sheen on the river was observed around the Navy vessel, USNS YUKON.	Direct discharge to river	PSY Suppl. PA, App. F (2006) NRC Incident Reports

Table 4.3-3. Overwater Releases from Vessels and Other Spills in the Study Area.

Party	River Mile	Type of Operation (s)	Date of Release	Summary of Release	Pathway to River	Reference
Werner Enterprises	8-9	Transportation	1/13/2000, 10/19/2001	In January 2000, a spill from tractor trailer of 60 gallons occurred at the Werner facility. The spill discharged to a storm sewer and approximately 30 gallons reached the river. In October 2001, a report to the NRC stated that approximately 30 gallons of fuel oil was released when a crossover line on a tractor trailer saddle tank ruptured. The oil was released to the roadway then flowed into a storm drain. The roadway is situated in the City of Portland's storm water Outfall Basin 18.	Direct discharge to river	NRC Incident Report #516905; NRC Incident Reports
Western Towboat Co.	8-9	Tugboat operator	3/9/2004	During an internal transfer, vessel Ocean Mariner discharged 4 gallons of diesel from an overhead vent. Diesel ran out scupper and discharged to river.	Direct discharge to river	NRC Incident Report #715543
American Transport	9-10	Transportation company	8/1991	American Transport Inc. (now American Energy, Inc.) has been reported as a responsible party for a number of spills in the City of Portland, some of which have entered a waterway. One incident within the Study Area reported in the OSFM database involved 4,400-gallon tanker that broke off its mount, spilling diesel fuel. OSFM reported that 500 gallons were released and material entered a waterway. The location of the spill is situated in the City of Portland's Stormwater Basin No. 19A, which discharges to the Willamette River.	The intersection is situated in the City of Portland's OF 19A stormwater basin.	Oregon State Fire Marshal database NRC Incident Reports, NRC Incident Reports #303504 & 777997
CPS Express	9-10	Transportation company	One-time event occurring in March 1995	OSFM incident report stated that a tractor trailer rig leaked approximately 10-15 gallons of an unknown chemical into the public street. OSFM reported that approximately 10 gallons were released into a storm sewer. The storm sewer is situated in the City of Portland's Stormwater Basin No. 17, which discharges to the Willamette River.	Stormwater from the area flows into the Lower Balch Creek Basin which discharges to City of Portland Outfall 17 thence into the Willamette River.	Oregon State Fire Marshal database
Crowley Marine Services		Marine transportation company	10/5/1990, 2/9/1993, 4/10/1997, 5/2/1997	A 1990 report to the NRC stated that a 10-gallon release occurred with an unknown amount of diesel oil flowing into the Willamette River when a tank was overfilled. A 1993 report to the NRC stated that approximately 2 gallons of ballast water were released into the river. An April 1997 report to the NRC stated that approximately 1 pint of hydraulic oil was released from the tug ADVENTURER into the Willamette River due to a seal leak on a propeller shaft. A May 1997 report to the NRC stated that approximately 0.5 cup of diesel oil was released from the tug CAVALIER into the Willamette River due to a seal failure.	Direct discharge to river	NRC Incident Reports
General Electric Company	9-10	Electrical apparatus decommissioning facility	2/4/1994	A report to the NRC stated that approximately 1 pint of PCB-contaminated oil was released when a capacitor motor leaked onto concrete due to an equipment failure. The report confirmed that there was a release to the water, although a "zero" was the amount reaching the water in the report.	Discharge to river via storm sewer	NRC Incident Reports
LASCO Shipping	9-10	Transportation	10/9/1998	A report to the NRC stated that approximately 1 liter of hydraulic oil was released from the M/V PACKING into the river due to a broken hydraulic hose on a hatch cover.	Direct discharge to river	NRC Incident Reports
Michael Wakefield dba Three Hats Farm	9-10	Transportation company	One-time event occurring in May 2001	OSFM incident report stated that a semi-tractor trailer jack-knifed during an auto accident. The seam on the trailer tank ruptured, spilling 30-40 gallons of diesel fuel onto the roadway in the vicinity of two storm drains. OSFM estimated that 20-30 gallons discharged into the storm drains. The intersection is situated in the City of Portland's Stormwater Basin No. 15, which discharges to the Willamette River.	Stormwater from the area flows into the Nicolai Basin which discharges to City of Portland Outfall 15 thence into the Willamette River.	Oregon State Fire Marshal database
Portland Bagel	9-10	Bakery	12/1995	OSFM incident report stated that a truck was leaking diesel fuel in a nearby parking lot (3571 NW Yeon). OSFM reported that 2-3 gallons of diesel fuel spilled and may have flowed into a storm sewer sump. The storm sewer is situated in the City of Portland's Stormwater Basin No. 17, which discharges to the Willamette River.	Stormwater from the area flows into the Lower Balch Creek Basin which discharges to City of Portland Outfall 17 thence into the Willamette River.	Oregon State Fire Marshal database
Pro Truck Lines	9-10	Transportation	5/25/1995	A report to the NRC stated that approximately 80 gallons of diesel oil was released to the ground from ruptured fuel line on a truck. An unknown amount of oil was released to the Willamette River via public conveyance system.	Discharge of material to river via storm drain	NRC Incident Reports
Stevedoring Services Inc.	9-10	Terminal stevedoring operations for loading and unloading container cargo, bulk and breakbulk for products	1/15/1995	A report to the NRC stated that an unknown amount of paint thinner was released into the Willamette River when a paint pallet spilled from the M/V PAC PRINCE's crane.	Direct discharge to river	NRC Incident Reports
Truax Oil, Inc.	9-10	Transportation company	12/19/1990	As reported to the NRC, a tanker truck driver lost control of the vehicle. The accident ruptured the tanker, releasing at least 50 gallons of diesel fuel. An unknown amount discharged to the storm drain and then entered the Willamette River. The accident occurred within the City of Portland's Stormwater Basin No. 17, which discharges to the Willamette River.	Stormwater from the area flows into the Lower Balch Creek Basin which discharges to City of Portland Outfall 17 thence into the Willamette River.	National Response Center

Table 4.3-3. Overwater Releases from Vessels and Other Spills in the Study Area.

Party	River Mile	Type of Operation (s)	Date of Release	Summary of Release	Pathway to River	Reference
Rexel/Taylor Electric	12-13	Warehouse	5/18/2006	A 120 gallon spill/unrecoverable sheen on river caused by firefighting efforts at facility warehouse. Spill traced to three utility pole transformers that were damaged in the fire. Oils were released to the ground and water from firefighting efforts washed oil down storm drain. Unknown whether the transformers contained PCB oil.	Discharge of material to river via storm drain	NRC Incident Report #797606
National Oceanic and Atmospheric Administration	Unknown	Research vessel	2/5/2001	A discharge of approximately 1 cup of No. 2 diesel occurred from the R/V MCARTHUR to Willamette River.	Direct discharge to river	USCG Pollution Report
Wilson Oil	Unknown	Transportation company	12/1987	OSFM incident report stated that a tanker truck overturned leaking approximately 3,000 gallons of gasoline on the roadway. The OSFM report does not provide enough information concerning the spill, but it is assumed that some volume of gasoline discharged into storm sewers on St. Helens Road which then flowed to the Willamette River. More research is necessary to determine where the tanker truck picked up the load and the exact location of the accident.	Stormwater system	Oregon State Fire Marshal database
Zidell Explorations Inc.	Unknown	Ship scrapping	9/6/1973	On September 6, 1973, the hull of the USS PRINCETON sank while moored at the Kingsley Lumber dock in Linnton. The hull, which was owned by Zidell, released an estimated 50,000 gallons of heavy black oil directly to the Willamette River. Cleanup activities took at least three weeks and both a state enforcement action and federal suit were brought against Zidell for the incident.	Direct discharge to river	On Scene Commander's Reports

Notes:

[a] National Response Center Database, http://www.nrc.uscg.mil/ NRC. 2002.

[b] Supplemental Preliminary Assessment, Swan Island Upland Facility (Ash Creek and Newfields 2006)

LWG - Lower Willamette Group
NARA - National Archives and Records Administration
NMIW - Northwest Marine Iron Works
NRC - National Response Center
OSFM - Oregon State Fire Marshal
PCB - polychlorinated biphenyl
PSY - Portland Shipyard
USCG - U.S. Coast Guard
WISCO - Willamette Iron and Steel Company

Table 4.4-1. LWG Summary Statistics for Sediment Trap and Stormwater Based on Land Use Type.

						Detected Concentrations					Detected and Nondetected Concentrations				
Analyte	CAS RN	Units	N	N Detected	% Detected	Minimum[a]	Maximum[a]	Mean	Median[b]	95th[b]	Minimum (full DL)[a]	Maximum (full DL)[a]	Mean (half DL)	Median (half DL)[b]	95th (half DL)[b]
Heavy Industrial															
Solid															
Metals															
Arsenic	7440-38-2	mg/kg	13	13	100	3.53	58.6	23.4	22.6	52.5	3.53	58.6	23.4	22.6	52.5
Chromium	7440-47-3	mg/kg	13	13	100	15.5 T	726	165	107	540	15.5 T	726	165	107	540
Copper	7440-50-8	mg/kg	13	13	100	22.6 T	59400	4810	165	24300	22.6 T	59400	4810	165	24300
Zinc	7440-66-6	mg/kg	13	13	100	319	21000	3150	1280	12100	319	21000	3150	1280	12100
Total PCBs[c]															
Total PCBs	TOTPCBS	µg/kg	24	24	100	48.4 JT	9900 JT	977	288	2600	48.4 JT	9900 JT	977	288	2600
Pesticides															
Aldrin	309-00-2	µg/kg	18	3	16.7	2.4 J	48 NJ	18.8	5.9	43.8	0.76 U	48 NJ	5.82	2.38	17.8
Dieldrin	60-57-1	µg/kg	18	1	5.56	470 J	470 J	470	470		0.8 U	470 J	29.3	2.03	79
Total Chlordanes	TOTCHLDANE	µg/kg	18	10	55.6	1.3 JT	1000 JT	155	20.5	730	1.3 JT	5800 UT	251	16	1290
Total of 2,4'- and 4,4'-DDD, DDE, DDT	E966176	µg/kg	18	18	100	4.8 JT	160000 T	9070	81	24700	4.8 JT	160000 T	9070	81	24700
Polycyclic Aromatic Hydrocarbons															
Benzo(a)pyrene	50-32-8	µg/kg	14	13	92.9	120 J	52000	10100	4500	39400	120 J	52000	9360	3450	38400
Total cPAH BaPEq	BAPEQ	µg/kg	14	14	100	70.5 JT	73400 T	14000	5160	55400	70.5 JT	73400 T	14000	5160	55400
Phthalates															
Bis(2-ethylhexyl)phthalate	117-81-7	µg/kg	14	14	100	280 J	120000	27200	13300	101000	280 J	120000	27200	13300	101000
Water															
Metals															
Arsenic (dissolved)	7440-38-2	µg/L	76	68	89.5	0.024 J	21.1	1.88	0.362	12.7	0.024 J	21.1	2.13	0.576	12
Arsenic	7440-38-2	µg/L	100	91	91	0.091 J	19.8	2.93	0.87	17.2	0.091 J	20 U	3.12	1.03	16.9
Chromium (dissolved)	7440-47-3	µg/L	76	60	78.9	0.3	13.6	1.95	0.865	6.97	0.23 U	13.6	1.6	0.78	6.93
Chromium	7440-47-3	µg/L	97	94	96.9	0.62	495	20	3.56	111	0.62	495	19.4	3.44	110
Copper (dissolved)	7440-50-8	µg/L	76	76	100	1.9	99.9	16.5	7.93	61.2	1.9	99.9	16.5	7.93	61.2
Copper	7440-50-8	µg/L	97	97	100	3.1	809	66.9	23.3	296	3.1	809	66.9	23.3	296
Zinc (dissolved)	7440-66-6	µg/L	76	71	93.4	1.3	2300	240	99.3	924	1.3	2300	226	94.1	745
Zinc	7440-66-6	µg/L	97	97	100	43.6	11900	547	233	2360	43.6	11900	547	233	2360
Total PCBs[c]															
Total PCBs (dissolved)	TOTPCBS	µg/L	21	20	95.2	0.00000409 JT	0.052 T	0.00875	0.00517	0.0262	0.00000409 JT	0.052 T	0.00833	0.00478	0.0248
Total PCBs	TOTPCBS	µg/L	88	88	100	0.000344 JT	11.6 JT	0.352	0.0526	1.04	0.000344 JT	11.6 JT	0.352	0.0526	1.04
Pesticides															
Aldrin (dissolved)	309-00-2	µg/L	12	1	8.33	0.00034 J	0.00034 J	0.00034	0.00034	--	0.00034 J	0.0061 U	0.00133	0.000775	0.00275
Aldrin	309-00-2	µg/L	25	6	24	0.00022 J	0.027	0.0118	0.0109	0.0255	0.00022 J	0.027	0.00389	0.00135	0.0208
Dieldrin (dissolved)	60-57-1	µg/L	12	1	8.33	0.0015	0.0015	0.0015	0.0015	--	0.00042 U	0.0059 U	0.00134	0.00113	0.0027
Dieldrin	60-57-1	µg/L	25	7	28	0.00079	0.25	0.11	0.089	0.244	0.0004 U	0.25	0.0328	0.0013	0.222
Total Chlordanes (dissolved)	TOTCHLDANE	µg/L	12	7	58.3	0.00054 JT	0.023 JT	0.01	0.013	0.0206	0.00054 JT	0.023 JT	0.00783	0.0054	0.0186
Total Chlordanes	TOTCHLDANE	µg/L	25	14	56	0.00098 JT	0.13 JT	0.0302	0.0122	0.101	0.00098 JT	0.54 UT	0.0336	0.0084	0.121
Total of 2,4'- and 4,4'-DDD, DDE, DDT (dissolved)	E966176	µg/L	12	11	91.7	0.00066 JT	0.35 JT	0.0382	0.0081	0.183	0.00066 JT	0.35 JT	0.0352	0.0065	0.166
Total of 2,4'- and 4,4'-DDD, DDE, DDT	E966176	µg/L	25	22	88	0.0048 JT	11 JT	0.858	0.0185	3.51	0.002 UJT	11 JT	0.755	0.015	3.22
Polycyclic Aromatic Hydrocarbons															
Benzo(a)pyrene (dissolved)	50-32-8	µg/L	28	10	35.7	0.007 J	1.3 J	0.304	0.13	1.1	0.0043 U	1.3 J	0.133	0.0495	0.653
Benzo(a)pyrene	50-32-8	µg/L	85	67	78.8	0.0054 J	3.7	0.257	0.044	1.26	0.0043 U	3.7	0.211	0.04	0.918
Total cPAH BaPEq (dissolved)	BAPEQ	µg/L	28	12	42.9	0.000294 JT	2.12 JT	0.405	0.131	1.69	0.000294 JT	2.12 JT	0.197	0.0658	1.02
Total cPAH BaPEq	BAPEQ	µg/L	86	76	88.4	0.00107 JT	5.76 T	0.372	0.0562	1.74	0.00107 JT	5.76 T	0.336	0.0572	1.38
Phthalates															
Bis(2-ethylhexyl)phthalate (dissolved)	117-81-7	µg/L	16	4	25	0.38 J	0.82	0.638	0.675	0.802	0.23 U	2 UJ	0.543	0.648	0.865
Bis(2-ethylhexyl)phthalate	117-81-7	µg/L	48	32	66.7	0.37 J	10	2.77	1.75	8.14	0.19 UJ	10	2.07	0.985	7.97

Table 4.4-1. LWG Summary Statistics for Sediment Trap and Stormwater Based on Land Use Type.

						Detected Concentrations					Detected and Nondetected Concentrations				
Analyte	CAS RN	Units	N	N Detected	% Detected	Minimum[a]	Maximum[a]	Mean	Median[b]	95th[b]	Minimum (full DL)[a]	Maximum (full DL)[a]	Mean (half DL)	Median (half DL)[b]	95th (half DL)[b]
Light Industrial															
Solid															
Metals															
Arsenic	7440-38-2	mg/kg	2	2	100	3.39	4.43	3.91	3.91	4.38	3.39	4.43	3.91	3.91	4.38
Chromium	7440-47-3	mg/kg	2	2	100	122 J	160 J	141	141	158	122 J	160 J	141	141	158
Copper	7440-50-8	mg/kg	2	2	100	65.8	68	66.9	66.9	67.9	65.8	68	66.9	66.9	67.9
Zinc	7440-66-6	mg/kg	2	2	100	442	517	480	480	513	442	517	480	480	513
Total PCBs[c]															
Total PCBs	TOTPCBS	µg/kg	2	2	100	264	661	463	463	641	264	661	463	463	641
Pesticides															
Aldrin	309-00-2	µg/kg	1	1	100	6.2 J	6.2 J	6.2	6.2	--	6.2 J	6.2 J	6.2	6.2	--
Dieldrin	60-57-1	µg/kg	1	0	0	--	--	--	--	--	29 UJ	29 UJ	14.5	14.5	--
Total Chlordanes	TOTCHLDANE	µg/kg	1	1	100	6.8 JT	6.8 JT	6.8	6.8	--	6.8 JT	6.8 JT	6.8	6.8	--
Total of 2,4'- and 4,4'-DDD, DDE, DDT	E966176	µg/kg	1	1	100	34 JT	34 JT	34	34	--	34 JT	34 JT	34	34	--
Polycyclic Aromatic Hydrocarbons															
Benzo(a)pyrene	50-32-8	µg/kg	2	2	100	1500	2500	2000	2000	2450	1500	2500	2000	2000	2450
Total cPAH BaPEq	BAPEQ	µg/kg	2	2	100	2710 T	4710 T	3710	3710	4610	2710 T	4710 T	3710	3710	4610
Phthalates															
Bis(2-ethylhexyl)phthalate	117-81-7	µg/kg	2	2	100	17000	28000	22500	22500	27500	17000	28000	22500	22500	27500
Water															
Metals															
Arsenic (dissolved)	7440-38-2	µg/L	14	14	100	0.08	0.34	0.189	0.182	0.324	0.08	0.34	0.189	0.182	0.324
Arsenic	7440-38-2	µg/L	20	20	100	0.13	2.27	0.789	0.754	1.87	0.13	2.27	0.789	0.754	1.87
Chromium (dissolved)	7440-47-3	µg/L	14	12	85.7	0.24	1.76	0.804	0.67	1.72	0.24	1.76	0.714	0.57	1.71
Chromium	7440-47-3	µg/L	20	20	100	1.39	12.7	4.18	2.88	10.3	1.39	12.7	4.18	2.88	10.3
Copper (dissolved)	7440-50-8	µg/L	14	14	100	1.7	8.4	4.54	4.5	7.22	1.7	8.4	4.54	4.5	7.22
Copper	7440-50-8	µg/L	20	20	100	2.92	22.9	11.5	9.09	22.2	2.92	22.9	11.5	9.09	22.2
Zinc (dissolved)	7440-66-6	µg/L	14	14	100	15.4	88.8	40.8	34	85.4	15.4	88.8	40.8	34	85.4
Zinc	7440-66-6	µg/L	20	20	100	28.9	227	108	91.9	217	28.9	227	108	91.9	217
Total PCBs[c]															
Total PCBs (dissolved)	TOTPCBS	µg/L	5	5	100	0.000569	0.002	0.00121	0.00121	0.00186	0.000569	0.002	0.00121	0.00121	0.00186
Total PCBs	TOTPCBS	µg/L	20	20	100	0.0017 JT	0.594 J	0.0734	0.0136	0.382	0.0017 JT	0.594 J	0.0734	0.0136	0.382
Pesticides															
Aldrin (dissolved)	309-00-2	µg/L	3	0	0	--	--	--	--	--	0.00066 UJ	0.0055 U	0.00114	0.00034	0.00251
Aldrin	309-00-2	µg/L	6	0	0	--	--	--	--	--	0.00049 U	0.0088 U	0.00124	0.000318	0.00378
Dieldrin (dissolved)	60-57-1	µg/L	3	0	0	--	--	--	--	--	0.00048 U	0.0055 U	0.00113	0.000395	0.00251
Dieldrin	60-57-1	µg/L	6	0	0	--	--	--	--	--	0.00049 UJ	0.0088 U	0.00129	0.000925	0.00355
Total Chlordanes (dissolved)	TOTCHLDANE	µg/L	3	2	66.7	0.0007 T	0.0029 JT	0.0018	0.0018	0.00279	0.0007 T	0.0029 JT	0.00145	0.00075	0.00269
Total Chlordanes	TOTCHLDANE	µg/L	6	4	66.7	0.0012 JT	0.0052 JT	0.00235	0.0015	0.00466	0.0012 JT	0.0073 UT	0.00232	0.0015	0.00481
Total of 2,4'- and 4,4'-DDD, DDE, DDT (dissolved)	E966176	µg/L	3	0	0						0.0021 UJT	0.013 UJT	0.0031	0.00175	0.00603
Total of 2,4'- and 4,4'-DDD, DDE, DDT	E966176	µg/L	6	2	33.3	0.0071 JT	0.031 JT	0.0191	0.0191	0.0298	0.0011 UT	0.031 JT	0.00774	0.0036	0.025
Polycyclic Aromatic Hydrocarbons															
Benzo(a)pyrene (dissolved)	50-32-8	µg/L	7	5	71.4	0.018 J	0.03 J	0.024	0.026	0.0296	0.018 J	0.03 J	0.02	0.018	0.0294
Benzo(a)pyrene	50-32-8	µg/L	17	16	94.1	0.013 J	0.092	0.0343	0.0235	0.0635	0.0049 U	0.092	0.0324	0.023	0.0616
Total cPAH BaPEq (dissolved)	BAPEQ	µg/L	7	6	85.7	0.00047 JT	0.0498 JT	0.034	0.0393	0.0491	0.00047 JT	0.0498 JT	0.0306	0.032	0.049
Total cPAH BaPEq	BAPEQ	µg/L	17	17	100	0.00374 T	0.162 T	0.0554	0.0359	0.13	0.00374 T	0.162 T	0.0554	0.0359	0.13
Phthalates															
Bis(2-ethylhexyl)phthalate (dissolved)	117-81-7	µg/L	2	2	100	0.17 J	0.18 J	0.175	0.175	0.18	0.17 J	0.18 J	0.175	0.175	0.18
Bis(2-ethylhexyl)phthalate	117-81-7	µg/L	14	14	100	1 J	4.2 J	1.93	1.6	4.14	1 J	4.2 J	1.93	1.6	4.14

Table 4.4-1. LWG Summary Statistics for Sediment Trap and Stormwater Based on Land Use Type.

						Detected Concentrations					Detected and Nondetected Concentrations				
Analyte	CAS RN	Units	N	N Detected	% Detected	Minimum[a]	Maximum[a]	Mean	Median[b]	95th[b]	Minimum (full DL)[a]	Maximum (full DL)[a]	Mean (half DL)	Median (half DL)[b]	95th (half DL)[b]
Major Transportation															
Solid															
Metals															
Arsenic	7440-38-2	mg/kg	1	1	100	3.37	3.37	3.37	3.37	--	3.37	3.37	3.37	3.37	--
Chromium	7440-47-3	mg/kg	1	1	100	52.8	52.8	52.8	52.8	--	52.8	52.8	52.8	52.8	--
Copper	7440-50-8	mg/kg	1	1	100	148	148	148	148	--	148	148	148	148	--
Zinc	7440-66-6	mg/kg	1	1	100	799	799	799	799	--	799	799	799	799	--
Total PCBs[c]															
Total PCBs	TOTPCBS	µg/kg	3	3	100	125 JT	223 JT	163	142	215	125 JT	223 JT	163	142	215
Pesticides															
Aldrin	309-00-2	µg/kg	2	0	0	--	--	--	--	--	1.1 U	2.5 U	0.9	0.9	1.22
Dieldrin	60-57-1	µg/kg	2	0	0	--	--	--	--	--	4 U	4.1 U	2.03	2.03	2.05
Total Chlordanes	TOTCHLDANE	µg/kg	2	1	50	8.8 JT	8.8 JT	8.8	8.8	--	4.5 UT	8.8 JT	5.53	5.53	8.47
Total of 2,4'- and 4,4'-DDD, DDE, DDT	E966176	µg/kg	2	2	100	3.4 JT	17 JT	10.2	10.2	16.3	3.4 JT	17 JT	10.2	10.2	16.3
Polycyclic Aromatic Hydrocarbons															
Benzo(a)pyrene	50-32-8	µg/kg	2	2	100	540	680	610	610	673	540	680	610	610	673
Total cPAH BaPEq	BAPEQ	µg/kg	2	2	100	788 T	930 T	859	859	923	788 T	930 T	859	859	923
Phthalates															
Bis(2-ethylhexyl)phthalate	117-81-7	µg/kg	2	2	100	19000	39000	29000	29000	38000	19000	39000	29000	29000	38000
Water															
Metals															
Arsenic (dissolved)	7440-38-2	µg/L	10	10	100	0.23	1.58	0.687	0.597	1.48	0.23	1.58	0.687	0.597	1.48
Arsenic	7440-38-2	µg/L	13	13	100	0.52	2.33	1.15	0.982	2.02	0.52	2.33	1.15	0.982	2.02
Chromium (dissolved)	7440-47-3	µg/L	10	8	80	0.7	5.52	1.96	1.62	4.38	0.7	5.52	1.66	1.28	4.05
Chromium	7440-47-3	µg/L	14	14	100	4.99	28.2	10.5	8.31	22	4.99	28.2	10.5	8.31	22
Copper (dissolved)	7440-50-8	µg/L	10	10	100	4.2	24.8	11.7	9.82	22	4.2	24.8	11.7	9.82	22
Copper	7440-50-8	µg/L	14	14	100	24.6	66	42.9	37.6	65.4	24.6	66	42.9	37.6	65.4
Zinc (dissolved)	7440-66-6	µg/L	10	10	100	39.1	525	118	64.5	375	39.1	525	118	64.5	375
Zinc	7440-66-6	µg/L	14	14	100	113	1140	364	254	871	113	1140	364	254	871
Total PCBs[c]															
Total PCBs (dissolved)	TOTPCBS	µg/L	1	1	100	0.00407 JT	0.00407 JT	0.00407	0.00407	--	0.00407 JT	0.00407 JT	0.00407	0.00407	--
Total PCBs	TOTPCBS	µg/L	11	11	100	0.0085 T	0.185 JT	0.0517	0.0395	0.135	0.0085 T	0.185 JT	0.0517	0.0395	0.135
Polycyclic Aromatic Hydrocarbons															
Benzo(a)pyrene (dissolved)	50-32-8	µg/L	1	0	0	--	--	--	--	--	0.0048 U	0.0048 U	0.0024	0.0024	--
Benzo(a)pyrene	50-32-8	µg/L	12	12	100	0.03	0.65	0.143	0.101	0.386	0.03	0.65	0.143	0.101	0.386
Total cPAH BaPEq (dissolved)	BAPEQ	µg/L	1	0	0						0.0048 UT	0.0048 UT	0.0024	0.0024	
Total cPAH BaPEq	BAPEQ	µg/L	12	12	100	0.0499 JT	0.984 T	0.231	0.168	0.594	0.0499 JT	0.984 T	0.231	0.168	0.594
Phthalates															
Bis(2-ethylhexyl)phthalate (dissolved)	117-81-7	µg/L	1	1	100	1.8 J	1.8 J	1.8	1.8	--	1.8 J	1.8 J	1.8	1.8	--
Bis(2-ethylhexyl)phthalate	117-81-7	µg/L	4	4	100	2.6	17	9.95	10.1	16.1	2.6	17	9.95	10.1	16.1
Multiple Land Uses															
Solid															
Metals															
Arsenic	7440-38-2	mg/kg	5	5	100	2.36	5.6	3.37	2.89	5.19	2.36	5.6	3.37	2.89	5.19
Chromium	7440-47-3	mg/kg	5	5	100	22.5	74.3	40.2	37.5	67.6	22.5	74.3	40.2	37.5	67.6
Copper	7440-50-8	mg/kg	5	5	100	32.3	164	64.3	38	141	32.3	164	64.3	38	141
Zinc	7440-66-6	mg/kg	5	5	100	229	1020	556	289	1010	229	1020	556	289	1010
Total PCBs[c]															
Total PCBs	TOTPCBS	µg/kg	7	7	100	74.5 JT	696 JT	232	140	578	74.5 JT	696 JT	232	140	578

Table 4.4-1. LWG Summary Statistics for Sediment Trap and Stormwater Based on Land Use Type.

						Detected Concentrations					Detected and Nondetected Concentrations				
Analyte	**CAS RN**	**Units**	**N**	**N Detected**	**% Detected**	**Minimum[a]**	**Maximum[a]**	**Mean**	**Median[b]**	**95th[b]**	**Minimum (full DL)[a]**	**Maximum (full DL)[a]**	**Mean (half DL)**	**Median (half DL)[b]**	**95th (half DL)[b]**
Pesticides															
Aldrin	309-00-2	µg/kg	6	3	50	2.5	21 J	9.27	4.3	19.3	0.78 U	21 J	5.25	2.28	16.8
Dieldrin	60-57-1	µg/kg	6	4	66.7	1.3 J	3.6	2.6	2.75	3.5	1.3 J	13 U	3.16	2.75	5.78
Total Chlordanes	TOTCHLDANE	µg/kg	6	6	100	11 JT	94 JT	32.2	21.5	78.8	11 JT	94 JT	32.2	21.5	78.8
Total of 2,4'- and 4,4'-DDD, DDE, DDT	E966176	µg/kg	6	6	100	6.3 JT	180 JT	55.6	39.5	147	6.3 JT	180 JT	55.6	39.5	147
Polycyclic Aromatic Hydrocarbons															
Benzo(a)pyrene	50-32-8	µg/kg	6	6	100	54 J	1600	556	215	1480	54 J	1600	556	215	1480
Total cPAH BaPEq	BAPEQ	µg/kg	6	6	100	72.1 JT	2080 JT	764	340	1940	72.1 JT	2080 JT	764	340	1940
Phthalates															
Bis(2-ethylhexyl)phthalate	117-81-7	µg/kg	6	6	100	890 J	27000	9830	4450	25300	890 J	27000	9830	4450	25300
Water															
Metals															
Arsenic (dissolved)	7440-38-2	µg/L	11	11	100	0.305	1.37 J	0.744	0.449	1.37	0.305	1.37 J	0.744	0.449	1.37
Arsenic	7440-38-2	µg/L	15	15	100	0.49	2.22	1.39	1.44	2.21	0.49	2.22	1.39	1.44	2.21
Chromium (dissolved)	7440-47-3	µg/L	11	7	63.6	0.48	1.18	0.739	0.67	1.15	0.48	1.18	0.588	0.49	1.13
Chromium	7440-47-3	µg/L	15	15	100	2.84	11.6	7.34	6.41	11.5	2.84	11.6	7.34	6.41	11.5
Copper (dissolved)	7440-50-8	µg/L	11	11	100	2.88	12.7	6.67	6.87	11.8	2.88	12.7	6.67	6.87	11.8
Copper	7440-50-8	µg/L	15	15	100	10.3	55.6	26.6	24.3	48.7	10.3	55.6	26.6	24.3	48.7
Zinc (dissolved)	7440-66-6	µg/L	11	10	90.9	49.8	115	74.2	70.1	105	49.6 U	115	69.7	61.4	104
Zinc	7440-66-6	µg/L	15	15	100	83.6	391	217	220	387	83.6	391	217	220	387
Total PCBs[c]															
Total PCBs (dissolved)	TOTPCBS	µg/L	1	1	100	0.000661 JT	0.000661 JT	0.000661	0.000661	--	0.000661 JT	0.000661 JT	0.000661	0.000661	--
Total PCBs	TOTPCBS	µg/L	12	12	100	0.00949 JT	0.503 T	0.0836	0.0231	0.295	0.00949 JT	0.503 T	0.0836	0.0231	0.295
Polycyclic Aromatic Hydrocarbons															
Benzo(a)pyrene (dissolved)	50-32-8	µg/L	1	0	0	--	--	--	--	--	0.0046 U	0.0046 U	0.0023	0.0023	--
Benzo(a)pyrene	50-32-8	µg/L	12	11	91.7	0.015 J	0.14	0.0634	0.054	0.12	0.0046 U	0.14	0.0583	0.0515	0.118
Total cPAH BaPEq (dissolved)	BAPEQ	µg/L	1	0	0						0.0046 UT	0.0046 UT	0.0023	0.0023	
Total cPAH BaPEq	BAPEQ	µg/L	12	12	100	0.000947 JT	0.224 T	0.0856	0.0725	0.187	0.000947 JT	0.224 T	0.0856	0.0725	0.187
Phthalates															
Bis(2-ethylhexyl)phthalate (dissolved)	117-81-7	µg/L	1	0	0	--	--	--	--	--	0.44 U	0.44 U	0.22	0.22	--
Bis(2-ethylhexyl)phthalate	117-81-7	µg/L	4	4	100	1.8 J	8.9	5.03	4.7	8.41	1.8 J	8.9	5.03	4.7	8.41
Open Space															
Solid															
Metals															
Arsenic	7440-38-2	mg/kg	1	1	100	1.5	1.5	1.5	1.5	--	1.5	1.5	1.5	1.5	--
Chromium	7440-47-3	mg/kg	1	1	100	17.9	17.9	17.9	17.9	--	17.9	17.9	17.9	17.9	--
Copper	7440-50-8	mg/kg	1	1	100	12.2	12.2	12.2	12.2	--	12.2	12.2	12.2	12.2	--
Zinc	7440-66-6	mg/kg	1	1	100	48.9 J	48.9 J	48.9	48.9	--	48.9 J	48.9 J	48.9	48.9	--
Total PCBs[c]															
Total PCBs	TOTPCBS	µg/kg	1	1	100	4.13 JT	4.13 JT	4.13	4.13	--	4.13 JT	4.13 JT	4.13	4.13	--
Pesticides															
Aldrin	309-00-2	µg/kg	1	0	0	--	--	--	--	--	0.24 U	0.24 U	0.12	0.12	--
Dieldrin	60-57-1	µg/kg	1	0	0	--	--	--	--	--	0.4 U	0.4 U	0.2	0.2	--
Total Chlordanes	TOTCHLDANE	µg/kg	1	0	0	--	--	--	--	--	0.4 UT	0.4 UT	0.2	0.2	--
Total of 2,4'- and 4,4'-DDD, DDE, DDT	E966176	µg/kg	1	1	100	3.9 JT	3.9 JT	3.9	3.9	--	3.9 JT	3.9 JT	3.9	3.9	--
Polycyclic Aromatic Hydrocarbons															
Benzo(a)pyrene	50-32-8	µg/kg	1	1	100	28	28	28	28	--	28	28	28	28	--
Total cPAH BaPEq	BAPEQ	µg/kg	1	1	100	36.9 T	36.9 T	36.9	36.9		36.9 T	36.9 T	36.9	36.9	
Phthalates															
Bis(2-ethylhexyl)phthalate	117-81-7	µg/kg	1	0	0	--	--	--	--	--	30 U	30 U	15	15	--

Table 4.4-1. LWG Summary Statistics for Sediment Trap and Stormwater Based on Land Use Type.

						Detected Concentrations					Detected and Nondetected Concentrations				
Analyte	CAS RN	Units	N	N Detected	% Detected	Minimum[a]	Maximum[a]	Mean	Median[b]	95th[b]	Minimum (full DL)[a]	Maximum (full DL)[a]	Mean (half DL)	Median (half DL)[b]	95th (half DL)[b]
Water															
Metals															
Arsenic (dissolved)	7440-38-2	µg/L	2	2	100	0.124 J	0.138	0.131	0.131	0.137	0.124 J	0.138	0.131	0.131	0.137
Arsenic	7440-38-2	µg/L	3	3	100	0.196	0.228 J	0.209	0.202	0.225	0.196	0.228 J	0.209	0.202	0.225
Chromium (dissolved)	7440-47-3	µg/L	2	2	100	0.54	0.76	0.65	0.65	0.749	0.54	0.76	0.65	0.65	0.749
Chromium	7440-47-3	µg/L	3	3	100	0.87	3.05	1.71	1.22	2.87	0.87	3.05	1.71	1.22	2.87
Copper (dissolved)	7440-50-8	µg/L	2	2	100	0.74 J	1.23	0.985	0.985	1.21	0.74 J	1.23	0.985	0.985	1.21
Copper	7440-50-8	µg/L	3	3	100	1.01 J	3.07	1.75	1.16	2.88	1.01 J	3.07	1.75	1.16	2.88
Zinc (dissolved)	7440-66-6	µg/L	2	2	100	3.96	12.3 J	8.13	8.13	11.9	3.96	12.3 J	8.13	8.13	11.9
Zinc	7440-66-6	µg/L	3	3	100	3.69 J	13.1 J	8.46	8.59	12.6	3.69 J	13.1 J	8.46	8.59	12.6
Total PCBs[c]															
Total PCBs	TOTPCBS	µg/L	5	3	60	0.0000808 JT	0.000641 JT	0.00031	0.000208	0.000598	0.0000524 UT	0.000641 JT	0.000197	0.0000808	0.000554
Polycyclic Aromatic Hydrocarbons															
Benzo(a)pyrene	50-32-8	µg/L	3	0	0	--	--	--	--	--	0.0044 U	0.0046 U	0.00225	0.00225	0.0023
Total cPAH BaPEq	BAPEQ	µg/L	5	1	20	0.00088 JT	0.00088 JT	0.00088	0.00088		0.00088 JT	0.0045 UT	0.00183	0.0019	0.00224
Phthalates															
Bis(2-ethylhexyl)phthalate	117-81-7	µg/L	5	1	20	0.83 J	0.83 J	0.83	0.83	--	0.071 U	0.83 J	0.206	0.055	0.677
Residential															
Solid															
Metals															
Arsenic	7440-38-2	mg/kg	2	2	100	2.38 T	8.69	5.54	5.54	8.37	2.38 T	8.69	5.54	5.54	8.37
Chromium	7440-47-3	mg/kg	2	2	100	29.2 JT	71.8	50.5	50.5	69.7	29.2 JT	71.8	50.5	50.5	69.7
Copper	7440-50-8	mg/kg	2	2	100	49.6 T	128	88.8	88.8	124	49.6 T	128	88.8	88.8	124
Zinc	7440-66-6	mg/kg	2	2	100	334 T	856	595	595	830	334 T	856	595	595	830
Total PCBs[c]															
Total PCBs	TOTPCBS	µg/kg	2	2	100	66.7 JT	377	222	222	361	66.7 JT	377	222	222	361
Pesticides															
Aldrin	309-00-2	µg/kg	3	0	0	--	--	--	--	--	0.22 U	40 U	11.9	15.5	19.6
Dieldrin	60-57-1	µg/kg	3	1	33.3	4 NJ	4 NJ	4	4		4 NJ	31 UT	8.17	5	14.5
Total Chlordanes	TOTCHLDANE	µg/kg	3	2	66.7	9.1 JT	22 JT	15.6	15.6	21.4	9.1 JT	29 UT	15.2	14.5	21.3
Total of 2,4'- and 4,4'-DDD, DDE, DDT	E966176	µg/kg	3	2	66.7	36 JT	260 JT	148	148	249	36 JT	260 JT	115	48.5	239
Polycyclic Aromatic Hydrocarbons															
Benzo(a)pyrene	50-32-8	µg/kg	1	1	100	830 JT	830 JT	830	830	--	830 JT	830 JT	830	830	--
Total cPAH BaPEq	BAPEQ	µg/kg	1	1	100	1210 JT	1210 JT	1210	1210		1210 JT	1210 JT	1210	1210	
Phthalates															
Bis(2-ethylhexyl)phthalate	117-81-7	µg/kg	1	1	100	8200 JT	8200 JT	8200	8200	--	8200 JT	8200 JT	8200	8200	--
Water															
Metals															
Arsenic (dissolved)	7440-38-2	µg/L	4	4	100	0.245	0.41	0.321	0.315	0.4	0.245	0.41	0.321	0.315	0.4
Arsenic	7440-38-2	µg/L	6	6	100	0.255	1.36	0.556	0.415	1.17	0.255	1.36	0.556	0.415	1.17
Chromium (dissolved)	7440-47-3	µg/L	4	3	75	0.28	0.73	0.53	0.58	0.715	0.28	0.73	0.481	0.458	0.708
Chromium	7440-47-3	µg/L	6	6	100	0.83	31.8	6.78	1.59	24.8	0.83	31.8	6.78	1.59	24.8
Copper (dissolved)	7440-50-8	µg/L	4	4	100	3.44	6.94	5.52	5.84	6.93	3.44	6.94	5.52	5.84	6.93
Copper	7440-50-8	µg/L	6	6	100	6.92	83.5	21.5	9.28	65.8	6.92	83.5	21.5	9.28	65.8
Zinc (dissolved)	7440-66-6	µg/L	4	4	100	19.6	69.1	35	25.7	63.4	19.6	69.1	35	25.7	63.4
Zinc	7440-66-6	µg/L	6	6	100	30.7	609	142	49.6	477	30.7	609	142	49.6	477
Total PCBs[c]															
Total PCBs (dissolved)	TOTPCBS	µg/L	1	1	100	0.00264	0.00264	0.00264	0.00264	--	0.00264	0.00264	0.00264	0.00264	--
Total PCBs	TOTPCBS	µg/L	6	6	100	0.00114 JT	0.134 J	0.0376	0.0118	0.117	0.00114 JT	0.134 J	0.0376	0.0118	0.117

Table 4.4-1. LWG Summary Statistics for Sediment Trap and Stormwater Based on Land Use Type.

						Detected Concentrations					Detected and Nondetected Concentrations				
Analyte	**CAS RN**	**Units**	**N**	**N Detected**	**% Detected**	**Minimum[a]**	**Maximum[a]**	**Mean**	**Median[b]**	**95th[b]**	**Minimum (full DL)[a]**	**Maximum (full DL)[a]**	**Mean (half DL)**	**Median (half DL)[b]**	**95th (half DL)[b]**
Pesticides															
Aldrin (dissolved)	309-00-2	µg/L	3	0	0	--	--	--	--	--	0.00073 UJ	0.0056 UJ	0.00136	0.0009	0.00261
Aldrin	309-00-2	µg/L	3	0	0	--	--	--	--	--	0.00077 UJ	0.0053 UJ	0.00125	0.0007	0.00246
Dieldrin (dissolved)	60-57-1	µg/L	3	0	0	--	--	--	--	--	0.00049 U	0.0056 U	0.00111	0.00027	0.00255
Dieldrin	60-57-1	µg/L	3	0	0	--	--	--	--	--	0.0005 U	0.0053 U	0.00115	0.00055	0.00244
Total Chlordanes (dissolved)	TOTCHLDANE	µg/L	3	1	33.3	0.0011 T	0.0011 T	0.0011	0.0011	--	0.0011 T	0.012 UT	0.00255	0.0011	0.00551
Total Chlordanes	TOTCHLDANE	µg/L	3	3	100	0.00054 T	0.0039 JT	0.00198	0.0015	0.00366	0.00054 T	0.0039 JT	0.00198	0.0015	0.00366
Total of 2,4'- and 4,4'-DDD, DDE, DDT (dissolved)	E966176	µg/L	3	0	0						0.0012 UJT	0.023 UJT	0.00443	0.0012	0.0105
Total of 2,4'- and 4,4'-DDD, DDE, DDT	E966176	µg/L	3	1	33.3	0.00081 T	0.00081 T	0.00081	0.00081	--	0.00081 T	0.011 UJT	0.0028	0.0021	0.00516
Polycyclic Aromatic Hydrocarbons															
Benzo(a)pyrene (dissolved)	50-32-8	µg/L	3	3	100	0.011 J	0.025 J	0.0173	0.016	0.0241	0.011 J	0.025 J	0.0173	0.016	0.0241
Benzo(a)pyrene	50-32-8	µg/L	7	5	71.4	0.0062 J	0.099 J	0.0383	0.037	0.0874	0.0044 U	0.099 J	0.028	0.0085	0.0816
Total cPAH BaPEq (dissolved)	BAPEQ	µg/L	3	3	100	0.0158 JT	0.0402 JT	0.0283	0.0289	0.0391	0.0158 JT	0.0402 JT	0.0283	0.0289	0.0391
Total cPAH BaPEq	BAPEQ	µg/L	7	7	100	0.0014 JT	0.157 JT	0.0447	0.0102	0.13	0.0014 JT	0.157 JT	0.0447	0.0102	0.13
Phthalates															
Bis(2-ethylhexyl)phthalate (dissolved)	117-81-7	µg/L	1	1	100	0.2 J	0.2 J	0.2	0.2	--	0.2 J	0.2 J	0.2	0.2	--
Bis(2-ethylhexyl)phthalate	117-81-7	µg/L	6	6	100	1	6.7	3.78	3.6	6.45	1	6.7	3.78	3.6	6.45

Notes:

[a] Whenever several result values match maximum or minimum value, qualifier preference has been given in the following order: U over J over A over N over T over no qualification.

[b] Median is the exact result value ranking as the 0.50 percentile in an ascending list of all results, and 95th percentile is the exact result value of the 0.95 ranking result. When the ascending list of all results doesn't produce an exact match to the corresponding percentile rank, average of two adjacent results ranking closest to 0.50 percentile is the median, and an interpolated value is the 95th percentile. Such median or 95th percentile value is always qualified with "V". It is qualified with "U" if both results ranking immediately above and below the corresponding percentile are "U" qualified, and with "J" if at least one of the results is "J" qualified.

[c] Total PCBs are total PCB congeners whenever available, regardless of their qualification.

Reason codes for qualifiers:

J - The associated numerical value is an estimated quantity.
N - Presumptive evidence of presence of material; identification of the compound is not definitive.
T - The associated numerical value was mathematically derived (e.g., from summing multiple analyte results such as Aroclors, or calculating the average of multiple results for a single analyte). Also indicates all results that are selected for reporting in preference to other available results (e.g., for parameters reported by multiple methods) for the Round 2 data.
U - The material was analyzed for, but was not detected. The associated numerical value is the sample quantitation limit.

-- data not available.
BaPEq - benzo(a)pyrene equivalents
cPAH - carcinogenic polycyclic aromatic hydrocarbon
DL - detection limit
PCB - polychlorinated biphenyl
PCDD/Fs - dioxins/furans

Table 4.4-2. Stormwater and Catch Basin Investigations under the JSCS Program.

Survey Name	Survey ID	Included in Stats?	Study Objective	River Mile(s)	Begin Date	End Date	Number of Samples	Composite (Y/N)	QA Category	Conv.	Metals	SVOCs (includes PAH & Phthalates)	PAH only	Phthalates Only	PCBs (Aroclors)	Pest.	VOCs	TPH-Gas	TPH-Diesel & Oil	Other
ABF Freight	WLCAFF07	Yes	Catch basin solids	9.1	6/4/2007	6/4/2007	2 Catch basin solids	N	Cat 1 QA 1 TOC & Pesticides Cat 2	X	X		X	X	X	X				X
Advanced American Construction Property	WLCAAE06	Yes	Stormwater sampling	5.6	5/26/2006	5/2/2007	3 Stormwaters	N	Cat 1 QA1 Some TPH data Cat 2		X		X					X	X	
Anderson Bros., Stormwater, March 2007	WLCABL06	Yes	Stormwater sampling	7.8, 7.9	12/26/2006	3/7/2007	4 Stormwaters	N	Cat 1 QA 1 VOCs Cat 2		X	X			X	X	X		X	
Ashland Chemical	WLCALF07	Yes	Catch basin solids	9.2	6/21/2007	6/21/2007	1 Catch basin solid	N	Cat 1 QA 1 TOC Cat 2	X	X		X	X	X	X				
Boydstun Metal Works at Burgard Industrial Park	WLCBSA02	No, too old	Catch basin solids	4.2	1/28/2002	1/28/2002	1 Catch basin solid	N	Cat 1 QA 1		X		X				X	X	X	
Calbag Metals/Former ACME Supply and Trading Company	WLCCBA05	Yes	Stormwater and catch basin solids	8.3 - 8.5	1/4/2005	1/6/2005	7 Catch basin solids 10 Stormwaters	Y	Cat 1 QA1 Oil & Grease & some Aroclor & PAH data Cat 2	X	X	X			X			X	X	
Chapel Steel	WLCCSJ05	Yes	Catch basin solids	8.7	6/11/2007	6/11/2007	1 Catch basin solid	N	Cat 1 QA 1 Pesticides Cat 2	X	X		X	X	X	X				X
Christenson Oil	WLCCHK01	Yes	Stormwater and catch basin solids	8.8	11/19/2001	6/9/2007	1 Catch basin solid 6 Stormwaters	N	Mixture of Cat1 QA1 & Cat 2	X	X	X			X		X	X	X	
Consolidated Metco-Rivergate-Response	WLCCMJ04	Yes	Stormwater sampling	2.8 - 3	10/26/2004	4/10/2006	9 Stormwaters	N	Cat 1 QA 1	X	X									
Container Recovery	WLCCRL06	Yes	Catch basin solids	8.9 - 9	6/5/2007	6/5/2007	2 Catch basin solids	N	Cat 1 QA 1 Pesticides Cat 2	X	X		X	X	X	X				X
Fred Devine Diving & Salvage, Inc.	WLCFDB01	No, too old	Stormwater and catch basin solids	8.2 - 8.4	2/21/2002	4/30/2002	4 Catch basin solids 1 Stormwater	N	Cat 2	X	X	X			X					
Freightliner Truck Manufacturing	WLCFLL06	Yes	Stormwater and catch basin solids	9.3	12/20/2006	6/5/2007	2 Catch basin solids 6 Stormwaters	Y	Cat 1 QA 1	X	X		X	X	X					
Galvanizers Company	WLCGLC07	Yes	Stormwater and catch basin solids	9.7	11/2/2006	6/24/2007	3 Catch basin solids 17 Stormwaters	N	Cat 1 QA 1 Grain size & some PAH Cat 2	X	X		X	X	X					
Stormwater-PGE-Forest Park	WLCGFE06	Yes	Source tracing	8.4 - 8.5	5/2/2006	10/11/2006	15 In-line solids	N	Cat 1 QA 1						X	X				
Linnton Plywood Association	WLCLPJ01	No, too old	Catch basin solids	4.5 - 4.6	10/16/2001	10/16/2001	4 Catch basin solids	N	Cat 2		X	X			X		X	X	X	
McCall Oil, RI, July 2004	WLCMOL00	Yes	Stormwater and catch basin solids	7.8 - 7.9	12/15/2000	5/2/2007	6 Catch basin solids 19 Stormwaters	N	Mixture of Cat1 QA1 & Cat 2	X	X	X			X			X	X	
Northwest Pipe Company	WLCNPI03	No, too old and Cat2	Stormwater source control efforts	3.9 - 4.3	9/9/2003	7/8/2005	8 Stormwaters	N	2003 PCBs, metals, TSS, & oil & grease Cat 1 QA 1 All else Cat 2	X	X		X		X			X		
Zidell Property at 5200 NW Front Avenue	WLCZDJ89	No, too old	One drain sediment	8.1	10/2/1989	10/2/1989	1 Catch basin solid	N	Metals Cat 1 QA1 Aroclors & TPH Cat2		X				X			X	X	
Oregon Steel Mill	WLCOSJ96	No, too old	Stormwater and catch basin solids	2 - 2.4	10/14/1996	10/23/2002	23 Catch basin solids 17 Stormwaters	N	CBSO Cat 1 QA2 Waters Cat 1 QA1	X	X	X			X		X	X	X	

Table 4.4-2. Stormwater and Catch Basin Investigations under the JSCS Program.

Survey Name	Survey ID	Included in Stats?	Study Objective	River Mile(s)	Begin Date	End Date	Number of Samples	Composite (Y/N)	QA Category	Conv.	Metals	SVOCs (includes PAH & Phthalates)	PAH only	Phthalates Only	PCBs (Aroclors)	Pest.	VOCs	TPH-Gas	TPH-Diesel & Oil	Other
Owens Corning Linnton Site	WLCOLB01	Yes	Stormwater and catch basin solids	3.6 - 3.8	2/2/2001	7/18/2007	2 Catch basin solids 13 Stormwaters	N	Cat 1 QA1 oil & grease & some pH Cat2	X	X		X	X	X			X	X	
Carson Oil	WLCCOF07	Yes	Catch basin solids	9.2	6/7/2007	6/7/2007	2 Catch basin solids	N	Cat 1 QA 1 TOC & pesticides Cat 2	X	X		X	X	X	X				X
Owens-Corning, 3750 N.W. Yeon Avenue	WLCOCF07	Yes	Catch basin solids	9.1	6/15/2007	6/15/2007	1 Catch basin solid	N	Cat 1 QA 1 Pesticides Cat 2	X	X		X	X	X	X				X
Paco / Sulzer Pumps	WLCPPF07	Yes	Stormwater and catch basin solids	9.6 - 10.4	1/28/2004	6/20/2007	23 Catch basin solids 16 Stormwaters	Y	Mixture of Cat1 QA1 & Cat 2	X	X	X			X				X	
USCG catch basin sampling	WLCCGD06	Yes	Stormwater and catch basin solids	8 - 8.1	4/14/2006	6/1/2006	14 Catch basin solids 18 Stormwaters	N	Cat 1 QA 1 SVOC & some VOC Cat 2	X	X	X			X			X	X	X
UPRR Albina	WLCAYH00	No, too old	XPA stormwater and catch basin data	9.9 - 10.8	8/9/2000	8/17/000	4 Catch basin solids 9 Stormwaters	N	Mixture of Cat1 QA1 & Cat 2		X	X			X		X	X	X	
GE 2007 stormwater outfall monitoring	WLCGED07	Yes	Stormwater sampling	9.6	4/12/2007	6/10/2007	16 Stormwaters	Y	Cat 1 QA2	X	X		X	X	X				X	X
City Outfall Basin 19 Inline Solids Sampling at the Former Calbag Metals	WLCOFJ02	Yes	Source tracing	8.3	6/18/2007	6/18/2007	1 Sediment trap	N	QA1Cat1						X					
City Outfall Basin 22B Inline Solids Evaluation	WLCOFJ02	Yes	Source tracing	6.9	9/30/2003	11/8/2006	4 In-line solids	Y	NWTPH-Dx & PAH data Cat 1 QA1 All other data Cat 2	X	X	X			X	X	X	X	X	X
City Outfall Basin 22C Northwest Drainage Pond Evaluation	WLCOFJ02	No, Cat2	Source tracing	6.7 - 6.8	11/24/2003	12/19/2003	4 Soils	N	Cat 2		X	X				X	X	X	X	X
City Outfall Basin 22C, Inline Solids Sampling in the Vicinity of Kopp	WLCOFJ02	Yes	Source tracing	6.3 - 6.4	11/5/2003	9/11/2006	7 In-line solids	Y	Cat1 QA1 Some Cat 2 data	X	X	X			X			X	X	
City Outfall Basin 46 Inline Solids Sampling in the Vicinity of the Union Pacific Railroad Albina Yard	WLCOFJ02	Yes	Source tracing	10.4 - 10.7	8/9/2000	8/2/2005	5 In-line solids	N	QA1Cat1	X	X	X			X			X	X	
City Outfall Basin 47 Inline Solids Sampling	WLCOFJ02	Yes	Source tracing	9.8 - 9.9	6/28/2006	6/28/2006	4 In-line solids	N	Cat 1 QA1 Grain size Cat 2	X					X					
City Outfall Basin 48 Inline Solids Sampling	WLCOFJ02	Yes	Source tracing	7.2	6/20/2006	6/20/2006	1 In-line solid	N	Cat 1 QA1 Grain size & metals Cat 2	X	X		X	X	X	X				
City Outfall Basin 49 Inline Solids Sampling and Basin Priority Reassessment	WLCOFJ02	Yes	Source tracing	6.3 - 6.4	7/25/2005	7/25/2005	2 In-line solids	N	Cat 1 QA1		X									
City Outfall Basin 52A Catch Basin Solids Sampling Adjacent to Mar Com	WLCOFJ02	Yes	Source tracing	5.5 - 5.6	7/25/2005	7/25/2005	2 In-line solids	N	Cat 1 QA1 Metals Cat 2		X	X			X			X	X	
City Outfall Basin M-2 Dry-Weather Flow Sampling	WLCOFJ02	No, Cat2	Source tracing	8.8	9/19/2002	8/3/2005	4 Waters	N	Cat 2		X									
City Outfall Basin M-3 Dry-Weather Flow Sampling	WLCOFJ02	No, Cat2	Source tracing	9.1 - 9.3	9/19/2002	9/1/2005	5 Waters	N	Cat 2		X									

Table 4.4-2. Stormwater and Catch Basin Investigations under the JSCS Program.

Survey Name	Survey ID	Included in Stats?	Study Objective	River Mile(s)	Begin Date	End Date	Number of Samples	Composite (Y/N)	QA Category	Conv.	Metals	SVOCs (includes PAH & Phthalates)	PAH only	Phthalates Only	PCBs (Aroclors)	Pest.	VOCs	TPH-Gas	TPH-Diesel & Oil	Other
City Outfall Basin S-5 Inline Solids Sampling	WLCOFJ02	Yes	Source tracing	9 - 9.3	7/26/2005	7/26/2005	2 In-line solids	N	Cat 1 QA1 Phthalates & metals Cat 2		X		X	X						
City Outfall Basin S-6 Inline Solids Sampling	WLCOFJ02	Yes	Source tracing	8.4 - 8.6	6/20/2006	7/19/2006	4 In-line solids	N	Cat 1 QA1 Grain size & metals Cat 2	X	X		X	X	X					
Basin 19 Stormwater sampling	WLCOFJ02	Yes	Source tracing	8.3	3/8/2006	2/14/2007	8 Waters	Y	All 8082 data QA1Cat1 8270 data, except FY05/06 Event 3 data QA1Cat1 All else Cat 2 Will probably need reports to determine which 8270 data is Cat 1/2	X	X	X			X					
Basin 53 Stormwater sampling	WLCOFJ02	Yes	Source tracing	5.1	1/25/2008	3/13/2008	3 Composite waters plus one duplicate	Y	8270 & TOC data Cat 1 QA 1 All else Cat 2	X	X	X			X					X
Port of Portland Terminal 1 North Catch Basin Solids Data	WLCOFJ02	Yes	Source tracing	10.5 - 10.6	5/18/2007	5/18/2007	2 Catch basin solids	N	SVOC Cat 1 QA 1 All other data Cat 2	X	X	X			X					
Siltronic catch basin and stormwater - June 2001, Nov 2006, Feb 2007	WLCSLF01	Yes	Stormwaters and 1 catch basin solid	6.4 - 6.7	6/19/2001	2/14/2007	9 Stormwaters 1 Catch basin solid	Y	TOC & Metals Cat 1 QA 1 All other data Cat 2	X	X		X	X	X		X		X	
Gunderson Outfall Effluent and Seep Monitoring (additional data)	WLCGND05	Yes	Outfall and seep monitoring	8.5 - 9.1	1/28/1999	2/16/2007	55 Waters 132 Catch basin solids	N	Cat 1 QA1		X		X	X	X		X	X	X	X
T4 Spring 2007 outfall monitoring	WLCT4C07	Yes	Stormwater sampling	4.2 - 5.1	3/24/2007	5/20/2007	29 Stormwaters from 7 locations	N	Cat 1 QA 1 except 1668 data which is Cat 2	X	X		X	X	X	X				X
City of Portand 1200Z TSS monitoring data	WLC1200Z	No, Cat2	Outfall monitoring	2.1 - 10.8	05/21/1993	11/16/2007	777 Samples from 71 locations	N	Cat 2	X										
Chevron Willbridge Distribution Center catch basin monitoring	WLCCWK06	Yes	Catch basin solids	7.6 - 7.7	11/16/2006	11/21/2006	5 Catch basin solids	Y	Cat 1 QA 1 except 8081 data which is Cat 2	X	X	X			X	X	X			
Former Chevron Willbridge Asphalt Plant Catch Basin	WLCCAI06	Yes	Catch basin monitoring	7.8 - 8.1	9/5/2006	2/22/2007	2 Stormwaters, 7 catch basin solids, & 2 in-line solids	Y	Catch Basins Cat 2 Waters Cat 1 QA1	X	X	X	X	X	X	X	X	X	X	
Kinder Morgan Linnton catch basin (10/06) and stormwater (2007)	WLCKLJ06	Yes	Catch basin and stormwater monitoring	4.0 - 4.2	10/12/2006	10/24/2007	3 Waters 5 Catch basin solids	N	CBSO 8270 (PAH & phthalates) Cat 2 All else Cat1 QA 1	X	X		X	X	X		X	X	X	
Kinder Morgan Willbridge stormwater and catch basin May 2007	WLCKWE07	Yes	Catch basin and stormwater monitoring	7.4 - 7.5	5/11/2007	11/13/2007	4 Waters 3 Catch basin solids	N	Grain size & 8270 Cat 2 All else Cat 1 QA 1		X		X	X	X	X	X	X	X	
2005 stormwater sampling at the Arco/BP site	WLCARD05	Yes	Source control	4.8 - 4.9	4/25/2005	7/28/2005	2 Waters 3 Catch basin solids	N	Cat 1 QA1 Except Water TPH-G & -D data which is Cat 2		X		X				X	X	X	

Table 4.4-2. Stormwater and Catch Basin Investigations under the JSCS Program.

Survey Name	Survey ID	Included in Stats?	Study Objective	River Mile(s)	Begin Date	End Date	Number of Samples	Composite (Y/N)	QA Category	Conv.	Metals	SVOCs (includes PAH & Phthalates)	PAH only	Phthalates Only	PCBs (Aroclors)	Pest.	VOCs	TPH-Gas	TPH-Diesel & Oil	Other
Arkema Stormwater February 15, 2007	C250-0101_WO1	Yes	Stormwater monitoring	7.1 - 7.3	2/15/2007	2/15/2007	4 Stormwaters	N	QA2Cat1	X	X		X			X				
Arkema Stormwater March 2, 2007	C250-0101_WO2	Yes	Stormwater monitoring	7.1 - 7.3	3/2/2007	3/2/2007	4 Stormwaters	N	QA1Cat1	X	X		X			X				
Arkema Stormwater March 19, 2007	C250-0101_WO3	Yes	Stormwater monitoring	7.1 - 7.3	3/19/2007	3/19/2007	4 Stormwaters	N	QA1Cat1	X	X		X			X				
Arkema Stormwater June 5, 2007	C250-0101_WO4	Yes	Stormwater monitoring	7.1 - 7.3	6/5/2007	6/5/2007	2 Stormwaters	N	QA1Cat1	X	X		X			X				
Arkema Stormwater August 14, 2007	C250-0101_WO5	No, missing XY	Stormwater monitoring	7.1 - 7.3	8/14/2007	8/14/2007	1 Stormwater	N	QA1Cat1	X	X		X			X	X			X
Rhône-Poulenc Outfalls 22B and 22C Effluent	WLCRPI04	Yes	Stormwater monitoring	6.8 - 6.9	10/1/1993	9/23/2004	2 Stormwaters	N	QA2Cat1, except diesel & oil: QA2Cat2	X	X	X				X	X		X	
Willbridge Terminals Catch Basin Solids for Stormwater Source Control	WLCWTI07	Yes	Source control	7.7	9/24/2007	9/26/2007	12 Catch basin solids	N	Cat1	X	X	X			X	X	X	X	X	

Table 4.4-2. Stormwater and Catch Basin Investigations under the JSCS Program.

Survey Name	Comment	Reference[a]	Phase Code
ABF Freight	Conventionals: TOC, Grain Size. Herbicides also analyzed	Oregon Department of Environmental Quality ABF Freight Sight Discovery file	ODEQ0005
Advanced American Construction Property		Maul Foster & Alongi, 2007	MFA0006
Anderson Bros., Stormwater, March 2007		Wohlers Environmental Services, Inc., 2007	WOH0003
Ashland Chemical	Conventionals: TOC, Grain Size. Herbicides also analyzed	Oregon Department of Environmental Quality Ashland Chemical Site Discovery file	ODEQ0006
Boydstun Metal Works at Burgard Industrial Park	VOC limited to PCE & breakdown product.	Bridgewater Group, Inc. 2002	BGI0001
Calbag Metals/Former ACME Supply and Trading Company	Some samples composited, not all. Conventionals: pH, TSS, oil & grease TPH results from NWTPH-HCID	Creekside Environmental Consulting, LLC. 2005, 2006	CEC0001, CEC0002
Chapel Steel	Conventionals: TOC. Herbicides also analyzed	Oregon Department of Environmental Quality Chapel Steel Site Discovery file	ODEQ0008
Christenson Oil	Conventionals: pH, TSS, Oil & Grease	Wohlers Environmental Services, Inc. 2007	WOH0001, WOH0002
Consolidated Metco-Rivergate-Response	Conventionals: pH, TSS, Oil & Grease Metals: Cu, Pb, Zn only	Kennedy/Jenks Consultants, 2007	KJC0003
Container Recovery	Conventionals: TOC, Grain Size. Herbicides also analyzed	Oregon Department of Environmental Quality Container Recovery Site Discovery file	ODEQ0009
Fred Devine Diving & Salvage, Inc.	Conventionals: TSS, COD, pH, Oil & Grease, temperature	EVREN Northwest 2007; Evergreen Environmental Management, Inc.	EVN0001, EEM0001
Freightliner Truck Manufacturing	CBSO are composites, SW are not. Conventionals: TSS, Hexavalent chrome	Maul Foster & Alongi, 2007	MFA0008
Galvanizers Company	Conventionals: TOC	Anchor Environmental, LLC. 2007	AEL0006
Stormwater-PGE-Forest Park		City of Portland, 2007	COP0002
Linnton Plywood Association	Only TPH-Gas & diesel ranges reported	CH2M Hill, 2002	CH20006
McCall Oil, RI, July 2004	Conventionals: TOC, TSS	Anchor Environmental, LLC. 2004	AEL0005
Northwest Pipe Company	Conventionals: TSS, Oil & grease	CH2M Hill, 2005	CH20007
Zidell Property at 5200 NW Front Avenue	Only TPH-Gas & diesel ranges reported	Maul Foster Alongi, 1989	MFA0009
Oregon Steel Mill	Conventionals: TSS, pH, DO, Redox, conductivity, pH, Redox potential, temperature, turbidity.	Exponent, 2003 Hart Crowser 1998	EXP0003, HC0014

Table 4.4-2. Stormwater and Catch Basin Investigations under the JSCS Program.

