PDI Evaluation Report

Portland Harbor Pre-Remedial Design Investigation and Baseline Sampling

Portland Harbor Superfund Site
Portland, Oregon

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CERTIFICATION

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Betsy Ruffle

June 17, 2019

Betsy Ruffle
PDI Project Coordinator
AECOM Technical Services

Date

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

µg/kg	micrograms per kilogram
1,2,3,4,7,8-HxCDF	1,2,3,4,7,8-hexachlorodibenzofuran
1,2,3,7,8-PeCDD	1,2,3,7,8-pentachlorodibenzo-p-dioxin
2,3,4,7,8-PeCDF	2,3,4,7,8-pentachlorodibenzofuran
2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
2,3,7,8-TCDF	2,3,7,8-tetrachlorodibenzofuran
95 UCL	95% Upper Confidence Limit
AECOM	AECOM Technical Services
ARARs	applicable or relevant and appropriate requirements
ASAOC	Administrative Settlement Agreement and Order on Consent
BaP-TEQ	benzo(a)pyrene toxicity equivalence
BHHRA	Baseline Human Health Risk Assessment
bml	below mudline
BRV	bed replacement value
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter
cm/yr	centimeters per year
COC	contaminant of concern
CRD	Columbia River Datum
CSM	Conceptual Site Model
CUL	cleanup level
cy	cubic yards
D/U Reach	Downtown/Upriver Reach
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DDx	dichlorodiphenyltrichloroethane and its derivatives
EMPC	Estimated Maximum Possible Concentrations
ENR	enhanced natural recovery
EPA	United States Environmental Protection Agency
ESD	Explanation of Significant Differences
FS	Feasibility Study
ft	foot/feet
FWM	food web model
g/day	grams per day
Geosyntec	Geosyntec Consultants, Inc.

GIS	geographic information system
HI	hazard index
LTM	long-term monitoring
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MNR	monitored natural recovery
NAPL	non-aqueous phase liquid
NAVD88	North American Vertical Datum of 1988
NCP	National Contingency Plan
ODEQ	Oregon Department of Environmental Quality
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PDI	Pre-Remedial Design Investigation
Pre-RD AOC Group	Pre-Remedial Design Agreement and Order on Consent Group
PRG	preliminary remediation goal
PTW	principal threat waste
QAPP	Quality Assurance Project Plan
RAL	Remedial Action Level
RAO	remedial action objective
RI	Remedial Investigation
RM	river mile
ROD	Record of Decision
SDU	Sediment Decision Unit
SIL	Swan Island Lagoon
Site	Portland Harbor Superfund Site
SMA	Sediment Management Area
SMB	smallmouth bass
SRS	stratified random sample
SWAC	spatially weighted average concentration or surface weighted average concentration
TCDD-TEQ	2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalence
UTL	Upper Tolerance Limit
UTL95-95	95% Upper Tolerance Limit

EXECUTIVE SUMMARY

Introduction

The Portland Harbor Superfund Site (Site) extends along 9.9 miles of the lower Willamette River in Portland, Oregon, from river mile (RM) 1.9 to 11.8. The United States Environmental Protection Agency (EPA) listed the Site on the National Priorities List in December 2000. A remedial investigation and feasibility study (RI/FS) were performed between 2001 and 2016. On January 3, 2017, EPA issued a Record of Decision (ROD) selecting a remedy to be implemented for long-term Site cleanup. However, because the data utilized to develop the RI/FS and ROD were up to 20 years old, the ROD explicitly called for a post-ROD sampling effort to evaluate and update Site conditions prior to the development of a remedial design.

In December 2017, a group of four potentially responsible parties[1] voluntarily stepped forward and entered into an Administrative Settlement Agreement and Order on Consent (ASAOC) to perform the additional sampling, which is referred to as the Pre-Remedial Design Investigation (PDI). The PDI fieldwork was implemented between March 2018 and May 2019. This Evaluation Report presents summaries of the PDI data and analyses, as well as key findings and recommendations for refining the Conceptual Site Model (CSM) and updating the ROD in light of current data.

The PDI program is the most comprehensive, multi-media sampling effort performed at the Site since 2004. The program has met the data use objectives set forth in the ASAOC and provides EPA and other interested parties with valuable and scientifically sound information about current Site conditions and recovery trends. This information will help EPA and the performing parties update and optimize the remedial design and implementation strategies at the Site.

Overall, the data collected during the PDI demonstrate that the Site has recovered significantly in the decade and a half since the last comprehensive sampling program was performed. Concentrations of the focused contaminants of concern (COCs) have decreased in surface water and surface sediment at the Site.[2] Similarly, fish tissue concentrations of focused COCs have decreased. The PDI study also confirms that the areas of the Site that show elevated concentrations have not migrated substantially and has refined the boundaries of those areas.

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[1] Arkema Inc., Evraz Inc. NA, Schnitzer Steel Industries, Inc., and The Marine Group LLC.

[2] The focused COCs are total polychlorinated biphenyls (PCBs); total polycyclic aromatic hydrocarbons (PAHs); dichlorodiphenyltrichloroethane and its derivatives (DDx); and three dioxin/furan congeners (2,3,7,8-tetrachlorodibenzo-p-dioxin; 1,2,3,7,8-pentachlorodibenzo-p-dioxin; and 2,3,4,7,8-pentachloro-dibenzofuran). This subset of COCs was developed by EPA based on co-location with all COCs, toxicity, and significance in the risk assessments, as well as other factors outlined in the RI.

The PDI results show that several important updates are needed to the remedial approach outlined in the ROD. Adoption of the updates discussed in this report is consistent with EPA's adaptive management approach at other contaminated sediment sites (EPA 2005, 2017a) and will optimize and accelerate Site cleanup while still resulting in a long-term remedy that is equally protective of human health and the environment.

Study Objectives

The PDI was designed to generate an updated dataset across a range of media previously examined in multiple rounds of the RI/FS (EPA 2016a, 2016b). As stated in the PDI Workplan (attached to the ASAOC), "*collection and use of new 'baseline' data to revisit and refine understanding of site conditions and, as appropriate, the remedial design, remedial action and operations and maintenance are consistent with EPA regulations, policies and guidance including EPA's guidance documents related to Superfund contaminated sediment sites.*"

Summary of Studies

The PDI program consisted of eight separate field studies conducted in 2018 and 2019. The studies were performed within the Site boundaries (between RM 1.9 and RM 11.8) and in two upstream areas referred to by EPA as the Downtown Reach (between RM 11.8 to RM 16.6) and the Upriver Reach (between RM 16.6 to RM 28.4). The field investigations included the following:

- **Bathymetry Survey.** A detailed, Site-wide bank-to-bank bathymetry survey was conducted from RM 1.9 to RM 11.8 with 98% Site coverage.
- **Surface Sediment Sampling.**
  - A total of 714 surface sediment samples were collected from 0 to 30 centimeters within the Site to establish baseline conditions and assist with further characterization of sediment management areas (SMAs).
  - A total of 59 sediment samples were collected upstream (RM 11.8 to RM 28.4) to revisit background conditions.
- **Subsurface Sediment Coring.** Ninety subsurface sediment core samples were collected.
- **Sediment Trap Sampling.** Four sediment sampling traps were deployed at two upstream transects over three 3-month deployments to reflect seasonal and flow-dependent conditions. Twelve samples were collected.
- **Surface Water Sampling.** Three rounds of surface water sampling were conducted during high-flow, low-flow, and storm-flow events. A total of 21 samples were collected from seven transects and combined into cross-sectional composite samples.
- **Fish Tissue Sampling.** A total of 135 smallmouth bass (SMB) were collected for tissue sampling.

- **Fish Tracking Study.** Forty SMB were tagged and tracked with acoustic receivers to examine SMB home range and exposure patterns.
- **Background Porewater Sampling.** A background porewater study was conducted upstream of the Site to examine background arsenic and manganese concentrations.

Key Findings

The PDI program generated a significant volume of data across multiple media, allowing for an updated assessment of conditions, both within the Site and upstream. Comparison of the RI/FS and PDI data (samples taken in two different decades) affords a meaningful timescale on which to assess Site recovery processes.

The PDI characterization and resultant data analyses are summarized in this report into five key findings:

- **System Recovery is Occurring Broadly and Rapidly.** Multiple lines of evidence from the PDI show that Site recovery is consistently occurring on both localized and Site-wide scales.
- **The System and Sediment Bed are Hydrographically and Geomorphologically Stable.** The PDI bathymetry study shows that river flows and sediment bed have remained consistent and stable throughout decades of human activity and episodic natural events. This long-term stability provides confidence that areas of the Site with concentrations of COCs above the ROD cleanup levels (CULs) have not migrated substantially and that *in situ* remedial technologies are likely to remain stable over time.
- **Surface Sediment Concentrations and SWACs Have Improved.** COC concentrations in surface sediments have decreased throughout the Site. This is most clearly illustrated by the statistically significant reductions in spatially weighted average concentrations (SWACs) of total PCBs since 2004 at multiple spatial scales.
- **Upstream Conditions Support Updates to Background.** PDI data show that concentrations in the D/U Reach continue to exceed ROD sediment CULs and fish tissue targets for a number of the focused COCs, including total PCBs, DDx, and dioxins and furans. The PDI data demonstrate that the ROD CULs and risk-based tissue targets for those focused COCs cannot be realistically achieved and sustained.
- **Fish Consumption Risk is Reduced Relative to Previous Estimates.** PDI SMB tissue sampling shows significant reductions in concentrations relative to historical tissue data and a corresponding significant decrease in the risk from fish consumption since the Baseline Human Health Risk Assessment (BHHRA) for the RI/FS.

These key findings from the PDI should be used to refine and update the CSM. The CSM presents information about the physical, chemical, and biological processes at the Site and will be an important resource as EPA and the performing parties move into the remedial design and remedial action phases. It is critical that the CSM include the most up-to-date, scientifically sound information about the Site.

Updated Remedial Approach

The PDI supports the following specific updates to the remedy discussed in the ROD:

- **Updated Background Sediment COC Concentrations.** The estimates of background concentrations for the focused COCs and arsenic in the ROD warrant upward refinement. The PDI data show that upstream sediment concentrations of total PCBs, dioxins/furans, and arsenic are higher than CULs set in the ROD. Site background concentrations are important because they are used to set CULs for certain COCs and represent the lower limits of concentrations that may be practicably achievable and sustainable at the Site due to the continuing inputs from upstream areas. EPA guidance recognizes that setting numerical cleanup goals at levels below background is impractical.

  The PDI data provide broad spatial coverage throughout relevant upstream areas; these data were used to calculate the statistically robust, updated background concentrations presented in this report. These updated concentrations should be considered by EPA in setting achievable cleanup goals.

- **Background Porewater Arsenic and Manganese Concentrations Support Groundwater CUL Updates.** The RI did not establish background conditions for these naturally occurring metals in porewater, and ROD cleanup levels do not reflect naturally occurring concentrations of these metals in porewater. In collaboration with EPA, the goal of the PDI study was to establish background concentrations of arsenic and manganese in porewater. The ROD CULs for these metals in groundwater are not achievable and need to be removed or, at a minimum, updated. High levels of arsenic and manganese are naturally present in the volcanic rocks of the Willamette River basin, and geologic weathering processes introduce arsenic and manganese into the sediment and river environment. Background porewater average concentrations measured during the PDI porewater study are greater than 85% of transition zone dissolved water concentrations measured during the RI for arsenic and manganese. This report presents updated porewater background values that should be used by EPA for removing or adjusting groundwater CULs for arsenic and manganese.

- **Updated Sediment CULs.** The ROD CULs for sediment address direct (i.e., sediment contact) and indirect (i.e., uptake into biota) exposures for humans and wildlife and should be updated based on the PDI data. For several COCs, including PCBs, DDx, aldrin, dieldrin, and dioxins/furans, the lowest sediment goals, and therefore, the ROD CULs, are based on human consumption of fish (Remedial Action Objective 2). For PCBs and DDx, a mechanistic food web model (FWM) was used to relate COC concentrations in sediment to resident fish species, including SMB. The fundamental FWM assumption that fish tissue concentrations are largely a function of localized sediment COCs is not supported by the PDI data, including the fish tracking study, and significantly overstates this relationship. PDI data analysis also shows that the FWM that was relied on to set ROD CULs does not accurately predict fish tissue concentration trends over time. The fish tracking results indicate that some SMB are highly mobile, with home ranges of several miles, including outside of the Site. Overall, the inability of the FWM to reliably and accurately predict or relate sediment and fish tissue concentrations should preclude its use in setting Site sediment CULs. Assuming that risk-based concentrations would still be below background concentrations (for PCBs and dioxin/furan-focused COCs), the sediment CULs should default to the updated background concentrations presented in this report. Those background concentrations should then be used to calculate updated sediment CULs and RALs. Updated sediment CULs and RALs based on this methodology are presented in this report.

- **Updated Fish Tissue Targets.** The ROD fish tissue target concentrations should be reviewed in light of recently updated human exposure assumptions, including more recent regional and national studies on fish consumption rates, updated EPA exposure assumptions for body weight and exposure duration, and the PDI upstream SMB dataset. Though issued in 2017, the ROD relied on the 2013 BHHRA assumptions, without the benefit of relevant 2014 EPA guidance or more recent regional studies of tribal and recreational fisher populations. For example, the ROD tissue targets are based on a subsistence consumption scenario that assumes 228 meals per year of resident fish, which is not consistent with current EPA fish consumption data and statistical analysis methods. The updated fish tissue targets and background concentrations presented in this report should be used to monitor progress toward achieving the remedial action objectives for the Site.

