PROPOSED EXPLANATION OF SIGNIFICANT DIFFERENCES

DRAFT FOR PUBLIC COMMENT

January 2021

Lower Duwamish Waterway Superfund Site
Seattle, Washington

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Name Date
Administrator

U.S. Environmental Protection Agency Region 10

Seattle, Washington

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or Relevant and Appropriate Requirement
BaP	benzo(a)pyrene
BaP-eq	benzo(a)pyrene equivalent
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
cm	centimeter
COC	Contaminant of Concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSF	Cancer Slope Factor
Dioxins/furans	polychlorinated dibenzo-p-dioxins and furans
dw	dry weight
EAA	Early Action Area
Ecology	Washington Department of Ecology
ENR	enhanced natural recovery
EPA	United States Environmental Protection Agency
ERA	Ecological Risk Assessment
ESD	Explanation of Significant Differences
FS	Feasibility Study
ft	feet
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IRIS	Integrated Risk Information System
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
mg/kg	milligram per kilogram
mg/kg-day	milligram per kilogram per day
MNR	Monitored Natural Recovery
NCP	National Contingency Plan
PCB	polychlorinated biphenyl
RAL	Remedial Action Level
RAO	Remedial Action Objective
RBTC	Risk-Based Threshold Concentration
RM	River Mile
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SCO	Sediment Cleanup Objective
Site	Lower Duwamish Waterway Superfund Site
SMS	Sediment Management Standards
TTL	Target Tissue Level
UCL95	95 percent Upper Confidence Limit on the Mean
ww	wet weight
µg/kg	microgram per kilogram

EXPLANATION OF SIGNIFICANT DIFFERENCES
LOWER DUWAMISH WATERWAY SUPERFUND SITE

January 2021

1 INTRODUCTION

This proposed Explanation of Significant Difference (ESD) documents changes to the Record of Decision (ROD) issued in 2014 for the Lower Duwamish Waterway Superfund Site (LDW) in Seattle, Washington. After considering public comments on the proposed ESD, the U.S. Environmental Protection Agency (EPA) will issue a final ESD and response to comments.

1.1 SITE NAME AND LOCATION

The Lower Duwamish Waterway (LDW) Superfund Site (Site) was included on the National Priorities List on September 13, 2001. The EPA identification number for the Site is WA00002329803. The Site includes upland sources of contamination as well as the waterway.

The in-waterway portion of the Site extends approximately five miles, from River Mile (RM) 5 in Tukwila, Washington, to the southern tip of Harbor Island at RM 0 (Figure 1) in Seattle. The LDW includes approximately 441 acres of intertidal and subtidal habitat. The average width of the LDW is 440 ft (feet).

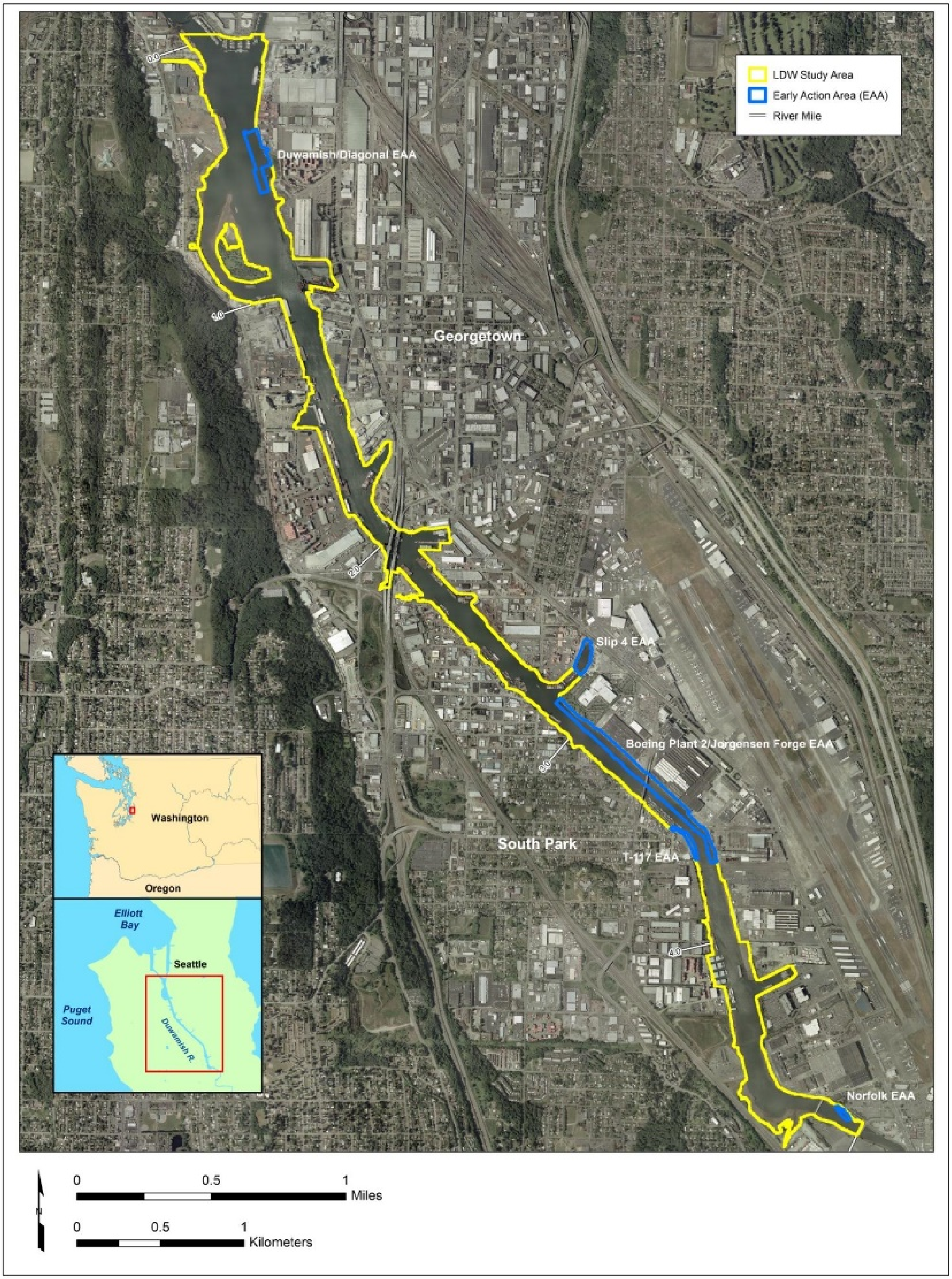

Figure 1. Lower Duwamish Waterway and Early Action Areas

1.2 LEAD AND SUPPORT AGENCIES

EPA is the lead agency for the in-waterway portion of the Site. The Washington Department of Ecology (Ecology) is the support agency. Ecology is the lead agency for addressing upland sources of contamination to the waterway.

1.3 STATEMENT OF PURPOSE

This proposed ESD provides the basis for changes to the Selected Remedy. The LDW ROD, which documents the selection of the remedy for the in-waterway portion of the Site, was signed on November 21, 2014 (EPA, 2014). The Selected Remedy is summarized in Section 2.3, below. The changes are significant but not fundamental. The changes will become effective when the ESD is signed.

This proposed ESD is issued in accordance with Section 117(c) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and based on EPA published guidance for preparation of decision documents (EPA, 1999).

As described herein, the changes affect human cancer risk-based concentrations of carcinogenic polycyclic aromatic hydrocarbons (cPAHs) established in the ROD as remedial action levels and cleanup levels to achieve remedial action objectives. The remedial action objectives remain the same.

1.4 ADMINISTRATIVE RECORD

This proposed ESD and supporting documents will become part of the Site Administrative Record file, in accordance with the National Contingency Plan (NCP), 40 CFR § 300.825. The proposed ESD and supporting documents in the administrative record will be available at the following locations and online:

EPA Region 10 Superfund Records Center
1200 Sixth Avenue
Seattle, WA 98101
(206) 553-4494 or (800) 424-4372
Monday through Friday 9 am–4 pm

South Park Central Library
8604 8th Ave. S.
Seattle, WA 98108
(206) 615-1688
Monday, Tuesday 1 pm–8 pm
Wednesday through Saturday 11 am–6 pm
Sunday 12 pm–5pm

2 SITE HISTORY, CONTAMINATION, AND SELECTED REMEDY

2.1 Site History

The LDW and adjacent upland areas have served as Seattle's major industrial corridor since the early twentieth century, when part of the Duwamish River was straightened through dredging and filling. The Duwamish River is a continuation of the Green River, which flows from headwaters in the Cascade Mountains. A few miles after changing to the Duwamish River in Tukwila, the estuarine river flows through the channelized 5-mile Lower Duwamish Waterway in Tukwila and Seattle, then splits into the East and West Waterways at the south end of Harbor Island before discharging into Elliott Bay in Seattle, Washington.

2.2 Sources of Contamination

Hazardous substances generated by industrial and urban activities entered the waterway environment through direct discharges, spills, leaks, dumping, and other inappropriate management practices. See ROD Section 2 for additional information.

2.2.1 Contaminated Media

Site contaminants have been documented in intertidal and subtidal sediment, suspended sediment, stormwater and surface water, groundwater seeps and sediment porewater, biota tissue, and some bank soils.

2.2.2 Nature and Extent of Contamination

A summary of site contamination, based on the dataset developed for the remedial investigation and feasibility study (RI/FS), is included in Section 5.3 of the ROD.

Polychlorinated biphenyls (PCBs) are the most widespread contaminant in LDW surface sediment. They were detected at 94 percent of the locations where samples were analyzed for PCBs. Forty-one hazardous substances, including PCBs and individual polycyclic aromatic hydrocarbons, were detected in LDW sediment at concentrations that exceed the benthic chemical Sediment Cleanup Objectives (SCO) set forth in the Washington Sediment Management Standards (SMS).

The cPAH concentrations in surface sediments ranged from 9.7 to 11,000 µg/kg dry weight (dw) benzo(a)pyrene equivalents (BaP-eq), with a spatially weighted average concentration of 388 µg/kg dw BaP-eq. Map 4-37 of the Remedial Investigation (RI) shows the distribution of cPAH concentrations in surface sediment (LDWG, 2010). Map 4-38 of the RI shows the distribution of cPAH by percentile.

The RI evaluated fish, shellfish, and invertebrate tissues. Concentrations of cPAHs were highest in clam, mussel, and benthic invertebrate tissue. No strong relationship was evident between sediment and clam tissue cPAH concentrations.

2.3 SUMMARY OF SITE RISKS AND CONTAMINANTS OF CONCERN

Section 7 of the ROD summarizes the results of the Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA) completed as part of the RI/FS.