Survey Name	Comment	Reference[a]	Phase Code
Owens Corning Linnton Site	Conventionals: TSS, oil & grease, pH, TOC. TPH-Gas result from NWTPH-HCID	Kennedy/Jenks Consultants. 2001, 2002, & 2007	KJC0001, KJC0002
Carson Oil	Conventionals: TOC, grain size Herbicides also analyzed	Oregon Department of Environmental Quality Carson Oil Site Discovery file	ODEQ0007
Owens-Corning, 3750 N.W. Yeon Avenue	Conventionals: TOC, Grain Size. Herbicides also analyzed	Oregon Department of Environmental Quality Site Discovery file	ODEQ0010
Paco / Sulzer Pumps	Some CBSO samples composited, not all. Conventionals: TSS, TOC, grain size, oil & grease.	Sterling Technologies, 2006; GeoDesign 2007; City of Portland 2007	STT0001, GD0001, COP0001
USCG catch basin sampling	Conventionals: pH, flow, conductivity, temperature, turbidity, Na & K	TEC Inc,. 2006	TEC0001
UPRR Albina	TPH-Gas result from NWTPH-HCID Butyltins also analyzed	Jacobs Engineering, 2000	JBE0003
GE 2007 stormwater outfall monitoring	Conventionals: TOC, DOC, TSS TPH - Only diesel range reported PCB congeners also reported.	AMEC, 2008	AMEC0001
City Outfall Basin 19 Inline Solids Sampling at the Former Calbag Metals		City of Portland, 2008	COP0004
City Outfall Basin 22B Inline Solids Evaluation	1 of the 4 samples is a composite. Conventionals: TOC. Herbicides also analyzed.	City of Portland, 2008	COP0008
City Outfall Basin 22C Northwest Drainage Pond Evaluation	Conventionals: TOC, volatile residue PCDD/Fs & Herbicides also reported	City of Portland, 2007	COP0007
City Outfall Basin 22C, Inline Solids Sampling in the Vicinity of Kopp	1 of the 7 samples is a composite. Conventionals: TOC, Cyanide	City of Portland, 2007	COP0006
City Outfall Basin 46 Inline Solids Sampling in the Vicinity of the Union Pacific Railroad Albina Yard	Conventionals: TOC Butyltins also analyzed	City of Portland, 2006	COP0010
City Outfall Basin 47 Inline Solids Sampling	Conventionals: TOC, grain size	City of Portland, 2007	COP0017
City Outfall Basin 48 Inline Solids Sampling	Conventionals: TOC, grain size	City of Portland, 2008	COP0011
City Outfall Basin 49 Inline Solids Sampling and Basin Priority Reassessment	Mercury only	City of Portland, 2006	COP0009
City Outfall Basin 52A Catch Basin Solids Sampling Adjacent to Mar Com		City of Portland, 2006	COP0012
City Outfall Basin M-2 Dry-Weather Flow Sampling	Zinc only	City of Portland, 2006	COP0013
City Outfall Basin M-3 Dry-Weather Flow Sampling	Metals: Cu, Pb, Zn	City of Portland, 2006	COP0014

Table 4.4-2. Stormwater and Catch Basin Investigations under the JSCS Program.

Survey Name	Comment	Reference[a]	Phase Code
City Outfall Basin S-5 Inline Solids Sampling		City of Portland, 2006	COP0015
City Outfall Basin S-6 Inline Solids Sampling	Conventionals: TOC, grain size	City of Portland, 2008	COP0016
Basin 19 Stormwater sampling	7 of the 8 samples are composites Conventionals: Oil & grease, nitrate, N-ammonia, total kjeldahl nitrogen, orthophosphate, total phosporous, hardness, conductivity, TDS, TSS, temperature, pH, BOD, COD, hardness, E. Coli	City of Portland, 2008	COP0003
Basin 53 Stormwater sampling	4 of the 6 samples are composites Conventionals: TSS, TOC, pH, conductivity, temperature PCB Congeners also reported	City of Portland, 2008	COP0018
Port of Portland Terminal 1 North Catch Basin Solids Data	Conventionals: Grain size, TOC	City of Portland, 2007	COP0005
Siltronic catch basin and stormwater - June 2001, Nov 2006, Feb 2007	CBSO was a composite, stormwaters were not. Conventionals: TDS, cyanide, TOC	AMEC, 2003, 2004, 2005	KJG0001
Gunderson Outfall Effluent and Seep Monitoring (additional data)	Tributyl tin (only) also analyzed	Kleinfelder, 2008	KFI0008
T4 Spring 2007 outfall monitoring	Conventionals: TOC, DOC, turbidity, Oil & Grease PCB congeners also analyzed	Ash Creek Assoc., 2007	
City of Portand 1200Z TSS monitoring data	TSS data	City of Portland data	
Chevron Willbridge Distribution Center catch basin monitoring	Conventionals: Grain size, cyanide	Arcadis, 2007	ARCB0002
Former Chevron Willbridge Asphalt Plant Catch Basin	Solid samples were composites Conventionals: TSS, grain size, cyanide. Some SVOCs full list, others PAH/Phthalates only	Arcadis, 2007	ARCB0001
Kinder Morgan Linnton catch basin (10/06) and stormwater (2007)	Conventionals: TSS, TOC VOC: Benzene only	Delta Environmental Assoc.	
Kinder Morgan Willbridge stormwater and catch basin May 2007	Conventionals: TSS, TOC VOC: BTEX, n-, sec-butlybenzenes, n-propylbenzene, & 1,2,4-trimethylbenzene only	Delta Environmental Assoc.	
2005 stormwater sampling at the Arco/BP site		URS, 2006	URS0003

Table 4.4-2. Stormwater and Catch Basin Investigations under the JSCS Program.

Survey Name	Comment	Reference[a]	Phase Code
Arkema Stormwater February 15, 2007	TSS, perchlorate, Mg, hexchrome, PAH, pesticides	ESI 1/10/2007, Arkema Report 2_stormwater	
Arkema Stormwater March 2, 2007	TSS, perchlorate, Mg, hexchrome, PAH, pesticides	ESI 1/10/2007, Arkema Report 3_stormwater	
Arkema Stormwater March 19, 2007	TSS, perchlorate, Mg, hexchrome, PAH, pesticides	ESI 1/10/2007, Arkema Report 4_stormwater	
Arkema Stormwater June 5, 2007	TSS, perchlorate, pH, Mg, hexchrome, PAH, pesticides	ESI 1/10/2007, Arkema Report 6 & 7_stormwater	
Arkema Stormwater August 14, 2007	Solids, Hg, PCDD/Fs, PAH, PCP, pesticides, herbicides, VOC	ESI 1/10/2007, Arkema Report 9_stormwater	
Rhône-Poulenc Outfalls 22B and 22C Effluent		Rhône-Poulenc Outfalls 22B and 22C Effluent	AMEC0001
Willbridge Terminals Catch Basin Solids for Stormwater Source Control		Upland Stormwater Source Control Status Report	DLT0001

Notes:
[a]See Appendix A1.

BOD - biological oxygen demand
BTEX - benzene, toluene, ethylbenzene, and xylenes
CBSO - catch basin solid
COD - chemical oxygen demand
DO - dissolved oxygen
DOC - dissolved organic carbon
FY - fiscal year
JSCS - Joint Source Control Strategy
NWTPH - Northwest total petroleum hydrocarbons
QA - quality assurance
PAH - polycyclic aromatic hydrocarbon
PCB - polychlorinated biphenyl
PCDD/Fs - dioxins/furans
PCP - pentachlorophenol
SVOC - semivolatile organic compound
TDS - total dissolved solids
TOC - total organic carbon
TPH - total petroleum hydrocarbon
TSS - total suspended solids
VOC - volatile organic compound
XPA - expanded preliminary assessment

Table 4.4-3. Non-LWG Summary Statistics for Sediment Trap and Stormwater.

						Detected Concentrations					Detected and Nondetected Concentrations				
Analyte	CAS RN	Units	N	N Detected	% Detected	Minimum[a]	Maximum[a]	Mean	Median[b]	95th[b]	Minimum (full DL)[a]	Maximum (full DL)[a]	Mean (half DL)	Median (half DL)[b]	95th (half DL)[b]
Solid															
Metals															
Arsenic	7440-38-2	mg/kg	138	134	97.1	1.38	259	21.6	9.61	65.1	1.38	259	21.1	9.53	62.7
Chromium	7440-47-3	mg/kg	176	176	100	15.1	517	117	91.8	301	15.1	517	117	91.8	301
Copper	7440-50-8	mg/kg	184	184	100	23.9	13200	1370	413	5550	23.9	13200	1370	413	5550
Zinc	7440-66-6	mg/kg	184	184	100	135	17300	2410	1240	8000	135	17300	2410	1240	8000
Butyltins															
Tributyltin ion	36643-28-4	µg/kg	16	14	87.5	21	77	39.9	34.5	64.7	1.19 U	77	35	32.5	62.8
Total PCBs[c]															
Total PCBs	TOTPCBS	pg/g	192	127	66.1	11000 T	16700000	764000	266000	3350000	1550 UT	16700000	514000	94500	2510000
Pesticides															
Aldrin	309-00-2	µg/kg	36	2	5.56	1.1	70.2	35.7	35.7	66.7	1.1	144 U	16.4	2.74	55.1
Dieldrin	60-57-1	µg/kg	36	5	13.9	4.42	47.1	24	12	47.1	1.9 U	463 U	21.4	3.94	47.8
Total Chlordanes	TOTCHLDANE	µg/kg	36	4	11.1	2.8 A	18 JT	9.38	8.35	17.3	0.93 UA	144 UA	16.9	4.34	47.2
Total of 2,4' and 4,4'-DDD, -DDE, -DDT	E966176	µg/kg	36	15	41.7	8.91 A	360 A	58	37.4	163	3.95 UA	718 UA	72.9	39.8	277
Polycyclic Aromatic Hydrocarbons															
Benzo(a)pyrene	50-32-8	µg/kg	142	72	50.7	29 J	85000	4100	473	15600	6.67 U	85000	2230	301	4900
Total cPAH BaPEq	BAPEQ	µg/kg	146	131	89.7	0.213 T	127000 T	3400	180	9360	0.213 T	127000 T	3090	204	7610
Phthalates															
Bis(2-ethylhexyl) phthalate	117-81-7	µg/kg	154	145	94.2	150	475000	34500	20900	101000	60 U	475000	32700	17500	99100
Water															
Metals															
Arsenic (dissolved)	7440-38-2	µg/L	30	3	10	1.08	5.49	3.42	3.7	5.31	0.028 U	1000 U	33.9	0.425	277
Arsenic	7440-38-2	µg/L	87	42	48.3	0.18 J	20.2	2.9	1.5	8.04	0.028 U	1000 U	7.36	0.5	6.88
Chromium (dissolved)	7440-47-3	µg/L	32	11	34.4	0.2	5	1.24	0.9	3.16	0.129 U	5 U	1.35	0.98	2.5
Chromium	7440-47-3	µg/L	113	82	72.6	0.512	88.7	7.91	3	40	0.129 U	88.7	6.03	2.32	29
Copper (dissolved)	7440-50-8	µg/L	40	28	70	2.46	48	12.8	8.27	36.7	0.788 U	48	10.4	5.95	32.4
Copper	7440-50-8	µg/L	139	128	92.1	0.81	1400	72.3	20.5	242	0.81	1400	66.9	18.4	207
Zinc (dissolved)	7440-66-6	µg/L	40	39	97.5	2.34	24000	1980	240	8640	2.34	24000	1930	232	8620
Zinc	7440-66-6	µg/L	144	141	97.9	2.87 J	48200	1670	260	7650	0.193 U	48200	1640	255	7550
Butyltins															
Tributyltin ion	36643-28-4	µg/L	2	1	50	0.00544	0.00544	0.00544	0.00544	--	0.000424 U	0.00544	0.00283	0.00283	0.00518
Total PCBs[c]															
Total PCBs	TOTPCBS	pg/l	64	2	3.13	29000 JT	1400000 T	715000	715000	1330000	9460 UT	1720000 UT	197000	195000	500000
PCDD/Fs															
Dioxin/furan TCDD toxicity equivalent (ND = 0)	TEQ_DIOXIN.0	pg/l	2	1	50	0.042 T	0.042 T	0.042	0.042	--	0.042 T	8.9 UT	2.25	2.25	4.23
Pesticides															
Aldrin	309-00-2	µg/L	10	2	20	0.00021 J	0.00026 J	0.000235	0.000235	0.000258	0.00011 UJ	0.0976 U	0.0108	0.00195	0.0381
Dieldrin	60-57-1	µg/L	10	0	0	--	--	--	--	--	0.0004 U	0.0976 U	0.0108	0.00195	0.0381
Total Chlordanes	TOTCHLDANE	µg/L	10	1	10	0.0017 JT	0.0017 JT	0.0017	0.0017	--	0.00073 UT	0.0976 UA	0.0109	0.00158	0.0381
Total of 2,4' and 4,4'-DDD, -DDE, -DDT (dissolved)	E966176	µg/L	14	13	92.9	0.00213 A	0.247 A	0.0415	0.0286	0.128	0.00213 A	0.247 A	0.0387	0.0272	0.118
Total of 2,4' and 4,4'-DDD, -DDE, -DDT	E966176	µg/L	24	18	75	0.00044 JT	4.48 A	0.592	0.314	1.85	0.00044 JT	4.48 A	0.456	0.264	1.3

Table 4.4-3. Non-LWG Summary Statistics for Sediment Trap and Stormwater.

						Detected Concentrations					Detected and Nondetected Concentrations				
Analyte	**CAS RN**	**Units**	**N**	**N Detected**	**% Detected**	**Minimum[a]**	**Maximum[a]**	**Mean**	**Median[b]**	**95th[b]**	**Minimum (full DL)[a]**	**Maximum (full DL)[a]**	**Mean (half DL)**	**Median (half DL)[b]**	**95th (half DL)[b]**
Polycyclic Aromatic Hydrocarbons															
Benzo(a)pyrene	50-32-8	µg/L	108	23	21.3	0.0046 J	0.21	0.0384	0.017	0.109	0.0043 U	10 U	0.0774	0.024	0.103
Total cPAH BaPEq	BAPEQ	µg/L	108	59	54.6	0.00000509 T	0.381 T	0.0274	0.00783	0.102	0.00000509 T	10 UT	0.0801	0.0222	0.0994
Phthalates															
Bis(2-ethylhexyl) phthalate	117-81-7	µg/L	87	63	72.4	0.734	40 J	3.6	2.2	9.24	0.27 U	40 J	2.9	1.8	9.17

Notes:

[a] Whenever several result values match maximum or minimum value, qualifier preference has been given in the following order: U over J over A over N over T over no qualification.

[b] Median is the exact result value ranking as the 0.50 percentile in an ascending list of all results, and 95th percentile is the exact result value of the 0.95 ranking result. When the ascending list of all results doesn't produce an exact match to the corresponding percentile rank, the average of two adjacent results ranking closest to 0.50 percentile is the median, and an interpolated value is the 95th percentile. Such median or 95th percentile value is always qualified with "V". It is qualified with "U" if both results ranking immediately above and below the corresponding percentile are "U" qualified, and with "J" if at least one of the results is "J" qualified.

[c] Total PCBs are total PCB congeners whenever available regardless of their qualification.

Reason codes for qualifiers:

A - Total value based on limited number of analytes.

J - The associated numerical value is an estimated quantity.

T - The associated numerical value was mathematically derived (e.g., from summing multiple analyte results such as Aroclors, or calculating the average of multiple results for a single analyte). Also indicates all results that are selected for reporting in preference to other available results (e.g., for parameters reported by multiple methods) for the Round 2 data.

U - The material was analyzed for but was not detected. The associated numerical value is the sample quantitation limit.

-- data not available.

BaPEq - benzo(a)pyrene equivalent

cPAH- carcinogenic polycyclic aromatic hydrocarbon

DL - detection limit

PCB - polychlorinated biphenyl

PCDD/Fs - dioxins/furans

Table 4.4-4. Shared Conveyance System Basin Characteristics and Potential Sources.

Outfall ID	River Bank	Owner	Outfall Size (Inches)	Outfall Material[a]	Outfall Status	CSO[b]/SSO[c]	2008 Stormwater Basin Acreage and Zoning[d]	COIs within Outfall Basin Area Identified during Independent Investigations[e]	Other Potential Sources in the Outfall Basins and Associated COIs (in Addition to Sources Identified during Independent Investigations—see previous column)	Potential Sources Adjacent or Upstream and Associated COIs
OF10A	West	CITY OF PORTLAND	30"	Concrete	Active		5 - commercial and residential		No ECSI sites have been identified in this basin.	Albers Mill (ECSI #4590) - PAHs, TPH, and metals
OF11	West	CITY OF PORTLAND	78"	Concrete	Active	CSO	942 - open space and residential, some light industrial		Hoyt St. Railroad (former) (ECSI #1080) - none Hoyt St. Trainyard Parcel 1 (ECSI #1624) - none Pearl Block (ECSI #4960) - none Sylvan Cleaners (ECSI #1897) - PCE and TCE Union Station Agric. Marketing Ctr. (ECSI #1962) - PAHs, TPH, and metals Union Station Horse Barn (ECSI #2407) - Metals, PAHs, benzene, and benzo(a)pyrene Union Station Track #5 (ECSI #1414) - PAHs, TPH, and metals US Postal Processing & Distribution (ECSI #2183) - VOCs, PAHs, TPH, and metals *Dan Rasmussen Co (former) (ECSI #1684) - VOCs and TPH* *Dynagraphics Inc. (ECSI #4523) - TPH* *Esquire Motors (ECSI #4906) - VOCs and TPH* *Gender Machine Works (ECSI #2313) - PAHs, TPH, and metals* *Lu Yen Restaurant (former) (ECSI #2197) - TPH* *Pacific States Galvanizing (former) (ECSI #1024) - Cadmium, chromium, lead, zinc, PCE, and TPH* *RiverTec Property (ECSI #3067) - TPH and metals* *Unocal Service Station #0738 (ECSI #1396) - TPH* *Wilbur-Ellis Co. (ECSI #1331) - VOCs, SVOCs, PAHs, TPH, pesticides, PCBs, and metals*	Centennial Mills (ESCI #5136) - TPH, metals, PCBs, and asbestos
OF12	West	CITY OF PORTLAND	16"	Unknown	Abandoned	CSO	NA		No ECSI sites have been identified in this basin.	
OF13	West	CITY OF PORTLAND	24"	Concrete	Active	CSO	8 - residential and heavy industrial		No ECSI sites have been identified in this basin.	
OF14	West	CITY OF PORTLAND	30"	Concrete	Active	CSO	23 - heavy/light industrial and residential		Zehrung (ECSI #187) - Pentachlorophenol and 2,4-D	POP Terminal 1 South (ECSI #2642) - None
OF15	West	CITY OF PORTLAND	102"	Concrete	Active	CSO	1 - heavy industrial	Sulzer Pumps (ECSI #1235) - PAHs,TPH, arsenic, copper, chromium, and zinc	*Consolidated Freightways Inc. (ECSI #32) - VOCs and TPH* *Drew Paints Inc. (ECSI #4465) - VOCs* *ESCO Plant #3 (ECSI #112) - Phenols* *Groundwater - NW 22nd Ave. (ECSI #2015) - VOCs*	POP Terminal 1 North (ECSI #3317) - None
OF16	West	CITY OF PORTLAND	36"	Concrete	Active	CSO[f]	66 - mostly heavy industrial, some highway	Calbag - Nicolai (ECSI #5059) - Copper, lead, zinc, silver, chromium, nickel, cadmium, PCBs, BEHP, and TPH	.	POP Terminal 2 (ECSI #2769) - TPH and PAHs
OF17	West	CITY OF PORTLAND	90"	Concrete	Active	CSO/SSO	1,895 - mostly open space and heavy industrial, small % of residential	GE-NW 28 (No ECSI #, TSCA site) - PCBs Paco Pumps (ECSI #146) - PCBs and TPH Galvanizers (ECSI #1196) - TPH, PAHs, phthalates, arsenic, chromium, copper, and zinc *SFI (ECSI #5103) - VOCs, PCBs, TPH, PAHs, chromium, cadmium, and lead* GE Decommissioning (ECSI #4003) - PAHs, PCBs, TPH, arsenic, chromium, copper, and zinc	Guild's Lake Yard (ECSI #100) - Antimony, arsenic, cadmium, chromium, copper, mercury, selenium, zinc, TPH, VOCs, sodium cyanide, ethylene glycol, and creosote constituents Mogul Corp. (ECSI #1307) - No COIs listed in ECSI *King Ries (ECSI #4560) - Lead* *Mercer (ECSI #144) - Chromium and TPH* *AM Machine (ECSI #2261) - PAHs and TPH* *Schmidt Forge (ECSI #1347) - TPH*	POP Terminal 2 (ECSI #2769) - TPH and PAHs

Table 4.4-4. Shared Conveyance System Basin Characteristics and Potential Sources.

Outfall ID	River Bank	Owner	Outfall Size (Inches)	Outfall Material[a]	Outfall Status	CSO[b]/SSO[c]	2008 Stormwater Basin Acreage and Zoning[d]	COIs within Outfall Basin Area Identified during Independent Investigations[e]	Other Potential Sources in the Outfall Basins and Associated COIs (in Addition to Sources Identified during Independent Investigations—see previous column)	Potential Sources Adjacent or Upstream and Associated COIs
OF18	West	CITY OF PORTLAND	72"	Concrete	Active	CSO[f]	465 - open space and heavy industrial	Columbia American Plating (ECSI #29) - Lead, PCBs, VOCs, and SVOCs Gunderson (ECSI #1155) - TPH, butyltins, PCBs, phthalates, arsenic, copper, chromium and zinc McWhorter Technologies (ECSI #135) - VOCs, SVOCs, PAHs, TPH, and phthalates Christenson Oil (ECSI #2426) - Cadmium, copper, lead, mercury, zinc, PAHs, VOCs, and TPH Container Recovery (ECSI #4015) - Cadmium, lead, zinc, PAHs, PCBs, and phthalates Magnus/Wilhelm (ECSI #69) - Lead Trumbull (ECSI # 1160) - PAHs, PCBs, phthalates, arsenic, chromium, copper, and zinc Univar/Van Waters (ECSI #330) - Lead, pesticides, TPH, and VOCs Container Management (ECSI #4784) - PCBs, lead, mercury, zinc, PAHs, PCBs, TPH ANRFS (ECSI #1820) - Arsenic, chromium, copper, zinc, PCBs, PAHs, BEHP Ashland Chemical (ECSI #1076) - Arsenic, chromium, copper, zinc, PCBs, PAHs, BEHP Carson Oil (ECSI #1405) - VOCs, PAHs, TPH, arsenic, chromium, copper, zinc, PCBs, BEHP	Texaco/Equilon - Pipeline (ECSI #2117) - PAHs, VOCs, and TPH Texaco/Equilon - Bulk Terminal (ECSI #169) - PAHs, VOCs, and TPH PTRR (ECSI #100) - Antimony, arsenic, cadmium, chromium, copper, mercury, selenium, zinc, PAHs, PCBs, phenols, TPH, VOCs, sodium cyanide, ethylene glycol, and creosote constituents Schnitzer Investment - NW 35th (ECSI #2424) - VOCs, SVOCs, and metals	Gunderson (ECSI #1155) - Metals, butyltins, PCBs, phthalates, and TPH
OF19	West	CITY OF PORTLAND	42"	Concrete	Active	CSO[f]	486 - open space and heavy residential, small % of highway	Greenway Recycling (ECSI #4655) - VOCs, TPH, PCBs, arsenic, chromium, copper, and zinc PGE - Forest Park (ECSI #2406) - PCBs Calbag Metals (ECSI #2454) - Cadmium, lead, mercury, zinc, PCBs, and phthalates Unocal - Willbridge Terminal (ECSI #177) - VOCs, TPH, and metals Chevron Asphalt Refinery (ECSI #1281) - VOCs, PAHs, TPH, and metals Front Avenue LP (ECSI #1239)-Metals, PAHs, PCBs, VOCs, SVOCs, phthalates, and TPH	Chapel Steel (ECSI #4920) - Aluminum, antimony, lead, nickel, zinc, PAHs, PCBs, and BEHP Penske Truck Leasing - NW Yeon (ECSI #5055) - TPH, PAHs, VOCs, SVOCs, and metals Dura Industries (ECSI #111) - Cadmium, chromium, and lead Anderson Brothers (ECSI #970) - VOCs, PAHs, TPH, and metals Brazil & Co (ECSI #1026) - PCBs Mt. Hood Corp. (ECSI #81) - methylene chloride (VOCs) Mt. Hood Property (ECSI #1328) - VOCs Schnitzer Kittridge (ECSI #2442) - Cadmium, lead, mercury, zinc, PCBs, VOCs, and TPH Willbridge Yard (ECSI #3395) - TPH	Gunderson (ECSI #1155) - Metals, butyltins, PCBs, phthalates, and TPH Lakeside Industries (ECSI #2372) - VOCs, PAHs, TPH, and metals Shaver Transportation (ECSI #2377) - none Front Avenue LP (ECSI #1239) - Metals, PAHs, PCBs, VOCs, SVOCs, phthalates, and TPH
OF19A	West	CITY OF PORTLAND	60"	Concrete	Active		1.5 - heavy industrial		No ECSI sites have been identified in this basin.	Gunderson (ECSI #1155) - Metals, butyltins, PCBs, phthalates, and TPH Front Ave LP (ECSI #1239) - VOCs, SVOCs, PAHs, TPH, PCBs, metals, and phthalates Lakeside Industries (ECSI #2372) - VOCs, PAHs, TPH, and metals
OF22	West	CITY OF PORTLAND	60"	Concrete	Active	CSO[f]	94 - mostly heavy industrial, some open space and highway	McCall Oil (ECSI #134) - PAHs, PCBs, butyltins, VOCs, SVOCs, BEHP, TPH, arsenic, chromium, copper, lead, and zinc Chevron Asphalt Refinery (ECSI #1281) - Metals, PAHs, VOCs, and TPH Willbridge (ECSI # 1549) - Metals, PAHs, pesticides/herbicides, phthalates, VOCs, and TPH		McCall Oil (ECSI #134) - Metals, PAHs, PCBs, VOCs, SVOCs, BEHP, and TPH

Table 4.4-4. Shared Conveyance System Basin Characteristics and Potential Sources.

Outfall ID	River Bank	Owner	Outfall Size (Inches)	Outfall Material[a]	Outfall Status	CSO[b]/SSO[c]	2008 Stormwater Basin Acreage and Zoning[d]	COIs within Outfall Basin Area Identified during Independent Investigations[e]	Other Potential Sources in the Outfall Basins and Associated COIs (in Addition to Sources Identified during Independent Investigations—see previous column)	Potential Sources Adjacent or Upstream and Associated COIs
OF22B	West	CITY OF PORTLAND	48"	Concrete	Active	SSO	32 - heavy industrial	Arkema (ECSI #398) - DDx Gould Inc./NL Industries Inc. (ECSI #49) - Arsenic, lead, zinc, PAHs, PCBs, pesticides/herbicides, and VOCs Schnitzer Investment - Doane Lake (ECSI #395) - Arsenic, PCBs, and VOCs Rhone Poulenc–East Doane Lake (ECSI #155) - VOCs, pesticides/herbicides, PCBs, metals, dioxin/furans, and phthalates. Historic discharges from Doane Lake. Rhone Poulenc–East Doane Lake (ECSI #155) - SVOCs, pesticides/herbicides, arsenic, lead, phthalates, and dioxin/furans. Current GW infiltration into OF22B.	Metro Central Transfer Station (ECSI #1398) - Heavy metals and pesticides.	Arkema (ECSI #398) - DDx Rhone Poulenc–East Doane Lake (ECSI #155) - VOCs, pesticides/herbicides, PCBs, metals, dioxin/furans, and phthalates. The Rhone Poulenc site discharges to private outfall WR-06 offshore of Outfall. Outlet for historic drainage from Doane Lake just upstream of Outfall
OF22C	West	CITY OF PORTLAND	84"	Concrete	Active		1,107 - mostly open space, small % of heavy industrial, residential and highway	Koppers Industries Inc. (ECSI #1348) - See Gasco (ECSI #84) - VOCs, SVOCs, PAHs, TPH, and metals Gasco (ECSI #84) - PAHs and cyanide. GW infiltration Siltronic (ECSI # 183) - VOCs, SVOCs, PAHs, TPH, and metals Santa Fe Pacific Pipeline Co. (ECSI #2104) - none	St. Helens Road Petroleum (ECSI #2630) - VOCs, PAHs, and TPH V & K Services (ECSI #2423) - VOCs and TPH	Rhone Poulenc–East Doane Lake (ECSI #155) - VOCs, pesticides/herbicides, PCBs, metals, dioxin/furans, and phthalates. The Rhone Poulenc site discharges to private outfall WR-06 upstream of Outfall. Outlet for historic drainage from Doane Lake upstream of Outfall.
OF22D	West	CITY OF PORTLAND	48"	CSP	Active		240 - mostly open space, small % of residential and highway		No ECSI sites have been identified in this basin.	Foss Maritime/Brix Maritime (ECSI #2364) - VOCs, PAHs, and TPH
OF23	West	CITY OF PORTLAND	27"	RCP	Abandoned	CSO	NA - discharges to CBWTP		No ECSI sites have been identified in this basin.	ExxonMobil (ECSI #137) - VOCs, PAHs, TPH, and metals Olympic Pipeline (ECSI #3342) - none
OF24	West	CITY OF PORTLAND	12"	CMP	Emergency Overflow point	CSO/SSO	NA - discharges to CBWTP		*Babcock Land Co. (ECSI #2361) - No COIs listed in ECSI*	West Coast Adhesive (ECSI #333) - phenol, formaldehyde, and TPH
OF42	East	CITY OF PORTLAND	10"	STL	Active	CSO[f]	6 - commercial and open space		No ECSI sites have been identified in this basin.	
OF43	East	CITY OF PORTLAND	56"	Other	Active	CSO	51 - light industrial	Tucker Building (ECSI #3036) - Metals, PAHs, PCBs, and TPH Westinghouse/CBS (no ECSI #, TSCA site) - PCBs	Master Chemical (ECSI #1302) - No COIs listed in ECSI *Mammal Survey & Control Service (ECSI #1301) - Pesticides* *Shopping Center Prop. - Nature's Fresh NW (ECSI #1855) - VOCs* *Steve Adams Prop. (ECSI #1500) - PCBs* *Union Ave - PBC Site (ECSI #991) - PCBs* *Wagstaff Battery Mrg. Co. (ECSI #1243) - TPH and lead*	
OF44	East	CITY OF PORTLAND	12"	STL	Active	CSO[f]	17 - mostly light industrial, some heavy industrial	Tucker Bldg. (ECSI #3036) - Metals, PAHs, PCBs, and TPH	Pacific Power & Light (ECSI #5117) - PCBs and TPH Valvoline (ECSI #3215) - VOCs, PAHs, TPH, and metals Vermiculite NW Inc. (former) (ECSI #2761) - asbestos	
OF44A	East	CITY OF PORTLAND	72"	STL	Active	CSO/SSO	139 - mostly residential and light industrial, some open space and commercial		Tarr Inc. (ECSI #1139) - VOCs and TPH *Coverall Uniform Supply (ECSI #1775) - PCE* *Standard Dairy (ECSI #2055) - VOCs and TPH* *Abraham's Fabric Clinic (ECSI #4592) - No COIs listed in ECSI* *Grant Warehouse (ECSI #2385) - Asbestos, PAHs, TPH, and metals* *McCann/Lenske Property (ECSI #4711) - TPH and lead* *North Portland Bible College (ECSI #4354) - TPH* *Nurenberg Scientific Co. (ECSI #87) - VOCs and metals* *Portland Cleaning Works (ECSI #3529) - TPH and PCE*	
OF45	East	CITY OF PORTLAND	27"	Concrete	Active	CSO	10 - heavy and light industrial	UPRR (ECSI #178) - Arsenic, chromium, lead, zinc, PAHs, PCBs, phthalates, SVOCs, and TPH		

Table 4.4-4. Shared Conveyance System Basin Characteristics and Potential Sources.

Outfall ID	River Bank	Owner	Outfall Size (Inches)	Outfall Material[a]	Outfall Status	CSO[b]/SSO[c]	2008 Stormwater Basin Acreage and Zoning[d]	COIs within Outfall Basin Area Identified during Independent Investigations[e]	Other Potential Sources in the Outfall Basins and Associated COIs (in Addition to Sources Identified during Independent Investigations—see previous column)	Potential Sources Adjacent or Upstream and Associated COIs
OF46	East	CITY OF PORTLAND	80"	Varies	Active	CSO	77 - residential, open space and heavy industrial	UPRR (ECSI #178) - Arsenic, chromium, lead, zinc, PAHs, PCBs, phthalates, SVOCs, and TPH	Industrial Battery Bldg (ECSI #935) - Metals *Abraham's Fabric Clinic (ECSI #4592) - No COIs listed in ECSI* *Betty Campbell Bldg. (ECSI #1902) - TPH and PAHs* *Flowers by Victor (ECSI #4712) - Pesticides* *Grant Warehouse (ECSI #2385) - Asbestos, PAHs, TPH, and metals* *Henry Wong (ECSI #989) - No COIs listed in ECSI* *McCann/Lenske Property (ECSI #4711) - TPH and lead* *North Portland Bible College (ECSI #4354) - TPH* *Nurnberg Scientific Co. (ECSI #87) - VOCs and metals* *Portland Cleaning Works (ECSI #3529) - VOCs* *PP&L Mason Station (ECSI #2136) - PCBs*	UPRR (ECSI #178) - Arsenic, chromium, lead, zinc, PAHs, PCBs, phthalates, SVOCs, and TPH
OF47	East	CITY OF PORTLAND	48"	CSP	Active	CSO	9.5 - light industrial	UPRR (ECSI #178) - Arsenic, chromium, lead, zinc, PAHs, PCBs, phthalates, SVOCs, and TPH	*Elks Cleaners (ECSI #4954) - TCE (VOCs)* *Sunny's Dry Cleaners (ECSI #2848) - No COIs listed in ECSI*	UPRR (ECSI #178) - Arsenic, chromium, lead, zinc, PAHs, PCBs, SVOCs, and TPH
OF48	East	CITY OF PORTLAND	30"	CMP	Active	CSO	6 - residential 1.5 - stormwater treatment facility		No ECSI sites have been identified in this basin.	Triangle Park (ECSI #277) - VOCs, SVOCs, PAHs, TPH, pesticides, PCBs, and metals McCormick & Baxter (ECSI # 74) - PAHs, metals, and creosote
OF49	East	CITY OF PORTLAND	15"	Concrete	Active	CSO	31 - mostly residential, some commercial and open space 1.5 acres - stormwater treatment facility		No ECSI sites have been identified in this basin.	Willamette Cove (ECSI #2066) - none
OF50	East	CITY OF PORTLAND	30"	Concrete	Active	CSO	39 - mix residential, commercial, and light industrial 1 acre- stormwater treatment facility		BES WPCL (ECSI #2452) - none	Crawford Street Corp. (ECSI #2363) - VOCs, PAHs, TPH, PCBs, arsenic, chromium, copper, and zinc
OF52	East	CITY OF PORTLAND	30"	Unknown	Active	CSO/SSO	23 - mostly light industrial with some residential and open space	Crawford Street Corp. (ECSI #2363) - VOCs, PAHs, TPH, PCBs, arsenic, chromium, copper, and zinc	*Unocal Service Station #3911 (ECSI #1593) - TPH and PCBs*	
OF52A	East	CITY OF PORTLAND	36"	Concrete	Active		25 - mostly light industrial and residential with some commercial and open space		No ECSI sites have been identified in this basin.	Mar Com North Parcel (ECSI #4797) - none Mar Com South Parcel (ECSI #2350) - VOCs, SVOCs, PAHs, TPH, PCBs, metals, butyltins, and phthalates
OF52C	East	CITY OF PORTLAND	36"	Concrete	Active		22 - light industrial		No ECSI sites have been identified in this basin.	Port of Portland T4 Slip 1 (ECSI # 2356) - PAHs, TPH, pesticides/herbicides, PCBs, metals, and phthalates
OF53	East	CITY OF PORTLAND	48"	CMP	Active	CSO	21 - residential		*Multnomah County - St. Johns Site (ECSI #2421) - VOCs and TPH*	POP T4 Auto Storage (ECSI #172) - none
OF53A	East	CITY OF PORTLAND	48"	Concrete	Active	SSO	82 - heavy industrial	Consolidated Metco (ECSI #3295) - PAHs, TPH, PCBs, phthalates, zinc, and copper EVRAZ (ECSI# 141) - Metals, PAHs, PCBs, and TPH	JR Simplot (ECSI #3343) - TPH S. Rivergate Industrial Park (ECSI #2980) - No COIs listed in ECSI Union Chemical (ECSI #329) - Anhydrous ammonia	EVRAZ (ECSI #141), during reverse flow - metals, PAHs, PCBs, and TPH
OFM-1	East (Mocks Bottom)	CITY OF PORTLAND	60"	CSP	Active	SSO	162 - light	Fred Devine Diving and Salvage (ECSI #2365) - Metals, PAHs, SVOCs, TPH, and phthalates Freightliner TMP (ECSI #2366) - Metals, PAHs, and PCBs	Roadway Express (ECSI #3807) - TPH, nitric acid, and methyl iodide US Navy and Marine Reserve Center (ECSI #5109) - TPH	Cascade General (ECSI #271) - VOCs, PAHs, TPH, PCBs, metals, butyltins, and phthalates
OFM-2	East (Mocks Bottom)	CITY OF PORTLAND	60"	CSP	Active		127 - light industrial		GI Trucking (ECSI #1840) - TPH	Cascade General (ECSI #271) - VOCs, PAHs, TPH, PCBs, metals, butyltins, and phthalates

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OFM-3	East (Mocks Bottom)	CITY OF PORTLAND	60"	CSP	Active		111 - light industrial	Freightliner TMP Parts Plant (ECSI #115) - Metals Fred Meyer - Swan Island (ECSI #44) - PCBs		Cascade General (ECSI #271) - VOCs, PAHs, TPH, PCBs, metals, butyltins, and phthalates
OFS-1	East (Swan Island)	CITY OF PORTLAND	36"	CMP	Active		25 - heavy industrial, some light industrial	Cascade General (ECSI #271) - VOCs, PAHs, TPH, PCBs, metals, butyltins, and phthalates		Cascade General (ECSI #271) - VOCs, PAHs, TPH, PCBs, metals, butyltins, and phthalates
OFS-2	East (Swan Island)	CITY OF PORTLAND	36"	CSP	Active		27 - light industrial, some heavy industrial		AutoVending (ECSI #1430) - TPH Crosby & Overton (ECSI #877) - PCBs	Cascade General (ECSI #271) - VOCs, PAHs, TPH, PCBs, metals, butyltins, and phthalates
OFS-5	East (Swan Island)	CITY OF PORTLAND	36"	CSP	Active		39 - light industrial		No ECSI sites have been identified in this basin.	
OFS-6	East (Swan Island)	CITY OF PORTLAND	36"	CSP	Active		22 - heavy industrial, some light industrial	Cascade General (ECSI #271) - VOCs, PAHs, TPH, PCBs, metals, butyltins, and phthalates		
Other Non-City Shared Conveyance Systems										
WR-121	East	Burgard Industrial Park	Unknown	Unknown	Active		19 - heavy industrial	Schnitzer Steel/Calbag (ECSI #2355) - VOCs, TPH, PCBs, and metals		
WR-123	East	Burgard Industrial Park	48"	Concrete	Active		101 - heavy industrial	Boydstun Metal Works (ECSI #2362) - PAHs, PCBs, and metals NW Pipe (ECSI #138) - VOCs, PAHs, TPH, PCBs, and metals Joseph Ryerson (ECSI #2441) - No COIs listed in ECSI		
WR-124	East	Burgard Industrial Park	48"	Concrete	Active	SSO	1.4 - heavy industrial	Schnitzer Steel/Calbag (ECSI #2355) - VOCs, PCBs, TPH, and metals NW Pipe (ECSI #138) - VOCs, PAHs, TPH, PCBs, and metals		
WR-517[g]	East	Burgard Industrial Park	Unknown	Unknown	Active		10 - heavy industrial		Portland Container Repair (ECSI #2375) - TPH	Schnitzer Steel/Calbag (ECSI #2355) - VOCs, PCBs, TPH, and metals
WR-83	East	Burgard Industrial Park	30"	Unknown	Active		6 - heavy industrial		Jefferson Smurfit (ECSI #2371) - TPH and metals	Premier Edible Oils (ECSI #2013) - VOCs, PAHs, TPH, and metals Schnitzer Steel/Calbag (ECSI #2355) - VOCs, PCBs, TPH, and metals
WR-84	East	Burgard Industrial Park	30"	Unknown	Active		14 - heavy industrial		Jefferson Smurfit (ECSI #2371) - TPH and metals	Premier Edible Oils (ECSI #2013) - VOCs, PAHs, TPH, and metals Schnitzer Steel/Calbag (ECSI #2355) - VOCs, PCBs, TPH, and metals
WR-85	East	Burgard Industrial Park	10"	Concrete	Abandoned		Unknown - heavy industrial		Basin area has not been delineated.	Premier Edible Oils (ECSI #2013) - VOCs, PAHs, TPH, and metals Schnitzer Steel/Calbag (ECSI #2355) - VOCs, PCBs, TPH, and metals
WR-21	East	Burgard Industrial Park	36"	Sump	Abandoned		Unknown - heavy industrial		Basin area has not been delineated.	Premier Edible Oils (ECSI #2013) - VOCs, PAHs, TPH, and metals Schnitzer Steel/Calbag (ECSI #2355) - VOCs, PCBs, TPH, and metals
WR-207	West	ODOT	24"	STL	Active		Unknown - mostly highway		Basin area has not been delineated.	USACE Portland Moorings (ECSI #1641) - PAHs, TPH, metals, and butyltins
WR-510	West	ODOT	Unknown	Unknown	Active		Unknown - mostly highway		Basin area has not been delineated.	
WR-514	East	ODOT	Unknown	Unknown	Active		Unknown - mostly highway		Basin area has not been delineated.	
WR-306	East	ODOT	48"	Concrete	Active		Unknown - mostly highway		Basin area has not been delineated.	
WR-308	East	ODOT	15"	Concrete	Active		Unknown - mostly highway		Basin area has not been delineated.	

Table 4.4-4. Shared Conveyance System Basin Characteristics and Potential Sources.

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WR-307 (aka OF12A)	West	ODOT	48"	Concrete	Active	CSO	Unknown - mostly highway		Basin area has not been delineated.	
WR-210	West	Unknown Multiparty	48"	CMP	Abandoned		Unknown		Basin area has not been delineated.	Foss Maritime/Brix Maritime (ECSI #2364) - VOCs, PAHs, and TPH
WR-126	East	Unknown Multiparty	36"	CMP	Active		Unknown		Basin area has not been delineated.	Linnton Plywood (ECSI #2373) - VOCs, SVOCs, PAHs, TPH, PCBs, metals, and phthalates
WR-79	West	Unknown Multiparty	36"	Concrete	Active		Unknown		Basin area has not been delineated.	Owens Corning Linnton (ECSI #1036) - none
WR-102	West	Unknown Multiparty	48"	Concrete	Active		Unknown		Basin area has not been delineated.	ARCO (ECSI #1528) - VOCs, PAHs, TPH, and metals
WR-202	East	Unknown Multiparty	60"	CMP	Active		Unknown		Basin area has not been delineated.	ExxonMobil (ECSI #137) - VOCs, PAHs, TPH, and metals
WR-205	West	Unknown Multiparty	24"	Concrete	Active		Unknown		Basin area has not been delineated.	Gasco (ECSI #84) - VOCs, SVOCs, PAHs, TPH, metals, and cyanide
WR-203	East	Unknown Multiparty	36"	CMP	Active		Unknown		Basin area has not been delineated.	
WR-204	East	Unknown Multiparty	24"	Unknown	Active		Unknown		Basin area has not been delineated.	
WR-211	West	Unknown Multiparty	36"?	CMP	Active		Unknown		Basin area has not been delineated.	Marine Finance (ECSI #2352) - VOCs, PAHs, TPH, metals, and butyltins
WR-209	West	Unknown Multiparty	48"	Unknown	Active		Unknown		Basin area has not been delineated.	ST Services/Shore Terminal (ECSI #1989) - none
WR-208	West	Unknown Multiparty	24"	STL	Active		Unknown		Basin area has not been delineated.	Marine Finance (ECSI #2352) - VOCs, PAHs, TPH, metals, and butyltins
WR-206	West	Unknown Multiparty	24"	STL	Active		Unknown		Basin area has not been delineated.	
Saltzman Creek[h]	West	Unknown Multiparty	96"	Concrete	Active		1,076 - open space and heavy industrial, small % of highway and residential		GS Roofing (ECSI #117) - VOCs, PAHs, TPH, and metals Kinder Morgan GATX (ECSI #1096) - VOCs, PAHs, TPH, and metals St. Helens Road Petroleum Contamination (ECSI # 2630) - VOCs, PAHs, and TPH V&K Services (ECSI # 2423) - VOCs, and TPH	Willbridge Terminal (ECSI #1549) - VOCs, PAHs, TPH, pesticides/herbicides, metals, and phthalates GS Roofing (ECSI #117) - VOCs, PAHs, TPH, and metals. Discharges through WR-390 and WR-391

Notes:

This table is not an exhaustive list of current or historical sources of contamination. The table includes sites identified in DEQ's ECSI database and sites where TSCA cleanup documents could be located.
Identification and evaluation of potential sources is ongoing.
Italicized cells indicate upland areas within current or former CSO basins. Non-italicized text indicates upland areas within stormwater basins.

[a] Codes for outfall materials are as follows:

PVC - polyvinyl chloride	CSP - corrugated steel pipe
Metal	Plastic
STL - Steel	Ditch - drainage pipe, absent of hard-piping
Concrete	Other - variable not listed here
CMP - corrugated metal pipe	Unknown

[b] CSO listed if outfall is a current or historical CSO; see Table 3.1-3 for additional information.
[c] SSO listed if there is an emergency overflow connection from a sanitary pump station to the outfall.
[d] Separated stormwater basins. For CSO outfalls already controlled, these separated areas will continue to discharge stormwater to the river downstream of the diversion. For CSO outfalls that will be controlled in 2011, some of these separated storm basins will be diverted to the tunnel
[e] COIs are identified based on recent investigations of up-the-pipe investigations and site summaries. These sources have known or likely stormwater pathways and therefore are included in the conceptual site model (see Section 10).
[f] Outfall historically drained combined flows before full separation. Contributions of sanitary and industrial wastewater unknown unless noted in Table 3.1-3.
[g] This outfall, located at the head of International Slip, has been newly delineated, and is not included in the outfall layer on the maps in Sections 3, 4, and 10.
[h] This outfall is also not included in the outfall layer on the maps in Sections 3, 4, and 10.

BEHP - bis(2-ethylhexyl)phthalate	ODOT - Oregon Department of Transportation	T4 - Port of Portland Terminal 4
BES - City of Portland Bureau of Environmental Services	PAH - polycyclic aromatic hydrocarbon	TCE - trichloroethene
CBWTP - Columbia Boulevard Wastewater Treatment Plant	PCB - polychlorinated biphenyl	TPH - total petroleum hydrocarbons
COI - chemical of interest	PCE - tetrachloroethene	TSCA - Toxic Substances Control Act
CSO - combined sewer overflow	PGE - Portland General Electric	UPRR - Union Pacific Railroad
ECSI - Environmental Cleanup Site Inventory	POP - Port of Portland	USACE - U.S. Army Corps of Engineers
GW - groundwater	SSO - sanitary sewer overflow	VOC - volatile organic compound
NA - not available	SVOC - semivolatile organic compound	WPCL - Water Pollution Control Laboratory

Table 4.4-5. Active NPDES Permitted Discharges to the Portland Harbor Study Area.[a]

File No.	Facility	Permit Category	Permit Type	River Mile[b]
Major NPDES - Individual Permit				
108015	City of Portland, Port of Portland, Multnomah County - Municipal Stormwater Permit	STM	NPDES-DOM-MS4-1	multiple
110870	ODOT Municipal Stormwater Permit	STM	NPDES-DOM-MS4-1	multiple
93450	Wacker Siltronic Corporation	IND	NPDES-IW-B14	6.5
994109	Columbia Boulevard Wastewater Treatment Plant (CBWTP)	STM	NPDES-DOM-A1	multiple[c]
Minor NPDES - Individual Permit				
64905	Evraz Oregon Steel Mills, Inc.	IND	NPDES-IW-B08	2.3
3690	Ash Grove Cement	IND	NPDES-IW-B16	2.8
100025	Kinder Morgan/Portland Bulk Terminal 4	IND	NPDES-IW-B15	4.6
108460	Columbia River Sand & Gravel - Linnton Dist. Facility	IND	NPDES-IW-B16	4.7
47430	Koppers, Inc.	IND	NPDES-IW-B15	6.0
74995	Starlink Logistics	IND	NPDES-IW-B15	7.2
68471	Arkema, Inc. (closed, now stormwater only)	IND	NPDES-IW-B16	7.3
70596	Vigor Industrial LLC (aka Cascade General, Inc.)	IND	NPDES-IW-B15	8.3
100517	Univar USA	IND	NPDES-IW-B15	8.9
115251	The Metropolitan Condominium Complex	IND	NPDES-IW-B16	11.5
115018	The Pinnacle Condominiums Owners' Association	IND	NPDES-IW-B16	11.4
General Permits				
100415	J. R. Simplot Company - Rivergate Terminal	IND	GEN01	2.6
65589	Owens Corning (Corp.)	IND	GEN01	3.7
106458	Hexion Specialty (aka Borden Chemicals)	IND	GEN01	4.5
62231	Northwest Natural Gas Company	IND	GEN01	6.0
8550	GS Roofing Products Company, Inc.	IND	GEN01	7.4
110322	Oregon Transfer Co.	IND	GEN01	9.0
101321	Freightliner Truck Manufacturing Plant 2 (TMP2)	IND	GEN01	9.2
102334	Sulzer Pumps	IND	GEN01	10.2
44571	Glacier Northwest, Inc.	IND	GEN01	11.1
65589	Owens Corning (Corp.)	IND	GEN05	3.7
54175	McCall Oil And Chemical Corporation	IND	GEN05	7.9
64905	Oregon Steel Mills	STM	GEN12Z	2.3
100415	J. R. Simplot Company - Rivergate Terminal	STM	GEN12Z	2.6
108101	Alder Creek Lumber Co., Inc.	STM	GEN12Z	2.8
109186	Time Oil Co. - NW Terminal	STM	GEN12Z	3.4
32876	Morse Bros. Linnton Terminal	STM	GEN12Z	3.5
111395	Boydstun Metal Works, Inc.	STM	GEN12Z	3.6
109845	Jefferson Smurfit Corporation (U.S.)	STM	GEN12Z	3.6
111236	Portland Container Repair Corporation	STM	GEN12Z	3.6
65589	Owens Corning (Corp.)	STM	GEN 12Z	3.7
108103	Schnitzer Steel Industries, Inc. - DBA	STM	GEN12Z	3.9
32300	Kinder Morgan Linnton Terminal	IND	GEN12Z	4.1
111396	Boydstun Metal Works Inc.	STM	GEN12Z	4.2
6739	Northwest Pipe Company	STM	GEN12Z	4.2
108460	Columbia River Sand & Gravel - Linnton Dist. Facility	STM	GEN12Z	4.7
4248	BP West Coast Products (ARCO)	STM	GEN12Z	4.8
113672	Toyota Logistics Services, Inc.	STM	GEN12Z	4.8
112017	Exxon Mobil Oil Corporation	STM	GEN12Z	5.0

Table 4.4-5. Active NPDES Permitted Discharges to the Portland Harbor Study Area.[a]

File No.	Facility	Permit Category	Permit Type	River Mile[b]
112103	Olympic Pipe Line Co.	IND	GEN12Z	5.1
109938	Shore Terminals LLC	STM	GEN12Z	5.3
108394	USACE - US Government Moorings	STM	GEN12Z	6.0
111157	Pacific Terminal Services	IND	GEN12Z	6.2
93450	Siltronic Corporation	STM	GEN12Z	6.5
107922	Air Liquide (See Liquid Air File 50791)	STM	GEN12Z	7.3
110646	Metro Central Transfer Station	STM	GEN12Z	7.3
8550	GS Roofing Products Company, Inc.	STM	GEN12Z	7.4
80841	Kinder Morgan Liquid Terminals - Willbridge Terminal	IND	GEN12Z	7.4
107564	Chevron U.S.A. - Willbridge Transportation	STM	GEN12Z	7.6
100122	Chevron U.S.A. Inc. - Willbridge Distribution Center	IND	GEN12Z	7.7
107172	Brenntag Pacific Inc. (aka Quadra Chemicals Western Inc.)	STM	GEN12Z	7.8
90845	Conocophillips Company	STM	GEN12Z	7.8
54175	McCall Oil and Chemical Corporation	IND	GEN12Z	7.9
16055	Paramount Petroleum	STM	GEN12Z	8.0
104856	Tube Forgings of America, Inc.	STM	GEN12Z	8.1
100408	Western Star-Truck MFG (aka Freightliner TMP)	STM	GEN12Z	8.2
111878	RM Beverage Delaware, - Maletis Beverage	STM	GEN12Z	8.3
101536	United Parcel Service, Inc.	STM	GEN12Z	8.3
70596	Vigor Industrial LLC (aka Cascade General, Inc.)	STM	GEN12Z	8.3
111221	A.G.G. Enterprises, Inc.	STM	GEN12Z	8.5
104250	Columbia Distributing Company	STM	GEN12Z	8.5
114961	Greenway Recycling	STM	GEN12Z	8.6
107443	Roadway Express, Inc.	STM	GEN12Z	8.6
109872	Western Wire Works, Inc.	STM	GEN12Z	8.7
101620	Auto Truck Transport Corporation	STM	GEN12Z	8.7
87693	Equilon Enterprises L.L.C. (DBA)-Shell Oil Products	STM	GEN12Z	8.8
30386	Gunderson, Inc.	STM	GEN12Z	8.8
108730	HAJ DBA Christenson Oil	STM	GEN12Z	8.8
108995	SAIA Motor Freight Line, Inc.	STM	GEN12Z	8.8
111845	Becker Trucking, Inc. See File #109849	STM	GEN12Z	8.9
113286	Environmental Fibers International	STM	GEN12Z	8.9
103380	Pacific Rail Services	STM	GEN12Z	8.9
110272	Container Recovery, Inc.	STM	GEN12Z	9.0
107748	G. I. Trucking Company	STM	GEN12Z	9.0
100721	Tarr Acquisition LLC (Rudie Wilhelm Warehouse Co.)	STM	GEN12Z	9.1
103803	Owens Corning Corp.	STM	GEN12Z	9.1
107658	ABF Freight System, Inc	STM	GEN12Z	9.1
100447	Carson Oil Co., Inc.	STM	GEN12Z	9.2
101321	Freightliner Truck Manufacturing Plant 2 (TMP)	STM	GEN12Z	9.2
111065	IMACC Corporation - Container Management Services	STM	GEN12Z	9.2
112482	Barrich, Inc. - MRP Services Inc.	STM	GEN12Z	9.2
109852	Portland Terminal Railroad Company	STM	GEN12Z	9.4
110778	Rose City Moving & Storage Company	STM	GEN12Z	9.5
108673	Fred Meyer Dairy Plant (Swan Island Dairy)	STM	GEN12Z	9.6
104892	Galvanizers Company	STM	GEN12Z	9.7
110199	Federal Express Corporation	STM	GEN12Z	9.8

Table 4.4-5. Active NPDES Permitted Discharges to the Portland Harbor Study Area.[a]

File No.	Facility	Permit Category	Permit Type	River Mile[b]
109851	Peninsula Truck Lines, Inc.	STM	GEN12Z	9.9
110261	Lincoln & Allen Company	STM	GEN12Z	10.0
107985	Stevedoring Services of America, Inc.	STM	GEN12Z	10.0
104836	ESCO Corporation	STM	GEN12Z	10.1
107213	Ash Grove Cement	STM	GEN12Z	10.1
110258	McCracken Motor Freight, Inc.	STM	GEN12Z	10.1
114024	Port of Portland Terminal 2	STM	GEN12Z	9.7
107179	Calbag Metals Co.	STM	GEN12Z	10.2
102334	Sulzer Pumps	STM	GEN12Z	10.2
107655	Savage Services Corp.	STM	GEN12Z	10.3
111331	Sakrete of the Pacific Northwest	STM	GEN12Z	10.9
111356	CLD Pacific Grain, LLC	STM	GEN12Z	11.4
100571	Tarr Acquisition, LLC	STM	GEN12Z	11.2
109826	USDOT; National Railroad Passenger Corp. (AMTRAK)	STM	GEN12Z	11.6
109186	Time Oil Co. - NW Terminal	STM	GEN12C	3.4
114961	Greenway Recycling	STM	GEN12C	8.6
110908	Hoyt Street Properties, LLC	STM	GEN12C	11.6
113814	Waterfront Pearl, LP	STM	GEN12C	11.4
116131	Andersen Construction Company	STM	GEN12C	11.7
113630	GSL Properties, Inc.	STM	GEN12C	11.8
105307	Jacobsen & Co. Inc., K.F.	STM	GEN12A	11.0
4248	BP West Coast Products (ARCO)	IND	GEN15A	4.8
32300	Kinder Morgan Linnton Terminal	IND	GEN15A	4.1
87693	Equilon Enterprises L.L.C. (DBA)-Shell Oil Products	IND	GEN15A	8.8
110908	Hoyt Street Properties, LLC	IND	GEN15A	11.6

Notes:

[a] River miles were determined by Integral GIS based on City-provided GIS layers.

[b] DEQ Wastewater permits database accessed 5/20/2009 (http://www.deq.state.or.us/wq/sisdata/facilitycriteria.asp)

[c] Discharges from the CBWTP are directed to the Columbia River. The CBWTP also covers CSO and SSO discharges to the Willamette River

CBWTP - Columbia Boulevard Wastewater Treatment Plant
CSO - combined sewer overflow
DEQ - Oregon Department of Environmental Quality
GEN - general
GIS - geographical information system
IND - industrial
NPDES - National Pollutant Discharge Elimination System
ODOT - Oregon Department of Transportation
SSO - sanitary sewer overflow
STM - municipal stormwater
USACE - U.S. Army Corps of Engineers
USDOT - U.S. Department of Transportation

Definitions:

GEN01 - Cooling water/heat pumps
GEN05 - Boiler blowdown
GEN12Z - Industrial stormwater
GEN12A - Stormwater: Sand, gravel and other non-metallic mining
GEN12C - Stormwater: Construction activities - 1 acre or more
GEN15A - Tank cleanups and treated groundwater
NPDES MS4 - Municipal Stormwater Permit
NPDES-IW-B08 - Primary smelting and/or refining - Ferrous and non-ferrous metals not elsewhere classified above
NPDES-IW-B14 - Facilities not elsewhere classified which dispose of process wastewater (includes remediated groundwater) - Tier 1 sources
NPDES-IW-B15 - Facilities not elsewhere classified which dispose of process wastewater (includes remediated groundwater)
NPDES-IW-B16 - Facilities not elsewhere classified which dispose of non-process wastewaters

Table 4.4-6. Discharge Monitoring Requirements for Individual NPDES Permits within the Study Area[a]

Facility File No.	Permit No.	Facilty Name	Conventional Monitoring Parameters	Chemical Monitoring Requirements
68471	100752	Arkema, Inc.	Flow, oil and grease, pH, TSS, floating solids, oil and grease sheen	Lead, zinc, copper
108460	102452	Columbia River Sand & Gravel - Linnton Dist. Facility	Suspended solids, turbidity	
64905	101007	Evraz Oregon Steel Mills, Inc.	Outfall 001: flow, TSS, total dissolved solids, turbidity, oil & grease, pH, total residual chlorine, excess thermal load (May-October) Outfall 004: flow, turbidity Internal monitoring point: flow, Intake water monitoring: turbidity	Outfall 001: total recoverable copper, whole effluent toxicity testing Internal monitoring point: lead, zinc
3690	102465	Ash Grove Cement	Flow, TSS, pH	
70725	994109	Columbia Boulevard Wastewater Treatment Plant (CBWTP)	The CBWTP discharges its effluent to the Columbia River; discharge monitoring requirements are applicable to the Columbia River only.	This permit covers CBWTP effluent discharged to the Columbia River and CSO and SSO discharges to the Willamette River; discharge monitoring requirements are applicable to the Columbia River only.
93450	101128	Wacker Siltronic Corporation	Outfall 001: flow, TSS, BOD, fluoride, total phosphates, turbidity, pH Outfall 002: flow, total phosphate Outfall 003: free available chlorine, pH, temperature	Outfall 001: total chromium, hexavalent chromium, total toxic organics Outfall 003: bioassays
70596	10393	Vigor Industrial LLC (aka Cascade General, Inc.)	Outfall 001: flow, pH, TSS, TDS, oil and grease Outfall 002: flow,TSS, oil and grease, pH Outfalls 005, 006, 007, 008: flow, temperature, excess thermal load	Outfall 001: copper, zinc Outfall 002: copper, lead, zinc, tributyltin, iron, manganese, whole effluent toxicity testing, priority pollutant scan
108015	101314	City of Portland, Port of Portland, Multnomah County - Municipal Stormwater Permit	MS4 Discharge and Ambient monitoring: TSS, hardness, pH, conductivity, DO, temperature, nitrate-nitrogen, total phosphorous, oil and grease (non-polar and total)	MS4 Discharge and Ambient monitoring: total and dissolved metals - copper, lead, zinc; biological - E.coli
47430	101642	Koppers, Inc.	Flow, temperature, pH, oil and grease, turbidity	Phenols, cyanide, polynuclear aromatic hydrocarbons (total), benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, benzene, BTEX, silver, pentavalent arsenic, cadmium, copper, mercury, lead, tin

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This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part.

Table 4.4-6. Discharge Monitoring Requirements for Individual NPDES Permits within the Study Area[a]

Facility File No.	Permit No.	Facilty Name	Conventional Monitoring Parameters	Chemical Monitoring Requirements
74995	101180	Starlink Logistics (aka Rhone Poulenc)	Outfall 001: TSS, temperature, pH Internal Monitoring Point 101: Flow, TSS	Outfall 001: chlorinated phenols, phenol, arsenic, lead, mercury, bromoxynil, DDT, 2,3,7,8-TCDD Internal Monitoring Point 101: lead, arsenic
100025	102446	Kinder Morgan/Portland Bulk Terminal 4	pH, TSS, oil and grease, floating solids, oil and grease sheen	Total copper, total lead, total zinc
100517	101613	Univar USA	Treated groundwater: pH, oil and grease Stormwater: pH, TSS, oil and grease, floating solids, oil and grease sheen	Treated groundwater: benzene, chloroethane, 1,2-dichloroethane, 1,2-dichloroethene, 1,1,1-TCA, 1,1,2-TCA, trichloroethene, tetrachloroethene, vinyl chloride, cyanide Stormwater: total copper, total lead, total zinc
115018	102880	The Pinnacle Condominium Owners' Association	pH, TSS, oil and grease, floating solids, oil and grease sheen	Outfall 001: copper, lead, mercury, silver, zinc, iron, petroleum hydrocarbons, BTEX and benzene
115251	102881	The Metropolitan Condominium Complex	pH, TSS, oil and grease, floating solids, oil and grease sheen	Outfall 001: copper, lead, mercury, silver, zinc, iron, petroleum hydrocarbons, BTEX and benzene

Notes:

[a] DEQ Wastewater permits database accessed 5/20/2009 (http://www.deq.state.or.us/wq/sisdata/facilitycriteria.asp)

BOD - biological oxygen demand
BTEX - benzene, toluene, ethylbenzene, and total xylene
CBWTP - Columbia Boulevard Wastewater Treatment Plant
CSO - combined sewer overflow
DEQ - Oregon Department of Environmental Quality
DO - dissolved oxygen
NPDES - National Pollutant Discharge Elimination System
SSO - sanitary sewer overflow
TDS - total dissolved solids
TSS - total suspended solids

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Table 4.4-7. Discharge Monitoring Requirements in General NPDES Permits.

Type		No. in Study Area	Conventional Monitoring Parameters[a]	Chemicals Monitoring Requirements[a] Parameter	Frequency
GEN01	Cooling water/heat pumps	9	Flow, temp, pH, total residual chlorine	---	---
GEN05	Boiler blowdown	2	Flow, temp, pH, TSS, total residual chlorine[b]	---	---
GEN12A	Stormwater: sand, gravel, and other non-metallic mining	1	pH, TSS, settleable solids, oil & grease; Oil & grease sheen, turbidity	---	Four times per year; once per month (when discharging)
GEN12C	Stormwater: construction activities - 1 or more acres	6	Inspection/visual characteristics	---	---
GEN12Z	Industrial stormwater	78	pH, TSS, oil & grease, E. coli[b], visual monitoring	Copper, lead, zinc	Four times per year
GEN15A	Petroleum hydrocarbon cleanups	4	Flow, pH, visual monitoring	TPH, BTEX, benzene, lead[b]	Weekly to quarterly

Notes:

[a] Permits for specific facilities may include other parameters.

[b] Not applicable to all facilities.