- **Updated Sediment RALs.** The sediment RALs should be updated to reflect the fact that the Site has undergone measurable and significant recovery since the RI data were collected. The same target SWACs selected in the ROD can be achieved by remediating fewer acres. For PCBs in particular, the Site-wide SWAC has decreased from 92 micrograms per kilogram (µg/kg) (as specified in the ROD) to 44 µg/kg (>50% decrease), and the area-wide SWACs outside of ROD SMAs have largely recovered to background conditions for PCBs. This report presents updated RAL curves that incorporate 2018 PDI surface sediment data, as well as updated sediment RALs for all six focused COCs. The updated RALs are protective of human health and the environment, and a remedy based on these updated RALs is expected to result in post-construction SWACs near, or even below, the target SWACs set forth in the ROD.

- **Updated Risks.** Site-wide cancer risks and hazards have decreased, on average, by about 70% to 96% as a result of decreased concentrations in SMB tissue in the PDI dataset and by about 91% to 99% when coupled with up-to-date and realistic exposure assumptions. Meaningful risk reduction has already occurred, with potential cancer risk to recreational fishers now within acceptable limits. The recreational fisher should no longer be a focus of remedy design. Background fish consumption risks, which were not previously evaluated in the RI/FS, are significant based on the PDI upstream fish tissue dataset and need to be considered when evaluating remedy effectiveness.

- **Principal Threat Waste (PTW) Management.** Concentration thresholds and other criteria for PTW management should be reviewed in light of PDI findings and EPA guidance on this issue. Overall, PDI analyses demonstrate a substantial decline in the estimates of Site risks, such that subsistence fisher pathway risks fall below the 1×10^{-3} threshold. Therefore, concentration-driven PTW designations (i.e., highly toxic PTW) should be eliminated. Additionally, the ROD requirement that a reactive cap is necessary to reliably contain all areas of remaining "highly toxic" PTW exceedance is overly conservative and likely unnecessary, as demonstrated by the updated PDI cap modeling. The PDI modeling results presented in this report demonstrate that unamended/nonreactive caps could be protective at concentrations above ROD PTW levels. Highly mobile PTW designations, mostly associated with NAPL, will be further evaluated during remedial design.

Remedy Design Considerations

One of the key objectives of the PDI was to assist in updating Site SMA boundaries. SMA footprints represent areas where COC concentrations exceed RALs and will require active remediation such as dredging and capping, according to the ROD. A Refined SMA footprint incorporating PDI and historical data and analysis is presented in this report. This footprint is smaller than the ROD SMA footprint. The Refined SMA footprint incorporates RAL exceedances for total PCBs, total PAHs, and DDx. Spatial mapping of dioxin/furan RAL exceedances was excluded from the Refined SMA footprint and should be further evaluated during remedial design because of dioxin/furan data uncertainty. The Refined SMA footprint highlights the magnitude and extent of Site recovery that has occurred since the RI/FS data were collected. The Refined SMA footprint meets targets for interim and post-construction (Time 0) risks and hazards. The more targeted acreage requiring active remediation (to reach the same cleanup goals) will also expedite the construction time of Site cleanup.

In addition to presenting the Refined SMA footprint, this report also explores several other important aspects of Site design and remedial considerations, such as technology assignments and long-term monitoring considerations. This PDI information and analysis are reliable and should be used as a foundation to further inform the remedial design phase.

Conclusion

The PDI program is the most comprehensive, multi-media sampling effort performed at the Site since 2004. The PDI program has met its stated data use objectives and provides EPA and other interested parties with scientifically sound information about current Site conditions and recovery trends. While additional sampling will be necessary during the remedial design phase, as the PDI Statement of Work (attached to the ASAOC) acknowledges, the "*proposed PDI* *sampling program is extensive and the data will be used to update the CSM to inform future remedial design activities and future long-term monitoring in accordance with [CERCLA].*"

The PDI generated new data and analyses to refine the Site CSM and provide a more accurate understanding of Site processes, including background influences and risk assumptions. The PDI data and analyses show that Site conditions have improved substantially since the last comprehensive sampling was performed in 2004. Substantial risk reduction has already occurred, and fish consumption risks are at or below EPA's interim targets for recreational fishers and subsistence fishers. The analyses contained in this report support important refinements to the remedial approach outlined in the ROD, including updates to certain background values, CULs, sediment RALs, and fish tissue targets and should be used to inform remedial design decisions.

In addition, the data generated by the PDI can also be used for key additional analyses as the Site cleanup process moves forward. For example, the PDI data will be used to inform ongoing source control studies, support long-term monitoring, and evaluate appropriate institutional controls for the Site.

1. INTRODUCTION

The Portland Harbor Superfund Site (Site) extends along 9.9 miles of the lower Willamette River in Portland, Oregon, from river mile (RM) 1.9 to 11.8 (Figure 1.1). The United States Environmental Protection Agency (EPA) first listed the Site on the National Priorities List in December 2000. On January 3, 2017, EPA issued a Record of Decision (ROD) selecting a remedy to be implemented for long-term Site cleanup (EPA 2017b). However, because many of the underlying data were collected between 1997 and 2014, and because the lower Willamette River is a "highly dynamic and heterogeneous" system,[3] the ROD provided for a post-ROD sampling effort to evaluate and update Site conditions prior to the development of the remedial design. This report is an analysis of that Pre-Remedial Design Investigation (PDI) and baseline sampling conducted in 2018/2019.

The activities detailed in this PDI Evaluation Report (Evaluation Report) were conducted in accordance with the December 19, 2017, Administrative Settlement Agreement and Order on Consent (ASAOC) between the performing parties and EPA and in compliance with the EPA-approved PDI Work Plan (Geosyntec Consultants, Inc. [Geosyntec] 2017) and various media-specific Field Sampling Plans. All PDI-related activities have been conducted under strict EPA oversight by the four ASAOC signatory parties known as the Pre-Remedial Design Agreement and Order on Consent Group (Pre-RD AOC Group), which includes Arkema Inc.; Evraz Inc. NA; Schnitzer Steel Industries, Inc.; and The Marine Group LLC. This report was prepared by AECOM Technical Services [AECOM] and Geosyntec on behalf of the Pre-RD AOC Group.

1.1 Study Objectives

The objectives and intended uses of the PDI are detailed in ASAOC Section III, Statement of Purpose:

> *3.1 In entering into this Settlement, the objectives of the Parties are to:*
>
> *(a) implement investigation baseline sampling to update existing site-wide data;*
>
> *(b) gather data to be used as part of a baseline dataset for future long-term monitoring;*
>
> *(c) inform certain analysis regarding scope and extent of remedial actions;*
>
> *(d) collect data to facilitate completion of the third party allocation by potentially responsible parties ("PRPs") (this allocation process is independent of EPA oversight);*

[3] EPA, Record of Decision – Portland Harbor Superfund Site, Portland, Oregon, Part 3 – Responsiveness Summary Report, EPA Region 10, Seattle, Washington, January 2017.

(e) assist in refining the scope and extent of the remedial actions that will be performed at the Site, including refining Sediment Management Areas (SMAs), informing technology assignments consistent with the decision tree in the ROD (Figure 28) throughout the Site, and refining the horizontal and vertical extent of the dredging and capping areas;

(f) collect additional data regarding upstream conditions and contaminant loading into the Site;

(g) update and evaluate Site conditions to refine the conceptual site model for all pathways consistent with the ROD, p. 106 (Post-ROD Data Gathering); and

(h) provide for recovery of response and oversight costs incurred by EPA and Oregon Department of Environmental Quality (ODEQ) with respect to the Settlement. (ASAOC, p. 4)

With these objectives in mind, the PDI was designed to generate an updated dataset across a range of media previously examined in multiple rounds of the Remedial Investigation/Feasibility Study (RI/FS; EPA 2016a, 2016b). The PDI updates core elements of the Conceptual Site Model (CSM). Consistent with the ROD, these updates to the CSM relate primarily to the six focused contaminants of concern (COCs) identified in the ROD (EPA 2017b, p. 59): total polychlorinated biphenyls (PCBs); total polycyclic aromatic hydrocarbons (PAHs); dichlorodiphenyltrichloroethane and its derivatives (DDx); and three dioxin/furan congeners (2,3,7,8-tetrachlorodibenzo-p-dioxin [2,3,7,8-TCDD]; 1,2,3,7,8-pentachlorodibenzo-p-dioxin [1,2,3,7,8-PeCDD]; and 2,3,4,7,8-pentachlorodibenzofuran [2,3,4,7,8-PeCDF]). The remedial alternatives, including the selected remedy (Alternative F Modified), were developed using focused COC data. As stated in Section 10.1 of the ROD,

The COCs used to define the SMA boundaries encompassed most of the spatial extent of contaminants posing the majority of the risks as identified in the baseline risk assessments. However, since it is difficult to design a range of alternatives for multiple COCs that have different distributions in various media throughout the Site, the FS alternatives were developed using COCs that were the most widespread and posed the greatest risk, called "focused COCs."

The ROD (Section 6.5.1) also states:

This subset [of six focused COCs] *was developed by evaluating colocation of all COCs, their toxicity, and significance in the risk assessments, as well as other factors outlined in the RI.*

1.2 2018/2019 Pre-Remedial Design Investigation

The PDI work consisted of eight separate field studies conducted in 2018 and 2019 (Table 1.1). The studies were performed within the Site boundaries (between RM 1.9 and RM 11.8) and in two upstream areas referred to by EPA as the Downtown Reach (between RM 11.8 to RM 16.6) and the Upriver Reach (between RM 16.6 to RM 28.4) (Figure 1.2). Collectively, the river reach from RM 11.8 to RM 28.4 is referred to as the Downtown/Upriver Reach (D/U Reach).[4] The field investigations are summarized in Table 1.1 and included the following:

- **Bathymetry Survey.** A detailed bank-to-bank bathymetry survey was conducted in three field deployments within the Site and in Multnomah Channel (RM 3), at varying water levels. Multi-beam sonar depth readings were collected within the Site, supplemented by single-beam data from areas of limited access.
- **Surface Sediment Sampling.** Surface sediment was sampled from 0 to 30 centimeters (cm) into the surface of the river bed; the program included a total of 714 samples collected throughout the Site and D/U Reach. Within the Site, these samples included 424 stratified random samples (SRS) within a grid system and 231 samples from locations in or adjacent to the sediment management areas (SMAs) designated in the ROD. The program also included 59 SRS upstream sediment samples from within the D/U Reach (29 Downtown Reach samples and 30 Upriver Reach samples).
- **Subsurface Sediment Coring.** Subsurface sediment samples were collected at multiple depths from 90 sediment coring locations selected to target spatial gaps in the RI data in the vicinity of the ROD SMAs. Cores were advanced to 6 feet (ft) below mudline (bml) in one-third of the cores and from approximately 10 to 20 ft bml in remaining locations.
- **Sediment Trap Sampling.** Sediment sampling traps were deployed in 3-month seasonal collection periods, from August 2018 through May 2019, to reflect seasonal and flow-dependent conditions. Four sediment traps collected suspended solids during each deployment. Traps were located on the east and west sides of the river just above the Site at RM 11.8 and farther upstream at RM 16.2.
- **Surface Water Sampling.** Three rounds of surface water sampling were conducted from August 2018 through February 2019. Samples were collected at seven transects during high-flow, low-flow, and storm-flow events; five of the transects were within the Site, and two were within the D/U Reach. At each transect location, samples were composited vertically and horizontally to characterize the quality of surface water passing through the river's cross section (east, west, and mid-navigation channel sampling points) and at three different depths: upper depth (3 ft below water surface), near bottom (3 ft above sediment surface), and middle (equal distance between upper and bottom depths).
- **Fish Tissue Sampling.** The fish tissue field study was conducted from August to September 2018. A total of 135 smallmouth bass (SMB; *Micropterus dolomieu*) were collected by rod and reel: 95 SMB from within the Site, 20 from the Downtown Reach, and 20 from the Upriver Reach. SMB was selected as the target resident fish species because of its abundance, representativeness, and utility for trend analyses.

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[4] The Downtown Reach includes the urban area of downtown Portland adjacent to the Site. The Upriver Reach is less urbanized.

- **Fish Tracking Study.** The fish tracking study was conducted from May 2018 to May 2019 to examine SMB home range and exposure patterns that may affect the relationship between sediment conditions and the bioaccumulation of contaminants in SMB fish tissues. Forty SMB were tagged and tracked with acoustic receivers from which tracking data were downloaded at 3, 6, 9, and 12 months. The study captured seasonal variations in SMB movements through a full year.

- **Background Porewater Sampling.** The background porewater study was conducted in August and September 2018 to examine background arsenic and manganese concentrations. Background concentrations of these metals were not quantified in the RI/FS and were predicted as likely to exceed cleanup levels (CULs) identified in the ROD; hence, sampling was performed in the PDI to meet this data need. Passive porewater samplers were deployed for 28 days at a target depth of between 6 cm and 30 cm below the sediment-water interface in nine upstream locations approved by EPA.

Table 1.2 presents the total sample counts by media collected during the PDI program. The comparative analyses of PDI and historical data documented in this report relate to key Site features, such as sedimentation rates, changes in contaminant concentrations, and other dynamic trends within and/or impacting the Site. As specified in the ROD and in the ASAOC, this report offers data-driven recommendations for refinement of the CSM and provides useful information about Site risks. The report also refines the SMAs and presents important implications for remedial design.

1.3 Document Organization

To streamline this report and focus primarily on PDI data analysis and its implications for Site remediation, the detailed technical information regarding field activities, sampling methods and procedures, and results and analyses are presented in the supporting technical appendices. The remainder of this report is organized as follows:

- **Section 2, Key Findings:** Presents important data analyses and findings from the PDI field programs and discusses refinement of the CSM.