2.3.1 HUMAN HEALTH RISK ASSESSMENT

The HHRA (LDWG, 2007) identified potentially complete human exposure pathways and estimated the health risks associated with those exposures. The exposure pathways evaluated in the HHRA were:

- Water recreation
- Beach play in intertidal areas
- Human consumption of resident seafood
- Fishing/shellfishing in intertidal areas
- Occupational exposure (netfishing)

The majority of human health risks associated with consumption of seafood are due to PCBs and arsenic in resident fish, crabs, and clams. The vast majority of risks due to inorganic arsenic and cPAHs (96-98 percent) were attributable to consumption of clams.

Lower risks were associated with activities that involve direct contact with sediment, such as clamming, beach play, and net-fishing. Figure 2 (see also Figure 6 of the ROD) identifies LDW areas with beach play activities and potential for clamming.

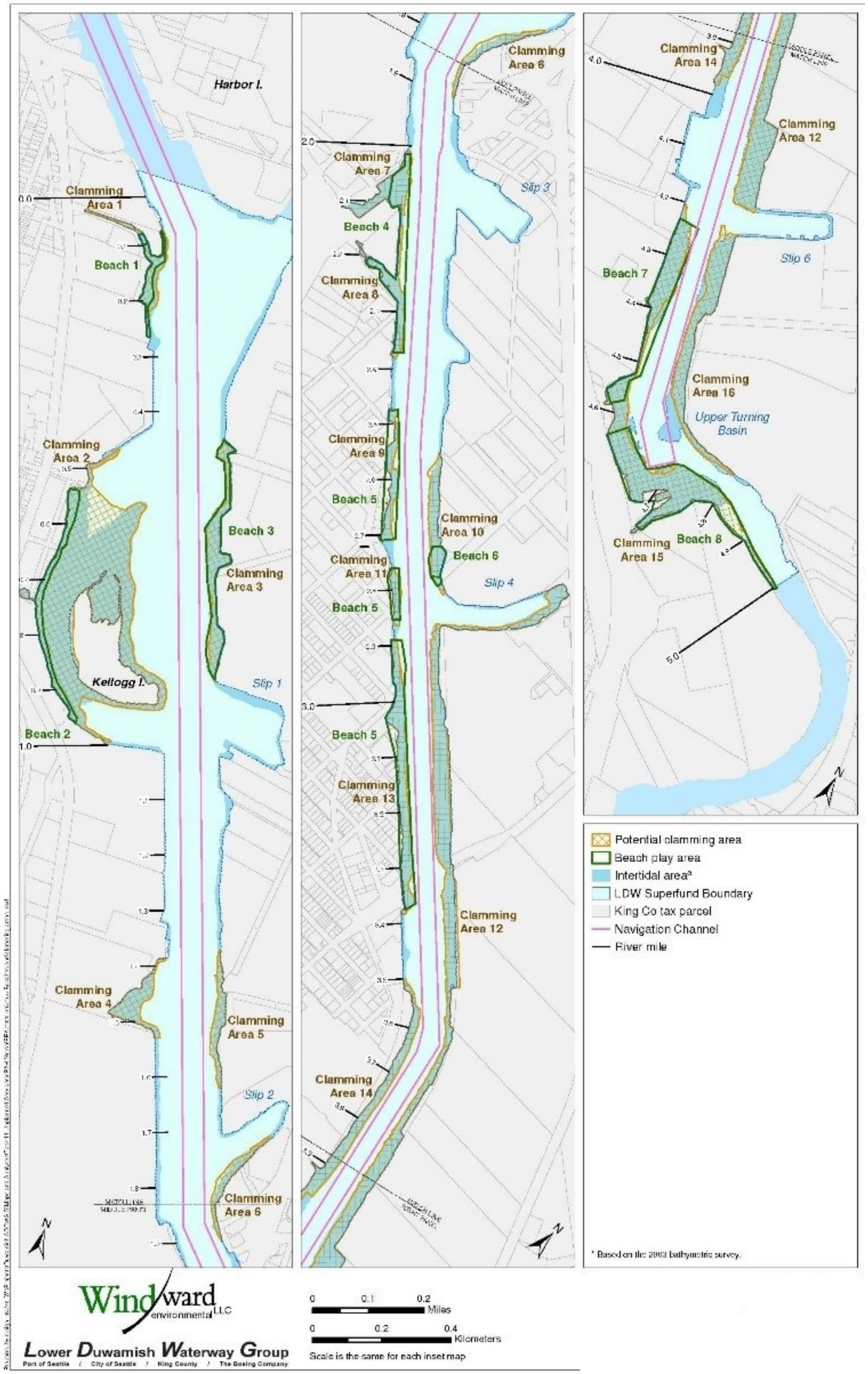

Figure 2. Potential intertidal clamming areas and beach play areas in the LDW

2.3.2 ECOLOGICAL RISK ASSESSMENT (ERA)

The baseline ERA estimated risks for four types of ecological receptors of concern exposed to the contaminants in the LDW, either directly or via ingestion of prey: benthic invertebrates and crabs, fish, birds, and certain wildlife species (river otter, harbor seal) (LDWG, 2010).

2.3.3 CONTAMINANTS OF CONCERN

Four Contaminants of Concern (COCs) for human health (PCBs, arsenic, cPAHs, and dioxins/furans (polychlorinated dibenzo-p-dioxins and furans)) were identified based on the HHRA (see ROD Section 7.1), and Risk-Based Threshold Concentrations (RBTCs) calculated for use as preliminary remediation goals.

Forty-one contaminants (including PCBs and arsenic) identified based on the ERA (see ROD Section 7.2) were selected as COCs for benthic protection. The human health RBTCs, an RBTC for otters, and the SCOs for benthic protection were selected as preliminary remediation goals for the Feasibility Study (FS) and were considered in developing draft remedial action levels (RALs) to identify areas for evaluation of cleanup alternatives in the FS (LDWG, 2012).

2.4 REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives (RAOs) describe what the proposed cleanup is expected to accomplish to protect human health and the environment. The RAOs for LDW are listed in Section 8 of the ROD and summarized below:

RAO 1: Reduce risks associated with the consumption of contaminated resident LDW fish and shellfish by adults and children with the highest potential exposure to protect human health.

RAO 2: Reduce risks from direct contact (skin contact and incidental ingestion) to contaminated sediments during netfishing, clamming, and beach play to protect human health.

RAO 3: Reduce to protective levels risks to benthic invertebrates from exposure to contaminated sediments. Risks will be reduced by reducing sediment concentrations of the 41 contaminants listed in Table 20 of the ROD to the chemical or biological benthic SCO.

RAO 4: Reduce to protective levels risks to crabs, fish, birds, and mammals from exposure to contaminated sediment, surface water, and prey.

3 SELECTED REMEDY

3.1 OVERALL CLEANUP STRATEGY

The overall strategy for addressing contamination and the associated risks in the LDW Site includes:

1) early identification and cleanup of Early Action Areas (EAAs) to address the most contaminated areas in the waterway;

2) controlling sources of contamination to the waterway; and

3) cleanup of the remaining contamination in the waterway, including long-term monitoring to assess the success of the remedy in achieving cleanup goals.

These three components together are designed to address the areal extent of waterway contamination, including sediment contamination, resident seafood tissue (edible portions of fish and shellfish) concentrations, and water quality, to the extent practicable. The Selected Remedy in the ROD addresses the third element of the overall strategy.

3.2 ROD CLEANUP LEVELS, TARGET TISSUE LEVELS, AND REMEDIAL ACTION LEVELS

The ROD identified sediment cleanup levels and tissue concentration goals (called Target Tissue Levels or TTLs) for seafood, established Remedial Action Levels (RALs), and specified the remedial technologies that apply in areas exceeding the RALs (See ROD, Section 8).

Sediment cleanup levels for human health RAOs 1 and 2 are calculated as RBTCs set at a 1×10^{-6} excess cancer risk level for individual carcinogens or a noncancer Hazard Quotient (HQ) or Hazard Index (HI) of 1, consistent with the NCP and SMS (WAC 173-204-560 and 561). In accordance with EPA policy, where risk-based cleanup goals are less than background concentrations, the cleanup goals are generally set at the background concentration (see ROD Section 5.3.4.1).

Consistent with the SMS (WAC 173-204-562), cleanup levels associated with RAO 3 (protection of benthic invertebrates) are based on the SCO for the protection of benthic invertebrates, which are defined by chemical and biological criteria for specific hazardous substances, as explained in ROD Section 5.3.1.1. A cleanup level for PCBs in sediment was established for RAO 4.

3.3 DESCRIPTION OF THE SELECTED REMEDY

Section 13 of the ROD described specific cleanup technologies and where they are applied based on comparison of RI/FS sediment contamination levels to the RALs in ROD Table 28, and according to the decision trees in Figures 19 and 20, as corrected in the ROD erratum. The RALs and the application of the technologies differ, depending on location (e.g. intertidal, subtidal, navigation channel), the potential for natural recovery, and other features.

The ROD anticipated the following active remediation (as shown in Figure 18 of the ROD):

- Dredging or partially dredging and capping approximately 105 acres of highly contaminated sediments (approximately 960,000 cubic yards).
- Placing engineered sediment caps on approximately 24 acres of highly contaminated sediments where there is sufficient water depth for a cap.
- Placing a thin layer (6 to 9 inches) of clean material (referred to as Enhanced Natural Recovery [ENR]) on approximately 48 acres of sediments in areas that meet the criteria for ENR.

- Applying location-specific cleanup technologies to areas with structural or access restrictions (such as under-pier areas and in the vicinity of dolphins/pilings, bulkheads, and riprapped or engineered shorelines).

In addition, the ROD estimated 235 acres for Monitored Natural Recovery (MNR). MNR relies on natural processes to reduce ecological and human health risks to acceptable levels while monitoring sediments over time to determine remedy success. Within the LDW, the natural burial of contaminants through sedimentation from upstream is the primary natural recovery mechanism.

The ROD required sampling and analysis during remedial design, construction, post-construction, and long-term monitoring, as described in ROD Section 13.2.3, and called for effective and appropriate institutional controls.

4 BASIS FOR THE PROPOSED ESD

EPA released the final *Toxicological Review of Benzo(a)pyrene* on January 19, 2017 (EPA, 2017). The review, a comprehensive review of available animal studies and other toxicological information, replaced the 1987 Integrated Risk Information System (IRIS) cancer slope factor (CSF) for benzo(a)pyrene (BaP) of 7.3 $(\text{mg/kg-day})^{-1}$ with an updated value of 1 $(\text{mg/kg-day})^{-1}$. It also established a BaP reference dose for non-cancer effects, based on a developmental endpoint (neurobehavioral changes) in humans, of 3×10^{-4} mg/kg-day. These toxicity values were published on EPA's IRIS website and documented in the toxicological review for BaP (EPA 2017).

The process for updating these values involved more than five years of research and four EPA drafts for agency or public comment between 2011 and 2016. The results confirmed that BaP is a human carcinogen but that it is over 7 times less potent than previously estimated.