--- = not available

BTEX - benzene, toluene, ethylbenzene, and xylenes

NPDES - National Pollutant Discharge Elimination System

TPH - total petroleum hydrocarbons

TSS - total suspended solids

Table 4.5-1. Shoreline or Nearshore Facilities Upstream of RM 11.8 Listed in DEQ's ECSI Database.[a]

ECSI #	Facility or Site Name/Status	Address	Type(s) of Operation	Hazardous Substances/Waste Types	Detected Chemicals in Upland Samples[b]	Potential Pathways to River[c]
71	Martin Electric (aka. Warren Oliver Co.)/ NFA - 1993	91 Foothills Rd. Lake Oswego, OR 97034	Electrical equipment firm	PCBs from transformer waste oils	PCB 1221(S)	
123	Huntington Rubber Corp.	7030 SW Macadam Ave. Portland, OR 97219	Rubber products manufacturer	Petroleum	Petroleum-contaminated wastewater	WW
129	Jeff Lohr Residence (aka. Agnes Olsen Residence, Ivan B. Carlson Residence, The Barlow House [1887], Eileen Olsen Property)/FA 8/01	1206 Washington St. Oregon City, OR 97045	Private home	PCBs, oil	Oil- or fuel- related compounds(S), PCBs(S)	
151	Portland General Electric Station L/ NFA 1994 sediment cap	1841 SE Water Ave. Portland, OR 97214	Steam electric plant, electrical equipment maintenance and warehousing	PCBs, heavy metals, BTEX, PAHs	PCB(S)	DR, GW
263	West Linn Paper Company (aka. Crown Zellerbach, James River Corp. - West Linn Mill, Simpson Paper Co. Evergreen Mill, West Linn Paper Co. Willamette Falls Mill, Simpson Hog Fuel Site)/ EPA recommended SI in 4/04	4800 Mill St. West Linn, OR 97068	Wood pulping and specialty paper mill in operation since 1888	Oil, PCBs, PCDD/Fs	Oil- or fuel- related compounds(S), PCB 1221(S)	DR, GW
283	Willamette Falls Locks (COE Civil Willamette Falls Locks, US Army Corps of Engineers)/ XPA 1992	Between lock gates 4 & 5, west side of West Linn, OR 97068	Water transportation, freight	Heavy metals, ammonia, methylene chloride, oils, latex, clarified white water	Ammonia(S), arsenic(S), chromium(S), lead(S), methylene chloride (surface water)	DR
334	I-5/I-84 pesticide spill/DEQ spill response initiated cleanup, site screening recommended 2/94	I-5 & I-84 interchange Portland, OR 97232	450 lbs. CAPTAN (endosulfan) spilled from overturned truck on 2/86	Endosulfan		
383	Old Town Parking-Helistop Structure/ RA 1992	33 NW Davis St. Portland, OR 97209	Broadway Cab Co. service center (mid-1950s-1985)	PAHs, ammonia, heavy metals, PAHs, BTEX	VOCs (GW), PAHs (GW)	GW
602	South Waterfront Redevelopment Area - now Strand Condomininum Towers (aka. Lincoln Steam Plant, Pacific Power & Light)/ RA 10/05	SW River Dr. Portland, OR 97201	Parcel 3A - site of former Lincoln Steam Plant	PAHs, lead, arsenic, asbestos, PCBs	Lead(B), oil(S)	DR, GW, SW
689	Zidell Marine Corporation(aka. North Macadam Project, Zidell Explorations)/ROD 2/05, negotiations 7/05	3121 SW Moody Ave. Portland, OR 97201	Ship dismantling, barge construction, tube forging; numerous oil spills reported; fire pits for burning debris and insulation; ballast water discharged onsite	Metals, petroleum hydrocarbons, asbestos, PCBs	Antimony(B), arsenic(S), benzene(GW), chromium(S), lead(S), nickel(B), oil(B), PCBs(B), PAHs(S), tributyltin(S). Metals, PAHs, PCBs, and butyltins also present in sediments.	DR, GW, SW
812	BLE Inc. (aka. BLE Inc. Jeepers Its Ericksons, Ericksons Automotive, Groundwater - Foothills Road Industrial Area, Lake Oswego Area Groundwater Contamination, Lake Oswego Public Water Supply RPN)/ NFA 3/04	Eastern end of Lake Oswego; impacted city well at 101 Foothills Rd. Lake Oswego 97034	Inactive public water supply wells	PCE, TCE, cis-1,2-DCE	VOCs(GW)	GW
875	Schnitzer - SW Moody Ave. (also #1401 SW Moody Right-of-way)/ Unit B: NFA, Units A & C: Phase I RA done 12/95, Phase II RA incorporates development	Units A, B, & C Moody Ave. Portland, OR 97201	Former metals salvaging, processing, & pesticides formulation; property transferred to OHSU	Unit A soils: DDTs, hexachloropentadiene, PCBs, TCE, 1,2 DCE, acetone; Unit A groundwater: barium, lead, cadmium, chromium, lead, zinc, acetone, carbon disulfide, benzene, toluene, 4- methyl-2-pentanone, ethylbenzene, cineole, cyanide; Unit C soils: lead, PCBs, cPAHs	Unit A soils: DDTs, hexachloropentadiene, PCBs, TCE, 1,2-DCE, acetone; Unit A groundwater: barium, lead, cadmium, chromium, lead, zinc, acetone, carbon disulfide, benzene, toluene, 4- methyl-2-pentanone, ethylbenzene, cineole, cyanide; Unit C soils: lead, PCBs, cPAHs	SW, GW
876	North Waterfront Park	NW Front Ave. Portland, OR 97209		Benzene, toluene, xylene, ethylbenzene	Benzene(GW), ethylbenzene(B), toluene(B), xylenes(B)	SW, GW

Table 4.5-1. Shoreline or Nearshore Facilities Upstream of RM 11.8 Listed in DEQ's ECSI Database.[a]

ECSI #	Facility or Site Name/Status	Address	Type(s) of Operation	Hazardous Substances/Waste Types	Detected Chemicals in Upland Samples[b]	Potential Pathways to River[c]
985	Grunbaum Property (aka. Winter Products [former], North Macadam District Project, Konell Construction & Demolition Corp.)/Confirmed Release List 4/04	3604 SW Macadam Ave. Portland, OR 97201	Winter manufactured die-cast zinc furniture hardware with finishes used in the die-cast process; treated wastewater discharged to City sewer. Winter Products relocated in mid-1980s. Currently being redeveloped by Dane Development.	Electroplating wastes - zinc, copper, nickel, cyanide; petroleum products, PCE, TCE	Arsenic (GW), lead (S), petroleum (S), PCE (B), TCE (GW)	SW, GW
986	Winkler Scrap Metal Inc.	1737 SE Rhine St. Portland, OR	Scrap metal recycling, including transformers	PCBs, solvents, phenols, BEHP, dioxin/furans		
1006	Oaks Bottom Landfill (aka. Sellwood Disposal Site)/ NFA 1996	1S/1E/S23 Portland, OR 97202	Closed solid waste landfill	Former demolition debris and brush landfill		
1066	Gross Property Disposal Site/ NFA 1992	3S/1E/S2 West Linn, OR 97068	Vacant farm land	PCBs	PCBs(S)	
1135	NW Cast Metal Products, Broad Spectrum Electronics Lab (aka. Auric Ent., H & M Electronics, Pacific Meats, NW Cast Metal Products, Ross Electric)/Site confirmatory sampling required 3/96	79 SE Taylor St. Portland, OR 97214	Former Southern Pacific Railroad warehouse, 1912 International Harvester Building, warehouse for several other parties over the years, lab located on 3rd floor in corner of building	Alleged dumping of PCBs, solvents, lead, arsenic, mercury, zinc, cyanide compounds, phenols, acids	PAHs (S)	
1138	Natural Gas Building Garage (aka. Portland Gas Manufacturing Site, Portland Gas & Coke Co.,MGP, Portland Gas Light Co.)/Options Letter for Further Action Letter sent 3/02	NW 1st and Everett Portland, OR 97209	Former coal/gas manufacturing (Portland Gas and Coke) (1860-1913)	Coal and oil tars, BTEX, spent iron oxide, process wastewaters	No testing has been completed but locations south of this site have detected compounds consistent with coal and oil tars.	
1258	Abes Main St. Cleaners (aka. Chris & Jessies Main St. Cleaners, ODEQ Abes Main St. Cleaners, Parker J Former Abes Main St. Cleaners)/RA recommended 7/06	10863 SE Main St. Milwaukie, OR 97222	Laundry/dry cleaner	Perchloroethylene, trichloroethylene, Stoddard solvent	Tetrachloroethylene(B)	GW, WW
1292	Gibson-Homans Co./EPA SI 1985, site screening recommended in 1994	3419 SW Moody Ave. Portland, OR 97201	Manufactures protective coatings, including asphaltic roof coatings, aluminum roof coatings, putty, caulk, sealants, wood preservatives, adhesives	No noticable discharges		
1394	Louis Dreyfus Facility/placed on Confirmed Release List 3/97 (low priority)	(foot of) N Holladay St. Dock & Elevator Portland, OR 97227		Petroleum	TPH(S)	DR, GW (unknown)
1923	Westwood Corp.(aka. Swinterton Builders)/ FS 2000, NFA 2000	3030 SW Moody Ave., Ste. 250 Portland, OR 97201	Foundry & scrap business (1930s-1984)	Diesel-range petroleum, metals, possibly PCBs and PAHs	Diesel, kerosene, lead (S)	SW, GW
1925	Mackenzie/Saito Property (North Macadam District Project)	690 SW Bancroft St. Portland, OR 97201	Lumber mill (former)	Oil-range hydrocarbons, PAHs	Benzene(GW), PAHs(GW), ethylbenzene(GW), oil(S), toluene(GW), xylenes(GW)	GW
1973	PECO Mfg. Co., Inc.	4707 and 4720 SE 17th Ave. Portland, OR	Manufacturer of specialty cast and machine parts	PCBs, PCE, TCE	PCBs(S), PCE and TCE(GW)	GW
2114	Sullivan Electrical Substation/ Site screening recommended	5600 Willamette Falls Dr. West Linn, OR 97068	Electrical substation			

Table 4.5-1. Shoreline or Nearshore Facilities Upstream of RM 11.8 Listed in DEQ's ECSI Database.[a]

ECSI #	Facility or Site Name/Status	Address	Type(s) of Operation	Hazardous Substances/Waste Types	Detected Chemicals in Upland Samples[b]	Potential Pathways to River[c]
2232	Innventures (aka. CM Company Inc. a corp. of Id., Marriott Residence Inn, Portland Development Commission - lot 5)/ hotspot cleanup, site effectively capped, delisted 2002	2115 SW River Pkwy. Portland, OR 97201	Lumber storage (~1900-1950) for the Portland Lumber Company; scrap steel storage (1950s-1970s); 1994-1995 storage for PAH-contaminated soil	Diesel & heavy oil, petroleum hydrocarbons, metals	PAHs, gasoline, oil or fuel-related compounds (S)	
2247	Heath Oregon Sign Company	4644 SE 17th Ave. Portland, OR	Sign manufacturing	Metals, PCBs, TCE, PCE	Arsenic(S), berylium(S), PCBs(S), TCE and PCE(GW)	GW
2301	Clackamette Cove Area (aka. City of Gladstone, Clackamas County Sheriff's Office, Dakota Minerals, Klineline Sand & Gravel, Portland Traction Railroad, City of Oregon, Jack Parker Property, Northwest Aggregates Co., Western Pacific Construction Materials Co.)/ RA 1/04	16288 Main St. Oregon City, OR 97045		Gasoline (BTEX, PAHs), heavy metals, asphalt, diesel & lube oil-range TPH, PAHs, chlorinated hydrocarbons	Arsenic(B), chlorobenzene(GW), chromium(S), dichlorobenzene(GW), iron(GW), lead(B), TPH(S)	GW
2409	Ross Island Sand & Gravel Co. (Hardtack Island Plant)/RA 11/05 & land-use assessment 3/06	Hardtack Island-Willamette River Milepost 15, 4315 SE McLoughlin Blvd Portland, OR 97201		PCBs, PAHs, petroleum, metals, pesticides/herbicides	Copper(S), PCBs(S), PAHs(S), tributyltin(S)	GW
2414	Eastbank Riverfront Project (aka. Eastbank Esplanade, Portland Development Commission)/ partial NFA 1999	Portland, OR 97214		Lead, petroleum	Lead(S), petroleum(S)	
2492	South Waterfront Redevelopment Area 3/ ROD 1/04, RA 2/04, Inventory 4/04	SW River Pkwy. & SW Harbor Dr. Portland, OR 97201	Portland Lumber Company (former)	PAHs, metals, diesel, lead, oil	PAHs(B), cadmium(GW), chromium(GW), diesel(S), lead(GW), oil(S)	GW
2613	Willamette View Inc. (aka. Spears, Willie Hot, Willamette View Manor, Willamette View Retirement Home,)/ Site screening recommended 2001	12705 SE River Rd. Portland, OR 97222	Retirement home	diesel-range TPH, lead (offsite source suspected)	TPH(B)	GW
2616	Erickson's Automotive (aka. BLE Inc. Jeepers Its Ericksons, Ericksons Automotive, Groundwater - Foothills Road Industrial Area, Lake Oswego Area Groundwater Contamination, Lake Oswego Public Water Supply RPN)/ NFA 3/04	101 Foothills Rd. Lake Oswego, OR 97034		Petroleum, PAHs, VOCs (benzene, toluene, ethylbenzene, xylenes, and chlorinated hydrocarbons)	Dichloroethylene(GW), naphthalene(GW), tetrachloroethylene(GW), trichloroethylene(GW)	GW
3104	Rodda Paint Building (former)/ Placed on Inventory 4/02	6932 SW Macadam Ave. Portland, OR 97219	Paint-making operation (former)	Toluene, xylene-based solvents, mineral spirits, paint wastes containing metals, water-based resins, petroleum hydrocarbons, chlorinated VOCs	Acetone(S), butylbenzenes(S), chloroform(GW), cumene(B), dichloroethane(GW), dichloroethylenes(GW), ethylbenzene(S), propylbenzene(B), tetrachloroethylene(GW), toluene(GW), trichloroethane(GW), trichloroethylene(GW), trichloromonofluoromethane(GW), trimet	GW, SW, WW, DR
3993	Pacific Richfield - South Waterfront (aka.North Macadam Investors, North Macadam Central district, Rosebud Holdings, Waterfront South)/cleanup 1/04 & partial NFA 4/06	3305-3401, 3500 SW Bond St. Portland, OR 97239	Previously used for sand & gravel operations (1930-1989); small welding shop operated for short period afterward.	Petroleum hydrocarbons, SVOCs, PAHs in localized areas	TPH (S), arsenic (S), low levels of PAHs (GW)	

Table 4.5-1. Shoreline or Nearshore Facilities Upstream of RM 11.8 Listed in DEQ's ECSI Database.[a]

ECSI #	Facility or Site Name/Status	Address	Type(s) of Operation	Hazardous Substances/Waste Types	Detected Chemicals in Upland Samples[b]	Potential Pathways to River[c]
4007	Prometheus Property (aka. Lakeside Industries [circa 1989], North Landing, The Landing at Macadam, LLC)/ placed on Confirmed Release List 11/05	Bond & Lowell St. T1S/R1E/S10 Portland, OR 97201	Undeveloped, former asphalt manufacturing plant (formerly Lakeside); 6-8 USTs with leakage	PAHs, diesel, PCBs, metals	Diesel (S), HPAH (S)	GW, SW
4026	Lake Oswego Chip Facility (Crown Zellerback, Georgia Pacific Wood Chip Facility, Foothills Park, James River Paper Company, City of Lake Oswego)/ RA 2/05 & NFA 10/05	199 Foothills Rd. Lake Oswego, OR 97034	Chip processing, rail lines, barge loading, wood chip loading	PAHs, metals, herbicides	Gasoline (GW), PAHs (S)	GW, SW
4036	US Bank/Blocks 25 & 29 excavated in 2004, partial NFA 5/05	3505-3439 & 3400-3500 SW Bond Ave. Portland, OR 97239	Currently being redeveloped for mixed urban res./comm.; past uses include shipbuilding (1943-1945), steel and metal fabricating, electrical products manufacturing. Blocks 25/29 used for storage of logging and surplus Zidell equipment. Recently used for warehouse/office space with parking/loading dock.	Localized areas of petroleum hydrocarbon contamination	TPH (S)	SW
4085	Two Main Place/ quick cleanup performed for redevelopment	101 SW Main St. Portland, OR 97204	Parking lot for approximately past 20 years; gas stations and laundries in the past	Gasoline and chlorinated hydrocarbons	Petroleum (S, GW), PCE (GW)	
4416	Oak Tower Redevelopment/ RA 4/06 & proposed for inventory 10/06	225 Oak St. Portland, OR 97204	Heating oil spill	TPH, PAHs, TCE	Diesel (S), TCE (GW)	
4420	South Waterfront at River Place - Stanford's Rest., RiverPlace Square Apts (Trammel Crow)/ added to database 5/05	Parcel 2 Areas B&C SW River Dr. Portland, OR 97201				
4421	South Waterfront at River Place - SW River Drive & SW River Parkway w/ storm drains	Parcel 2 Area A, SW River Dr. and SW River Pkwy., Portland, OR 97201				
4422	South Waterfront Park - on the river (aka. South Waterfront Redevelopment Area, Parcel 3A/3B)/ RA (capped PAH-contaminated soil, bank stabilization) 10/05	Parcel 3A & 3B, Area D Foot of SW Montgomery St., Portland, OR 97201	Parcel 3A - site of former Lincoln Steam Plant			
4423	South Waterfront Park- PGT Building(aka. South Waterfront Parcel 3B)/NFA 1994, added to database 5/05	Parcel 3B SW River Pkwy. Portland, OR 97201				
4424	South Waterfront River Place Lot 108- NE corner SW River Dr/SW River Pkwy/ FS 2/05, asbestos removal alternatives 5/05	Parcel 3B, Area D SW River Pkwy./SW River Dr. (NE Corner) Portland, OR 97201		Buried asbestos		
4426	East Portland Gas Works (former)/site screening recommended 6/05	110 SE 2nd Ave. & 5 SE Martin Luther King Ave. Portland, OR 97214	Former gas plant	PAHs	No testing has been completed	
4527	Neighborhood Park (public Storage)/RA 6/06	3508 SW Moody Ave. Portland, OR 97239	Machine shop and door manufacturer (1950's-1960's), now storage units	PAHs, VOCs, metals	Diesel-range petroleum hydrocarbons (GW), VOCs (B), metals (B), PAHs (S)	

Table 4.5-1. Shoreline or Nearshore Facilities Upstream of RM 11.8 Listed in DEQ's ECSI Database.[a]

ECSI #	Facility or Site Name/Status	Address	Type(s) of Operation	Hazardous Substances/Waste Types	Detected Chemicals in Upland Samples[b]	Potential Pathways to River[c]
4578	Everett Street Building/site screening recommended 1/06 (Kronke, Trutz)	509 NW Everett St. Portland, OR 97209		PAHs and lead, unknown source	PAHs (S), lead (S)	Unknown at this time
4597	Traschel Property (aka. American Cleaners)/Indepenedent cleanup 3/06	502/503 Main St. Oregon City, OR 97045	Former dry cleaner, auto sales, auto repair	Gas, diesel, VOCs	Diesel (B), PCE (GW), gas (S), waste oil (S)	
4612	Waterside Development Project	4850 SW Macadam Ave. Portland, OR 97201			Barium (B), diesel-range petroleum hydrocarbons (S), heavy-oil total petroleum hydrocarbons (S), naphthalene (GW), lead (S)	
4621	King Crusher	1306 NE 2nd Ave. Portland OR 97323	This is a heavy equipment manufacturer (rock crushing equipment).	Petroleum Hydrocarbons		
4629	South Waterfront Central District Blocks 46 and 49	601 SW Abernathy St. Portland, OR 97201	Past use: warehouse (furniture, doors, lumber), road construction equipment storage, asphalt storage, and gravel storage. Current use: vacant land and temporary parking area. Three USTs formerly onsite; operational practices.	TPH, PAHs, VOCs, and metals		GW
4825	South Waterfront Central District Blocks 46 and 49 Was originally a subset of ECSI # 4629	601 SW Abernathy St. Portland, OR 97201		Oil-range petroleum hydrocarbons and polynuclear aromatic hydrocarbons.		
4632	Rexel/Taylor Electric Warehouse	1709 SE 3rd St. Portland, OR		Estimated 10 gallons of oil released during an onsite fire	PCBs	SW, GW
4723	Pacific Pride	6230 SW Macadam Ave. Portland, OR 97239	The site is the former location of an auto wrecking yard (Mesher/Union Auto Wrecking Co.; 1930-35), a former boat building facility (Willamette Boat & Manufacturing Co.; 1936-41), and a bulk fuel storage facility	TPH, PAHs, VOCs, and metals	PAHs (GW), VOC's (GW), TPH-diesel (GW), TPH-gas (B)	GW
4772	Macadam Sunset Fuel - Pacific Pride Site 2	6230 SW Macadam Ave.	The site is the former location of an auto wrecking yard (Mesher/Union Auto Wrecking Co.; 1930-35), a former boat building facility (Willamette Boat & Manufacturing Co.; 1936-41), and a bulk fuel storage facility	TPH, PAHs, VOCs, and metals	PAHs (GW), VOC's (GW), TPH-diesel (GW), TPH-gas (B)	GW
4724	JC Cleaners	6141 SW Macadam Ave. Ste. 101 Portland, OR 97239	Dry cleaning facility, former metal fabrication	PCE and TCE		GW
4789	Lake Texaco Service	496 N State St. Lake Oswego, 97034	The property has been an operating service station since 1939.	Gasoline and heavy oil and grease		GW
4811	Blue Heron Paper Mill	419 Main St. Oregon City, 97045	Wood pulping and paper manufacturing activities since 1908	PCBs, metals, TPH, PCDD/Fs		
4824	Pollock Building	406 A Avenue Lake Oswego, OR 97034	Former dry cleaning operation	PCE		GW

Table 4.5-1. Shoreline or Nearshore Facilities Upstream of RM 11.8 Listed in DEQ's ECSI Database.[a]

ECSI #	Facility or Site Name/Status	Address	Type(s) of Operation	Hazardous Substances/Waste Types	Detected Chemicals in Upland Samples[b]	Potential Pathways to River[c]
4914	ODOT Right-of-Way, SW Harbor Dr. below I-405 RAMP	East edge of SW Harbor Drive, below westbound I-5 exit ramp onto I-405 Portland, OR 97201				
4925	Oregon Plating Company	436 SE 6th Ave Portland, OR 97214	Electroplating activities for the past 75 years			SW, GW
No ECSI#	Portland General Electric Company	301 SE Morrison St. Portland, OR	Spill from pole transformer	PCBs		DR

Notes:

[a] Source: http://www.deq.state.or.us/lq/ecsi/ecsi.htm

[b] S=soil or sediment, GW=groundwater, B=both

[c] Pathways Identified in ECSI Site Summary Reports: GW = groundwater, SW = stormwater/surface runoff, WW = wastewater discharge, DR = direct release, spill

BTEX - benzene, toluene, ethylbenzene, and xylenes
cPAH - carcinogenic polycyclic aromatic hydrocarbon
DEQ - Oregon Department of Environmental Quality
EPA - U.S. Environmental Protection Agency
ECSI - Environmental Cleanup Site Inventory
FS - feasibility study
HPAH - high molecular weight polycyclic aromatic hydrocarbon
NFA - No Further Action
PAH - polycyclic aromatic hydrocarbon
PCB - polychlorinated biphenyl
PCDD/Fs - dioxins/furans
PCE - tetrachloroethene
RA - risk assessment
ROD - Record of Decision
SI - site investigation
SVOC - semivolatile organic compound
TCE - trichloroethene
UST - underground storage tank
VOC - volatile organic compound

Table 4.5-2. Active NPDES Permitted Discharges to the LWR, Outside the Study Area.[a]

File No.	Facility	Location Latitude	Location Longitude	Permit Category	Permit Type	River Mile
Major NPDES - Individual Permit						
108015	PORTLAND, CITY OF AND CO-APPLICANTS	45.5506	-122.6204	STM	NPDES-DOM-MS4-1	2.0
108013	GRESHAM, CITY OF; FAIRVIEW, CITY OF; MULTNOMAH COUNTY	45.5164	-122.5353	STM	NPDES-DOM-MS4-1	12.6
16590	CLACKAMAS COUNTY SERVICE DISTRICT #1	45.4398	-122.6424	DOM	NPDES-DOM-A3	18.7
62795	OAK LODGE SANITARY DISTRICT	45.4241	-122.6518	DOM	NPDES-DOM-C1a	20.1
70725	PORTLAND, CITY OF	45.4213	-122.6579	DOM	NPDES-DOM-Ba	20.2
110870	ODOT MUNICIPAL STORMWATER PERMIT	multiple	multiple	STM	NPDES-DOM-MS4-1	multiple
985931	COLUMBIA BOULEVARD WASTEWATER TREATMENT PLANT (CBWTP)	multiple	multiple	STM	NPDES-DOM-A1	multiple[b]
Minor NPDES - Individual Permit						
110220	GSL PROPERTIES, INC.	45.5174	-122.6726	IND	NPDES-IW-B16	11.9
113611	INTELLIGENT COMMUNITY SERVICES	45.4994	-122.6706	IND	NPDES-IW-B16	14.5
109444	ANKROM MOISAN ASSOCIATED ARCHITECTS, INC.	45.4752	-122.6714	IND	NPDES-IW-B15	15.8
General Permits						
111283	COLUMBIA GRAIN, INC.	45.6358	-122.769	STM	GEN12Z	1.1
70613	KINDER MORGAN BULK TERMINALS, INC.	45.6346	-122.771	STM	GEN12Z	1.5
107609	US POSTAL SERVICE	45.5294	-122.6789	STM	GEN12Z	11.9
104545	NORCREST CHINA COMPANY; WHEAT MARKETING CENTER, INC.	45.5292	-122.673	IND	GEN01	12.0
38192	HERCULES INCORPORATED	45.5473	-122.709	IND	GEN01	12.0
113816	HALSEY STREET - DPP LLC	45.5334	-122.6197	STM	GEN12C	12.1
117323	PROVIDENCE HEALTH SYSTEM-OREGON	45.533	-122.5969	STM	GEN12C	12.3
112042	PACIFIC COAST FRUIT COMPANY	45.5237	-122.6643	STM	GEN12Z	12.3
116153	STACY WITBACK/KIEWIT PACIFIC, INC. A J.V.	45.5212	-122.6767	STM	GEN12C	12.5
117047	FIRST AND MAIN	45.5147	-122.6756	STM	GEN 12C	12.9
106750	EAST SIDE PLATING, INC.	45.5134	-122.663	STM	GEN12Z	13.0
116730	MONTGOMERY BLOCKS 1700 BUILDING	45.5115	-122.6799	STM	GEN 12C	13.1
117164	SKANSKA USA BUILDING	45.5117	-122.6825	STM	GEN 12C	13.1
115140	RIVERS EAST LLC	45.5115	-122.6663	STM	GEN12C	13.3
115102	KIEWIT-BILFINGER BERGER, AJV (KBB)	45.5074	-122.6627	STM	GEN12C	13.4
107211	DARIGOLD, INC.	45.503	-122.6597	STM	GEN12Z	13.9
104861	ZIDELL MARINE CORPORATION	45.5002	-122.6705	STM	GEN12Z	14.0
100103	PACIFIC SAW AND KNIFE COMPANY - DBA	45.465	-122.6355	STM	GEN12Z	14.2
111942	NORTH MACADAM INVESTORS, LLC	45.4971	-122.6689	STM	GEN12C	14.3
117570	BLOCK 46	45.4944	-122.6714	STM	GEN 12C	14.4
117548	BLOCK 49 IMPACTED SOIL REMOVAL	45.4934	-122.6724	STM	GEN 12C	14.5
109995	ARCHER-DANIELS-MIDLAND COMPANY	45.4848	-122.6438	STM	GEN12Z	15.0
62795	OAK LODGE SANITARY DISTRICT	45.4241	-122.6518	STM	GEN12Z	19.9
107661	LAKE-SHORE CONCRETE CO.	45.4204	-122.6613	STM	GEN12A	20.2
107631	EDWARDS, MARJORIE L	45.4624	-122.7029	IND	GEN15A	20.2
115866	PALUMBO, JOHN	45.4025	-122.66	STM	GEN12C	21.5
101733	STANLEY WORKS, THE - DBA THE STANLEY WORKS, INC.	45.3996	-122.6234	STM	GEN12Z	21.5
116325	SKYLINE RIDGE # 5	45.3916	-122.6573	STM	GEN 12C	21.9
114940	HOME PORT, INC.	45.3976	-122.6238	STM	GEN12C(AGENT)	22.8
48480	LAKE OSWEGO, CITY OF	45.3859	-122.6325	IND	GEN02	23.8

Notes:

[a] DEQ Wastewater permits database accessed 5/27/2009 (http://www.deq.state.or.us/wq/sisdata/facilitycriteria.asp)

[b] The CBWTP also covers CSO and SSO discharges to the Willamette River

Definitions:

DOM - Domestic
GEN01 - Cooling water/heat pumps
GEN02 - Filter backwash
GEN12A - Stormwater from gravel mining
GEN12C - Construction that disturbs more than one acre
GEN12C(AGENT) - Construction that disturbs more than one acre, issued by agent
GEN12Z - Industrial stormwater
GEN15A - Petroleum hydrocarbon cleanups
IND - Industrial
NPDES-DOM-A3 - Sewage - 10 MGD or more but less than 25 MGD
NPDES-DOM-Ba - Sewage - 5 MGD or more but less than 10 MGD
NPDES-DOM-C1a - Sewage - 2 MGD or more but less than 5 MGD
NPDES-DOM-MS4-1 - Municipal Stormwater Permit
NPDES-IW-B15 - Facilities not elsewhere classified which dispose of process wastewater (includes remediated groundwater)
NPDES-IW-B16 - Facilities not elsewhere classified which dispose of non-process wastewaters
STM - Stormwater

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This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part.

Table 4.5-3. Summary of Willamette River Sub-basin TMDLs.

	Parameter					
Sub-basin	**Temperature**	**Dissolved Oxygen**	**Bacteria**	**pH**	**Toxics**	**Other**
Approved 9/2006						
Clackamas Subbasin	X		X			
McKenzie Subbasin	X					
North Santiam	X					
South Santiam	X					
Coast Fork	X		X		Mercury	Ammonia & nutrients (carried through from 1995)
Middle Fork	X					
Upper Willamette	X	X	X		Mercury	Turbidity
Middle Willamette	X		X		Mercury	
Lower Willamette	X		X	X	DDT and dieldrin (Johnson Creek), mercury	
Willamette Main Stem	X		X		Mercury	
Approved 2/1991						
Willamette River					PCDD/Fs	
Approved 8/2001						
Tualatin	X	X	X	X		Ammonia, chlorophyll a (phosphorus), volatile solids
Approved 12/2008						
Mollala-Pudding	X		X		Arsenic, iron, manganese, chlordane, dieldrin, DDT	Nitrate
In Progress (expected approval in 2009)						
Yamhill						

Source: Oregon Department of Environmental Quality (www.deq.state.or.us/wq/tmdls/tmdls.htm); accessed in January 2009.

Notes:
PCDD/Fs - dioxins/furans
TMDL - total maximum daily load

5.0 IN-RIVER DISTRIBUTION OF INDICATOR CHEMICALS

The distribution of ICs in sediment, in-river sediment traps, surface water, TZW and groundwater seeps, and biota is summarized in this section.[1]

Numerous chemical and physical parameters were analyzed and detected in sampled media from the Study Area, and these are referred to as chemicals of interest, or COIs (Table 5.0-1). From the list of COIs, an IC list was identified to represent the nature and extent of the range of contaminants that potentially pose risk to human health and the environment in sediment, surface water, TZW, and biota for the Draft RI. This IC list was generated, in consultation with EPA in the spring/summer of 2008, based on the chemicals that emerged from the Round 2 risk screening and preliminary risk evaluation process and consideration of the following non-risk-based factors:

- Frequency of detection—Chemicals with a high frequency of detection (e.g., generally >50%) were selected as an IC.
- Cross media comparisons—Preference was given to chemicals that would allow comparisons across media.
- Representative chemicals—Several ICs were selected to represent a suite of compounds (e.g., BEHP was selected to represent the phthalate group).
- EPA requests—EPA requested the inclusion of several additional chemicals for sediment and biota based on their review of the Round 2 Report (Integral et al. 2007). EPA also requested the inclusion of certain other chemicals with widespread sources in the harbor (metals, PAHs, and TPH) during the IC lists development discussions in 2008.

Table 5.0-2 lists the ICs selected by this process for various uses in the Draft RI. This includes nature and extent for abiotic and biotic media chemicals (Section 5); loading, fate, and transport (Section 6); fate and transport modeling (part of FS); and the site-wide CSM (Section 10).

Once the baseline risk assessments were completed (the BHHRA is provided in Appendix F; the BERA in Appendix G), a final list of COCs was documented. Additional chemicals resulting from this work are also shown in Table 5.0-2. These COCs are not ICs for the RI but are shown in Table 5.0-2 (see asterisks) for completeness.

The nature and extent of four ICs or compound groups were identified in the ecological and human health risk evaluations as posing risk in the Study Area. These four chemicals, hereafter referred to as bounding ICs, are total PCBs, total PCDD/Fs (as both total dioxins/furans and dioxin/furan TCDD TEQ[2]), total DDx, and total PAHs. These

[1] The discussion of chemical nature and extent may include use of facility names and landmarks (e.g., bridges) for location references; mention of such names does not necessarily indicate a source or origin.
[2] The dioxin/furan TCDD TEQ does not include dioxin-like PCB congeners.

four chemicals are considered "bounding" because their distribution is believed to encompass the spatial extent of potentially unacceptable risks associated with all COCs identified in the baseline risk assessments. This is not intended to imply that other COCs will not be evaluated in the FS.[3] These bounding chemicals are discussed in detail in the Section 5 subsections that follow. For each medium, the nature and extent of an additional set of ICs is also described. This set varies by media but it includes all chemicals that are the focus of the comprehensive cross-media and fate and transport evaluations presented in Section 10 (CSM) of this RI. This set of CSM chemicals was selected in consultation with EPA to provide a relatively complete picture of the distribution, transport, and fate of chemicals in the Study Area across a range of physical, chemical, and biological processes, as well as known and potential sources. Finally, the nature and extent data for the balance of the ICs listed in Table 5.0-2 are presented on all tables, maps, and figures in Appendix D but not addressed in the narrative.

The following sections are organized by media and focus on the nature and extent of ICs in and immediately adjacent to the Study Area in sediments (Section 5.1), sediment traps (Section 5.2), surface water (Section 5.3), TZW (Section 5.4), and biota (Section 5.5). Section 5.6 then summarizes sediment data from areas upstream and downstream of the Study Area, as well as in known depositional areas in the navigation channel at the upper end of the Study Area.

Depending on the medium examined, the nature and extent discussion is supported by a variety of tabular and graphical materials: 1) plan-view and core maps for sediment showing the extent of each chemical's distribution, 2) summary statistics tables, 3) scatter-plot graphs depicting chemical concentrations by river mile, and 4) bar charts and box-whisker plots for comparing values and distributions. Summary statistics for ICs are tabulated in the main text for sediment (Tables 5.1-1, 5.1-2, and Tables 5.6-1 through 5.6-13), in-river sediment traps (Tables 5.2-1 through 5.2-4), surface water (Tables 5.3-2 through 5.3-7), and biota (Tables 5.5-1 and 5.5-2). Summary statistics for all parameters analyzed in each medium are presented in tables included in Appendix D.

For each IC, the following summary statistics are tabulated: the frequency of detection; the minimum, maximum, mean, median, and 95th percentile; and the station locations of the maximum values. Two sets of statistics are presented for each IC. One set reflects only detected values and the other set shows detected and undetected values combined. The statistics have been compiled separately for areas inside the Study Area (RM 1.9–11.8, ≤13 ft NAVD88, exclusive of the Multnomah Channel) and areas outside of it. Summary statistics for sediments include both point samples and composite samples to provide a general understanding of IC concentration distributions. The discussion of

[3] These four COCs largely represent the areal extent of unacceptable risk to humans and wildlife (birds and mammals). Other COCs are associated with unacceptable risk, but generally within the areas represented by these four COCs. The exception may be where toxicity test results indicate unacceptable risk to the benthic invertebrate community, but no specific chemical has been associated with the toxicity.

the nature and extent of ICs in media provided in the remainder of this section is based on statistics calculated for detected concentrations only.

Where specific results are cited in the text (i.e., the concentration of a sample, median and 95th percentile values) qualifiers associated with that result are also cited, with one exception. The qualifier "T" is not cited as it generally indicates that the result was mathematically derived through summing multiple results (e.g., total PCB congeners equal the sum of the PCB congener results). The "T" qualifier may also indicate that a result is an average of multiple results for a single analyte (e.g., field replicates) or that a result was selected for reporting in preference to other available results (e.g., for parameters reported by multiple methods). The following qualifiers are cited with the results:

A – Total value is based on a limited number of analytes.

J – The associated numerical value is an estimated quantity.

N – Presumptive evidence of presence of material; identification of the compound is not definitive.

U – The material was analyzed for, but was not detected. The associated numerical value is the sample quantitation limit.

V – Median or 95th percentile was obtained through interpolation of data.

In certain cases, concentrations of closely related analytes were added together to create a group sum. When calculating group concentrations for this nature and extent evaluation, a value of zero was used for non-detected concentrations on an individual sample basis; other analyte summing approaches were used in the risk evaluations presented in Appendices F and G of this report for the BHHRA and BERA, respectively.[4] The 2,3,7,8- TCDD TEQ values for dioxin-like PCB congeners and PCDD/Fs were calculated with World Health Organization (WHO) 2005 TEFs for mammals (Van den Berg et al. 2006). The cPAH BaPEq values were calculated using PEFs provided in EPA (1993). Tables in Appendix D1.5 present the constituent concentrations used in each group sum. Further information on summing methods is provided in Section 2.1.4.

[4] For the RI, the summation methods use zero for non-detects within sums. This allows a clear presentation of results for assessment of nature and extent, avoiding bias presented by the detection limits. This also prevents high detection limits from creating confusion in the evaluation of nature and extent. For the BHHRA and BERA, the summation method uses one-half the detection limit for non-detects within the sums. This was the agreement with EPA.

5.1 INDICATOR CHEMICALS IN SEDIMENT

This section summarizes the surface and subsurface sediment data collected in the Study Area. The locations of all sediment samples in the nature and extent data set are shown on Maps 2.2-1a–y and 2.2-2a–t. The surface sediment data set includes all samples with intervals starting at 0 cm and extending to depths ranging to 40 cm bml.[5]

5.1.1 Sediment Data Set

The sediment RI data set is composed of all Category 1 LWG and non-LWG data collected within the Study Area (below +13 ft NAVD88) from May 1997 to December 2007. Sediments collected below +13 ft NAVD88 include both subaqueous sediment and beach sediment. Sediment data are used to characterize contaminant distribution and potential source effects, to provide data necessary for the risk assessments, to provide data for the FS, and to refine the understanding of the physical dynamics of the river system.

Summary statistics for grain size, TOC, and ICs in the surface and subsurface sediment samples from the Study Area are presented in Tables 5.1-1 and 5.1-2; the full data set is provided in Appendix D1.2. These summary statistics do *not* include results from locations that were dredged or capped subsequent to sample collection. However, post-dredged sediment samples are included in the summary statistics.

5.1.2 Indicator Chemicals in Sediment

The IC list for sediment is presented in Table 5.0-2. The selection of ICs was guided by the considerations detailed in Section 5.0. A total of 34 individual analytes and calculated chemical sums were identified as ICs for sediment. They are organized as follows:

- PCBs
  - Total PCBs*
  - PCB TEQ (ND=0)
- PCDD/Fs
  - Total PCDD/Fs* and TCDD TEQ (ND=0)*
- DDx
  - Total DDx (sum of 2,4'- and 4,4'-DDD, DDE, DDT)*

[5] The functional definition of surface sediments for this site is 0–30 cm based on physical system studies. However, the recorded lower depth of a set of sediment samples (i.e., shallow cores that begin at the mudline) in the nature and extent data set reached to 40 cm. These samples were grouped with the surface data set, thus extending the maximum depth for the surface horizon to 40 cm. Core samples that extended from the mudline to depths greater than 40 cm were grouped with the subsurface sediment data set.

  - Total of 2,4'- and 4,4'-DDT
  - Total of 2,4'- and 4,4'-DDE
  - Total of 2,4'- and 4,4'-DDD
- PAHs
  - Total PAHs*
  - Total cPAH BaPEq values
  - Total LPAHs
  - Total HPAHs
  - Phenanthrene
  - Naphthalene
  - BAP
- Petroleum Hydrocarbons
  - TPH
  - TPH - Diesel-range hydrocarbons (DRH)
  - TPH - Residual-range hydrocarbons (RRH)
- Semivolatile SVOCs
  - BEHP*
  - Butylbenzyl phthalate
  - Pentachlorophenol
  - Hexachlorobenzene
- Pesticides
  - Total chlordanes*
  - gamma-Hexachlorocyclohexane (HCH)
  - Aldrin*
  - Dieldrin*
- Metals
  - Arsenic*
  - Cadmium
  - Chromium*
  - Copper*

  - Lead
  - Mercury
  - Nickel
  - Zinc*
- Organometallic Compounds
  - Tributyltin ion (TBT)*.

This section focuses on the distribution of a subset of 13 ICs in surface and subsurface sediment within the Study Area, which are indicated with an asterisk (*) in the above list (total PCDD/Fs and TCDD TEQ are grouped as one chemical in this count). The 13 ICs were selected to match the chemicals for presentation and discussion in the site-wide CSM (Section 10). Of these, four chemical groups—total PCBs, total PCDD/Fs (including TCDD TEQ), total DDx, and total PAHs—have been identified as bounding ICs based on the risk evaluations and their nature and extent are discussed in depth here. The discussion focuses primarily on the following items:

- A description of the data set for each chemical, including sample counts, concentration range, and frequency of detection.
- A discussion of the surface and subsurface concentration distributions in the Study Area organized by eastern nearshore, western nearshore, and navigation channel subareas.
- Additional information is provided for the four bounding ICs:
  - The vertical trends in sediment concentrations
  - The relationship of subsurface sediment to surface sediment
  - The nature and composition of these complex chemical groups and distribution patterns.

The discussion of the other 9 ICs in the subset is less comprehensive, omitting the data set description and referring instead to maps, tables, and figures to provide a complete picture of the distribution of these chemicals. The data for the remaining 21 sediment ICs is presented in Appendix D1. In Section 10, chemical distributions across abiotic and biotic media and in relation to specific potential sources are presented in more detail for the subset of 13 ICs.

5.1.3 Description of Sediment Presentation Tools

The sediment chemistry distributions are depicted in five graphical formats: surface plan-view concentration maps and subsurface core concentration maps (Maps 5.1-1 through 5.1-28), scatter-plot graphs (Figures 5.1-1 through 5.1-32), and histograms and stacked bar charts (Figures 5.1-33 through 5.1-47). Maps and scatter-plot graphs of

surface and subsurface concentrations for the remaining 21 ICs, plus percent fines and TOC, are included in Appendices D1.1 and D1.3, respectively. Appendix D1.2 provides statistical summaries of all sediment analytes.

Surface Chemistry Maps: The plan-view concentration maps present all surface sample data using color-coded dots that correspond to a concentration scale for that particular chemical. Non-detected concentrations are differentiated from detected concentrations on the surface maps by a dot in the center of the sample symbol (i.e. ⊙). The maps include data points from locations that were dredged or capped subsequent to the collection of the sample(s) (shown by a circle centered around the sample symbol [i.e., ⊙]).[6] Data from these areas are presented to show spatial patterns of chemicals from a historical perspective. In addition, the surface maps include histograms showing the distributions and frequencies of the detected and non-detected results. Data from all samples shown on the maps are included in the histograms.

The concentration ranges (or intervals) used in color-coding the chemical data shown on the maps (e.g., the threshold value for the red labels) were based on the frequency distributions (i.e., natural breaks) in the historical data set for these compounds and as approved or modified by EPA for use in the Programmatic Work Plan. These concentration range intervals were also used in the Round 2 Report.

Subsurface Core Maps: The core maps show the distribution of ICs with depth at the subsurface sediment sampling stations (these maps also include the surface sample data). Inset maps for densely sampled core areas are provided for most sets. However, if core samples in these inset areas were archived (i.e., for possible future chemical analysis), the inset map is deleted from the set. In these maps, the actual core station is marked with a triangle (i.e., △). The core segment divisions displayed on the maps are scaled to the thickness of each sample interval. Note that these maps include cores from locations that have been subsequently dredged or capped, as indicated on the maps. Cores taken post-dredging are also included on the maps. The subsurface concentration maps do not indicate samples where concentrations are based on partial sums (the few cases where data are based on partial sums are from non-LWG studies).

Scatter Plots: Scatter plots of the distribution of analytes in surface and subsurface sediment per river mile are presented in Figures 5.1-1 through 5.1-32. To aid in differentiating potential concentration trends, the data in these plots are further separated into eastern nearshore, western nearshore, navigation channel, and Multnomah Channel stations as defined by the federal navigation channel boundary. The areas falling into these categories are shown in Map 5.1-29. Unlike the plan-view maps, the scatter plots do *not* include data for samples from locations that have been subsequently dredged or capped.

[6] Surface interval sample locations G088, G087, and G091 collected in 2004 in the International Terminals Slip were dredged subsequent to sampling. These locations were resampled in 2005 at C088, C087, and C091.

Histograms: Histograms were developed to supplement the subsurface core maps and support examination of vertical trends in chemical concentrations with depth in the sediment column. The histograms compare the magnitude of the ratios of surface and subsurface sediment chemical concentrations for the bounding ICs on subarea basis (e.g., RM 8-9 west of channel; see Figures 5.1-33, 5.1-39, 5.1-42, and 5.1-45). The ratios were calculated by dividing the mean of all detected surface sample concentrations in a given subarea by the mean of all detected subsurface core interval samples. The absolute magnitude of the ratios is plotted on the histograms (i.e., where the subsurface mean is greater than the surface mean, the inverse of the ratio is plotted).

The y-axis in the plots is centered on a value of 1, which represents no difference between surface and subsurface concentrations. Values extending downward from the y-axis indicate areas where the mean of subsurface values exceeds the surface mean. Bars extending upward show where the surface sediment means are greater. The y-axis value indicates the magnitude of the differences between the surface and subsurface means. In some instances, a ratio could not be determined because only surface sediments were analyzed for the bounding ICs in that subarea. Subareas included east, navigation channel, and west zones for each river mile in the Study Area, as well as downstream (RM 0–2), Multnomah Channel, and Swan Island Lagoon. Mean concentrations were also calculated for the Study Area as a whole (see leftmost column in each figure).

These histograms are useful in providing a summary of spatially averaged surface/subsurface trends throughout the Study Area. However, some caution is needed in interpreting the trends due to the biased nature of the RI sampling program (i.e., subsurface core samples were generally focused on known areas of contamination, whereas surface samples were distributed more widely). Consequently, these histograms should be examined in conjunction with the subsurface core maps in evaluating surface to subsurface trends for a specific IC and subarea. This is particularly true for the relative low density PCDD/F data plotted in Figure 5.1-39, where a single extreme data point can skew the calculated ratio. Finally, the actual surface and subsurface concentrations for individual samples by RM are shown on the scatter plots (Figures 5.1-1 through 5.1-32) noted above.

Stacked Bar Charts: Stacked bar charts are designed to reveal distinctive patterns in the relative abundance of bounding IC components. These graphs provide a line showing concentrations of the IC (i.e., totals) on a logarithmic scale, but do not display concentrations of the analyte components (e.g., homologs, isomers). The analyte components are shown as a percent of the total concentration. Station location labels are provided on the x-axis, and river mile is indicted on the secondary x-axis along the top of the chart. On subsurface figures, the sample interval with the maximum concentration of the analyte is displayed.

5.1.4 Sampling Methods

LWG surface sediment samples were collected in a consistent, repeatable manner with a stainless-steel, 0.3-m^2 hydraulic power-grab sampler. The maximum penetration of the power-grab sampler was approximately 30 cm. Non-LWG surface samples were collected using a variety of sampling devices, including ponar samplers, power grabs, Eckman samplers, box cores, and spoons. A limited number of non-LWG surface samples were collected from the mudline to depths of 30 to 40 cm bml, and these data are also included in the RI surface sediment data set.

Subsurface sediment was collected by the LWG using a customized vibracorer equipped with either 14-ft or 20-ft core tube. Non-LWG subsurface samples were collected by a variety of methods and depths, the most common being a vibracore, followed by a "driven tube." The driven tube could include the vibracore, impact, or gravity methods. Other coring samplers included gravity corer, macro-core sampler, impact corer, hand core, split-spoon sampler, Mudmole™, and steam auger.

5.1.5 Total PCBs in Sediment (Congeners and Aroclors)

This subsection summarizes the surface and subsurface distribution of total PCB concentrations in the Study Area, compares the PCB congener and Aroclor concentrations, and discusses PCB homolog and Aroclor patterns across the Study Area. For the purpose of sediment characterization, total PCB congener concentrations represent the sum of detected congener concentrations in a sample. In cases where no congeners were detected, the single highest detection limit of all congeners analyzed is used to represent the total value. Similarly, total PCB Aroclor values reflect the sum of detected Aroclors in a sample.

To simplify characterization of PCBs in the Study Area, the total PCB congener and total Aroclor data were combined into a single data set of total PCBs. These total PCB data were used to create Maps 5.1-1 and 5.1-2a–m. The total PCB data set includes the result for total PCB congeners for each sample when available (with one exception), and the result for total Aroclors when no total PCB congener data are available. Priority was given to PCB congener data based on the greater specificity and accuracy of the laboratory method for congeners (see Appendix D1.4). The exception is that total Aroclor data were selected to represent total PCBs for Round 2A beach sediment samples because the beach samples were only analyzed for coplanar PCB congeners, which constitute a small fraction of the total PCBs. Congener analyses for the remaining LWG sediment samples included all 209 congeners. Total PCB concentration data for the Study Area are available for 1,184 surface and 1,325 subsurface samples. Most of the PCB data are based on Aroclor analyses (Tables 5.1-1 and 5.1-2). Maps 5.1-30 and 5.1-31 display the locations of surface and subsurface sediment samples analyzed for PCBs and indicate whether PCB congener data, Aroclor data, or both are available.

The distribution of maximum total PCB concentrations at each surface sediment sampling station throughout the Study Area is depicted on Map 5.1-1; concentrations with depth at subsurface stations are depicted on Maps 5.1-2a–m. The complete data set is plotted on scatter plots presented in Figures 5.1-1 and 5.1-2. Scatter plots for total PCB congeners and Aroclors are shown in Figures 5.1-3 through 5.1-6. The summary statistics values shown in Tables 5.1-1 and 5.1-2 for total Aroclors and total PCB congeners indicate overall higher sample concentrations of total PCB when summing congeners. The higher concentrations measured by summing congeners are a result of different sampling approaches and are not a result of differences in laboratory methodology. The data set for total PCB congeners is smaller than the Aroclor data set, and samples selected for PCB congener analysis frequently targeted areas of known or suspected contamination.

5.1.5.1 Total PCB Congener and Aroclor Correlation

The relationship between total PCB congener and total Aroclor concentrations is discussed in detail in Appendix D1.4. Both methods represent the total PCB concentrations well, and summed total PCB concentrations are fairly comparable between methods in most cases. The surface sediment correlation (coefficient of determination) between same sample congener and Aroclor totals was $r^2 = 0.761$, and the subsurface correlation was $r^2 = 0.476$. Plots of these regressions are presented in Appendix D1.4. For all data (sediment, sediment trap, and biota), r^2 was 0.70. PCB totals based on congeners and Aroclors did not correspond well for 11 sediment samples (i.e., an order of magnitude difference between the total congener and total Aroclor results); these are also described in Appendix D1.4. The evaluation of the relationship between PCB congener and PCB Aroclor concentrations in Appendix D1.4 indicates that total Aroclor data may overpredict total PCB congeners in concentrations below ~750 µg/kg total Aroclors and may result in underprediction above 750 µg/kg.

PCB congener data better represent total PCB concentrations than Aroclor data, as the congener method is less affected by "weathering," non-PCB interferences, and subjective Aroclor identifications. For this reason, in this report, total PCB congener concentrations are given priority over total Aroclor concentrations when total PCB congener data exist for any given sample. Because measured total PCB concentrations are fairly comparable between methods in most cases (especially when measurement error is considered), it is useful to use Aroclor concentrations when no PCB congener data exist. Combining the PCB data in this way provides greater spatial and temporal coverage than using congener data alone.

5.1.5.2 Total PCBs in Surface Sediment

Total PCBs were detected in 940 surface samples within the Study Area (detection frequency of 79 percent), with concentrations ranging from 0.851 J µg/kg to 35,400 µg/kg (Table 5.1-1). Ninety-five percent of the concentrations in surface samples were less than 641 V µg/kg.

Total PCB concentrations in surface sediment varied along the Study Area. With few exceptions, concentrations were relatively low (generally less than 100 µg/kg) throughout the navigation channel, whereas many areas in the nearshore zones contained concentrations greater than 100 µg/kg in surface samples (Figure 5.1-1). Total PCB concentrations exceeding 1,000 µg/kg in the scatter plots are indicated in red on Map 5.1-1. A prominent peak in the surface data from the western nearshore zone occurred at RM 8.8, where the highest surface concentration in the data set was detected (Station G453). The highest subsurface concentration was also found in this vicinity (Station C455; 30–153 cm bml).

5.1.5.3 Total PCBs in Subsurface Sediment

PCBs were detected in 862 subsurface samples (detection frequency of 65 percent) and ranged from 0.00138 J µg/kg to 36,800 µg/kg (Table 5.1-2).

Similar to surface sediment, total PCB concentrations in the subsurface also varied within the Study Area (Figure 5.1-2; Maps 5.1-2a–m). With few exceptions, concentrations were generally less than 100 µg/kg throughout the navigation channel. Areas with subsurface concentrations greater than 1,000 µg/kg generally occurred in areas with surface concentrations also greater than 1,000 µg/kg (Figures 5.1-1 and 5.1-2).

5.1.5.4 Total PCB Surface and Subsurface Sediment Relationships

Surface and subsurface sediment relationships were examined by calculating ratios of mean total PCB concentrations (i.e., surface/subsurface) for the Study Area; for the east, middle, and west sides of the Study Area; for Multnomah Channel; and for Swan Island Lagoon. Ratios compared all surface and all subsurface sample intervals and excluded non-detected data. The magnitude of surface and subsurface mean total PCB concentrations were then plotted in a histogram to illustrate general trends in surface and subsurface chemical distributions. Statistical summaries for river mile reaches are provided in Table 5.1-3.

Total PCB concentrations were higher in subsurface sediments within the Study Area as a whole (left side of Figure 5.1-33)[7], with localized exceptions. Where mean surface sediment total PCB concentrations are greater than subsurface concentrations the magnitude of difference is generally low, with the exception of the navigation channel at RM 11 to 11.8. Higher surface sediment concentrations on the east side the navigation channel between RM 11 and 11.8 are also evident in the core plots (see Map 5.1-2m), indicating a probable ongoing source.

[7] Note that the magnitude of mean surface/mean subsurface concentrations above "1" in Figure 5.1-33 indicate higher surface sediment concentrations while those below "1" reflect higher subsurface sediment concentrations. In situations where only surface samples were analyzed (i.e., RM 2–3 west bank, and RM 10–11 west bank), a ratio could not be calculated and is indicated by an asterisk on the figure.

5.1.5.5 Patterns and Trends of PCBs in Sediment

This subsection includes a general description of the distribution of PCB homologs and Aroclors in sediment to provide information that may be used to infer the presence of different sources and PCB transport within the Study Area. Aroclor distributions are compared to homolog distributions to evaluate the Aroclor identifications made by the laboratories.

PCB homologs are congeners grouped according to chlorination level (i.e., the number of chlorine atoms [1–10] bonded to the biphenyl molecule). All of the PCB congeners in each homolog group are isomers. Homolog groups are identified as monochlorobiphenyl (one chlorine atom [$C_{12}H_9C_l$]; monoCB) through decachlorobiphenyl (10 chlorine atoms [$C_{12}Cl_{10}$]; decaCB). Examples of the PCB congener content of Aroclors has been reported by several authors (e.g., Erickson 1997, Frame et al. 1996) and was used to present the PCB homolog content of Aroclors in Figure 5.1-34. Identification of PCB Aroclors at the analytical laboratory can be subjective if the PCB pattern in the sample does not closely reflect the Aroclor standards. This is frequently the case in environmental samples as a result of fate and transport processes, the presence of more than one Aroclor in a sample, and chromatographic interference. Differing sorption, solution, and volatilization rates for different congeners and degradation processes can lead to weathering of Aroclors in the natural environment. Varying degrees of weathering were observed in the sediment samples, with some samples exhibiting what appeared to be weathered Aroclor patterns and other samples exhibiting Aroclor patterns that closely resembled Aroclor standards. Complex mixtures of two or more Aroclors were also observed in many sediment samples. Additional discussion about weathering and comparison of PCB congener and Aroclor totals is provided in Appendix D1.4.

PCB homolog and Aroclor compositions for samples within the Study Area are presented as bar charts in Figures 5.1-35 through 5.1-38. The bar charts show the percent composition of individual PCB homologs and Aroclors for each sample. The figures are organized to show the east zone, navigation channel, and west zone (relative to the top of the navigation channel boundary). The dominant homolog (i.e., the homolog group detected at the highest concentration) at each sampling location is displayed on Maps 5.1-32 and 5.1-33, and the dominant Aroclor at each sampling location (i.e., the Aroclor detected at the highest concentration) is shown on Maps 5.1-34 and 5.1-35. Subsurface homolog and Aroclor patterns are shown only for the depth interval with the highest PCB concentration at each location. The PCB composition at other depths may differ from that at the depth of maximum concentration.

Spatial variations in PCB patterns are evident throughout the Study Area, and areas of high PCB concentrations often exhibit homolog patterns that are distinct from surrounding areas of lower PCB concentrations. These variances in the relative abundances of the homolog groups potentially reflect the differences in the sources of the PCBs and the transport and weathering processes affecting the Aroclors. Overall,

the tetrachlorobiphenyl (tetraCB), pentachlorobiphenyl (pentaCB), hexachlorobiphenyl (hexaCB), and heptachlorobiphenyl (heptaCB) homolog groups are predominant in the Study Area, with localized exceptions (Figures 5.1-35a–c and 5.1-36a–c). In the eastern nearshore zone, the overall chlorination level of PCBs in the surface and subsurface sediments tends to be higher upriver in the Study Area and lower downstream. Between RM 6.7 and 11.3 in the eastern nearshore zone, the highest concentration samples are chiefly composed of hexaCBs and heptaCBs. The chlorination levels are lower at several locations of higher PCB concentrations, from about RM 2 to 4 east, with a dominance of trichlorobiphenyls (triCB), tetraCBs, and pentaCBs. Homolog patterns in areas of high PCB concentration tend to be more variable in the western nearshore zone.

The PCB homolog patterns in subsurface sediment are generally similar to surface sediment patterns at the 37 locations where PCB congener data are available for both surface and subsurface sediment. However, PCB homolog patterns in subsurface sediment are different from surface sediment at RM 2.8 (sample location LW3-G609/LW3-C609), RM 3.7 (sample location LW3-C093), and RM 8.4 (sample location LW3-C393) in the eastern nearshore zone; RM 10.1 (sample location LW3-G747) in the navigation channel; and at RM 5.1 (sample location LW3-G184), RM 7.7 (sample location LW3-G401), and RM 9.6 (sample location LW3-G738) in the western nearshore zone.

Aroclors 1248, 1254, and 1260 were identified throughout the Study Area (Figures 5.1-37a–h and 5.1-38a–d). Aroclor 1221 was identified locally in surface sediments, and Aroclors 1242 and 1268 were identified locally in both surface and subsurface sediments; however, these Aroclors were not widespread (Figures 5.1-37a–h and 5.1-38a–d). Within the Study Area, Aroclor 1016 was identified in one surface sediment sample, and Aroclors 1232 and 1262 were identified in one subsurface sediment sample each. Aroclor patterns in the subsurface sediments were also generally similar to the surface sediment patterns.

5.1.5.5.1 Comparison of PCB Homolog Patterns with Reported Aroclors

For areas with total PCB concentrations greater than 1,000 µg/kg and infrequently reported Aroclors, a comparison of identified Aroclors to the PCB homolog groups was made by comparing the Aroclor homolog profiles as presented in Figure 5.1-34. The PCB homolog data, where available, generally supported the Aroclor identifications of Aroclors 1242, 1248, 1254 and 1260, with two notable exceptions.

Near RM 8.8 (western nearshore zone) Aroclors 1242 and 1248 dominated the PCBs in surface and subsurface sediment, and concentrations greater than 1,000 µg/kg of Aroclor 1260 in surface sediment and Aroclor 1254 in subsurface sediment were also reported. Aroclors 1242 and 1248 are generally difficult to differentiate on a gas chromatogram and may be reported differently by different laboratories or analysts. The PCB homolog distribution in this area supports the identification of Aroclor 1242, although it does not definitively rule out the additional presence of Aroclor 1248

(Figures 5.1-37a–h and 5.1-38a–d). TriCBs were notably abundant in the sediment, often in a pattern that resembled Aroclor 1242 more than Aroclor 1248. The presence of dichlorobiphenyls (diCBs) further supports the identification of Aroclor 1242. Overall, the homolog patterns were very similar for the two samples in this area with the highest concentration (LW2-G453 and LW2-GBT028), even though the Aroclors identified in these samples were different. The reporting of two Aroclors in this area by the laboratories appears to reflect the difficulty of Aroclor identification rather than a difference in the PCBs present in the samples.

In samples with total PCB concentrations greater than 1,000 µg/kg at RM 2.1–2.5 (eastern nearshore zone), Aroclors 1248, 1254, and 1260 were identified in the surface and subsurface sediments in this area, and Aroclor 1242 was identified in five of the subsurface sediment samples. The PCB homolog distribution in this area was consistent with the identification of Aroclor 1248 as the predominant Aroclor in the surface sediments. However, for some subsurface samples (e.g. LW2-C015-B) the homolog pattern was not consistent with the reported Aroclors. Aroclors 1254 and 1260 were reported as dominant in these samples, but the homolog profiles for these samples resemble the profile for Aroclor 1242 or 1248, with a potential contribution of Aroclors 1254 or 1260. The lack of agreement between the homolog profiles and Aroclor identifications suggests the influence of weathering effects.

Aroclors not commonly reported in the Study Area (i.e., identified in fewer than 100 sediment samples or Aroclors other than 1242, 1248, 1254, and 1260) were also evaluated using PCB homolog data as described in the following paragraphs.

Aroclor 1221 was reported in surface sediment in the eastern nearshore zone and eastern edge of the navigation channel between RM 9.3 and 10 at concentrations up to 109 µg/kg (Station G472). However, the PCB homolog pattern is not consistent with Aroclor 1221 in the two samples from this area that were analyzed for PCB congeners. MonoCBs and diCBs are the dominant homologs in Aroclor 1221 (Erickson 1997; Figure 5.1-34), but tetra- through heptaCBs dominated the homolog profiles in this area. The same homolog profile was also present at adjacent location BT031, which was sampled at a later date and analyzed by a different lab, and for which Aroclor 1221 was not identified. Based on the PCB homolog patterns, and the fact that Aroclor 1221 is rarely reported in environmental samples, the identification of Aroclor 1221 in this area appears questionable.

Aroclor 1221 was also identified in surface sediment at four isolated locations: in the eastern nearshore zone near RM 11, in the western edge of the navigation channel near RM 10.3, in the western nearshore zone at RM 7, and in the navigation channel near RM 8. PCB congeners were analyzed at all of these stations, and in all four cases, monoCBs and diCBs were not reported at sufficient levels to support the identification of Aroclor 1221. A focused review of Aroclor chromatograms confirmed the laboratory identifications, although some differences were noted in the PCB patterns in the

samples relative to the standards. The differences in PCB patterns identified by the two methods may be the result of sample heterogeneity or another unidentified cause.

Aroclor 1268 was reported in surface and subsurface sediment in the eastern nearshore zone near RM 5.6 at concentrations up to 474 J µg/kg. PCB congener profiles generally confirm the presence of Aroclor 1268. Nonachlorobiphenyls (nonaCBs) and decaCBs are present in Aroclor 1268 (Figure 5.1-34) and were more abundant in both surface sediment locations and in one of the two subsurface sediment locations analyzed in this area than in areas without Aroclor 1268 detections.

Aroclor 1268 was also identified in isolated locations in several other areas. The Aroclor 1268 identifications were confirmed by the PCB homolog profile in surface sediments in the eastern nearshore zone at RM 3.7, off the mouth of the International Terminals Slip. PCB homolog profiles did not confirm the presence of Aroclor 1268 reported in surface and subsurface samples in the eastern nearshore zone near RM 4, the surface sediments in the eastern nearshore near RM 7.3, or in the subsurface sediments in the western nearshore zone near RM 7.4. Aroclor 1268 could not be evaluated at other locations because either no PCB homolog data were available, or Aroclor 1268 constituted a relatively small fraction of the Aroclor total.

Highly chlorinated PCBs were present at one location where Aroclor 1268 was not identified. At one subsurface location (C093-B) in the International Terminals Slip, nonaCBs and decaCB together accounted for approximately 25 percent of the PCB congener total, suggesting the presence of Aroclor 1268. A review of the Aroclor chromatogram for this sample confirmed the laboratories' Aroclor identifications. Again, the differences in PCB patterns identified by the two methods may be the result of sample heterogeneity or another unidentified cause.

Aroclors 1232 and 1016 were each identified in only one sample. Aroclor 1232 was identified in subsurface sediment at location PSY36C in the navigation channel near RM 8, and Aroclor 1016 was identified in surface sediment sample PP01M105 near the east bank of Swan Island Lagoon at approximately RM 8. The unique Aroclor constituted a small fraction of the total PCB Aroclors at both locations. PCB homolog data are not available at either location to corroborate the identifications; PCB homolog data at locations near these samples do not show evidence of Aroclors 1232 or 1016. The identity of these Aroclors is questionable.

Aroclor 1262 was also identified in only one sample, a subsurface sediment sample in the navigation channel at location LW3-C760 near RM 10.5. No PCB homolog data are available at or near this location and the Aroclor identification could not be confirmed.

5.1.6 Total PCDD/Fs and TCDD TEQ in Sediment

This section discusses the nature and extent of PCDD/Fs in surface and subsurface sediment samples collected within the Study Area. Also discussed is the distribution of TCDD TEQ concentrations and observed trends in the relative abundance of PCDD/F

homologs in surface and subsurface samples. TCDD toxicity with respect to 2,3,7,8-TCDD was calculated from concentrations of PCDD/F congeners designated by the WHO as similar in mechanism of toxicity to 2,3,7,8-TCDD (Van den Berg et al. 2006). Each WHO-designated congener is assigned a specific TEF indicating its degree of toxicity compared to 2,3,7,8-TCDD, which is given a reference value of 1.

The distribution of total PCDD/Fs and TCDD TEQ concentrations at each surface sampling station throughout the Study Area is depicted in Maps 5.1-3 and 5.1-5, respectively; concentrations with depth at subsurface stations are depicted in Maps 5.1-4a–m and 5.1-6a–m, respectively. The complete data set is plotted on scatter plots presented in Figures 5.1-7 through 5.1-10.

5.1.6.1 Total PCDD/Fs in Surface Sediment

Total PCDD/Fs were detected in all 216 surface sediment samples in which this suite of chemicals was analyzed. Surface concentrations ranged from 2.48 to 264,000 pg/g (Table 5.1-1). Ninety-five percent of the surface data was below 5,620 JV pg/g.

The data show concentrations greater than 2,000 pg/g (indicated in red on Map 5.1-3) total PCDD/Fs at several locations along the eastern and western nearshore zones. Limited surface PCDD/F data are available for the navigation channel and spatial resolution is somewhat limited. However, of the channel samples that were analyzed, most concentrations were less than 500 pg/g, and a pattern of relatively high concentrations in nearshore areas compared with markedly lower levels in the adjacent channel areas is evident.

5.1.6.2 Total PCDD/Fs in Subsurface Sediment

Of the 241 subsurface samples analyzed, total PCDD/Fs were detected in all but one of the samples. Concentrations ranged from 0.0578 J pg/g to 218,000 pg/g (Table 5.1-2).

PCDD/F concentrations greater than 2,000 pg/g in subsurface sediment were generally found at the same surface locations with PCDD/F concentrations greater than 2,000 pg/g along the eastern and western nearshore zones (Maps 5.1-4a–m).

Core sample C455 (30–152 cm bml) collected along the western shoreline at RM 8.8 contained the highest subsurface concentration of total PCDD/Fs in the data set (Table 5.1-2). This station also contained the maximum total PCBs and total chlordanes concentrations in the Study Area.

Limited subsurface PCDD/F data are available for the navigation channel; of the samples that were analyzed, most concentrations were less than 100 pg/g (Maps 5.1-4a–m).

5.1.6.3 TCDD TEQ in Surface Sediment

A total of 217 surface samples were selected for analysis of WHO-designated PCDD/Fs, with a frequency of detection of 100 percent. The resulting calculated TCDD TEQs show a wide range of values, from 0.00803 J pg/g to 14,100 J pg/g in surface sediment (Table 5.1-1). Ninety-five percent of the surface data were below 43.2 JV pg/g.

The data show that TCDD TEQ values vary spatially along the length of the Study Area (Figure 5.1-9). In general, values were higher in the western nearshore zone than in the eastern nearshore and navigation channel zones. The most significant peak in the data in the western nearshore occurred between approximately RM 6.8 and 7.3, where data points are relatively dense in comparison to the rest of the Study Area.

Limited data for WHO-designated PCDD/Fs are available for sediments in the navigation channel (Map 5.1-5). TCDD TEQ surface values within the channel were relatively low, with the exception of two samples with relatively elevated concentrations along the eastern edge of the navigation channel between RM 6.6 and 6.7.

5.1.6.4 TCDD TEQ in Subsurface Sediment

WHO-designated PCDD/Fs were detected in approximately 93 percent of the 245 subsurface samples in which they were analyzed. The resulting calculated TEQs show a wide range of values, from an estimated 0.000262 J pg/g to an estimated 7,480 J pg/g in subsurface sediment (Table 5.1-2; Figure 5.1-10).