- **Section 3, Updated Remedial Approaches:** Presents updates to background estimates, baseline risks, CULs, RALs, and principal threat waste (PTW) criteria.

- **Section 4, Remedy Design Considerations:** Presents updated SMA footprints and volumes based on the remedial approaches presented in Section 3. This section also addresses considerations related to technology assignments and evaluates the projected post-construction (i.e., Time = 0) status of remedial action objective (RAO) attainment.

- **Section 5, Conclusions:** Highlights key conclusions from the results and analyses presented in the prior sections.

- **Section 6, References:** Provides a list of sources referenced in this report.

Supporting materials, including tables, figures, and appendices, follow Section 6. Some of the appendices are provided only on DVD due to format (e.g., database, geographic information system [GIS]) and/or file size (e.g., laboratory reports, data validation reports).

2. KEY FINDINGS

The 2018/2019 PDI[5] generated a significant volume of data across multiple media, providing an updated assessment of conditions, both within the Site and in upstream reaches. This section presents the analytical conclusions, CSM refinement, and remedial implications of numerous analyses performed using the PDI datasets. These analyses are presented in detail in the appendices to this report.

Comparison of the RI/FS and the PDI data, drawn from samples taken in two different decades, affords a meaningful timescale on which to assess Site recovery processes. The associated datasets include system-wide bathymetry and grain size distributions; COC characterization in various media, including surface and subsurface sediments, surface water, and fish tissue; and several aspects of the Site background, including upstream bedded sediment, sediment trap, and surface water. The physical, chemical, and biotic systems have been tested in at least two, and in some cases as many as five, time frames.

The PDI characterization and resultant data analyses are summarized into five key findings:

- **System recovery is occurring broadly and rapidly.** Multiple lines of evidence demonstrate patterns and rates of ongoing Site recovery that have important implications for remedial design and subsequent remedial actions. The PDI data and analyses provide compelling evidence that ongoing recovery of Site media is occurring both on a localized and Site-wide scale.
- **The system and sediment bed are hydrographically and geomorphologically stable.** Generalized river flows and sediment bed have remained consistent throughout decades of human activity and episodic natural events. System-wide patterns of deposition and erosion support the understanding of system stability. This long-term stability provides confidence that areas of the Site with concentrations of COCs above the ROD CULs have not migrated substantially and that *in situ* remedial technologies will remain permanent and stable over time. Furthermore, the physical stability of the system promotes ongoing recovery of COCs in multiple media due to net sediment deposition and attendant burial of COCs.
- **Surface sediment concentrations and spatially weighted average concentrations (SWACs) have improved.** Focused COC concentrations in surface sediments have decreased to varying degrees throughout the Site. Multiple comparative analyses of historical datasets to 2018 PDI data, conducted over several spatial scales, demonstrate

[5] Depending on media, the PDI data were collected in either 2018 (bathymetry, surface sediment, subsurface sediment, fish tissue, background porewater) or in both 2018 and 2019 (sediment traps, surface water, fish tracking). This report will note either 2018 or 2018/2019 as appropriate for the data being discussed.

these reductions. This is most clearly illustrated by the statistically significant reductions in SWACs[6] of total PCBs at multiple spatial scales.

- **Upstream conditions support updates to background.** Measured concentrations in the D/U Reach continue to exceed risk-based and background-based CULs and tissue targets set by EPA in the ROD for several of the focused COCs, including total PCBs, DDx, and dioxins/furans, as validated by the PDI multi-media upstream background characterization study (Appendix F.1). Therefore, the ROD CULs and risk-based tissue targets cannot be realistically achieved given the contribution of focused COCs from the D/U Reach, upland areas adjacent to the Site, and other upgradient areas. Consequently, background values should be updated.
- **Fish consumption risk is reduced relative to previous estimates.** PDI whole body SMB sampling shows significant reductions in body burden concentrations relative to historical data and a corresponding significant decrease in the risk from fish consumption, which is the principal basis of the remedy, since the Baseline Human Health Risk Assessment (BHHRA) for the RI/FS.

Sections 2.1 through 2.5 illustrate and discuss these key findings, with references made to further detail in corresponding appendices to this report. Section 2.1 provides an overview of system recovery. Several media-specific findings, such as those relating to sediment or fish tissue concentration reductions, are introduced in Section 2.1 and described in greater detail in subsequent sections.

2.1 System Recovery is Occurring Broadly and Rapidly

The PDI datasets show that the Site is restoring itself in most areas through ongoing recovery processes. Physical observations in the last 14 years (net bathymetric changes) show that the Site is subject to extensive deposition of sediment. The contributing factors and positive effects of this recovery mechanism are evident in declining focused COC concentrations across multiple media. While the mechanisms contributing to recovery are not uniform throughout the Site, and there are locally specific and/or COC-specific patterns, the comparative analyses measuring PDI data against the RI/FS data confirm that reliance on natural recovery, enhanced by continued source control, is an important part of the Site remedy.

The multiple lines of evidence used in this report for quantitatively assessing Site recovery processes are consistent with scientific literature and regulatory guidance (Magar et al. 2009; EPA 2014a; EPA 2008; EPA 2005). They include the analysis of long-term trends of chemical concentrations in sediment core profiles, physical conditions such as bathymetry and grain size,

[6] In the PDI Work Plan, the term "spatially weighted average concentration" (SWAC) is used. In previous Site documents, including the ROD, the SWAC term is also defined as "surface area weighted average concentration." For surface sediments, these terms can be used interchangeably. For this report, the term "spatially weighted average concentration" will continue to be used to remain consistent with the PDI Work Plan.

and reductions in focused COC concentrations in surface sediment, fish tissue, sediment trap samples, and surface water over time. These lines of evidence were used by EPA in the Portland Harbor ROD and are supported by EPA guidance (2014a), which identifies three key questions related to Site recovery:

- Is there evidence that the system is recovering over time?
- What processes are controlling system recovery?
- Is system recovery occurring at a rate sufficient to meet remedial objectives?

These questions are evaluated and addressed below for multiple media and spatial scales. Taken together, the findings demonstrate that river conditions are improving more broadly and more rapidly than previously recognized or projected by the RI/FS or contemplated in the ROD. Additionally, the findings provide reliable indicators as to where in the river, and under what conditions, system recovery processes can be predicted. These factors should all be considered in the remedial design.

2.1.1 System Bathymetry

Bathymetric changes evaluated from 2002 to 2018 confirm that the Site is net depositional, therefore providing evidence of the on-going natural recovery occurring at the Site. These results are presented in detail, with interpreted bathymetric results, in the PDI Footprint Report and in Appendix D.1 of this report (AECOM and Geosyntec 2019). Net changes in sediment bed elevations observed between bathymetry surveys taken in 2004 (RI)[7] and 2018 (PDI) were used to calculate sediment volume changes Site-wide and in discrete Site Sediment Decision Units (SDUs), navigational and non-navigational channel areas, and SMAs. Key findings from the bathymetric analyses include the following:

- The Site is net depositional, with approximately 5 million cubic yards (cy) of net deposition over the surveyed area, averaging about 1.5 ft of accumulation, over 14 years. Of this net total, approximately 491,000 cy of surface sediment has been deposited in the 339 acres of ROD SMA footprints with bathymetric coverage. Assuming this amount of deposition is over the entire 339 acres, this constitutes an average of 0.9 ft of deposition. Figures 2.1a and 2.1b and Table 2.1 show the spatial extents of depositional (909 acres), neutral (1,008 acres), and erosional (70 acres) areas.[8] Roughly 21% of the erosional area is likely attributable to past dredging events.[9]

[7] The 2004 survey was selected for comparison because it was conducted the same year as the 2004 Site-wide, Round 2 RI sampling event.

[8] The three acreages given (909 acres, 1,008 acres, and 70 acres) total 1,987 acres, which equals the area of overlap of 2004 and 2018 bathymetry.

[9] Of the 70 acres classified as net erosional, a portion is regularly dredged; hence, sediment loss does not stem from erosive riverine processes. Based on visual indications of dredged areas from the bathymetry survey (e.g., square depressions with steep gradients located near established berthing areas), approximately 15 of the 70 acres (21%) are likely attributable to dredging operations.

- Bathymetric change data indicate elevation changes (by deposition or erosion) of 5 ft or less in most areas of the Site over the 14-year period. Where there is net deposition and data coverage, the shallow regions (-2 ft Columbia River Datum [CRD] to shore) typically show sediment accumulations of about 0.7 cm per year (cm/year). Deeper portions of the Site in the intermediate region and navigational channel (-2 ft CRD and deeper) experience about 1 to 5 cm/yr. Shoreline areas do not show the degree of deposition seen in many other portions of the river and may be subject to wave disturbance generated by wind and vessel activity and changes in water elevation, tidal influences, and other erosive forces (see Feasibility Study [EPA 2016b], Appendix D, p. D-26). Areas between 6 and 13 ft North American Vertical Datum of 1988 (NAVD88) elevation are most likely to receive heavy wave/wake action; less forceful action would be expected between 0 and 6 ft NAVD88, and minimal disturbance is expected below these elevations. These shoreline areas are difficult to assess for trends because of lack of bathymetry coverage at the higher elevations; therefore, they should be evaluated further during remedial design.
- The estimated 5 million cy yard net volume change is due to sediment deposition. As a result, river bed elevations and associated water depths are also changing. In some areas, intermediate regions defined in the ROD may be transitioning to shallow regions due to the observed sedimentation rates. These data indicate that potential future changes to river bed elevations, river storage capacity, and habitat zones by natural and anthropogenic processes should be considered during remedial design. For example, capping without dredging within stable or depositional areas of SMAs may be considered to increase or improve shallow habitat if it does not adversely affect cumulative storage capacity.

2.1.2 Sediment Recovery

Comparative analysis of RI and PDI surface and subsurface core data shows that sediment recovery is occurring. Analyses of changes in surface sediment concentrations are presented in detail in the PDI Footprint Report and Appendix D.2 to this report (AECOM and Geosyntec 2019, Section 2.1.1). This section presents sediment recovery information in three different formats and spatial scales: (i) comparisons of 2004 RI and 2018 PDI surface sediment SWACs at RM scales[10] and in depositional areas, (ii) sample-by-sample paired comparison of proximal RI and PDI surface sediment samples, and (iii) core profile analysis comparing concentrations in the top interval to the interval with the maximum concentration.

[10] See Section 2.3 for other spatial scales and comparison to FS/ROD SWACs.

Surface Sediment SWACs

Surface sediment recovery was documented for three of the six focused COCs for which extensive RI and PDI datasets are available (i.e., total PCBs, total PAHs, and DDx)[11] as follows:

- Sediment recovery is occurring in multiple RMs (Figure 2.2 series). Comparative analysis of 2004 RI and 2018 PDI data indicates that PCB SWACs decreased in 8 of 9 RMs,[12] PAH SWACs decreased in 6 of 10 RMs, and DDx SWACs decreased in 9 of 10 RMs.
- Average concentrations of the three focused COCs generally decreased by more than 50% in depositional areas distributed throughout the Site (as defined by the 2004 RI/2018 PDI bathymetric comparison). The SWACs within depositional areas with more than 1.2 ft of sediment accumulation since 2004 are 20.6 micrograms per kilogram (µg/kg) for total PCBs, 2,990 µg/kg for total PAHs, and 28.6 µg/kg for DDx (Table 2.1). For PCBs, this depositional SWAC is approximately the same as the 95% Upper Confidence Limit (95 UCL) on the average for concentrations observed in upstream sediment traps and surface sediment (Section 3.3), indicating recovery approaching background conditions.

Surface Sediment Paired Sample-by-Sample Changes

Point-by-point comparisons of historical and PDI results in close proximity show widespread reductions in concentrations for several COCs (total PCB, total PAH, and DDx). For paired sample-by-sample analysis, between 438 and 589 historical RI/FS sample locations, depending upon parameter, are considered proximal[13] to 2018 PDI locations, with the following conclusions:

- Reductions in COC concentrations were detected in 71% of paired samples that were analyzed for total PCBs, total PAHs, and DDx. Among the paired sample sets, average concentrations of PCBs, PAHs, and DDx in the PDI were lower than those of the RI/FS by 66%, 69%, and 78%, respectively.
- Scatterplot and regression model analyses confirm patterns of COC concentration reductions over the 14-year period (or less, depending on when the RI/FS sample was collected) (Figure 2.3). The regression analysis for paired samples shows more significant concentration reduction of COCs at higher concentration levels; that is, in those areas

[11] Assessment of temporal trends for the focused dioxin and furan congeners is constrained by (i) the relatively low data density in the RI/FS, in which fewer samples in a more spatially limited coverage were analyzed for dioxins and furans than for other COCs and (ii) the large percentage of qualified dioxin and furan data for the PDI dataset. See Appendix E for detailed discussion of dioxin and furan results.

[12] The Figure 2.2 series presents SWACs computed for 10 main stem (i.e., not Swan Island Lagoon [SIL]) RMs, i.e., RM 1.0–2.0, RM 2.0–3.0, etc., concluding with RM 11.0–11.8 at the upstream boundary of the Site. RI data were not collected for PCBs in RM 11.0–11.8 at a density sufficient to compute SWACs; hence, only nine RM comparisons are presented for total PCBs.

[13] In this report, a proximal PDI sample is defined as being within 100 feet of the original RI/FS sample (see Appendix D.2).

where ongoing recovery is occurring, the highest COC concentrations tend to diminish at a faster rate than lower concentrations. Less change is observed at lower concentrations as levels approach equilibrium.

Subsurface Core Profiles

The majority of sediment cores confirm the focused COC distribution and patterns of recovery noted in surface sediment (Figure 2.4; Appendix D.3).