EPA uses BaP as an index to estimate cancer risk from exposure to mixtures of cPAHs. Since cPAHs, as a group, are a contaminant of concern for human health at LDW, EPA determined that an ESD may be warranted. EPA used the exposure assumptions in the HHRA and the new CSF to calculate changes in the human cancer risk-based cPAH cleanup levels, TTLs, and RALs in the ROD. See Appendix A for a detailed discussion of the revised risk calculations.

When a chemical has both cancer and non-cancer modes of toxicity, EPA uses the toxic endpoint that results in the most stringent level when selecting cleanup levels or other remediation targets. Cancer is a more sensitive endpoint for cPAHs than non-cancer. Cancer RBTCs based on the revised CSF are more stringent than those based on the new BaP non-cancer reference dose (See Section 1.4 of Appendix A). Thus, cleanup actions that achieve Preliminary Remediation Goals based on a target cancer risk of 1×10^{-6} will be protective for both cancer and non-cancer effects.

The change in the human toxicological values for BaP does not affect cleanup levels or RALs in the LDW ROD for RAOs 3 and 4, protection of ecological receptors.

5 DESCRIPTION OF SIGNIFICANT DIFFERENCES

The changes to the Selected Remedy are summarized below and consist of changes to cleanup levels, TTLs and RALs for cPAHs. The proposed ESD does not change the RAOs: the target cancer risks used to develop cleanup levels, TTLs, and RALs for RAO 1 and RAO 2 are the same as those in the ROD. The change in the BaP CSF does not affect RAO 3 and RAO 4, which focus on non-cancer endpoints for ecological receptors.

Concentrations of cPAHs, including the cleanup levels, target tissue levels, and remedial action levels, were expressed in the RI/FS and ROD as µg TEQ/kg dw. The proposed ESD describes mixtures of cPAH in terms of benzo(a)pyrene equivalent concentrations, or BaP-eq dw. The terms differ, but the values are calculated identically.

All other elements of the Selected Remedy, including Applicable or Relevant and Appropriate Requirements (ARARs), remain unchanged.

The EPA has determined that the Selected Remedy, incorporating the significant differences below, is protective of human health and the environment.

5.1 CHANGES TO cPAH CLEANUP LEVELS

The sediment cleanup levels are contaminant concentrations in sediment that will be used to measure the success of the cleanup alternatives in meeting the RAOs. Sediment cleanup levels for RAOs 1, 2, and 4 are shown in the ROD in Table 19, while RAO 3 cleanup levels for benthic protection are listed in ROD Table 20.

The sediment cleanup levels for cPAH for RAO 2 direct contact scenarios, calculated based on a 1 x 10^{-6} cancer risk, are changed as described below and shown in Revised Table 19 (Table 1). Revised Table 19 (Table 1) supersedes ROD Table 19.

5.1.1 cPAH CLEANUP LEVEL FOR SEDIMENT DIRECT CONTACT – NETFISHING SCENARIO

The sediment cleanup level selected in the ROD of 380 µg/kg dw for the LDW-wide 0–10 cm sediment interval is revised to **2,800 µg/kg dw**. (Table 1).

The FS estimated that completion of the Early Action Area cleanups as planned would achieve sitewide average cPAH concentrations for the 0-10 cm interval at the cleanup level of 380 µg/kg dw, a concentration lower than the revised cleanup level.

5.1.2 cPAH CLEANUP LEVEL FOR SEDIMENT DIRECT CONTACT – CLAMMING SCENARIO

The sediment cleanup level selected in the ROD of 150 µg/kg dw for all clamming areas for the 0–45 cm sediment interval is revised to **1,100 µg/kg dw.** (Table 1).

5.1.3 cPAH Cleanup Level for Sediment Direct Contact – Beach Play Scenario

The sediment cleanup level selected in the ROD of 90 µg/kg cPAHs at each of eight individual beach play areas is revised to **590 µg/kg dw**. (Table 1).

Table 1. Revised ROD Table 19 Cleanup Levels for PCBs, Arsenic, cPAHs, and Dioxins/Furans in Sediment for Human Health and Ecological COCs (RAOs 1, 2 and 4) with updates for cPAH (in red text)

COC	Cleanup Levels			Application Area and Depth			
	RAO 1: Human Seafood Consumption	**RAO 2: Human Direct Contact**	**RAO 4: Ecological (River Otter)**	**Basis for Cleanup Levels[a]**	**Spatial Scale of Application[b]**	**Spatial Compliance Measure[e]**	**Compliance Depth[b]**
PCBs (µg/kg dw)	**2**	1,300	128 - 159	background (RAO 1) RBTC (RAO 2) RBTC (RAO 4)	LDW-wide	UCL95	0 – 10 cm
	NA	500	NA	RBTC	All Clamming Areas[c]	UCL95	0 – 45 cm
	NA	1,700	NA	RBTC	Individual Beaches[d]	UCL95	0 – 45 cm
Arsenic (mg/kg dw)	NA	7	NA	background	LDW-wide	UCL95	0 – 10 cm
	NA	7	NA	background	All Clamming Areas[c]	UCL95	0 – 45 cm
	NA	7	NA	background	Individual Beaches[d]	UCL95	0 – 45 cm
cPAH BaP-eq (µg/kg dw)[i]	NA	*2800*[f]	NA	RBTC	LDW-wide	UCL95	0 – 10 cm
	NA	*1100*[g]	NA	RBTC	All Clamming Areas	UCL95	0 – 45 cm
	NA	*590*[h]	NA	RBTC	Individual Beaches[d]	UCL95	0 – 45 cm
Dioxins/Furans (ng TEQ/kg dw)	**2**	37	NA	background (RAO 1) RBTC (RAO 2)	LDW-wide	UCL95	0 – 10 cm
	NA	13	NA	RBTC	All Clamming Areas[c]	UCL95	0 – 45 cm
	NA	28	NA	RBTC	Individual Beaches[d]	UCL95	0 – 45 cm

NOTE: where there are multiple cleanup levels for a cleanup area, the lowest cleanup level is shown in bold.

a. Background – see Table 3 and Section 5.3.4.1, RBTC – Risk-based threshold concentration (based on 1 in 1,000,000 excess cancer risk or HQ of 1)

b. In intertidal areas including beaches used for recreation and clamming, human-health direct contact cleanup levels (for PCBs, arsenic, cPAHs, and dioxins/furans) must be met in the top 45 cm because in intertidal areas exposure to sediments at depth is more likely through digging or other disturbances. Human health cleanup levels for RAO 1 (seafood consumption) and ecological cleanup levels must be met in surface sediments (top 10 cm). In subtidal areas, cleanup levels for all COCs must be met in surface sediments (top 10 cm).

c. Clamming areas are identified in Figure 2 of the ESD.

d. Beach play areas are identified in Figure 2 of the ESD.

e. The UCL 95 is the upper confidence limit on the mean. The determination of compliance with RAOs 1, 2 and 4 cleanup levels will be made by one of two methods: 1) comparison of the UCL 95 of LDW data with the RBTC or background-based cleanup level, or 2) for background-based cleanup levels, a statistical comparison of the distribution of LDW data to the OSV BOLD study background dataset (USACE et al. 2009) may be used. In either case, testing will use an alpha level of 0.05 and a beta level of 0.10. For details, see ProUCL technical manual (EPA 2013) or most current version). For either method, a sufficient number of samples must be collected to assure statistical power for the test.

f. Value increased by ESD from 380 to 2,800 µg/kg dw due to updated BaP cancer slope factor (EPA, 2017).

g. Value increased by ESD from 150 to 1,100 µg/kg dw due to updated BaP cancer slope factor (EPA, 2017).

h. Value increased by ESD from 90 to 590 µg /kg dw due to updated BaP cancer slope factor (EPA, 2017).

i. Change in terminology: cPAH µg TEQ/kg dw and cPAH BaP-eq are the same.

5.2 CHANGE TO CPAH TARGET TISSUE LEVEL

Table 21 of the ROD identifies TTLs, goals for contaminant concentrations in seafood to address RAO 1. The TTLs are based on the higher of either risk-based threshold concentrations or non-urban Puget Sound background concentrations.

Because clam consumption accounts for more than 95 percent of the total seafood consumption risk from cPAHs, the TTL for cPAH is for clam tissue only. The ROD TTL for cPAHs in clams (Table 21) is an RBTC of 0.24 µg/kg ww.

This proposed ESD changes the cPAH TTL from 0.24 µg/kg ww to **1.5 µg/kg ww**, as shown in Table 2. Table 2 supersedes ROD Table 21.

Table 2. Revised ROD Table 21 LDW Resident Fish and Shellfish Target Tissue Concentrations with updates for cPAH (in red text)

Species/Group and Tissue Type	Species[a,b]	Target Concentration	Source of Target Concentration[c]
PCBs (µg/kg ww)			
Benthic fish, fillet	English sole	12	Non-urban background
Pelagic fish, whole body	Perch	1.8	RBTC
Crab, edible meat	Dungeness crab	1.1	Non-urban background
Crab, whole body	Dungeness crab	9.1	Non-urban background
Clams	Eastern softshell clam	0.42	Non-urban background
Inorganic arsenic (mg/kg ww)			
Clams[e]	Eastern softshell clam	0.09	Non-urban background
cPAH BaP-eq[g] (µg/kg ww)			
Clams[e]	Eastern softshell clam	1.5[f]	Species-specific RBTC[d]
Dioxin/furan TEQ (ng/kg ww)			
Benthic fish, whole body	English sole	0.35	Non-urban background
Crab, edible meat	Dungeness crab	0.53	Non-urban background
Crab, whole body	Dungeness crab	2.0	Non-urban background
Clams	Eastern softshell clam	0.71	Non-urban background

Note:
a Substitutions of similar species may be made if sufficient numbers of the species listed here are not available.
b. For non-urban background statistics, see also Table 4. Non-urban background is based on UCL95.
c. The statistic used to compare site data to target tissue concentrations will be based on the UCL95 for each compound listed for fish and crabs collected throughout the waterway, and each compound for clams collected across all clamming areas in the waterway.
d. Species-specific RBTCs were used to determine target concentration when RBTCs exceed background, or background data were not available.
e. Only clam tissue values are shown for inorganic arsenic and cPAH TEQ because most of the risk associated with these COCs was associated with consumption of clams.
f. Changed by ESD due to updated BaP slope factor (EPA, 2017). Value increased from 0.24 to 1.5 µg/kg ww.
g. Change in terminology: cPAH µg TEQ/kg dw and cPAH BaP-eq are the same

5.3 CHANGES TO CPAH REMEDIAL ACTION LEVELS (RALS)

RALs are contaminant-specific sediment concentrations that trigger the need for active remediation (dredging, capping, or ENR). The LDW RALs are generally higher than cleanup levels, which represent the long-term cleanup standards that must be achieved. The RALs consider the magnitude of risk reduction achieved, the rate of natural recovery, and the different types of remedial actions, such as dredging or enhanced natural recovery. The development of RALs for the LDW is detailed in the Feasibility Study (LDWG, 2012).