The maximum subsurface TCDD TEQ value was found at Station SD092 (0–90 cm vertically composited sample) at RM 7.2W (Map 5.1-6h).

Within the navigation channel, TCDD TEQ values over 10 pg/g (indicated in red in Maps 5.1-6a-m) were calculated only at one subsurface station near the western channel boundary at RM 6.6 (33.3 J pg/g in the interval from 132 to 243 cm bml at Station C314; Figure 5.1-10).

5.1.6.5 PCDD/F Surface and Subsurface Sediment Relationships

The magnitude of the mean surface and subsurface sediment concentrations for PCDD/Fs is shown on Figure 5.1-39. Summary statistics are presented in Table 5.1-4. The methods used to develop these presentations are described in Section 5.1.5.4. It should be noted that fewer data points are available for PCDD/Fs than for the other bounding chemical groups (PCBs, DDx, and PAHs). For example, the PCDD/F data set is approximately one-fifth the size of the PCBs and DDx data sets, and this small sample size combined with the effect on the mean of one or two elevated values in a given subarea limits the interpretability of Figure 5.1-39; the actual mapped data patterns shown in Maps 5.1-4a-m are also discussed here.

The surface/subsurface mean ratios show that total PCDD/F concentrations were slightly higher in surface sediments within the Study Area overall (left side of Figure 5.1-39), but the magnitude of the ratios are small, indicating that the average surface and subsurface concentrations were comparable across most of the Study Area. This pattern is supported by Maps 5.1-4a–m, which show that most areas lack strong or consistent vertical concentration gradients. Some exceptions to this include the area under and just upstream of the Railroad Bridge at RM 6.9, where surface layers show higher concentrations than at depth (Map 5.1-4g) and the northwest corner of Willbridge Terminal where higher levels are evident at depth (Map 5.1-4h). This suggests a current source or sources at the former location and an historical source or sources at the latter. Elsewhere in the Study Area, significant changes in the level of PCDD/F inputs over time are generally not indicated.

5.1.6.6 Patterns and Trends of PCDD/Fs in Sediment

PCDD/F homolog compositions for samples within the Study Area are presented as bar charts in Figures 5.1-40a–c and 5.1-41a–c. The bar charts show the percent composition of the individual PCDD/F homologs for each sample. The figures are organized to show the east zone, navigation channel, and west zone (relative to the navigation channel boundary). Subsurface homolog patterns are shown only for the depth interval with the highest total PCDD/F concentration at each location. The PCDD/F composition at other depths may differ from that at the depth of maximum concentration.

OCDD is generally the dominant homolog (>50 percent of the total concentration) present in surface and subsurface sediments throughout the Study Area, with HpCDDs present to a significant but lesser degree. The other homolog groups generally constitute 20 percent or less of the total concentration. Exceptions where PCDD/F homolog distributions vary significantly (possibly reflecting isolated areas of differing sources or weathering patterns) are clustered throughout the Study Area, with the largest clusters occurring along the western nearshore area around RM 6.8 and near RM 7.4, where data points are relatively dense in comparison to the rest of the Study Area.

The variations in PCDD/F homolog compositions do not always reflect variations in total PCDD/F concentrations. Near RM 6.7E and from RM 6.8 to 7.4W, samples with high total PCDD/F concentrations are marked by a high proportion of furans relative to other areas. However, in general, samples with high PCDD/F concentrations have homolog profiles that match the prevailing pattern of OCDD and HpCDD dominance. Also, the surface and subsurface homolog distributions did not vary greatly for any given location.

Finally, and as noted previously, the highly biased sampling design, particularly for PCDD/Fs, precludes making definitive statements about spatial patterns in PCDD/F composition, and this was not a primary goal of the RI sampling program.

5.1.7 Total DDx in Sediment

The distribution of concentrations of total DDx and its constituent compounds DDD, DDT, DDE in the Study Area sediment is summarized in this section. Observed trends in DDx isomers in surface and subsurface samples are also discussed. Frequencies of detection of total DDx were approximately 89 percent for surface samples and 81 percent for subsurface samples.

The distribution of total DDx concentrations at each surface sampling station throughout the Study Area is depicted in Map 5.1-7; concentrations with depth at subsurface stations are depicted in Maps 5.1-8a–m. The complete data set is plotted on scatter plots presented in Figures 5.1-11 and 5.1-12. The individual total DDT, DDD, and DDE concentrations (totals of the 2,4'- and 4,4'-isomers) are depicted in Maps D1.1-3 through D1.1-8 in Appendix D1.1.

Some of the results of the component isomers that were summed in the total DDx concentrations were N-qualified (Section 2.1.3.2). Additionally, some of the DDx isomer data are uncertain and potentially biased high because of the analytical interference from the presence of PCB congeners in the sample. The N qualifier indicates that the quantity is estimated because there is only presumptive evidence that the chemical compound exists. When an individual isomer result is N-qualified, the N qualifier is carried forward to the reported summed total. For individual isomers, the percentages of N-qualified sediment data range from zero (2,4'-DDE) to approximately 30 percent (2,4'-DDD) of both the surface and subsurface data. N-qualified total DDx concentrations range from 0.051 NJ µg/kg to 84,900 NJ µg/kg in surface sediment and from 0.054 NJ µg/kg to 51,800 NJ µg/kg in subsurface sediment.

5.1.7.1 Total DDx in Surface Sediment

The results of the 1,210 surface samples that were analyzed for both the 2,4'- and 4,4'-isomers of the DDx compounds are depicted on Map 5.1-7. Detected concentrations ranged from an estimated 0.051 NJ µg/kg to an estimated 84,900 A µg/kg in surface sediment (Table 5.1-1; Figure 5.1-11). Ninety-five percent of the samples were less than 470 JV µg/kg.

Areas of total DDx concentrations greater than 100 µg/kg occurred at several locations scattered along the nearshore zones and channel margins (Figure 5.1-11). The most prominent area of total DDx concentrations greater than 100 µg/kg occurred along the western shoreline between RM 6 and 7.5. Concentrations above 10,000 µg/kg (shown in red on Map 5.1-7) were found only in surface sediment near the western shore at RM 7.5. The maximum concentration was found at Station OSS002 in this vicinity. Upstream along the western shoreline at RM 8.8, DDx was detected in a single sample at a concentration greater than 1,000 µg/kg.

With the exception of four samples, samples collected within the navigation channel were less than 100 µg/kg. Concentrations greater than 100 µg/kg were located at RM 5.6, 6.5, and 11.3 (Figure 5.1-11).

The DDD, DDE, and DDT components show generally similar patterns of distribution, though relative concentrations vary (Maps D1.1-3, D1.1-5, and D1.1-7).

5.1.7.2 Total DDx in Subsurface Sediment

Of the 1,291 subsurface samples analyzed for total DDx, detected concentrations ranged from an estimated 0.058 J µg/kg to an estimated 3,643,000 A µg/kg in subsurface sediment (Table 5.1-2).

The maximum subsurface concentration was found in the interval 323 to 384 cm bml at Station WB-24 at RM 7.2E. Of the samples collected within the navigation channel, the cores with concentrations greater than 100 µg/kg corresponded to areas of similar concentrations within the nearshore (Figure 5.1-12; Maps 5.1-8a–m).

5.1.7.3 Total DDx Surface and Subsurface Sediment Relationships

The magnitude of total DDx mean surface and subsurface sediment concentrations is shown on Figure 5.1-42. Summary statistics are presented in Table 5.1-5. The methods used to develop these presentations are described in Section 5.1.5.4.

With the exception of one area (RM 11-11.8), the mean subsurface concentrations of DDx are higher than the surface concentrations throughout the Study Area (Figure 5.1-42). The magnitude of the ratios are generally low, mostly around 5 or less; however, at RM 7-8 W, the mean subsurface levels greatly exceed the surface mean, indicating a large historical source or sources that has been markedly reduced over time. The only portions of the Study Area where surface sediment total DDx concentrations are higher than subsurface sediments are from RM 11–11.8E and in the navigation channel, possibly suggesting a current source or sources, but the magnitude of these ratios is relatively low. The surface/subsurface trends revealed by Figure 5.1-42 are supported by the data plotted in Maps 5.1-8a-m.

5.1.7.4 Patterns and Trends of Total DDx in Sediment

DDx patterns varied widely across the Study Area, as shown in Figures 5.1-43a–h (surface sediments) and 5.1-44a–d (subsurface sediments). Selected trends are summarized below. The bar charts in these figures include samples that may lack results for the 2,4'-isomers of a DDx compound if these were not analyzed (see Appendix D1.5). The DDx patterns are incomplete for these samples. The discussion of subsurface sediment trends is based on the evaluation of DDx patterns only for the depth interval with the highest concentration at each location, presented in Figures 5.1-44a–d. The DDx composition at other depths may differ from that at the depth of maximum concentration.

As noted above, total DDx concentrations exceeded 10,000 µg/kg in one area located near RM 7 in the western nearshore zone. The main constituent of the surface sediments in this area was the 4,4'-isomer of DDT (Figure 5.1-43g), while the 4,4'-isomers of DDT and DDD were the main constituents of the subsurface sediments (Figure 5.1-44d). This pattern may indicate degradation of DDT to DDD in deep anoxic sediments.

The relative concentrations of the DDx isomers were highly variable from station to station across the Study Area in both surface and subsurface sediment samples. However, a few general trends were observed:

- The 4,4'-isomer concentrations were greater than those for the 2,4'-isomers of the DDx constituents overall. In some locations, the 2,4'-isomers were more abundant than their 4,4'- counterparts, particularly 2,4'-DDD and, less frequently, 2,4'-DDT. 2,4'-DDE was rarely detected and was dominant only in samples with relatively low concentrations.
- Overall, samples with the highest concentrations tended to display a dominance of DDT and/or DDD isomers, particularly below RM 8.
- There was a broad trend in the western nearshore DDx patterns. Both surface and subsurface sediment samples collected upstream of RM 8 generally had low total DDx concentrations and a large DDE component, whereas samples collected between RM 7.5 and 6.9 had higher total DDx concentrations and were dominated by DDT, and samples downstream of RM 6.9 had lower total DDx concentrations and a larger DDD component. These upstream/downstream trends were also evident in the navigation channel, which generally paralleled the western nearshore trends from RM 12 to about RM 4 (except where embayments such as Willbridge are crossed). In contrast, the eastern nearshore patterns were more like those of the western nearshore zone above RM 8.

5.1.8 Total PAHs in Sediment

The distribution and composition of total PAH concentrations in Study Area sediment are summarized in this section. The data set of total PAH concentrations includes 1,603 surface samples and 1,545 subsurface samples. Frequencies of detection of PAH compounds were high, approximately 99 percent in surface samples and 95 percent in subsurface samples.

Map 5.1-9 shows the distribution of total PAH concentrations at each surface sampling station throughout the Study Area; concentrations with depth at subsurface stations are depicted in Maps 5.1-10a–m. The complete data set is plotted on scatter plots presented in Figures 5.1-13 and 5.1-14.

5.1.8.1 Total PAHs in Surface Sediment

The concentration range of total PAHs in surface sediment varied widely, from 3.3 J µg/kg to 7,260,000 µg/kg (Table 5.1-1). Ninety-five percent of the 1,603 surface samples were less than 66,600 JV µg/kg.

The data, particularly above RM 6.5 where samples are more abundant, showed variable concentrations throughout the Study Area. Except for several areas of relatively higher concentrations, total PAH levels were generally 1,000 µg/kg or less in channel and nearshore zones of the main stem of the river (i.e., outside Swan Island Lagoon) in the upper portion of the Study Area between RM 7 and 11.8 (Figure 5.1-13; Map 5.1-9).

Scattered areas of concentrations greater than 1,000 µg/kg were found throughout the Study Area, but the highest concentrations (>30,000 µg/kg; indicated in red on Map 5.1-9) were most commonly found in the eastern and western nearshore zones between approximately RM 4 and 7.5 (Figure 5.1-13).

PAH concentrations above 30,000 µg/kg were also found in surface and subsurface sediment in the navigation channel adjacent to the RM 5.2–6.8 reach.

5.1.8.2 Total PAHs in Subsurface Sediment

Of the 1,545 subsurface samples analyzed for total PAHs, the concentration range varied widely, from 0.15 J µg/kg to 53,300,000 µg/kg in subsurface sediment (Table 5.1-2).

Similar to surface sediment, scattered areas of concentrations greater than 1,000 µg/kg in subsurface sediment were found throughout the Study Area, and concentrations greater than 30,000 µg/kg were most commonly found in the eastern and western nearshore zones between approximately RM 3 and 7.5 (Figure 5.1-14; Maps 5.1-10a–m).

PAH concentrations above 30,000 µg/kg were also found in subsurface sediment in the navigation channel adjacent to and downstream from RM 6.5.

5.1.8.3 Total PAHs Surface and Subsurface Sediment Relationships

The magnitude of mean total PAH surface/subsurface sediment concentrations is shown on Figure 5.1-45. Summary statistics are presented in Table 5.1-6. The methods used to develop these presentations are described in Section 5.1.5.4.

The surface/subsurface mean ratios show that total PAH concentrations were slightly higher in subsurface sediments within the Study Area as a whole (left side of Figure 5.1-45).

In areas where mean subsurface total PAH concentrations were greater than mean surface total PAH concentrations, the highest magnitude was at RM 6-7 in the navigation channel followed by RM 11–11.8 E. In areas where mean surface sediment total PAH concentrations were greater than subsurface concentrations the highest magnitude was at RM 5–6 in the navigation channel. Inspection of Map 5.1-10g indicates that the high subsurface mean at RM 6–7W is driven by some very high PAH concentrations in core samples collected at the channel edge off of the Gasco early action area. The relatively high surface/subsurface mean ratio in the channel from RM 5–6 is driven by several relatively high concentration surface only samples in the channel.

5.1.8.4 Patterns and Trends of Total PAHs in Sediment

The distribution of detected PAHs at each location is presented in Figures 5.1-46a–j (surface sediment) and Figures 5.1-47a–f (subsurface sediment). In order to simplify the bar charts, PAHs were grouped according to the number of fused aromatic rings in the PAH. A list of individual PAHs included in the sum for each of these groups is provided in Table 5.1-7. Only PAHs analyzed for LWG samples are summed. Of these PAHs, two-ring PAHs include only naphthalenes (i.e., naphthalene and 2-methylnaphthalene). LPAHs include PAHs with two or three rings (green and yellow segments), and HPAHs include PAHs with four to six rings (purple, red, and blue segments). Only the depth interval that contained the highest total PAH concentration is shown in Figures 5.1-47a–f (i.e., the subsurface charts represent a variety of depths based on the interval of the maximum concentration) and evaluated below.

Surface sediments within the Study Area are generally dominated by HPAHs, primarily four-ring PAHs, with localized exceptions. Five-ring PAHs are the second most abundant HPAH, followed by six-ring PAHs. Three-ring PAHs are the principal LPAH in surface sediments, with two-ring PAHs generally being a minor component of the surface sediment PAH profile. Surface sediments from the western nearshore zone exhibited higher proportions of LPAHs than sediments from the eastern nearshore zone and the navigation channel, but follow the general trend of HPAH dominance. Some areas of high total PAH concentration have PAH profiles that differ from the prevailing trend of HPAH dominance, the most notable between RM 6.2 and 6.9 in the western nearshore zone. In this area increased contributions from two and three-ring PAHs, and a corresponding reduced six-ring PAH abundance is also observed. Similar high PAH profiles are observed between RM 6.4 and 7.2 in the eastern nearshore zone and between RM 5.6 and 7.4 in the navigation channel.

Subsurface sediments have greater contributions from two- and three-ring PAHs than the surface sediments, but generally exhibit similar PAH profiles to the surface sediments.

The proportions of individual PAH compounds varied throughout the Study Area, reflecting PAH contributions from multiple types of hydrocarbon sources, as well as weathering and degradation. Hydrocarbon source types include pyrogenic (e.g., tars

and creosote), petrogenic (e.g., fresh oil), and a variety of combustion processes and natural biological production processes. PAHs characteristic of these source types include alkylated PAH compounds, which are especially useful in distinguishing between pyrogenic and petrogenic source types. Alkylated PAH data are available for selected sediment and clam tissue samples and are presented in the SCRA database and summary statistics in Appendix D; however, these data are not discussed in the RI report.

5.1.9 Additional Indicator Chemicals in Sediment

This section discusses the occurrence and distribution of nine additional ICs in sediment within the Study Area. The narrative in this section is less comprehensive than the preceding sections, omitting the data set description, surface/subsurface relationships, patterns and trends, and referring instead to maps, tables, and figures to provide a general picture of the distribution of those chemicals.

5.1.9.1 Bis(2-ethylhexyl)phthalate in Sediment

Concentrations of BEHP were ≤1,500 µg/kg in the majority of samples analyzed (Maps 5.1-11 and 5.1-12a–m, see frequency plot inset; Figures 5.1-15 and 5.1-16). Limited areas with concentrations greater than 1,500 µg/kg were found at several locations within the Study Area. Frequencies of detection were 61 percent for surface samples and 39 percent for subsurface samples. Ninety-five percent of the surface samples were below 2,230 JV µg/kg (Table 5.1-1).

Clusters of concentrations greater than 1,500 µg/kg occurred in the surface data set from the eastern nearshore, in Swan Island Lagoon, and between RM 3.8 and 4.1 in the International Terminals Slip and along the riverfront (Maps 5.1-11 and 5.1-12a–m). The highest surface concentration detected in the Study Area was found at Station G367 at the mouth of Swan Island Lagoon.

Additional isolated occurrences of concentrations greater than 1,500 µg/kg were found. With few exceptions, these concentrations occurred outside the navigation channel, in the eastern and western nearshore zones. The most notable exception is the western side of the navigation channel at RM 10.3, where the highest subsurface concentration in the Study Area was found in the interval of 0–195 cm bml at Station WR-VC-110. A similarly elevated subsurface concentration was detected in the channel at RM 8 near the mouth of Swan Island Lagoon.

5.1.9.2 Total Chlordanes in Sediment

Overall, detected concentrations of total chlordanes were below 5 µg/kg throughout most of the Study Area (Maps 5.1-13 and 5.1-14a–m, see frequency plot inset) and, with few exceptions, were generally lower along the navigation channel (Figures 5.1-17 and 5.1-18; Tables 5.1-1 and 5.1-2). Sediment, concentrations greater than 5 µg/kg were detected at several locations throughout the Study Area, but occurred most

extensively along the western nearshore zone between approximately RM 6 and 7.4 (Maps 5.1-13 and 5.1-14a–m).

Frequencies of detection were 64 percent and 55 percent, respectively, for surface and subsurface samples. Approximately ninety-five percent of the surface samples were below 12.2 JV µg/kg. The maximum surface concentration was found at Station G355 (RM 7.3W). Another cluster of concentrations greater than 5 µg/kg in surface and subsurface samples occurred at RM 8.8W and at the head of the International Terminals Slip (RM 3.7E; some areas have subsequently been dredged). A sample collected at RM 8.8 contained the highest subsurface concentration of total chlordanes in the Study Area (Station C455 in the interval of 30–152 cm bml). This same core sample contained the maximum concentrations of total PCBs and total PCDD/Fs in the Study Area.

Except for elevated detections from RM 10 to 10.2 and RM 11.2 to 11.6, peaks in the navigation channel were typically located near elevated concentrations in the nearshore.

5.1.9.3 Aldrin and Dieldrin in Sediment

The insecticides, aldrin and dieldrin, have similar chemical structures and are discussed together here because aldrin quickly breaks down into dieldrin in the environment. Detected concentrations of both chemicals were generally less than 1 µg/kg (Maps 5.1-15 and 5.1-16a–m, see frequency plot inset), though higher concentrations occurred at several locations scattered along the nearshore zones and navigation channel (Figures 5.1-19 through 5.1-22).

Frequencies of detection for aldrin were low, 23 percent for surface samples and only 13 percent for subsurface samples (Tables 5.1-1 and 5.1-2). Ninety-five percent of the surface samples were below 10.6 JV µg/kg. The most prominent area of detected aldrin concentrations was at RM 7.4, where the maximum surface (Station G355) and subsurface (Station C356, 136–256 cm bml) concentrations were detected. Concentrations greater than 1 µg/kg extended downstream along the western shoreline to approximately RM 5.2 (Maps 5.1-15 and 5.1-16a–m).

Two other prominent aldrin peaks are shown by the data, one indicated by concentrations exceeding 100 µg/kg in surface and subsurface samples at RM 8.8, the other indicated by concentrations approaching 100 µg/kg in the subsurface from approximately RM 6 to 6.5 (Figures 5.1-19 and 5.1-20). Some of these data are N-qualified.

Aldrin concentrations above 1 µg/kg were detected at several locations within the navigation channel. The maximum concentration of aldrin within the navigation channel occurred in the interval of 30 to 137 cm-bml at core Station C206 (approximately RM 5.6 near the east bank). This same interval also recorded high concentrations for PAHs, arsenic, chromium, copper, lead, mercury, zinc, and PCBs.

Aldrin concentrations above 1 µg/kg were also detected in the navigation channel in the RM 11.2–11.5, 10–10.2, and 8.6–8.9 reaches.

Frequencies of detection for dieldrin were even lower, 21 percent for surface samples and only 7 percent for subsurface samples. Ninety-five percent of the surface samples were below 5.93 JV µg/kg. Dieldrin concentrations above 1 µg/kg were detected in subsurface samples collected along the eastern nearshore between RM 3.8 and 4, where the highest subsurface concentration in the Study Area was found at Station C092 (30–152 cm bml; N-qualified) at the head of the International Terminals Slip (Maps 5.1-17 and 5.1-18a–m). Dieldrin concentrations above 1 µg/kg were also detected in several cores collected in the navigation channel downstream from the Broadway Bridge. Along the western shoreline, dieldrin concentrations above 1 µg/kg were detected in the RM 8.5–8.8 reach, at RM 7.4, and between RM 5.7 and 6.6 (Figures 5.1-21 and 5.1-22). The maximum surface sediment concentration of dieldrin in the Study Area was found at Station G453 located in the western nearshore zone at RM 8.8.

5.1.9.4 Arsenic in Sediment

Overall, detected concentrations of arsenic were below 10 mg/kg throughout most of the Study Area (Maps 5.1-19 and 5.1-20a–m, see frequency plot inset) and were generally below 5 mg/kg in most of the navigation channel. Frequencies of detection for arsenic were 92 percent for surface samples and 96 percent for subsurface samples (Tables 5.1-1 and 5.1-2). Ninety-five percent of the surface samples were below 8.98 V mg/kg. Clusters of concentrations greater than 10 mg/kg were identified in several areas (Maps 5.1-19 and 5.1-20a–m; Figures 5.1-23 and 5.1-24).

The highest concentration among surface sediment samples was detected at RM 2.3 along the eastern bank (Station RB08). The highest subsurface concentration was found in the interval of 150–236 cm bml at Station C708 near the mouth of Swan Island Lagoon.

5.1.9.5 Chromium in Sediment

Chromium concentrations were relatively low (<50 mg/kg) throughout the majority of the Study Area (Maps 5.1-21 and 5.1-22a–m, see frequency plot inset), including the navigation channel. Detection frequencies were nearly 100 percent for both surface and subsurface samples (Tables 5.1-1 and 5.1-2). Ninety-five percent of the surface samples were below 55.8 V mg/kg.

Clusters of chromium concentrations greater than 50 mg/kg were identified in several areas along the eastern and western shorelines (Maps 5.1-21 and 5.1-22a–m; Figures 5.1-25 and 5.1-26). The maximum chromium surface concentration was found at Station RB06 in the RM 2.2 vicinity. The maximum subsurface concentration was found at Station HA-42 (46–61 cm bml) at RM 8.9.

5.1.9.6 Copper in Sediment

Copper data showed concentrations greater than 60 mg/kg (Maps 5.1-23 and 5.1-24a–m, see frequency plot inset) at many locations along the eastern and western nearshore zones, but few in the navigation channel. Detection frequencies were nearly 100 percent for both surface and subsurface samples (Figures 5.1-27 and 5.1-28; Tables 5.1-1 and 5.1-2). Ninety-five percent of the surface samples were below 172 V mg/kg.

As shown in Maps 5.1-23 and 5.1-24a–m, copper was greater than 60 mg/kg in isolated groupings at several locations along the eastern and western shorelines. A surface sample at RM 11.2 (Station UG01) contained the highest concentration of copper. The maximum subsurface copper concentration was found at Station C384 (30–128 cm bml), at the mouth of Swan Island Lagoon.

5.1.9.7 Zinc in Sediment

Zinc was found at concentrations greater than 200 mg/kg (Maps 5.1-25 and 5.1-26a–m, see frequency plot inset) at many locations along the eastern and western nearshore zones, but few in the navigation channel. Detection frequencies were 100 percent for both surface and subsurface samples (Figures 5.1-29 and 5.1-30; Tables 5.1-1 and 5.1-2). Where the latter elevations appeared, extent was generally limited (Maps 5.1-25 and 5.1-26a–m). Ninety-five percent of the surface samples were below 375 V mg/kg.

The highest surface (HA-43) and subsurface (HA-42; 46–61 cm bml) concentrations were found between RM 8.2 and 9.2. Station HA-42 also recorded the highest chromium concentration in the Study Area.

5.1.9.8 Tributyltin Ion in Sediment

Sediment samples at selected locations were analyzed for butyltins. Bulk sediment TBT concentrations varied among locations (Maps 5.1-27 and 5.1-28a–m; Figures 5.1-31 and 5.1-32). Frequencies of detection for TBT were 94 percent for surface samples and 59 percent for subsurface samples (Tables 5.1-1 and 5.1-2). Ninety-five percent of the surface samples were less than 851 V µg/kg. Concentrations greater than 1,000 µg/kg (Maps 5.1-27 and 5.1-28a–m; see frequency plot inset) were measured in surface samples near the western nearshore zone at RM 9 and near the entrance to the International Terminals Slip. Most concentrations greater than 1,000 µg/kg were found near RM 8 in areas surrounding Swan Island and immediately downstream of Swan Island. The maximum surface concentration of TBT was found at the mouth of the International Terminals Slip (Station SD012). Station PSY30C (121–152 cm bml) at RM 8.2 near Swan Island contained the highest subsurface concentration of TBT in the Study Area.

5.1.10 Summary of the Nature and Extent of Indicator Chemicals in Sediment

PCBs, PCDD/Fs, DDx, and PAHs were found across the Study Area, but concentrations varied by orders of magnitude. Concentrations of these chemicals were lowest in the navigation channel and highest in localized, generally well-defined, nearshore areas along both the west and east river banks.

The surface to subsurface ratios showed that PCBs were higher in the subsurface than surface in the Study Area as a whole. A notable exception was RM 11–11.8, where mean PCB concentrations were notably higher in the surface sediment than in the subsurface sediment. In general, the overall chlorination level of PCBs in the surface and subsurface sediments in the eastern nearshore zone tended to be higher upriver in the Study Area and lower downstream. Homolog patterns in areas of high PCB concentration tended to be more variable in the western nearshore zone. These variances in the relative abundances of the homolog groups may reflect differences in the sources of the PCBs.

For PCDD/Fs, the surface to subsurface ratios were generally close to one, indicating that the surface and subsurface concentrations were comparable across the entire Study Area. Exceptions to this pattern occurred in the area under and just upstream of the Railroad Bridge at RM 6.9, where surface concentrations were higher, and in the northwest corner of Willbridge Terminal, where subsurface concentrations were higher. OCDD was the predominant homolog (>50 percent) in surface and subsurface sediment within the Study Area.

The surface to subsurface ratios for DDx within the Study Area showed that concentrations were higher in the subsurface than in the surface layer. Along the west bank from RM 7 to 8, where total DDx levels were highly elevated, the average subsurface concentration greatly exceeded the overall surface concentrations. The 4,4'-isomer of DDT dominated the surface sediment profile here, while DDT and DDD dominated the subsurface profile, possibly indicating degradation of DDT to DDD in the deeper anoxic sediments. Overall, the 4,4'-isomers were more abundant than the 2,4'-isomers within the Study Area.

The surface to subsurface ratios for PAHs showed that concentrations were higher in the subsurface than in surface sediments. A notable exception occurs at RM 5–6 where the mean channel surface concentration was considerably higher than the mean subsurface concentration. The proportions of individual PAHs varied throughout the Study Area, possibly reflecting PAH contributions from multiple sources, as well as weathering and degradation. Three-ring LPAHs and four-ring HPAHs dominated the western shoreline profile between RM 5.4 and 6.6 where the highest PAH concentrations were found.

5.2 INDICATOR CHEMICALS IN SEDIMENT TRAPS

This section summarizes the sediment trap data for the LWG rounds of investigation. The geographic locations of all sediment trap stations are presented on Map 2.2-3. The following subsections present histograms and stacked bar charts to support discussion and evaluation of the nature and extent of selected ICs. Additional tabular and graphical summaries of the sediment trap data set are included in Appendix D2.

The primary purpose of sediment trap sampling was to gather data for the evaluation of FS alternatives (Anchor 2006b). In addition, the sediment trap investigation was designed to capture anticipated spatial and temporal variability of suspended sediment mass, fill data gaps related to the nature and extent of potential sources, and support the preparation of the BERA (Anchor 2006b).

5.2.1 Sediment Trap Data Set

This section focuses on the concentrations of 15 ICs associated with samples from in-river sediment trap samples collected within the LWR. These samples were analyzed to measure the sediment trap mass accumulation and concentrations of sediment-bound chemicals that enter the Study Area from upstream sources, chemical concentrations associated with regional sources within the Study Area, and concentrations of sediment-bound chemicals that migrate downstream from the Study Area. Additional information on LWR hydrology, sediment accumulation, and the role of fine sediments provided to aid with interpretation of the chemical data, is presented in Figures 5.2-1 through 5.2-4. Distributions of selected ICs and patterns of bounding ICs—total PCBs, total PCDD/Fs, total DDx, and total PAHs—are shown in Figures 5.2-5 through 5.2-26 and are summarized in Tables 5.2-1 through 5.2-4.

5.2.2 Indicator Chemicals in Sediment Traps

The IC list for sediment is presented in Table 5.0-2. A total of 34 individual analytes and calculated analyte sums were identified as ICs for bedded sediment in Section 5.1. Specific chemicals and chemical sums selected as ICs for sediment traps were identical to those selected for sediments, with one exception: total PCB Aroclors and total PCB congeners are presented separately in this section, whereas total PCBs in Section 5.1 were evaluated in a single presentation (i.e., total Aroclors were selected when total PCB congeners were not available). The ICs for sediment traps are organized as follows:

- PCBs
  - Total Aroclors*
  - Total PCB Congeners*
  - PCB TEQ (ND=0)

- PCDD/Fs
  - Total PCDD/Fs*
  - TCDD TEQ (ND=0)*
- Total DDx
  - Total DDx (2,4'- and 4,4'-DDD, DDE, DDT)*
  - Total of 2,4'- and 4,4'-DDT
  - Total of 2,4'- and 4,4'-DDE
  - Total of 2,4'- and 4,4'-DDD
- PAHs
  - Total PAHs*
  - Total LPAHs
  - Total HPAHs
  - Total cPAH BaPEq values
  - Phenanthrene
  - Naphthalene
  - BAP
- Petroleum Hydrocarbons
  - TPH
  - TPH - DRH
  - TPH - RRH
- SVOCs
  - BEHP*
  - Butylbenzyl phthalate
  - PCP
  - Hexachlorobenzene
- Pesticides
  - Total chlordanes*
  - gamma-HCH
  - Aldrin*
  - Dieldrin*

- Organometallic Compounds
  - TBT*
- Metals
  - Arsenic*
  - Cadmium
  - Chromium*
  - Copper*
  - Lead
  - Mercury
  - Nickel
  - Zinc*.

Fourteen of the ICs, which are indicated with an asterisk (*) in the above list, are discussed in this section (total PCDD/Fs and TCDD TEQ are grouped as one chemical in this count). As indicated in Section 5.1, 13 ICs were selected for sediments to match the chemicals identified for the site-wide CSM (Section 10). In this section, PCB congeners and PCB Aroclors are described separately, bringing the total up to 14. The remaining ICs are not discussed in this section, but their concentrations, as well as percent fines and TOC, in sediment traps are displayed graphically in Appendix D2.1 (see Figures D2.1-1 through D2.1-24).

Discussion of the ICs addressed in Section 5.2 focuses primarily on the following elements:

- A description of the data set for each analyte, including frequency of detection and concentration range
- The sampling locations and periods (sampling quarters) with elevated analyte concentrations and any apparent spatial or temporal gradients among the data set
- An evaluation of analyte concentrations found in the Study Area compared to concentrations found at locations upstream of the Study Area
- Brief comparisons between analyte concentrations in east-west paired samples.

As noted previously, the bounding ICs—total PCBs, total PCDD/Fs, total DDx, and total PAHs—are discussed in more detail. Patterns in the relative abundance of each chemical's components (e.g., homologs, isomers) are examined to evaluate the potential for source identification among spatial and temporal dimensions.

5.2.3 Description of Sediment Trap Presentation Tools

The sediment trap chemistry distributions are depicted in several graphic display formats. The two primary graphical formats are histograms showing concentrations for each location and grouped by sampling quarter (Figures 5.2-5, -6, -10, -12, -13, -15, and 5.2-18 through 5.2-26), and stacked bar charts depicting patterns of bounding ICs (Figures 5.2-8, -9, -11, -14, -16, and 5.2-17).

The blank spaces in the histograms within station groups signify that the volume of material collected for the quarter was not sufficient for analysis or the sediment trap was lost. Sample analyses resulting in non-detects are flagged in the histograms to distinguish them from cases where results are not available. Scales for IC concentrations (y-axis) were selected to emphasize higher concentrations yet visually distinguish comparatively low concentrations. In some cases, values above scale maximums are labeled with the sample concentration.

Stacked bar charts are designed to reveal distinctive patterns in the relative abundance of bounding IC components. These graphs provide a line showing concentrations of the IC (i.e., totals) on a logarithmic scale, but do not display concentrations of the analyte components (e.g., homologs, isomers). The analyte components are shown as a percent of the total concentration.

Other graphic displays used to assist with data interpretation include two scatter plots (Figures 5.2-3 and 5.2-7) with lines to fit the data and accompanying regression equations. Natural log-transformed PCB congener concentrations are regressed on natural log-transformed Aroclor concentrations in Figure 5.2-7 to display the relationship between PCB results obtained using different analytical methods. The relationship between sediment accumulation rates and the percentage of fines (i.e., silt and clay, particles ≤62 μm) is shown in a scatter plot of the un-transformed data sets (Figure 5.2-3). A line graph (Figure 5.2-1) is used to display the Willamette River daily discharge hydrograph for the entire sediment trap sampling period, with quarterly sampling periods identified by different colors. This hydrograph also displays average historical daily discharges for a 36-year period (1972–2008). Figure 5.2-4 shows the quarterly distribution of the daily Willamette River discharge combined with sediment accumulation rates (also depicted in Figure 5.2-2), and percent fines (also depicted in Appendix D2.1, Figure D2.1-23).

5.2.4 Overview of Sample Collection Effort

The Round 3A in-river sediment trap sampling consisted of four rounds of sample collection over the course of a year's deployment in the LWR. A detailed description of field efforts associated with sediment trap deployment and recovery is included in the sediment trap data report (Anchor and Integral 2008) and in the respective FSRs for the initial deployment and each collection quarter (Anchor 2006c; 2007a,b,c; 2008c).

Sediment traps were deployed at 16 locations in the LWR from late 2006 through late 2007 (see Map 2.2-3). Twelve of the locations were within the Study Area between

RM 1.9 and 11.5. One sediment trap was deployed just downstream of the Study Area at RM 1.8, two were located just upstream of Ross Island at RM 15.6 and 15.7, and one was located in Multnomah Channel. Paired sediment traps were deployed and maintained on opposite sides of the river at approximately RM 1.9, 6, 11.5, and 15.7. A total of 52 sediment trap samples were collected and analyzed per the protocols used in Rounds 2A and 2B. Sediment traps were deployed, sampled, and retrieved during the following periods:

Event	Date
Initial deployment of sediment traps	October 30 to November 2, 2006
Quarter 1 sample collection	January 30 to February 2, 2007
Quarter 2 sample collection	April 30 to May 2, 2007
Quarter 3 sample collection	August 8, 16, and 17, 2007
Quarter 4 sample collection and final retrieval of sediment traps	November 13 and 14, 2007

Table 5.2-5 lists river miles, water depths, and location coordinates for each station. Sampling dates and sample recovery information for each deployment are shown in Table 5.2-6.

Several factors precluded the collection and analysis of all 64 field sample attempts (16 locations x 4 quarters) plus accompanying QC samples as described in the FSP (Anchor 2006b). Traps were lost at three stations during the initial deployment period (Quarter 1) and at one location during Quarter 2. In addition, eight trap retrievals during Quarter 2 and Quarter 3 had sediment accumulation too low to warrant collection. In total, 52 field samples were collected. Among the samples collected, an analytical prioritization scheme was used to determine the parameter schedule for samples with limited mass. PCB congener analysis had the highest priority and grain-size analysis had the lowest priority. A detailed discussion of the decision rules for analytical priorities is included in the data report (Anchor and Integral 2008).

5.2.4.1 Sample Collection Methods and River Conditions

Sediment traps were deployed and maintained on both sides of the river at approximately RM 1.9, 6, 11.5, and 15.7. Individual sediment traps were deployed and maintained at seven other locations throughout the Study Area and at one location in Multnomah Channel. The number and locations of sediment traps and the frequency of recovery and redeployment were designed to capture anticipated spatial and temporal variability of suspended sediment mass and to investigate the potential accumulation of suspended sediment chemical constituents in suspected depositional areas.

Sediment traps were initially deployed October 30 to November 2, 2006. Thereafter, sediment traps were recovered, sampled, and redeployed on a quarterly schedule until final recovery and sampling on November 13 and 14, 2007.

Hydrologic data used to assess flow patterns during sampling were obtained from the USGS stream flow station located upstream of the Morrison Bridge (Willamette River

at Portland, gage no. 14211720). The highest flows during sampling occurred during Quarter 1, with a median daily discharge of 79,000 cfs (Figure 5.2-1). This period was characterized by variable flows, reaching twice the historical average discharge on a number of separate events. Much lower than normal discharge periods (≤50 percent of average) also occurred twice during Quarter 1, the latter depression stretching into Quarter 2. The discharge record for Quarters 2 and 3 (median discharges of 31,000 cfs and 10,000 cfs, respectively) did not demonstrate the variability that characterized Quarter 1. In general, sampling during Quarters 2 and 3, and at least a portion of Quarter 4 (median discharge of 11,000 cfs), occurred during river flows that were very similar to historical averages. Discharge data from the last half of Quarter 4 (October 2007 through mid-November 2007) are considered estimates due to uncertainty about the accuracy of the rating curve used at the Portland location for flows less than 20,000 cfs.

5.2.4.2 Rates of Sediment Accumulation

Sediment accumulation rates at each station/quarter were calculated from the height of the sediment column in the traps and from the specific gravity and moisture content of the material. The highest rates of accumulation occurred during Quarter 1, with the largest accumulation in the sediment traps placed at RM 11.3 and 15.6 (Figure 5.2-2); sediment accumulation rates were lower in the sediment traps placed downstream of RM 11.3. As mentioned previously, traps were lost at stations ST014 (RM 7.5), ST006 (Swan Island Lagoon), and ST016 (RM 9.9) during Quarter 1.

Medium-coarse silt made up approximately 50 percent of the trapped material during each quarter, although the highest sediment accumulation rates generally corresponded with a comparatively low percentage of fine material in the sediment traps. Figure 5.2-3 shows rates of accumulation as a function of percent fines, demonstrating the moderately strong inverse relationship. TOC showed relatively small differences among samples, with concentrations ranging from 1.1 to 3.5 percent and approximately 75 percent of the measured values between 2 and 3 percent (Appendix D2.1, Figure D2.1-24).

Because sediment trap samples do not constitute temporally discrete samples (i.e., they represent a continuous collection over a three-month period), river conditions during sampling can only be discussed meaningfully in seasonal terms. Accumulation rates of trapped sediment may have been substantially affected by instantaneous events, such as high water resulting from heavy rainfall, but the impact of these isolated events cannot be quantified based on the existing data or the sampling methodology employed.

The higher rate of sediment accumulation and the entrainment of sandy material in the sediment traps placed at RM 11.3 and 15.6 during Quarter 1 may be due in part to the frequency of higher flow events that occurred during this period (Figure 5.2-4). The distribution of flows shows that the maximum daily flows during Quarter 2 were approximately the same as median Quarter 1 flows, and approximately 75 percent of the Quarter 1 daily discharge levels were higher than any of those recorded during

Quarter 3 and 4. A lower accumulation of trapped sediments, particularly at upriver stations, occurred during Quarters 3 and 4 when comparatively low-flow events were typical.

5.2.5 Total PCBs in Sediment Traps (Congeners and Aroclors)

PCB congener analysis was conducted for all 52 sediment trap samples; 48 of these samples were also analyzed for PCB Aroclors. PCB congeners were detected in all 52 samples, with total PCB congener concentrations ranging from 3.14 J µg/kg to 11,100 J µg/kg (Figure 5.2-5). PCB Aroclors were detected in 30 of the 48 samples analyzed, with total Aroclor concentrations ranging from 7.1 J µg/kg to 2,600 µg/kg (Figure 5.2-6).

The relationship between total PCB congener and total PCB Aroclor concentrations is shown in Figure 5.2-7 and discussed in detail in Appendix D1.4. Although the PCB concentrations in sediment trap samples correlated well for the two methods, concentrations of total PCBs measured as congeners were higher overall than total PCBs measured as Aroclors. The methods used for analysis of PCB congeners and Aroclors are fundamentally different and would be expected to yield moderate differences in total PCB concentrations, as described in Appendix D1.4. In addition, among detected Aroclor results for the sediment trap samples, almost half of the individual concentrations (21 of 50 results) were below the method reporting limit (MRL). There is less confidence that these estimated Aroclor concentrations are as accurate and precise as concentrations above the MRL. Ten additional Aroclor results were reported at concentrations less than two times the MRL. These values are also expected to be less precise than concentrations that are farther above the noise level of the system and well within the calibration range.

The accuracy and precision of Aroclor data are also affected by PCB "weathering." An examination of the Aroclor chromatograms indicates that many of the Aroclor patterns in the sediment trap samples were weathered, and that the PCB patterns in the samples did not match the Aroclor standards well. This affects the laboratory's ability to identify, as well as quantify, the Aroclor(s) in the sample and is an inherent limitation to the Aroclor method. Because of the uncertainties in the Aroclor data related to concentrations near or below the MRL and to "weathering," the following summary of PCB patterns and trends in sediment trap samples gives preference to PCB congener data.

PCB concentrations were generally higher in sediment traps located between RM 6.7 and 11.3 compared to other locations. PCB concentrations upstream of RM 11.3 did not exceed 24 µg/kg for total Aroclors or 13 µg/kg for total congeners.

Increasing concentrations generally occurred with each successive period at locations downstream of ST007 (RM 11.3E), a trend that was clear in the PCB congener data but not apparent for Aroclors, possibly due to the lower number of samples with detectable Aroclor concentrations. PCB concentrations at Station ST007 during low and

medium-flow periods (Quarters 2, 3 and 4) were elevated two to three orders of magnitude above concentrations at other locations for the respective periods. ST007 PCB congener concentrations during the highest flow period (Quarter 1) were much lower than during subsequent quarters, and only slightly above concentrations at downstream locations during the same period. Aroclors concentrations at ST007 were similarly elevated relative to other locations during Quarters 3 and 4, but unlike congeners, the total Aroclor concentration during Quarter 2 was one-half the Quarter 1 concentration.

Aside from large differences in PCB levels between ST007 (RM 11.3E) and its paired location ST008 (RM 11.5W), there was little relative difference in PCB concentrations between other cross-river sample pairs. Total PCB congener concentrations in the Study Area samples were all higher than the average PCB concentrations from upstream locations—one-to-five fold greater than upstream concentrations, in most cases. These trends were generally also reflected in the Aroclor data.

The distribution of detected PCB homologs and Aroclors is shown in Figures 5.2-8 and 5.2-9, respectively. TetraCBs, pentaCBs, hexaCBs, and heptaCBs were the predominant homolog groups in the sediment trap samples. Aroclors 1254 and 1260 accounted for most of the reported Aroclors, which is consistent with the homolog composition. Aroclor 1254 consists primarily of pentaCBs followed by tetraCBs and hexaCBs, and Aroclor 1260 contains mostly hexaCBs and heptaCBs (Figure 5.1-34). DiCBs and triCBs were detected in most samples and are consistent with patterns displayed by weathered Aroclors 1254 and 1260.

In addition to 1254 and 1260, Aroclors 1221 and 1242 were reported in eight instances. Aroclor 1221 was reported once, in the Quarter 3 sample from ST011 (RM 3.5E) at a concentration just above the method detection limit (MDL) and with qualifiers "NJ" (i.e., tentatively identified and estimated). Aroclor 1242 was identified in seven samples from Quarter 2, all at concentrations below the MRL of approximately 10 µg/kg, but was not identified during other sampling periods. Considering the low levels at which these Aroclors were detected and the regular occurrence of weathered Aroclor components among samples, it is conceivable that the partially dechlorinated PCBs in these samples led to misidentifications as Aroclors 1221 and 1242.

Overall, PCB homolog distributions were generally similar from quarter to quarter at each location, with a few exceptions. The samples were dominated by tetraCBs, pentaCBs, hexaCBs, and heptaCBs, with localized or temporal variations. Notable variations and a comparison of the paired sediment trap samples are discussed below:

- The Quarter 1 sample at ST009 (RM 15.7E) was predominantly pentaCBs and hexaCBs, with contributions from tetraCBs and octaCBs. Samples at this station from the other three quarters had greater contributions from diCBs, triCBs, tetraCBs, and octaCBs. ST010 (RM 15.6W) is located west of ST009,

and the Quarter 1 sample from this station showed a slightly elevated contribution of pentaCBs, but to a lesser degree than was seen at ST009.

- PCBs at ST007 were more highly chlorinated than at other locations, with PCB patterns dominated by hexaCBs and heptaCBs. The proportion of octaCBs was also elevated in these samples, and the contribution of tetraCB and pentaCB was lower, relative to those from upstream locations. This distinct PCB pattern, combined with the high concentrations, indicates the presence of a localized source of PCBs in this vicinity during Quarters 2, 3, and 4. The PCBs in Quarter 1 at this location were different from the following quarters, with higher triCB and tetraCB fractions, and a much lower total PCB concentration.
- The PCB patterns at ST008, across from ST007, were different from ST007, and the PCB concentrations were lower; ST008 does not appear to exhibit significant influence from ST007 in terms of PCB composition.
- A pattern of highly chlorinated PCBs was consistently seen at ST006 (Swan Island Lagoon), ST015 (RM 9.7W), and ST016 (RM 9.9E). All samples from these stations were predominated by pentaCBs, hexaCBs, and heptaCBs.
- ST013 (RM 6.7E) in Willamette Cove was composed primarily of moderately chlorinated homologs (tetra- through heptaCBs), with relatively high contributions from octaCBs in all three quarters sampled. While the PCB homolog distribution was consistent for all samples from this location, the total PCB congener concentration in the Quarter 4 sample was five times higher than during Quarter 1.
- The Quarter 1 sample at ST004 (RM 6.0E) consisted mainly of hexaCBs and heptaCBs, while samples from other quarters at this station more closely matched the tetraCB, pentaCB, hexaCB, and heptaCB distribution of the other stations. ST005 (RM 6.0W), opposite ST004, had a relatively higher proportion of tetraCBs and pentaCBs, and lower abundance of heptaCBs compared to ST004.
- ST011 in Quarters 1 and 2 had larger contributions of triCBs than other locations, in addition to the pattern of tetra- through heptaCBs seen at other stations. The octaCB proportion was elevated in the Quarter 4 sample from this station. Quarter 3 and 4 samples from ST011 had total PCB congener concentrations two-to-three times higher than the Quarter 1 and 2 samples.

5.2.6 Total PCDD/Fs in Sediment Traps

At least one dioxin (PCDD) or furan (PCDF) homolog constituent was detected in each of the 48 samples analyzed (Figure 5.2-10). Total PCDD/F homolog concentrations ranged from 5.16 J to 6,100 J pg/g.

There was no apparent spatial gradient or trend in total PCDD/F concentrations. The highest PCDD/F homolog concentration (6,100 J pg/g) occurred during Quarter 4 at ST006 (Swan Island Lagoon), and was elevated 1 to 2 orders of magnitude above

concentrations at most other locations. However, the incidence of elevated PCDD/Fs at ST006 other than during Quarter 4 could not be assessed since no samples from previous quarters were analyzed at this location. PCDD/F spikes of 1,820 J pg/g and 1,250 J pg/g occurred during Quarter 3 at ST007 (RM 11.3E) and at ST002 (RM 1.8W), respectively, representing the next highest levels found. Relatively high concentrations were also seen in Quarter 4 samples from ST014 (RM 7.5W; 1,060 J pg/g) and ST007 (745 J pg/g), and Quarter 1 samples from ST001 (RM 1.9E; 563 pg/g) and ST011 (RM 3.5E; 535 pg/g).

Study Area locations generally had total PCDD/F concentrations higher than average concentrations from the upstream locations. However, total PCDD/F concentrations from the two upstream locations were not similar to each other, with concentrations from ST009 (RM 15.7E) averaging more than six times those from ST010 (RM 15.6W). ST009 samples typically had higher total PCDD/F concentrations than those sampled concurrently from Study Area locations.

The highest PCDD/F concentrations among stations generally occurred during Quarters 4 and 3. Stations ST002, ST007, and ST009 all contained higher total PCDD/Fs than their counterparts during these periods. However, the east (ST004) and west (ST005) pair at RM 6 had nearly identical concentrations during all quarters analyzed.

Homolog patterns for sediment trap samples showed OCDD as the dominant homolog in almost all sediment trap samples, with HpCDDs present to a substantial degree in most samples (Figure 5.2-11). PCDFs generally accounted for less than about 20 percent of the total PCDD/Fs in most of the samples. OCDF typically accounted for the highest furan concentrations, followed by HpCDFs.

Samples with homolog patterns different from the prevailing pattern were observed at several locations, but these patterns are obscured because U-qualifiers were applied during data validation in most cases; non-detects are treated as zero in the graphs of chemical patterns. However, the Quarter 2 sample from ST008 (RM 11.5W) was notable for its relatively high proportions of OCDF and low proportions of OCDD compared to other samples.

The following samples have incomplete PCDD/F patterns because some of the PCDD/F homolog data were qualified as undetected during validation (Anchor and Integral 2008): ST010, Quarter 2 (HpCDDs undetected) and Quarter 4 (HpCDFs and OCDF undetected); ST003 (Multnomah Channel), Quarter 2 (HxCDDs, HxCDFs, HpCDDs, HpCDFs, and OCDD undetected); ST008, Quarter 4 (HpCDFs and OCDF undetected); and ST016 (RM 9.9E), Quarter 4 (HpCDFs undetected).

Samples with total PCDD/F concentrations >500 pg/g—ST001 and ST011 from Quarter 1; ST002 and ST007 from Quarter 3; and ST014, ST006, and ST007 from Quarter 4—had similar homolog patterns.

5.2.6.1 TCDD TEQs in Sediment Traps

Measurable TCDD TEQs were found in all samples at concentrations ranging from 0.05 J pg/g to 16.3 J pg/g (Figure 5.2-12). The highest TCDD TEQ was found in the Quarter 4 sample from ST006 (Swan Island Lagoon). Since Quarter 4 was the only time PCDD/Fs were analyzed at this location, it is difficult to gauge the occurrence of similar PCDD/F concentrations during other periods or the potential that there is a localized source. TEQs ≥1 pg/g were also found at ST007 (RM 11.3E) during Quarters 3 and 4; the Quarter 3 sample from ST002 (RM 1.8W); ST014 (RM 7.5W) during Quarter 4; and Quarter 1 samples from ST001 (RM 1.9E), ST011 (RM 3.5E), and ST005 (RM 6.0W), where the Quarter 2 sample was also >1 pg/g.

TEQ concentrations derived from PCDD/Fs closely track total PCDD/F homolog concentrations, both geographically and seasonally. The close parallel is due to the resemblance in homolog patterns among samples. TEQ concentrations are generally two-to-three orders of magnitude lower than total PCDD/F homolog concentrations due to the abundance of higher chlorinated 2,3,7,8-substituted dioxins and furans, which have less toxic equivalency than tetra- and penta-chlorinated congeners.

5.2.7 Total DDx in Sediment Traps

DDx compounds were detected in all but one sediment trap sample (Figure 5.2-13). Concentrations of total DDx ranged from 0.98 J µg/kg to 150 µg/kg in samples with detectable concentrations.

The highest total DDx concentration occurred during Quarter 4 at ST007 (RM 11.3E) and was an order of magnitude higher than most other samples. Quarter 4 samples from ST005 (RM 6.0W) and ST006 (Swan Island Lagoon) had the second and third highest concentrations, 33 J µg/kg and 31 J µg/kg, respectively. At most locations, total DDx concentrations were highest during Quarter 4.

Among locations, samples collected from sediment traps at RM 6 to 11.3 generally had the highest total DDx concentrations. Downstream of RM 6, total DDx concentrations appeared to be similar within quarters or to decrease slightly with distance downstream. The maximum concentration found downstream of RM 6 (15 J µg/kg) was low relative to maximum concentrations from stations located at RM 6 through 11.3.

Total DDx concentrations in Study Area samples were generally higher than those from upstream locations. Overall, 35 of the 43 (81 percent) Study Area samples had higher total DDx concentrations than average concentrations from concurrent upstream samples. Differences between Study Area and upstream samples were most pronounced during Quarters 3 and 4, when the combined average Study Area total DDx concentration was six-fold that of the combined average concentrations from upstream locations. By contrast, Study Area samples from the first two quarters had a combined average total DDx concentration 34 percent higher than the combined average concentration of upstream samples.

Paired samples from opposite sides of the river at RM 1.8–1.9 (ST002/ST001) and at RM 15.6–15.7 (ST010/ST009) had similar total DDT concentrations, whereas high Quarter 4 total DDT levels were noted at ST005 and ST007 compared to their respective counterparts, ST004 (RM 6.0E) and ST008 (RM 11.5W).

The relative concentration of DDD, DDE, and DDT varied widely among samples. Among the 2,4'- and 4,4'-isomers, the 4,4'-isomers generally predominated (Figure 5.2-14). On average, 4,4'-DDT comprised the largest proportion of total DDx (29 percent of total), followed by 4,4'-DDE (26 percent), and 4,4'-DDD (21 percent). Among the 2,4'-isomers, 2,4'-DDT was found at the highest percentage of total DDx (12 percent on average), followed by 2,4'-DDD (10 percent), and 2,4'-DDE (one percent).

Stations ST007 and ST015 (RM 9.7E) had the highest proportion of 2,4'-DDx compounds due to comparatively high percentages of 2,4'-DDD and 2,4'-DDT. Station ST013 (RM 6.7W) also had a high percentage (52 percent) of 2,4'-DDT in the Quarter 4 sample. Upstream samples were primarily composed of 4,4'-DDx isomers.

The DDD isomers exhibited variability in both their concentration and relative contributions at most stations; no seasonal or geographic trends were evident. DDT isomers appeared to have the highest relative concentrations during Quarter 1, although no geographical trends were apparent. A more seasonal trend was observed for DDE isomers, where they were reported at detectable concentrations in all but two of the samples from Quarters 2 through 4, yet were detected in only three of the 13 samples from Quarter 1. Relative contributions of DDE compounds to total DDx were generally highest during Quarter 4.

Patterns of relative concentrations of DDx constituents among samples are somewhat confounded by elevated detection limits and interferences. Of the 300 DDx results, detection limits were elevated in 18 percent, and another four percent were classified as non-detects due to contamination in the associated laboratory or field blanks (Anchor and Integral 2008). The elevated detection limits could obscure low concentrations of DDx. Because non-detected results are treated as zero in Figure 5.2-14, true patterns of relative concentration among the various isomers and congener compounds may also be obscured. In addition, 9 percent of the results were qualified as tentatively identified and estimated (NJ) during data validation due to poor confirmation, and another 15 percent were estimated (J) as a result of the confirmation data.

Total DDx at ST007 Quarter 3 and 4 samples (24 and 150 µg/kg, respectively) were composed entirely of 2,4'-DDD. However, 2,4'-DDD reported by the laboratory in these cases may be artifacts of PCB interference. High concentrations of Aroclor 1260 were also detected at this station in these samples (1,800 and 2,600 µg/kg respectively). Aroclors have the potential to interfere with the analysis of DDx due to co-elution of Aroclor peaks with DDx compounds. While the 2,4'-DDD results were not N-qualified during data validation, the results for other isomers (2,4'-DDT and 4,4'-DDT in both

Quarters 3 and 4, and 2,4'-DDE in Quarter 4) were N-qualified. It is possible that the reported results are affected by Aroclor interferences.

5.2.8 Total PAHs in Sediment Traps

PAHs were detected in all samples analyzed, with concentrations of total PAHs ranging from 77 J µg/kg to 11,000 µg/kg (Figure 5.2-15). Total PAH concentrations at ST005 (RM 6.0W) were elevated an order of magnitude above most other locations during Quarters 1, 2, and 4 (PAHs were not analyzed at ST005 during Quarter 3). In general, total PAH concentrations were higher at locations between RM 3 and 6, including Multnomah Channel (ST003) which had a relatively high Quarter 4 level (2,700 J µg/kg). Total PAH concentrations upstream of RM 9.7 were generally lower, with only two samples exceeding 500 µg/kg: 640 µg/kg at ST007 (RM 11.3E) during Quarter 3 and 1,300 J µg/kg at ST010 (RM 15.6W) during Quarter 1.

The highest PAH concentrations within stations tended to occur during Quarters 3 and 4, but additional seasonal differences among stations were not apparent. Most samples analyzed from Study Area locations had total PAH concentrations exceeding average upstream concentrations during concurrent sampling periods. Overall, 33 of the 43 (77 percent) Study Area samples had total PAH concentrations higher than concurrent samples from upstream locations, with the exception of Quarter 1, where the average total PAH concentration of upstream samples (700 µg/kg) was higher than most Study Area samples. During subsequent quarters, however, concentrations upstream were lower (combined average of 190 µg/kg), and 91 percent of Study Area samples had total PAH concentrations an average of six times greater than those from upstream.

Paired samples generally did not display substantial differences in total PAH concentrations, with two notable exceptions. There were large differences between total PAH concentrations at ST005 and its cross-river counterpart (ST004, RM 6.0E) during all quarters where samples from both stations were analyzed. Total PAH concentrations during Quarter 1 at ST010 were also higher than the concurrent sample from ST009 (RM 15.7E).

An evaluation of the PAH composition among samples was done by combining the 17 individual PAH compounds into categories determined by their number of fused rings, as described in Section 5.1.8.4. Fused ring patterns did not vary substantially among samples, with four-ring PAHs as the predominant component, followed by those with five rings (Figure 5.2-16). HPAHs (PAHs with four or more fused rings) generally accounted for more than 80 percent of total PAHs. LPAHs (PAHs with two or three fused rings) accounted for a maximum of one-third total PAH concentrations, and exceeded 20 percent of total PAHs in only nine of 49 samples analyzed. A bar chart of all site PAHs (Figure 5.2-17) shows that the four-ring PAHs consist primarily of fluoranthene and pyrene and the five-ring PAHs consist primarily of BAP and benzo(b)fluoranthene. These four PAHs account for approximately 50 percent of the total PAHs in all samples.

The PAH distributions at ST005, the location with the highest total PAH concentrations, were similar to the prevailing pattern. Samples with PAH distributions that differed somewhat from the prevailing pattern were observed at several locations:

- The Quarter 2 sample from ST009 (RM 15.7E) exhibited increased contributions from five-ring PAHs, mainly BAP.
- At ST002 (RM 1.8W) the Quarter 2 and 3 samples exhibited increased contributions from five-ring and six-ring PAHs. However, the distribution of the individual PAHs within the five-ring and six-ring PAH groups were similar to other samples.
- At ST003 (Multnomah Channel), increased contributions from five-ring and six-ring PAHs were seen in the Quarter 2 and 4 samples. The distribution of the individual PAHs within the five-ring and six-ring PAH groups were similar to other samples.

The evaluation of the LPAH distributions is confounded by the fact that eight results for naphthalene (a two-ring PAH) from Quarter 2 were restated as undetected because of laboratory blank results (Anchor and Integral 2008). The levels of LPAHs in these Quarter 2 samples may be under-represented. With that caveat, samples from Quarter 1 at ST010 (RM 15.6W), Quarter 3 at ST011 (RM 3.5E), and Quarter 4 at ST003 (Multnomah Channel)—all with total PAH concentrations greater than 1,000 µg/kg (1,300 J µg/kg, 1,600 J µg/kg, and 2,700 J µg/kg, respectively)—are notable for their low contribution (less than 20 percent) of LPAHs to the total PAHs.

In cases where LPAHs constitute more than 20 percent of the total, naphthalene accounts for 60 to 85 percent of the two-ring PAHs. Phenanthrene accounts for over 50 percent of the three-ring PAHs, with anthracene accounting for an additional 10 to 30 percent of the three-ring PAHs. Samples with more than 20 percent LPAHs include: ST009, Quarters 1 and 3; ST010, Quarter 4; ST008 (RM 11.5W), Quarters 1 and 2; ST007, Quarter 3; ST015 (RM 9.7W), Quarter 3; ST013 (RM 6.7E), Quarter 1; and ST004, Quarters 1 and 2.

5.2.9 Additional Indicator Chemicals in Sediment Traps

5.2.9.1 Bis(2-ethylhexyl)phthalate in Sediment Traps

BEHP was detected in all samples analyzed at concentrations ranging from 35 µg/kg to 1,600 µg/kg (Figure 5.2-18). BEHP concentrations at ST006 (Swan Island Lagoon) were elevated an order of magnitude above most other locations, although BEHP at ST010 (RM 15.6W) approached the Quarter 4 level from ST006 (480 J µg/kg vs. 710 µg/kg). Concentrations downstream of Swan Island Lagoon varied less within and among stations and sampling periods than did BEHP concentrations upstream of Swan Island Lagoon. BEHP concentrations upstream of Swan Island Lagoon were generally highest during Quarters 3 and 4, whereas the highest concentrations downstream of Swan Island Lagoon generally occurred during Quarters 1 and 2.

Average upstream BEHP concentrations at ST009 (RM 15.7E) and ST010 were generally lower than Study Area locations during concurrent sampling. During Quarter 4, however, ST006 was the only Study Area location where BEHP exceeded the upstream concentration at ST010 (RM 15.6W).

Paired samples showed closely matched BEHP concentrations at RM 6 and locations downstream. Upstream of RM 6, paired samples showed less similarity, with BEHP concentrations at ST007 (RM 11.3E) and ST010 (RM 15.6W) generally higher than their respective counterparts (ST008 and ST009).

5.2.9.2 Total Chlordanes in Sediment Traps

One or more chlordanes were detected in approximately 70 percent of samples analyzed (Figure 5.2-19). Detectable concentrations of total chlordanes ranged from 0.22 J to 3.7 NJ µg/kg, although reporting limits for non-detects ranged from 0.63 to 460 µg/kg.

The highest total chlordanes concentration was found at ST008 (RM 11.5W) during Quarter 1. Other comparatively high concentrations (>3 µg/kg) were found during Quarter 4 at ST011 (RM 3.5E) and during Quarter 3 at ST006 (Swan Island Lagoon). Total chlordane concentrations were highly variable within and among locations and within and among seasons. Therefore, spatial and seasonal gradients or trends were not apparent.

Overall, Study Area total chlordane concentrations were higher than upstream concentrations. The maximum total chlordanes in all upstream samples was 1 J µg/kg, whereas nine of the 14 Study Area stations had at least one sample with greater than 1 µg/kg total chlordane. West-side samples from RM 6 (ST005) and 11.5 (ST008) had higher levels during Quarter 1 than their respective east-side sediment traps, ST004 and ST007, but similarities or differences between paired samples were difficult to assess due to the number of non-detects and the vast range of reporting limits.

5.2.9.3 Aldrin and Dieldrin in Sediment Traps

Aldrin and dieldrin, two closely related organochlorine pesticides, were detected in five samples each (Figures 5.2-20 and 5.2-21). None of the samples analyzed contained detectable levels of both aldrin and dieldrin. All of the detected concentrations of aldrin were at similar levels (0.61 NJ µg/kg to 1.1 NJ µg/kg), with the highest concentration found at Station ST005 (RM 6W). Detected dieldrin concentrations were more variable, with concentrations ranging from 0.15 NJ µg/kg at ST003 (Multnomah Channel) to a maximum of 4.9 µg/kg at ST006 (Swan Island Lagoon). Two of the five dieldrin detections were at the upstream location ST009 (RM 15.7E).

Eighty percent of the aldrin detections occurred during Quarter 1, while all of the detectable dieldrin concentrations were found during Quarters 3 and 4. The infrequency of detections did not allow for assessment of a possible geographical concentration gradient or trend. Of the three instances where either aldrin or dieldrin was detected at a paired sample location, corresponding cross-river locations had no detectable

concentration. All detected aldrin concentrations occurred at or below RM 7.5, while dieldrin was detected in Multnomah Channel (ST003), RM 3.5E (ST011), Swan Island Lagoon (ST006), and upriver at RM 15.7E (ST009).

5.2.9.4 Arsenic in Sediment Traps

Arsenic was detected in all samples analyzed at concentrations ranging from 1.48 J mg/kg to 7.01 mg/kg (Figure 5.2-22). There was relatively little variation in concentrations among samples, with approximately 80 percent of the values between 3 mg/kg and 6 mg/kg.

The highest arsenic concentration was found at Station ST011 (RM 3.5E) during Quarter 4. There was little difference between paired samples. The highest levels were generally found during Quarter 4, particularly downstream of RM 9.

Most concentrations of arsenic from Study Area stations were the same or slightly above arsenic concentrations in upstream locations, except during Quarter 3. Arsenic levels in Study Area samples rarely varied from the arsenic levels at upstream stations by more than a factor of two.

5.2.9.5 Chromium in Sediment Traps

Chromium was detected in all samples analyzed at concentrations ranging from 10.8 mg/kg to 59.5 mg/kg (Figure 5.2-23). There was relatively little variation in concentrations among samples, with approximately 80 percent of the values between 28 and 40 mg/kg.

The highest chromium concentration was found during Quarter 3 at Station ST009 (RM 15.7E), the location furthest upstream. However, the highest concentrations within stations tended to occur during Quarter 1. There were no locations with levels of chromium consistently higher than all others, and there was little difference in chromium concentrations between paired samples.

Although the highest chromium concentration was found in a sample from an upstream location during Quarter 3, most chromium concentrations from Study Area stations were the same or slightly above chromium concentrations typically found in upstream locations. Chromium levels in Study Area samples rarely varied from average chromium levels at upstream stations by more than a factor of two.

5.2.9.6 Copper in Sediment Traps

Copper was detected in all samples analyzed at concentrations ranging from 15.2 mg/kg to 93.6 mg/kg (Figure 5.2-24). There was relatively little variation in concentrations among samples, with approximately 80 percent of the values between 34 mg/kg and 58 mg/kg.