- Broadly speaking, the RI (2006-2010) and 2018 PDI datasets show similar spatial distributions of COCs in subsurface sediments, which demonstrates the overall stability of the river bed and is consistent with the bathymetric finding of stable deposition/erosion patterns within the Site (Section 2.1.1).
- Of the 90 PDI subsurface sediment cores, 31 did not have any exceedances of ROD RALs for total PCBs, total PAHs, and DDx.
- When the maximum concentration is deeper in the core than the surface interval, the sediment column shows recovery, which is seen in 68%, 63%, and 68% of cores with ROD RAL exceedances for total PCBs, total PAHs, and DDx, respectively.

2.1.3 Surface Water Recovery

Overall, the PDI surface water results show reductions in focused COC concentrations since the RI. Concentration reductions are strongest within the Site; concentration patterns in the D/U Reach do not show consistent reduction. Transect-composite surface water focused COC data for samples collected in the 2006/2007 RI and 2018/2019 PDI are compared in Appendix D.5 and in the Figure 2.5 series.[14] These figures show whole water results (combined particulate and dissolved-phase data) under low-flow, storm-flow, and high-flow conditions. Surface water sampling results vary based on the conditions at the time of sampling, but the following trends are observed:

- Across the focused COCs and in most sampling transects within the Site, PDI surface water concentrations are lower than during the 2006/2007 RI. BaP-TEQ results are substantially reduced compared to the RI across all three events, with more moderate reductions observed for total PCBs, 2,3,7,8-TCDD-TEQ, and DDx.
- The concentrations entering the Site from the D/U Reach are consistently above ROD CULs for PCBs, 2,3,7,8-TCDD-TEQ, and BaP-TEQ in low-, storm-, and high-flow conditions. This indicates that the D/U Reach represents a consistent source of ongoing inputs to Site surface water for these focused COCs.
- Concentrations of the focused COCs in PDI samples were generally consistent across the three sampling events (low-flow, storm-flow, and high-flow) with differences observed at

[14] The focused COCs are presented in these analyses as PCBs, DDx, PAHs as benzo(a)pyrene toxicity equivalence [BaP-TEQ] and dioxins and furans as 2,3,7,8-TCDD-TEQ.

select locations (e.g., RM 16.2 under high-flow conditions). Hence, the PDI has established a good understanding of typical surface water COC concentrations across a range of river flow and weather conditions.

2.1.4 Fish Tissue Recovery

SMB tissue, used by EPA as an indicator for human health exposures across multiple fish consumption scenarios, has been monitored for PCBs in five events over the last 16 years (2002, 2007, 2011, 2012, and 2018 PDI); DDx and dioxins/furans have been monitored in three events (2002, 2007, and 2018 PDI). The PDI fish tissue study provides an updated dataset of current COC concentrations in SMB[15] within the Site, the Downtown Reach, and the Upriver Reach.

- Statistical analysis comparing the 2018 PDI data with the historical datasets shows a statistically significant decrease on a Site-wide basis for all fish tissue–focused COCs (Appendix D.6).[16]
- Since initial RI sampling in 2002, the median total PCB concentration in Site whole body SMB tissue has decreased threefold, from approximately 610 µg/kg to 210 µg/kg (65% reduction); similarly, median concentrations of DDx, 2,3,4,7,8-PeCDF, 2,3,7,8-TCDD, and 1,2,3,7,8-PeCDD have each dropped by at least half (specifically, 64%, 76%, 55% and 55%, respectively) (see Figure 2.6 series).
- Current fish tissue concentrations for the majority of PDI SMB samples are notably well within the range of UCLs and Upper Tolerance Limits (UTLs) of upstream SMB, as discussed in Appendices D.6 and F.2.
- Despite these marked reductions in fish tissue–focused COC concentrations, the risk-based target tissue concentrations established in the ROD remain unachievable because they do not consider regional background concentrations in fish tissue or analytical detection limits for some focused COCs. The vast majority of SMB sample results exceed their respective ROD target tissue concentrations throughout the upstream, background reaches, which flow into the Site (Figure 2.7 series). This includes SMB collected in the Upriver Reach, which may be less impacted by Site conditions than potentially mobile SMB collected in the Downtown Reach (see Appendix D.7 for discussion of SMB movement).

2.1.5 Upstream Sediment Conditions

Concentrations of most focused COCs in upstream sediment exceed ROD CULs based on the PDI characterization. This places practical limits on the degree of Site sediment restoration that

[15] The fish tissue–focused COCs are PCBs, DDx, and three dioxin/furan congeners (2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, and 2,3,4,7,8-PeCDF).

[16] Although not focused COCs, arsenic and mercury were also analyzed, and concentrations have remained relatively stable.

is achievable. The PDI upstream sediment sampling characterized three sediment categories: (i) bedded sediments, tested through conventional sediment sampling; (ii) settleable sediments, evaluated from sediment traps at RM 11.8 and RM 16.2, and (iii) suspended sediments, sampled through the surface water sampling program. Results of all three sediment categories are presented with results expressed in mass/mass basis (i.e., μg/kg) in the Figure 2.7 series. The data indicate ongoing transport of suspended and settleable sediment into the Site at focused COC concentrations similar to upper-bound estimates of PDI Downtown Reach sediments. The Downtown Reach data reflect incoming sediment concentrations to the Site and must be included in the evaluation of upstream background conditions. The sediment trap and surface sediment data, and general trends, are discussed in more detail in Section 2.4 and Section 3.

The PDI upstream sediment background characterization program targeted fine-grained sediments to characterize the upstream sediments that are more likely to be transported to and deposited within the Site. Upstream surface water particulate and sediment trap results corroborate the findings of the upstream bedded sediment sampling. All three demonstrate that upstream sediments exceed ROD CULs for most focused COCs.

2.1.6 Summary of Site Recovery Analyses

Physical, chemical, and biological data collected in two different decades confirm the broad-scale recovery of the Site. Ongoing sediment deposition observed across much of the Site, including portions of the more highly impacted areas, provides the primary mechanism for COC reduction. While these recovery processes are not without exception, the comparative analyses measuring PDI against RI/FS datasets indicate that expanded use of natural recovery is an appropriate part of the Site remedy.

Improved characterization of upstream background conditions in multiple media provide additional insight into the achievable degree of Site recovery. Similarity between background sediment concentrations and Site sediment concentrations outside the ROD SMAs confirm that recovery is occurring and effective. At the same time, the levels of focused COCs present in multiple upstream media place practical limits on the degree of Site restoration that can be reasonably achieved, whether by system recovery or by active remediation.

The PDI sediment dataset, discussed in more detail in Section 2.3, identifies localized areas of elevated focused COC impacts for which active remediation will be necessary. These areas tend to correlate with zones of erosion or low deposition with higher COC concentrations (Table 2.1) and limited mechanisms for recovery. Hence, it is anticipated that the recovery processes documented above will not be sufficient to remediate these areas and that active remediation of focused areas integrated with the broader recovery processes together form the foundation of an effective and optimal remedy.

2.2 The System and Sediment Bed are Hydrographically and Geomorphologically Stable

The Site is hydrographically and geomorphologically stable on a large scale, based on six empirical converging lines of evidence discussed below (EPA 2014a; EPA 2008). Site stability, especially for sediments, is an important consideration for the long-term effectiveness of remedial technologies employed at the Site and for reliable use of monitored natural recovery (MNR) (Magar et al. 2009).

- **Consistency of Erosion/Deposition Patterns.** The patterns and locations of erosional/depositional areas are largely unchanged since the FS (Figure 2.1 series). A comparison of bathymetry elevation changes between 2009/2018 and 2002/2009 shows that local areas are stable and predominantly depositional or erosional over space and time (see Appendix D.1 for time series; Figure 2.1 series presents 2004-2018). The stability of these patterns indicates consistent natural and anthropogenic influences (e.g., industrial/commercial operations such as vessel use, berthing, dredging, bow wake patterns) over time.
- **Bathymetry Changes Over Time.** The system is stable in many areas of the river where the sediment bed is net depositional over time based on cross-sectional transects in the main stem of the river (Figure 2.8 series; see Appendix D.1 for other time series). Table 2.2 presents a summary of elevation changes expressed by volume gains/losses in each SDU. Most of the SDUs are showing net accumulation of sediment; discrete areas with net elevation loss (net erosional) are often in berthing areas or areas of known dredging and high-energy portions of the main stem of the river channel with fine-grained sediment.
- **SMA Boundary Patterns.** The highest concentrations of focused COCs detected among the 2018 surface sediment samples were within SMAs already identified in the ROD; no new areas of elevated concentrations beyond a few isolated ROD RAL exceedances were identified, indicating stability of the high concentration areas. The general locations of the SMAs remain similar to the FS/ROD areas, providing additional support for bed stability with respect to potential dispersion of contaminants (see PDI Footprint Report [AECOM and Geosyntec 2019]).
- **Grain Size Patterns.** As described in Appendix D of the FS (p. D-25), the percentage of fine-grained material (i.e., silts and clays, defined as passing the #200 sieve, or less than 75 micron) can be used to identify low-energy areas not subjected to high flow on a regular basis. Grain size distribution over time has been consistent at the Site, providing additional evidence of bed stability.
  - Paired sample-by-sample comparisons of proximal 2018 and RI samples show that depositional areas generally have greater than 60% fines; net neutral areas consistently average 40% to 60% fines, and erosional areas exhibit a variance of grain sizes but generally less than 40% fines (Figure 2.9a).

- The depositional areas of the Site show fines content of 65% or more, with very little change over time (less than 10%), as shown in Figure 2.9b, indicating grain size stability over time with the exception of upstream of RM 10, where the river is narrower and subject to more erosion.

- **Sediment Cores Patterns:** Of the 31 subsurface sediment cores with RAL exceedances, approximately 63% to 86% of cores, depending on COC, contained lower concentrations of focused COCs at the present-day surface compared to subsurface maximum concentrations. This trend also shows bed stability and recovery (see Appendix D.3). The presence of greater COC contamination at depth in a core profile can be attributed to improved operational practices through time, upland source control, and natural recovery. Newly deposited sediment is cleaner, and the sediment bed is adequately stable (i.e., has not been displaced during high-flow events). Remaining cores with maximum concentrations observed at the surface (0 to 2 ft interval) were in ROD SMAs, where active cleanup is expected.
- **Hydrograph History and Flood Rise Potential:** The river is naturally depositing a substantial amount of sediment, and although there have been several winter season high-flow events that have approached flood stage height over the past 14 years (Figure 2.10), the COC patterns have remained relatively stable (high concentrations are still in the same places). In addition, approximately 4.4 million cy of sediment has accumulated in the navigation channel above the U.S. Army Corps of Engineers maintenance depth (based on 2018 bathymetry survey); this quantity is about three times more volume than would be placed in the river for sediment remediation capping and enhanced natural recovery (ENR) in the ROD (1.4 million cy) (EPA 2017b, Table 28).

In summary, the sediment bed has remained consistent throughout decades of regular commercial and industrial harbor activity and episodic natural events. Therefore, areas of the Site with concentrations of focused COCs above the ROD CULs have not changed substantially, and *in situ* remedial technologies are likely to remain permanent and stable under normal conditions as well as when subject to a wide range of hydrographic event-driven stresses.[17]

2.3 Surface Sediment Concentrations and SWACs Have Improved

Focused COC concentrations in surface sediments have decreased in many locations throughout the Site. Evidence of significant focused COC recovery is found in multiple comparative analyses of 1997-2014 EPA FS data and 2018 PDI data. For example, PCB concentrations show statistically significant reductions in SWACs at multiple spatial scales.

SWACs were discussed on RM scales and in depositional areas in Section 2.1.2. This section presents a comparison of current and historical SWACs on several additional spatial scales to evaluate changes over time (see Appendix D.2 for additional details):

[17] See EPA 2005, Appendix A, principle #4.

- 2018 PDI SWACs on Site-wide, 1-mile Rolling RM, and SDU-specific spatial scales are compared to the EPA SWACs using the FS/ROD dataset from 1997 to 2014 (referred to as EPA ROD SWACs).
- 2018 PDI SWACs are also compared on a Rolling RM basis (single lane), a Site-wide basis, a multi-RM river segments basis, and on an SDU-specific basis to a single data collection period (2004), which provided the most synoptic RI dataset in terms of the numbers of samples and spatial coverage within the Site.

2.3.1 Comparison to ROD SWACs

Comparisons to SWACs presented in the ROD demonstrate recovery of surface sediment on the following spatial scales (Appendix D.2):

- **Site-Wide:** On a Site-wide basis, the 2018 SWACs are lower than the Site-wide SWACs reported in the ROD[18] by 52% for total PCBs, 79% for total PAHs, and 31% for DDx.
- **Rolling RM:** Among the east nearshore, west nearshore, and navigational channel 1-mile Rolling RMs, 2018 SWACs for total PCBs, total PAHs, and DDx decreased compared to the ROD SWACs for 95%, 65%, and 82% of the Rolling RMs, respectively. The spatial pattern of the SWACs across Rolling RMs for the ROD SWACs and 2018 SWACs agree and indicate consistency over time in the location of RMs with the highest SWACs. Dioxin and furan concentrations decreased for 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, and 2,3,4,7,8-PeCDF SWACs in 6%, 4%, and 31% of the Rolling RMs, respectively; however, these SWAC calculations specific to dioxin/furans contain a higher level of uncertainty due to a spatially limited FS/ROD dataset and considerable data qualification issues (see Section 4.3 and Appendix E).
- **SDU:** Within the eight PCB-focused SDUs, the 2018 SWACs are consistently lower for total PCBs in all SDUs (10% to 85% decrease) compared to ROD SWACs. Within the six PAH-focused SDUs, total PAH SWACs are lower in five of six SDUs (23% to 74% decrease); in the RM3.9W SDU, the 2018 PAH SWAC increases by 67% relative to the ROD SWAC. Within the DDx-focused SDUs, DDx SWACs are lower in two of three DDx-focused SDUs (14% and 36% lower).