Table 28 of the ROD presents the selected RALs for contaminants of concern for human and ecological health. The RALs apply to the sediment depth intervals associated with the exposure scenarios. The RALs also consider the recovery category assigned (indicating whether natural recovery is presumed to be limited, less certain, or likely). While the cleanup levels apply across specific areas at specified depths of compliance, the RALs are applied point by point.

The ROD also established concentrations below which the technology of ENR could be applied. These upper limits, or ULs, for ENR, were provided only for Recovery Category 2 and 3 areas and were calculated by applying a factor of 3 (for the 0-10 cm interval) or 1.5 (for the 0-45 cm intertidal interval) to the applicable RAL.

This proposed ESD changes the RALs and ENR ULs for cPAHs as described below and shown in ESD Table 3. Table 3 supersedes ROD Table 28.

5.3.1 cPAH RAL for Intertidal and Subtidal Sediments for the 0-10 cm depth interval

The FS evaluated several potential cPAH RALs for the overall reduction of average cPAH concentrations (FS Figure 6-2c and Figure 6-3). A potential RAL of 5,500 µg TEQ/kg dw was considered, to address hot spots, and two other potential RALs, 3,800 and 1,000 µg TEQ/kg, were used to provide a range. The ROD selected the cPAH RAL of 1,000 µg/kg dw for the 0–10 cm sediment interval (ROD Table 28), applicable in intertidal and subtidal areas.

This proposed ESD changes the cPAH RAL for the 0-10 cm depth interval from 1,000 µg/kg dw to **5,500 µg/kg dw** to address hotspots.

5.3.2 cPAH RAL for Subtidal Sediments for the 0-60 cm depth interval and for Shoaled Areas of the Navigation Channel

The ROD selected a cPAH RAL of 1,000 µg/kg dw for the 0-60 cm depth interval of subtidal sediments in Recovery Category 1 areas and for shoaled areas of the navigation channel (Table 28) to ensure that erosion, scour, or dredging would not result in concentrations above the RAL in the 0-10 cm sediment interval.

Consistent with the change to the RAL for the 0-10 cm interval, this proposed ESD changes the RAL for the 0-60 cm interval from 1,000 µg/kg to **5,500 µg/kg dw** (See Table 3).

5.3.3 cPAH RAL for Intertidal 0-45 cm Sediment

The ROD selected a RAL of 900 µg/kg for the 0-45 cm depth interval in all intertidal areas, to achieve overall risk reduction. The RAL in the ROD is a risk-based threshold concentration based on beach play exposure and a target risk of 1 x 10^{-5}.

This proposed ESD uses the same target risk and incorporates the updated BaP slope factor to revise the intertidal RAL for cPAHs from 900 µg/kg to **5,900 µg/kg dw** (See Table 3).

Table 3. Revised ROD Table 28 - Remedial Action Levels, ENR Upper Limits, and Areas and Depths of Application

			Intertidal Sediments (+11.3 ft MLLW to -4 ft MLLW)				Subtidal Sediments (-4 ft MLLW and Deeper)				
			Recovery Category 1 RALs, ENR ULs, and Application Depths		Recovery Category 2 and 3 RALs, ENR ULs, and Application Depths		Recovery Category 1 RALs, ENR ULs, and Application Depths		Recovery Category 2 and 3 RALs, ENR ULs, and Application Depths		Shoaled Areas[b] in Federal Navigation Channel
Risk Driver COC	**Units**	**Action Levels**	Top 10 cm (4 in)	Top 45 cm (1.5 ft)	Top 10 cm (4 in)	Top 45 cm (1.5 ft)	Top 10 cm (4 in)	Top 60 cm (2 ft)	Top 10 cm (4 in)	Top 60 cm (2 ft)[c]	Top to Authorized Navigation Depth Plus 2 ft
Human Health Based RALs											
PCBs (Total)	mg/kg OC	RAL	12	12	12	65	12	12	12	195	12
		UL[a] for ENR	--	--	36	97	--	--	36	195	--
Arsenic (Total)	mg/kg dw	RAL	57	28	57	28	57	57	57	--	57
		UL[a] for ENR	--	--	171	42	--	--	171	--	--
cPAH BaP-eq[f]	µg/kg dw	RAL	*5,500*[e]	*5,900*[e]	*5,500*[e]	*5,900*[e]	*5,500*[e]	*5,500*[e]	*5,500*[e]	--	*5,500*
		UL[a] for ENR	--	--	*16,500*[e]	*8,850*[e]	--	--	*16,500*[e]	--	--
Dioxins/Furans	ng TEQ/kg dw	RAL	25	28	25	28	25	25	25	--	25
		UL[a] for ENR	--	--	75	42	--	--	75	--	--
Benthic Protection RALs											
39 SMS COCs[d]	Contaminant-specific	RAL	Benthic SCO	Benthic SCO	2x Benthic SCO	--	Benthic SCO	Benthic SCO	2x Benthic SCO	--	Benthic SCO
		UL[a] for ENR	--	--	3x RAL	--	--	--	3x RAL	--	--

Notes: This table reflects changes from the 2020 ESD to Table 28 in the ROD.
-- not applicable
a. The ENR UL is the highest concentration that would allow for application of ENR in the areas described. For areas with no ENR limit listed, ENR is not a currently designated technology (see Section 13.2.1.2 for further discussion).
b. Shoaled areas are those areas in federal navigation channel with sediment accumulation above the authorized depth including a 2 ft over-dredge depth that USACE uses to maintain the channel for navigation purposes. The authorized channel depths are (1) from RM 0 to 2 (from Harbor Island to the First Avenue South Bridge), 30 ft below MLLW, (2) from RM 2 to RM 2.8 (from the First Avenue South Bridge to Slip 4), 20 ft below MLLW, and (3) from RM 2.8 to 4.7 (Slip 4 to the Upper Turning Basin), 15 ft below MLLW. For shoaled areas, the compliance intervals will be determined during Remedial Design, these are typically 2-4 ft core intervals. For areas in the channel that are not shoaled, Recovery Categories 1 or 2 & 3 RALs apply as indicated in the other subtidal columns.
c. Applied only in potential vessel scour areas. These are defined as subtidal areas (below -4 ft MLLW) that are above -24 ft MLLW north of the 1st Ave South Bridge, and above -18 ft MLLW south of the 1st Ave South Bridge (see Figure 17 in the ROD).
d. There are 41 SMS COCs, but total PCBs and arsenic ENR ULs are based upon human health based RALs only (see Table 20 in the ROD).
e. Intertidal RAL modified by ESD, based on beach play RBTC at 1×10^{-5}. The RAL of 5,500 µg/kg dw for subtidal and intertidal 0-10 cm sediments is to address hotspots. As in the ROD, the Upper Limits for ENR, where applicable, are 1.5 times the 0-45 cm RAL (in intertidal areas) and 3 times the 0-10 cm RAL (in subtidal and intertidal areas).
f. Change in terminology: cPAH µg TEQ/kg dw and cPAH BaP-eq are the same

6 RAO EVALUATION AND EXPECTED OUTCOMES

This proposed ESD does not change the RAOs in Section 8 of the ROD or the expected outcomes described in Section 13 of the ROD.

The Selected Remedy, as modified by this ESD, will achieve substantial risk reduction by dredging and capping the most contaminated sediments, reduce remaining risks to the extent practicable through ENR and MNR, and manage remaining risks to human health through institutional controls.

RAO 1 seeks to reduce risk from the consumption of contaminated seafood. Seafood consumption cancer risks for cPAH were largely attributable to eating clams. The ROD does not include a cleanup level or RAL for cPAHs in sediment to address RAO 1. Data collected during the RI/FS showed little relationship between concentrations of cPAH in sediment and their concentrations in clam tissue. Additional studies completed following the ROD continue to indicate that cPAH concentrations in sediment are not predictive of cPAH concentrations in clam tissue (LDWG, 2020). EPA will use the clam TTL for cPAHs, as revised by the proposed ESD, to measure the reduction in cPAH concentrations in clams.

6.1 EFFECT OF THE ESD ON REMEDIAL ACTION AREAS

The ROD identified areas potentially requiring active cleanup (dredging, capping, or ENR) based on sediment concentrations greater than any of the RALs, as shown in Figure 18 of the ROD. To assess the effect of the proposed changes to cPAH RALs on remedial action areas and costs, EPA assessed whether any of the cleanup areas in Figure 18 were determined based only on samples with cPAH concentrations greater than the applicable RAL for cPAHs in the ROD. If a different COC exceeded its RAL at or very close to that location, cleanup would be required whether cPAHs exceeded the cPAH RAL in the ROD or a higher cPAH RAL. Based on this analysis, the effect of the proposed cPAH RAL is minor and within the uncertainty of the remedial action area estimate in the ROD. See Appendix B for details to support this analysis.

6.2 EFFECT ON REMEDIAL QUANTITIES AND COST

Based on the evaluation above, greater than 98 percent of the remedial action areas identified in the ROD would still require remedial action, regardless of whether the RAL for cPAHs is increased as proposed in the ESD. EPA estimated the areas associated with the remedial technology applied in the ROD to adjust the cost estimate (Table 4 ESD Effects on Remedial Areas and Costs). The changes result in approximately 1percent reduction in the ROD cost estimate, within the FS goal of +50/-30 percent accuracy.

As cleanup progresses, remedial design investigations will be used to refine the ROD estimates of remedial action areas and technologies, dredge volumes, and costs. EAA cleanups, source control efforts, and ongoing deposition of Green River sediments have led to reductions in average sediment concentrations since the RI/FS (LDWG, 2020).