The highest copper concentration was found at Station ST006 (Swan Island Lagoon) during Quarter 3. The second highest concentration (75.1 mg/kg) was found at the

upstream location ST009 (RM 15.7E), also during Quarter 3. The highest concentrations among sampling periods occurred during Quarter 4, particularly at stations from RM 3.5 through 6.7. There was little difference in copper concentrations between paired samples.

Although the second highest copper concentration was found in a sample from one of the upstream locations, most copper concentrations from Study Area stations were slightly above copper concentrations in upstream locations, except during Quarter 3. Copper levels in Study Area samples rarely varied from the copper levels at upstream stations by more than a factor of two.

5.2.9.7 Zinc in Sediment Traps

Zinc was detected in all samples analyzed at concentrations ranging from 71.6 mg/kg to 319 mg/kg (Figure 5.2-25). There was relatively little variation in concentrations among samples, with approximately 80 percent of the values between 99 mg/kg and 170 mg/kg.

The highest zinc concentration was found during Quarter 3 at Station ST006 (Swan Island Lagoon). ST006 was the only station that appeared to contain comparatively high localized concentrations, although only two quarters of data were available from this location. Among sampling periods, the highest zinc concentrations occurred during Quarter 4. Quarter 1 generally had the lowest zinc levels among sampling periods. Samples from paired stations had nearly identical zinc concentrations during concurrent sampling periods, except for the relatively large difference between ST010 (RM 15.6W; 125 mg/kg) and ST009 (RM 15.7E; 71.6 mg/kg) during Quarter 4.

Most concentrations of zinc from Study Area stations were slightly above zinc concentrations in upstream locations, except during Quarter 3. Zinc levels in Study Area samples rarely varied from the zinc levels at upstream stations by more than a factor of two.

5.2.9.8 Tributyltin Ion in Sediment Traps

TBT was detected in approximately 80 percent of the samples analyzed. Detectable concentrations of TBT ranged from 0.48 J µg/kg to 81 µg/kg (Figure 5.2-26).

TBT concentrations at ST006 (Swan Island Lagoon) were elevated an order of magnitude above other locations. Concentrations within locations were generally highest during Quarter 4, and concentrations during all sampling periods were generally highest downstream of Swan Island Lagoon. The median TBT concentration downstream of RM 9 was 3.8 µg/kg, with only one sample below the reporting limit (0.17 µg/kg). Upstream of RM 9, the median TBT concentration was 0.48 J µg/kg, assuming non-detects equal zero, and nearly one-half of the samples were undetected at reporting limits of 0.12–0.87 µg/kg.

Differences between paired samples were difficult to assess due to the number of non-detects. The largest within-pair differences occurred at RM 6, where TBT concentrations from east-side (ST004) samples were higher than those from the west side (ST005) during Quarter 1 (4.6 µg/kg vs. non-detect at 0.17 U µg/kg) and Quarter 2 (4.9 µg/kg vs. 1.5 J µg/kg). However, this situation was reversed during Quarter 4, with higher concentrations found at ST005 (13 µg/kg) compared to ST004 (3.9 µg/kg).

In general, TBT levels in the Study Area were higher than TBT levels upstream of the Study Area. However, since only one of six samples from ST010 (RM 15.6W) and ST009 (RM 15.7E) had a detectable TBT concentration, the degree of elevation upstream cannot be meaningfully quantified.

5.2.10 Summary of Nature and Extent of Indicator Chemicals in Sediment Traps

PCBs, PCDD/Fs, DDx, and PAHs were found in sediment traps throughout the Study Area and at upstream locations, with concentrations of each IC varying by two-to-three orders of magnitude. In general, samples with the highest IC concentrations were found in sediment traps located from RM 6 through RM 11.3. Specific locations with the consistently greatest PCB and PAH concentrations were easily distinguishable; it was less obvious if maximum PCDD/Fs and DDx consistently corresponded to specific locations over the course of the study.

Total PCB concentrations (as congeners) ranged from 3.14 J to 11,100 J µg/kg, with the highest PCB concentrations consistently found on the east side of the river at RM 11.3. Samples from RM 11.3E during low- and medium-flow periods (Quarters 2, 3, and 4) had total PCB concentrations elevated two-to-three orders of magnitude above those at other locations, with concentrations generally diminishing with distance downstream. Total PCB concentrations in sediment traps located above Ross Island (RM 15.6–15.7) were generally lower, with an overall median concentration one-third of those from Study Area sediment traps.

For PCDD/Fs in sediment traps, it was more difficult to identify a distinct location with the highest total concentrations. Total PCDD/F homolog concentrations ranged from 5.16 J pg/g to 6,100 J pg/g, with the highest concentration found in the solitary sample from Swan Island Lagoon. There didn't appear to be a consistent geographical gradient in PCDD/F concentrations, and intermittently elevated concentrations (relative to other samples) occurred at RM 11.3E, 1.8W, and 7.5W. Study Area samples had an overall median total PCDD/F concentration approximately 40 percent higher than the overall median of upstream samples.

Total DDx concentrations in sediment traps were also variable enough to preclude assigning the highest concentrations to a single location. Concentrations of total DDx ranged from 0.98 J µg/kg to 150 µg/kg, with the highest concentration found at RM 11.3E. However, the unusual composition of DDx in samples from RM 11.3E (100 percent 2,4'-DDD during Quarters 3 and 4) coupled with possible analytic

interference from Aroclors calls into question the validity of the DDx results from this location. Like other ICs, total DDx was higher in Study Area samples, with an overall median concentration double that of upstream samples.

Total PAH concentrations at RM 6W were elevated an order of magnitude above most other locations. Concentrations of total PAHs ranged from 77 J µg/kg to 11,000 µg/kg and, in general, were highest at locations from RM 3 through RM 6, including Multnomah Channel. Although one sample from RM 15.6W had comparatively high total PAH concentrations during one of the sampling periods, the overall median concentration in Study Area samples was triple that of samples from upstream sediment traps.

5.3 INDICATOR CHEMICALS IN SURFACE WATER

This section summarizes the surface water data for the LWG rounds of investigation. The geographic locations of all Round 2A and 3A surface water sampling locations are presented on Map 2.2-4. The following subsections present hydrographs, histograms, scatter plots, line plots, and stacked bar graphs to support discussion and evaluation of the nature and extent of selected ICs. Additional tabular and graphical summaries of the surface water data set are included in Appendix D3.

5.3.1 Surface Water Data Set

There were two rounds of surface water investigation completed for this RI. The Round 2A and 3A surface water sampling programs consisted of seven field collection events that occurred between November 2004 and March 2007. The surface water study was designed to characterize surface water chemical concentrations and flow conditions of the river during three different flow regimes: low river flow (low-flow; <50,000 cfs), high river flow (high-flow; >50,000 cfs), and stormwater-influenced flow (sampling during active runoff in the Study Area). The threshold discharge rate of 50,000 cfs was selected because it is the river discharge at which significant transport of streambed sediment begins (Willamette Basin Task Force 1969). The seven events are listed below:

- November 2004 (Round 2A, low-flow)
- March 2005 (Round 2A, low-flow)
- July 2005 (Round 2A, low-flow)
- January 2006 (Round 3A, high-flow)
- September 2006 (Round 3A, low-flow)
- November 2006 (Round 3A, stormwater-influenced)
- January 2007 (Round 3A, high-flow[1]).

A summary of the sampling events, including dates of collection, flow rates, and relative flow conditions, are presented in Table 5.3-1. Average discharge rates (recorded as cfs) for each event are based on measurements collected by the USGS at the stream flow station located upstream of the Morrison Bridge at RM 12.8 (Station 14211720). Flow measurements from the USGS gauge at this station are collected every 30 minutes and were used to calculate flow rates for each of the seven sampling

[1] The January 2007 high-flow event was cancelled after two days of sampling due to unexpected change in flow conditions. Sampling recommenced on February 21, 2007 once high-flow conditions (>50,000 cfs) were once again observed.

events.[2] It should be noted that discharge rates below 20,000 cfs measured at this station are considered to be unreliable by the USGS. Therefore, the average discharge rates calculated for the low-flow events should be considered estimates.

Surface water data from the Study Area (RM 1.9–11.8) and areas immediately upstream and downstream of the Study Area were generated during the Round 2A and 3A collection programs. Summary statistics for ICs for all sampling events are provided in Tables 5.3-2 through 5.3-7. In addition, summary statistics for all chemicals measured in surface water are presented in Tables D3.2-1 through D3.2-6.

5.3.1.1 Round 2A and 3A Sample Collection Conditions

Surface water samples were collected at 23 target locations from RM 2 to 11 in the LWR during three Round 2A sampling events in 2004 and 2005. Single-point samples were collected by peristaltic pump at all locations. Additional samples were collected by employing the high-volume XAD sampling method (description of XAD sampling method in Section 5.3.1.2 below) at seven of the 23 locations, including three cross-sectional river transects and four discrete locations. All high-volume samples were collected using an Infiltrex 300 water collection system which pumped water through an inline 0.5-micron glass fiber pre-filter and then through an XAD-2 resin column. Each filter and the resin column was extracted and analyzed separately to determine chemical concentrations in the particulate and dissolved phases of each sample, respectively. The Round 2A surface water study is described in Section 2.1.3.4 of the Round 2 Report (Integral et al. 2007). The Round 2A Surface Water SCSR (Integral 2006a) provides details regarding the sampling program, sample collection procedures, and laboratory analyses.

During the Round 3A sampling events, surface water was collected at 18 target locations from RM 2 to 16 in 2006 and 2007. A transect station located at the upper end of Multnomah Channel (RM 2.9) was added to the program to provide a better understanding of the flux of chemicals exiting the Study Area via Multnomah Channel; and a transect station at RM 16 was added to assist with the analysis of upstream sources and loading into the Study Area. Peristaltic and high-volume samples were collected from 18 stations, including 6 transects and 12 single-point locations. Table 5.3-8 summarizes sampling methods at each station for all Round 2A and 3A sampling events.

Peristaltic surface water samples were analyzed for conventional analytes, metals, and organic compounds (PCB Aroclors, organochlorine pesticides, and SVOCs). High-volume samples were analyzed by high-resolution gas chromatography/high-resolution mass spectrometry (HRGC/HRMS) for PCB congeners, PCDD/Fs, organochlorine pesticides, phthalate esters, and PAHs.

[2] The flow rate values presented here are daily mean stream flow measurements from the USGS National Water Information System, http://waterdata.usgs.gov/nwis. These values were taken from the USGS Web site on June 16, 2008, and are considered to be draft and subject to change by USGS.

The seven Round 2A and 3A surface water sampling events and their corresponding flow rates are presented against the backdrop of the average year (1972–2008) hydrograph measured at Morrison Bridge (RM 12.8) in Figure 5.3-1. Overall, the sampling events were well distributed over the average water year, capturing the range of flow conditions, including base flow, rising limb, peak flow, and falling limb conditions. Additionally, the November 2006 sampling captured a stormwater-influenced event during a low-flow period. Figures 5.3-2 through 5.3-5 present the actual annual hydrograph measured at Morrison Bridge (RM 12.8) and hyetograph during each year of sampling (2004–2007), including daily average and historical average (1978–2008) discharge rates and daily precipitation levels. Several rainfall events occurred during the November 2004 sampling event, and one day of measurable rainfall occurred during each of the March and July 2005 sampling events.

The seasonal cycle of water discharge in the Willamette River is also apparent in Figure 5.3-1. Annual low water levels occur during the summertime regional dry season, and flows increase during the wetter winter months (November to March). Furthermore, a distinct and persistent period of relatively high water levels occurs from late May through June when Willamette River flow into the Columbia is slowed by high-water stage/flow in the Columbia River during the spring freshet in the much larger Columbia River Basin. As described in Section 3.3.2, water levels and currents in the LWR can be influenced by the Columbia River in several ways. The most apparent influence occurs during spring and summer when high flows from the Columbia River act as a hydraulic dam to Willamette River, resulting in rises in the Willamette River stage. The Columbia River flow drops as the summer progresses and this effect is diminished. During the winter, high seasonal flows on the Willamette River pass through to the Columbia River, which may have diminished flows due to retention at dams.

Hydrodynamic model estimates of flow dynamics at the lower end of the Study Area show that the relative stages of the Columbia and Willamette rivers determines the fraction of the Willamette River flow which flows down Multnomah Channel (WEST 2006a). Figure 5.6-6 presents the average annual hydrograph, based on modeled discharge rates for 2003 through 2007, for RM 4, RM 2, and Multnomah Channel. The Morrison Bridge 25-yr average hydrograph is also shown for comparison. Figure 5.6-7 presents the modeled daily average flows for 2003 through 2007, and highlights the time periods when surface water samples were collected at RM 4, RM 2, and Multnomah Channel. A few key observations are apparent in these figures. First, for a significant portion of each year, generally May through September, the relatively higher Columbia River stage drives a reversal in flow direction at RM 2. During these periods, the Multnomah Channel flow increases and includes the entire Willamette River flow plus some flows from the Columbia River. Second, Figure 5.3-7 shows that surface water sampling events at the RM 2 and Multnomah Channel sample transects did not occur during these flow reversal periods; rather, sampling was conducted when the Willamette River flow was in the downstream direction, and flows split between Multnomah Channel and the main stem. This indicates that surface water samples

collected at RM 2 and Multnomah Channel are representative of Willamette River water and are not strongly influenced by mixing with Columbia River water.

Tidal action also compounds the hydrology and interplay of the two rivers, and affects the Willamette River upstream as far as Portland Harbor and beyond. The high (i.e., flood) tide can influence Willamette River levels by up to 3 ft in Portland Harbor when the river is at a low stage. These tidal fluctuations can result in short-term flow reversals (i.e., upstream flow) in Portland Harbor during times of low river stage combined with large flood tides. Tidal changes were observed at multiple stations during the surface water sampling events. At this time, there is not adequate high-resolution discharge information to determine the potential influence of tidal fluctuations and water mixing on surface water sampling results; however, the overall tidal impact is not expected to be significant.

5.3.1.2 Sampling Methods

Sampling stations included both river-wide transects and single-point sampling stations at specific locations. Transect samples involved vertically integrated (VI) sample composites collected from multiple lateral substations across the width of the river channel. Transect sampling is designed to estimate integrated water concentration and flux through a cross-section of the river or fraction of a cross-section at a point in time. Single-point samples are stationary samples or sample pairs at a constant depth.

Round 2A surface water samples were collected at three transect stations (RM 4, 6.3, and 11) and 20 single-point stations. Round 2A transect samples were collected as equal discharge increment (EDI)[3] composite samples across the channel. Round 2A single-point samples were collected as either NB or VI samples. Single-point NB samples were collected between 1 and 3 ft off the river bottom in water less than 20 feet deep. Single-point VI samples were vertically integrated from 1 ft below the water surface to within 1 to 3 ft of the river bottom at BHHRA stations.

Round 3A surface water samples were collected at six transect stations (RM 2, 2.9 [Multnomah Channel], 4, 6.3, 11, and 16) and 12 single-point stations. Round 3A transect samples were collected as either a single EDI composite sample, a pair (not composited) of near-bottom/near-surface (NB/NS)[4] samples horizontally integrated across the channel, or three VI composite samples at three points across the channel (located at east, middle, and west channel; VI-EMW). Round 3A single-point samples were collected as a pair (not composited) of NB/NS samples at a stationary point in the channel. The Round 3A single-point sampling stations were selected to provide water

[3] At each Round 2A transect station, samples were spatially integrated across the entire width and depth of the channel based on a flow-weighted method (USGS 2000). At each transect, the river was divided into equal flow subareas (i.e., EDIs) using existing bathymetry and river flow data. VI samples were collected from 1 ft below the water surface to within 1–3 ft of the river bottom in each subarea; these samples were combined to produce integrated river cross-section composite samples.

[4] Surface water was collected from two points in the water column. The NB sample was collected at a depth of 1 ft off the river bottom. The NS sample was collected 3 ft below the surface.

chemistry data in areas in higher flow conditions than were sampled in Round 2 to support source identification and the FS. Selected Round 3A single-point stations were relocated into deeper water to accommodate the NB/NS sampling.

XAD water samples were passed through a 0.5-µm filter and an XAD-2 resin column. Chemical mass captured on the filter provides the particulate fraction concentration, while chemical mass on the resin column provides the "dissolved fraction" concentration. Note that this approach to definition of the dissolved and particulate fractions of the whole sample constitutes an operational definition of these fractions. In reality, it is likely that colloidal-sized particles less than 0.5 µm in diameter are present in the "dissolved" fraction. This is a critical consideration in review of the data set.

A summary of the sampling methods employed at each station for all sampling events is presented in Table 5.3-8. Sampling techniques at each station included both standard (peristaltic) and high-volume (XAD) methods as described in detail in the surface water sampling FSPs (Integral 2004c, 2006h).

Sample locations and samples are labeled on the figures and tables according to the following scheme:

- High-volume XAD samples were collected as two analytical samples. The surface water particulates associated with the XAD filter are labeled in tables and figures as XAD-F or XAD filter. The sample from the XAD column represents the dissolved phase and is labeled as XAD-C or XAD column.
- In Round 3A, near-bottom and near-surface samples were collected and are labeled as NB and NS in the tables and figures.
- Also in Round 3A, three VI composite samples were collected at three points across the channel and these stations and samples are labeled as -E, -M, or -W for the samples collected on the east, mid-channel, and west sides of the river.

5.3.1.3 Data Processing and Calculations

For all analyte group total calculations in this report (total PCB congener, total PCDD/Fs, total DDx, and total PAHs), the RI method for summing parameters was applied.[5] All particulate and dissolved total PCB congener and total PCDD/F concentrations were above detection limits. One total DDx particulate concentration was non-detect; in this case, a value of one-half the detection limit was used in calculations and plots.

To support the data analysis presented in this section, several terms were calculated from the surface water data set: the fraction of organic carbon (f_{oc}), POC, average

[5] For all totals, zero is always assigned for individual non-detect values included in the group total. If any of the values included in a total are estimated (J-qualified), then the total value is estimated (J-qualified). If all analytes in a total are non-detects, then the highest detection limit is used for the total and the total is U-qualified. For additional information, see Section 2.1.4.

particle IC concentration (C_s), and apparent organic carbon partitioning coefficient (K_{oc}). The f_{oc} describes the percent of mass of the suspended solids that is made up of organic material, which is truly a TSS-normalized version of the POC value. The f_{oc} was calculated from the peristaltic TOC, dissolved organic carbon (DOC), and TSS values, using the following equation:

$$f_{oc} = \frac{TOC - DOC}{TSS} = \frac{POC}{TSS}$$

For the few cases where the sample DOC was greater than TOC, the POC and f_{oc} values were set equal to zero.

The POC was calculated in this study to represent how much adsorbed (to suspended particulate material) organic carbon was present in the surface water in each sample. This value was simply estimated by subtracting the peristaltic sample DOC results from the corresponding peristaltic sample TOC results.

$$POC = TOC - DOC$$

5.3.2 Indicator Chemicals in Surface Water

The IC list for surface water is presented in Table 5.0-2. The selection of ICs was guided by the considerations provided in Section 5.0, in coordination with EPA. A total of 22 individual analytes and calculated chemical sums were identified as ICs for surface water. Low frequencies of detection in surface water samples resulted in fewer ICs than for sediment. Indicator chemicals for surface water are organized as follows:

- PCBs
  - Total PCBs*
  - PCB TEQ (ND=0)
- PCDD/Fs
  - Total PCDD/Fs*
  - TCDD TEQ (ND=0)*
- DDx
  - Total DDx (total of 2,4' and 4,4'-DDD, -DDE, and -DDT)*
  - Total of 2,4'- and 4,4'-DDT
  - Total of 2,4'- and 4,4'-DDE
  - Total of 2,4'- and 4,4'-DDD

- Pesticides (non-DDx)
  - Total chlordanes*
  - gamma-Hexachlorocyclohexane
  - Aldrin*
  - Dieldrin*
- PAHs
  - Total PAHs*
  - Total LPAHs
  - Total HPAHs
  - Total cPAHs BaPEq values
  - Benzo(a)pyrene
- SVOCs
  - Hexachlorobenzene
- Metals
  - Arsenic*
  - Copper*
  - Lead
  - Zinc.*

This section focuses on the distribution of a subset of 11 ICs, which are indicated with an asterisk (*) in the above list, in surface water in the Study Area, as well as upstream (i.e., RM 16) and at Multnomah Channel (approximately RM 2.9). The 11 ICs in surface water were selected from the chemicals for presentation and discussion in the site-wide CSM (Section 10). Four of these chemicals—total PCBs, total PCDD/Fs, total DDx, and total PAHs—were selected for in depth discussion. The discussion focuses primarily on a description of the data set for each analyte, including concentration ranges for the various sampling event types (low-flow, high-flow, and stormwater-influenced) and frequency of detection. For these four bounding ICs, the narrative also includes the relationship of chemical concentration to location, flow rate, association with suspended solids, and associated organic carbon.

The discussion of the other six ICs in the subset is abbreviated and includes a description of the data set, concentration ranges, and frequency of detection, with references to figures and tables to provide a complete picture of the distribution of those chemicals. Figures for the remaining 11 chemicals are included in Appendix D3.

The nature and composition of the four bounding ICs are discussed to provide background on their environmental chemistry and to provide a site-wide perspective on their distribution. Chemical distributions across abiotic and biotic media in relation to specific potential sources are discussed in more detail in Section 10.

5.3.3 Description of Surface Water Presentation Tools

The surface water chemistry distributions and supporting information are depicted in several graphical formats: hydrographs and hyetographs of sampling events, discharge rates, and precipitation events (Figures 5.3-1 to 5.3-7), and histograms of sample concentrations for all sampling events for the ICs, along with line plots, stacked bar charts, and scatter plots for the bounding ICs (Figures 5.3-8 through 5.3-85). The stacked bar charts and scatter plots present the data by river mile. Station W027 (RM 2.9) was located in Multnomah Channel, and Stations W018 (RM 8.3), W020 (RM 9.1), W021 (RM 8.7), and W035 (RM 8.5) were located in Swan Island Lagoon. Multnomah Channel and Swan Island Lagoon are indicated by "MC" and "SIL", respectively, on the histograms.

Hydrographs and Hyetographs: The hydrographs show the average discharge rates during the Round 2A and 3A surface water sampling events and the hyetographs show precipitation events and amounts to provide perspective on the timing of the Round 2A and 3A sampling events and the specific conditions prior to, during, and after each event.

Histograms: The histograms provide a graphical summary of the distribution of chemicals for all the surface water sampling events. For the XAD samples (units in pg/L), the individual data points are composed of shaded stacked bars to distinguish between the XAD column and XAD filter samples. The bars are color-coded to distinguish between the single-point samples (blue) and the transect samples (orange). The non-detected samples are displayed with a hatch pattern. The same scheme is used for the peristaltic samples (units in µg/L), with shaded stacked bars for total and dissolved fractions and blue and orange colors for the single-point and transect samples. In Round 2, stations were analyzed for PAHs in both the XAD and peristaltic sample, the histograms for the peristaltic samples only display samples where PAHs were not analyzed in the XAD sample.

Line Plots: The line plots present the concentrations of the bounding ICs for each flow type (high-flow, low-flow, stormwater-influenced) at the transect stations for all surface water sampling events. The squares, diamonds, and triangles represent the data points. Prior to generating the plots, data were averaged so that only one value per transect per sampling event was used. NB and NS total (dissolved plus particulate) concentrations were averaged for samples from stations W027 (Multnomah Channel), W005 (RM 4), W011 (RM 6.3), and W024 (RM 16) and east, west, and mid-channel total concentrations were averaged for stations W025 (RM 2) and W023 (RM 11), where applicable. The data for the 2007 high-flow event is displayed in two colors because

this event was completed in two phases with a stand-down period between high-flow conditions.

Scatter Plots: Scatter-plot presentations of the surface water data show concentrations of the four bounding ICs by river mile, flow, TSS, and organic carbon, and particulate versus dissolved concentrations are displayed for detailed evaluation of the results. The symbols on the scatter plots distinguish between flow types (high-flow, low-flow, stormwater-influenced) and single-point and transect samples.

Stacked Bar Charts: Bar charts are designed to reveal distinctive patterns in the relative abundance of bounding IC components. These graphs provide a line showing concentrations of the IC (i.e., totals) on a logarithmic scale, but do not display concentrations of the analyte components (e.g., homologs, isomers). The analyte components are shown as a percent of the total concentration. The samples are sorted by flow type and also by river mile within each flow type.

5.3.4 Suspended Solids

Suspended sediment loads and dynamics are potentially an important component of the LWR physical system, and TSS data have been collected as part of the surface water data collection effort to understand distributions and patterns of chemical concentrations. Peristaltic samples were collected and analyzed for TSS (reported in mg/L) during Round 2A and 3A. TSS concentrations in surface water are presented in Figure 5.3-8.

TSS measured in single-point samples collected during low-flow conditions ranged from 3 J to 15 J mg/L at Station W013 (RM 6.7) in March 2005. Concentrations in transect samples during low flow ranged from undetected (at a detection limit of 1 U mg/L) to 25 J mg/L at Station W011 (RM 6.3) in July 2005.

TSS measured in single-point samples collected during high-flow conditions ranged from 13 to 60 mg/L at Station W031 (RM 6.1) in January 2007. Transect concentrations during high flow ranged from 9 to 62 mg/L at Station W023 (RM 11) in January 2006.

TSS concentrations in single-point samples collected during the November 2006 stormwater-influenced event ranged from 2 to 7 mg/L at Station W026 (RM 2.1). Concentrations in transect samples during the stormwater-influenced event ranged from undetected (at a detection limit of 1 UJ mg/L) to 6 mg/L at Station W005 (RM 4).

The City of Portland also collected TSS data from the Willamette River and concurrent precipitation levels between February 5, 1992 and March 15, 2006 (Sanders 2006). The surface water samples were collected at a 10-ft depth from the east, middle, and west locations along transects at RM 1.1, 6.8, 8.8, 12.7, 17.9, and 20, and were composited by transect. The range of TSS concentrations (0.4 to 243 mg/L) measured in the City of Portland composite samples was wider than that measured by LWG or the City of

Portland during the time period of the Round 2A and 3A sample collection events (LWG TSS data ranged from 1 U to 62 mg/L). The City's TSS data corresponding to the timing of the Round 2A events and the Round 3A January 2006 high-flow event (extent of TSS data collected) are presented in Figure 5.3-9.

The TSS concentrations as a function of flow rate for all samples in the surface water data set are presented in Figure 5.3-10. A general trend of increasing TSS concentration with increasing flow rate is more readily apparent in Figure 5.3-11, which presents TSS concentration as a function of river mile. TSS concentrations varied over a large concentration range (single-point and transect samples) upstream from RM 16 to 4. By RM 2, there is a decrease in the TSS concentration range.

Figures 5.3-12 and 5.3-13 present the f_{oc} on the TSS in each surface water sample as a function of flow rate and river mile, respectively. The f_{oc} values on the TSS range from 0 to 20 percent in the low-flow samples and 0 to 50 percent in the stormwater-influenced samples. Conversely, the f_{oc} on the TSS in high-flow samples is distinctly lower, ranging from 0 to less than 4 percent, suggesting the introduction of suspended particles with low organic carbon content during high-flow events. Generally low f_{oc} values may be a function of larger particles (lower surface area per volume and therefore fewer organic carbon binding sites) introduced during high-flow conditions.

Figure 5.3-14 presents a scatter plot of f_{oc} and TSS that summarizes the overall trend of solids concentrations and f_{oc} in the data set. High-flow samples tend to exhibit lower f_{oc} associated with TSS. The shape of the curve is largely driven by the fact that f_{oc} is a function of TSS. The suspended solids associated with the stormwater-influenced samples appear to have the highest levels of organic carbon content. The TSS concentrations and corresponding f_{oc} values vary somewhat between flow types, and the low-flow samples appear to fall between the high-flow and stormwater-influenced samples based on the level of organic carbon. There is the possibility that there may be local nearshore effects at the point of discharge that were not captured in the surface water sampling data set.

5.3.5 Total PCBs in Surface Water

High-volume surface water samples were analyzed for PCB congeners (reported in units of pg/L) by HRGC/HRMS, and peristaltic samples were analyzed for PCB Aroclors (reported in units of μg/L) by routine methodology (i.e., EPA method 8081). There are 1,000,000 pg in 1 μg. PCB Aroclors were not detected in the majority of the peristaltic samples (approximately 90 percent undetected) at an average detection limit of 0.00125 μg/L.

Peristaltic samples (single-point samples) were collected and analyzed for PCB Aroclors during Round 2A low-flow conditions only (i.e., November 2004, March 2005, and July 2005). Total Aroclor concentrations ranged from below detection limits (0.0025–0.0027 U μg/L) to 0.015 μg/L. Detections were limited to six samples

with concentrations ranging from 0.0047 J µg/L to 0.015 µg/L. Because of the low frequency of detection, these data are not summarized in the figures. The discussion of the extent of PCBs in the Study Area within this section is limited to PCB congeners (XAD samples) because of the high frequency of non-detects for the PCB Aroclor analysis.

Dissolved and particulate PCB congener concentrations in surface water XAD columns and filters are depicted in Figures 5.3-15 and 5.3-16. The figures show the data arranged by sampling conditions (high-flow, low-flow, and stormwater-influenced) and river mile. Figure 5.3-16 is a scaled version of Figure 5.3-15 showing details of lower concentrations. Both figures present the particulate (0.5-µm filter) and dissolved (XAD column) fractions of the total concentration as stacked bar graphs.

Total PCB congener concentrations (the sum of the dissolved and particulate concentrations) measured in single-point samples during low-flow conditions ranged from 375 J pg/L to 12,000 J pg/L (Station W013 at RM 6.7 collected in March 2005). Concentrations measured in transect samples during low-flow ranged from 159 J pg/L to 950 J pg/L (Station W005 at RM 4 in September 2006).

Total PCB congener concentrations measured in the single-point samples during high-flow conditions ranged from 111 J pg/L to 749 J pg/L at Station W035 (RM 8.5) in January 2007. Concentrations measured in transect samples during high-flow ranged from 41.9 J pg/L to 391 J pg/L at Station W005 (RM 4) in January 2007.

A single stormwater-influenced flow event was observed and sampled in November 2006. Total PCB congener concentrations measured in single-point samples during this stormwater-influenced event ranged from 112 J pg/L to 2,590 J pg/L at Station W030 (RM 5.5). Concentrations measured in transect samples ranged from 121 J pg/L to 1,290 J pg/L at Station W025E (RM 2).

The following subsections describe observations of total PCB congener concentrations (PCBs) in the complete Round 2A and 3A data set. The spatial distribution of dissolved and particulate PCB concentrations and relationships to flow rate, TSS, and f_{oc} are described. The composition of this multi-component IC is also described. Total PCB congeners were detected in all XAD filter and column samples collected during Round 2A and 3A sampling events.

5.3.5.1 PCB Spatial Distribution

The distribution of total PCB concentrations by river mile throughout the Study Area (and upstream to RM 16 and downstream to Multnomah Channel) is presented in Figures 5.3-17 and 5.3-18. (Note the symbols and colors indicate the sample type—point vs. transect—and the general flow conditions of the sampling event—low-flow, stormwater-influenced, or high-flow.) The majority of the highest total PCB concentrations (six out of seven >2,000 pg/L) were associated with single-point samples collected at RM 6.7 (Station W013) within Willamette Cove during low-flow

conditions. The fourth highest single-point concentration was collected at RM 5.5 (W030 during the stormwater-influenced event). These data suggest that local PCB sources may exist in this region of the Study Area. The range of total PCB concentrations within the complete data set across the Study Area was fairly consistent between RM 11 and 2, excluding the highest single-point concentrations, and elevated concentrations near the east side of the river at RM 6.7.

Upstream of the Study Area (Figure 5.3-19), the total PCB concentrations at RM 11 were consistently higher than at RM 16, suggesting the existence of a source or sources between these two locations. Two of the three highest total PCB concentrations at RM 11 were from the sampling stations on the east side of the channel (Figure 5.3-16), indicating a possible source in this area. The second highest result at RM 11 was from a Round 2A vertically- and horizontally-integrated transect, and the field crew noted stormwater runoff entering the east side of the channel during collection of this sample (Jones 2007, pers. comm.). Within the Study Area, total PCB concentrations continued to increase between RM 11 and RM 4 in six of seven transect-based sampling events (the sole exception is the November 2004 low-flow sampling event). Total PCB concentrations at both RM 2 and in Multnomah Channel transects generally decreased from those at RM 4 but remained higher than those at RM 16. An exception to this was the RM 2 total PCB concentration from the November 2006 stormwater-influenced event, which was higher than other transect concentrations measured in that event.

5.3.5.2 PCB Relationships to Flow Rate

Total PCB concentrations as a function of flow rate are presented in Figures 5.3-20 and 5.3-21. Twelve concentrations above 1,000 pg/L were associated with samples collected during low-flow events. PCB concentrations were consistently lower in high-flow samples as compared to the low-flow and stormwater-influenced samples, suggesting that inflow concentrations at high flow rates overwhelm local effects and control PCB concentrations until flow rates subside. No concentrations above 1,000 pg/L were observed at flows of 60,000 cfs and concentrations were below 210 pg/L for the 160,000 cfs event.

5.3.5.3 Distribution between PCB Dissolved and Particulate Fractions

The following subsections describe the observed trending of dissolved and particulate fractions by river mile, event type, sample type, TSS, and f_{oc} of the TSS. This analysis was specific to total PCBs and, therefore, does not extend to individual congener analysis. However, Section 5.3.5.4 provides a discussion of PCB composition (i.e., homologs) and observed patterns, which may assist with the identification of observed PCBs in the Study Area.

5.3.5.3.1 PCB Particulate and Dissolved Concentrations

Figures 5.3-22 and 5.3-33 present the dissolved vs. particulate concentrations of total PCBs. Samples with concentrations less than 500 pg/L particulate and less than 500 pg/L dissolved showed a fairly consistent trend in particulate/dissolved ratios.

Low-flow point samples collected at the upper end of the dissolved concentration range (>500 pg/L) had a higher particulate component. Stormwater-influenced point samples collected at the upper end of the dissolved concentration range had the lowest particulate component.

The PCB concentrations of the particulate (filter) and dissolved (column) fractions of each sample are shown on Figures 5.3-15 and 5.3-16. The transect sample collected at RM 11 during the low-flow event in November 2004, exhibited a high particulate to dissolved ratio. As noted previously, during collection of this sample, the field crews observed runoff from a nearby storm drain, which may have contributed to this result.

5.3.5.3.2 PCB Associations with Suspended Solids

The associations of PCBs with suspended solids and apparent partitioning were evaluated from the surface water data set. Total PCB concentrations as a function of TSS are presented in Figures 5.3-24 and 5.3-25. High-flow samples (single-point and transect) exhibited the widest range and highest concentrations of TSS but the lowest PCB concentrations. Conversely, the remaining samples exhibited a wide range in concentration over a small range in TSS.

Particulate total PCB concentrations and particulate organic carbon (POC; TOC–DOC) concentrations are compared in Figures 5.3-26 and 5.3-27. The high-flow samples (single-point and transect) exhibited relatively low PCB concentrations for the corresponding POC associated with the solids. The low POC values are consistent with the lower f_{oc} associated with TSS observed in high-flow samples, as shown on Figure 5.3-14. As discussed in Section 5.3.5.2, this observation may suggest the introduction of suspended particles with low organic carbon content during high-flow events. Further, the solids that become suspended in the water column during high-flow events may have a different character (low f_{oc} and low PCB concentrations) than those introduced during low-flow or stormwater-influenced events. The single-point samples characterized by high concentrations of PCBs (RM 5.5, 6.9, 8.3, and 11) did not have corresponding high TSS concentrations from the same events (Figures 5.3-24 and 5.3-25). However, these samples did exhibit high particulate-phase PCB concentrations as a function of POC (Figures 5.3-26 and 5.3-27), reflecting a higher f_{oc}.

5.3.5.4 PCB Patterns and Trends

The patterns and trends of PCB homologs in surface water XAD column and filter samples are discussed below. PCB homologs are described in Section 5.1.5. Stacked bar graphs depicting the PCB homolog distributions in the surface water dissolved (XAD column) and particulate (XAD filter) samples by flow condition and river mile are presented in Figures 5.3-28 and 5.3-29. The discussion of patterns and trends in the PCB homologs is qualitative based on visual examinations of the stacked bar graphs.

The PCB composition of the particulate fraction generally exhibited a more highly chlorinated pattern than the PCBs in the dissolved phase. Several November 2006 stormwater-influenced samples, which exhibited greater contributions from monoCBs

and/or diCBs than other particulate samples and their dissolved counterparts, were exceptions to this pattern. This PCB distribution reflects the greater solubility and lower partitioning coefficients of the less-chlorinated congeners, as described in Section 6.

The PCB composition was generally similar in the dissolved fractions of the four Study Area transect locations and the downstream transect (Station W027, Multnomah Channel) during all sampling events. The dissolved PCBs at the transect locations generally consisted of a fairly equal mixture of diCBs, triCBs, tetraCBs, and pentaCBs, with contributions from hexaCBs. The sample from transect W005 (RM 4) collected during the January 2006 high-flow event had a high percentage of tetraCBs and no diCBs. However, this sample had a relatively low total PCB congener concentration (73 pg/L), and therefore, this homolog distribution may be reflective of this low concentration.

Generally, the PCB compositions in the dissolved fraction of the upstream transect (W024, RM 16) exhibited a less chlorinated pattern than the PCBs in the Study Area transect samples. The samples from the low-flow events collected at Station W024 had high proportions of diCBs. Conversely, the sample from this station collected during the January 2007 high-flow event was characterized by a high proportion of monoCBs. The PCB homolog patterns in stormwater-influenced samples collected from W024 were similar to stormwater-influenced samples from the Study Area.

The more highly chlorinated PCB composition of the particulate fractions of the transect locations is reflected in the predominance of tetraCBs, pentaCBs, hexaCBs, and heptaCBs, with spatial variations in the proportions of each homolog present. The PCBs at transects W023 (RM 11) in November 2004 (low-flow), from W023E in September 2006, and the NB sample from W005 (RM 4) in January 2007 (high-flow) contained higher proportions of hexaCBs and heptaCBs than samples collected during other events. The sample from transect W025E (RM 2) collected during the November 2006 stormwater-influenced event contained a higher proportion of triCBs than samples from other events. The W023 (RM 11) sample collected during the November 2004 low-flow event may have been influenced by stormwater discharges from a nearby outfall (OF-45) due to a relatively heavy rainfall event (0.37 inches) on the day the sample was collected (Integral 2006a); however, the September 2006 low-flow sample from the east side of this transect had a higher total PCB concentration and a similar PCB composition to the November 2004 sample. No stormwater discharges were noted during the collection of the September 2006 sample. The interpretation of these surface water samples may be confounded by maintenance dredging conducted at Glacier's docking facility located at RM 11.3. Glacier apparently conducted dredging following approval in June 2004 by the USACE. Attempts by the LWG to obtain post-dredging information have not been successful.

The PCB composition of particulate fractions of the upstream transect Station W024 (RM 16) generally exhibited a less chlorinated pattern than the PCBs in the Study Area

transect samples upstream of RM 2 for the low- and high-flow sampling events. The stormwater-influenced (September 2006) NB sample at this station had a similar PCB composition to the Study Area transect profiles, while the NS transect from this event exhibited the same less-chlorinated pattern observed at this station during the other sampling events.

The particulate fractions of the Multnomah Channel transect, Station W027, exhibited PCB profiles similar to that of the Study Area transect stations during the high- and low-flow sampling events. The PCB profile at Station W027 during the September 2006 stormwater-influenced event was similar to the profiles of the west and mid-channel samples from transect W025 (RM 2) collected during the same event, exhibiting a more highly chlorinated PCB profile. The east sample from transect W025 exhibited a less chlorinated PCB profile than other transect stations during the stormwater-influenced event. PCB patterns in several other samples from location W025 were also less chlorinated than other Study Area transect samples.

Several of the single-point particulate fraction samples from the November 2006 stormwater-influenced sampling contained unusually high proportions of the less chlorinated homolog groups in comparison to the other sampling events. At Station W037 (RM 9.6), the NB sample had a higher proportion of diCBs and the NS sample had higher proportions of monoCBs and diCBs. Higher proportions of monoCBs and diCBs were observed in the NS sample at Station W031 (RM 6.1) and in the NB sample at Station W028 (RM 3.6). The dissolved fractions of these samples had a similar homolog distribution to the other samples from these locations. MonoCBs accounted for 91 percent of PCBs in the dissolved fraction of the NS sample at Station W030 (RM 5.5). This sample had a high total PCB congener concentration (2,370 J pg/L). With the exception of Station W037 (RM 9.6), the corresponding NS or NB samples did not exhibit similar distributions. These findings would point to a stormwater-related source of monoCBs and diCBs near these locations.

The PCB homolog composition in samples from the NS and NB locations differed from that of the transect samples to varying degrees, likely reflecting local sediment conditions or upland sources. With the exceptions mentioned above, the NS and NB samples exhibited similar PCB distributions at both the NB/NS transect and single-point stations. The PCBs in Swan Island Lagoon, Stations W018 (RM 8.3) and W035 (RM 8.5), were slightly more chlorinated overall than PCBs in the transect samples and the sampling locations in the main river channel, with the exception of particulate fractions from Willamette Cove (Station W013, RM 6.7) and Station W029 (RM 4.4), both of which are discussed below. The predominant homolog groups in this area are pentaCBs, hexaCB, and heptaCBs.

At Station W015 (RM 6.9) on the west bank, the abundance of tetraCBs was generally slightly less than at Station W016, located less than half a mile upstream. However, in November 2004, the triCBs were unusually abundant at this station in both the particulate and dissolved fractions. The total PCB congener concentration in the

November 2004 sample was also unusually high (1,290 pg/L in the particulate fraction and 639 J pg/L in the dissolved fraction). The PCB concentration and homolog profiles imply contributions from an additional source or sources in November 2004. Because rainfall of 0.24 inches was recorded on this sampling date (Integral 2006a), a source or sources related to stormwater discharge near this sampling location is possible.

In Willamette Cove, Station W013 (RM 6.7) east bank, the total PCB concentration was high relative to other areas (maximum of 9,560 J pg/L for particulate PCBs and 2,420 J pg/L for dissolved PCBs). The PCB profile in the particulate fraction was more chlorinated than other areas, dominated by hexaCBs and heptaCBs. The dissolved PCB profile was similar to that of the transect samples.

5.3.6 Total PCDD/Fs in Surface Water

High-volume surface water samples were analyzed for PCDD/Fs by HRGC/HRMS. Concentrations of PCDD/Fs in surface water XAD column and filter samples are depicted in Figure 5.3-30.

Total PCDD/Fs (dissolved plus particulate concentrations) measured in single-point samples collected during low-flow conditions ranged from 30.7 pg/L to 162 pg/L at Station W013 (RM 6.7) collected in July 2005. Concentrations measured in transect samples collected during low-flow conditions ranged from 5.9 J pg/L to 51.6 J pg/L at Station W005 (RM 4) in September 2006.

Total PCDD/Fs measured in single-point samples collected during high-flow conditions ranged from 24.7 pg/L to 74.9 pg/L at Station W035 (RM 8.5) in January 2007. Concentrations measured in transect samples collected during high-flow conditions ranged from 5.3 J pg/L to 44.0 pg/L (Station W005 at RM 4 in January 2006).

Total PCDD/Fs measured during the stormwater-influenced event (November 2006) ranged from 36.0 pg/L to 55.2 J pg/L (Station W032 at RM 6.7) in single-point samples and 5.5 J pg/L to 118 pg/L (Station W023E) at RM 11 in transect samples.

The following subsections describe observations of total PCDD/Fs congener concentrations. The spatial distribution of dissolved and particulate concentrations and relationships to flow rate, TSS, and f_{oc}, as well as the composition of this multi-component IC are described. Total PCDD/Fs were detected in all XAD filter and column samples collected during Round 2A and 3A sampling events.

5.3.6.1 PCDD/F Spatial Distribution

The distribution of total PCDD/F concentrations (dissolved plus particulate concentrations) by river mile throughout the Study Area (and upstream to RM 16 and downstream to Multnomah Channel) is presented in Figure 5.3-31. The highest concentration (162 pg/L) was measured in the single-point sample collected at RM 6.7 (Station W013) during the July 2005 low-flow sampling event. The concentration

measured in the field replicate from this location (30.8 pg/L) collected the following day was much lower. The second highest PCDD/F concentration (118 pg/L) was measured in the transect sample from RM 11 on the east side of the river (Station W023E), collected during the stormwater-influenced event (November 2006). This value is more than twice the concentration of the other samples collected at RM 11, which were all less than 40 pg/L. This observation may indicate the presence of a localized PCDD/F source or sources within this area.

The next highest concentrations were measured at RM 6.9 (third highest concentration; Station W015) and RM 8.5 (fourth and fifth highest concentrations; Station W035). The distribution of PCDD/Fs throughout the Study Area and upstream to RM 16 did not vary greatly, with the exception of the five highest concentrations. The lowest concentrations were generally measured at RM 2 (Figures 5.3-30 and 5.3-31).

At the downstream end of the Study Area total PCDD/F concentrations in Multnomah Channel were generally higher than those at RM 16 while total PCDD/F concentrations at RM 2 were generally lower than those at RM 16 (Figure 5.3-32). From sampling event to sampling event, total PCDD/F concentrations within the Study Area were variable and did not display consistent trends from upstream to downstream.

5.3.6.2 PCDD/F Relationships to Flow Rate

Total PCDD/F concentrations as a function of flow rate are presented in Figure 5.3-33. Two of the three highest concentrations were measured in single-point samples during low-flow conditions. The second highest concentration was measured in a transect sample on the east side of the river at RM 11 during the stormwater-influenced event. However, excluding these high-concentration samples, there doesn't appear to be a trend towards high total PCDD/F values associated with low-flow conditions. At the downstream end of the Study Area, the low-flow sample concentration ranges decreased relative to ranges observed within the Study Area.

5.3.6.3 Distribution between PCDD/F Dissolved and Particulate Fractions

The following subsections describe the observed trending of dissolved and particulate fractions by river mile, event type, sample type, TSS, and f_{oc} of the TSS. This analysis was specific to total PCDD/Fs and therefore does not extend to individual dioxins and furans. However, Section 5.3.6.4 provides a discussion of PCDD/F composition and patterns, which may assist with the identification of observed concentrations in the Study Area.

5.3.6.3.1 PCDD/F Dissolved and Particulate Concentrations

The dissolved and particulate fractions of total PCDD/F concentrations are presented for each surface water sample by river mile on Figure 5.3-30. This figure clearly demonstrates that PCDD/Fs tend to partition to the particulate fraction in surface water within the Study Area. The extent of this tendency is presented in Figure 5.3-34, which

shows the dissolved vs. particulate concentrations of total PCDD/Fs. The two highest concentrations measured at RM 6.7 and 11 during low-flow and stormwater-influenced conditions, respectively, exhibit extremely high particulate to dissolved ratios (greater than an order of magnitude difference between the two phases). If these samples are excluded from the analysis, as presented in Figure 5.3-35, where the x-axis (particulate concentration) is zoomed, the tendency for partitioning into the solid phase is also apparent for low-flow and high-flow samples. However, the stormwater-influenced sample concentrations appear to be more evenly distributed within the data set.

5.3.6.3.2 PCDD/F Associations with Suspended Solids

The associations of total PCDD/Fs with suspended solids and apparent partitioning were evaluated from the surface water data set. Total concentrations as a function of TSS are presented in Figures 5.3-36 and 5.3-37. PCDD/F concentrations increased slightly with higher suspended solids for high-flow transect samples. However, concentrations appear to increase more rapidly with increased suspended solids for the high-flow single-point samples. The stormwater-influenced samples increased independently of suspended solids in surface water. The transect and single-point samples collected during this event were all characterized by TSS values less than 10 mg/L. The low-flow transect samples appear to have a non-linear distribution with varying TSS and PCDD/F concentrations and, therefore, do not exhibit a clear trend (Figures 5.3-36 and 5.3-37).

Particulate total PCDD/F concentrations and POC concentrations are compared in Figures 5.3-38 and 5.3-39. As with PCBs, the high-flow samples (single-point and transect) exhibited relatively low PCDD/F concentrations for the corresponding POC associated with the solids. Conversely, the stormwater-influenced samples tended to exhibit higher POC values in relation to total PCDD/F concentrations and were associated with lower TSS (less than 10 mg/L) values. This may indicate that solids that become suspended during stormwater-influenced events may have a unique character of high f_{oc} and varying loads of PCDD/Fs. Samples characterized by high concentrations of PCDD/Fs did not have corresponding high TSS concentrations compared to other samples from the same events (Figures 5.3-36 and 5.3-37). However, these samples did exhibit a high particulate-phase PCDD/F concentration as a function of POC.

5.3.6.4 PCDD/F Patterns and Trends

Stacked bar graphs depicting the PCDD/F homolog distributions in the surface water dissolved (XAD column) and particulate (XAD filter) samples by flow condition and river mile are presented in Figures 5.3-40 and 5.3-41. The discussion of patterns and trends in the PCDD/F homologs is qualitative based on visual examinations of the stacked bar graphs.

Overall, the PCDD/F homolog profiles were dominated by OCDD and HpCDDs in both the dissolved and particulate fractions. At most transect stations and in most sampling events, OCDD constituted more than half of the PCDD/Fs in the particulate fraction,

and from 30 to 95 percent of the PCDD/Fs in the dissolved fraction. HpCDDs accounted for another 15 to 30 percent of the total in both the dissolved and particulate fractions. As would be expected, the dissolved fraction generally contained a greater abundance of the less chlorinated homolog groups than the particulate fraction. The homolog pattern for the particulate fraction PCDD/Fs varied little from transect to transect and from upstream to downstream of the Study Area.

In the dissolved fraction of the transect samples, only a few samples differed from the trend of OCDD and HpCDD dominance. The NS sample from the eastern bank at transect W024 (RM 16) and the eastern bank sample from transect W025 (RM 2) from the January 2007 sampling event, and the November 2006 sample from the west bank at transect W025 exhibited high abundance of TCDDs. Two samples from the November 2006 sampling event had very low (<0.01 pg/L) total PCDD/F concentrations, and only TCDDs were detected in these samples. With these exceptions, only minor differences between the transects were observed; the low-flow sampling events exhibited higher proportions of the less chlorinated homolog groups in the dissolved fraction, and the upriver stations exhibited a less chlorinated profile than those in the Study Area.

The NS and NB transects had very similar particulate PCDD/F homolog profiles during all sampling events, with similar dissolved profiles during low-flow events. Homolog patterns in the NS samples were different than their corresponding NB samples at Stations W011 (RM 6.3) and W005 (RM 4) in the November 2006 stormwater-influenced sampling event and at Station W024 (RM 16) in the January 2007 high-flow sampling event. The NS and NB single-point samples also generally exhibited similar particulate and dissolved PCDD/F homolog profiles during all events.

The single-point samples from Stations W035 (RM 8.5) and W033 (RM 7) exhibited similar PCDD/F homolog profiles to the transect stations in both the dissolved and particulate fractions under high-flow and stormwater-influenced conditions. These stations were not sampled under low-flow conditions.

However, at Station W015, on the western riverbank at RM 6.9, furans were somewhat more abundant than at other locations during all sampling events, in both the dissolved and particulate fractions. The pattern of the dioxins was similar to that of the transect locations. This area may be influenced by a different PCDD/F source compared to the river as a whole.

In Willamette Cove, Stations W013 and W032 (both at RM 6.7), the profile for PCDD/Fs in the dissolved and particulate fractions generally resembled the profiles at the transect locations during each sampling event, but the particulate PCDD/F concentrations found at this location were consistently higher than at nearby transect Station W011 (RM 6.3). The PCDD/F patterns in field replicate samples LW2-W3013-2 F (particulate phase, July 2005) and LW2-W2013-2 C (dissolved phase, March 2005) included a distinctly larger fraction of dioxins and a smaller furan fraction than the respective "parent" samples and were not similar to transect Station W011.

These replicate samples were collected sequentially, a day apart, and may reflect temporal differences in the PCDD/Fs in Willamette Cove.

5.3.7 Total DDx in Surface Water

High-volume samples were analyzed for total DDx by HRGC/HRMS. Concentrations of total DDx in surface water XAD column and filter samples are depicted in Figures 5.3-42 and 5.3-43. Peristaltic total DDx data are presented in Figure 5.3-44.

Total DDx was detected in virtually all of the XAD samples (99 percent of XAD filters and 100 percent of XAD columns) collected during Round 2A and 3A sampling events. In contrast, total DDx was detected in only 34 percent of the peristaltic samples, due to elevated detection limits based on smaller sample volumes than those collected for XAD samples.

Total DDx measured in single-point XAD samples collected during low-flow conditions ranged from 49.2 J pg/L to 9,760 pg/L (Station W016 at RM 7.2 in July 2005). Concentrations measured in transect samples collected during low-flow ranged from 42.8 J pg/L to 546 J pg/L (Station W005 at RM 4 in September 2006).

Total DDx measured in single-point XAD samples collected during high-flow conditions ranged from 266 J pg/L to 857 J pg/L (Station W031 at RM 6.1) in January 2007. Concentrations measured in transect samples collected during high-flow ranged from 162 J pg/L to 618 J pg/L (Station W023E) at RM 11 also in January 2007.

Total DDx measured in single-point XAD samples collected during the stormwater-influenced event (November 2006) ranged from 76.7 J pg/L to 675 J pg/L at Station W033 (RM 7). Concentrations measured in transect samples ranged from 33.2 J pg/L to 201 J pg/L at Station W011 (RM 6.3).

Total DDx was detected in only four peristaltic samples collected from single-point stations during low-flow conditions. Concentrations ranged from 0.000693 J µg/L to 0.0187 NJ µg/L at Station W001 (RM 2 in March 2005).

Total DDx was detected in 12 of 14 single-point peristaltic samples collected during high-flow conditions. Concentrations ranged from 0.00017 J µg/L to 0.00205 NJ µg/L at Station W037 at RM 9.6 in January 2007.

Concentrations of total DDx measured in peristaltic samples during the stormwater-influenced event ranged from 0.0015 µg/L to 0.0047 NJ µg/L at Station W037 (RM 9.6).

The following subsections present observations of total DDx concentrations in the combined Round 2A and Round 3A surface water data set.

5.3.7.1 DDx Spatial Distribution

The distribution of total DDx concentrations (dissolved plus particulate concentrations) by river mile throughout the Study Area (and upstream to RM 16 and downstream to Multnomah Channel) is presented in Figures 5.3-45 and 5.3-46 (scatter plots), 5.3-47 (line plot), as well as 5.3-42 and 5.3-43 (histograms). The highest concentrations were measured in single-point samples collected during low-flow conditions near the middle of the Study Area at RM 6.9 (Station W015; 3,590 to 7,660 pg/L) and RM 7.2 (Station W016; 1,240 J to 9,760 pg/L). Excluding these higher concentrations, the overall range of observed concentrations across the Study Area and upstream to RM 16 was fairly consistent. Further, concentrations measured in the high-flow samples were generally higher than those associated with the low-flow and stormwater-influenced samples. This was especially evident at RM 11 and 16, where the high-flow concentrations were much greater than the low-flow and stormwater-influenced samples. These high-flow sample concentrations also covered a fairly consistent range across the Study Area, including RM 2.9 (Multnomah Channel) and RM 16 (Figures 5.3-42 and 5.3-43). This observation may suggest that DDx concentrations in the majority of the Study Area during high-flow are primarily controlled by upstream loading (see Section 6.1.1). Finally, the stormwater and low-flow sample concentrations covered a low range through RM 16 and 11, and increased around RM 7.5, suggesting a potential source or sources in this portion of the Study Area.

Total DDx concentrations increased from upstream (RM 16 and 11) to downstream (RM 4) in six of seven transect sampling events (Figure 5.3-47); the sole exception was the February 2007 high-flow event, during which concentrations dropped slightly from RM 11 to RM 4. Further downstream at RM 2.9 (Multnomah Channel) and RM 2, transect total DDx concentrations were also generally higher than upstream transect concentrations in low-flow and stormwater-influenced conditions, but were generally lower than upstream concentrations in high-flow conditions.

5.3.7.2 DDx Relationships to Flow Rate

Total DDx concentrations as a function of flow rate are presented in Figures 5.3-48 and 5.3-49. With the exception of the highest total DDx concentrations that were measured at RM 6.9 and 7.2 (as discussed above in Section 5.3.7.1), the range of concentrations was fairly consistent across all flow regimes (Figure 5.3-43). Again, this indicates that total DDx is transported from upstream sources into the Study Area during high-flow conditions. This figure does not demonstrate a clear relationship between flow rate and total DDx concentrations; however, the highest concentrations were measured during low-flow conditions (Figure 5.3-48). This may suggest the potential for localized sources within the mid-Study Area vicinity, especially near RM 6.9 and 7.2.

5.3.7.3 Distribution between DDx Dissolved and Particulate Fractions

The following subsections describe the observed trending of total DDx dissolved and particulate fractions by river mile, event type, sample type, TSS, and f_{oc} of the TSS.

Section 5.3.7.3 provides a discussion of total DDx composition and patterns and trends, which may assist with the identification of observed concentrations in the Study Area.

5.3.7.3.1 DDx Particulate and Dissolved Concentrations

The distribution of total DDx (i.e., the sum of the dissolved and particulate concentrations) by river mile is presented on Figures 5.3-42 and 5.3-43. Although these figures show distinctly high total DDx concentrations at RM 6.9 and 7.2, there doesn't appear to be any clear patterns in the ratio of dissolved and particulate fractions or the distribution between single-point and transect samples.

The dissolved and particulate fractions of total DDx are plotted in Figure 5.3-50 and 5.3-51. The single-point and transect samples collected during the high-flow events followed the general trend of the other flow types. The samples characterized by the highest dissolved concentration tended to have a higher particulate concentration.

Three samples collected at RM 2 (Station W025) had higher dissolved to particulate ratios. This may be due to the lower suspended solids load in the downstream portion of the Study Area (at RM 2) rather than an actual shift in partitioning behavior. There does not appear to be a clear distinction between low-flow and stormwater-influenced or single-point and transect samples in these figures.

5.3.7.3.2 DDx Associations with Suspended Solids

The associations of total DDx with suspended solids and apparent partitioning were evaluated from the surface water data set. Total concentrations as a function of TSS are presented in Figures 5.3-52 and 5.3-53. The high-concentration, low-flow samples exhibited the highest ratios of total DDx to TSS. The single-point and transect high-flow samples exhibited a much lower ratio of total DDx concentration to TSS. The low-flow and stormwater-influenced samples had low suspended solids loads (25 J mg/L or lower) compared to high-flow samples (up to 62 mg/L).

Particulate total DDx concentrations and POC concentrations are compared in Figures 5.3-54 and 5.3-55. The high-flow transect and single-point samples tended to exhibit higher total particulate DDx concentrations and lower POC concentrations in the water column. As discussed in Section 5.3.4 and shown on Figure 5.3-14, high-flow samples exhibited higher TSS concentrations and lower f_{oc} on TSS percentages. Therefore, the higher concentrations in the surface water during high-flow events (Figure 5.3-48 and 5.3-49) were present in spite of lower POC in the water column. Again, this may suggest a different source or sources of particles, possibly upstream of the Study Area, given the high inflow concentrations at RM 16 and 11 during high-flow events. Higher POC concentrations were found in transect and single-point stormwater-influenced and low-flow samples with lower total particulate DDx concentrations.

5.3.7.4 DDx Patterns and Trends

Stacked bar graphs depicting the DDx patterns for the surface water dissolved (XAD column) and particulate (XAD filter) samplings by flow condition and river mile are

presented in Figures 5.3-56 and 5.3-57. The discussion of patterns and trends in the DDx distributions is qualitative based on visual examinations of the stacked bar graphs.

The DDx distributions for the dissolved fractions varied little from transect to transect within each sampling event, including the stations upstream and downstream of the Study Area. Patterns differed between flow conditions, however. The high-flow transect samples were dominated by the 4,4'-isomers of DDE and DDT, with generally decreasing contributions from DDT as the transects move downriver. The low-flow and stormwater-influenced transect samples had much higher proportions of DDD, primarily the 4,4'-isomer, with a substantial contribution by 2,4'-DDD. For the transects, the contribution of 4,4'-DDD varied with sampling event, whereas the contribution of 2,4'-DDD increased overall moving downriver.

Patterns for particulate DDx were similar to dissolved DDx for high-flow transects, dominated by the 4,4'-isomers of DDE and DDT. The proportion of 4,4'-DDT was more consistent upstream to downstream in the particulate fraction than in the dissolved fraction. 2,4'- and 4,4'-DDD dominated the particulate DDx under low-flow conditions at most transects, with generally decreasing contributions from 4,4'-DDT and increasing contributions from 2,4'-DDD as the transects move downriver. The March and July 2005 transect samples at stations W023 (RM 11) and W005 (RM 4) had higher fractions of 4,4'-DDE than other transect samples, while the 4,4'-DDE contribution in the dissolved fractions of these samples was similar to other transects. The particulate DDx patterns for the transect samples taken during stormwater-influenced flow conditions were also generally dominated by the DDD isomers, although 4,4'-DDE and 4,4'-DDT were also prevalent in these samples. The DDD isomers were not detected in stormwater-influenced samples from the upriver transect (W024) at low DDx concentrations.

The NS and NB samples were generally similar in most flow conditions for both dissolved and particulate DDx in both transect and single-point samples. Patterns for the NB and NS samples were different at Station W011 (RM 6.3; November 2006 stormwater-influenced sampling event), Station W031 (RM 6.1; January 2007 high-flow sampling event), and for Station W024 (RM 16; November 2006 stormwater-influenced sampling event), where the patterns may be obscured by method sensitivity limits.

The DDx compound distribution for the dissolved and particulate fractions of the single-point stations were generally similar to those of the transects in high-flow conditions, with the exception of particulate DDx in the NB sample and dissolved DDx in both samples for location W031 (RM 6.1).

During low-flow conditions, stations W016 (RM 7.2) and W015 (RM 6.9) total DDx concentrations were much higher than the other samples (5 to 60 times higher in the dissolved fraction and 14 to 80 times higher in the particulate fraction). These stations are both on the west bank of the river, located a short distance apart (0.3 mile). The

particulate DDx patterns varied fairly widely between the two stations and between sampling events at each location, and were distinct from patterns in surrounding areas and at the transect locations at RM 6.3 and 11. Dissolved DDx patterns at these two locations were more consistent and included a larger fraction of DDD than is typical in the Study Area. Under stormwater-influenced conditions, the DDx concentration at nearby Station W033 (RM 7) was higher than surrounding areas, but the DDx composition did not vary as distinctly.

5.3.8 Total PAHs in Surface Water

High-volume (XAD) samples were analyzed for PAHs by HRGC/HRMS (reported in pg/L). Peristaltic samples were also collected and analyzed for PAHs (reported in µg/L) by HRGC/low-resolution mass spectrometry (LRMS). Concentrations of total PAHs in surface water XAD column and filter samples are depicted in Figures 5.3-58 and 5.3-59. Peristaltic data are presented in Figures 5.3-60 and 5.3-61.

Total PAHs were detected in all surface water samples (XAD filters and columns) collected during Round 2A and 3A sampling events. In contrast, total PAHs were detected in only 58 percent of peristaltic samples.

Total PAHs measured in single-point XAD samples collected during low-flow conditions ranged from 12,500 J pg/L to 231,000 J pg/L at Station W015 (RM 6.9 in July 2005). Concentrations in transect samples measured during low-flow ranged from 3,970 J pg/L to 66,000 J pg/L at Station W005 (RM 4) in September 2006.

Total PAHs measured in single-point XAD samples collected during high-flow conditions ranged from 10,400 J pg/L to 107,000 J pg/L at Station W035 (RM 8.5) in January 2007. Concentrations measured in transect samples during high-flow ranged from 5,680 J pg/L to 59,400 J pg/L at Station W005 (RM 4 in January 2006).

Total PAHs measured in single-point XAD samples collected during the November 2006 stormwater-influenced event ranged from 5,860 J pg/L to 50,700 J pg/L at Station W033 (RM 7). Concentrations measured in transect samples during this event ranged from 2,790 J pg/L to 38,900 J pg/L at Station W005 (RM 4).

Concentrations of total PAHs measured in single-point peristaltic samples during low-flow conditions ranged from 0.00260 J µg/L to 2.46 J µg/L at Station W012 (RM 6.3 in July 2005).

Total PAHs measured in single-point peristaltic samples during high-flow conditions ranged from 0.0047 J µg/L to 7.4 µg/L at Station W031 (RM 6.1) in January 2007.

Concentrations of total PAHs measured in peristaltic single-point samples in November 2006 ranged from 0.005 J µg/L to 0.12 J µg/L at Station W033 (RM 7).

The following subsections describe observations of PAHs in the complete data set, as well as identified trends.

5.3.8.1 PAH Spatial Distribution

The distribution of total PAH concentrations (dissolved plus particulate concentrations) by river mile throughout the Study Area (and upstream to RM 16 and downstream to Multnomah Channel) is presented in Figures 5.3-62 and 5.3-63. Three of the five highest total PAH concentrations (including the highest measured value) were measured in single-point samples at RM 6.9 (Station W015) near the west end of Railroad Bridge during low-flow conditions. The second and third highest concentrations were measured in samples collected at RM 8.5 (Station W035 during the January 2007 high-flow event; Swan Island) and RM 7.2 (Station W016 during the July 2005 low-flow event), respectively. The range of total PAH concentrations within the complete data set across the Study Area was fairly consistent between RM 11 and 2, excluding the five highest single-point values. However, total PAH concentrations increased from RM 11 and 16 downstream to RM 4 in six of seven transect sampling events (Figure 5.3-64), suggesting some influence on surface water PAH concentrations from sources within the Study Area. The sole exception to this pattern occurred in the March 2005 low-flow event. Further downstream, at RM 2.9 (Multnomah Channel) and RM 2, concentrations decreased from those at RM 4 in high-flow, low-flow, and stormwater-influenced conditions.

5.3.8.2 PAH Relationships to Flow Rate

Total PAH concentrations as a function of flow rate are presented in Figures 5.3-65 and 5.3-66. As previously noted, four of the five highest concentrations of total PAHs were measured in single-point samples collected during low-flow conditions. Total PAH concentrations tended to vary within a flow condition rather than over the range of flow conditions sampled, although elevated PAHs were evident in low-flow samples from RM 7 to 2 compared to the high-flow and stormwater-influenced sampling events. Downstream near RM 2, the low-flow sample concentration ranges decreased relative to ranges observed further upstream within the Study Area (Figure 5.3-58).

5.3.8.3 Distribution between PAH Dissolved and Particulate Fractions

The following subsections describe the observed trending of the dissolved and total fractions by river mile, event type, sample type, TSS, and f_{oc} of the TSS. Section 5.3.8.4 provides a discussion of PAH patterns and trends (i.e., LPAHs, HPAHs), which may assist with the identification of observed concentrations in the Study Area.

5.3.8.3.1 PAH Particulate and Dissolved Concentrations

The spatial distribution of dissolved and particulate total PAH concentrations is presented for each surface water sample by river mile on Figure 5.3-58 and the scale is adjusted in Figure 5.3-59. The majority of total PAH concentrations were found in the dissolved rather than the particulate phase. However, there was one notable exception

to this trend: Station W035 at RM 8.5 collected during the January 2007 high-flow event. Both the NB and NS samples collected in January 2007 exhibited a much greater particulate to dissolved ratio. Also, at Stations W011 (RM 6.3) and W005 (RM 4) the NB samples had noticeably higher particulate total PAH concentrations in the low-flow and stormwater-influenced sampling events. In the January 2007 high-flow sampling event, this pattern was reversed at Station W035 (RM 8.5), and the NS sample had the highest particulate total PAH concentration.