2.3.2 Comparison to Single-Year 2004 SWACs

Based on the comparisons between the two large synoptic datasets (2004 and 2018), recovery of surface sediment is apparent on many spatial scales throughout the Site (Appendix D.2). Additionally, the size of the two compared datasets supports analyses of statistical significance, which are included in the summaries below for Site-wide, Rolling RM, SDU, and segment comparisons:

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[18] The ROD SWACs discussed herein were computed from RM 1.9 to RM 11.6.

- **Site-wide:** On a Site-wide basis, the 2018 SWACs are lower than the 2004 SWACs by 29% and 68% for total PCBs and total PAHs, respectively; the Site-wide DDx SWAC increased 11%. The total PCB decrease is statistically significant.
- **Rolling RM:** Decreases in total PCBs, total PAHs, and DDx SWACs from 2004 to 2018 are observed in 76%, 49%, and 74%, respectively, of the Rolling RMs evaluated.
- **SDU:** Within the seven PCB-focused SDUs with sufficient 2004 data to support comparisons, the 2018 SWACs are lower than 2004 SWACs for total PCBs in five of seven SDUs (8% to 88% decrease), of which four are statistically significant. Within the six PAH-focused SDUs, PAH SWACs are lower in five of six SDUs (41% to 88% decrease), with one decrease showing statistical significance. Within the DDx-focused SDUs, DDx SWACs are lower in two of three DDx-focused SDUs (16% and 49% decrease). None of the DDx changes are statistically significant.
- **Segments:** Of six segments identified for this analysis (four main stem segments and SIL-East[19] and SIL-West), total PCB SWACs are lower in five of six segments, with SIL-West as the exception. All decreases are statistically significant. Total PAH SWACs decrease in four of six segments, with Segment 2 and SIL-West as the exceptions; no changes are statistically significant. DDx SWACs are lower in four of six segments, with Segment 3 and SIL-West as the exceptions. Three of the four DDx decreases are statistically significant.

In summary, multiple analyses of sediment concentration patterns have been performed, encompassing two different sets of temporal comparisons and up to four different spatial scales. Extensive recovery of sediment focused COC concentrations has occurred, with the patterns most strongly observed for total PCBs and DDx in portions of the Site. Site RALs should be updated to reflect the current surface sediment conditions, because RALs are a function of Site-wide COC concentrations. A remedy based on the updated RALs is expected to result in post-construction SWACs near the target SWACs provided in the ROD.

2.4 Upstream Conditions Support Updates to Background

The 2018/2019 PDI upstream background characterization shows that upstream surface sediment and sediment trap concentrations of several focused COCs (total PCBs and dioxins/furans) exceed ROD CULs and ROD background concentrations for sediment. In addition, surface water and fish tissue in the D/U Reach are well above the ROD CUL and tissue targets for PCBs and dioxins/furans (Figure 2.7 series).

Focused COC concentrations for 2018/2019 in surface sediment and sediment traps within the D/U Reach are similar to results from the RI. Conversely, upstream fish tissue concentrations

[19] Some SWAC analyses in the main report and Appendix D.2 analyze SIL data as "SIL-East" and "SIL-West," i.e., divided by the mid-point in the length of SIL. This division was made due to observed concentration differences between the two halves of SIL in the 2004 and 2018 datasets and SWACs.

have generally decreased for focused COCs, as have surface water concentrations across most flow events and COCs.[20] As background areas for the Site, these upstream reaches reflect ongoing conditions and inputs that directly influence the nature and degree of recovery that is achievable and sustainable within the Site. These background conditions are also important in the formulation of remedial objectives and CULs for the Site.

The D/U Reach analyses summarized below provide evidence that upstream background concentrations are above ROD CULs for many focused COCs and in multiple media and, in some cases, are higher than previously estimated. Background concentrations should be updated, particularly with respect to the establishment of appropriately protective and attainable CULs for the Site consistent with EPA guidance (EPA 2002) (see Section 3).

2.4.1 Upstream Background Conditions

Whole body SMB tissue concentrations and COC concentrations of the incoming sediment load from the D/U Reach were used to characterize upstream background conditions (see Appendices D.4, D.5, F.1, and F.2). Table 2.3 presents a multiple lines-of-evidence summary across multiple media and focused COCs.

Surface Sediment

A statistically robust, stratified random surface sediment sampling program was conducted in the D/U Reach to evaluate contaminant concentrations upstream of the Site. A total of 59 samples (29 samples from the Downtown Reach and 30 samples from the Upriver Reach) were collected as 3-point composites from 0 to 30 cm depth, targeting areas with fine-grained sediment throughout the D/U Reach. These finer-grained samples (average 45% fines) represent bedded sediment potentially subject to resuspension and down-river transport during high-energy flow event.[21] Results are summarized below.

- Concentrations of total PCBs, 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, and 2,3,4,7,8-PeCDF in D/U Reach surface sediment are roughly 26% to 144% higher than their respective background-level-based ROD CULs. Therefore, the RI-based sediment ROD CULs do not reflect the ongoing impact of upstream focused COC concentrations. Both the CULs and 2018 concentrations were based on 95 UCL values (Table 2.4).

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[20] For surface sediment, sediment traps, surface water, and, to some extent, fish tissue, there were differences between the PDI and the RI in terms of study design, sample locations, and Site conditions at the time of sampling. Surface water sampling, in particular, is event-based with year-to-year variation of river flows, rainfall, and gauge height measurements that can limit the strength and certainty of year-to-year comparisons with historical RI data. The PDI D/U Reach surface sediment sampling also focused on fine-grained sediment.

[21] For the calculation of 2018 PDI summary statistics (see Appendix F.1), one sample location (sample B459) was excluded because this sampling station was subsequently found to be in area targeted for cleanup. This sample, located at RM 16.7 in the Upriver Reach, had elevated concentrations of PCBs (667 µg/kg) and PAHs (7,219 µg/kg) and was removed from the calculations.

- 2018 D/U Reach surface sediment concentrations of total PAHs and the dioxin/furan focused COCs (2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, and 2,3,4,7,8-PeCDF) are higher than those from the RI; total PCBs and DDx concentrations are similar. However, the 2018 sampling program targeted fine-grained sediments, which may account for some of the difference, as the RI sampling was not based on grain size distribution.[22] Therefore, a statistical comparison to the RI/FS dataset was not conducted as part of the PDI analysis.[23]
- The Downtown Reach exhibits statistically higher concentrations of total PCBs and total PAHs in sediment than the Upriver Reach (see Appendix F.1).

Sediment Traps

Sediment traps were placed at four upstream stations along two transects, one at RM 11.8 (downstream end of the Downtown Reach) and the other at RM 16.2 (near the upstream end of the Downtown Reach/downstream end of the Upriver Reach). Focused COC concentrations in suspended/settleable sediment were evaluated during low-flow summer conditions, storm-flow conditions, and high-flow, late spring/early winter conditions (see Appendix D.4). Results are summarized below.

- Average sediment trap results are greater than ROD CULs for total PCBs, 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, and 2,3,4,7,8-PeCDF by a factor of 1.1 to 3.6.
- Sediment trap results do not show consistent temporal trends among COCs. This may be due to variations in sampling locations and seasonal river flow (Appendix D.4). Exceptions were dioxins and furans, which were generally higher in both the Upriver Reach and Downtown Reach in all flow conditions compared to the RI.
- Within the 2018 data, the sediment trap located at RM 11.8 exhibited higher average concentrations of total PCBs and total PAHs compared to the RM 16.2 concentrations (by factors of 1.5 and 3.4, respectively). DDx results were generally similar between trap locations and sampling events. Conversely, concentrations of 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, and 2,3,4,7,8-PeCDF in the upstream end of the Downtown Reach (RM 16.2) were a factor of 1.9 to 2.6 times higher than concentrations at the downstream end (RM 11.8).

Depositional areas of the Site tend to have higher fines content (60% to 80%), which is generally consistent with the higher fines content observed in the sediment traps (average of 73% fines). In addition, sources farther upstream in the Upriver Reach and in the watershed contribute dioxins

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[22] The average percent fines (sum of silt and clays) was 45% for 2018 PDI D/U Reach samples compared to 30% fines (and 17% fines in the Downtown Reach) in the RI.

[23] In Appendix H (Background Supporting Information) of the Final RI Report (2016a), surface sediment samples located between about RM 15.5 and RM 28.4 were included in the analysis (data did not extend down to RM 11.8). Several outliers were removed from the dataset used for RI summary statistics, including five cPAH samples. PCBs and dioxins were not included in the referenced appendix, but EPA removed four PCB outliers.

and furans and DDx (EPA 2017b). Fine-grained suspended sediment containing these COC concentrations passes through the higher-energy/swifter-flowing Downtown Reach and contributes to the sediment load to the Site, consistent with the spatial changes in hydrodynamics and sediment texture described in Section 3 of the RI Report (EPA 2016a). These background concentrations and suspended sediment loads are not accounted for in the current ROD CULs for the Site.

Surface Water

2018/2019 PDI surface water sampling was conducted at two upstream transects located at either end of the Downtown Reach (at RM 11.8 and at RM 16.2) and evaluated during low-flow summer conditions, storm-flow conditions, and high-flow, late spring/early winter conditions (Appendix D.5). Concentrations of COCs in whole water samples collected from the Downtown Reach in 2018 and 2019 were compared to 2006 and 2007 data (averaged for low-flow, storm-flow, and high-flow events). The surface water sampling during the PDI was based on the RI sampling design, although there were slight differences (see Appendix D.5). While differences in sample design as well as meteorological and river flow conditions between the RI and PDI events preclude statistical comparisons of the two datasets, general comparisons of the two time periods are discussed below as context for surface water that enters the Site:

- Average concentrations of BaP-TEQ (PAH metric for surface water) and DDx were lower in 2018/2019 (as compared to 2006/2007) by 55% and 16%, respectively. Concentrations of total PCBs were about the same (2% higher in 2018/2019), and TCDD-TEQ concentrations were higher in 2018/2019 by 13%.
- Surface water samples collected in 2018 at the downstream end of the Downtown Reach (RM 11.8) generally exhibited slightly higher average concentrations of TCDD-TEQ (by about 10%) compared to the upstream end of the Downtown Reach (RM 16.2). BaP-TEQ and DDx were lower at RM 11.8 when compared to RM 16.2 (by about 20% and 80%, respectively). Total PCB concentrations were almost identical (difference of 2%).
- The highest upstream concentrations of DDx (0.446 nanograms per liter) were observed during the high-flow event at RM 16.2, indicating an upriver/watershed source of this COC.

Whole water concentrations of several COCs, including total PCBs, TCDD-TEQ, BaP-TEQ, dichlorodiphenyldichloroethylene (DDE), and arsenic, exceeded their respective surface water ROD CULs in all samples collected from the Downtown Reach (Appendix D.5). For several of these COCs, concentrations entering the Site are already above their respective federal and state surface water quality standards, which are identified as Applicable or Relevant and Appropriate Requirements (ARARs) for the Site (EPA 2016b).

Fish Tissue

For the 2018/2019 PDI fish tissue study, 40 SMB were collected in the Downtown Reach (20 samples) and Upriver Reach (20 samples) (Appendix F.2). Concentrations of total PCBs, DDx, 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, and 2,3,4,7,8-PeCDF in SMB samples from the D/U Reach were compared to the limited RI data for upstream SMB and to the ROD risk-based targets for fish tissue (Table 2.5; 2018 whole body results were converted to fillet concentrations for comparison to the fillet-based ROD tissue targets). Results are summarized below.

- The geometric mean concentrations of focused COCs in SMB from the Upriver Reach are lower in 2018 compared to the 2002 EPA RI data by about 62% for total PCBs, 55% for DDx, and 30%, on average, for 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, and 2,3,4,7,8-PeCDF (Appendix F.2). This comparison is based on two sampling events and limited sample numbers during the RI.
- Despite the decline in upstream tissue concentrations, 2018 mean (95 UCL) concentrations of total PCBs, DDx, 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, and 2,3,4,7,8-PeCDF in SMB from the D/U Reach are higher than the ROD risk-based tissue targets by a factor of 2 (PeCDF lowest) to 64 (PCBs highest) (Appendix F.2).
- 2018 concentrations of total PCBs and DDx in SMB collected in the Downtown Reach are higher compared to the Upriver Reach by a factor of 1.8 to 1.9, and the difference is statistically significant. Differences between the Downtown Reach and Upriver Reach SMB are not statistically significant for the dioxin/furan COCs (ranging from 8% to 13%). The highest concentrations of dioxin/furan COCs observed in the PDI study were found in an SMB sample from the Upriver Reach collected near RM 17.
- Ongoing urban background and watershed sources likely contribute to COC concentrations in upstream fish. This is supported by the higher concentrations of PCBs in sediment and sediment traps, as discussed above, and indicates the importance of surface water and suspended sediment exposures to fish.