Table 4. ESD Effect on Remedial Areas and Cost

<table>
<tr><th rowspan="2">Remedial Technology</th><th rowspan="2">Estimate Acres in ROD (Section 3.2)</th><th rowspan="2">Estimated Cost[a] (Table 29 in ROD)</th><th colspan="3">Areas Reduced by Change in cPAH RAL</th><th rowspan="2">Cost Reduction by Technology</th></tr>
<tr><th>Location (RM)[b]</th><th>Estimate of Acres</th><th>Sum of Acres reduced</th></tr>
<tr><td rowspan="4">**Dredge**</td><td rowspan="4">105</td><td rowspan="4">$33,496,452</td><td>0.1W</td><td>0.38</td><td rowspan="4">2.89</td><td rowspan="4">$920,569.78</td></tr>
<tr><td>0.9E</td><td>1.25</td></tr>
<tr><td>1.3W</td><td>0.25</td></tr>
<tr><td>2.1E</td><td>1.00</td></tr>
<tr><td rowspan="2">**ENR**</td><td rowspan="2">48</td><td rowspan="2">$6,143,912</td><td>0.8W</td><td>1.05</td><td rowspan="2">1.53</td><td rowspan="2">$196,474.93</td></tr>
<tr><td>2.2W</td><td>0.49</td></tr>
<tr><td>**MNR**</td><td>235</td><td>0</td><td>4.4E</td><td>0.38</td><td>0.38</td><td>0</td></tr>
<tr><td colspan="3"></td><td colspan="3">**Total Cost Reduction**</td><td>$1,117,044.72</td></tr>
<tr><td colspan="3"></td><td colspan="3">**Total Remedy Cost Estimate in ROD**</td><td>$342,233,932</td></tr>
<tr><td colspan="3"></td><td colspan="3">**Cost with Reduced Acreage (cPAH only areas removed)**</td><td>**$341,116,887**</td></tr>
<tr><td colspan="3"></td><td colspan="3">**Percent Reduction in Cost**</td><td>**0.33%**</td></tr>
</table>

a. Does not include cost for disposal, dredge residuals, backfill, or monitoring line items (assumed to be nominal).
b. All locations included where cPAH-only RAL exceedance (RAL = 1,000 BaP-eq µg/kg dw) without nearby exceedances of other RALs are identified. Select locations with cPAH-only RAL exceedance (RAL = 1,000 BaP-eq µg/kg dw) also included on a case-by-case basis if determined remedy assignment would be substantially impacted.

6.3 ENVIROMENTAL JUSTICE CONCERNS

EPA acknowledges environmental justice concerns, and in Section 13.2.8 of the ROD, identified means to address these issues before, during, and after implementation of the remedy. The ESD does not change the commitments made in the ROD.

7 SUPPORT AGENCY AND TRIBAL COMMENTS

Ecology's written concurrence will be sought after consideration of comments received during the public review and comment period.

EPA has engaged the Muckleshoot, Suquamish, and Yakama Tribes with formal consultation. Comments from the consultation /will be/ addressed and recorded in the Administrative Record.

8 STATUTORY DETERMINATIONS

The Selected Remedy for the LDW Superfund Site, as modified by this proposed ESD, continues to satisfy the statutory requirements of Section 121 of CERCLA, 42 USC § 9621, to protect human health and the environment, comply with federal and state requirements that are applicable or relevant and appropriate to the remedial action, are cost-effective, and utilize permanent solutions and alternative treatment technologies to the maximum extent practicable.

9 PUBLIC PARTICIPATION COMPLIANCE

The public participation requirements set out in the NCP, 40 CFR § 300.435(c)(2), have been met by adding the proposed ESD and supporting information to the administrative record established under Section 300.815. The final ESD, public comments, and responsiveness summary will be added when finalized. EPA will publish a notice that briefly summarizes the final ESD, including the reasons for the differences described in the ESD, in a major local newspaper of general circulation.

EPA recognizes that there is strong community interest in the LDW Superfund Site. EPA intends to hold a public meeting to discuss the changes to the Selected Remedy in the proposed ESD.

10 KEY TERMS

Applicable or relevant and appropriate requirements (ARARs) - ARARs are promulgated, or legally enforceable federal and state requirements. They are generally divided into three categories: (1) chemical-specific ARARs, (2) location-specific ARARs, and (3) action-specific ARARs, depending on whether the requirement is triggered by the presence or emission of a chemical, by a vulnerable or protected location, or by a particular action. ARARs provide the basis for certain cleanup levels. A complete list of ARARs is shown in Table 26 of the ROD.

CERCLA – the Comprehensive Environmental Response, Compensation, and Liability Act—also known as Superfund—CERCLA is a federal law which authorizes response actions to reduce the dangers associated with releases or threats of releases of hazardous substances, pollutants, or contaminants that may endanger public health or welfare or the environment.

Contaminant of Concern (COC) – a hazardous substance or group of substances that pose an unacceptable risk to human health or the environment.

Cleanup Levels (CULs) - The selected cleanup levels are contaminant concentrations that will be used to measure the success of the cleanup alternatives in meeting the RAOs.

Sediment cleanup levels for RAOs 1 and 2 (for protection of human health) are calculated as RBTCs at a 1×10^{-6} excess cancer risk level for individual carcinogens and noncancer HQ or HI of 1. Where RBTCs are more stringent than the background, cleanup levels are set at the natural background level (see Section 5.3.4.1 of the ROD).

Cancer Risk – also referred to as Excess Lifetime Cancer Risk, the incremental probability of an individual developing cancer over a lifetime as a result of exposure to site-related contamination.

Hazard Index (HI) – the sum of more than one hazard quotient for multiple substances and/or multiple exposure pathways. An HI may be used to evaluate the potential for adverse health effects from exposure to more than one hazardous substance with similar modes of toxic action.

Hazard Quotient (HQ) –the ratio of estimated exposure to a specific chemical to its reference dose.

Human Health Risk Assessment (HHRA) – The process to estimate the nature and probability of adverse health effects in humans who may be exposed to chemicals in contaminated environmental media, now or in the future.

Mean Lower Low Water (MLLW) – the average height of the lowest tide recorded at a tide station each day over the period from 1983 to 2001.

Reasonable Maximum Exposure (RME) – an estimate of the highest level of human exposure that would reasonably be expected to occur.

Remedial Action Levels (RALs) – contaminant-specific sediment concentrations designed to identify specific areas of sediments that require active remediation, taking into consideration the human health and ecological risk reduction achieved by the different remedial technologies.

Remedial Action Objectives (RAOs) – objectives that describe what the proposed cleanup is expected to accomplish to protect human health and the environment.

Risk-based Threshold Concentrations (RBTCs) – the calculated concentrations in any medium estimated to be protective of a particular receptor for a given exposure pathway and target risk level. RBTCs are calculated using the assumptions and methods from the baseline risk assessments conducted during the RI.

Sediment Cleanup Objective (SCO) – SCO represents the environmental goal for establishing sediment cleanup levels under the Washington State Sediment Management Standards.

Sediment Management Standards (SMS) - The SMS are State standards designed to reduce and ultimately eliminate adverse effects on biological resources and significant health threats to humans from surface sediment contamination.

Cancer Slope Factor (CSF) – An upper bound estimate of the increased cancer risk from exposure to an agent at a dose of 1 mg/kg-day for a lifetime. The CSF can be multiplied by an estimate of lifetime exposure (in mg/kg-day) to estimate the lifetime cancer risk.

Target Tissue Levels (TTLs) - Target tissue levels, or concentrations, are not cleanup levels. They will be used for informational purposes to assess ongoing risks to people who may consume resident LDW fish and shellfish. Tissue monitoring data will also inform the content or degree of any potential future fish advisories, other institutional controls intended to minimize risk to the LDW fishing community, or other response actions.

Upper Confidence Limit (95 percent) on the Mean (UCL95) – A value that, when calculated repeatedly for randomly drawn subsets of data, equals or exceeds the true population mean 95 percent of the time. The UCL95 is used as the exposure concentration in risk assessment. It accounts for variability in the distribution of the data and the potential for exposure throughout different areas. The use of this statistic assures no more than a 5 percent chance that the average exposure concentrations is actually higher.

11 REFERENCES

EPA. (1999, July). A Guide to Preparing Superfund Proposed Plans, Records of Decision, and other Remedy Selection Decision Documents. EPA/540/R-98/031.

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USACE et. al. (2009). OSV Bold Summer 2008 Survey Data Report. (Prepared by USACE Seattle District Dredged Material Management Program; EPA Region 10; USACE; and Washington Departments of Natural Resources and Ecology). June 25, 2009.

Appendix A

Calculation of Human Health Risk-Based Benzo(a)pyrene-equivalent Threshold Concentrations for cPAHs – Basis for Revised cPAH Cleanup Levels and Target Tissue Levels

1.0 Calculation of Human Health Risk-Based Benzo(a)pyrene-equivalent Threshold Concentrations for cPAHs – Basis for Revised cPAH Cleanup Levels and Target Tissue Levels

This section presents the calculation of human health risk-based threshold concentrations (RBTCs) for cPAHs, expressed as a benzo(a)pyrene-equivalent concentration in sediment and clam tissue, assuming a target excess cancer risk of 1×10^{-6}. The revised RBTCs were calculated using the exposure assumptions and values from Section B.3.2 of the Lower Duwamish Waterway (LDW) Human Health Risk Assessment (HHRA, LDWG 2005), and errata (LDWG, 2009). When RBTCs are greater than established background concentrations, they are the basis for the revised cleanup levels in this Explanation of Significant Differences (ESD).

RBTCs associated with Remedial Action Objective 2, direct contact with sediment, were calculated to account for incidental ingestion and dermal exposures. These values were then combined to derive a single RBTC protective of both exposure pathways as follows:

$$RBTC_{sed} = \frac{1}{\dfrac{1}{RBTC_{sed-Ingestion}} + \dfrac{1}{RBTC_{sed-Dermal}}}$$

1.1 Netfishing/Clamming

RBTCs protective of the adult tribal netfishing and clamming RME scenarios were calculated using the exposure assumptions described in Tables B.3-15 and 16, and B.3-23 and 24 of the HHRA, respectively.

RBTCs protective of incidental ingestion of sediment were calculated using the following equation:

$$RBTC_{sed\text{-}ingestion} = \frac{TR \times BW \times AT_c}{EF \times ED \times CSF \times IR_{sed} \times CF_{kg/mg} \times CF_{mg/\mu g}}$$

RBTCs for dermal contact with sediment were calculated using the following equation:

$$RBTC_{sed-dermal} = \frac{TR \times AT_c \times BW_a}{EF \times ED \times CSF \times SA \times AF \times ABS \times CF_{kg/mg} \times CF_{mg/\mu g}}$$

$RBTC_{sed\text{-}ingestion}$	=	risk-based threshold concentration in sediment (µg/kg)
$RBTC_{sed\text{-}dermal}$	=	risk-based threshold concentration in sediment (µg/kg)
IR_{sed}	=	incidental sediment ingestion rate (mg/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)

BW_a	=	body weight – adult (kg)
ABS	=	dermal absorption factor
SA	=	exposed skin surface area (cm^2)
AF	=	soil-to-skin adherence factor (mg/cm^2)
AT_c	=	averaging time (days)
$CF_{kg/mg}$	=	conversion factor – kg/mg (0.000001)
$CF_{mg/\mu g}$	=	conversion factor – mg/µg (0.001)
CSF	=	cancer slope factor $(mg/kg\text{-}day)^{-1}$
TR	=	target excess cancer risk

Exposure assumptions are shown in Table 1.

1.2 Beach Play

As discussed in Section 8.5.1.1 of the HHRA, EPA guidance (EPA 2005) notes that exposures to a carcinogen in early life may result in higher lifetime cancer risks than a comparable duration adult exposure, and recommends the application of age-dependent adjustment factors of 10 and 3, respectively, for exposures occurring before 2 years of age and from ages 2 through 6 when a carcinogen is known to cause cancer through a mutagenic mode of action. RBTCs for the RME beach-play scenario were calculated using the exposure assumptions presented in Tables B.3-19 and 20 of the HHRA.