The dominance of the dissolved fraction is also illustrated in Figures 5.3-67 and 5.3-68. The apparently unique ratio at RM 8.5 is well illustrated on these figures (data points in the lower right quadrant) and does not appear to apply to other high-flow samples. The unique ratio may suggest a different character/source of PAHs and/or suspended solids concentration and character for this sample location.

5.3.8.3.2 PAH Associations with Suspended Solids

Total PAH concentrations as a function of TSS are presented in Figures 5.3-69 and 5.3-70. High-flow samples (single-point and transect) exhibited the widest range and highest concentrations of TSS but generally lower total PAH concentrations compared to the majority of the data set. However, there does appear to be a trend of gradually increasing total PAH concentrations with higher TSS values (somewhat linear) for the high-flow samples. Otherwise, the low-flow and stormwater-influenced samples tended to cluster together exhibiting low TSS but varying PAH concentrations. The stormwater-influenced (single-point and transect) and low-flow single-point samples tended to exhibit this pattern most prevalently, with TSS values below 12 mg/L.

Samples collected from RM 8.5 during high-flow in January 2007 did not adhere to the pattern of other samples collected during this particular flow regime as they exhibited high concentrations of total PAHs relative to TSS (Figures 5.3-69 and 5.3-70). Although total PAHs measured in these samples were high relative to TSS, the particulate concentrations were much greater than the dissolved fractions (Figures 5.3-58, 5.3-59, 5.3-67, and 5.3-68).

Particulate total PAH concentrations and POC concentrations are compared in Figure 5.3-71. The high-flow samples (single-point and transect) exhibited relatively low total PAH concentrations and POC. The low POC values are consistent with the lower observed f_{oc} of the suspended solids during this flow condition (Figure 5.3-14). Several high-flow samples (e.g., the sample with the highest particulate total PAH concentration at Station W035, NS) exhibited POC values equal to zero (Figure 5.3-71). The explanation for this is that the calculated POC was set to equal zero if the DOC was greater than the TOC. This scenario provides further confirmation that the high-flow events are characterized by suspended solids with low f_{oc}.

5.3.8.4 PAH Patterns and Trends

Stacked bar graphs depicting the PAH distribution by individual PAHs and summed by number of rings in the surface water dissolved (XAD column) and particulate (XAD

filter) samples by flow condition and river mile are presented in Figures 5.3-72 and 5.3-73. A summary of PAHs included in each sum is provided in Section 5.1.8.4.

The dissolved PAH profiles varied between locations and flow events. During all sampling events, LPAHs (i.e., two-ring and three-ring PAHs) accounted for at least 50 percent of the dissolved PAHs at most transect, as well as single-point, stations. The two-ring PAHs (i.e., naphthalene and 2-methylnaphthalene) were dominant in many samples. In several samples, these results were restated as undetected during data validation, as discussed below, confounding the interpretation. The principal three-ring PAHs in many of the samples were acenaphthene and phenanthrene, although fluorene and anthracene were also present in many of the samples. Fluorene is dominant in two stormwater-influenced samples, collected from W023 (RM 11) and W024 (RM 16).

Generally, the remainder of the dissolved PAH profile consisted of four-ring HPAHs, primarily fluoranthene and pyrene in the high- and low-flow events. With several exceptions, the four-ring PAHs in the November 2006 stormwater-influenced sampling event were chiefly chrysene upstream of RM 8.5 and fluoranthene downstream of this point.

PAH patterns are affected by the presence of elevated detection limits, which result when individual PAHs are restated as undetected in the samples, since non-detects are treated as zeros in the evaluation of PAH patterns. Elevated detection limits may obscure the presence of a PAH at a concentration above the MDL. The concentrations reported by the laboratory for each of the PAHs in one or more samples were restated as undetected during data validation. Reasons for restating data as undetected included PAHs detected in laboratory and field blanks and details related to identification of the PAHs (i.e., ion abundance criteria were not met on the mass spectrometer). Data for XAD filter and column samples were affected. Results for LPAHs were restated as undetected more frequently than HPAHs. The evaluation of PAHs in this section takes elevated detection limits into consideration.

The PAH profiles in the particulate fractions also varied between sampling locations and flow events. Among transect locations, the low-flow and stormwater-influenced samples included primarily HPAHs with four and five rings, with fluoranthene, pyrene, and the benzofluoranthene isomers prevalent but many other HPAHs present as well. Samples from the high-flow sampling events were still predominantly four- and five-ring HPAHs but had more contribution of LPAHs, primarily the three-ring phenanthrene. The six-ring PAHs in the high- and low-flow events consisted of both benzo(g,h,i)perylene and indeno(1,2,3-cd)pyrene, while the stormwater event consisted almost entirely of benzo(g,h,i)perylene. Particulate PAHs in single-point samples varied from these patterns in many locations, particularly during low-flow conditions.

There was generally little difference in composition between the NS and NB samples for both transect and single-point samples. In the November 2006 stormwater-influenced sampling event, the dissolved NS samples at stations W024 (RM 16), W035

(RM 8.5), and W005 (RM 4) all had high contributions from 2-methylnaphthalene (a two-ring PAH) that was not present in the NB samples. The NS samples also had total dissolved PAH concentrations more than double the NB samples. A similar pattern is not seen in the particulate fractions of these samples. The higher NS concentrations may be related to a hydrocarbon sheen observed during sample collection for the stormwater event that was not thoroughly mixed within the water column, resulting in higher concentrations in the NS samples than the NB samples.

5.3.9 Additional Indicator Chemicals in Surface Water

This section discusses the occurrence and distribution of seven additional ICs in surface water within the Study Area. These additional ICs are included because they figure prominently in the CSM for the Site. The narrative in this section is abbreviated compared to the evaluation of ICs above and includes references to figures and tables to provide a complete picture of the distribution.

5.3.9.1 TCDD TEQ

High-volume surface water sampling results for PCDD/Fs (analyzed by HRGC/HRMS) were used to calculate TCDD TEQ values. TCDD TEQs were calculated using the 2005 WHO consensus TEF values for mammals (Van den Berg et al. 2006) as the sum of each detected congener concentration multiplied by the corresponding TEF value. Concentrations of TCDD TEQ in surface water XAD column and filter samples are depicted in Figure 5.3-74.

TCDD TEQ measured in single-point samples collected during low-flow conditions ranged from 0.110 J pg/L to 0.917 J pg/L at Station W013 (RM 6.7) in July 2005. Concentrations in transect samples measured during low-flow ranged from 0.0181 J pg/L to 0.327 J pg/L at Station W005 (RM 4 in July 2005).

TCDD TEQ measured in single-point samples collected during high-flow conditions ranged from 0.0491 J pg/L to 0.168 J pg/L at Station W035 (NS; RM 8.5) in January 2007. Concentrations measured in transect samples during high-flow ranged from 0.0113 J pg/L to 0.0912 J pg/L at Station W023 (RM 11 in January 2006).

TCDD TEQ measured in single-point samples collected during the November 2006 stormwater-influenced event ranged from 0.0777 J pg/L to 0.212 J pg/L at Station W033 (NB; RM 7). Concentrations measured in transect samples during this event ranged from 0.0133 J pg/L to 0.278 J pg/L at RM 11, Station W023E.

The TCDD TEQ particulate concentrations were greater than the dissolved values, consistent with the total PCDD/F data. TCDD TEQ concentrations were lowest upstream of the Study Area at RM 16 and at RM 2, the downstream extent (Figure 5.3-74).

5.3.9.2 Total Chlordanes in Surface Water

High-volume (XAD) samples were analyzed for total chlordanes (reported in pg/L) by HRGC/HRMS. Peristaltic samples were also collected and analyzed for total chlordanes (reported in µg/L) by routine methodology (i.e., EPA 8081A). Dissolved and particulate total chlordanes concentrations in surface water XAD column and filter samples are depicted in Figures 5.3-75 and 5.3-76. Peristaltic data are presented in Figure 5.3-77. Total chlordanes were detected in 85 percent of particulate samples (XAD filters), 100 percent of dissolved samples (XAD columns), and 34 percent of peristaltic samples.

Total chlordanes measured in single-point XAD samples collected during low-flow conditions ranged from 17.3 J pg/L to 241 J pg/L at Station W015 (RM 6.9) in November 2004. Concentrations in transect samples measured during low-flow ranged from 13.4 J pg/L to 58.8 J pg/L (Station W005 [NB] at RM 4 in September 2006).

Total chlordanes measured in single-point XAD samples collected during high-flow conditions ranged from 46.6 J pg/L to 85.9 J pg/L (Station W033 [NB] at RM 7) in January 2007. Concentrations measured in transect samples during high-flow ranged from 33.6 J pg/L to 94.3 J pg/L (Station W005 [NB] at RM 4) in January 2007.

Total chlordanes measured in single-point XAD samples collected during the November 2006 stormwater-influenced event ranged from 7.3 J pg/L to 36.8 J pg/L at Station W033 (NS; RM 7). Concentrations measured in transect samples during this event ranged from 13.4 J pg/L to 37.6 J pg/L at Station W027 (NS; RM 2.9).

Total chlordanes were detected in only one single-point peristaltic sample during low-flow conditions: 0.0021 J µg/L at Station W002 (RM 2.2) in July 2005.

Total chlordanes were detected in three single-point peristaltic samples during high-flow conditions: 0.00029 J µg/L at Station W029 (NB; RM 4.4), 0.00051 µg/L at W030 (NS; RM 5.5), and 0.0006 NJ µg/L at W030 (NB; RM 5.5) in January 2007.

Total chlordanes were detected in two single-point peristaltic samples during the stormwater-influenced event: 0.00055 NJ µg/L at Station W038 (NS; RM 9.9) and 0.0016 J µg/L at Station W036 (NS; RM 8.6).

The total chlordanes dissolved concentrations were greater than the particulate values, with a major exception at RM 6.9 (W015). Total chlordanes concentrations at RM 16 and at RM 2 were similar except the high-flow event, in which upstream sample concentrations were generally higher.

5.3.9.3 Aldrin in Surface Water

High-volume samples were analyzed for aldrin (reported in pg/L) by HRGC/HRMS. Peristaltic samples were also collected and analyzed for aldrin (reported in µg/L). Dissolved and particulate aldrin concentrations in surface water XAD column and filter

samples are depicted in Figure 5.3-78. Peristaltic data are presented in Figure 5.3-79. Aldrin was detected in 69 percent of particulate (XAD filter) and 73 percent of dissolved (XAD column) samples and only 1 percent of the peristaltic samples during Round 2A and 3A sampling activities.

Total aldrin measured in single-point samples collected during low-flow conditions ranged from 0.31 J pg/L to 16.3 J pg/L at Station W015 (RM 6.9) in November 2004. Concentrations in transect samples measured during low-flow conditions ranged from undetected to 6.62 J pg/L at Station W005 (RM 4) in September 2006.

Total aldrin was not detected in peristaltic samples during the Round 2A and 3A low-flow events.

Total aldrin measured in single-point samples collected during high-flow conditions in January 2007 ranged from undetected to 4.1 J pg/L at Station W033 (NB; RM 7) in January 2007. Concentrations measured in transect samples during high-flow conditions ranged from 1.2 J pg/L to 6.0 J pg/L at Station W025M (RM 2) in January 2007.

Total aldrin was detected in only one peristaltic sample (single-point) during high-flow conditions: 0.0052 µg/L at Station W030 (NB; RM 5.5) in January 2007.

Total aldrin measured in single-point samples collected during the November 2006 stormwater-influenced event ranged from undetected to 4.8 J pg/L at Station W033 (NS; RM 7). Concentrations measured in transect samples during this event ranged from undetected to 5.8 J pg/L at Station W027 (NB; RM 2.9).

Total aldrin was not detected in peristaltic samples during the stormwater-influenced event.

The aldrin dissolved concentrations were greater than the particulate values, with a major exception at RM 6.9 (W015). With several exceptions, total aldrin concentrations were fairly consistent within the flow conditions, with downstream samples typically somewhat higher than upstream samples.

5.3.9.4 Dieldrin in Surface Water

High-volume samples were analyzed for dieldrin (reported in pg/L) by HRGC/HRMS. Peristaltic samples were also collected and analyzed for dieldrin (reported in µg/L) by routine methodology (i.e., EPA 8081A). Dissolved and particulate dieldrin concentrations in surface water XAD column and filter samples are depicted in Figure 5.3-80. Peristaltic data are presented in Figure 5.3-81. Dieldrin was detected in all dissolved (XAD columns) and 70 percent of particulate (XAD filters) surface water samples and 3 percent of peristaltic samples collected during Round 2A and 3A sampling activities.

Total dieldrin measured in single-point XAD samples collected during low-flow conditions ranged from 22.7 to 62.5 pg/L at Station W015 (RM 6.9 in November 2004). Concentrations in transect samples measured during low-flow ranged from 16.7 J pg/L to 48.7 J pg/L at Station W005 (RM 4 in September 2006). Total dieldrin was not detected in peristaltic samples during the low-flow events.

Total dieldrin measured in single-point XAD samples collected during high-flow conditions in January 2007 ranged from 108 J pg/L to 190 pg/L at Station W033 (NB; RM 7). Concentrations measured in transect samples during high flow ranged from 70.5 J pg/L to 384 pg/L (Station W005 at RM 4 in January 2006).

Total dieldrin measured in single-point XAD samples collected during the November 2006 stormwater-influenced event ranged from 31.9 J pg/L to 50.1 J pg/L at Station W031 (NB; RM 6.1). Concentrations measured in transect samples during this event ranged from 25.1 J pg/L at Station W025W (RM 2) to 53.7 J pg/L at Station W024 (NS; RM 16).

Total dieldrin was detected in three single-point peristaltic samples during the high-flow sampling event at concentrations of 0.001 NJ µg/L at Station W029 (NB; RM 4.4), 0.0012 J µg/L at Station W028 (NB; RM 3.6), and 0.0012 NJ µg/L at Station W036 (NB; RM 8.6) in January 2007.

Total dieldrin was not detected in peristaltic samples during the stormwater-influenced event.

The dieldrin dissolved concentrations were much greater than the particulate values (typically on the order of 90 percent of the total concentration). Total dieldrin concentrations had a small range in the low-flow and stormwater-influenced samples, and were higher with the high-flow event. The high-flow upstream concentrations were higher than all Study Area concentrations during the low-flow and stormwater-influenced events, whereas concentrations in the Study Area were comparable during the low-flow and stormwater-influenced events, making upstream to downstream patterns difficult to assess with the existing range of sampling events.

5.3.9.5 Arsenic in Surface Water

Peristaltic samples were collected and analyzed for arsenic during Round 2A and 3A. Dissolved and particulate arsenic concentrations in surface water are depicted in Figure 5.3-82. Arsenic was detected in 78 percent of dissolved peristaltic samples and 90 percent of total peristaltic samples during the Round 2A and 3A sampling events.

Total arsenic measured in single-point samples collected during low-flow conditions ranged from 0.33 µg/L to 0.75 µg/L at Station W001 (RM 2) July 2005. Concentrations in transect samples measured during low-flow ranged from 0.35 to 0.64 µg/L (Station W025E at RM 2 in September 2006).

Total arsenic measured in single-point samples collected during high-flow conditions in January 2007 ranged from 0.3 µg/L to 0.63 J µg/L at Station W034 (NS; RM 7.5). Concentrations measured in transect samples during high-flow ranged from 0.25 to 0.54 µg/L at Station W005 (RM 4) and Station W023 (RM 6.3), in January 2006.

Total arsenic measured in single-point samples collected during the November 2006 stormwater-influenced event ranged from 0.43 J µg/L to 0.53 J µg/L at Station W038 (NB; RM 9.9). Concentrations measured in transect samples during this event ranged from undetected to 0.48 J µg/L at Station W005 (NB; RM 4).

Total arsenic concentrations were generally consistent across the entire Study Area during the Round 2A and 3A sampling events. Concentrations were generally higher in low-flow sampling events.

5.3.9.6 Copper in Surface Water

Peristaltic samples were collected and analyzed for copper during Round 2A and 3A. Dissolved and particulate copper concentrations in surface water are depicted in Figure 5.3-83. Copper was detected in 99 percent of dissolved and 100 percent of total copper samples during Round 2A and 3A sampling events.

Total copper measured in single-point samples collected during low-flow conditions ranged from 0.68 µg/L to 2.09 µg/L at Station W004 (RM 3.7) in March 2005. Concentrations in transect samples measured during low-flow ranged from 0.68 µg/L to 1.55 µg/L at Station W005 (NB; RM 4) in September 2006.

Total copper measured in single-point samples collected during high-flow conditions in January 2007 ranged from 1.47 µg/L to 3.49 µg/L at Station W031 (NB; RM 6.1). Concentrations measured in transect samples during high-flow ranged from 1.1 µg/L to 3.68 J µg/L at Station W023 (RM 11) in January 2006.

Total copper measured in single-point samples collected during the November 2006 stormwater-influenced event ranged from 0.79 to 1.14 µg/L at Station W035 (NS; RM 8.5). Concentrations measured in transect samples during this event ranged from 0.65 µg/L to 1.1 µg/L at Station W024 (NS; RM 16).

Total copper concentrations were generally consistent across the entire Study Area during the Round 2A and 3A sampling events. Concentrations were generally higher in the high-flow sampling events.

5.3.9.7 Zinc in Surface Water

Peristaltic samples were collected and analyzed for zinc during Round 2A and 3A. Dissolved and particulate zinc concentrations in surface water are depicted in Figures 5.3-84 and 5.3-85. Zinc was detected in 42 percent of dissolved peristaltic samples and 76 percent of total peristaltic samples collected during Round 2A and 3A sampling events.

Total zinc measured in single-point samples collected during low-flow conditions ranged from 1.7 µg/L to 57.9 µg/L; the highest concentration was found at Station W022 (RM 9.7) in November 2004. Concentrations in transect samples measured during low-flow ranged from 2.1 µg/L to 6.1 µg/L; the highest concentration was found at Station W023W (RM 16) in September 2006.

Total zinc measured in single-point samples collected during high-flow conditions ranged from 3.0 µg/L to 8.4 µg/L; the maximum concentration was found at Station W031 (NB; RM 6.1) in January 2007. Concentrations measured in transect samples during high-flow ranged from 1.9 µg/L to 6.4 µg/L; maximum concentrations were found at Station W023 (RM 11) and Station W024 (RM 16) in January 2006.

Zinc in samples collected during stormwater-influenced conditions was found in the dissolved fraction only. Single-point concentrations ranged from 4.8 µg/L to 6.6 µg/L; the maximum concentration was found at Station W034 (NS; RM 7.5) in November 2006. Zinc was detected in only one transect sample (5.1 µg/L) at Station W025M (RM 2) in November 2006.

The concentrations of total zinc were generally consistent throughout the Study Area during the Round 2A and 3A sampling events.

5.3.10 Summary of Nature and Extent of Indicator Chemicals in Surface Water

The four ICs selected for discussion for surface water exhibited distinct maxima at one or more of the Study Area locations. This discussion includes concentrations of bounding ICs that are notably high relative to other locations in the surface water data set. Trends relative to flow conditions are also discussed.

Upstream between RM 11 and 16, there were elevated PCB and PCDD/F concentrations (compared to other concentrations in this reach) at RM 11. Two of the three highest PCB concentrations and the second highest PCDD/F concentration at RM 11 were measured on the east side of the river, suggesting the existence of localized sources in this area. For DDx, the high-flow concentrations at RM 11 and 16 were much greater than the low-flow and stormwater-influenced samples, indicating an upstream source or sources of DDx mobilized during high-flow conditions. PAH concentrations between RM 11 and 16 tended to be lower than those within the Study Area.

There is a trend of decreasing PCB concentrations with increasing flow rates. Five of the six highest PCB concentrations were associated with low-flow sampling events, and concentrations were consistently lower in high-flow samples as compared to the two other flow regimes. Excluding the samples at RM 6.7, the, stormwater-influenced samples appear to be lower than the low-flow samples. High-flow conditions may overwhelm the local effects and control PCB concentrations in the Study Area until flow rates subside.

PCDD/F concentrations don't appear to be as dependent upon flow rate as PCBs. At the downstream end of the Study Area, the low-flow sample concentration ranges for both total PCBs and total PCDD/Fs decreased relative to ranges observed within the Study Area.

Within the Study Area, the highest concentrations of PCBs (highest including six of seven) and PCDD/Fs (highest) were found in Willamette Cove (RM 6.7) during low-flow conditions, which suggests a localized source or sources of these ICs in this vicinity.

Total DDx concentrations in surface water across the Study Area were dominated by five high-concentration samples (3,000 pg/L to 10,000 pg/L) collected at RM 6.9 and 7.2, adjacent to known pesticide sources to the river. The highest PAH concentrations (100,000 J pg/L to 230,000 J pg/L) were found at RM 6.9, as well as RM 7.2 and 8.5, adjacent to known PAH sources in the Study Area.

The highest total DDx (RM 6.9 and 7.2) and total PAH (three out of the five highest; RM 6.9) concentrations were measured in single-point samples during low-flow conditions. With the exception of these high-concentration samples, the range of PAH concentrations were fairly consistent across the Study Area. However, total DDx concentrations were elevated in high-flow samples from RM 11 and 16, as compared to the two other flow regimes, indicating an upstream source or sources of total DDx that becomes mobilized during high-flow conditions.

At the downstream end of the Study Area, total PCDD/Fs, DDx, and PAHs had consistently low concentrations with less variability among sampling event types than seen in Study Area samples. In contrast, total PCB congener concentrations in the downstream end of the Study Area were approximately 900 to 1,300 pg/L in single-point samples near RM 2 for the stormwater-influenced event, and total PCB congener concentrations downstream were higher than the upstream (RM 16) concentrations for all event types (low-flow, high-flow, stormwater-influenced).

5.4 INDICATOR CHEMICALS IN TRANSITION ZONE WATER AND GROUNDWATER SEEPS

This section summarizes the Study Area data for TZW and groundwater seeps. As described in Section 3, the transition zone is defined as the interval where both groundwater and surface water comprise some percentage of the water occupying pore space in the sediments. The primary focus area of the transition zone for this investigation is the surface sediment mixed layer, which is considered to be the upper 30 cm of the sediment and includes the biologically active zone.[1] The mixed layer is characterized by TZW samples collected in the shallow (0 to 38 cm bml) sediments. Deeper (>90 cm bml) TZW samples are also discussed here to lend insight into observed chemical distribution patterns and to support an assessment of potential TZW loading impacts to surface water and surface sediment that is provided in Appendix E and Section 6.1.6.

The following subsections present tables, plan view maps, histograms, scatter plots, and stacked bar charts to support brief discussions of nature and extent for the select IC list (Table 5.0-2). The full RI data sets for TZW and groundwater seeps for all sampled chemicals (those data of adequate quality for use in decision making for the Study Area per the Portland Harbor RI/FS Programmatic Work Plan [Integral et al. 2004]) are presented in the project SCRA database (Appendix A3) and summarized in Appendix D4, Tables D4-1 and D4-2.

The TZW presentation provided in Section 5.4 supports the detailed site-by-site presentation and analysis of groundwater pathways presented in Appendix C2. The Appendix C2 presentation of TZW provides data analysis focused on identification of complete groundwater pathways from upland plumes to the transition zone, including some cross-media analysis. This section (Section 5.4) focuses on presentation of the distribution of ICs observed in the transition zone. As such, this section does not attempt to present cross-media analysis or to relate observations to sources. Due to the spatially focused nature of the TZW and seep sampling programs, this discussion of nature and extent includes use of facility names for location reference; mention of facility names does not necessarily indicate source origin.[2] The findings presented in Appendix C2 and in this nature and extent discussion are incorporated into the detailed cross-media analysis and sources discussions presented in the Study Area-wide CSM discussion (Section 10).

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[1] The surface sediment mixed layer depth is based on analysis of bathymetric data, as discussed in Section 2, which indicates that processes disturb or mix sediments from >20 to 30 cm bml in some areas of the Study Area. The biologically active zone is defined by the depth of biological processes. The depth of the true biologically active zone varies widely throughout the Study Area, based on factors that control benthic community structure, such as sediment texture, sediment-water interface dynamics, and organic loading.

[2] The TZW sampling effort was a focused investigation offshore of nine upland sites and was not a harbor-wide study. The approach taken for selection of TZW study sites is presented in Appendix C2. It is possible that other sites will be identified that have a complete pathway for upland groundwater plumes to the Study Area.

This section is organized somewhat differently than the *In-River Distribution* discussions for other media. Specifically, this TZW section includes presentation of all TZW ICs in the main report, which is unlike the discussion format used for other media such as sediment (Section 5.1) and surface water (Section 5.3). This difference reflects the lists of chemicals that were the focus of the various upland site-specific TZW investigations. In particular, PCBs were not sampled in TZW,[3] and only two TZW sampling locations were analyzed for PCDD/Fs.[4] Neither PCBs nor PCDD/Fs are expected to be migrating to the river via groundwater given their high hydrophobicity and the lack of evidence of facilitated transport at upland sites with these COIs. Because of the unique TZW IC list and the complexities of the groundwater pathway, discussion of all TZW ICs is needed for a meaningful presentation of the in-river distribution of TZW results. Because all TZW ICs are discussed in the main text, a paired summary statistics table of a subset of ICs is not provided in the main text, as is done for other media. Instead, all summary statistics are presented in Appendix D4 (Tables D4-1 and D4-2).

5.4.1 TZW Data Set

This subsection describes the TZW chemistry data set presented in this RI Report. The TZW chemistry data were generated during the following field events (sampling locations are shown on Map 2.2-6):

2004 Pilot Study – In 2004, a pilot study was conducted offshore of the Arkema and ARCO sites to evaluate various TZW sampling methods, including Trident® push probe, small-volume peepers, large-volume peepers, bulk sediment centrifugation, Geoprobe®, and vapor diffusion samplers. The findings of the 2004 Pilot Study are discussed in detail in Appendix B of the GWPA Sampling and Analysis Plan (SAP; Integral 2005c), the Discharge Mapping FSP (Integral 2005b), and the TZW FSP (Integral 2006a). The pilot study found that TZW samples collected by Trident push probe and small-volume peepers provided the most accurate and reproducible results for the targeted zones and sediment conditions encountered.[5] Based on those findings, only those tools were applied to subsequent LWG investigations. The 2004 Pilot Study results included in the RI TZW data set consist of results for only the 10 Trident push probe and 9 small-volume peeper locations sampled offshore of the ARCO and Arkema sites (data collected by other evaluated methods are not included). Included Pilot Study

[3] PCBs were not identified as COIs for any of the nine TZW sites. PCB data were not collected in TZW and are not discussed here.

[4] PCDD/Fs were detected in only one TZW sample: Trident filtered (0.865 pg/L) and unfiltered (29 pg/L) at station RP-07-B.

[5] The Round 2 GWPA TZW SCSR (Integral 2006e) presents detailed information regarding the quality of the Round 2 TZW data set developed and analyzed as part of the Round 2 GWPA. These data meet project-specific data quality objectives specified in the SAP (Integral 2005c) and QAPP (Integral 2005a), and statistical analysis of sample replicates shows excellent overall reproducibility of sample results, with both small-volume peepers and Trident samples comparing well. These findings support a high level of confidence in both the analytical data sets and the methods and equipment used for sample collection.

samples were collected in the shallow sediment interval at 30 cm bml (Trident) and from 0 to 38 cm bml (peeper).

2005 Round 2 GWPA – Between August and December 2005, the LWG conducted an investigation of TZW offshore of nine upland sites with known or likely pathways for groundwater plume transport of chemicals to the river. Site selection is discussed further in Section 5.4.1.1 (below) and in Appendix C2. Fifty-six Trident and 27 small-volume peeper locations were sampled as part of this investigation, and all of those results are included here. Trident samples were collected in the shallow sediment interval at 30 cm bml at all 56 sample locations, as well as in deeper sediment (90, 120, or 150 cm bml) at 23 of these locations. Peeper samples were collected in the shallow sediment interval, from 0 to 38 cm bml, at all 27 peeper sample locations. The sampling program is described in detail in the TZW FSR (Integral 2006d), and the findings related to groundwater pathways are discussed in detail in Appendix C2.

2005 Siltronic Investigation – In 2004 and 2005, on behalf of Siltronic, Maul Foster & Alongi (MFA) conducted an investigation of the groundwater pathway offshore of the Siltronic site. These data are presented in detail by MFA (HAI 2005b; MFA 2005b), and discussed in Appendix C2. The results of the 2004 and 2005 investigations indicate areas of groundwater discharge in a subset of the area investigated (MFA 2007). Additional results of these studies are presented in Appendix C2. The TZW samples were collected with a Geoprobe sampler, which can be used as a push probe type of sampling tool for TZW. Forty-one TZW samples collected in the shallow sediment interval at 31 cm bml, as well as 24 samples collected in a deeper interval at 91 cm bml, are included in this presentation of TZW nature and extent.

2007 Gasco Investigation – In 2007, on behalf of Gasco, Anchor Environmental conducted an investigation of the groundwater pathway offshore of the Gasco site. These data are presented in detail in Anchor (2008b) and discussed in Appendix C2. TZW samples were collected with a Geoprobe sampler. Twenty-two TZW samples collected between 0 and 90 cm bml are included in this presentation of TZW nature and extent. Note that very few samples were collected in the shallow (0 to 38 cm bml) sediment interval for this Gasco investigation. Therefore, the sample collected at the uppermost depth at each location is used in this nature and extent discussion as the best available representation of the TZW concentrations in the shallow layer. No deeper data collected as part of the Gasco Investigation was included in this nature and extent discussion.[6]

5.4.1.1 Study Sites

These sampling activities described above focused on the offshore area of nine sites along the west bank of the river (see Map 2.2-6):

- Kinder Morgan Linnton Terminal (RM 4.1 to RM 4.2)

[6] Only one sample (GS-C2, 73 to 103 cm bml) in the 2007 Gasco Investigation was collected in the deeper (90 to 150 cm bml) sample interval; this sample is not included in this nature and extent discussion.

- ARCO Terminal 22T (RM 4.7 to RM 4.9)
- ExxonMobil Oil Terminal (RM 4.8 to RM 5.1)
- Gasco (RM 6.1 to RM 6.5)
- Siltronic (RM 6.3 to RM 6.5)
- Rhone Poulenc (RM 6.7 to RM 6.9)
- Arkema (Acid Plant and Chlorate Plant areas; RM 7.2 to RM 7.5)
- Willbridge Terminal (RM 7.6 to RM 7.8)
- Gunderson (RM 8.3 to RM 8.5).

These nine sites were identified for investigation as part of the Round 2 GWPA as high-priority Category A upland groundwater sites, selected in agreement with EPA as sites with a confirmed or reasonable likelihood for discharge of COIs to Portland Harbor.[7] The approach to site selection is discussed in greater detail in Appendix C2. TZW sampling offshore of each site was focused largely on the in-river areas adjacent to the site shoreline, often extending to, and occasionally just beyond, the navigation channel boundary. As such, the TZW sampling effort was not a harbor-wide study of TZW, but instead was a focused investigation offshore of the nine Round 2 study sites. (Note: non-LWG TZW investigations offshore of the Siltronic and Gasco sites are considered with the LWG Round 2 GWPA results, as discussed in Section 5.4.1 above.) It is possible that there are other areas of groundwater plume discharge to the river not captured in this data set.

The TZW investigations performed for the RI focused solely on areas of confirmed or likely groundwater plume discharge to the river and did not seek to characterize pore water chemistry elsewhere in the Study Area. Accordingly, this discussion does not address TZW/pore water chemistry in areas with no upland groundwater discharge, or areas of clean groundwater flowing through contaminated sediments. Additionally, this study does not distinguish the relative contribution of upland groundwater plumes and chemicals in sediment to the concentrations measured in TZW. Consideration of pore water chemistry affected by in-river sediment contamination is evaluated in Section 6 loading calculations through equilibrium partitioning calculations based on the large data set of sediment concentrations. These calculated estimates of pore water

[7] Site selection criteria included: (1) Existing offshore groundwater sampling data indicate that a potentially complete transport pathway exists for groundwater COIs to reach the transition zone; (2) Existing shoreline sampling data from groundwater wells or seeps indicate a reasonable likelihood of a complete transport pathway for groundwater COIs to reach in-river exposure points; (3) Existing observations of NAPL seepage to the river indicate that a complete transport pathway may exist for groundwater COIs to reach in-river exposure points; and (4) Shoreline groundwater seeps containing COIs are known to be present and represent a potentially complete exposure pathway for human receptors.

concentrations are not presented here as part of the TZW nature and extent presentation because they are not actual field measurements.

5.4.1.2 Sampling Techniques

Two general types of sampling techniques were used to collect the TZW samples: small-volume peepers and push probe samplers (Trident and Geoprobe[8] tools were used as push probe samplers). These are described in detail in the Pilot Study FSP (Integral 2004a). The Round 2 TZW investigation used both Trident and small-volume peepers, and the non-LWG investigations at Gasco and Siltronic used Geoprobe to collect TZW samples.

For the Round 2 TZW investigation, paired unfiltered and filtered samples were collected with the Trident tool, where possible. At these locations, collection of unfiltered samples was given priority, and volume limitations prevented collection of filtered samples in some cases. Filtered samples were not collected for small-volume peeper samples from the Round 2 TZW investigation due to volume limitations and the across-membrane-equilibration nature of the sampling technique,[9] which was expected to introduce fewer solids than peristaltic pumping for push probe samples. Filtered Geoprobe samples were collected as part of the Anchor (2008b) investigation at Gasco for metals and PAHs only. No filtered Geoprobe samples were collected by MFA as part of the Siltronic investigation (MFA 2005b).

All peeper samples were collected over the depth interval of 0 to 38 cm bml. Trident samples were collected at 30 cm bml, with a few deeper samples collected between 90 and 150 cm bml.[10] Geoprobe samples were collected at depths ranging from 30 to 6,300 cm bml, though only Geoprobe samples from 0 to 91 cm bml are presented in this discussion of TZW nature and extent. The nature and extent presentation focus on the shallow (0 to 38 cm bml) TZW data corresponds to the surface sediment mixed layer (≤30 cm bml). Deeper Trident and Geoprobe TZW sample data (90 to 150 cm bml) are presented here to advance the understanding of the completeness of specific groundwater pathways, and are discussed in more detail in Appendix C2.

5.4.1.3 Spatial and Temporal Representativeness of the TZW Data Set

TZW sampling was limited to the offshore areas of the nine study sites as described above. As noted above, there may be additional upland plumes for which delineation was not adequate enough to have been categorized as having a confirmed or likely pathway to the river (upland site plume delineation is outside of the LWG investigation responsibility). Further, the sampling investigation of TZW did not seek to delineate

[8] Geoprobe sampling of TZW was performed by Siltronic and Gasco. The data are included in the SCRA project database as non-LWG collected data.

[9] Note that the peeper is a diffusion-based sampling device, and water samples captured in the peeper device must pass through a ~5-μm Teflon® membrane. Therefore, peeper samples are not whole water samples, yet these samples do include particles larger than the 0.45-μm diameter filter used for Trident filtered samples.

[10] One Trident sample was collected at 60 cm bml at location CP-07-B. This sample is included with the 90 to 150 cm bml data set.

TZW chemistry in areas unimpacted by upland plumes but possibly impacted by river sediments.[11]

Because TZW samples were collected at a single point in time (for Trident and Geoprobe sampling) or over a 3-week equilibration period (for peeper sampling), LWG field sampling events were carefully timed to maximize the expected upland groundwater signal (i.e., the time of greatest groundwater discharge rate). For the Pilot Study and Round 2 TZW investigations, TZW analytical samples were collected from November 2004 to January 2005 and October to December 2005, respectively, before river water levels increased to the higher levels that typically occur from mid-winter through spring. The non-LWG TZW samples collected at Gasco that are included in this nature and extent discussion were collected between July and September 2007. The non-LWG TZW samples collected at Siltronic that are discussed here were collected in May and June of 2005.

Daily tidal fluctuations are not expected to have affected the representativeness of the analytical chemistry results collected by either small-volume peepers or the push probe samplers. First, small-volume peepers were left in place over 3 weeks, allowing equilibration over many tidal cycles. Second, seepage meter results (presented and discussed in Appendix C2) suggest that Trident samples from depths of 30 cm bml or deeper are unlikely to be affected by tidal changes in the areas sampled. The typical discharge rate measured by seepage meters was on the order of a few cm/day (average = 1.40 cm/day; minimum daily average = -18.9 cm/day; maximum daily average = 14.2 cm/day). The largest net negative recharge rate[12] among seepage meter locations showing an average positive discharge (i.e., locations where the tidal influence could potentially have a significant timing impact on TZW chemistry) was observed offshore of the Siltronic site. At this location, the negative recharge period covered roughly 9.5 hours, with an average seepage rate of -6.7 cm/day during this period. This corresponds to a net seepage flux of 2.65 cm over the 9.5 hour tidal recharge period. Assuming sediment porosity of 25 percent, the maximum depth of influence for this period of negative seepage would be roughly 10.6 cm before the direction reverses to positive discharge with the tidal change. At this location with the greatest period and magnitude of negative flux (among all locations with net positive flux), this estimated periodic depth of influence of surface water is still well above the minimum sampling depth of 30 cm bml. Therefore, the timing of tidal conditions during Trident sample collection is not expected to have had any effect on chemistry results.[13]

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[11] In areas not directly affected by transport of chemicals originating in upland groundwater, chemicals may be present in TZW as a result of desorption from contaminated sediments and/or geochemical processes within the sediments and associated TZW.

[12] The negative seepage rate values are the focus here because they correspond to observed recharge to the TZW from surface water, which is the concern related to tidal influence on the timing of TZW sampling.

[13] These calculations are further supported by a temporal tidal study conducted offshore of the Gasco and Siltronic sites as part of the Anchor (2007) investigation. That investigation involved collection of 30 TZW samples from three mini-piezometers (~45 cm bml) over multiple tidal cycles and concluded that there were no correlations with river stage for any of the COIs analyzed.

5.4.2 Indicator Chemical List for TZW

The IC list for TZW is presented in Table 5.0-2. A total of 39 individual analytes and calculated sums (total cPAHs, total HPAHs, and total PAHs; total DDE, total DDD, total DDT, and total DDx; total xylenes) were identified as ICs for TZW in consultation with EPA (see Section 5.0). These chemicals were selected from the complete list of TZW sampled analytes, taking into consideration the subset of chemicals found to be relevant through the human health and ecological risk screening process, the chemicals identified for detailed assessment in the CSM discussion in Section 10, as well as any additional chemicals which were the focus of the Round 2 TZW investigation. The resulting list of chemicals can be placed into seven groups, as follows (chemicals included in the Section 10 CSM discussion are denoted with an asterisk [*]):

- PAHs
  - Total PAHs*
  - Total LPAHs[14]
  - Total HPAHs
  - Total cPAHs BaPEq values
  - BAP
  - Naphthalene
- TPH[15]
  - TPH - DRH
  - TPH - RRH
  - TPH- Gasoline-range hydrocarbons (GRH)
- Metals
  - Arsenic*
  - Barium
  - Cadmium
  - Copper*
  - Lead
  - Manganese
  - Nickel

[14] LPAHs are discussed here to provide for complete discussion of total PAHs and HPAHs though they are not included in the indicator chemical list for TZW.

[15] TPH is not on the TZW indicator chemical list; however, it is presented in this section to support discussion of DRH, RRH, and GRH.

  - Zinc*
- Pesticides
  - Total DDx (2,4'- and 4,4'-DDD, DDE, DDT)*
  - Total of 2,4'- and 4,4'-DDT
  - Total of 2,4'- and 4,4'-DDE
  - Total of 2,4'- and 4,4'-DDD
- Herbicides
  - 2,4,5-TP (Silvex®)
- VOCs
  - Monochlorobenzene (MCB)
  - 1,2-Dichlorobenzene (1,2-DCB)
  - 1,2,4-Trimethylbenzene
  - Chloroethane
  - 1,2-Dichloroethane (1,2-DCA)
  - 1,1,2-Trichloroethane (1,1,2-TCA)
  - Vinyl chloride
  - cis-1,2-Dichloroethene (cis-1,2-DCE)
  - Trichloroethene (TCE)
  - Chloroform
  - Methylene chloride
  - Carbon disulfide
  - Total BTEX (including individual component chemicals)
- Other
  - Perchlorate
  - Cyanide.

Five chemicals (total PAHs, total DDx, arsenic, copper, zinc) included on the TZW IC list are presented in the cross-media analysis of results in Section 10. The following sections present detailed discussions of results for two of these ICs (DDx and PAHs), followed by summary discussions and figures for the remaining ICs on the TZW list.

5.4.3 Description of TZW Presentation Tools

TZW data for TZW ICs are presented on plan-view maps and/or scatter plots, as well as stacked bar charts for select chemicals to support evaluation of sample composition. These presentations vary by analyte and are summarized in Table 5.4-1. As reflected in Table 5.4-1, the TZW analyte lists varied by study site; therefore, it was often unnecessary to produce maps for each river mile for a given analyte. All maps, scatter plots, and bar charts were generated with consistent approaches as described below.

Maps: Map presentations of TZW data use color-coded symbols and flyout labels to provide the individual concentration values. This presentation includes distinction of shallow TZW Trident samples (0 to 38 cm bml) and deeper Trident samples (90 to 150 cm bml), as well as non-LWG shallow (0 to 90 cm bml)[16] and deeper (91 cm bml) Geoprobe samples. Paired map sets are presented for each river mile to show filtered and unfiltered results, where available. Peeper samples are presented with a unique symbol on both filtered *and* unfiltered images to allow for a detailed evaluation of results. A histogram of detected chemical concentrations is inset on each map to provide context for the results presented on the given river mile relative to the results from the entire Study Area. Histogram bins and concentration color ranges were selected based on professional judgment to best present the complete range of filtered and unfiltered concentration values observed across the Study Area.

Scatter Plots: Scatter-plot presentations of TZW data show sample concentrations plotted according to the river mile of the sample location. Color-coded symbols distinguish sample type and depth. Paired plot sets are presented for each chemical to show filtered and unfiltered results, where available. Peeper samples are presented with a unique symbol on both filtered *and* unfiltered images to allow for a detailed evaluation of results.

Bar Charts: Stacked bar charts of total DDx, total PAHs, and TPH present, for each individual TZW sample, the fractional contribution of each individual constituent of the total concentration (detected sums only). The total sum concentration is also denoted on the figure with a black line (scale on the right-hand y-axis). Samples are organized along the x-axis according to descending river mile order, grouped by understanding of groundwater discharge areas as discussed in detail in Appendix C2. Where available, peeper ("PR"), filtered and unfiltered Trident ("TR"), and Geoprobe ("GP") data are shown for each sample location. Sample IDs for filtered results ("-f" in the sample ID) are indicated by highlighting. Deeper Trident samples are denoted by "-90", "-120", or "-150" in the sample ID, referring to depth bml in centimeters. Further, field duplicate samples on these figures are denoted by "dup" in the sample ID.

[16] For the Gasco study (sample IDs that begin with "GS-"), the sample collected at the uppermost depth in the 0 to 90 cm bml interval at each location is presented on maps as the best available representation of the TZW concentrations in the shallow layer. No deeper data collected as part of the Gasco study is presented. For the Siltronic study (sample IDs that begin with "GP-"), samples collected at 31 cm bml are presented as shallow TZW, and samples collected at 91 cm bml are presented as deeper TZW.

5.4.4 DDx in TZW

The following subsections present the in-river distribution of DDx results in TZW samples. The TZW IC list includes total DDx, total DDD, total DDE, and total DDT. This presentation also discusses the individual DDx components (2,4'-DDE, 4,4'-DDE, 2,4'-DDD, 4,4'-DDD, 2,4'-DDT, and 4,4'-DDT).

5.4.4.1 Observed Chemical Distribution of DDx in TZW

DDx components were identified as upland groundwater COIs at the former Acid Plant area of the Arkema site in the Round 2 GWPA SAP (Integral et al. 2005). Ten locations offshore of this area were analyzed for DDx pesticides in TZW as part of the Round 2 GWPA sampling effort. Additionally, one sample collected offshore of the adjacent Rhone Poulenc site[17] (RP-03-C) was analyzed for DDx pesticides. There are six peeper samples, 14 shallow (0 to 38 cm bml) Trident samples (with collocated filtered and unfiltered samples collected at six locations), and three deep (90 to 150 cm bml) Trident samples in this data set (with collocated filtered and unfiltered samples collected at one location).

Map 5.4-1 presents filtered (top panel) and unfiltered (bottom panel) total DDx (and constituent sums 2,4'- and 4,4'-DDD, 2,4'- and 4,4'-DDE, 2,4'- and 4,4'-DDT)[18] concentrations measured in shallow (0 to 38 cm bml) Trident and deep (90 to 150 cm bml) Trident samples. Peeper samples are presented with a unique symbol on both filtered *and* unfiltered images to allow for a detailed evaluation of results. Inset histograms on Map 5.4-1 show the distribution of total DDx sample concentrations for detected filtered, unfiltered, and peeper results. All sample results for summed and individual DDx isomers in TZW are presented in the SCRA database (Appendix A3) and are summarized in Appendix D4, Table D4-1.

Total DDx concentrations in the six shallow peeper and six filtered Trident samples ranged from below detection limits (detection limits ranged from 0.0042 UA µg/L to 0.035 UA µg/L) to 0.158 J µg/L. The highest filtered shallow DDx concentration was measured at RP-03-C, at the downstream Rhone Poulenc site. Only one filtered, deep Trident sample was collected (at RP-03-C); this sample had a total DDx concentration of 0.179 J µg/L.

Total DDx concentrations in the eight shallow unfiltered Trident samples ranged from 0.0075 JA µg/L to 3.05 J µg/L. The highest (>3 µg/L, shown as red symbols on Map 5.4-1) unfiltered shallow DDx concentration was measured at AP-03-A (3.05 J µg/L). The three unfiltered deep DDx sample concentrations ranged from 0.169 J µg/L to 5.73 J µg/L, with the highest deep concentration collocated with the highest shallow

[17] DDx was not included on the COI list for the Rhone Poulenc site for the GWPA sampling because pesticides were not expected to be mobile in groundwater at the site (Integral et al. 2005). Subsequent to completion of the GWPA site categorization process, DDx was detected in groundwater at the site (AMEC 2006).

[18] Note that 2,4'-DDD, 2,4'-DDE, and 2,4'-DDT were not sampled during the 2004 Pilot Study; therefore, the total DDx sum for these samples consists of only the 4,4'-DDx isomers. These results are distinguished with an "A" qualifier on Map 5.4-1.

concentration at AP-03-A. Patterns and trends in the data set are discussed in the following subsection.

5.4.4.2 Patterns and Trends of DDx in TZW

Patterns and trends of DDx distribution are evaluated based on maps and stacked bar charts, as described in Section 5.4.3. Evaluation of these patterns and trends for DDx is limited due to low sample size and detection frequencies; however, development of basic conclusions regarding chemical composition and the influence of filtration and sample depth is possible, as presented in the following paragraphs.

As shown on the histograms on Map 5.4-1 and described above, the observed ranges of DDx concentrations are generally higher in unfiltered samples as compared to the observed range for filtered and peeper samples. This tendency observed in the histogram ranges is upheld in a point-by-point assessment of the seven collocated filtered and unfiltered Trident pairs, where unfiltered sample concentrations are over 90 percent greater than filtered samples in four pairs collected offshore of the Arkema Acid Plant area. Higher sample concentrations in unfiltered samples as compared to filtered samples is expected for these highly hydrophobic chemicals, indicating the presence of DDx sorbed to solids larger than the filter diameter (>0.45 μm) in the unfiltered Trident samples. These results indicate that the unfiltered samples in the former Acid Plant area are likely affected by intake of sediment in the unfiltered sampling process. Further, the highest filtered sample result is observed offshore of the Rhone Poulenc site, whereas the collocated unfiltered result offshore of the Rhone Poulenc site (0.21 J μg/L) is well below the average (1.78 μg/L) of all measured unfiltered concentrations; this result suggests that uptake of solids did not influence the unfiltered concentrations measured at RP-03-C.

Comparison of total DDx concentrations in unfiltered samples at the three sample locations (RP-03-C, AP-03-A, R2-AP-02) where both shallow (0 to 38 cm bml) and deep (90 to 150 cm bml) TZW samples were collected shows that the deeper samples consistently have higher concentrations than the shallow samples at AP-03-A and R2-AP-02. However, at RP-03-C the deeper sample is generally comparable to the corresponding shallow samples in both filtered and unfiltered data sets.

Figure 5.4-1 presents bar charts showing percent composition of the six DDx congeners in the 15 samples with a detected total DDx result. The chart only presents samples where all six DDx congeners were analyzed.[19] Samples are organized along the x-axis in groups referring to groundwater discharge zones. (These zones are indicative of areas of similar groundwater discharge conditions, as described in Appendix C2.) On these figures, sample IDs indicate sample location, sample method, sample depth, and field duplicates, as described above in Section 5.4.3. Evaluation of the stacked bar chart in Figure 5.4-1 yields the following observations:

[19] The 2004 Pilot Study samples were analyzed for 4,4'-DDx congeners only, and are therefore not shown on the stacked bar chart in Figure 5.4-1.

- The two duplicate sample pairs (AP-03-A-TR-f and AP-03-A-TR-f-dup; AP-03-A-TR-uf and AP-03-A-TR-uf-dup) show good reproducibility in composition trending.

- Two of the three shallow and deep sample pairs show similar compositions at both depths. The shallow and deep pair collected at R2-AP-02-TR-uf has an extreme concentration difference and shows different composition between the shallow and deep result.

- The bar chart trends further support the overall observed trends noted above in discussions of spatial distribution and filtration effects. The highest total DDx concentrations (concentration indicated by the black line corresponding to the right y-axis) are mainly associated with unfiltered samples (filtered sample IDs are highlighted). These total concentration peaks (designated by the black line) correspond to DDx compositions dominated by 4,4'-DDT plus 4,4'-DDD.

In summary, for the limited data set available, the highest DDx concentrations were observed in unfiltered deep (90 to 150 cm bml) samples collected offshore of the former Acid Plant area. Filtration greatly reduced DDx concentrations measured offshore of the Acid Plant, indicating that DDx is present on solids. The highest filtered sample result is observed offshore of the Rhone Poulenc site. Filtration did not significantly reduce DDx concentrations measured at the single Rhone Poulenc sample location, and the unfiltered results offshore of the Rhone Poulenc site are below the average of unfiltered concentrations observed offshore of the former Acid Plant site. Further, offshore of the former Acid Plant area, TZW concentrations are generally greater at depth (90 to 150 cm bml) as compared those in shallow TZW (0 to 38 cm bml). Conclusions about completeness of the groundwater pathway are presented in detail with additional lines of evidence in Appendix C2 and summarized in Section 4.

5.4.5 Total PAHs in TZW

The following subsections present the in-river distribution of PAHs in TZW samples and note patterns and trends in this data set. The TZW IC list includes total PAHs, HPAHs, cPAHs, BaPEq, as well as individual PAHs BAP and naphthalene. LPAHs are also discussed here to provide for complete discussion of total PAHs and HPAHs, though they are not on the IC list for TZW. The physical properties and behavior patterns of individual PAHs vary with molecular weight, with the larger PAHs exhibiting more hydrophobicity and a stronger tendency to adsorb to sediments.

5.4.5.1 Observed Chemical Distribution of PAHs in TZW

In the Round 2 GWPA SAP (Integral et al. 2005), PAHs were identified as an upland groundwater COI for six of the nine TZW study sites: Kinder Morgan, ARCO, ExxonMobil, Gasco, Siltronic, and Willbridge Terminal. TZW samples for individual PAHs, total PAHs, HPAHs, and cPAHs were collected at a total of 53 individual sample locations offshore of these sites during the 2004 Pilot Study and 2005 GWPA sampling events. Twenty-two locations were sampled for individual PAHs and PAH

sums by Gasco in 2007 (Anchor 2008b), and 13 locations were sampled by Siltronic in 2005 (HAI 2005a; MFA 2005a). An additional 24 deep (90 cm bml) naphthalene samples were also collected by Siltronic. All sample results for summed and individual PAH parameters in TZW are presented in the SCRA database (Appendix A3) and are summarized in Appendix D4, Table D4-1.

These sample results are presented on Maps 5.4-2a–e, 5.4-3a–d, 5.4-4a–d, and 5.4-5a–e, for PAHs (including LPAHs and HPAHs), cPAHs (including BaPEq values), BAP, and naphthalene, respectively. Each map set presents filtered (top panel) and unfiltered (bottom panel) TZW results, where available, with inset histograms summarizing the distribution of samples shown on each map relative to the distribution across the TZW data set. There are 34 collocated filtered and unfiltered Trident sample pairs, and there are seven deep (90 to 150 cm bml) Trident samples in this data set. For naphthalene, there are an additional 24 deep (90 cm bml) samples collected from RM 6 to 7. For total PAHs, cPAHs, and BAP, sample results collected between RM 6 and 7 are presented on two maps to allow for presentation of all sample concentration results in this densely sampled area (the first map shows concentration labels for LWG-collected data, and the second map shows concentration labels for non-LWG collected data).

Naphthalene sample results are presented on Maps 5.4-5a–e. Naphthalene is a two-ring LPAH, and has the lowest molecular weight of all the PAHs. Naphthalene data were collected as part of VOC sample analysis (EPA method SW8260), as well as PAH sample analysis (EPA method 8270), and therefore naphthalene was sampled at more locations (160) than other individual PAHs or total PAH sums (88 locations). Where naphthalene results were generated using both analysis techniques, the method 8260 results are presented.[20] Due to its high volatility, only unfiltered sample results are presented on Maps 5.4-5a–e. For naphthalene, sample results collected between RM 6 and 7 are presented on three maps (Map 5.4-5b presents all shallow sample results; Map 5.4-5c is a zoom-in to show shallow sample results in the most densely sampled area; Map 5.4-5d presents all deep sample results).

5.4.5.1.1 Total PAHs

PAHs were detected in TZW samples offshore of all six sites. Total PAH values observed in TZW cover a large concentration range. In shallow filtered Trident and peeper samples, concentrations ranged from detection limits (0.042 U µg/L to 0.073 U µg/L) to 1,200 J µg/L; in unfiltered Trident and Geoprobe samples, concentrations ranged from detection limits (0.036 U µg/L to 0.043 U µg/L) to 15,100 JA µg/L. The highest PAH sample results were observed offshore of the Gasco and Siltronic sites, with the maximum filtered result measured at GS-02-A, at the downstream end of the Gasco site. The highest (>1,000 µg/L; shown as red symbols on Maps 5.4-2a-e) unfiltered concentrations of total PAHs in TZW were observed at stations GP-73 (15,100 JA µg/L), GP-68 (13,100 JA µg/L), GP-64 (12,600 JA µg/L),

[20] Seventy-eight naphthalene samples were analyzed with both 8260 and 8270 methods. Of these, 49 samples were below detection limits for both methods. For the 19 samples which were detected with both methods, higher concentrations were found with method 8260 in 73% of the samples.

and GP-69 (12,100 JA µg/L), all located roughly offshore of the property line between the Gasco and Siltronic sites. Unfiltered, deep Trident (90 to 150 cm bml) total PAH sample concentrations ranged from 0.67 to 430 µg/L, with the highest deep concentration at GS-08-D, also located offshore of the property line between the Gasco and Siltronic sites. No filtered deep Trident samples were collected.

Observed PAH concentration ranges varied substantially among the offshore study areas, with the highest total PAH concentrations consistently being observed offshore of the Gasco (up to 15,100 JA µg/L) and Siltronic (up to 13,100 JA µg/L) sites. The lowest range of TZW PAH concentrations was observed offshore of the Willbridge Terminal site. These relative concentration ranges are apparent on the inset histograms on Maps 5.4-2a–e.

5.4.5.1.2 LPAHs and HPAHs

LPAH and HPAH components of the total PAH sum are shown in concentration labels on Maps 5.4-2a–e. These maps indicate that LPAH concentrations are consistently higher than HPAHs in TZW sampled across the Study Area. Further, LPAH concentrations show similar spatial patterns to the total PAH concentrations.

In peeper and filtered Trident samples, HPAH concentrations range from detection limits (0.0071 U µg/L to 0.38 U µg/L) to 7.6 J µg/L, while LPAH concentrations range from detection limits (0.042 U µg/L to 0.073 U µg/L) to 1,190 µg/L. In unfiltered Trident and Geoprobe samples, HPAH concentrations covered a higher range, from detection limits (0.036 U µg/L to 0.66 U µg/L) to 880 µg/L, as did LPAH concentrations, ranging from detection limits (0.016 U µg/L to 0.069 U µg/L) to 14,600 JA µg/L.

For both HPAH and LPAH sums, the highest results were recorded offshore of the Gasco and Siltronic sites. The highest unfiltered HPAH concentration was recorded at GS-B2 near the north end of the Gasco site. The highest filtered and peeper HPAH concentrations were also measured in this area at GS-01-B (7.6 J µg/L) and GS-02-A (5.46 J µg/L). The highest unfiltered LPAH concentration was recorded at GP-73, roughly offshore of the property line between the Gasco and Siltronic sites. The highest filtered LPAH results were located at the north end of the Gasco site at GS-02-A (1,190 µg/L) and GS-01-B (290 µg/L).

5.4.5.1.3 Total Carcinogenic PAHs

cPAH represents the sum of a subset of HPAHs and, as expected, the cPAH distribution follows that of HPAHs as shown on Maps 5.4-3a–d. In peeper and filtered Trident samples, cPAH concentrations range from detection limits (0.0024 U µg/L to 0.017 U µg/L) to 0.64 J µg/L. In unfiltered Trident and Geoprobe samples, cPAH concentrations range from detection limits (0.0077 U µg/L to 0.086 U µg/L) to 300 µg/L. The maximum filtered, peeper, and unfiltered cPAH concentrations measured were collocated with the maximum HPAH results at GS-02-A, GS-01-B, and GS-B2, respectively. Toxicity-weighted BaPEq concentrations range from detection

limits (0.0018 U µg/L to 0.028 U µg/L) to 70.3 µg/L. cPAH BaPEq concentrations are positively correlated with cPAH concentrations and maximum results were collocated with HPAH and cPAH maximum results.

5.4.5.1.4 Benzo(a)pyrene

BAP is a five-ring HPAH. Maps 5.4-4a–d show that the BAP spatial distribution follows that of HPAHs. In peeper and filtered Trident samples, BAP concentrations range from below detection limits (0.0018 U µg/L to 0.012 U µg/L) to 0.082 µg/L. In unfiltered Trident and Geoprobe samples, BAP concentrations range from detection limits (0.0021 U µg/L to 0.062 U µg/L) to 50 µg/L. The maximum filtered, peeper, and unfiltered BAP concentrations measured were collocated with the maximum HPAH results at GS-02-A, GS-01-B, and GS-B2, respectively.

5.4.5.1.5 Naphthalene

Naphthalene is a two-ring LPAH, and has the lowest molecular weight of all the PAHs. Maps 5.4-5a–e present naphthalene concentrations for peeper, unfiltered Trident, and unfiltered Geoprobe samples. In unfiltered shallow Trident and Geoprobe samples, naphthalene concentrations range from detection limits (0.0063 U µg/L to 15 U µg/L[21]) to 13,700 µg/L. The highest (>10,000 µg/L; shown as red symbols on Maps 5.4-5a–e) concentrations were observed offshore of the Gasco and Siltronic sites, with maximum shallow naphthalene concentrations collocated with or proximal to the maximum total PAH and LPAH locations at GP-73 (13,700 µg/L), GP-71 (12,400 µg/L), GP-68 (12,300 µg/L), and GP-64 (12,200 µg/L). Deep Trident (90 to 150 cm bml) and Geoprobe (91 cm bml) naphthalene sample concentrations ranged from detection limits (0.041 U µg/L to 150 U µg/L[22]) to 11,200 µg/L, with the highest deep concentration at GP-76, also located offshore of the property line between the Gasco and Siltronic sites.

Patterns and trends in the data sets for total PAHs, cPAHs, BAP, and naphthalene are discussed in the following subsection.

5.4.5.2 Patterns and Trends of PAHs in TZW

As shown on the river-mile-specific portions of the histograms of Maps 5.4-2a–e and described above, the observed ranges of unfiltered total PAH concentrations for each river mile sampled are higher than filtered and peeper-sampled concentrations. This trend is upheld in a point-by-point assessment of the 34 collocated filtered and unfiltered Trident pairs for total PAHs. Looking at the filtered and unfiltered Trident pairs, filtration decreased the average total PAH concentration by 24 percent, with a maximum decrease of up to 99 percent (AR-02-B). Note that the apparent large decrease in the total PAH concentration range with filtration seen on the harbor-wide portion of the histograms is largely attributable to the lack of filtered PAH samples from

[21] High detection limits were reported for six samples, all located offshore of the former Arkema Acid Plant site and the Rhone Poulenc site. The median detection limit for naphthalene for the entire TZW data set is 0.29 µg/L.

[22] See previous note above.

the non-LWG investigations offshore of the Siltronic and Gasco sites. The Siltronic and Gasco unfiltered results account for most of the >1,000 µg/L values.

By examining the effects of filtration, the effects of individual PAH hydrophobicity can be seen in the data set. As shown on inset histograms on Maps 5.4-3a–d and 5.4-4a–d, the large, hydrophobic cPAHs and BAP show extreme differences between filtered and unfiltered results (with an average of over 95 percent decrease in a paired sample comparison for both cPAHs and BAP), suggesting that these chemicals are present on solids >0.45 µm in diameter in unfiltered TZW samples. In contrast, the smaller, less hydrophobic individual PAHs have a lesser tendency to bind to sediment and would be expected to be less affected by filtration, contributing the lower net effect of filtration on total PAH concentrations. This filtration effect on total PAHs is therefore a function of the composition of each sample.

Comparison of total PAH concentrations in the seven collocated deep and shallow (0 to 38 cm bml) TZW samples shows that the unfiltered deep samples consistently exhibit higher concentrations than the corresponding shallow samples. In some cases, the unfiltered, deep sample concentrations are up to 2 orders of magnitude greater than the collocated shallow samples. The three filtered deep/shallow sample pair results, however, show no clear relative trend. As with total PAHs, analysis of collocated deep/shallow sample pair results shows that unfiltered concentrations of HPAHs, cPAHs, and BAP are generally much higher in deep samples. For naphthalene, 17 collocated deep (90 to 150 cm bml) and shallow (0 to 38 cm bml) Trident samples and 24 collocated deep (91 cm bml) and shallow (31 cm bml) Geoprobe samples were collected. In general, for the high (>1,000 µg/L) concentration samples collected from RM 6 to 7, shallow samples showed somewhat higher concentrations than collocated deep samples. For other parts of the Study Area, no clear trends with depth were observed for naphthalene.

Stacked bar charts showing percent composition of detected total PAH sums are shown on Figures 5.4-2a–f. The charts present total PAH concentration (indicated by the black line corresponding to the right y-axis), as well as the fraction of the total contributed by each of the 17 PAHs. Charts are presented for each relevant TZW study site, with samples organized along the x-axis in groups referring to groundwater discharge zones. These zones are indicative of areas of similarly mapped groundwater discharge conditions offshore of the given study site and are presented and discussed in detail in Appendix C2.

There are a several patterns apparent in these stacked bar charts. First, duplicate sample pairs show good reproducibility in composition trending. Second, the shallow and deep pairs frequently show variable compositions, particularly in cases where the deeper concentration is greater than the shallow concentration (e.g., EM04C-TR-uf-150, which has an extreme concentration difference between the shallow and deep result). This may reflect weathering in the biologically active zone and/or differences in PAH composition in sediment with depth. Next, a distinct chemical composition is generally

present at sample locations with very high total PAH concentrations. Acenaphthene is the dominant component of total PAH sums in most samples; however, at sample locations with total PAHs greater than ~1,000 µg/L, naphthalene concentrations clearly dominate the composition. This result is interesting to evaluation of TZW because naphthalene is the most mobile chemical of the PAHs. This composition pattern is apparent in the bar charts for TZW data offshore of the Gasco and Siltronic sites (Figures 5.4-2d and 5.4-2e). These areas correspond to suspected discharge zones offshore of the Siltronic and Gasco sites (discussed in detail in Appendix C2). Composition trends with concentration and location are less apparent at the other TZW study sites, where total PAH concentrations cover a much lower concentration range.

In summary, of the sites sampled, total PAH concentrations were found to be highest offshore of the Gasco and Siltronic sites. Total HPAH, total cPAH, and BAP results showed similar distribution and filtration patterns. Because LPAHs tend to compose the majority of the total PAH concentrations, LPAH and naphthalene results generally followed the distribution patterns apparent for total PAHs. Filtration was observed to decrease the total PAH concentration slightly, with greater effects on the more hydrophobic PAHs, as expected. For total PAHs, total HPAH, total cPAH, and BAP, the unfiltered deeper (90 to 150 cm bml) Trident samples consistently showed higher concentrations than corresponding unfiltered shallow (0 to 38 cm bml) samples. Review of the fractional composition of the 17 individual chemicals that comprise total PAH shows a clear pattern of high naphthalene concentrations associated with high total PAH concentrations offshore of the Gasco and Siltronic sites. For these high-concentration naphthalene locations, shallow (31 cm bml) Geoprobe samples generally had slightly higher concentrations than the collocated deeper (91 cm bml) samples. Additional evaluation of PAHs in TZW is provided in the detailed, site-specific discussions of groundwater pathways in Appendix C2.

5.4.6 TPH in TZW

The following subsections present the in-river distribution of TPH results in TZW samples, as well as a discussion of patterns and trends in this data set. The TZW IC list includes DRH, RRH, and GRH. TPH is not a TZW IC, but it is presented and discussed here to support the discussion of the distribution and patterns of the components. TPH, as analyzed for the Round 2 investigation, is the measure of all hydrocarbons and non-hydrocarbons that can be quantified in the carbon range from n-C_6 to n-C_{38}. Likewise, the components (DRH, RRH, and GRH) are simply descriptive laboratory terms for the fractions of TPH, and not source assignments or indications of toxicity. Further, the TPH data contain hydrocarbons of both natural and anthropogenic origin.

5.4.6.1 Observed Chemical Distribution of TPH in TZW

In the Round 2 GWPA SAP (Integral et al. 2005), TPH was identified as an upland groundwater COI for six of the nine TZW study sites: Kinder Morgan, ARCO, ExxonMobil, Gasco, Siltronic, and Willbridge Terminal. Shallow TZW samples for TPH were collected at a total of 47 individual sample locations offshore of these sites during the 2004 Pilot Study and 2005 GWPA sampling events. Paired filtered and

unfiltered samples were collected at 30 of these locations, and deep samples (90 to 150 cm bml) were collected at eight of these locations. TPH was not sampled during the non-LWG TZW investigations at Siltronic in 2005 (MFA 2005a,b) and Gasco in 2007 (Anchor 2008b).

Sample results are presented on Maps 5.4-6a–d, including distinction in the flyout boxes of diesel-range, residual-range, and gasoline-range fractions of TPH. These maps present filtered (top panel) and unfiltered (bottom panel) TZW results, where available, with inset histograms summarizing the distribution of samples shown on each map relative to the distribution across the entire Study Area. Note that gasoline-range fractions of TPH are volatile, and were therefore not evaluated for filtered samples. All summed and individual TPH sample results for TZW are presented in the SCRA database (Appendix A3) and are summarized in Appendix D4, Table D4-1.