2.4.2 Summary of Upstream Findings

Based on the surface sediment, sediment trap, surface water, and fish tissue lines of evidence reviewed above and summarized in Table 2.3, the following key conclusions are drawn:

- All lines of evidence converge, showing that upstream media entering the Site from the D/U Reach contribute ongoing focused COCs to the Site at concentrations that exceed ROD sediment CULs (except total PAHs), surface water CULs, and risk-based fish targets established in the ROD for focused COCs. Hence, Site remediation to the ROD cleanup goals and tissue targets is not attainable.
- Focused COC sediment concentrations within the D/U Reach are generally similar to the RI data, even though the RI data were collected more than 10 years ago. Fish tissue concentrations have declined. Surface water concentrations have declined in the D/U Reach since the RI under most conditions for focused COCs (PDI results were higher than the RI during high flow, but there was variability in flow rates). However, sources

from the D/U Reach and the watershed will continue to contribute COCs to the Site at levels exceeding the ROD CULs.

- The Downtown Reach has higher concentrations than the Upriver Reach for some media and focused COCs, especially with respect to total PCBs and total PAHs (in sediment), due to the ongoing contributions of urban non-point sources. It is important to include the Downtown Reach in the calculation of upstream background contributions to the Site.
- Concentrations of focused COCs in surface water particulate and sediment trap samples are reflective of upstream conditions and what is coming into the Site; they should be considered background in addition to bedded surface sediment.

These findings indicate the need for updated background concentrations that include the entire D/U Reach. The findings also underscore the importance of taking appropriately calculated background values into consideration when evaluating remedial approaches and remedy effectiveness.

2.5 Fish Consumption Risk is Reduced Relative to Previous Estimates

The results of the PDI fish tissue sampling show significant reductions in SMB body burden concentrations relative to historical data (RI 2002 and 2007) for all COCs except arsenic and mercury, which are relatively unchanged and consistent with upstream concentrations.[24] The PDI data for SMB also establish that the risk from fish consumption, which is the basis of RAO 2[25] in the ROD (EPA 2017b), has decreased significantly since the BHHRA[26] for the RI/FS (see Appendix G for PDI risk update).

2.5.1 Summary of Updated Cancer Risks and Noncancer Hazards

Updated baseline risks were calculated using the 2018 SMB fish tissue data and the 2013 BHHRA exposure assumptions to evaluate the impact on RI/FS risks.[27] Additionally, updated baseline risks were calculated using the 2018 PDI fish tissue data and up-to-date exposure assumptions, including fish consumption rates based on more recent studies and guidance, updated exposure parameters for adult body weight and exposure duration, and the incorporation of some loss of lipophilic contaminants due to fish preparation and cooking. Cancer risks and

[24] Arsenic is associated with natural background (rock formations); mercury's presence in fish tissue is a broad regional issue that has resulted in a statewide consumption advisory on smallmouth and largemouth bass (https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/RECREATION/FISHCONSUMPTION/Pages/mercury-in-bass-faqs.aspx).

[25] RAO 2 and RAO 6 address risk reduction through human and wildlife consumption of fish and shellfish, respectively (EPA 2017a).

[26] The 2013 BHHRA (Kennedy/Jenks 2013), attached as Appendix F to the RI/FS, concluded that consumption of fish is the primary exposure pathway of concern.

[27] The RI/FS risk evaluation update also considered any changes in toxicity factors, used PDI summing rules for calculation of analyte group totals and TEQs, estimated fillet tissue concentrations from PDI SMB whole body data, and used SMB as a surrogate for a mixed diet of resident fish species.

noncancer hazards for tribal, subsistence, and recreational fishers were updated, consistent with the 2013 BHHRA approach.

- Applying the 2013 BHHRA exposure assumptions to the 2018 PDI fish tissue data, cancer risks and noncancer hazards decreased by 70% to as much as 96% (depending on receptor) due to the decrease in SMB COC concentrations over time.
- Using the 2018 PDI data and up-to-date exposure assumptions, cancer risks and noncancer hazards are 91% to 99% lower than the 2013 BHHRA, depending on receptor. Table 2.6 and Figures 2.11a and 2.11b provide a comparison of baseline cancer risks and noncancer hazards for the 2013 BHHRA (based on RI/FS data) and the two PDI risk update scenarios.

RAO 2 identifies interim and long-term risk management targets for the consumption of fish and shellfish as follows:

- Interim: Cumulative cancer risk of 10^{-4} and noncancer hazard index (HI) of 10
- Long-term: Cumulative cancer risk of 10^{-5} and HI of 1

According to the 2013 BHHRA (based on historical data and RI/FS assumptions), Site-wide cancer risk for subsistence fishers is 1×10^{-2}, and noncancer hazard is 1,000. For recreational fishers, the cancer risk is 4×10^{-3}, and the noncancer hazard is 300. These risks and hazards change significantly when the updated PDI fish tissue data are used.[28]

- Applying the PDI fish tissue data with updated and more realistic exposure assumptions, the cancer risk and hazard estimates for the recreational fisher are essentially already below the interim targets EPA set for the Site. For the subsistence fisher, the updated risk only slightly exceeds the interim target of 1×10^{-4}, and noncancer hazard is below the interim target HI of 10 (highest target endpoint HI of 7).
- The noncancer hazard for recreational fishers is below a HI risk management threshold of 10, and the Site-wide cancer risk of $2x10^{-4}$ only slightly exceeds the risk management threshold of $1x10^{-4}$, when applying the PDI fish tissue data to the very conservative and uncertain exposure assumptions from the RI/FS BHHRA.[29] Site-wide risk and hazard (on a target endpoint basis) for subsistence fishers decreases to 6×10^{-4} and 16, respectively.
- Achievement of long-term risk management targets for frequent fish consumers will be challenged by background conditions, as recognized by EPA in the ROD and discussed

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[28] The 2013 BHHRA evaluated a mixed diet of resident species including SMB, carp, bullhead, and crappie. For the PDI, SMB was selected as the representative resident fish species because they are an abundant, popular sport fish and generally have higher tissue concentrations than other resident species (except for carp).

[29] See Appendix G. The highest target endpoint-based HI for the recreational fisher is 5 for the RI/FS risk evaluation update and 2 for the PDI risk evaluation update.

above in Section 2.4. Institutional controls in the form of fish consumption advisories will continue to be needed post-construction.

PCBs are the primary contributor to total Site risk under both the updated RI/FS and PDI risk evaluations, but their share has been reduced. For the subsistence fisher scenario, PCBs contribute 64% of total Site cancer risk and 60% of total Site noncancer hazard,[30] compared to more than 90% of total Site cancer risk and noncancer hazard in the 2013 BHHRA. The reduction in percent contribution reflects the decline in PCB concentrations over time.

TCDD-TEQ contributes about 20% of total cancer risk and about 11% of noncancer hazard.[31] DDx contributes about 3% to total cancer risk and 1% to noncancer hazard. Arsenic contributes less than 10% to total cancer risk and about 1% to noncancer hazard. Mercury contributes about 25% to noncancer hazard. Arsenic and mercury are driven by non-Site-related, watershed-wide factors (EPA 2017b).

2.5.2 Contribution from Background

Understanding background risk is important for placing Site risk into perspective. Many of the Site COCs are anthropogenic contaminants commonly found in urban waterways or are naturally occurring (e.g., arsenic). Despite this, background fish consumption risk was not addressed in the 2013 BHRRA because the RI upstream fish tissue data were insufficient to quantify background levels of COCs in fish tissue. By filling this data gap, the PDI fish tissue study provides an opportunity to calculate background fish consumption risks for the subsistence fisher in the Downtown Reach, Upriver Reach, and the combined D/U Reach (Appendix G). As shown in Table 2.7, background risks and hazards are equal to or slightly lower than Site-wide cancer risks/hazards and exceed interim targets in the Upriver Reach when using the full dataset.[32] Notably, background risks/hazards (even excluding SMB117) are above EPA's long-term risk management goals for the Site (10^{-5} and HI of 1).

In summary, the PDI data and updated analyses show that background fish consumption cancer risks and noncancer hazards are substantial, exceeding EPA's long-term risk targets and, in some cases, exceeding EPA's interim risk targets for the Site (e.g., full dataset for the Upriver Reach).

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[30] COC percent contributions are based on the PDI risk evaluation.

[31] A high percentage of the dioxin and furan results in fish tissue are qualified as estimated (flagged with J, JN or J+ qualifiers) and are associated with greater uncertainty than results that are not estimated. The risk-based tissue targets in the ROD for dioxin and furan COCs are also below analytical limits. JN qualified results (also referred to as Estimated Maximum Possible Concentrations [EMPC]) are associated with particular uncertainty, as discussed in Appendix E (EPA 2014). Summary statistics for TCDD-TEQ calculated using alternate treatments of EMPC results are presented in Appendix D.9 (along with statistics for all COCs and PDI datasets). It should also be noted the cancer toxicity factor for TCDD-TEQ is a Tier 3 value, as EPA and scientific experts have not reached consensus on the cancer potency of TCDD-TEQ in humans (EPA 2012); there is less confidence in Tier 3 values than Tier 1 or Tier 2 values (EPA 2003).

[32] When the single SMB sample in the Upriver Reach with significantly elevated concentrations of dioxins and furans is removed (SMB117), background risks and hazards are about 30% to 50% of Site-wide risks and hazards.

These findings underscore the importance of taking appropriately calculated background values into consideration when evaluating remedial approaches and remedy effectiveness (EPA 2002, 2005).

2.5.3 Implications of Fish Tissue Data for CSM and Remedy

The results of the PDI fish tissue study and updated risk analyses provide further evidence that the Site is recovering. Key findings include the following:

- Site-wide cancer risks and hazards have decreased, on average, by about 70% to 96% as a result of decreased concentrations in SMB tissue in the PDI dataset and by about 91% to 99% when coupled with up-to-date and realistic exposure assumptions.
- Meaningful risk reduction has already occurred, with potential cancer risk to recreational fishers now within acceptable limits and noncancer hazard only slightly above the long-term target HI of 1. The recreational fisher should no longer be a focus of remedy design.
- Background fish consumption risks are significant based on the upstream fish tissue dataset and need to be considered when evaluating remedy effectiveness.

Evaluation of fish consumption exposure on a RM scale and for a single river bank, as was done for the recreational fisher in the 2013 BHHRA and the FS for evaluation of post-construction risk, does not appropriately reflect the mobility and home range of the targeted fish. The PDI fish tracking study found that some SMB are highly mobile and travel within and outside the Site, and a consistent pattern of movement is not apparent (Appendix D.7). The results of the fish tracking study suggest that linking SMB tissue concentrations to localized sediment concentrations is not realistic or reliable for characterizing consumption/exposure estimates. The poor predictive relationship between SMB body burdens and COC concentrations in sediment is discussed in Section 3.3.1 and indicates the need to update the FWM used in the ROD.

The 2013 BHHRA acknowledges that many of the exposure assumptions used are conservative and uncertain, which could cumulatively result in baseline risk estimates well above actual risks that may be posed by the Site. The 2013 BHHRA states, *"While conservative, the results of the BHHRA are intended to show the relative risks associated with the exposure scenarios, and which contaminants are contributing the highest percentage of the calculated risks"* (Kennedy/Jenks 2013). Observations include the following:

- Because they are based on the cumulative uncertainties and conservative assumptions of the 2013 BHRRA, the ROD's risk-based fish tissue targets, and the sediment CULs derived from these targets, are overly conservative and are not confirmed by the PDI dataset.
- The uncertainties highlighted in the 2013 BHHRA are further compounded by uncertainty in the FWM used to relate risk-based fish tissue concentrations to sediment CULs.

The existence of the PDI data and the comparative analyses it affords provide an opportunity to address some of the uncertainty of the 2013 BHHRA. Updated risk-based fish tissue targets that consider new exposure data, as well as new background fish tissue concentrations calculated using the upstream PDI data, are presented in Section 3.4 (see also Appendix F.2 and Appendix G).

2.5.4 Implications of Fish Tissue Data on Oregon Fish Consumption Advisories

The PDI fish tissue study provides an updated baseline of focused COC concentrations in SMB tissue within and upstream of the Site. It demonstrates a statistically significant decreasing trend in SMB tissue Site-wide. The PDI fish tissue data should be used by the Oregon Health Authority to update its fish consumption advisories.

2.6 Summary of CSM Refinement

Based on the findings presented in Sections 2.1 through 2.5, the PDI supports refinement of the CSM as follows:

- The 2018 data confirm that ongoing recovery processes have occurred at the Site since the RI/FS. This has been driven in part by the substantial input of deposited sediment to the Site (approximately 5 million cy) and is manifest in COC concentrations in multiple media that in some cases have dropped by 50% or more. Therefore, SMAs and remedial targets should be updated for the focused COCs.
- The 2018 surface sediment data with high concentrations for focused COCs are generally located in the same areas identified in the RI/FS (i.e., distribution patterns are generally stable with minimal dispersion of COCs and no identification of new "hot spots"). This further supports the finding of geomorphological stability of the Site.
- Upstream data in multiple media frequently exceed ROD CULs, including several upstream sediment fractions (suspended, settleable, and bedded). Therefore, background concentrations and background-based CULs need to be updated. Whereas the ROD background dataset focused on the Upriver Reach, the PDI characterization demonstrates that the Downtown Reach and Upriver Reach, collectively, represent ongoing focused COC contributions to the Site above ROD CULs and should both be considered in estimates of background and recovery potential for the Site.
- Estimates of risk associated with fish tissue consumption have decreased substantially (more than 90% based on PDI data and up-to-date and realistic exposure assumptions) due in part to reductions in tissue concentrations and in part to an improved understanding of likely exposures. Fish tissue concentrations are a result of exposure to surface water, prey, and sediment over several RMs, including exposure upstream and downstream of the Site for some fish. Fish tracking results have shown that spatial scales of 1 mile or less are not appropriate for SMB at this Site but that there is a broad range of movement with up to 50% of the SMB study population traveling several miles and/or

spending time outside the Site. Hence, fish tissue should not be used to dictate localized sediment management decisions.