The RBTC based on incidental ingestion of sediment was calculated using the following equation:

$$RBTC_{sed-ingestion} = \frac{TR \times AT_c}{CSF \times IR_{beach-adj} \times CF_{kg/mg} \times CF_{mg/\mu g}}$$

Where:

$$IR_{beach-adj} = \left(\begin{array}{l} \frac{(EF_{0\text{-}1} \times ED_{0\text{-}1} \times IR_{sed-beach}) \times 10}{BW_{0-1}} + \frac{(EF_{0\text{-}1} \times ED_{1-2} \times IR_{sed-beach}) \times 10}{BW_{1-2}} + \frac{(EF_{0\text{-}1} \times ED_{2-3} \times IR_{sed-beach}) \times 3}{BW_{2-3}} \\ + \frac{(EF_{0\text{-}1} \times ED_{3-4} \times IR_{sed-beach}) \times 3}{BW_{3-4}} + \frac{(EF_{0\text{-}1} \times ED_{4-5} \times IR_{sed-beach}) \times 3}{BW_{4-5}} + \frac{(EF_{0\text{-}1} \times ED_{5-6} \times IR_{sed-beach}) \times 3}{BW_{5-6}} \end{array} \right)$$

RBTCs for cPAHs based on dermal exposure to sediments was calculated using the following equation:

$$RBTC_{sed-dermal} = \frac{TR \times AT}{CSF \times DF_{beach-adj} \times ABS \times CF_{kg/mg} \times CF_{mg/\mu g}}$$

Where

$$DF_{beach-adj} = \left(\begin{array}{l} \dfrac{EF_{beach} \times ED_{0\text{-}1} \times AF_{beach} \times SA_{0-1} \times 10}{BW_{0-1}} + \dfrac{EF_{beach} \times ED_{1-2} \times AF_{beach} \times SA_{1-2} \times 10}{BW_{1-2}} + \dfrac{EF_{beach} \times ED_{2-3} \times AF_{beach} \times SA_{3-4} \times 3}{BW_{2-3}} \\ + \dfrac{EF_{beach} \times ED_{3-4} \times AF_{beach} \times SA_{3-4} \times 3}{BW_{3-4}} + \dfrac{EF_{beach} \times ED_{4-5} \times AF_{beach} \times SA_{4-5} \times 3}{BW_{4-5}} + \dfrac{EF_{beach} \times ED_{5-6} \times AF_{beach} \times SA_{5-6} \times 3}{BW_{5-6}} \end{array} \right)$$

and:

$RBTC_{sed\text{-}ingestion}$	=	risk-based threshold concentration in sediment (µg/kg)
$RBTC_{sed\text{-}dermal}$	=	risk-based threshold concentration in sediment (µg/kg)
IR_{beach_adj}	=	incidental sediment ingestion – beach play (mg/kg)
DF_{beach_adj}	=	dermal sediment contact factor – beach play (mg/kg)
EF_{beach}	=	exposure frequency – beach play (days/year)
ABS	=	dermal absorption factor
AF_{beach}	=	soil-to-skin adherence factor – beach play (mg/cm^2)
$ED_{0\text{-}1}$	=	exposure duration age 0-1 (years)
$ED_{1\text{-}2}$	=	exposure duration age 1-2 (years)
$ED_{2\text{-}3}$	=	exposure duration age 2-3 (years)
$ED_{3\text{-}4}$	=	exposure duration age 3-4 (years)
$ED_{4\text{-}5}$	=	exposure duration age 4-5 (years)
$ED_{5\text{-}6}$	=	exposure duration age 5-6 (years)
$SA_{0\text{-}1}$	=	exposed skin surface area age 0-1 (cm^2)
$SA_{1\text{-}2}$	=	exposed skin surface area age 1-2 (cm^2)
$SA_{2\text{-}3}$	=	exposed skin surface area age 2-3 (cm^2)
$SA_{3\text{-}4}$	=	exposed skin surface area age 3-4 (cm^2)
$SA_{4\text{-}5}$	=	exposed skin surface area age 4-5 (cm^2)
$SA_{5\text{-}6}$	=	exposed skin surface area age 5-6 (cm^2)
$BW_{0\text{-}1}$	=	body weight age 0-1 (kg)
$BW_{1\text{-}2}$	=	body weight age 1-2 (kg)
$BW_{2\text{-}3}$	=	body weight age 2-3 (kg)
$BW_{3\text{-}4}$	=	body weight age 3-4 (kg)
$BW_{4\text{-}5}$	=	body weight age 4-5 (kg)
$BW_{5\text{-}6}$	=	body weight age 5-6 (kg)
$CF_{kg/mg}$	=	conversion factor – kg/mg (0.000001)
$CF_{mg/\mu g}$	=	conversion factor – mg/µg (0.001)
AT_c	=	averaging time (days)
TR	=	target excess cancer risk
CSF	=	cancer slope factor (mg/kg-day)$^{-1}$
TR	=	target cancer risk

Exposure assumptions are shown in Table 1. RBTCs for cPAHs in sediment are shown in Table 2.

1.3 Clam Tissue Risk-Based Concentrations

As discussed in the LDW ROD Section 8.2.3, fish and shellfish Target Tissue Levels (TTLs) were included to measure progress toward achieving RAOs 1 and 4. The TTL for cPAHs is a risk-based concentration in clam tissue, calculated based on tribal clam consumption rates.

The RBTC based on consumption of clams by adults was calculated using the following equation:

$$RBTC_{clams} = \frac{TR \times BW_a \times AT_c}{ED_a \times EF_{cc} \times CSF \times CR_{a-cc} \times CF_{kg/mg} \times \mathrm{CF}_{\mathrm{mg}/\mu\mathrm{g}} \times \mathrm{CF}_{\mathrm{mg/g}}}$$

The RBTC based on consumption of clams by children was calculated using the following equation:

$$RBTC_{clams} = \frac{TR \times AT_c}{CSF \times CR_{cc-c-adj} \times CF_{kg/mg} \times CF_{mg/\mu g} \times \mathrm{CF}_{\mathrm{mg/g}}}$$

where:

$$CR_{cc-c-adj} = \left(\begin{array}{l} \dfrac{EF_{cc} \times ED_{0\text{-}1} \times CR_{cc-c} \times 10}{BW_{0-1}} + \dfrac{EF_{cc} \times ED_{1-2} \times CR_{cc-c} \times 10}{BW_{1-2}} + \dfrac{EF_{cc} \times ED_{2-3} \times_c \times CR_{cc-c} \times 3}{BW_{2-3}} \\ + \dfrac{EF_{cc} \times ED_{3-4} \times CR_{cc-c} \times 3}{BW_{3-4}} + \dfrac{EF_{cc} \times ED_{4-5} \times CR_{cc-c} \times 3}{BW_{4-5}} + \dfrac{EF_{cc} \times ED_{5-6} \times CR_{cc-c} \times 3}{BW_{5-6}} \end{array} \right)$$

and:

$RBTC_{clams}$	=	risk-based concentration in clams (µg/kg, wet-weight)
CR_{c-cc}	=	consumption rate clams – child (g/day, wet-weight)
CR_{a-cc}	=	consumption rate – clams – adult (g/day, wet-weight)
$CR_{cc-c-adj}$	=	consumption rate clams – age-adjusted (g/kg)
EF_{cc}	=	exposure frequency clam consumption (days/year)
ED_c	=	exposure duration – child (years)
ED_a	=	exposure duration – adult (years)
ED_{0-1}	=	exposure duration age 0-1 (years)
ED_{1-2}	=	exposure duration age 1-2 (years)
ED_{2-3}	=	exposure duration age 2-3 (years)
ED_{3-4}	=	exposure duration age 3-4 (years)
ED_{4-5}	=	exposure duration age 4-5 (years)
ED_{5-6}	=	exposure duration age 5-6 (years)
BW_{0-1}	=	body weight age 0-1 (kg)
BW_{1-2}	=	body weight age 1-2 (kg)
BW_{2-3}	=	body weight age 2-3 (kg)
BW_{3-4}	=	body weight age 3-4 (kg)
BW_{4-5}	=	body weight age 4-5 (kg)

BW_{5-6} = body weight age 5-6 (kg)
BW_a = body weight – adult (kg)
$CF_{kg/mg}$ = conversion factor – kg/mg (0.000001)
$CF_{mg/\mu g}$ = conversion factor – mg/µg (0.001)
$CF_{mg/g}$ = conversion factor – mg/g (1,000)
AT_c = averaging time, cancer (days)
CSF = cancer slope factor $(mg/kg\text{-}day)^{-1}$
TR = target cancer risk

The exposure assumptions are shown in Table 1. Revised RBTCs for cPAHs are shown in Table 3. Consistent with selection of the TTL in the ROD, the more stringent value is the basis for the TTL in the ESD.

1.4 Risk-Based Threshold Concentrations for Benzo(a)pyrene Based on a Non-Cancer Endpoint

The 2014 ROD did not provide cleanup goals based on noncancer effects of cPAHs because no noncancer reference doses were available at that time. However, as part of the 2017 revised cancer assessment for benzo(a)pyrene, EPA established a reference dose (RfD) for benzo(a)pyrene of 0.003 mg/kg-day. Unlike the cancer slope factor, which may be applied to the other cPAHs through the application of Potency Equivalency Factors, the RfD is only applicable to benzo(a)pyrene. In order to assess whether the revised cleanup goals based on a cancer endpoint would be protective of non-cancer effects associated with benzo(a)pyrene, EPA conducted a screening assessment using its Regional Screening Levels (RSLs, EPA 2020) as a basis for such a comparison. The RSLs are risk-based screening levels, regularly updated using the latest toxicity values and default exposure assumptions. Because cancer risk and noncancer hazard are directly proportional to the degree of exposure and the toxicity of a chemical, a comparison of RSLs calculated based on cancer and noncancer endpoints can be used to determine which value is more protective. Assuming default exposure assumptions for incidental ingestion and dermal exposure associated with residential land use and a target cancer risk of 1×10^{-6} or noncancer hazard quotient of 1, the RSLs are 0.1 mg/kg and 18 mg/kg, respectively. Thus, cleanup goals calculated in the ESD based on the noncancer RfD for benzo(a)pyrene would be greater than those based on a cancer risk of 1×10^{-6} by more than two orders of magnitude.