TPH was detected in TZW samples offshore of all six of the studied sites. TPH values observed in TZW cover a fairly large concentration range, varying from undetected (detection limits ranged from 0.058 U mg/L to 0.26 U mg/L) to 4.1 J mg/L in filtered Trident and peeper samples. In unfiltered Trident samples, observed concentrations ranged from undetected (detection limits ranged from 0.038 U mg/L to 0.18 U mg/L) to 11.3 J mg/L. The highest concentrations of TPH in TZW were observed offshore of the Gasco and Siltronic sites, with the highest unfiltered Trident concentrations of TPH observed at Gasco locations GS-07-B (11.3 J mg/L) and GS-02-A (6.01 J mg/L) in unfiltered samples, and the highest filtered or peeper TPH results observed at Gasco location GS-02-A (4.1 J mg/L) and Siltronic location SL-04-F (2.35 J mg/L). The lowest range of TZW TPH concentrations were observed offshore of the Willbridge Terminal site.

5.4.6.2 Patterns and Trends of TPH in TZW

As shown on the histograms of the TPH map series, the distribution of unfiltered samples covers a larger and higher concentration range than the distribution of filtered samples; however, it should be noted that filtered TPH values do not include GRH (per sampling protocols for VOCs, filtered samples of GRH were not collected). Focusing on DRH and RRH (Table D4-1), it is clear, however, that filtration consistently decreases the concentration of these components. Further interpretation of this apparent effect of filtration is complicated by the expected variability in TPH composition (and corresponding hydrophobicity) from site to site (and likely sample to sample). As noted above, TPH, as analyzed for the Round 2 investigation, is simply the measure of all hydrocarbons and non-hydrocarbons that can be quantified in the carbon range from n-C_6 to n-C_{38}, with no distinction/identification of specific component chemicals.

Comparison of TPH concentrations in the eight deep sample locations (90 to 150 cm bml) with the corresponding shallow results (0 to 38 cm bml) shows deep unfiltered results to be generally greater than shallow unfiltered results. Filtered deep results, however, show no clear trend. As discussed in Appendix C2, this information was

evaluated in greater detail for each TZW study site in the consideration of groundwater pathway along with other lines of evidence.

To support consideration of patterns in the fractional composition of TPH, stacked bar charts are presented in Figures 5.4-3a–f, with one figure for each relevant TZW study site. Each figure presents results grouped by interpreted groundwater discharge zones. These zones are indicative of areas of similarly mapped groundwater discharge conditions offshore of the given study site and are discussed in detail in Appendix C2. These figures present both filtered and unfiltered results, with filtered sample IDs highlighted. As noted above, the filtered results for TPH do not contain GRH fractions. A general review of these figures reveals that, with few exceptions, duplicate results (indicated by "dup" in the sample ID) show similar composition and total concentration to the original sample.

Looking at the bar chart results site-by-site, there are few notable patterns in these plots relative to the interpreted zoning of groundwater discharge. Offshore of the Siltronic site, the "offshore discharge zone," where there is a complete pathway for groundwater discharge of select VOCs (discussed in Appendix C2), shows a fairly clear TPH composition shift toward GRHs, as compared to the samples from the other Siltronic zones. (Note again that the highlighted filtered samples do not contain GRH in the TPH composition presented.) Similar increases in GRH fractional composition of TPH can be seen in samples offshore of the Gasco, ARCO, and ExxonMobil sites; however, dominance of the TPH concentration in these unfiltered samples offshore of these sites is also generally accompanied by a sharp decrease in TPH concentration, making the pattern more difficult to interpret (possibly more reflective of the lack of DRH and RRH than any increase in GRH). Further, these concentration ranges are close to detection limits, and the GRH results typically have lower detection limits (the average gasoline-range detection limit was 0.06 mg/L compared to 0.14 and 0.16 mg/L for RRH and DRH samples).

In summary, the general nature of the analyte TPH (unknown mixture of anthropogenic and natural hydrocarbons and non-hydrocarbons that can be quantified in the carbon range from n-C_6 to n-C_{38}) significantly confounds detailed, source-related interpretation of results. Overall, filtration was observed to decreases the DRH and RRH fractions. Review of the fractional components (DRH, RRH, and GRH) showed a composition shift toward GRH in the offshore discharge zone at the Siltronic site; however, patterns elsewhere were generally weak and more difficult to interpret when TPH concentration changes were also considered. Site-specific conclusions about groundwater pathway are presented in detail with additional lines of evidence in Appendix C2 and summarized in Section 4.

5.4.7 Additional Indicator Chemicals in TZW

The following subsections present brief descriptions of the in-river distribution of TZW ICs not on the Study Area-wide bounding chemical list (total PCBs, total PCDD/Fs, total DDx, total PAHs). Note that the bounding ICs were not the focus chemicals at all

TZW study sites and were not sampled at many of the sites. As described in the introduction to Section 5.4, the distribution of additional ICs in TZW is briefly discussed here. These additional ICs are grouped by chemical type, where possible, in the subsequent discussions. Supporting maps are presented for all chemicals. All sample results for TZW are presented in the SCRA database (Appendix A3) and are summarized in Appendix D4, Table D4-1.

5.4.7.1 Silvex in TZW

Samples were analyzed for the herbicide Silvex in TZW in the vicinity of the former Rhone Poulenc plant. The sampling results for Silvex in TZW are shown on Map 5.4-7. Seven locations were sampled in the shallow TZW (0 to 38 cm bml), and 2 collocated deeper samples were collected (90 to 150 cm bml). Additionally, six collocated filtered samples were collected.

Silvex was detected in 27 percent of the samples. Silvex concentrations in TZW samples ranged from undetected (detection limits ranged from 0.06 U µg/L to 0.37 U µg/L) to 22 µg/L, with the maximum concentration measured at RP-03-E. All Silvex detections were located within a zone identified as an offshore groundwater discharge zone for the Rhone Poulenc site. This zone is presented in Section 4 and discussed in detail in Appendix C2, along with the lines of evidence used to make this determination.

5.4.7.2 Cyanide in TZW

Samples were analyzed for cyanide in TZW offshore of only the Gasco and Siltronic sites during the Round 2 GWPA sampling effort and during the two non-LWG sampling efforts (Anchor 2008b; MFA 2005a,b). The sampling results for cyanide in TZW are shown on Map 5.4-8. Fifty-two locations were sampled offshore of these two sites for cyanide, and three paired deep (90 to 150 cm bml) samples were collected. For cyanide, only unfiltered samples were collected. Total cyanide, very soluble and chemically stable, is not expected to adsorb significantly to solids. Measurements of the most toxic form of cyanide, free cyanide, were made offshore of the Gasco and Siltronic sites as part of the non-LWG 2007 investigation (Anchor 2008b); however, free cyanide was only detected in one of those samples (GS-B2). Free cyanide is discussed in detail in the *Offshore Investigation Report, NW Natural "Gasco" Site* (Anchor 2008b).

Total cyanide was detected in 95 percent of the TZW samples. Cyanide concentrations ranged from undetected (detection limits ranged from 0.003 U mg/L to 1.4 U mg/L) to 23.1 J mg/L, with the maximum concentration observed at GS-02-A. Cyanide concentrations in the three deeper TZW samples (90 to 150 cm bml) were comparable to the concentrations observed in the shallow (0 to 38 cm bml) samples. Site-specific conclusions about groundwater pathway are presented in detail with additional lines of evidence in Appendix C2.

5.4.7.3 Perchlorate in TZW

Samples were analyzed for perchlorate in TZW only offshore of the former Chlorate Plant and former Acid Plant areas of the Arkema site. The sampling results for perchlorate in TZW are shown on Map 5.4-9. Twenty locations were sampled in the shallow TZW (0 to 38 cm bml), and seven samples were collected in deeper TZW (90 to 150 cm bml). Only unfiltered samples were collected, since perchlorate is ionic and not expected to adsorb significantly to solids.

Perchlorate was detected in 52 percent of the samples. Perchlorate concentrations in shallow TZW samples ranged from undetected (detection limits ranged from 0.4 U µg/L to 20,000 U µg/L[23]) to 177,000 µg/L; and the maximum deeper (90 to 150 cm bml) sample concentrations ranged from undetected (detection limits ranged from 40 U µg/L to 40,000 U µg/L[24]) to 210,000 µg/L. These values are comparable to or higher than those observed in the upland nearshore groundwater. Perchlorate concentrations in the deeper TZW samples (90 to 150 cm bml) collected offshore of the Arkema site were often higher than in the collocated shallower samples (0 to 38 cm bml). The highest (>100,000 µg/L; shown as red symbols on Map 5.4-9) perchlorate concentrations were found along transect 7 (sampling locations CP-07-A, CP-07-B, and CP-07-D).

5.4.7.4 Metals in TZW

The TZW IC list includes eight metals: arsenic, barium, cadmium, copper, lead, manganese, nickel, and zinc. As part of the 2004 Pilot Study, Round 2 GWPA, and non-LWG Gasco and Siltronic sampling efforts, samples were analyzed for metals at all nine TZW study sites. Where sample volumes permitted in the Round 2 GWPA sampling effort, filtered samples were also collected; however, only three filtered metals samples were collected as part of the non-LWG investigation offshore of the Gasco and Siltronic sites. This distinction is important to note when reviewing the paired figures showing filtered and unfiltered results for each metal. In all, 126 locations were sampled for metals. Of these, filtered pairs were collected at 62 locations and paired deep samples (90 to 150 cm bml with Trident) were collected at 22 locations.

Sampling results for metals are also presented on scatter plots in Figures 5.4-4a–h. These figures show sample concentrations along an x-axis noting the river mile of each sample location. Color-coded symbols distinguish sample type and depth. Paired plot sets are presented for each chemical to show filtered and unfiltered results, where available. Additionally, arsenic, copper, and zinc results are presented on Maps 5.4-10a–e, 5.4-11a–e, and 5.4-12a–e, respectively, to support cross-media consideration in Section 10 (these are the TZW IC metals that are also included on the CSM IC list, Table 5.0-2).

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[23] High detection limits (4,000 U µg/L, 20,000 U µg/L, and 40,000 U µg/L) were reported for 3 samples, all located offshore of the former Arkema Acid Plant site. The median detection limit for perchlorate for the entire TZW data set is 10 µg/L.

[24] See note 23 above.

5.4.7.4.1 Arsenic Distribution

Arsenic TZW results are shown on Figure 5.4-4a and Maps 5.4-10a–e. Arsenic was detected in 88 percent of TZW samples, and detection limits ranged from 0.2 U µg/L to 20 U µg/L. Detected arsenic concentrations ranged from 0.3 J µg/L to 77.3 µg/L, with an average concentration of 11.1 µg/L. Both filtered and unfiltered arsenic concentrations spanned generally consistent ranges across the Study Area. Evaluation of paired filtered and unfiltered detected samples shows that filtration decreases the total arsenic concentration by 16 percent on average. Deep (90 to 150 cm bml) Trident samples showed higher concentrations than collocated shallow (0 to 38 cm bml) samples in 17 of 24 collocated deep/shallow sample pairs The tendency of arsenic compounds to associate with sediment particles can be highly variable and is strongly influenced by redox chemistry and microbial processes. A more detailed biogeochemical discussion of arsenic in TZW, sediments, and upland groundwater is presented in Appendix C2.

5.4.7.4.2 Barium Distribution

Barium TZW results are shown on Figure 5.4-4b. Barium was detected in 99 percent of TZW samples. Detected barium concentrations ranged from 4.06 to 4,630 µg/L, with an average concentration of 334 µg/L. The highest (>1,000 µg/L) peeper, unfiltered Trident, and unfiltered push probe barium concentrations were observed offshore of the Gasco, Arkema, and Rhone Poulenc sites, while notably high filtered barium measurements were observed offshore of the Arkema site. Evaluation of paired filtered and unfiltered detected samples shows that filtration decreases the total barium concentration by 38 percent on average. Deep (90 to 150 cm bml) Trident samples showed higher concentrations than collocated shallow (0 to 38 cm bml) samples in 14 of 24 collocated deep/shallow sample pairs. The tendency of barium compounds to associate with sediment particles can be highly variable and is strongly influenced by redox chemistry and microbial processes. A more detailed biogeochemical discussion of barium in TZW, sediments, and upland groundwater is presented in Appendix C2.

5.4.7.4.3 Cadmium Distribution

Cadmium TZW results are shown on Figure 5.4-4c. Cadmium was detected in 68 percent of TZW samples, with detection limits ranging from 0.002 U µg/L to 0.2 U µg/L and detected concentrations ranging from 0.004 J µg/L to 36 µg/L. The average cadmium concentration is 0.45 µg/L. The highest (>1.5 µg/L) peeper, unfiltered Trident, and unfiltered push probe cadmium concentrations were observed offshore of the Arkema (former Chlorate Plant area), Gasco, and Siltronic sites, while filtered Trident and push probe cadmium concentrations were consistently low across the Study Area. Evaluation of paired filtered and unfiltered detected samples shows that filtration decreases the total cadmium concentration by 53 percent on average. Deep (90 to 150 cm bml) Trident samples showed higher concentrations than collocated shallow (0 to 38 cm bml) samples in 9 of 24 collocated deep/shallow sample pairs. Neither the filtered nor unfiltered Trident samples exhibited consistent trends with depth.

5.4.7.4.4 Copper Distribution

Copper TZW results are shown on Figure 5.4-4d and Maps 5.4-11a–e. Overall, copper was detected in 51 percent of TZW samples, and detection limits ranged from 0.08 U µg/L to 32.9 U µg/L. Detected peeper, Trident, and push probe copper concentrations ranged from 0.28 to 555 µg/L, with an average concentration of 27.9 µg/L. The highest (>100 µg/L) concentrations were measured offshore of the Gasco and Siltronic sites in push probe samples. The low (30 percent) detection frequency for filtered copper samples is evident in the lower plot on Figure 5.4-4d, with few detected filtered copper samples observed across the Study Area. Evaluation of paired filtered and unfiltered detected samples shows that filtration decreases the total copper concentration by 92 percent on average, suggesting that most copper in the transition zone is associated with >0.45 µm particles. Deep (90 to 150 cm bml) Trident samples showed higher concentrations than collocated shallow (0 to 38 cm bml) samples in 5 of 24 collocated deep/shallow sample pairs. Neither the filtered nor unfiltered Trident samples exhibited consistent trends with depth.

5.4.7.4.5 Lead Distribution

Lead TZW results are shown on Figure 5.4-4e. Lead was detected in 55 percent of TZW samples, with detection limits ranging from 0.01 U µg/L to 20 U µg/L. Detected lead concentrations ranged from 0.01 J µg/L to 382 J µg/L, with an average concentration of 17.4 µg/L. The highest (>50 µg/L) total lead concentrations (peeper, unfiltered Trident, and unfiltered push probe) were observed offshore of the Gasco, Siltronic, Arkema, and ARCO sites, while filtered Trident and push probe lead concentrations were consistently low across the Study Area. Evaluation of paired filtered and unfiltered detected samples shows that filtration decreases the total lead concentration by 97 percent on average, suggesting that most lead in the transition zone is associated with solids. Deep (90 to 150 cm bml) Trident samples showed higher concentrations than collocated shallow (0 to 38 cm bml) samples in 11 of 24 collocated deep/shallow sample pairs. Neither the filtered nor unfiltered Trident samples exhibited consistent trends with depth.

5.4.7.4.6 Manganese Distribution

Manganese TZW results are shown on Figure 5.4-4f. Manganese was detected in all of the TZW samples collected, with a concentration range from 23 J µg/L to 66,200 µg/L and an average concentration of 4,930 µg/L. Filtered, peeper, and unfiltered manganese concentrations spanned generally consistent ranges across the Study Area. Filtration reduced manganese sample concentrations somewhat, with an average reduction of 22 percent for detected unfiltered and filtered sample pairs. Deep (90 to 150 cm bml) Trident samples showed higher concentrations than collocated shallow (0 to 38 cm bml) samples in 11 of 24 collocated deep/shallow sample pairs. Neither the filtered nor unfiltered Trident samples exhibited consistent trends with depth. The tendency of manganese compounds to associate with sediment particles can be highly variable and is strongly influenced by redox chemistry and microbial processes. A more detailed biogeochemical discussion of manganese in TZW, sediments, and upland groundwater is presented in Appendix C2.

5.4.7.4.7 Nickel Distribution

Nickel TZW results are shown on Figure 5.4-4g. Nickel was detected in 87 percent of TZW samples, and detection limits ranged from 0.2 UJ µg/L to 20 U µg/L. Detected nickel concentrations ranged from 0.2 J µg/L to 367 µg/L, with an average concentration of 18.5 µg/L. The highest (>100 µg/L) total nickel concentrations (peeper, unfiltered Trident, and unfiltered push probe) were observed offshore of the Gasco, Siltronic, and Arkema sites, while filtered Trident and push probe nickel concentrations were consistently low across the Study Area. Evaluation of paired filtered and unfiltered detected samples shows that filtration decreases the total nickel concentration by 49 percent on average. Deep (90 to 150 cm bml) Trident samples showed higher concentrations than collocated shallow (0 to 38 cm bml) samples in 8 of 24 collocated deep/shallow sample pairs. Neither the filtered nor unfiltered Trident samples exhibited consistent trends with depth.

5.4.7.4.8 Zinc Distribution

Zinc TZW results are shown on Figure 5.4-4h and Maps 5.4-12a–e. Zinc was detected in 66 percent of TZW samples, with detection limits ranging from 0.78 UJ µg/L to 16.4 U µg/L. Detected zinc concentrations ranged from 0.95 to 3,590 µg/L, with an average concentration of 113 µg/L. The highest (>1,000 µg/L) total zinc concentrations were observed offshore of the Gasco and Siltronic sites in unfiltered push probe samples, while the highest (>20 µg/L) filtered Trident and push probe zinc concentrations were measured offshore of the ARCO and Gasco sites. Evaluation of paired filtered and unfiltered detected samples shows that filtration decreases the total zinc concentration by 81 percent on average, suggesting that most zinc in the transition zone is associated with >0.45 µm particles. Deep (90 to 150 cm bml) Trident samples showed higher concentrations than collocated shallow (0 to 38 cm bml) samples in 9 of 24 collocated deep/shallow sample pairs.

5.4.7.4.9 Metals Patterns and Trends

In general, cadmium, copper, lead, nickel, and zinc in TZW showed a relatively consistent baseline range of concentrations offshore of all the nine TZW study sites, with relatively elevated levels offshore of a few of the study sites as shown on Figures 5.4-4a–h and Maps 5.4-10a–e, 5.4-11a–e, and 5.4-12a–e. Filtration reduced TZW concentrations by more than 50 percent for cadmium, copper, lead, nickel, and zinc. Both filtered and unfiltered arsenic and manganese concentrations spanned generally consistent ranges across the Study Area. The spatial distribution of metals likely reflects some combination of upland groundwater transport, local sediment redox conditions, and sediment contamination, varying by site and metal.

Filtration significantly and consistently reduced TZW sample concentrations for cadmium, copper, lead, nickel, and zinc, suggesting that much of the observed total concentration for these metals was associated with solid particles. Differences with filtration were not as pronounced for arsenic, barium, and manganese. (Note in review of Figures 5.4-4a–h, paired filtered results are not available for most samples collected offshore of the Gasco and Siltronic sites as part of the non-LWG investigations.)

Analysis of collocated shallow (0 to 38 cm bml) and deep (90 to 150 cm bml) TZW results did not show consistent trends with depth for any of the metals.

Site-specific conclusions about groundwater pathways are presented in detail with additional lines of evidence in Appendix C2 and summarized in Section 4. Additionally, a geochemical analysis of arsenic, barium, and manganese is presented in Appendix C2 to further investigate the origin of the observed TZW concentrations. The geochemical analysis includes a statistical evaluation of the spatial distribution of these metals in TZW across the nine TZW study sites and a comparison of TZW concentrations with available upland groundwater concentrations. Geochemical controls on arsenic, barium, and manganese in TZW were evaluated by exploring correlations between metal concentrations and measured variables (e.g., pH, oxidation-reduction potential [ORP], alkalinity, and TOC) that could be expected to exert an influence upon their geochemical behavior. Geochemical modeling was performed to identify stable mineral and aqueous phases as a function of pH and Eh, mineral saturation indices, and mineral phases controlling the aqueous solubility of arsenic, barium, and manganese.

5.4.7.5 Chlorinated VOCs and SVOCs in TZW

The TZW IC list includes nine chlorinated VOCs (MCB; chloroethane; 1,2-DCA; 1,1,2-TCA; vinyl chloride; cis-1,2-DCE; TCE; chloroform; and methylene chloride) and one chlorinated SVOC (1,2-DCB). These VOCs were sampled offshore of all nine study sites as part of the 2004 Pilot Study, Round 2 GWPA, and non-LWG Gasco and Siltronic sampling efforts. In all, 150 locations were sampled for VOCs. Of these, paired deep (90 to 150 cm bml) Trident samples were collected at 18 locations throughout the Study Area, and 24 paired deep (91 cm bml) Geoprobe samples were collected offshore of Gasco and Siltronic. No filtered VOC or 1,2-DCB samples were collected, per sampling protocols for volatile compounds. Sampling results for these chemicals are presented spatially on Maps 5.4-13 through 5.4-18. Results are presented graphically for only those river miles where the chemicals were detected (Table 5.4-1 summarizes the mapped areas for each chemical). All sample results for VOCs and SVOCs in TZW are also presented in the SCRA database (Appendix A) and are summarized in Appendix D4, Table D4-1. Detailed site-by-site assessments of VOC concentrations with depth, along with other lines of evidence, are provided in Appendix C2 to support the assessment of groundwater pathway.

5.4.7.5.1 MCB and 1,2-DCB

Maps 5.4-13a–e present observed MCB and 1,2-DCB concentrations in TZW offshore of the sites where these analytes were detected (Gasco, Siltronic, Rhone Poulenc, and Arkema; RM 6–7 and 7–8). Detected MCB concentrations ranged from 0.15 J µg/L to 30,000[25] µg/L, with the highest MCB concentrations (>1,000 µg/L; indicated by red

[25] The maximum value of 30,000 µg/L was measured in a deep (90 to 150 cm bml) sample. The maximum shallow (0 to 38 cm bml) concentration was 12,000 µg/L. Only shallow samples were used in the loading analysis presented in Section 6.

symbols in the upper panels on Maps 5.4-13a–e) observed offshore of the Arkema site. Detected 1,2-DCB concentrations ranged from 0.14 J µg/L to 640 µg/L. The highest 1,2-DCB concentrations (>250 µg/L; indicated by red symbols in the lower panels on Maps 5.4-13 a–e) were observed near Rhone Poulenc. There were no clear trends in sample concentration with depth for these chemicals across these study sites. The presence of both MCB and DCB offshore may be indicative of the chemicals' release and/or the degree of degradation that has occurred from 1,2-DCB to MCB.

5.4.7.5.2 1,2-DCA and 1,1,2-TCA

Maps 5.4-14a–b present observed 1,2-DCA and 1,1,2-TCA concentrations in TZW offshore of the sites where these analytes were detected[26] (Arkema and Gunderson; RM 7–8 and 8–9). For 1,2-DCA, there were seven detected observations offshore of the Arkema site and four detected observations offshore of the Gunderson site. Detected 1,2-DCA concentrations ranged from 0.13 J µg/L to 770 µg/L. The highest 1,2-DCA concentrations (>100 µg/L; indicated by red symbols in the upper panels on Maps 5.4-14a–b) were observed offshore of the Arkema area. 1,1,2-TCA was detected in three samples measured offshore of the Arkema site and four samples offshore of the Gunderson site. Detected 1,1,2-TCA concentrations ranged from 0.36 J µg/L to 400 µg/L.[27] The highest 1,1,2-TCA concentrations (>100 µg/L; indicated by red symbols in the lower panels on Maps 5.4-14a–b) were also observed offshore of the Arkema area. Detected concentrations in deeper Trident (90 to 150 cm bml) and Geoprobe (91 cm bml) were higher than concentrations observed in shallow samples (0 to 38 cm bml). The presence of both 1,1,2-TCA and 1,2-DCA offshore may be indicative of the chemicals' release and/or the degree of degradation that has occurred from 1,1,2-TCA to 1,2-DCA.

5.4.7.5.3 Chloroethane and Vinyl Chloride

Maps 5.4-15a–f present observed chloroethane and vinyl chloride concentrations in TZW offshore of the sites where these analytes were detected (Siltronic, Rhone Poulenc, Arkema, and Gunderson; RM 6–7, 7–8, and 8–9). The highest concentrations of chloroethane (>100 µg/L; indicated by red symbols in the upper panels on Maps 5.4-15a–f) were observed offshore of the Gunderson site, and chloroethane was only sporadically detected offshore of the other sites. Detected chloroethane concentrations ranged from 0.23 J µg/L to 160 µg/L. In general, chloroethane detections were located in the same areas as TCA and particularly DCA detections, likely related to this degradation chain. Vinyl chloride was more widely detected, with the highest concentrations (>100 µg/L; indicated by red symbols in the lower panels on Maps 5.4-15a–e) observed offshore of the Siltronic and Arkema sites. Detected vinyl chloride concentrations ranged from 0.05 J µg/L to 1,640 µg/L (GP-65; Siltronic), with the exception of higher concentrations measured in shallow (4,300 µg/L) and deep

[26] There were two or fewer detections for 1,2-DCA at RM 4–5 and at RM 6–7 for 1,1,2-TCA; therefore, these areas are not presented on maps.

[27] The maximum value of 400 µg/L was measured in a deep (90 to 150 cm bml) sample. The maximum shallow (0 to 38 cm bml) concentration was 360 µg/L. Only shallow samples were used in the loading analysis presented in Section 6.

(28,900 µg/L) samples collected offshore of Siltronic at station GP-67.[28] In general, vinyl chloride detections were located in the same areas as TCE and particularly DCE detections, likely related to known degradation patterns for chlorinated solvents. There were no clear trends in sample concentration with depth for these chemicals offshore of these study sites.

5.4.7.5.4 Chloroform and Methylene Chloride

Maps 5.4-16a–d present chloroform and methylene chloride concentrations in TZW offshore of the sites where these analytes were detected (Gasco, Siltronic, Rhone Poulenc, Arkema, and Gunderson; RM 6–7, 7–8, and 8–9). The highest concentrations of chloroform (>1,000 µg/L; indicated by red symbols in the upper panels on Maps 5.4-16a–d) were observed offshore of the Arkema site. Chloroform concentrations ranged from undetected (detection limits ranged from 0.056 U µg/L to 130 U µg/L) to 820,000 µg/L[29] (AP-03-A). The highest concentrations of methylene chloride (>100,000 µg/L; indicated by red symbols in the lower panels on Maps 5.4-16a–d) were also observed offshore of the Arkema site, with only sporadic detections offshore of other sites. Detected methylene chloride concentrations ranged from 0.23 J µg/L to 520,000 µg/L (AP-03-B). For both of these chemicals, the deeper Trident (90 to 150 cm bml) and Geoprobe (91 cm) samples generally exhibited higher concentrations than the corresponding shallow TZW samples.

5.4.7.5.5 cis-1,2-DCE and TCE

Maps 5.4-17a–g present cis-1,2-DCE and TCE concentrations in TZW offshore of the sites where these analytes were detected[30] (Siltronic, Rhone Poulenc, Arkema, and Gunderson; RM 6–7, 7–8, and 8–9). The highest concentrations of cis-1,2-DCE (>1,000 µg/L; indicated by red symbols in the upper panels on Maps 5.4-17a–g) were observed offshore of the Siltronic site and the former Acid Plant area of the Arkema site. Detected cis-1,2-DCE concentrations ranged from 0.12 J µg/L to 19,200 µg/L[31] (GP-65), with the exception of higher concentrations measured in shallow (67,000 µg/L) and deep (574,000 µg/L) samples collected offshore of the Siltronic site at GP-67.[32] The highest concentrations of TCE (>1,000 µg/L; indicated by red symbols in the lower panels on Maps 5.4-17a–g) were also observed offshore of the Siltronic site and the former Acid Plant area of the Arkema site. Detected TCE concentrations

[28] GP-67 is located in an area which is understood to be impacted by historical direct discharges of TCE from an outfall and may not be representative of upland groundwater, as discussed in Appendix C2 and Section 10.

[29] The maximum value of 820,000 µg/L was measured in a deep (90 to 150 cm bml) sample. The maximum shallow (0 to 38 cm bml) concentration was 770,000 µg/L, measured at AP-03-B. Only shallow samples were used in the loading analysis presented in Section 6.

[30] Note three low-level detections of TCE (0.15 J µg/L to 0.46 J µg/L) offshore of the ARCO site, and one low-level detection of cis1,2-DCE (0.59 µg/L) offshore of the ExxonMobil site are not shown on maps.

[31] The maximum value of 19,200 µg/L was measured in a deep (91 cm bml) sample. The maximum shallow (30 cm bml) concentration was 14,400 µg/L, also measured at GP-65. Only shallow samples were used in the loading analysis presented in Section 6.

[32] GP-67 is located in an area which is understood to be impacted by historical direct discharges of TCE from an outfall and may not be representative of upland groundwater, as discussed in Appendix C2 and Section 10.

ranged from 0.14 J µg/L to 7,100 µg/L[33] (AP-03-A), with the exception of higher concentrations measured in shallow (88,500 µg/L) and deep (585,000 µg/L) samples collected at GP-67.[34] For the higher-concentration (>1,000 µg/L) cis-1,2-DCE samples, the deeper (91 cm bml) Geoprobe samples had higher concentrations than collocated shallow (31 cm bml) Geoprobe samples. For TCE, the deeper Trident (90 to 150 cm bml) and Geoprobe (91 cm bml) samples generally exhibited higher concentrations than the corresponding shallow (0 to 38 cm bml) TZW samples.

5.4.7.6 Non-chlorinated VOCs in TZW

The TZW IC list includes two non-chlorinated VOCs, 1,2,4-trimethylbenzene and carbon disulfide. Maps 5.4-18a–e present 1,2,4-trimethylbenzene and carbon disulfide concentrations in TZW offshore of sites where these VOCs were present at concentrations above detection limits[35] (Gasco and Siltronic from RM 6–7 for 1,2,4-trimethylbenzene; Gasco, Siltronic, and Arkema from RM 6–8 for carbon disulfide).

Carbon disulfide was sampled at 150 locations offshore of all nine study sites. Of these, paired deep (90 to 150 cm bml) Trident samples were collected at 18 locations throughout the Study Area, and 24 paired deep (91 cm bml) Geoprobe samples were collected offshore of Gasco and Siltronic. Detected concentrations of carbon disulfide in shallow peeper, Trident, and non-LWG push probe samples ranged from 0.15 J µg/L to 800 µg/L, with the two highest concentrations (>10 µg/L; indicated by red and orange symbols in the upper panels on Maps 5.4-18a–e) observed offshore of the northern end of the Gasco site at locations GS-01-B (800 µg/L) and GS-02-A (53 µg/L). Due to low detection frequencies (only 1 detection in collocated shallow pairs), trends between the shallow (0 to 38 cm bml) and deeper (90 to 150 cm bml) Trident samples were not evaluated for carbon disulfide.

1,2,4-Trimethylbenzene samples were collected only during the Siltronic-led sampling event (MFA 2005; Hahn and Associates 2005). In all, 41 locations were sampled with Geoprobe for 1,2,4-trimethylbenzene offshore of the Siltronic and Gasco sites, and 24 collocated deep (91 cm bml) Geoprobe samples were also collected. No filtered samples were collected, per sampling protocols for VOCs. 1,2,4-Trimethylbenzene detected concentrations ranged from 1.04 µg/L to 69.9 µg/L, with the maximum concentrations (>40 µg/L; indicated by red symbols in the lower panels on Maps 5.4-18a–e) measured offshore of the property line between the Gasco and Siltronic sites. There were no clear trends in sample concentration with depth for 1,2,4-trimethylbenzene.

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[33] The maximum value of 7,100 µg/L was measured in a deep (90 to 150 cm bml) sample. The maximum shallow (0 to 38 cm bml) concentration was 48.7 µg/L, measured at GP-65. Only shallow samples were used in the loading analysis presented in Section 6. 48.7

[34] See note above.

[35] Note one low-level detection of carbon disulfide (0.23 J µg/L) offshore of the Kinder Morgan site is not shown on maps.

5.4.7.7 BTEX in TZW

Maps 5.4-19a–h present BTEX concentrations measured in TZW offshore of all nine study sites. The upper panel of each map presents the total BTEX concentration, and the lower half presents the relative contribution of each BTEX constituent (benzene, toluene, ethylbenzene, and xylenes) in the form of a pie chart.[36] To accommodate the large numbers of measurements taken between RM 6 and 7, this set of results is presented on four maps (Maps 5.4-19c–f). In all, BTEX was sampled in TZW at 150 locations, with 18 deeper (90 to 150 cm bml) paired Trident samples collected across the Study Area and 24 deep (91 cm bml) Geoprobe samples collected offshore of the Siltronic and Gasco sites. No filtered samples for BTEX constituent chemicals were collected, per sampling protocols for VOCs.

Across the study sites, total BTEX was detected in 75 percent of samples, with detected sample concentrations covering a large range, from 0.11 J µg/L to 4,700 µg/L (GP-68); detection limits for undetected samples ranged from 0.22 U µg/L to 11 U µg/L. The highest BTEX concentrations (>1,000 µg/L; indicated by red symbols in the upper panels on Maps 5.4–19a-h) were observed offshore of the Gasco and Siltronic sites, with one high value also observed offshore of Arkema (AP-04-D; 1,600 µg/L). In general, there were no consistent patterns with depth in the paired shallow and deep samples.

The pie charts presented in the lower panels on Maps 5.4-19a–h present the relative concentration of BTEX constituent chemicals for each detected sample. No consistent patterns of BTEX composition related to spatial distribution or magnitude of total BTEX concentration were apparent across all nine TZW study sites. More localized patterns may be evident in the data, such as a general tendency for toluene and xylenes to dominate BTEX composition offshore of sites where generally lower concentrations (detection limits to 1.79 J µg/L) of BTEX were observed in TZW (Kinder Morgan Linnton, ARCO, ExxonMobil, and Willbridge Terminal). These results are considered and discussed in detail on a site-by-site and sample-by-sample basis in Appendix C2 to support the assessment of groundwater pathway at each study site.

5.4.8 Groundwater Seeps

This section summarizes the location, available chemical data, and data quality assessment for upland groundwater seeps. Groundwater seeps were assessed for the BHHRA because of the potential for humans to come into contact with seep water. The potential effects of human exposure to groundwater discharge in surface seeps are presented in the initial BHHRA summary in Section 8 of this report. Seep data are not appropriate for assessing ecological risks and therefore were excluded from the TZW BERA.

[36] The pie charts show only those constituent chemical concentrations that are above detection limits. If all components of the total BTEX sum are non-detect for a given sample, no pie chart is shown for that sample.

The groundwater seep data set is limited and does not lend itself to the general organization of the nature and extent discussion applied to TZW and other media in this report (specifically, discussion of select analytes followed by remaining ICs and a summary). Instead, this section will present all available seep locations and data of adequate quality for use in BHHRA, presenting simple comparisons of concentration to upland groundwater and TZW, to provide context and support understanding of the groundwater seep data.

5.4.8.1 Groundwater Seep Locations

A seep reconnaissance survey was conducted during Round 1 of the Portland Harbor RI/FS (GSI 2003b) to support the BHHRA and CSM. This survey documented readily identifiable groundwater seeps based on visual observations along approximately 17 miles of riverbank from RM 2 to 10.5. For the purposes of this survey, a seep was defined as groundwater discharge above the Willamette River water line as observed during the seep reconnaissance survey. This groundwater may be discharged from local shallow groundwater systems, perched groundwater, water seeping through utility backfill, or return flow from tidally influenced bank storage. Observed seeps were classified into one or more of five types:

- Seepage line at the base of embankments (nine seeps)
- Linear and point seeps at the foot of beaches (six seeps)
- Seepage through backfill surrounding outfalls (four seeps)
- Seepage of NAPL (two seeps)
- Potential seep locations identified by observation of extensive ferric hydroxide staining of bank materials (eight potential seeps).

Additionally, eight seeps were categorized as combinations of the above seep types.

Twelve seeps were observed at or near potential human-use areas (GSI 2003b). No additional seeps or other surface expressions of groundwater have been observed on or near a human-use beach since the seep reconnaissance survey.

5.4.8.2 Groundwater Seep Water Quality Data

Water quality data have been collected at six seeps in four general areas (Figure 5.4-5). Groundwater seep discharge rates have not been empirically quantified. The water quality sampling efforts to date for upland groundwater seeps include:

- City of Portland stormwater Outfalls 22B and 22C, located directly north and south of the Railroad Bridge at RM 6.89 and 6.82, respectively, are type 3 (backfill surrounding outfalls) seeps. Both Rhone Poulenc and NW Natural have collected water quality samples in Outfalls 22B and 22C to evaluate potential groundwater infiltration to the conveyance systems.

- Rhone Poulenc sampled Outfall 22B on five occasions between October 1, 1993 and September 23, 2004 and Outfall 22C four times between August 13, 2002 and September 23, 2004. Samples were collected at the end of the pipe and were analyzed for 231 individual parameters, including conventionals, PCDD/Fs, herbicides, metals, PAHs, PCB Aroclors, pesticides, petroleum hydrocarbons, phenols, phthalates, SVOCs, and VOCs. The results are Category 1 data validated to the QA2 level.
- NW Natural sampled Outfall 22C on February 24, 2005 for 89 individual parameters, including conventionals, metals, PAHs, phenols, phthalates, SVOCs, and VOCs. Data were validated to Category 2, QA1 level.
- Seeps-01, -02, and -03 are located at the Gunderson site near RM 8.5. These type 3 seeps are associated with cracked stormwater drain pipes. Each seep was sampled once in November 2004 and again in April 2005, with samples analyzed for 31 individual parameters, including conventionals, metals, PCB Aroclors, petroleum hydrocarbons, and phthalates. Data were validated to Category 1, QA1.
- ExxonMobil sampled areas with visible sheen on sand and in pooled water along the riverbank at the ExxonMobil site under the direction of DEQ on August 13, 2004 (Kleinfelder 2004). Two composite samples were analyzed as soils for DRH, GRH, and RRH. Data were validated to the QA1 level.

The sampling events described above summarize all groundwater seep data collected to date; the associated data table presented in Appendix D4 (Table D4-2) focuses only on the City of Portland Outfall 22B seep location, which is the only seep relevant for use in the BHHRA based on data quality and location. Outfall 22B is located on a human use beach (Figure 5.4-5) and has Category 1 data validated to the QA2 level.

For this nature and extent discussion, a subset of the detected Category 1, QA2 Outfall 22B seep data was compared to nearshore upland groundwater data and TZW data from the Rhone Poulenc site (Figure 5.4-6). Because of the small number of seep, upland groundwater, and TZW samples, these data are presented as a simple comparison and should not be considered statistically significant. At Outfall 22B, detected seep concentrations of Silvex (0.14 µg/L), benzene (0.19 µg/L), and TCE (0.34 µg/L) were below the minimum concentrations found in upland groundwater and in TZW. The measured concentration of 1,2-DCB at Outfall 22B (0.864 µg/L) falls within the lower end of the range for upland groundwater and TZW.

5.4.9 Summary of Indicator Chemicals in TZW and Seeps

The following subsections present a brief summary of the findings for TZW and groundwater seeps.

5.4.9.1 Transition Zone Water Summary

The preceding discussions present the observed distribution and patterns of ICs in TZW. The TZW data set was generated for the purposes of assessing TZW offshore of upland groundwater plumes with likely or known complete pathways to the river; therefore, the data set does not cover all areas where TZW may be affected by unknown plumes or TZW quality impacted by contaminated sediments. Specifically, the data set is focused on the offshore area of nine sites, identified as high-priority, Category A upland groundwater sites due to a confirmed or reasonable likelihood for discharge of upland groundwater COIs to Portland Harbor. Consideration of pore water chemistry affected by in-river sediment contamination is evaluated in Section 6 through equilibrium partitioning calculations based on the large data set of sediment concentrations.

The observed distribution of TZW chemicals could not be adequately described focusing exclusively on the bounding ICs (total PCBs, total PCDD/Fs, total DDx, and total PAHs) because these chemicals were often not part of the focus of the upland site plume-defined analyte lists. Therefore, the TZW nature and extent presentation briefly addresses all TZW ICs, as opposed to focusing on chemicals also included as CSM ICs. Note that PCBs were not sampled in TZW, and only two TZW sampling locations were analyzed for PCDD/Fs; these chemicals are not included in the TZW nature and extent discussion.

DDx was measured in TZW at ten locations offshore of the former Acid Plant area of the Arkema site, as well as at one location offshore of the adjacent Rhone Poulenc site. The highest concentrations were observed in unfiltered samples collected in both shallow (0 to 38 cm bml) and deep (90 to 150 cm bml) TZW samples offshore of the former Acid Plant area. Review of the filtered and unfiltered results indicates that DDx is present on solids. Further, concentrations in unfiltered samples are generally greater in deep than shallow TZW samples. These results with filtration and depth were not apparent in the limited data collected at the single sample location offshore of the Rhone Poulenc site.

PAHs were sampled at six of the TZW sites (Kinder Morgan, ARCO, ExxonMobil, Gasco, Siltronic, and Willbridge Terminal). Total PAH concentrations were found to be highest offshore of the Gasco and Siltronic sites. Total HPAH, total cPAH, and BAP results showed similar distribution and filtration patterns. Because LPAHs tend to comprise the majority of the total PAH concentrations, LPAH and naphthalene results generally followed the distribution patterns apparent for total PAHs. Filtration was observed to decrease the total PAH concentration slightly, with greater effects on the more hydrophobic PAHs, as expected. Review of the fractional composition of the 17 individual chemicals that compose total PAHs shows a clear pattern of high naphthalene concentrations associated with high total PAH concentrations offshore of the Gasco and Siltronic sites.

TPH was sampled at six of the TZW sites (Kinder Morgan, ARCO, ExxonMobil, Gasco, Siltronic, and Willbridge Terminal). The highest concentrations of TPH in TZW were observed offshore of the Gasco and Siltronic sites, with the highest individual result measured offshore of the Gasco site. The complex-mixture nature of the analyte TPH, however, confounded detailed interpretation of results. Overall, filtration was observed to decrease TPH concentration; however, it is unclear whether this effect is related to loss of volatiles during filtration or loss of more hydrophobic portions of the TPH mixture, with composition varying in inconsistent ways across filtration pairs. Review of the fractional components (DRH, RRH, and GRH) showed a pattern of TPH composition shift toward GRHs offshore of a portion of the Siltronic site, but did not provide useful insights elsewhere.

Cyanide, Silvex, and perchlorate were detected offshore of the sites where they were sampled in areas that also showed detections of other upland COIs on the TZW analyte list for the sites. The highest detections of Silvex were observed offshore of the Rhone Poulenc site in an area thought to be an offshore discharge area for upland groundwater. Total cyanide was detected offshore of the Gasco and Siltronic sites. Perchlorate was observed offshore of the Arkema site former Chlorate Plant area

The TZW IC list includes eight metals: arsenic, barium, cadmium, copper, lead, manganese, nickel, and zinc. These were sampled offshore of all nine TZW study sites. Filtration significantly and consistently reduced TZW sample concentrations for cadmium, copper, lead, nickel, and zinc, suggesting that much of the observed total concentration for these metals was associated with >0.45 μm particles. Differences with filtration were not as pronounced for arsenic, barium, and manganese. Shallow versus deep TZW results did not show consistent trends for any of the metals. The spatial distribution of metals likely reflects some combination of upland groundwater transport, local sediment redox conditions, and sediment contamination, varying by site and metal. Detailed geochemical analysis of select metals concentrations in TZW is provided in Appendix C2.

The TZW IC list includes nine chlorinated VOCs (MCB; chloroethane; 1,2-DCA; 1,1,2-TCA; vinyl chloride; cis-1,2-DCE; TCE; chloroform; and methylene chloride) and one chlorinated SVOC (1,2-DCB). These chemicals were sampled at all nine TZW study sites. In summary, the chlorinated VOCs and 1,2-DCB show spatial distribution patterns that appear to reflect common groundwater pathways and degradation chains. Specifically, the highest concentrations of TCE, cis-1,2-DCE, and vinyl chloride are located offshore of the Siltronic site and the former Acid Plant area of the Arkema site. Likewise, the highest concentrations of 1,1,2-TCA, 1,2-DCA, and chloroethane are generally located offshore of the former Acid Plant area of the Arkema site and the Gunderson site. Further, the majority of detected results for chloroform and methylene chloride are also generally located offshore of the Arkema site. Finally, the highest concentrations of 1,2-DCB and MCB are generally located offshore of the former Acid Plant area of the Arkema site and the Rhone Poulenc site.

The TZW IC list includes two non-chlorinated VOCs, 1,2,4-trimethylbenzene and carbon disulfide. Carbon disulfide was sampled at all nine TZW study sites, but 1,2,4-trimethylbenzene was sampled offshore of the Siltronic site only. The highest concentrations of carbon disulfide were observed offshore of the Gasco site. These high concentrations were generally observed in areas of other elevated VOCs offshore of this site.

BTEX was analyzed in TZW samples from all nine study sites. The highest values were consistently observed offshore of the Gasco and Siltronic sites, with one high value also observed offshore of Arkema.

5.4.9.2 Groundwater Seeps Summary

The groundwater seep data are limited and do not allow for definitive conclusions. Only one seep, Outfall 22B (at the Rhone Poulenc site), is relevant for use in the BHHRA. At this location, groundwater infiltrates into the outfall pipe, which subsequently discharges to a beach. The beach where Outfall 22B discharges was identified as a potential transient use area, so exposure to the groundwater seep in that beach by transients is considered a potentially complete pathway. For most analytes evaluated, Outfall 22B concentrations were near or below detection limits and were well below nearby upland groundwater and TZW concentrations.

5.5 INDICATOR CHEMICALS IN BIOTA

This section summarizes the analytical tissue data collected from the LWR. Fish and invertebrates used to evaluate the nature and extent of chemical concentrations in biota were collected from the Study Area and from adjacent areas, including those immediately upstream and downstream of the Study Area and Multnomah Channel near its divergence from the LWR. Data are also available for biota from the upriver reach (RM 15.3–28.4) and above Willamette Falls. The sample set includes fish and invertebrates collected by the LWG as part of Rounds 1, 2, and 3 of the Portland Harbor RI/FS, as well as recent data collected by other parties as described in Section 2. Eleven fish species, four benthic invertebrate species, epibenthic communities, and fish stomach contents are represented.

The biota sample set and sampling locations are summarized below in Section 5.5.1. The ICs and the rationale for their selection are provided in Section 5.5.2. Data presentation tools are described in Section 5.5.3. The distribution of ICs in biota samples in the Study Area and immediately adjacent areas is provided in Sections 5.5.4 through 5.5.8. Chemical distribution in samples collected in the upriver reach and above Willamette Falls is described in Section 5.5.9. A summary is provided in Section 5.5.10. Tables, sample location maps, and a more detailed description of the samples and data set are provided in Section 2.2.8.

5.5.1 Biota Sample Set

Fish species collected in the Study Area and adjacent areas included brown bullhead (*Ameiurus nebulosus*), black crappie (*Pomoxis nigromaculatus)*, common carp (*Cyprinus carpio carpio*), juvenile Chinook (*Oncorhynchus tshawytscha*), largescale sucker (*Catostomus macrocheilus*), northern pikeminnow (*Ptychocheilus oregonensis)*, juvenile lamprey (i.e, ammocoetes and macropthalmia; *Lampetra* sp.), peamouth (*Mylocheilus caurinus*), sculpin (*Cottus* spp.), smallmouth bass (*Micropterus dolomieui*), and prebreeding white sturgeon (*Acipenser transmontanus*). With the exception of sturgeon, fish tissue samples were composites of more than one individual fish. The types of tissue examined were whole-body fish (all species) and fillets (limited to black crappie, brown bullhead, carp, smallmouth bass, and sturgeon). For Round 1 and non-LWG data, separate fish were caught for fillet and whole-body composite samples, but for Round 3, fillet and whole-body data were obtained from the same composite group of fish. Fillets were removed from Round 3 carp and smallmouth bass, and fillets and remaining bodies without fillets (i.e., carcass) were composited and analyzed separately. Calculated whole-body concentrations are provided in the SCRA database (Appendix A3). The calculations used to determine whole-body concentrations are described in Appendix A4.

Tissues from four invertebrate species were analyzed: the Asiatic clam (*Corbicula fluminea*), an oligochaete worm (*Lumbriculus variegatus*), mussels (tentatively identified as *Margaritifera falcata* and *Anodonta nuttalliana*), and crayfish

(*Pacifasticus spp.*). Clams included field-collected samples and laboratory-exposed samples, and worms included only laboratory-exposed samples. During Rounds 1 and 2, clams were not depurated. During Round 3, field-collected clam composite samples were generated with and without depuration for sampling locations where enough sample mass was collected. Clams were depurated as part of other non-LWG laboratory bioaccumulation studies. Epibenthic communities from multiplate samplers were composited for analysis. Epibenthic communities composed mostly of invertebrates belonged to four major taxonomic groups: Annelida (worms), Chironomidae (midges/blood worms), Crustacea (amphipods), and Anthozoa (freshwater *Hydra* sp.). Two zooplankton daphnid species were also identified on multiplates, with *Sida crystallina* being the most abundant. Stomach contents (primarily aquatic organisms and terrestrial insects) of sturgeon and juvenile Chinook salmon were also analyzed and are discussed as part of the invertebrate data.

Additional details regarding the number and type of tissues collected from the Study Area are provided in Section 2.2.8 of this report and in the BHHRA (Appendix F) and the BERA (Appendix G). Table 2.2-8 provides the study name, sample count, and a summary of analyses for each species and tissue type, and Table 2.2-9 details the sample count for each individual chemical analyzed for each species and tissue type for LWG and non-LWG samples. Table 2.2-10 provides the number of fish and invertebrates in each sample composite.

Fish and invertebrate sampling locations (Maps 2.2-7 through 2.2-14) represent either discrete locations or larger fishing areas as described below:

- For LWG Rounds 1, 2, and 3, the sampling design included collection of species over areas similar in size to likely home ranges, except for species that are assumed to have home ranges larger than the Study Area itself.
- Epibenthic community collection methods (artificial substrates) reflect essentially single-point samples.
- Clams, sculpin, crayfish, and collocated sediment (used in clam and worm bioaccumulation tests) were composite samples collected at multiple points, transects, or tows within discrete nearshore areas.
- Smallmouth bass, largescale sucker, northern pikeminnow, and peamouth may utilize fairly localized areas and were collected and composited over 1-mile river segments. In Round 3 smallmouth bass were composited from each bank of the river at 1-mile river segments.[1]
- Black crappie, brown bullhead, and carp may utilize home ranges on the scale of the entire Study Area (or greater) and were collected and composited over 3-mile river segments (4-mile segments for Round 3 carp).

[1] Due to a Round 3 labeling error in the field, one smallmouth bass (LW3-SB11W-11) collected from the west side of the river at RM 11 was inadvertently included in composite samples from the east side of the river at RM 11. The affected composites are LW3-SB11E-C00B and LW3-SB11E-C00F (see Integral 2008b).

- Sturgeon and juvenile Chinook also have large home ranges; however, the samples were collected within discrete set line areas (for sturgeon) or beach seine areas (for juvenile Chinook).

Map symbols of the same color represent individual fish in each composite collected within each of the sampling areas or fishing zones.

Sample locations are labeled on the maps according to the following scheme:

- Round 1 field-collected clams, crayfish, sculpin, and juvenile Chinook are shown as points that represent composites of several individuals collected within a narrow shoreline or nearshore transects and are referenced as single centroid points within a river mile reach (03Rnnn through 09Rnnn).
- Round 1 smallmouth bass, largescale sucker, northern pikeminnow, and peamouth were sampled over 1-mile increments of the Study Area, referenced as river mile areas (03Rnnn through 09Rnnn).
- The remaining Round 1 fish species (brown bullhead, black crappie, carp) are represented by fishing zones (FZ0306 and FZ0609 for RM 3–6 and 6–9).
- Round 2 invertebrate tissue sampling locations refer to FCnnn for field-collected clam tissue samples and BTnnn for collocated sediments collected for laboratory-exposed clams and worms.
- Epibenthic community tissue composites were collected from multiplate samplers deployed at locations referenced as MITnn.
- Juvenile Chinook whole-body and stomach content samples collected at beach transects during Round 2 are referenced as T01 through T04; stomach content samples end with the letters SC.
- Round 3 lamprey ammocoete and macropthalmia sampling locations are referenced as LTAnnn and LTMnnn.
- Round 3 sturgeon were collected at five reaches (e.g. ST001 refers to RM 2–3) and were split into three types of samples: sturgeon whole body minus liver (e.g., ST001-01), sturgeon liver (e.g. ST001-01 [liver]), and sturgeon gut content (SG001-01).
- Round 3 fish and invertebrates (except carp) use a sample nomenclature that includes species name, river mile, and river side designation (SSRRB or SSRRRB; SB011W refers to smallmouth bass from RM 10.5 to 11.5, western nearshore zone).
- Round 3 carp sampling locations use a 6-digit nomenclature to depict the species and river segment fished (e.g., CP0408 refers to RM 4–8).
- Samples collected by parties other than the LWG retain the label assigned by the original authors and represent single-point data.

Throughout this section, the river mile and river zone (east, west, navigation channel, Multnomah Channel) are provided with the sample location code when the location code does not include this information. River miles are not provided for composited biota samples that include individuals from different locations.

Summary statistics (sample size, frequency of detection, minimum, maximum, mean, median, and 95th percentile) for ICs in tissue samples are provided in Tables 5.5-1 through 5.5-5. Tables 5.5-1 (Study Area and adjacent locations), 5.5-3 (upriver reach, below falls), and 5.5-5 (above falls) contain summary statistics for fish, and Tables 5.5-2 (Study Area and adjacent locations) and 5.5-4 (upriver reach, below falls) for invertebrates. Two sets of summary information are provided in the summary statistics tables: one set for detected values only and a second set for detected and non-detected values combined. The discussion of the nature and extent of ICs in tissue provided in the remainder of this section is based on statistics calculated for detected concentrations only. Summary statistics for all analytes measured in tissue samples are provided in Tables D5.1-1 through D5.1-5 in Appendix D5.

5.5.2 Indicator Chemicals for Biota

ICs (Table 5.0-2) were selected in a multistage screening process as described in the introduction to Section 5. A total of 26 individual analytes and calculated chemical sums were identified as ICs for biota. Low frequencies of detection in tissue samples resulted in fewer ICs than for sediment. ICs for biota are organized as follows:

- PCBs
  - Total PCBs*
  - PCB TEQ (ND=0)
- PCDD/Fs
  - Total PCDD/Fs*
  - TCDD TEQ (ND=0)*
- DDx
  - Total DDx (sum of 2,4'- and 4,4'-DDD, DDE, DDT)*
  - Total of 2,4'- and 4,4'-DDT
  - Total of 2,4'- and 4,4'-DDE
  - Total of 2,4'- and 4,4'-DDD
- PAHs
  - Total PAHs*
  - Total cPAH BaPEq values

  - Total LPAHs
  - Total HPAHs
- SVOCs
  - BEHP*
  - Hexachlorobenzene
- Pesticides
  - Total chlordanes*
  - gamma-HCH
  - Aldrin*
  - Dieldrin*
- Metals
  - Arsenic*
  - Cadmium
  - Chromium*
  - Copper*
  - Lead
  - Mercury
  - Zinc*
- Organometallic Compounds
  - TBT*.

A subset of indicator chemicals, which are indicated with an asterisk (*) in the above list, are described in this section. The 13 ICs (total PCDD/Fs and TCDD TEQ are grouped as one chemical in this count) for biota were selected to match the chemicals for presentation and discussion in the site-wide CSM (Section 10).

Data for ICs are presented in the following sections for the Study Area and immediately adjacent areas, followed by discussion of the upriver reach and above falls areas. In addition, lipid content of samples is discussed in Sections 5.5.8.10 (Study Area) and 5.5.9.14 (upriver reach and above falls) to provide a context for understanding bioaccumulative substances. Data are not available for every IC in every tissue because study designs varied and because insufficient material was available in some cases to complete all planned analyses. Tables 2.2-8 and 2.2-9 provide summaries of samples and analyses available for the Study Area as provided in the SCRA database.

Four bounding ICs—total PCBs, total PCDD/Fs (as both total dioxin/furans and TCDD TEQ), total DDx, and total PAHs—are described first and in greater detail. The nature and composition of these four chemicals are discussed to provide background on their environmental chemistry and to provide a site-wide perspective on their distribution. The discussion of the remaining ICs is abbreviated and includes a description of the data set, concentration ranges, and frequency of detection, with references to figures and tables to provide a complete picture of the distribution of those chemicals. Graphic representations of distributions of the remaining ICs are provided in Appendix D5.

5.5.3 Description of Biota Presentation Tools

Three types of figures are provided to summarize the biota data: box-whisker plots, scatter plots, and bar graphs. Because the number of tissue samples collected from areas immediately adjacent to the Study Area (i.e., RM 0–1.9, RM 11.8–12.2, and Multnomah Channel) was small, these biota data are combined with the Study Area data set in the graphical displays and tissue summary statistics presented in this section. However, it is important to note that these data are combined for presentation purposes only and that these samples (tabulated below) are not part of the Study Area data set and so were not included in the Study Area BHHRA (Appendix F) and BERA (Appendix G) data sets.

River Mile	Species	Tissue	Sample ID
RM 1–2	clam	body without shell	LW3-CA01E-C01
RM 1–2	clam	depurated w/o shell	LW3-CA01E-C00D
RM 1–2	crayfish	whole body	LW3-CR01E-ALT-C00
RM 1–2	crayfish	whole body	LW3-CR01W-C00
RM 1–2	sculpin	whole body	LW3-SP01E-C00
RM 1–2	sculpin	whole body	LW3-SP01W-C00
RM 11.8–12.2	clam	body without shell	LW3-CA12W-C00
RM 11.8–12.2	clam	body without shell	LW3-CA12E-C00
RM 11.8–12.2	clam	depurated w/o shell	LW3-CA12E-C00D
RM 11.8–12.2	crayfish	whole body	LW3-CR12W-C00
RM 11.8–12.2	crayfish	whole body	LW3-CR12E-C00
RM 11.8–12.2	sculpin	whole body	LW3-SP12W-ALT-C01
RM 11.8–12.2	sculpin	whole body	LW3-SP12E-C00
Multnomah Channel	clam	body without shell	LW2-BTFC003
Multnomah Channel	lab clam	body without shell	LW2-BTLC003
Multnomah Channel	*Lumbriculus variegatus*	whole body	LW2-BTLW003

Box-Whisker Plots: Figures 5.5-1 through 5.5-8 are a series of box-whisker plots that present the concentrations of ICs for the various fish and invertebrate species and tissue types. These plots were developed using R for Windows v. 2.7.0. (R Development Core Team 2008). The horizontal center line in each box represents the median concentration, and the top and bottom of the box represent the upper and lower quartiles, respectively. The upper whisker represents the highest concentration that is

less than the upper quartile plus 1.5 times the interquartile range, and the lower whisker represents the lowest concentration that is greater than the lower quartile minus 1.5 times the interquartile range. Outliers are represented individually by small circles above and below the boxes.

Scatter Plots: A series of scatter plots (Figures 5.5-9 through 5.5-23) for each IC provides chemical concentrations by river mile for each species and tissue type. A number of species were caught within target fishing zones, including smallmouth bass, largescale sucker, northern pikeminnow, and peamouth (1-mile fishing zones); brown bullhead and black crappie (3-mile fishing zones); and carp (3-mile fishing zones for Round 1 and 4-mile fishing zones for Round 3). Individual fish caught in different areas of each fishing zone were composited to create the sample for analysis. The centroid of the fishing zone is used to represent these samples on the scatter plots.

Bar Graphs: Bar graphs (Figures 5.5-24 through 5.5-30) show the distribution of PCB homologs, PCDD/F homologs, and individual components of total DDx in each sample, and the distribution of PAHs in clam samples (see Section 5.5.7).

Box-whisker plots and scatter plots for additional ICs identified in Table 5.0-2 are provided as part of Appendix D5.

The range of average concentrations for the various species is provided in the following sections for each IC for a general indication of the distribution of ICs across species. The maximum concentration is also provided for context and comparison to the average concentrations. For fish tissue samples, statistics for whole-body and fillet samples are summarized separately. All tissue concentrations are reported on a wet-weight basis in the following discussion.

5.5.4 Total PCBs in Biota

PCBs in tissue samples were analyzed as Aroclors or congeners. In most Round 1 samples, both analyses were completed; however, Round 1 whole-body largescale sucker, northern pikeminnow, peamouth, all fillets, and crayfish samples were only analyzed for Aroclors. In Rounds 2 and 3, only PCB congener analyses were completed for LWG biota samples and all 209 PCB congeners were analyzed. Biota samples collected by other parties were sometimes analyzed for a limited number of congeners. In accordance with the RI data summation rules, samples with fewer than 100 PCB congeners were not summed. This section presents a summary of the distribution of total PCBs using congeners, when available, because congener sums are considered a more reliable estimate of total PCBs than Aroclor sums, based on the greater specificity and accuracy of the PCB congener analysis. Data for total Aroclors are included when PCB congener data are not available. PCB homolog patterns in the biota samples are also summarized in this section.

Fish assimilate and metabolize different PCB congeners at different rates, and therefore the PCB pattern in fish tissue may not closely resemble the pattern of the Aroclor that

was released into the river or of the standard used by the laboratory to identify and quantify the PCBs in the sample. The limitations of the Aroclor analysis are described in Appendix D1.4. Because of the uncertainties related to Aroclor identification and because PCB congeners were analyzed in most of the tissue samples used for the Portland Harbor RI, PCB patterns in tissue are described only in terms of homologs (i.e., congeners grouped according to chlorination level).

A box-whisker plot showing the distribution of PCBs for each species and tissue type is provided in Figure 5.5-1. PCB concentrations by river mile for each species and tissue type are shown in Figures 5.5-9a–j.

5.5.4.1 PCBs in Fish

PCBs were detected in all fish samples from the Study Area. Average total PCBs in whole-body fish samples ranged from 111 µg/kg (juvenile Chinook) to 2,760 µg/kg (carp). The maximum total PCB concentration in whole-body fish occurred in a carp composite sample from the RM 4 to 8 fishing zone (CP0408; 25,100 J µg/kg). In fillets, average total PCB concentrations ranged from 24.1 µg/kg (black crappie) to 1,840 µg/kg (carp), with the maximum concentration also occurring in a carp fillet composite sample from CP0408 (19,700 J µg/kg). PCB concentrations are shown on Figures 5.5-9a–j.

Although PCB homolog composition varied throughout the river, tetraCBs, pentaCBs, hexaCBs, and heptaCBs were typically present in proportions greater than 10 percent (Figure 5.5-24). HexaCBs and heptaCBs were generally dominant in fish tissue samples from throughout the Study Area. MonoCBs, diCBs, and nonaCBs were very rare, while triCBs and octaCBs were rare in comparison to the other homologs.

For many fish species, more highly chlorinated PCB homologs were seen more frequently in the upper reaches of the Study Area than in the lower third.

5.5.4.2 PCBs in Invertebrates

PCBs were detected in all invertebrate samples from the Study Area that were analyzed for PCB congeners. PCBs were not detected in 10 crayfish tissue composites that were only analyzed for Aroclors, which have a higher detection limit than PCB congeners. Average total PCB concentrations ranged from 10.6 µg/kg (sturgeon stomach contents) to 514 µg/kg (laboratory-exposed worms). The maximum total PCB value (4,310 J µg/kg) was measured in worms exposed to sediment from location BT028 (RM 8.8W). Aroclors were only measured in Round 1 and non-LWG samples.

Among PCB homologs in invertebrate samples, tetraCBs, pentaCBs, hexaCBs, and heptaCBs were most abundant overall, similar to the fish tissue samples (Figure 5.5-25). Laboratory-exposed clams were distinctive in containing a relatively large fraction of diCBs, which were not present in field-collected clams from the same locations, with

the exception of location FC027 Rep 1 (RM 8.7E). PCB patterns in crayfish varied widely. In particular, the PCB pattern in crayfish sample 06R031 (RM 6.8E) is notable for its high content of monoCBs and diCBs and relatively low content of triCBs, tetraCBs, and pentaCBs. The PCB pattern in clams and worms exposed at the laboratory to sediments from three locations (BT002 at RM 2.3E, BT017 at RM 6.9W, and BT028 at RM 8.8W) contained distinctly higher levels of tetraCBs and lower levels of hexaCBs and heptaCBs than the remaining samples. This pattern was reflected only slightly in field-collected clam samples from these locations.

5.5.5 Total PCDD/F Homologs and TCDD TEQ in Biota

PCDD/Fs were analyzed for in all invertebrate tissue types (although not all clam or crayfish samples were analyzed) and in all fish species except largescale sucker, northern pikeminnow, and peamouth. Total PCDD/Fs are the sum of the various homologs (i.e., TCDD, PeCDD, HxCDD, HpCDD, and OCDD; and TCDF, PeCDF, HxCDF, HpCDF, and OCDF). PCDD/F results for individual congeners are expressed in terms of 2,3,7,8-TCDD toxicity by applying mammalian TEFs (Van den Berg et al. 2006) to the individual isomers and calculating a final TCDD TEQ concentration (see Section 2.0 for group summing rules).

Box-whisker plots showing the distribution of total PCDD/Fs and TCDD TEQ for each species and tissue type are provided in Figure 5.5-2. Total PCDD/F and TCDD TEQ concentrations by river mile for each species and tissue type are shown in Figures 5.5-10a–j and Figures 5.5-11a–j, respectively.

5.5.5.1 Total PCDD/F Homologs and TCDD TEQ in Fish

PCDD/Fs were detected in all fish tissue samples from the Study Area. The average total PCDD/F homolog concentrations in whole-body fish tissue samples ranged from 8.62 pg/g (sturgeon) to 78.9 pg/g (juvenile lamprey). The maximum whole-body concentration (388 pg/g) was measured in a sculpin composite sample from 07R006 (RM 7.3W). Average fillet concentrations ranged from 4.76 pg/g (smallmouth bass) to 29.6 pg/g (carp). The maximum total PCDD/F concentration in a fillet composite sample was measured in smallmouth bass from SB07W (56.9 J pg/g).

The homolog distribution in fish tissues was quite variable with differences evident between species as well as between locations and tissue types within species (Figure 5.5-26). In carp, juvenile lamprey, and sculpin tissues with total PCDD/F concentrations above 50 pg/g, OCDD tended to dominate many of the samples, with secondary dominance shown variously by HxCDDs, HpCDDs, TCDFs, PeCDFs, and HxCDFs. In smallmouth bass samples with total PCDD/F concentrations above 50 pg/g, PCDD/F patterns were dominated by PeCDFs and TCDFs. Overall, smallmouth bass were notable for the dominance of TCDFs and PeCDFs and relatively low levels of HpCDDs and OCDD at many locations compared to other fish species from the Study Area. Round 3 sturgeon, which were individual whole-body samples,

were dominated by TCDFs. The PCDD/F patterns for sturgeon samples from the ODHS/EPA/ATSDR Fish Contaminant Study, which were fillet samples, were distinctly different from Round 3 whole-body sturgeon.