- Remediation for RAOs 2 and 6 (protection of human and ecological receptors, respectively, through fish tissue consumption) should focus on tissue targets, rather than surface sediments, and should be aimed at reducing incremental risk at the Site.

In summary, the PDI has resulted in an updated description of Site conditions and a more refined CSM that in turn leads to the need for updated background concentrations, sediment CULs, fish tissue targets, RALs, and SMAs as described in Section 3 and Appendices F, I, and J. Furthermore, the ROD Technology Application Decision Tree and Section 14 of the ROD (Selected Remedy) must be updated, as the data collected and analyses conducted during the PDI support additional flexibility in the remedial decision-making and design process.

3. UPDATED REMEDIAL APPROACHES

The PDI study is the largest sampling event addressing both Site-wide and upstream multi-media characterization since 2004. Samples of surface and subsurface sediment, surface water, fish tissue, sediment from in-river traps, and porewater were collected over an approximately 12-month period, providing an updated and comprehensive dataset from which to evaluate current conditions. The PDI study also included a comprehensive Site-wide bathymetric survey and a 12-month fish tracking evaluation, refining the knowledge of current conditions and supporting an updated CSM. The ROD states that "*...updated information will inform the implementation of the Selected Remedy decision tree. When applying the decision tree logic with newly gathered information, the design and constructed remedy will reflect the newer information*" (EPA 2017b, p. 106); and "*Additional data will be collected during remedial design to assist in refining the remedy beyond the feasibility study level of analysis*" (EPA 2017b, Responsiveness Summary, p. 2-77).

As discussed in Section 2, many of the CSM elements from the RI/FS have been confirmed by the PDI data, while others warrant updating. Updates to background concentrations, ROD CULs, RALs, and baseline risks are needed. The justifications for these updates are discussed in more detail in this section.

3.1 Updated Background Sediment COC Concentrations

The estimates of background concentrations for the focused COCs and arsenic in the ROD warrant upward refinement (see PDI data analyses discussed in Section 2). The updated background concentrations for these COCs are important because they represent the lower limits of Site recovery and the lowest concentrations that may be practicably achievable and sustainable at the Site due to the continuing inflow of sediment from the D/U Reach and watershed.

The 2018 PDI D/U Reach sediment COC data provide an updated characterization of upstream areas for comparison to the Site conditions, specifically (i) concentrations of COCs immediately upstream of the Site, (ii) concentrations of COCs entering the Site in surface water as particulates and mobile suspended/settleable sediments, and (iii) concentrations in upstream fine-grained sediments.

3.1.1 PDI Background Dataset Represents Broad Coverage of Upstream Areas

The updated background concentrations for the six focused COCs are shown in Table 3.1. Background values for sediment should be updated for several reasons:

- **Role of Background.** The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) guidance considers background concentrations when formulating CULs and recognizes that setting numerical cleanup goals at levels below background concentrations is impractical (EPA 2002). In general, EPA does not select or enforce cleanup goals that are below natural or anthropogenic background levels. CERCLA guidance also considers cost-effectiveness, technical practicability, and the potential for recontamination of remediated areas from surrounding areas with elevated background levels in the development of background-based CULs (EPA 2002).

- **Statistically Robust Background Sampling Program.** Fifty-nine upstream surface sediment samples were collected in 2018 as part of the PDI sampling program.[33] All of the 2018 PDI samples were collected as 3-point composites, strengthening the statistical power of the dataset.[34]
- **Spatial Coverage and Percent Fines.** The PDI sampling was designed to provide spatial coverage throughout the D/U Reach, and samples were randomly placed in areas with similar fines and total organic carbon content to that of the Site. Random sampling minimizes the need for data exclusion or the removal of outliers that may bias the results. One upstream sampling station was subsequently found to be in an area targeted for potential remediation by the Oregon Department of Environmental Quality (ODEQ); therefore, this station was excluded from the dataset used to estimate updated background PCB and PAH concentrations in sediment
- **Updated and Combined D/U Reach Sediment Data Better Represent Upstream Concentrations.** The RI selected the Upriver Reach, defined there as RM 15.3 to 28.4, as the reference area for evaluating background sediment. Sediment from RM 11.8 to 15.3 was excluded from the RI analysis largely because significant areas in the Downtown Reach had been targeted for remediation. Since these earlier sampling events, the Downtown Reach remediation actions have largely been completed. As a result, the full extent of upstream data from RM 11.8 to 28.4 should be used to update background concentrations of the sediment inputs to the Site. The PDI data provide broad spatial coverage throughout the entire D/U Reach (see discussion in Appendices F.1 and F.3). In contrast, the RI dataset only included a few samples from the Downtown Reach. The 2018 PDI data from the D/U Reach, as a whole, provide better information about sediment loading to the Site and recovery potential than the Upstream Reach alone. For example, DDx concentrations are temporally and spatially consistent, which supports the use of the combined D/U Reach dataset.
- **2018/2019 Multi-Media Sediment Results Support Updated Background Values for the Site.** Suspended sediment concentrations upstream of the Site indicate similar (total

[33] By comparison, the RI dataset included 33 PCB congener samples, but only 29 PCB samples were used by EPA to assess background conditions due to removal of locations EPA identified as outliers. EPA also included Aroclor data from different sampling events in its background analysis, many of which were non-detects (25 out of 48). The PDI PCB dataset had 100% detections and analyzed for all 209 PCB congeners; results included a large percentage of detects among the congener data.

[34] See Figure 3 of PDI Work Plan Appendix B, reproduced from EPA's June 6, 2017, draft plan (Geosyntec 2017; EPA 2017c). The figure shows a PCB natural recovery power analysis, with power increasing from about 0.7 to 0.95 (N=30 samples) from single to 3-point composite (power to detect 10% annualized decay rate in 10 years).

PCBs and total PAHs) and higher (DDx, 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, 2,3,4,7,8-PeCDF) COC concentrations than those detected in bedded sediments within the D/U Reach (Figure 2.7 series).[35] Concentrations of all focused COCs are consistently highest in the surface water particulate fraction that has the smallest particle size. The sediment trap samples also had higher percentages of fines than the bedded sediments. Given that suspended and settleable sediments represent the watershed load of material in transit, and that the higher-concentration fines can transit into the Site before depositing, these higher sediment trap and particulate concentrations are also representative of background conditions and predictive of solids/sediment that may settle in the Site. Using 2018 surface sediment data to represent background conditions provides a conservatively low estimate of overall predicted contributions from upstream to the Site.

3.1.2 Summary Statistics and Updated Background Values

Table 2.4 presents summary statistics for the focused COCs in the D/U Reach based on the PDI surface sediment data sampling. Updated background concentrations are presented in Table 3.1 Two statistics are particularly important for the derivation of background concentrations as described below:[36]

- 95% upper confidence limit of the mean (95 UCL): For a random sampling of a population, the 95 UCL represents a value that equals or exceeds the population mean for those data 95% of the time. In accordance with EPA statistical guidance (2015), spatially averaged Site-wide or area-wide concentrations are compared to measures of central tendency, such as the 95 UCL for the upstream background area.
- 95% upper tolerance limit with 95% coverage (UTL95-95): Represents the upper end of the background population, or background threshold value. This statistic is used to demonstrate that 95% of the values in the dataset are less than a specific threshold with 95% confidence. These values may be more applicable for point-by-point comparisons.

The updated background concentrations for the six focused COCs shown in Table 3.1 are based on 95 UCL values of the D/U Reach surface sediment data collected in 2018. In summary, the updated background values for the six focused COCs are important because they represent lower limits to Site recovery, due to the continuing input of sediment from the D/U Reach and watershed. The PDI dataset represents current upstream conditions and characterizes the mobile fraction of upstream sediment that is likely to be deposited within the Site.

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[35] Bedded sediments are considered surface sediments measured in the upper 30 cm of the sediment profile. Suspended sediment (in surface water) and suspended/settleable sediment (in sediment traps) represent the mobile fraction of sediment that enter the Site from the D/U Reach. The 2018 sediment trap data are the suspended solids that settle in the traps; results are discussed in Appendix D.4. The 2018/2019 surface water particulate data is converted to dry weight mass for comparison to sediment trap and bedded sediment results, as discussed in Appendix F.1.

[36] The statistics were also used by EPA in the RI/FS.

3.2 Background Porewater Arsenic and Manganese Concentrations Support Groundwater CUL Updates

The ROD CULs for arsenic and manganese in groundwater are not achievable and need to be removed or, at a minimum, updated. Background porewater concentrations measured during the PDI study are above over 85% of transition zone water concentrations measured in impacted areas of the Site during the RI. All concentrations of arsenic and manganese in background porewater were above the ROD groundwater CULs of 0.000018 milligrams per liter (mg/L) and 0.43 mg/L, respectively. The updated porewater background concentrations for naturally occurring arsenic and manganese are presented in Table 3.2 (0.058 mg/L for arsenic and 32.0 mg/L for manganese; see Appendix D.8).

During the groundwater pathway assessment for the RI (EPA 2016a), arsenic and manganese were identified as groundwater COCs in transition zone water samples collected from the Site. However, the RI did not establish background conditions for these naturally occurring constituents in porewater, and ROD CULs do not reflect naturally occurring concentrations under the reducing conditions that are typical of Site sediment. High levels of arsenic and manganese are naturally present in the volcanic rocks of the Willamette River basin, and geologic weathering processes introduce arsenic and manganese into the river environment.

To establish background concentrations of arsenic and manganese in porewater, the PDI measured concentrations of arsenic and manganese in upstream sediment porewater under natural conditions (i.e., in sediments without a known anthropogenically derived addition of arsenic and manganese). Sampling stations were developed in collaboration with EPA for the purpose of establishing background concentrations (see Appendix D.8). Additional details on statistical analyses used in the calculation of background concentrations are provided in Appendix D.8. These background values are presented in Table 3.2 and should be adopted as Site porewater background and used as the basis of removing the groundwater CULs for arsenic and manganese.

3.3 Updated Sediment CULs

The new PDI data demonstrate a need to update sediment CULs. This section presents updated sediment CULs based on the PDI data.

3.3.1 Rationale for Sediment CUL Updates

The ROD CULs for sediment target direct (i.e., sediment contact) and indirect (i.e., uptake into biota) exposures for humans and wildlife (Table 3.3) and should be updated. For several COCs, including PCBs, DDx, aldrin, dieldrin, and dioxins/furans, the lowest sediment goals, and therefore, the CULs, are based on human consumption of fish (RAO 2) (EPA 2016b). For PCBs and DDx, a mechanistic FWM was used to relate COC concentrations in sediment to resident fish species, including SMB. The fundamental FWM assumption that fish tissue concentrations are largely a function of localized sediment COCs is not supported by the new PDI data, which demonstrates that the FWM significantly overstates this relationship (see Appendix H). The ROD acknowledges the uncertainty in the assumed biota-sediment relationship and the impact of a sediment remedy on tissue concentrations (EPA 2017b, p. 87):

> *However, fish and shellfish derive their COC concentrations from both sediments and surface water in proportions that at this time can only be approximated and estimates of the degree to which this CERCLA action will reduce fish and shellfish tissue concentrations are highly uncertain.*

For PCBs, application of the FWM to derive a CUL resulted in a target sediment concentration of less than zero, meaning any detectable concentration of PCBs in sediment would result in an unacceptable concentration in fish tissue. EPA's mathematical explanation for this was that dissolved water concentrations alone would result in unacceptable fish tissue concentrations (EPA 2016b). Absent a realistic FWM-based value, the ROD used an estimated background PCB sediment concentration of 9 µg/kg as the sediment CUL that was expected to be protective of fish consumption exposures (EPA 2016b, 2017b).

Given the reliance on the FWM for identifying ROD CULs, a model corroboration exercise was performed to assess the reliability of the model for predicting the 2018 PDI fish tissue concentrations for PCBs and DDx (see Appendix H). The datasets for these two COCs are extensive and permit examination of long-term spatial trends and model predictions across a variety of scales.

The PDI SMB data (see Section 2.5) demonstrated a consistent downward trend in measured fish tissue concentrations over time. However, applying the FWM to the PDI sediment data does not yield fish tissue concentrations observed in the PDI. When 2018 Site-wide sediment SWACs were input into EPA's FWM, the resulting estimated SMB tissue concentrations for PCBs and DDx were similar to concentrations observed several years ago and overestimated 2018 sampled concentrations by 75% for PCBs and 71% for DDx (see Appendix H). Over-prediction of SMB tissue concentrations was observed for most COC-spatial scale combinations evaluated, except PCBs and DDx in Segment 2 and DDx in Segment 4 (see Appendix D.6 for segment maps).

Additionally, a linear regression analysis of the 2018 fish tissue-surface sediment data on a 1-mile scale found little to no evidence to support a functional relationship between co-located sediment and fish tissue concentrations for PCBs or DDx (Appendix H). This indicates that other factors, such as the updated understanding of SMB home range from the PDI fish tracking study and dissolved surface water concentrations, play an important role in contaminant uptake into fish.

The results of such analysis based on the new PDI data and other procedural, conceptual, and technical issues (e.g., consideration of best modeling practices, errors in model assumptions and design, inability to account for surface water exposure) collectively demonstrate that the FWM is not appropriate for determining updated CULs for sediment (see Appendix H).

Overall, the inability of the FWM to reliably and accurately predict or relate sediment and fish tissue concentrations should preclude its use in setting updated Site sediment CULs for protection of fish consumption exposure. Assuming that risk-based concentrations would still be below background concentrations (for PCBs and dioxin/furan focused COCs), the sediment CULs should default to background concentrations, updated with 2018 data (see Section 3.1).