Table 1. Human Health Exposure Values

Symbol	Description	Units	Value
ABS	Dermal absorption factor	unitless	0.13
$AF_{\_beach}$	Soil to skin adherence factor- beach play	mg/cm^2-event	0.2
$AF_{\_clam}$	Soil to skin adherence factor- clamming	mg/cm^2- event	0.2
AF_{net}	Soil to skin adherence factor- netfishing	mg/cm^2- event	0.2
AT_c	Averaging time - cancer	days	25,550
$BW_{0-!}$	Body weight <1 yr	kg	9.1
BW_{1-2}	Body weight 1-2 yrs	kg	11.3
BW_{2-3}	Body weight 2-3 yrs	kg	13.3
BW_{3-4}	Body weight 3-4 yrs	kg	15.3
BW_{4-5}	Body weight 4-5 yrs	kg	17.4
BW_{5-6}	Body weight 5-6 yrs	kg	19.7
BW_a	Body weight - adult	kg	81.8
CF	Conversion factor - kg/mg	kg/mg	0.000001
CF	Conversion factor - mg/µg	mg/µg	0.001
CF	Conversion factor - mg/g	mg/g	1000
CR_{cc_a}	Clam consumption rate - adult	g/day	43.4
CR_{cc_c}	Clam consumption rate - child	g/day	17.4
$CR_{cc\_c\_adj}$	Age-adjusted clam consumption factor	g/kg	15047
DF_{beach_adj}	Age-adjusted dermal factor	mg/kg	62141
$ED_{\_clam}$	Exposure duration – clamming	years	64
ED_{a-cc}	Exposure duration – clam consumption- adult	years	70
ED_{0-1}	Exposure duration <1 yr– beach play	years	1
ED_{1-2}	Exposure duration 1-2 yrs– beach play	years	1
ED_{2-3}	Exposure duration 2-3 yrs– beach play	years	1
ED_{3-4}	Exposure duration 3-4 yrs– beach play	years	1
ED_{4-5}	Exposure duration 4-5 yrs– beach play	years	1
ED_{5-6}	Exposure duration 5-6 yrs– beach play	years	1
ED_{net}	Exposure duration - netfishing	years	44
$EF_{\_beach}$	Exposure frequency - beach play	days/yr	65
$EF_{\_clam}$	Exposure frequency - clamming	days/yr	120
EF_{cc}	Exposure frequency – clam consumption	days/yr	365
EF_{net}	Exposure frequency - netfishing	days/yr	119
$IR_{\_sed\_clam}$	Incidental sediment ingestion rate - clamming	mg/day	100
IR_{beach_adj}	Age-adjusted sediment ingestion rate	mg/kg	35493
$IR_{sed-beach}$	Incidental sediment ingestion rate	mg/day	200
$IR_{sed-net}$	Incidental ingestion rate	mg/day	50
$SA_{\_clam}$	Skin surface area exposed – adult - clamming	cm^2	6,040

Table 1. Human Health Exposure Values

Symbol	Description	Units	Value
SA_{0-1}	Skin surface area < 1 yr	cm^2	1,330
SA_{1-2}	Skin surface area 1-2 yrs	cm^2	1,750
SA_{2-3}	Skin surface area 2-3 yrs	cm^2	2,069
SA_{3-4}	Skin surface area 3-4 yrs	cm^2	2,298
SA_{4-5}	Skin surface area 4-5 yrs	cm^2	2,515
SA_{5-6}	Skin surface area 5-6 yrs	cm^2	2,751
SA_{net}	Skin surface area exposed – adult - netfishing	cm^2	3,600
CSF	Cancer slope factor - benzo(a)pyrene	$(mg/kg\text{-}day)^{-1}$	1
TR	Target cancer risk	unitless	1E-06

Table 2. Risk-Based BaP-equivalent Threshold Concentrations in Sediment

Scenario	Ingestion (µg/kg dw)	Dermal (µg/kg dw)	Total (µg/kg dw)
Netfishing	7,983	4,265	2,780
Clamming	2,721	1,733	1,059
Beach Play	720	3,163	586

Table 3. Risk-Based BaP-equivalent Threshold Concentrations in Clam Tissue

Child (µg/kg ww)	Adult (µg/kg ww)
1.5	1.9

2.0 References

EPA 2005. Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. Risk Assessment Forum. Washington, D.C. EPA/630/R-03/003F. March 2005.

EPA 2020, Regional Screening Levels, May 2020 update. https://www.epa.gov/risk/regional-screening-levels-rsls

LDWG. 2005. Lower Duwamish Waterway Remedial Investigation, Remedial Investigation Report. Appendix B: Baseline Human Health Risk Assessment

LDWG. 2007. Lower Duwamish Waterway Remedial Investigation, Remedial Investigation Report. Appendix B: Baseline Human Health Risk Assessment. Errata: Adjustment to Tulalip Tribes Seafood Consumption Rates and the Impact on Risk Estimates.

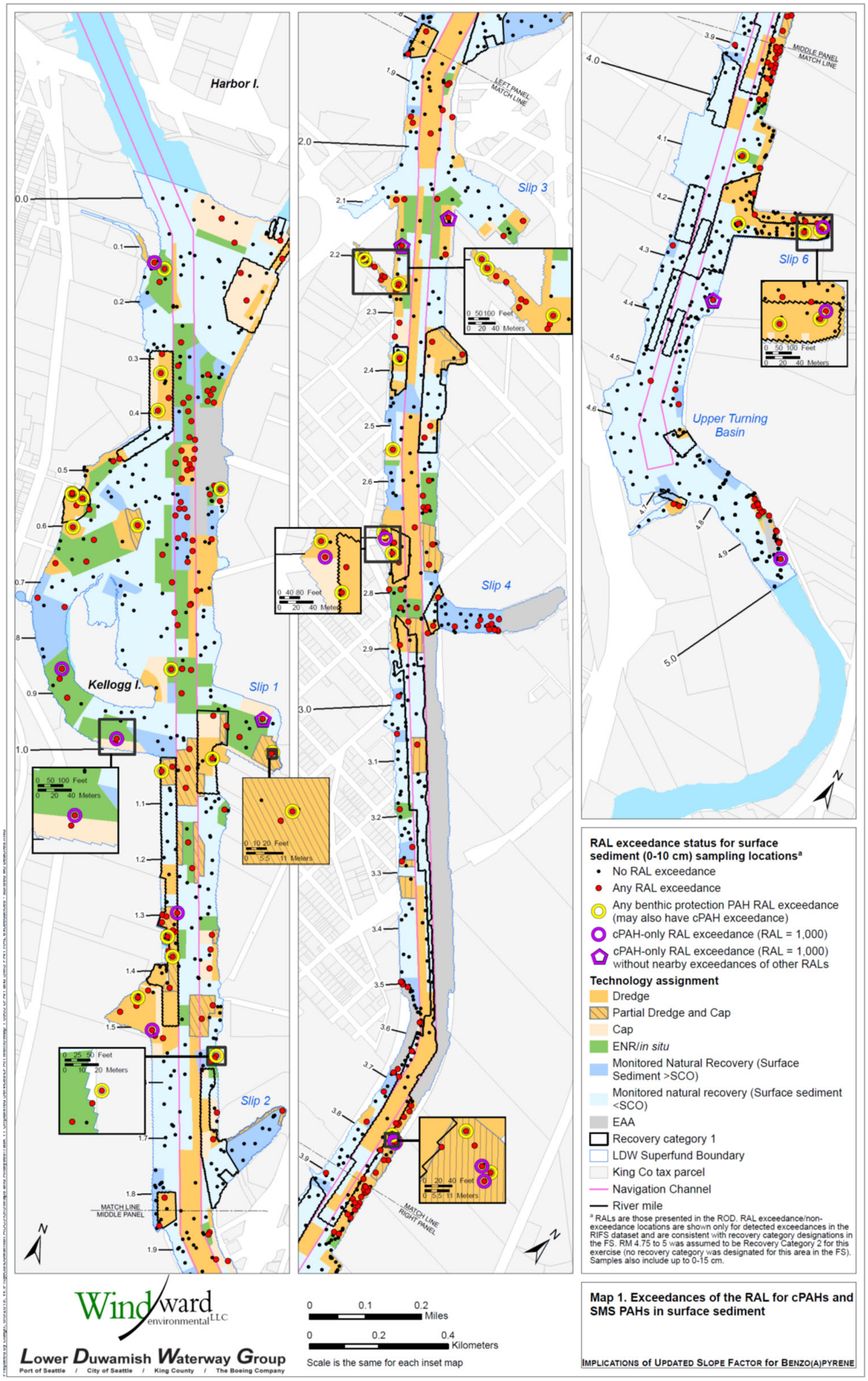
Appendix B

Evaluation of cPAH RAL Changes on Remedial Action Areas and Costs

1 Evaluation of cPAH RAL Changes on Remedial Action Areas and Costs

1.1 Evaluation of Surface Sediment

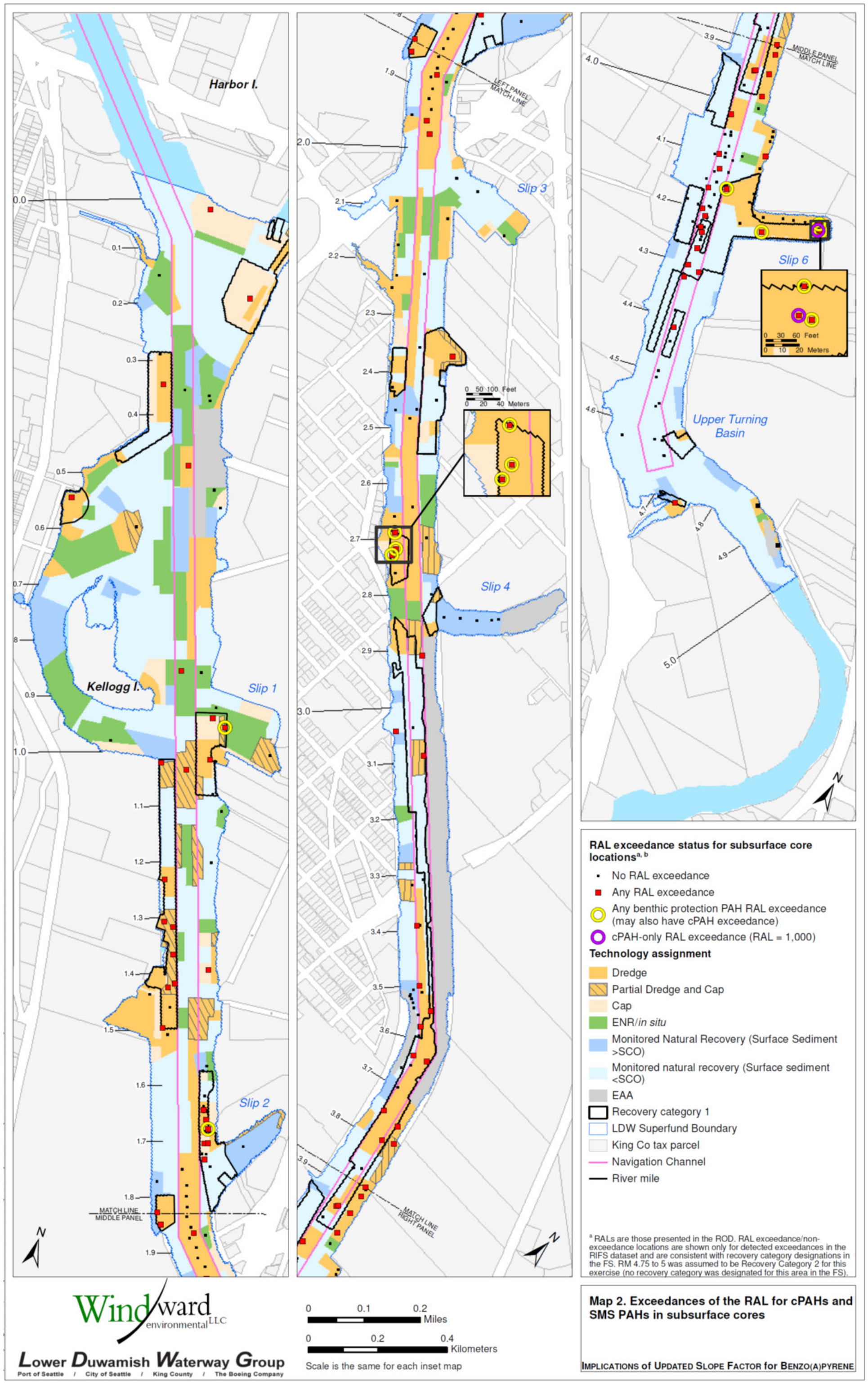
As an initial step to determine the potential magnitude of changes to remedial action areas and costs, surface sediment data was evaluated for cPAH only exceedances of the RAL. Based on a technical analysis conducted by LDWG (LDWG, 2019), Map 1 indicates cPAHs were detected at concentrations greater than the ROD RAL of 1,000 µg/kg dw at 49 of the 711 sample locations in the RI/FS (LDWG, 2012) dataset for the 0-10 cm depth interval. Of the 49 sample locations, four locations had sediment concentrations greater than only the cPAH RAL and were located far enough from other locations to potentially affect remedial area boundaries (see purple symbols on Map 1). These findings formed the basis for determining the potential changes to remedial actions for surface sediment and associated acreage so that subsequent cost impacts could then be estimated.