The average TCDD TEQs for whole-body samples ranged from 0.849 pg/g (sturgeon) to 4.77 pg/g (smallmouth bass). The maximum TCDD TEQ (51.9 J pg/g) among whole-body samples occurred in a smallmouth bass composite sample collected from SB07W. Average TEQs for fillet samples ranged from 0.564 pg/g (sturgeon) to 2.83 pg/g (carp). The maximum TEQ (8.74 J pg/g) in a fillet composite sample occurred in smallmouth bass from SB07W, the same location, and a composite of the same fish that yielded the maximum TEQ for whole-body composite samples.

5.5.5.2 Total PCDD/F Homologs and TCDD TEQ in Invertebrates

PCDD/Fs were detected in all invertebrate tissue samples from the Study Area. Average total PCDD/F homolog concentrations in individual invertebrate tissue composite samples ranged from 30.6 pg/g (field-exposed depurated clam tissue) to 360 pg/g (laboratory-exposed worm). The maximum concentration (6,440 pg/g) was measured in worms exposed in the laboratory to sediment from BT017 (RM 6.9W). All worm and epibenthic community samples, many field-collected clam samples, and several laboratory-exposed clam, crayfish, and mussel samples had total PCDD/F homolog concentrations greater than 50 pg/g. Homolog concentrations appear strongly associated with species in that concentrations in worms were typically higher than in field-collected clams, which in turn were higher than laboratory-exposed clams. Concentrations in epibenthic tissues and crayfish fell between worms and field-collected clams from similar locales (Figure 5.5-2).

The PCDD/F homolog distribution was more consistent across invertebrate species than fish tissue species in that OCDD was often the most abundant homolog, usually followed by TCDFs and HpCDDs. PeCDDs, HxCDDs, HpCDFs, and OCDF tended to be the least abundant homolog groups (Figure 5.5-27). Distinct homolog patterns were present in many samples that contained higher total PCDD/F concentrations than typically found for each invertebrate sample type. Unique signatures were seen in every species and in several locations. For example, various invertebrate samples collected from the vicinity of RM 7W exhibited a unique PCDD/F pattern, including field-collected and laboratory-exposed clam and worm samples from BT017 and BT018 and crayfish from location 07R006. TCDFs were the most abundant group in these samples, followed by PeCDFs. Among epibenthic samples, MIT003/005/006 (multiplate samples from RM 6.5–7.4) had an unusual pattern, with TCDFs most abundant, followed by OCDD. The PCDD/F pattern in crayfish from location 08R003 (RM 8W, near the mouth of Swan Island Lagoon) was also unusual, with PeCDFs dominant, followed by OCDD and TCDFs. Additional unique patterns were found in various samples from other locations (Figure 5.5-27).

The average TCDD TEQs ranged from 0.229 pg/g (field clams, depurated) to 16.5 pg/g (laboratory-exposed worms). The maximum TCDD TEQ occurred in a worm sample (448 J pg/g) exposed in the laboratory to sediments from Station BT017.

5.5.6 DDx Compounds in Biota

The distributions of DDx compounds—the sum of ortho (2,4'-) and para (4,4'-) isomers of DDD, DDE, and DDT—are described in this section, including concentration trends and DDx analyte patterns in tissue samples from the Study Area. A box-whisker plot showing the distribution of total DDx for each species and tissue type is provided in Figure 5.5-1. Total DDx concentrations by river mile for each species and tissue type are shown in Figures 5.5-12a–j.

5.5.6.1 DDx Compounds in Fish

DDx compounds were detected in all fish tissue samples from the Study Area. Average concentrations of total DDx ranged from 77.4 µg/kg (juvenile Chinook) to 322 µg/kg (northern pikeminnow) in whole-body tissues. Maximum total DDx concentrations in whole-body samples occurred in sculpin composites from 07R006 (RM 7.3W; 3,060 µg/kg total DDx). Average fillet concentrations ranged from 11.4 µg/kg (black crappie) to 151 µg/kg (carp). The maximum concentration in fillet samples was measured in a carp composite sample from CP0408 (RM 4–8; 494 J µg/kg total DDx).

4,4'-DDE accounted for more that 50 percent of the total DDx concentration in fish tissues, with some exceptions (Figure 5.5-28). DDDs constituted 25 percent or more of the total DDx in various samples of sculpin, carp, largescale sucker, juvenile Chinook, juvenile lamprey, and smallmouth bass, particularly in fishing areas from RM 3 to 9. In many of the sculpin samples and in juvenile Chinook samples from T01 (RM 3.4E) and T03 (RM 9.7W), 4,4'-DDT dominated; and in juvenile Chinook samples from T02 (RM 6.9W), 4,4'-DDD dominated the three whole-body composite samples.

5.5.6.2 DDx Compounds in Invertebrates

DDx compounds were detected in all invertebrate tissue samples from the Study Area. Average total DDx concentrations ranged from 2.47 µg/kg (mussel) to 114 µg/kg (laboratory-exposed worm). The maximum concentration (1,490 µg/kg total DDx) was measured in worms exposed in the laboratory to sediments from BT017 (RM 6.9W), with similar concentrations in laboratory-exposed worm tissues from Station BT018 (RM 7.2W).

In general, 4,4'-DDD and 4,4'-DDE were the dominant isomers in invertebrate tissues (Figure 5.5-29). Crayfish DDx profiles were dominated by 4,4'-DDE or various other DDx compounds, depending on location. Laboratory-exposed clam samples from the USACE investigation (Tetra Tech 2006) also had a high percentage of 4,4'-DDT;

however, the 2,4'-isomers of the DDx compounds were generally not detected in these samples, resulting in the absence of data for 2,4'-DDD and a shift in the DDx pattern.

5.5.7 PAHs in Clam Tissue

PAHs are a biota IC for clam tissue only (Table 5.0-2). PAHs are generally metabolized in vertebrates and do not bioaccumulate. However, they do bioaccumulate in invertebrates, and total PAHs are discussed in this section with respect to clam tissue.

PAHs were detected in all clam tissue samples collected from the Study Area or exposed to sediment from the Study Area. Average total PAH concentrations for clam tissue ranged from 76 µg/kg (depurated clam tissue) to 478 µg/kg (undepurated clam tissue), with the highest concentration found in undepurated clam tissue from FC015 at RM 6.4W (4,980 µg/kg). A box-whisker plot showing the distribution of PAHs for clams is provided in Figure 5.5-3. PAH concentrations by river mile for each clam sample type are shown in Figure 5.5-13.

Clam tissue from the Study Area generally contained high proportions of phenanthrene, fluoranthene, pyrene, and chrysene, with secondary proportions of benzo(a)anthracene. LPAHs other than phenanthrene and the five- and six-ring HPAHs (see Table 5.1-7) were generally present but not prevalent (Figure 5.5-30). Naphthalene and dibenzo(a,h)anthracene were each detected in only a few samples, but naphthalene was the dominant PAH in the field-collected, undepurated clam from location CA12E (RM 12.1E; sample LW3-CA12E-C00). Naphthalene was not detected in the depurated clam sample from this location. Additional samples with PAH patterns that differed from surrounding areas included field-collected clams from locations FC014 (RM 5.9W), FC015 (RM 6.4W), and FC025 (RM 8.5W), and laboratory-exposed clams for locations WR-VC-29 (RM 7.7, just downstream of Swan Island Lagoon in the navigation channel), BT026 (RM 8.5E, in Swan Island Lagoon), and BT031 (RM 9.5E). PAH patterns in three field-collected clam samples from Round 1 are obscured by non-detects; only fluoranthene and pyrene were detected in two of these samples.

5.5.8 Additional Indicator Chemicals in Biota

5.5.8.1 Bis(2-ethylhexyl)phthalate in Biota

A box-whisker plot showing the distribution of BEHP for each species and tissue type is provided in Figure 5.5-3. BEHP concentrations by river mile for each species and tissue type are shown in Figures 5.5-14a–j.

5.5.8.1.1 Fish

BEHP, the most frequently detected phthalate, was detected in 25 of the 160 fish samples analyzed from the Study Area, and was not detected in juvenile Chinook or carp. Black crappie, northern pikeminnow, and peamouth were not analyzed for phthalates. Average detected BEHP concentrations in whole-body tissues ranged from

150 µg/kg (sturgeon) to 21,000 µg/kg (smallmouth bass). The maximum concentration (87,000 J µg/kg) was measured in a smallmouth bass whole-body composite sample from 04R023 (fishing zone from RM 3.5 to 4.5). A second smallmouth bass composite sample from this location contained 32,000 J µg/kg BEHP. The BEHP concentration in a sculpin composite sample from Station 08R003 (RM 8.2E) was reported at 28,000 J µg/kg. All other concentrations were 1 to 2 orders of magnitude lower than the maximum concentration.

Phthalates were analyzed in brown bullhead skinless fillet, carp fillet, and smallmouth bass fillet samples. BEHP was not detected in any of the carp fillet samples and in only one brown bullhead fillet sample (100 µg/kg). BEHP was detected in three smallmouth bass fillet samples with an average concentration of 97 µg/kg and a maximum concentration of 130 J µg/kg.

5.5.8.1.2 Invertebrates

BEHP was most frequently detected in laboratory-exposed clams (82.2 percent), followed by laboratory-exposed worms (60 percent) and field mussels (57.1 percent). BEHP was not detected in crayfish. Epibenthic community composites were not analyzed for phthalates.

Average BEHP concentrations ranged from 91 µg/kg (mussels) to 360 µg/kg (laboratory-exposed clams). The maximum concentration (8,600 µg/kg) was measured in laboratory-exposed clams to sediments from BT028 (RM 8.8W). All other concentrations were below 350 µg/kg, and most were below 200 µg/kg (Figure 5.5-14f). Paired clam and worm samples exposed in the laboratory tended to have concentrations within the same order of magnitude (typically within a factor of 5 or less).

5.5.8.2 Total Chlordanes in Biota

A box-whisker plot showing the distribution of total chlordanes for each species and tissue type is provided in Figure 5.5-4. Total chlordane concentrations by river mile for each species and tissue type are shown in Figures 5.5-15a–j.

5.5.8.2.1 Fish

Chlordanes were detected with varying frequency in all species except northern pikeminnow. The frequency of detection ranged from 25 percent (black crappie fillets) to 100 percent (whole-body black crappie and sturgeon). Average whole-body concentrations ranged from 3.2 µg/kg (juvenile Chinook) to 20.1 µg/kg (juvenile lamprey); the maximum concentration (67 µg/kg) was measured in a brown bullhead whole-body composite sample at FZ0306 (fishing zone between RM 3 and 6). Average fillet concentrations ranged from 1.1 µg/kg (black crappie) to 9.15 µg/kg (carp). The maximum detected concentration in any fillet sample (12 NJ µg/kg) occurred in carp from Station CP0408 (fishing zone from RM 4 to 8).

5.5.8.2.2 Invertebrates

Chlordanes were detected in all invertebrate samples except 22 crayfish tissues. Species mean concentrations ranged from 0.45 µg/kg (mussels) to 6.51 µg/kg (laboratory-exposed worms). Maximum concentrations were below 9 µg/kg in juvenile Chinook stomach contents, laboratory-exposed clams, crayfish, and epibenthic community samples. For field-collected clams, the maximum was 16 J µg/kg; for laboratory-exposed worms, the maximum was 71.9 µg/kg. These highest concentrations were measured in samples exposed in the laboratory to sediments from BT028 (RM 8.8W).

5.5.8.3 Aldrin in Biota

A box-whisker plot showing the distribution of aldrin for each species and tissue type is provided in Figure 5.5-4. Aldrin concentrations by river mile for each species and tissue type are shown in Figures 5.5-16a–j.

5.5.8.3.1 Fish

Aldrin was only detected in Round 2 and Round 3 fish samples, including juvenile lamprey, carp, smallmouth bass, sturgeon and sculpin. Laboratory detection limits were lower for these samples than for Round 1 samples. The average whole-body concentrations for these species ranged from 0.014 µg/kg (sculpin) to 1.60 µg/kg (juvenile lamprey), with the maximum concentration found in juvenile lamprey from RM 2.4 (1.82 µg/kg). Aldrin was detected in the fillet composite samples of smallmouth bass and carp only (averages are 0.084 µg/kg and 0.0066 µg/kg, respectively).

5.5.8.3.2 Invertebrates

Aldrin was detected in all invertebrate species. The frequency of detection ranged from 2.8 percent (crayfish) to 100 percent. Average concentrations ranged from 0.004 µg/kg in the contents of sturgeon stomachs to 1.49 µg/kg in laboratory-exposed worms. The maximum concentration (37 µg/kg) occurred in worms exposed in the laboratory to sediment from BT028 on the west bank near RM 8.8W. Field-collected and laboratory-exposed clams also contained their maximum concentrations at Station BT028 (5.07 µg/kg and 2.14 µg/kg, respectively). The maximum aldrin concentrations in Chinook stomach contents and epibenthic community composites were below 0.1 µg/kg.

5.5.8.4 Dieldrin in Biota

A box-whisker plot showing the distribution of dieldrin for each species and tissue type is provided in Figure 5.5-5. Dieldrin concentrations by river mile for each species and tissue type are shown in Figures 5.5-17a–j.

5.5.8.4.1 Fish

Dieldrin was detected in all fish species except largescale sucker, northern pikeminnow, and peamouth. Laboratory detection limits for dieldrin were also higher for Round 1 samples than for subsequent LWG samples, and these species were only collected in Round 1. Among species with dieldrin detections, the frequency of detection ranged from 16.7 percent (brown bullhead fillets) to 100 percent. The average whole-body concentrations for these species ranged from 1.6 µg/kg (Chinook) to 4.56 µg/kg (sculpin). The maximum concentration was found in sculpin from 02R001 (24 J µg/kg at RM 2.4E). Similar concentrations were also found in sculpin from 03R004 and 03R005 (15 NJ µg/kg at RM 4.1E and 19 NJ µg/kg at RM 3.7E, respectively). Average fillet concentrations ranged from 0.555 µg/kg (smallmouth bass) to 2.1 µg/kg (brown bullhead). The maximum concentration in fillet occurred in a smallmouth bass fillet composite sample from 03R014 (3.3 NJ µg/kg; fishing zone from RM 2.4 to 3.5).

5.5.8.4.2 Invertebrates

Dieldrin was detected in all invertebrate species with frequencies from 22 percent (crayfish) to 100 percent (several species). Average concentrations ranged from 0.018 µg/kg (crayfish) to 1.48 µg/kg (Chinook stomach contents). The maximum concentration was from a laboratory-exposed worm composite sample exposed to sediment from BT028 (26.7 µg/kg at RM 8.8W). All other concentrations were less than 4.5 µg/kg.

5.5.8.5 Arsenic in Biota

A box-whisker plot showing the distribution of arsenic for each species and tissue type is provided in Figure 5.5-5. Arsenic concentrations by river mile for each species and tissue type are shown in Figures 5.5-18a–j.

5.5.8.5.1 Fish

Arsenic was detected in all fish species and tissues analyzed within the Study Area, with average whole-body concentrations consistently higher than those of fillets. Average whole-body arsenic concentrations ranged from 0.056 mg/kg (brown bullhead) to 0.594 mg/kg (sturgeon). The highest whole-body concentrations were associated with all sturgeon samples (0.46–1.06 mg/kg), peamouth from Swan Island Lagoon (0.48 mg/kg), black crappie from FZ0609 (0.42 mg/kg; fishing zone from RM 6 to 9), and smallmouth bass and northern pikeminnow from 03R014 (0.39 mg/kg and 0.36 mg/kg, respectively). Average fillet concentrations ranged from 0.02 mg/kg (brown bullhead) to 0.34 mg/kg (sturgeon), with the maximum concentration in sturgeon from RM 3.5 to 9.2 (0.54 mg/kg).

5.5.8.5.2 Invertebrates

Arsenic was detected in all invertebrate samples, with the exception of one crayfish composite sample. Average concentrations ranged from 0.34 mg/kg (crayfish) to 1.03 mg/kg (laboratory-exposed worms). The maximum concentrations (3.04 mg/kg) occurred in worms exposed in a laboratory to sediment collected from BT019

(RM 7.4E). Most of the field-collected and laboratory-exposed clam samples were below 1.0 mg/kg; most of the worm sample concentrations were higher, but below 2.0 mg/kg.

5.5.8.6 Chromium in Biota

A box-whisker plot showing the distribution of chromium for each species and tissue type is provided in Figure 5.5-6. Chromium concentrations by river mile for each species and tissue type are shown in Figures 5.5-19a–j.

5.5.8.6.1 Fish

Chromium was detected in all fish species with varying detection rates. Average whole-body concentrations were higher than those of fillets, except for black crappie, where chromium was only detected in fillets. Average whole-body chromium concentrations ranged from 0.13 mg/kg (Chinook) to 20.2 mg/kg (sturgeon). The maximum concentration in an individual sample occurred in a sturgeon from STWB01 near RM 2.3 (40.2 mg/kg). Maxima for all other species were less than one-tenth that of the sturgeon. Average fillet concentrations ranged from 0.12 mg/kg (brown bullhead) to 1.55 mg/kg (sturgeon), with the maximum concentration in sturgeon from RM 3.5 to 9.2 (3.25 mg/kg). All other fillet concentrations were less than 1.50 mg/kg.

5.5.8.6.2 Invertebrates

Chromium was detected in all invertebrate tissue samples, with detection rates ranging from 42.9 to 100 percent. Average concentrations ranged from 0.20 mg/kg (laboratory clams) to 1.6 mg/kg (sturgeon stomach contents). The highest concentration (4.1 mg/kg) occurred in sturgeon stomach content sample STWB03 (RM 6.6).

5.5.8.7 Copper in Biota

A box-whisker plot showing the distribution of copper for each species and tissue type is provided in Figure 5.5-6. Copper concentrations by river mile for each species and tissue type are shown in Figures 5.5-20a–j.

5.5.8.7.1 Fish

Copper was detected in all fish species and tissues analyzed within the Study Area, with whole-body concentrations consistently higher than those of fillets. Average whole-body copper concentrations ranged from 0.661 mg/kg (northern pikeminnow) to 4.27 mg/kg (juvenile lamprey). The maximum concentration occurred in a sculpin composite sample from location SP10W at RM 10.3W (7.16 mg/kg). Average fillet concentrations ranged from 0.178 mg/kg (black crappie) to 0.459 mg/kg (carp), with the maximum concentration in smallmouth bass from 05R006 (1.12 mg/kg; fishing zone from RM 4.5 to 5.5).

5.5.8.7.2 Invertebrates

Copper was detected in all invertebrate tissue samples. Average concentrations ranged from 1.39 mg/kg (mussel) to 14.8 mg/kg (crayfish). The maximum concentration (20.2 mg/kg) was found in laboratory-exposed worms, which were exposed to sediment collected from location BT023 (RM 8.1E), and crayfish from location CR11E (RM 11.3E). Copper concentrations were below 4 mg/kg in the remaining worm samples, while all crayfish samples contained more than 10 mg/kg of copper.

5.5.8.8 Zinc in Biota

A box-whisker plot showing the distribution of zinc for each species and tissue type is provided in Figure 5.5-7. Zinc concentrations by river mile for each species and tissue type are shown in Figures 5.5-21a–j.

5.5.8.8.1 Fish

Zinc was detected in tissues of all fish species analyzed within the Study Area, with whole-body concentrations consistently higher than fillet concentrations. Average whole-body zinc concentrations ranged from 9.53 mg/kg (sturgeon) to 91.9 mg/kg (carp). The maximum whole-body concentration was measured in a carp composite sample from fishing zone CP0408 (113 mg/kg; fishing zone from RM 4 to 8); sample maxima for all other species were less than 35 mg/kg. Average fillet concentrations ranged from 2.56 mg/kg (sturgeon) to 25.7 mg/kg (carp). The maximum fillet sample concentration occurred in a carp composite from CP0408 (31 J mg/kg); average zinc concentrations in fillet samples of the remaining fish species were below 11 mg/kg.

5.5.8.8.2 Invertebrates

Zinc was detected in all invertebrate tissues analyzed. Average concentrations ranged from 13 mg/kg (laboratory-exposed clams) to 33.1 mg/kg (field-collected clams). The maximum concentration (54 mg/kg) in an invertebrate sample was measured in field-collected clams from FC023 (RM 8.1E). All epibenthic community sample composites contained less than 25 mg/kg zinc. Zinc concentrations in crayfish tissue did not exceed 21 mg/kg; in laboratory-exposed worms and clam samples, concentrations were below 55 mg/kg.

5.5.8.9 Tributyltin Ion in Biota

A box-whisker plot showing the distribution of TBT for each species and tissue type is provided in Figure 5.5-7. TBT concentrations by river mile for each species and tissue type are shown in Figures 5.5-22a–i.

5.5.8.9.1 Fish

TBT was analyzed in samples of juvenile Chinook and all Round 3 samples, including carp, juvenile lamprey, sculpin, smallmouth bass, and sturgeon (see Table 2.2-8). Average whole-body concentrations ranged from 0.78 µg/kg (sturgeon) to 5.6 µg/kg

(carp). The maximum concentration occurred in a carp whole-body composite sample at CP0812 (8.6 µg/kg; fishing zone from RM 8 to 12). Average fillet concentrations were 0.68 µg/kg (smallmouth bass) and 5.4 µg/kg (carp). The maximum fillet sample concentration also occurred in a carp composite from CP0812 (11 J µg/kg; fishing zone from RM 8 to 12).

5.5.8.9.2 Invertebrates

TBT was detected in just over half of the field-collected clams (59.5 percent), laboratory-exposed worms (55.6 percent), and crayfish (55.6 percent), and slightly less frequently in the laboratory-exposed clams (42.2 percent). TBT was detected in all seven mussel tissue composite samples. It was not detected in the four field-collected clam samples that had been depurated prior to analysis and was not measured in epibenthic community samples.

Average TBT concentrations in invertebrate species ranged from 1.3 µg/kg (crayfish) to 77 µg/kg (laboratory-exposed worms). The maximum concentration in an individual composite sample (1,700 µg/kg) was measured in worms exposed in the laboratory to sediment from BT023 near the entrance to Swan Island Lagoon (RM 8.1E). The next-highest concentrations were also found at this location in the field-collected and laboratory-exposed clams (680 µg/kg and 530 µg/kg, respectively).

5.5.8.10 Lipids

A box-whisker plot showing the distribution of lipids for each species and tissue type is provided in Figure 5.5-8. Lipids concentrations by river mile for each species and tissue type are shown in Figures 5.5-23a–j.

5.5.8.10.1 Fish

The lipid content was measured in most fish tissue samples (Table 2.2-8). The average lipid content in fish whole-body tissues ranged from 1.8 percent (Chinook) to 8.93 percent (peamouth). The maximum lipid content (13 percent) in an individual composite was found in a carp whole-body composite from FZ0609 (fishing zone from RM 6 to 9). As expected, fillets typically had lower lipid content, with averages ranging from 1.04 percent (smallmouth bass) to 5.49 percent (carp).

5.5.8.10.2 Invertebrates

The lipid content was measured in most tissue samples with sufficient volume (e.g., no lipid was measured in epibenthic community samples). Average lipid content in invertebrates ranged from 0.40 percent (mussel) to 2.32 percent (laboratory-exposed worms). The maximum lipid content occurred in field-collected clam tissue from Station BT028, RM 8.8W (4.63 percent).

5.5.9 Indicator Chemicals in Biota Collected Upriver from the Study Area and Above Willamette Falls

Seven upriver locations, between Ross Island (RM 16) and Willamette Falls (RM 26) and above Willamette Falls, were sampled in connection with studies completed in Portland Harbor (see Table 5.5-6):

- Station 20R001 (sampling locations between RM 21 and 24) and Station 28R001 (sampling locations between the Tualatin River mouth and approximately RM 32, above Willamette Falls), where whole-body brown bullhead and smallmouth bass were collected during Round 1
- Stations LT023b (Sellwood Bridge, RM 16.5–17) and LT023c (Eld Rock Island, RM 18.7), where lamprey ammocoetes and macropthalmia were collected during Round 3
- Station 26R111 (just above Willamette Falls) and Station T04 (on the east bank of the river below RM 18), where juvenile Chinook whole-body tissue (and stomach content tissues in the case of T04) were collected during Round 1 (26R111) and Round 2 (T04)
- Station WR-PG-Ref03 below RM 19, which was used as a reference station for sediment sampled as part of the USACE investigation (Tetra Tech 2006) for bioaccumulation testing using worms and clams.

These data are discussed here to assist in establishing typical tissue concentrations of ICs outside of the Study Area. The results are summarized in this section and in Tables 5.5-3, 5.5-4, and 5.5-5. Adult Pacific lamprey from the Willamette Falls area and adult spring Chinook from the Clackamas River hatchery were not included in the evaluation of ICs in upriver areas because they are anadromous species and do not represent conditions upriver of the Study Area; their tissue burdens are representative of exposures throughout the Lower Willamette River and beyond.

5.5.9.1 Total PCBs in Biota

5.5.9.1.1 Fish

Average total PCB concentrations in fish from the upriver reach and above falls areas ranged from 14.5 µg/kg in juvenile Chinook to 238 µg/kg in smallmouth bass. The maximum concentration of 317 J µg/kg was measured in a smallmouth bass composite collected near RM 24, one of the samples from location 20R001.

As in the Study Area, PCB congeners in samples from the upriver reach and above-falls locations included predominantly tetraCBs, pentaCBs, hexaCBs, and heptaCBs. Chlorination levels were lower for juvenile Chinook and juvenile lamprey than for brown bullhead and smallmouth bass: juvenile Chinook and juvenile lamprey contained higher proportions of triCBs and tetraCBs, whereas brown bullhead and smallmouth bass contained more heptaCBs and octaCBs.

5.5.9.1.2 Invertebrates

Total PCBs (as congeners) were detected in one juvenile Chinook stomach content sample, at a concentration of 10.6 J µg/kg. Aroclors were not detected in laboratory-exposed clams and worms, and these samples were analyzed for too few PCB congeners to calculate a total PCB congener value.

5.5.9.2 Total PCDD/F Homologs and TCDD TEQ in Biota

5.5.9.2.1 Fish

Total PCDD/F averages for the various fish species ranged from 3.03 pg/g in brown bullhead to 53 pg/g in juvenile lamprey. The maximum concentration (63 pg/g) was measured in a juvenile lamprey composite collected near RM 18.9. As they did in the Study Area, dioxin and furan homolog patterns varied among species, locations and individual samples. For example, TCDFs dominated the PCDD/F pattern for juvenile lamprey from above the falls, whereas OCDD was the predominant homolog for juvenile lamprey from the upriver reach area (below the falls); OCDD was also clearly the dominant homolog in juvenile Chinook. Smallmouth bass contained a high proportion of PeCDF in many cases, whereas HxCDD was the most abundant homolog in two of the three brown bullhead samples. One brown bullhead sample was notable for its large proportion of TCDD (30 percent of total PCDD/Fs as the sum of homologs); this homolog did not account for more than 10 percent of the PCDD/Fs in any other sample from the upriver reach or above the falls. Additional differences were noted among samples from the same species and similar locations.

Average concentrations of TCDD TEQ ranged from 0.45 pg/g (brown bullhead) to 2 pg/g (juvenile lamprey). The maximum concentration was found in a juvenile lamprey composite collected near RM 18.5 (3.1 J pg/g).

5.5.9.2.2 Invertebrates

PCDD/F analyses were not conducted for juvenile Chinook stomach contents or bioaccumulation test organisms.

5.5.9.3 Total DDx in Biota

5.5.9.3.1 Fish

Average total DDx concentrations ranged from 8.5 µg/kg in juvenile Chinook whole-body tissues to 94 µg/kg in smallmouth bass. The highest concentrations, 120.4 NJ µg/kg and 104.5 J µg/kg, were measured in smallmouth bass (20R001 replicates collected near RM 23 and 24, respectively).

The most abundant isomer in all tissues was 4,4'-DDE, which accounted for at least 50 percent and up to 85 percent of the total DDx. Typically 4,4'-DDT was the next most abundant; all other DDx compounds were also present at varying levels.

5.5.9.3.2 Invertebrates

Three invertebrate samples from the upriver reaches were analyzed for DDx isomers. The total DDx concentration in the juvenile Chinook stomach content sample was 6.61 J µg/kg. The most abundant isomer was 4,4'-DDE, which contributed over 80 percent to the total DDx concentration. Total DDx concentrations were 11.3 J µg/kg and 5.89 J µg/kg in laboratory-exposed worm and clam samples, respectively. In worms, 4,4'-DDE and 2,4'-DDT were the two most abundant isomers; in the laboratory-exposed clams, 4,4'-DDE, 4,4'-DDT, and 2,4'-DDT were most abundant.

5.5.9.4 Total PAHs in Clam Tissue

PAH data are available for only one clam sample that represents exposures upriver of the Study Area. The total PAH concentration in this laboratory-exposed clam tissue was 29.7 J µg/kg. HPAHs accounted for almost two-thirds of this total.

5.5.9.5 Bis(2-ethylhexyl)phthalate in Biota

5.5.9.5.1 Fish

BEHP was detected in eight of the 12 fish tissue samples from the upriver reach and none of the five fish from above the falls. The detected concentrations ranged from 140 J µg/kg (in two juvenile Chinook composites) to 4,800 µg/kg in smallmouth bass from RM 21 to 24.

5.5.9.5.2 Invertebrates

BEHP was reported at 85 J µg/kg in clams and 66 J µg/kg in worms used in the bioaccumulation tests from the USACE investigation upriver area (Tetra Tech 2006). Contents of juvenile Chinook stomachs were not analyzed for phthalates.

5.5.9.6 Total Chlordanes in Biota

5.5.9.6.1 Fish

Chlordanes were detected in all fish tissue samples, except juvenile Chinook, from above Willamette Falls. Average total chlordanes ranged from 1.1 µg/kg (brown bullhead) to 15.4 µg/kg (juvenile lamprey). The maximum concentration (25.2 µg/kg) was reported in a juvenile lamprey composite sample collected near RM 18.9.

5.5.9.6.2 Invertebrates

Total chlordanes were reported at 2.26 J µg/kg in the juvenile Chinook stomach content sample and 4.6 J µg/kg in clam tissues analyzed from the reference area bioaccumulation tests. This pesticide group was not detected in the worms.

5.5.9.7 Aldrin in Biota

5.5.9.7.1 Fish

Aldrin was only detected in the four juvenile lamprey composite samples from RM 16.9 and 18.3, with an average concentration of 1.86 µg/kg. The maximum concentration was 2.72 µg/kg. The detection limits for aldrin in fish tissue were higher than for the Round 2 and 3 Study Area fish samples, which were the only Study Area fish tissue samples in which aldrin was detected.

5.5.9.7.2 Invertebrates

Aldrin was not detected in the juvenile Chinook stomach composite from fish collected at T04 or in the clams exposed to reference area sediments. The worm sample concentration was reported as 0.36 J µg/kg.

5.5.9.8 Dieldrin in Biota

5.5.9.8.1 Fish

Dieldrin was detected in 15 of 17 fish tissue samples from the upriver reach and above the falls. The average concentration of dieldrin in upriver fish tissue composites ranged from 0.74 µg/kg (juvenile Chinook) to 3.5 µg/kg (smallmouth bass) with a maximum concentration (5.36 µg/kg) reported in a juvenile lamprey composite sample from RM 18.9.

5.5.9.8.2 Invertebrates

Dieldrin concentrations in upriver invertebrates ranged from 0.22 J µg/kg (laboratory-exposed worms) to 0.905 µg/kg (juvenile Chinook stomach contents).

5.5.9.9 Arsenic in Biota

5.5.9.9.1 Fish

Arsenic was detected in all tissue samples from the upriver reach and above the falls. Average arsenic concentrations in the upriver fish tissues ranged from 0.03 mg/kg (juvenile Chinook) to 0.32 mg/kg (smallmouth bass). A maximum of 0.36 mg/kg occurred in a smallmouth bass composite collected near RM 23 (part of 20R001).

5.5.9.9.2 Invertebrates

The arsenic concentration in the laboratory-exposed clam composite was reported as 0.392 mg/kg; the laboratory-exposed worm composite sample had a higher concentration, at 1.52 mg/kg. Arsenic was not measured in juvenile Chinook stomach contents.

5.5.9.10 Chromium in Biota

5.5.9.10.1 Fish

Chromium was detected in 12 of 17 fish tissue samples from the upriver reach and above the falls. Average concentrations of chromium in fish tissues ranged from 0.28 mg/kg (juvenile lamprey) to 2.04 mg/kg (brown bullhead). A maximum concentration of 2.79 mg/kg occurred in smallmouth bass at 20R001, RM 21 to 24. Chromium was not detected in juvenile Chinook.

5.5.9.10.2 Invertebrates

The chromium concentration was 0.0936 mg/kg in the laboratory-exposed clam composite sample and 0.197 mg/kg in the laboratory-exposed worm composite sample. Chromium was not measured in juvenile Chinook stomach contents.

5.5.9.11 Copper in Biota

5.5.9.11.1 Fish

Copper was detected in all fish tissue samples from the upriver reach and above the falls. Average concentrations of copper in fish tissue ranged from 0.44 mg/kg (smallmouth bass) to 4.43 mg/kg (juvenile lamprey). A maximum concentration of 4.8 mg/kg occurred in juvenile lamprey (LT023c at RM 18.7).

5.5.9.11.2 Invertebrates

The copper concentration was 3.19 mg/kg in the laboratory-exposed clam composite sample and 1.86 mg/kg in the laboratory-exposed worm composite sample. Chromium was not measured in juvenile Chinook stomach contents.

5.5.9.12 Zinc in Biota

5.5.9.12.1 Fish

Zinc was detected in all fish tissue samples from the upriver reach and above the falls. The average concentrations of zinc in upriver fish tissue composites ranged from 13.8 mg/kg (smallmouth bass) to 34 mg/kg (juvenile Chinook) with a maximum concentration of 34 mg/kg in juvenile Chinook from Willamette Falls.

5.5.9.12.2 Invertebrates

The zinc concentration in the laboratory-exposed clam composite sample was reported as 10.6 mg/kg; the laboratory-exposed worm composite sample concentration was 22 mg/kg. Zinc was not measured in juvenile Chinook stomach contents.

5.5.9.13 Tributyltin Ion in Biota

5.5.9.13.1 Fish

TBT concentrations ranged from 0.37 J to 0.45 J µg/kg (average of 0.41 µg/kg) in the three juvenile Chinook samples from T04. TBT was not measured in other upriver fish tissues.

5.5.9.13.2 Invertebrates

The TBT concentration was reported as 0.091 NJ µg/kg in laboratory-exposed clams (although qualified as tentatively identified) and was not detected in laboratory-exposed worms from the USACE (Tetra Tech 2006) reference area. TBT was not measured in juvenile Chinook stomach contents.

5.5.9.14 Lipids

5.5.9.14.1 Fish

Average percent lipids ranged from 1.8 percent (juvenile Chinook composites) to 6.2 percent (smallmouth bass composites). These values were very similar to the range reported for the same species from the Study Area. The maximum concentration occurred in a juvenile lamprey composite from RM 18.9 (10 percent).

5.5.9.14.2 Invertebrates

Lipid levels in the single clam and single worm composite sample from the bioaccumulation tests were reported as 1.1 percent and 1.6 percent, respectively. These values fall within the range reported for clams and worms within the Study Area, although the upriver worm lipid value is lower (1.6 percent) than the average reported for worms used in Study Area bioaccumulation tests (2.3 percent). No lipid data are available for the upriver juvenile Chinook stomach contents.

5.5.10 Summary of Nature and Extent of Indicator Chemicals in Biota

The majority of the ICs discussed in this section are distributed across the entire Study Area at concentrations greater than those seen in the samples from the upriver reaches and above Willamette Falls. Concentrations generally varied by orders of magnitude within and between species, with localized areas of concentrations elevated in comparison to the rest of the Study Area for some species and ICs. Concentrations in fish tissues were greater than those in invertebrate samples, with the exceptions of PCDD/Fs, arsenic, copper, and TBT.

The average maximum total PCB concentrations within the Study Area were elevated in comparison to the upriver reaches by at least an order of magnitude. The distribution of PCB homologs varied within and between species, but was generally dominated by tetraCB, pentaCBs, hexaCBs, and heptaCBs.

The average maximum whole-body fish tissue concentrations of PCDD/Fs in the Study Area and the upriver reaches were similar; however the maximum Study Area concentration was greater than that of the upriver reach by more than a factor of five. Invertebrate concentrations were greater than fish tissue concentrations within the Study Area; no upriver invertebrate data is available for comparison. PCDD/F homolog distributions were variable between fish species but were more consistent between invertebrate species.

Average maximum total DDx concentrations within the Study Area were also elevated in comparison to the upriver reaches. The distribution of DDx isomers varied between and within species, with the 4,4'-isomer of DDE being dominant in fish tissues. Invertebrates from the upriver reaches were also dominated by 4,4'-DDE, while invertebrates (except crayfish) from the Study Area were dominated by a mixture of 4,4-DDD and 4,4'-DDE.

PAHs were an IC for clam tissues only, and only one sample from the upriver reach was available for comparison. The clam tissues from the Study Area were elevated in comparison to the upriver sample and were generally dominated by phenanthrene, fluoranthene, pyrene, and chrysene.

BEHP and TBT were the only ICs not found across the entire Study Area. These chemicals were found river-wide in clam and laboratory-exposed worm samples but only in localized areas in fish tissues.

Concentrations of total chlordanes, aldrin, dieldrin, arsenic, and copper within the Study Area were generally higher than those found in the upriver reaches, but were not elevated to the same degree relative to upriver reaches as were the other ICs.

5.6 DISTRIBUTION OF INDICATOR CHEMICALS IN UPSTREAM AND DOWNSTREAM AREAS AND IN UPPER STUDY AREA SEDIMENT DEPOSITIONAL AREAS

This section provides an overview of the nature and extent of the four bounding ICs (total PCBs, TCDD TEQ, total DDx, and total PAHs) in sediments in areas upstream and downstream of the Study Area, as well as in known depositional areas in the navigation channel at the upper end of the Study Area.

Following a description of data products given in Section 5.6.1, this section is divided into two main subsections: Section 5.6.2 compares bedded sediment contaminant concentration data in upstream (downtown and upriver reaches above RM 11.8) and downstream (RM 1.9 to the Columbia River and upper Multnomah Channel) reaches; Section 5.6.3 details the subsurface core data collected in several known depositional areas located near the upper Study Area boundary (from RM 9.5 to 10.9). This "natural sediment trap" data set reflects the levels of contamination accumulating in the upper Study Area over time (i.e., in the last 10 years or so).

5.6.1 Description of Sediment Presentation Tools

The sediment chemistry distributions are depicted in three graphical formats: box-whisker plots (Figures 5.6-1 through 5.6-6), core log plots (Figures 5.6-7), and vertical core concentration plots (Figures 5.6-8 through 5.6-12). Appendix D6.1 provides summary statistics of all sediment analytes.

Box-Whisker Plots: Box-whisker plots (Figures 5.6-1 through 5.6-6) were developed to compare the range of chemical concentrations for the four ICs immediately upstream and downstream of the Study Area. The data plotted includes both detected and undetected values. Box-whisker plots are useful in displaying and interpreting the distribution of data. The descriptive statistics graphically depict the sample minimum, the lower quartile, the median, the upper quartile, and the maximum. A box-whisker plot also shows which points may be outliers. Plotting data sets (i.e., from the Study Area and reaches adjacent to the Study Area) side-by-side allows visual comparisons between data sets. The scale of the plots has been adjusted to allow for comparison between the data sets, and some extreme outliers are not displayed. The box-whisker plots included here were developed in Statistica. Results of statistical analyses using the Mann-Whitney test (a.k.a. Wilcoxon) are shown to reveal significant differences in pair-wise comparisons. The Mann-Whitney test compares the distribution overlap of two data sets rather than their respective means. The Bonferroni adjustment was used to control the family-wise error rate (adj.p) at a significance level of $P \leq 0.05$. The results of pair-wise comparisons of selected ICs in surface sediments by reach are presented.

Core logs: Standard core logs were prepared for three cores collected from depositional areas located in the upper Study Area (Figure 5.6-7). Core length from the

mudline is plotted on the left side of the core log in centimeters with sediment texture descriptions provided adjacent to the corresponding core length.

Core plots: Vertical core concentration plots (Figures 5.6-8 through 5.6-12) show chemical concentrations plotted relative to core depth. Chemical concentrations for percent fines, percent TOC, and ICs (µg/kg) are plotted vertically, and core depth (cm) is plotted horizontally. The resulting plots display vertical concentration gradients with depth. Data from each core are organized by chemical for comparisons across cores.

5.6.2 Upstream and Downstream Subareas and Sediment Quality

Map 5.6-1 shows the four outlying (i.e., beyond the Study Area) LWR reaches that are addressed here. These subareas include the following:

1. The upriver reach (this reach overlaps with the background reach detailed in Section 7)
2. The downtown reach, which runs through downtown Portland and separates the upriver reach from the upstream end of the Study Area
3. The downstream reach, which extends from the downstream end of the Study Area to the Columbia River
4. The Multnomah Channel reach, which extends from the Willamette River at RM 3 to the Sauvie Island Bridge.

Summary statistics for the upstream and downstream reaches for all ICs in surface and subsurface sediments are provided in Tables 5.6-1 through 5.6-12. A summary of statistics for the four bounding ICs in surface sediments from the four outlying reaches and the Study Area are compiled in Table 5.6-13. The sediment data compiled for these subareas consist of all LWG-generated and non-LWG-generated data collected from May 1997 through February 2008. Data from the recent Downtown Portland Sediment Characterization completed by the City of Portland in June 2008 are also included to provide additional information on sediment quality in the downtown reach. Only Category 1 data (data of known quality) were compiled for all reaches (see Section 5.1.1).[1] Summary statistics for the downtown reach are provided both with and without the Zidell data (Table 5.6-3 through Table 5.6-6), as described below in Section 5.6.2.1. Summary statistics exclusively for the Zidell data are also included (Table 5.6-7 and Table 5.6-8).

[1] Sediment chemical distributions for 14 indicator chemicals in Multnomah Channel, to RM 0.9 in the downstream reach, and to RM 12.2 in the downtown reach, are also depicted in three graphical formats: surface plan-view concentration maps and subsurface core concentration maps (Maps 5.1-1 through 5.1-28), and scatter-plot graphs (Figures 5.1-1 through 5.1-32). Maps and scatter-plot graphs of surface and subsurface concentrations for the remaining 21 sediment indicator chemicals plus percent fines and TOC are included in Appendices D1.1 and D1.3, respectively.

Maps 2.2-1a–y and 2.2-2a–t show the distribution of all surface and subsurface sampling locations in the project data set from RM 0 to approximately RM 30, coded by survey.

Table 5.6-14 lists all sediment samples collected from the upstream and downstream reaches by reach and river mile.

5.6.2.1 Outlying Reach Sediment Data and Physical Characteristics

The four subareas are described in more detail below, followed by a comparison of the data distribution for bounding ICs between these reaches.

The **upriver reach** includes all Category 1 (i.e., data of known quality) surface sediment data from approximately RM 15.3 (upper end of Ross Island) to RM 28.4 (above Willamette Falls). Upstream of the major industrialized and urban portions of the LWR, bedded sediments in this reach should reflect the quality of material entering the LWR from upstream of Willamette Falls, from any tributaries (e.g., the Clackamas River), and from within-reach sources of contamination (e.g., stormwater runoff). As noted above, the upriver reach is also the focus of the background data evaluation presented in Section 7. Relative to the Study Area, most of the upriver reach is dynamic and the channel is coarse-grained with finer-grained sediments generally restricted to small off-channel areas (Map 5.6-2). In fact, most of the main channel above RM 20 could not be sampled with a grab sampler because the riverbed is cobbled or hard. The upriver reach data set contains subsurface data from three cores collected by the City of Portland between RM 15.5 and RM 16. The data presented for these three subsurface cores does not represent the entire upriver reach geographically.

The **downtown reach** includes all Category 1 surface sediment data from RM 11.8 (just downstream of the Steel Bridge), through downtown Portland to RM 15.3 (upper end of Ross Island). As noted in Section 3.4.2, the relatively narrow downtown reach contrasts with the Study Area in hydrodynamic and physical sediment characteristics. The bathymetric change data (see Map 3.4-5) show that, except for some off-channel areas around Ross Island, there are no sizable depositional zones in this reach. Sediment quality within this reach is influenced by local sources unrelated to sources in the Study Area and potentially by sources from the upriver reach. The Zidell DEQ cleanup site is within this reach and is scheduled for remedial action in the next few years. For this reason, downtown reach sediment quality is discussed here both with and without the Zidell data included.

Two other sediment cleanup sites in the downtown reach, Portland General Electric Company (PGE) Station L and Ross Island Lagoon, are not included in the data set. Historical data collected from these sites are not included because both sites have been capped, and underlying contaminated sediments are physically isolated from the environment. The following paragraphs provide a brief overview of these sites.

PGE Station L (ECSI No. 151) was a steam-powered electricity generating plant that operated from the early 1900s to 1975. The plant was located on an 18-acre site on the east bank of the LWR at approximately RM 13.4. A portion of this site is now occupied by the Oregon Museum of Science and Industry. The steam-powered plant was originally fed by hog fuel (saw dust and wood chips) and was later converted to oil. During Hart Crowser's sediment characterization off Station L, former employees noted the transformer storage area located immediately adjacent to the river was potentially affected by historical oil spills. PCB concentrations in nearby surface sediments ranged from non-detects (detection limit unknown) offshore to 1,150,000 µg/kg at the shoreline. Hart Crowser (1988) concluded the PCB concentration gradient pointed to the former transformer storage area as the primary source (Hart Crowser 1988). Sediments adjacent to the former facility were dredged and capped between July 1990 and January 1991. The cap consisted of multi-layered sand, gravel, and riprap in excess of 6 ft thick. Cap monitoring is ongoing through 2020 (DEQ 2009c). A certificate of No Further Action was issued on September 26, 1994.

Ross Island (ECSI No. 2409) is a former sand and gravel mine owned and operated by Ross Island Sand and Gravel Company (RISG). The Willamette River and Holgate Slough surround Ross Island and Hardtack Island at RM 15. An earthen dike constructed in the 1920s joined Ross and Hardtack Islands and formed Ross Island Lagoon (Landau 2002). RISG mined sand and gravel between 1926 and 2001 (DEQ 2009b). In 1979, the City of Portland issued a Conditional Use Permit that specified areas for continued mining and upland and in-water mined areas for reclamation. RISG began importing fill material to meet permit requirements. Fill materials included noncommercial material from onsite aggregate processing, dredged material from local sites, and other non-specified fill material. Some fill material, deemed unsuitable for unconfined open water disposal, was placed in five surface depressions and capped. Frequently detected chemicals in lagoon sediments were metals, TPH, PAHs, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, organotins, and endrin aldehyde (Landau 2002b). Maximum DDx and PCB concentrations occurred in subsurface sediment. DDx ranged from 0.2 µg/kg to 6,500 µg/kg. PCBs ranged from 4 µg/kg to 2,900 µg/kg (see Appendix A1). In the late 1990s, DEQ required the Port of Portland and RISG to characterize Ross Island Lagoon sediments and to assess risk to human health and the environment. A ROD for Ross Island Lagoon was signed in 2005 (DEQ 2009d).

The **downstream reach** includes all Category 1 surface samples from RM 0 (Columbia River) to RM 1.9. As a group, samples from this reach should reflect the quality of material both settling out downstream of the Study Area and moving along the riverbed. However, it is clear from the hydrodynamic interactions between the LWR, the Columbia River, and the Multnomah Channel (see Section 3.3.3) that upstream transport of suspended sediments and perhaps bedload transport of sediments from the Columbia River into this lower reach of the Willamette is also possible, especially during periods of low Willamette flows (see Section 6.1.1.2 and Table 6.1.3). Note that within the downstream reach, a distinct change in the hydrodynamic/sediment transport conditions occurs at approximately RM 1.5 (see Section 3.5.3). At this location, the

river narrows, the modeled bottom shear stresses increase, and the extensive area of sediment deposition along the eastern portion of the channel that begins around RM 3, and is referred to as Post Office Bar, ends.

The **Multnomah Channel reach** includes Category 1 samples located at the head of or within Multnomah Channel. As described in Section 3.3.3.2, significant discharge occurs through the Multnomah Channel under all combinations of flow conditions on the Willamette and Columbia rivers. Flow direction is always downstream (i.e., away from the Willamette) in the Multnomah Channel. In terms of discharge volume, the Multnomah flow can range anywhere from 25 to over 100 percent (supplemented by Columbia River flow) of the Willamette flow immediately upstream of the Multnomah Channel. Therefore, suspended sediments in the Willamette River both upstream and downstream (at times) of the Multnomah Channel entrance have the potential to be carried into the channel. The Multnomah Channel is approximately one-half the depth of the Willamette, and there is a distinct rise or sill in the riverbed at the channel entrance (a result of the LWR navigation channel dredge cut; see Map 3.4-4). This topographic feature likely severely limits bedload sediment transport from the LWR into the channel. The markedly reduced cross-sectional area in the Multnomah Channel (due to reduced depth) results in higher flow velocities and bottom shears relative to the adjacent regions of the Willamette River. Bottom sediments in the Multnomah Channel are dominated by sands, suggesting that fine-grained suspended sediments that enter the channel move through this reach rather than being deposited.

5.6.2.2 Outlying Reach Sediment Quality

The sediment quality between the upstream and downstream reaches is compared for four Portland Harbor ICs (total PCBs, total DDx, total PAHs, and TCDD TEQ), plus grain size (percent fines) and TOC in the sections that follow. Full summary statistics for these compounds as well as all sediment ICs are provided in Tables 5.6-1 through 5.6-12. A summary of statistics for the four chemicals listed above are compiled in Table 5.6-13 for surface sediments from the four outlying reaches and the Study Area. Figures 5.6-1 through 5.6-6 present box-whisker plots for each of these analytes in the four outlying reaches, and the Study Area, for both surface and subsurface sediments. Note that some extreme outliers are not displayed on these plots to better illustrate and compare the data distributions.

5.6.2.2.1 Grain Size and TOC

LWG sample collection in the upriver reach was strongly biased towards finer-grained, higher-TOC subareas in an attempt to collect sediment that more closely matched the Study Area texture (e.g., for toxicity testing as well as for comparisons to Study Area data). The grain-size and TOC data from the other three reaches reflect a more unbiased sampling scheme in those areas. Figures 5.6-1 and 5.6-2 show the percent fines and TOC trends across the four reaches. Despite the biased upriver sampling, surface sediments in the upriver reach, as well as in both the downtown and Multnomah Channel reaches, are dominated by sands. Subsurface sediments in the downtown reach are also predominantly sand. Surface and subsurface sediments in the downstream

reach are dominated by fine-grained material, reflecting the lower energy setting there. Notably, subsurface sediments in Multnomah Channel are relatively fine-grained in contrast to the surface sediments. These are likely relict deposits that reflect predevelopment hydrodynamic conditions in this part of the LWR (see Section 3.4.1).

The first column of Table 5.6-13 lists the percent fines and TOC for surface sediment in these outlying reaches and the Study Area. The relatively high energy upriver (mean and median of 30 and 28 percent fines, respectively) and downtown (mean of 21 and median of 14 percent fines) reaches are coarser grained than the sediments of the Study Area (mean of 51 and median of 61 percent fines) and the textural similarity of the lower energy Study Area and downstream (mean of 53 and median of 60 percent fines) reach is evident. Surface sediments in Multnomah Channel (mean of 12 and median of 12 percent fines) are notably coarser-grained than the upriver reaches and show a relatively narrow grain-size range compared with the other areas.

TOC concentrations among the outlying reaches and Study Area generally track the grain-size trends (Table 5.6-13 and Figure 5.6-2). The TOC percent concentration in surface sediment is lowest in the Multnomah Channel (mean of 0.91 median of 0.44 percent) and highest in the Study Area (mean and median of 1.8 percent). Study Area TOC values are significantly higher than all other areas compared on a pair-wise basis (Table 5.6-15).

5.6.2.2.2 Total PCBs

Outlying reach trends in total PCB concentrations[2] are shown in Figure 5.6-3 for surface and subsurface sediments and summarized for surface sediments only in Table 5.6-13. Full summary statistics are compiled in Tables 5.6-1 through 5.6-12. The upriver reach exhibits significantly lower PCB levels (mean of 5.7 and median of 2.9 J µg/kg) than all other reaches (see Table 5.6-15 for statistical testing results). The downtown reach, when the Zidell RI/FS site data are included, exhibits significantly higher surface sediment PCB levels than all other reaches, including the Study Area). The mean and median surface sediment value in the downtown reach is 589 and 49.9 V µg/kg, respectively; this compares with a mean and median of 176 and 19.5 U µg/kg in the Study Area.[3] The other outlying reaches exhibit much lower PCB levels. The downtown reach levels are biased high by the Zidell RI/FS site data, which accounts for nearly half (75 of 170) of the surface sediment PCB samples from that reach. When the Zidell data are removed from the downtown reach data set (as noted previously, Zidell site remediation is scheduled to occur in the next few years), the mean and median PCB concentrations of the downtown reach drop by approximately a factor of five to 102 and 11.9 µg/kg, respectively (Table 5.6-13).

The PCB homolog profiles of the outlying reach surface sediments are similar to the profiles of Study Area PCBs from locations with low PCB concentrations (i.e., tetraCBs

[2] Total PCBs are based on total PCB congeners when available, and total Aroclors when no congener data exist.
[3] The definitions of the "V" and "U" qualifiers associated with the medians in this sentence are noted in Table 5.6-13.

through heptaCBs are predominant). The PCB Aroclor profiles of the outlying reaches also mirror those of low-concentration locations in the Study Area, consisting primarily of Aroclors 1254 and 1260. Other Aroclors were detected infrequently.

5.6.2.2.3 TCDD TEQ

As shown in Figure 5.6-4, TCDD TEQ values are relatively low in outlying reaches. Mean TCDD TEQ in the upriver, downstream, and Multnomah Channel reaches is ≤0.4 pg/g (Table 5.6-13), with all three reaches displaying a narrow range of values. The range of values in downtown reach surface sediments is somewhat wider, with a median of 1.23 V pg/g, similar to the Study Area median value of 1.28 J pg/g.

The PCDD/F homolog distributions of the outlying reaches generally resemble the prevailing PCDD/F pattern in the Study Area, with OCDD dominant and significant contributions from HpCDDs and lesser fractions of the remaining homologs. PCDD/F patterns in samples dominated by HpCDDs have low total PCDD/F concentrations and may be affected by lower analytical precision and undetected individual PCDD/F congeners that contribute to the homolog totals.

5.6.2.2.4 Total DDx

Outlying reach trends in total DDx concentrations are shown in Figure 5.6-5 and summarized in Table 5.6-13. The range in means and median values in surface sediments across all outlying reaches is small. Upriver median and mean values are lowest among all reaches, with upriver values significantly lower than all but the downstream reach. Sediments from the downtown, downstream, and Multnomah Channel distributions have comparable total DDx concentrations, while Study Area mean and median values are higher than those from outlying areas, with significantly higher DDx concentrations than those from Multnomah Channel and the upriver and downstream reaches (Table 5.6-15).

Subsurface sediments in the downstream reach and in the limited subsurface data from the downstream end of the upriver reach are somewhat higher than the levels detected in surface sediments and show a larger range compared to the surface sediments (Figure 5.6-5). Again, this suggests that past inputs of DDx compounds to the LWR were generally higher than present inputs.

The DDx compounds in the upriver reach are mainly the 4,4'-isomers of DDD and DDE, although 4,4'-DDT was detected at RM 23.2 (13 µg/kg, Station HC10, Map 2.2-1w). In the downtown reach, larger fractions of 4,4'-DDT, 2,4'-DDD, and 2,4'-DDT are found, with 4,4'-DDE generally accounting for a smaller part of the total DDx. DDx patterns in the downstream reach and Multnomah Channel are highly variable, as they are in the Study Area. Multnomah Channel samples are chiefly composed of the 4,4'-isomers of DDD and DDT with less variability than found in the Study Area and downstream reach. Individual isomers for each sample are provided in Appendix D1.5.

5.6.2.2.5 Total PAHs

Among the outlying reaches, the median total PAH concentration in surface sediment is lowest in the upriver area (58.9 J µg/kg), followed by median concentrations in the downstream and the downtown reaches (273 µg/kg and 310 µg/kg, respectively; Table 5.6-13). Upriver surface sediments had significantly lower total PAH concentrations than the other outlying reaches, as well as the Study Area (Figure 5.6-6). The downtown reach shows a much wider range of total PAH concentrations, with some values elevated two orders of magnitude above the median, while surface sediments in Multnomah Channel exhibit a narrower distribution of concentrations, due in part to the small sample size (n=17). However, the median surface sediment concentration in Multnomah Channel (2,000 µg/kg) is high compared to the other reaches and the data distribution is significantly higher than the distribution of total PAH values from the downstream reach.

Subsurface sediments in all reaches are comparable. However, the range of values in both surface and subsurface sediments in all outlying reaches is much narrower than the range of PAH levels measured in the Study Area (Table 5.6-13). The surface sediment data from Multnomah Channel potentially suggests a local source within Multnomah Channel, as surface sediments in the downstream portion of the Willamette River main stem do not show comparable levels.

The PAH patterns in the four outlying reaches are similar to the pattern commonly found in surface sediments in the Study Area, with relatively low concentrations (less than 100 µg/kg), with four- and five-ring PAHs present in greatest abundance. Two- and three-ring PAHs constitute 20 to 40 percent of the total in the upriver reach upstream of RM 17 and in several areas of the downtown reach (RM 12.1E/W, 13.3E, 13.7W, 14.1 mid-river, and 14.5E/W); this is a higher percentage than in other areas. Six-ring PAHs generally make up 10 to 20 percent of the total in all subareas.

5.6.3 Upper Study Area Depositional Cores

As part of Round 3A of the Portland Harbor RI/FS, three cores were collected in the upper portion of the Study Area in three different known depositional areas based on the time-series bathymetric data (Figure 5.6-13). This sampling effort is detailed in the Round 3A FSP (Integral 2006c), and the full data sets are presented in the corresponding data report (Integral 2007c,d).

The objectives of this sampling effort were to analyze both radioisotopes and conventional/contaminant chemistry at uniform and continuous depth intervals in long-term depositional areas expected to act as natural sediment traps. Because of the location of these cores (i.e., in the upper portion of the Study Area [Figure 5.6-13]), these data should potentially allow inferences to be made about deposition rates and the chemical quality of sediments settling out in the upper Study Area. Two of the three stations sampled, RC02-2 at RM 10.9 and RC01-2 at RM 10.5, are situated in formerly excavated borrow pits with mudline depths well below the authorized channel depth of

-40 ft CRD. The third station, RC483-2 at RM 9.6, is located in the main channel on the large shoal that occurs along the western half of the channel in this area.

Detailed evaluation of the radioisotope data from these cores is provided in Appendix D6.2. Due to the heterogeneous origins of the sediments making up the deposits (e.g., a complex mix of suspended and bedload sediments over time from a variety of lateral, upstream, and atmospheric sources), the radiochemical data did not support the assignment of a timeline to the sediment profiles. However, empirical data on the history of the borrow pits (core samples RC02-2 and RC01-2; i.e., the timing and original depths of the excavations compared to the observed mudline elevations at the time of sampling), as well as the shorter-term LWG time-series bathymetric data, support overall sedimentation rates of approximately 1.5 ft/yr (45 cm/yr) at RC02-2 and 1 ft/yr (30 cm/yr) at RC01-2 (Appendix D6.2). It is important to note that these rates represent a long-term average over multiple years. The actual sedimentation in any given year is likely highly variable and may be higher or lower than this net long-term average.

The remainder of this section focuses on the conventional and contaminant chemical data (PCBs, TCDD TEQ, DDx, and PAHs) measured in these cores with depth. Unlike other RI/FS subsurface sampling, these core samples were subsectioned and sampled in 30-cm segments from the mudline to bottom of each core. This allows inferences to be made about the quality of material entering and settling in the upper portion of the Study Area over time.

5.6.3.1 Upper Study Area Depositional Core Sediment Quality

The locations of the three depositional cores in the upper Study Area are presented on Figure 5.6-13. As noted above, RC483 is a shoal area on the western side of the channel at RM 9.6. RC01 and RC02 are located in dredged borrow pits located on the western side of the channel at RM 10.5 and RM 10.9, respectively. Summary statistics for all core segments for all three cores combined are provided in Table 5.6-16 and for each core individually in Tables 5.6-17 through 5.6-19. All sediment ICs are included in these summary tables. The upper Study Area depositional core data evaluation that follows focuses on the physical nature of the cores and the measured concentrations of the four ICs discussed in the previous section.

5.6.3.1.1 Physical Texture

Figure 5.6-7 shows the core log physical description of each core. Core recovery ranged about 260 cm at RC01 to 330 cm at RC02. All three cores show a general pattern of an upper silt layer (30 to 40 cm in thickness) deposited over a distinct sand interval, which is approximately 40 cm thick at RC01 and approximately 15 cm at RC483 and RC02. This subsurface sand layer may represent coarse-grained material deposited during the most significant, recent high-flow event on the LWR (approaching 200,000 cfs; see Figure 3.3-2) that occurred in December 2005/January 2006. The overlying 30 to 40 cm of silt would be consistent with a 1-year time frame (cores collected in February 2007) and both the estimated long-term sedimentation rate of 30

to 45 cm/yr based on the borrow pit in-filling data noted above and the measured 2002 bathymetric change at stations RC01 and RC02, which averaged 38 cm/yr and 34 cm/yr, respectively, over the seven-year period from 2002 to 2009. Below this sand layer in each core, there is a thick silt layer that varies somewhat in character between the three cores. The silt layer is interbedded with fine sand lenses in RC483, the shoal location at RM 9.6, and RC02, the borrow pit at RM 10.9. In RC02, the texture becomes increasingly sandy below 240 cm down to another distinct sand layer at 315 cm. It is very possible that this deep sand layer reflects the high-flow event (approaching 250,000 cfs; see Figure 3.3-2) that occurred in the LWR during the winter of 1998/1999. The 315 cm of accumulation over the eight-year period from this horizon to 2007 equals an average sedimentation rate of 39 cm/yr. This is consistent with the long-term sedimentation rates estimated for this area. At RC01, the subsurface silt layer exhibits thick organic beds below 90 cm, suggesting some heterogeneity in the quality of material settling out within this portion of the river.

Figure 5.6-8 shows the 30-cm composite interval results for grain size and TOC with depth for each core. Grain size with depth is consistent with visual core log information at RC483 and RC02, with fine-grained sediments (60 to 80 percent fines) dominant throughout the core except for where distinct sand layers are evident. RC01 is more variable in texture with depth but does show the distinct shallow subsurface sand lenses. Reflecting the organic debris observed at depth in RC01, TOC values are somewhat higher in this core below 90 cm (exceeding 3 percent in most intervals) than in the other cores.

5.6.3.1.2 Contaminant Chemical Vertical Profiles

Figures 5.6-9 through 5.6-12 present vertical profiles of the bulk sediment chemistry concentrations on both a dry-weight and TOC-normalized basis for total PCBs, TCDD TEQ, total DDx, and total PAHs in each core. Non-detects are plotted at the full detection limit with an open symbol. Selected summary statistics (using detected values only) for the data from all three depositional cores combined, as well as each individual core, are included at the bottom of Table 5.6-13.

The vertical profile data across the four analytes show some general trends. First, as expected, it is evident from dry-weight data that chemical concentrations in all three cores vary with sediment grain size/TOC, with lower concentrations for all chemicals measured in the sand layers. Another noteworthy trend is the generally low measured values for all of these analytes across all cores and the corresponding minimal vertical gradients within and between cores. Some exceptions to these general trends include an isolated dioxin and PCB spike in the 180-to-210 cm interval in RC01, which may correlate with organic-rich beds in the silt layer. Assuming average sedimentation rates, this horizon is approximately six years old and may correspond to the atypically low-flow water year in 2001 (Figure 3.3-2). Another exception is the notably higher total PCB levels at RC02 (RM 10.9) compared with RC01 (RM 10.5) and RC483 (RM 9.6). While the levels in RC02 average less than 20 μg/kg, this compares with mostly undetected values in the cores farther downstream. This difference appears to

reflect the influence of the proximal source or sources of PCBs on the east side of the river at RM 11.5 (see Section 5.1). Finally, slight vertical trends with concentrations increasing with depth are evident in the TOC-normalized PCB and possibly the TOC-normalized PAH data at RC02.

The depositional core summary statistics included in Table 5.6-13 juxtapose these data from the upper Study Area depositional zones with similar statistics from the upstream and downstream reaches discussed in Section 5.6.2. As noted above, the levels observed in these cores are relatively low and more closely resemble the chemical concentration levels measured in the upriver reach (above Ross Island) than those from the downtown reach. For PCBs, DDx, and PAHs, the detected-only-value means and 95th percentiles for all cores combined are the second-lowest values after the upriver values. Perhaps this is not unexpected given that periods of significant sediment deposition and accumulation in the LWR are likely associated with conditions (higher flows, precipitation) that bring large volumes of sediment to the river, and this would act to dilute the relatively localized sources of contamination in bulk sediment deposits. Nonetheless, the data from these natural sediment traps in the upper Study Area do reveal the overall quality of sediments entering *and* settling out in this portion of the river.

5.6.4 Summary of Upstream, Downstream Areas and the Upper Study Area Depositional Cores

Of the four outlying areas, the upriver reach, the downtown reach, and Multnomah Channel differ notably from most of the Study Area in physical character and are dominated by sandy sediments and higher energy flow regimes. In contrast, much of the downstream reach is an extension of the lower Study Area in its physical nature. The upper Study Area depositional areas are located on an in-channel shoal and in two former borrow (excavated) areas that are accumulating sediments over time. The cores from these areas are dominated by fine-grained sediments, but there are distinct, subsurface sand layers that appear to reflect past deposition during high-energy events on the LWR.

The distributions of the four bounding ICs in the outlying reaches show some general trends. The upriver reach generally exhibits the lowest mean, median, and 95th percentile concentrations for all chemicals in surface sediments, followed by Multnomah Channel or the downstream reach. A notable exception to this pattern is total PAH concentrations in Multnomah Channel surface sediments, which have mean and median concentrations at or above those from all outlying reaches. Mean, median, and 95th percentile values for total PCBs are higher in the downtown reach than in the other three outlying reaches.

Subsurface sediments in the downstream reach show higher mean, median, and 95th percentile levels of total PCBs and total DDx than surface sediments, suggesting higher historical inputs. Very limited subsurface data from the upriver reach show higher mean, median, and 95th percentile levels of DDx and TCDD than surface sediments

there, also suggesting historical upstream inputs to the remaining LWR reaches may have been higher than during the present study.

The vertical profiles of the four ICs measured in three cores from known depositional areas in the upper portion of the Study Area show relatively low concentrations for all chemicals and minimal gradients with depth within each core and between cores. For PCBs, DDx, and PAHs, except for the upriver reach, the depositional core concentrations are lower than the levels in the outlying reaches. The farthest upriver core at RM 10.9 exhibits slightly elevated PCB levels (compared with the other cores), and this may reflect the influence of the PCBs detected just upstream at RM 11.5. Otherwise, the contaminant concentrations measured in these known depositional area cores appear to reflect the quality of sediments entering *and* settling out in the upstream portion of the Study Area over approximately the last 10 years.