Map 1. Exceedances of the RAL for cPAHs and SMS PAHs in Surface Sediment (Source: LDWG, 2019)

1.2 Evaluation of Subsurface Sediment

Data for the 0-60 cm depth interval in the RI/FS (LDWG, 2010) dataset for subtidal areas indicate that cPAHs were detected at concentrations greater than the ROD RAL of 1,000 µg/kg dw at only one sample location (see purple-circled locations on Map 2). This location is adjacent to sample locations where concentrations were greater than RALs for one or more other COCs. Based on this analysis, the effect on remedial action areas of revising the cPAH RAL for the 0-60 cm depth interval and for shoaled area depth intervals to 5,500 µg/kg dw is minor and within the uncertainty of the remedial action area estimate in the ROD (EPA, 2014).



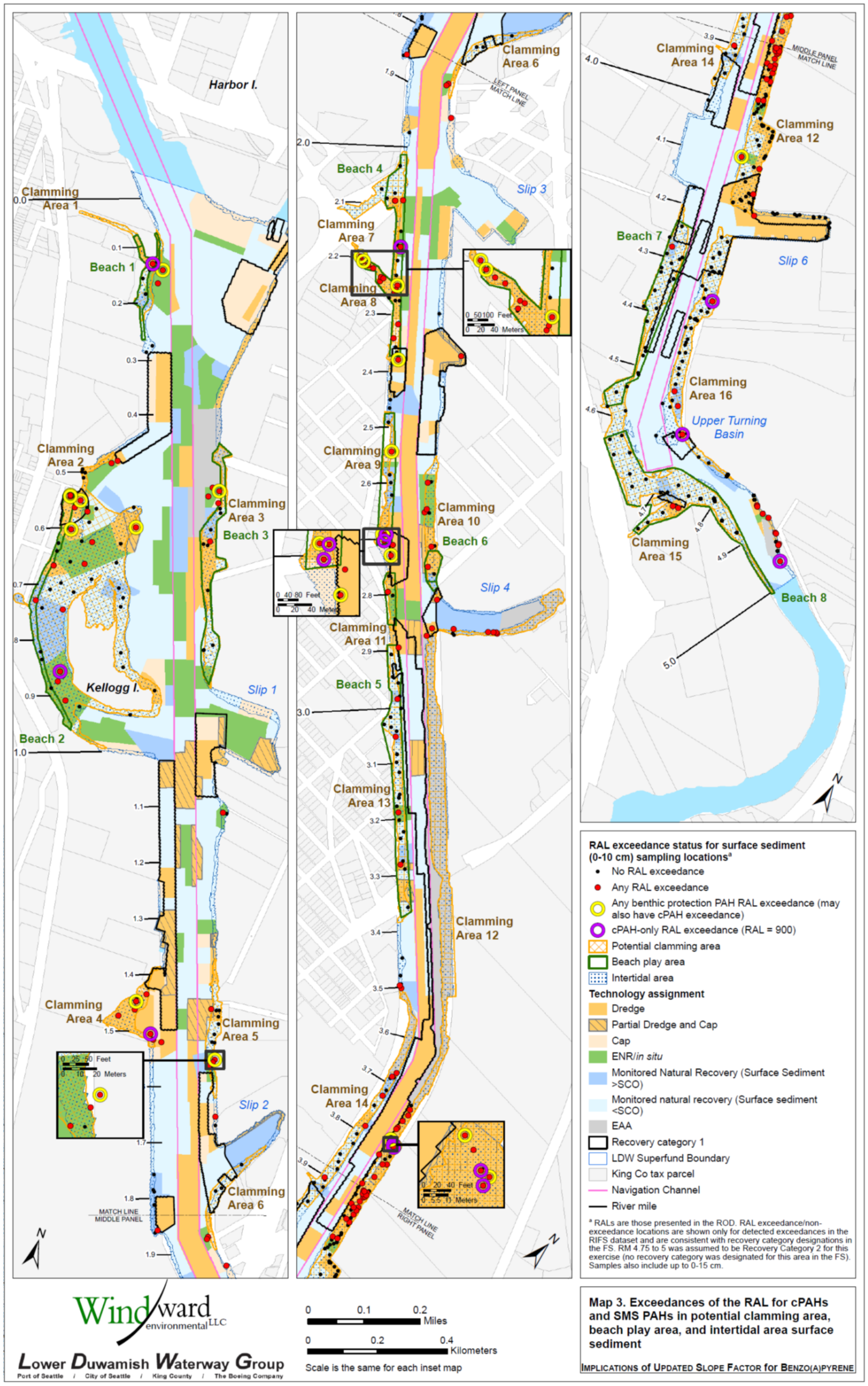
Map 2. Exceedance of the RAL for cPAHs and SMS PAHs in Subsurface Cores (Source: LDWG, 2019)

For intertidal sediments in the 0-45 cm depth interval, the RI/FS dataset is limited. As shown on Map 3, EPA compared data for intertidal sediments to the ROD intertidal RAL of 900 µg/kg using RI/FS data for the 0-10 cm interval and, where available, the 0-45 cm interval. Almost all of the sediment samples with concentrations greater than the ROD RAL for cPAHs also had concentrations of other COCs exceeding RALs or were located close to such samples and fell within the remedial action areas shown on ROD Figure 18 (EPA, 2014). Based on this comparison, the remedial action areas would not be affected by an increase in the RAL for cPAHs.

Three intertidal sediment samples with cPAH concentrations greater than the ROD RAL, between RM 4.3 and RM 5, were not close to samples where concentrations of other COCs exceeded RALs. These are in areas where monitored natural recovery, rather than active remediation, is indicated in Figure 18.

Based on this analysis, the effect of the proposed cPAH RAL for subsurface depth intervals on remedial action areas and volumes is minor and within the uncertainty of the remedial action area estimate in the ROD.

Likely, dredging volume estimates would also not change significantly, given that, as indicated above, the results of the 0-45 cm and 0-60 cm samples indicate concentrations of other COCs greater than RALs, which would drive remedial action. As such, impacts to the total project cost estimate were primarily driven by changes identified for surface sediment.



Map 3. Exceedances of the RAL for cPAHs and SMS PAHs in Potential Clamming Area, Beach Play Area, and Intertidal Area Surface Sediment (Source: LDWG, 2019)

1.3 Estimation of Area Impacts to Determine Cost Changes

In order to calculate the change in costs resulting from the RAL change for cPAHs, acreage was estimated based on the analysis conducted to determine sediment samples impacted by the change in RALs. Only seven locations were determined to have a quantifiable impact on the change to remedial technologies and associated acreage (Table 1).

Table 1. Locations, Acreage, and Technology Assignment Impacted by cPAH RAL changes

Location (RM)*	Acres Reduced	Technology Assigned in ROD
0.1W	0.38	Dredge
0.8W	1.05	ENR
0.9E	1.25	Dredge
1.3W	0.25	Dredge
2.1E	1.00	Dredge
2.2W	0.49	ENR
4.4E	0.38	MNR

*All locations included where cPAH-only RAL exceedance (RAL = 1,000) without nearby exceedances of other RALs are identified in accompanying map. Select locations with cPAH-only RAL exceedance (RAL = 1,000) also included on a case by base basis if determined remedy assignment would be substantially impacted.

A linear reduction in cost was then assumed for the decrease in acreage assigned to the three remedial technologies impacted by the cPAH RAL change. Costs from Table 29 of the ROD were accordingly scaled down to reflect the reduction in remedial action (Table 2).

Table 2. Estimated Cost Reduction by Remedial Technology

	Estimate Acres in ROD (Section 3.2)	**Estimated Cost*** (Table 29 in ROD)	**Acreage Reduced as a Result of cPAH Toxicity Update**	**Total Cost with Reduced Acreage**
Total Acres to be Dredged	105	$33,496,452	2.89	$920,569.78
Total Acres for ENR	48	$6,143,912	1.53	$196,474.93
Total Acres for MNR	235	0	0.38	0

* Does not include cost for disposal , dredge residuals, backfill, or monitoring line items (assumed to be nominal)

Lastly, this cost reduction was applied to the total project cost identified in the ROD to calculate a new total project cost of 341,116,887 (Table 3).

Table 3. Reduction in Total Project Cost

Total Project Cost Estimate in ROD	$342,233,932
Updated Project Cost Less cPAH Only Locations	$341,116,887
Percent Reduction in Cost	0.33%

2 References

EPA. (2014, November). Record of Decision for the Lower Duwamish Waterway Superfund Site.

LDWG. (2010). Lower Duwamish Waterway Remedial Investigation, Remedial Investigation Report Final. Submitted to U.S. EPA.

LDWG. (2012). Final Feasibility Study Lower Duwamish Waterway Superfund Site.

LDWG. (2019, June). Technical Memorandum: Implications of Updated Toxicity Values for Benzo(a)pyrene.