Alternatively, instead of sediment-based goals, target tissue concentrations could be used to evaluate progress toward meeting fish consumption goals for RAOs 2 and 6. Appropriately protective fish tissue targets and background fish tissue concentrations based on the 2018 PDI data are discussed in Section 3.4.

3.3.2 Updated Sediment CULs

Focused COCs

The ROD RAOs with background-based CULs (PCBs and dioxins/furans for RAOs 2 and 6) should be updated with 2018 data using the combined D/U Reach surface sediment dataset. The D/U Reach data collected in 2018 demonstrate that the background levels established in the RI, and thus the CULs in the ROD, for PCBs and the dioxin/furan congeners should be updated to the 95 UCL values for 2018 surface sediment data:

- Total PCBs = 20.4 µg/kg (value excludes data from sample location B459)[37]
- 2,3,7,8-TCDD = 0.00025 µg/kg
- 1,2,3,7,8-PeCDD = 0.00049 µg/kg
- 2,3,4,8,7-PeCDF = 0.00044 µg/kg

As discussed in Section 3.1, the 2018 PDI data provide a more comprehensive and contemporaneous assessment of COCs in D/U Reach sediments than EPA's RI dataset, which was collected between 1999 and 2007. These updated CULs represent the lowest achievable and sustainable post-remedial concentrations of these four focused COCs after Site cleanup. These changes are supported by EPA guidance (EPA 2002; EPA 2017c). EPA (2002) states:

> *The contribution of background concentrations to risk associated with CERCLA releases may be important for refining specific cleanup levels for COCs that warrant remediation action. For example, in cases where a risk-based cleanup goal for a COC is below background concentrations, the cleanup level may be established based on background. At large contaminated sediment sites, it may be important to evaluate background concentrations and the potential for*

[37] PDI sediment sample B459, located at RM 16.7, was excluded because this sampling station was subsequently found to be in area targeted for cleanup and had elevated PCBs and PAHs (see Section 2.4 and Appendix F.1).

recontamination to determine the level of risk reduction and contaminant levels that can be achieved through remedial action.

For DDx and PAHs, the ROD and Proposed Explanation of Significant Differences (ESD) CULs are not based on background. The ROD CUL for total PAHs of 23,000 µg/kg is based on RAO 5 (benthic risk) and was carried forward in the Proposed ESD (EPA 2018). The ROD CUL for DDx of 6.1 µg/kg is based on RAO 2 (fish consumption) and was calculated using the FWM. Given issues with FWM reliability for developing sediment CULs, other lines of evidence were evaluated. The 95 UCL for upstream bedded sediment is 5.6 µg/kg for DDx (Table 2.4). The combined multi-media solid-phase media concentration of DDx in upstream bedded sediment, sediment trap, and particulate fraction in surface water is 11.8 µg/kg (see Appendix F.1), indicating that DDx tends to be particulate-bound (as shown by PDI storm-flow and high-flow surface water data; see Appendix D.5) and watershed-related. Even though the ROD CUL of 6.1 µg/kg is conservative, no update to the CUL is recommended for DDx (Table 3.1).

Arsenic

Arsenic, although not a focused COC, also has a background-based sediment CUL. The value also needs to be updated with 2018 data. The updated background arsenic value in sediment is 4 mg/kg based on the 95 UCL of upstream 2018 PDI surface sediment data. However, this background value is likely not representative of watershed-wide, naturally occurring inputs of arsenic to the Site. For comparison, the mean background concentration of arsenic in Southern Willamette Valley soils is approximately 20 mg/kg (Hurtado 2015), and ODEQ reports regional arsenic background concentrations in soils as 8.8 mg/kg in the Portland basin and 18 mg/kg in the south Willamette Valley (ODEQ 2013). For comparison, the mean arsenic concentration among 2018 upstream sediment trap samples is 6.8 mg/kg and the 95 UCL is 7.8 mg/kg. The 95 UCL of all SRS samples within the Site is 5.1 mg/kg; the same value as the 95 UCL of PDI samples located outside of the ROD SMAs (5.1 mg/kg). A background-based CUL for arsenic consistent with these higher D/U Reach and watershed values should be further evaluated and established during remedial design.

3.4 Updated Fish Tissue Targets

The ROD fish tissue targets should be updated to account for updated human exposure assumptions, including more recent studies on fish consumption rates, updated EPA exposure assumptions for body weight and exposure duration (EPA 2014b, 2014c), and the 2018 PDI upstream SMB dataset. The ROD tissue targets are based on a subsistence consumption scenario that assumes 228 meals per year (142 grams per day [g/day]) of lower Willamette River resident fish.[38] This scenario is inconsistent with current EPA fish consumption data and statistical analysis methods.

[38] The 2013 BHHRA fish consumption rate of 142 g/day for the subsistence fisher was based on EPA's 99th percentile value for national consumption of all sources of freshwater and estuarine fish and shellfish (EPA 2002).

The fish consumption rates used in the 2013 BHHRA and to derive the ROD tissue targets were not based on Site-specific data or derived using the most current methods for calculating long-term fish consumption rates for use in risk assessment (EPA 2014c). More recent studies have been published that use up-to-date methods for calculating long-term consumption rates, including EPA's own updated study of national and regional fish consumption rates (EPA 2014c). Though issued in 2017, the ROD relied on the 2013 BHHRA assumptions, without the benefit of these relevant 2014 EPA updates or more recent regional studies of tribal and recreational fisher populations (see Appendix G).

For the subsistence fisher, the updated national consumption rate that is equivalent to the 99th percentile rate of 142 g/day used in the 2013 BHHRA is now 61 g/day (EPA 2014c). For the Pacific coast region, the updated equivalent 99th percentile rate is 81.3 g/day. This is more than 40% lower than the 142 g/day consumption rate assumed in the ROD. Risk-based tissue targets should be updated to account for these updated and more appropriate fish consumption rates and other exposure factors (see Appendix G for an updated assessment of baseline risk using the PDI data and current EPA guidance).

For the focused COCs, Table 3.3 proposes updated risk-based tissue targets, as well as a range of new background fish tissue concentrations (see Section 3.4 and Appendix F.2). As shown for comparison in Table 3.3, the ROD tissue targets are below even the most stringent of the updated risk-based tissue targets and background concentrations. For PCBs, the low end of the new range of background concentrations in upstream SMB fillet tissue exceeds both EPA's long-term targets of 10^{-5} and HI of 1 for fish consumption (RAO 2). The updated fish tissue targets (Table 3.3) and background concentrations (Table 3.1) should be used to monitor progress toward achieving RAOs 2 and 6.

3.5 Updated RALs

The sediment RALs should be updated because the Site has undergone measurable and significant recovery since the RI (see Section 2.1). For PCBs in particular, the Site-wide SWAC has decreased from 92 µg/kg (as specified in the ROD) to 44 µg/kg (>50% decrease), and the area-wide SWACs outside of ROD SMAs have largely recovered to background conditions (Table 3.5). Background values have been updated with new data from the D/U Reach (Section 3.1); therefore, the RAL curves have been updated to reflect 2018 Site and background conditions (Appendix I).

RALs are COC-specific sediment concentrations used to identify areas where active remediation will be conducted. They are point-based, not-to-exceed values, based on the premise that once active remediation is complete (in areas where the RALs are exceeded), the target SWACs will be achieved. Updated RALs are presented in Table 3.4. The RAL curves (see Appendix I) show that the same post-construction target SWAC identified in the FS/ROD can be achieved with fewer acres remediated. These curves also show that the Site will not recover to the CULs defined by EPA in the ROD, regardless of the acres remediated.[39] Site-wide concentrations will reach an asymptotic concentration (i.e., Site equilibrium) before reaching the ROD CULs.

3.5.1 Rationale for RAL Updates

The updated RALs are protective of human health and the environment and are estimated to achieve interim risk targets and target SWACs at Time 0 post-construction (see Section 4.1 and Section 4.2 for discussion of post-construction SWACs and risks). More specifically:

- The same target SWAC selected in the ROD can be achieved with fewer remediated acres than estimated in the ROD because of Site recovery to date.
- There is a notable decrease in SWACs from the RI to the PDI, which increases the RALs needed to achieve the same target SWAC.
- Total PCB Site-wide SWAC reductions have been statistically significant (29% lower) since 2004; total PAH SWACs have reduced by 68% since 2004. DDx changes have been more localized, consistent with the distribution of this COC (see Appendix D.2, Table D.2-7a).[40]
- The ROD had limited data coverage for DDx and dioxins/furans, and the RALs were not based on representative Site-wide data and SWACs. ROD RALs were generated from smaller areas with limited data coverage, then extrapolated for Site-wide application.

The 2018 PDI surface sediment dataset provides a robust, Site-wide SWAC for focused COCs, which warrants an update of Site RALs for the focused COCs.

3.5.2 Updated RALs and Target SWACs

The process for evaluating RALs followed the hill-topping methodology presented in the FS and ROD, but with new data. Using Natural Neighbor interpolation methods (see Appendix D.2), bed replacement values (BRVs), and sequential "remediation" of grid cells, a RAL curve was created for each focused COC that plots acres of remediation versus resultant SWACs (see Appendix I). Similarities and differences from the RAL methodology used by EPA in the FS/ROD are described in Appendix I.

Table 3.4 presents the updated RALs and the basis for the selected target SWACs for the six focused COCs using 2018 sediment data. The Figure 3.1 series presents the Natural Neighbor interpolation of 2018 PDI data using these updated RALs. RALs were selected to fall in the

[39] Also see post-construction risk reduction estimates for Alternative H in the ROD with 2,167 acres of active remediation.

[40] Statistical significance tests for 2004 and 2018 SWACs were conducted using Thiessen polygon interpolation methods; see Appendix D.2

portion of the RAL curve that indicates optimal remedial efficiency (target RAL Curve Range).[41] There is no change to navigation channel RALs from the ROD. The target SWACs are post-construction (Time 0) concentrations immediately following active remediation in areas above the RALs. Target SWACs are detailed in Appendix I. The target SWACs and updated RALs for the focused COCs are as follows:

- **Total PCBs.** The same target SWAC of 24 µg/kg total PCBs used in the FS/ROD was used in this report. This target SWAC can be achieved with fewer remediated acres than were estimated in the ROD because of the significant Site recovery that has occurred to date. The updated RAL required to achieve EPA's selected target SWAC is 350 µg/kg.
- **Total PAHs.** There is no recommended change to the Proposed ESD RAL of 30,000 µg/kg for total PAHs.
- **DDx.** The same target SWAC of 16 µg/kg used in the FS/ROD was initially considered. A lower target was selected based on the RAO 5 preliminary remediation goal (PRG) for protection of benthic organisms, which correlates to a RAL of 578 µg/kg.
- **2,3,7,8 TCDD.** The 95 UCL of the 2018 PDI upstream sediment data was selected as the target SWAC, which correlates with a RAL of 0.0011 µg/kg.
- **1,2,3,7,8-PeCDD.** The 95 UCL of the 2018 PDI upstream sediment data was selected as the target SWAC, which correlates with a RAL of 0.025 µg/kg.
- **2,3,4,7,8-PeCDF.** The same target SWAC of 0.002 µg/kg used in the FS/ROD was used in this report, which correlates with a RAL of 0.35 µg/kg.
- **PTW.** The ROD specifies that cleanup will include areas where PTW is present (non-aqueous phase liquid [NAPL] or highly toxic or cannot be reliably contained). These ROD PTW threshold criteria were not included in the active footprint mapping for the reasons discussed in Section 3.6.

All of the updated RAL values fall within the target RAL Curve Range. Updated RALs were developed with the understanding that remediation of these focused COCs will be protective of human health and the environment, reach interim target endpoints identified by EPA in the ROD, and address the COCs that do not have RALs. Post-construction target SWACs and risks are discussed in Section 4.1 and Section 4.2 and follow the same process and assumptions as in the FS/ROD.

[41] The optimal remedial efficiency features two points on the RAL curve: the maximum incremental reduction of the SWAC and the "knee of the curve." These features are described in more detail in Appendix I. The target SWAC was adjusted to be between these two points on the RAL curve, if needed. Below the knee of the curve, ongoing Site recovery and restoration is expected to continue until the asymptote of the curve (or Site equilibrium) is reached.

ROD RALs for Portland Harbor are conservative as they assume little or no restoration time frame. By comparison, for other contaminated sediment sites such as the Lower Duwamish Waterway in Washington State, EPA selected temporal RALs, whereby the desired target SWAC is not expected to be met immediately post-construction, but by some period of time after active remediation is complete in areas where site recovery is expected (i.e., a target SWAC that is predicted to be met 10 years after active remediation). The updated RALs presented in this report account for Site recovery measured to date but do not factor in the rate or extent of Site recovery going forward. The RAL curve applies a BRV within the active remedial footprint but assumes that the sediment bed contaminant concentrations outside of the active remedial footprint do not change (no recovery rate is applied).

3.6 PTW Management

Concentration thresholds and other criteria for PTW require substantial updates to reflect the refined CSM because updated media characterization data and risk calculations show that media concentrations now fall below levels that would trigger toxicity-based PTW designations. Accordingly, toxicity-based (i.e., concentration-based) PTW limits have been removed from updated tabulations of Site CULs and RALs in this report. Additionally, the identification of highly mobile separate phase material is deferred to remedial design.

The ROD remedy for the Site is primarily founded upon RAOs that seek to mitigate unacceptable Site risks and hazards as quantified in the baseline risk assessments. Additionally, per the requirements of the National Contingency Plan (NCP), the ROD remedy basis invokes the statutory preference for treatment of principal threats. This is summarized in the ROD (p. 5): "*The Selected Remedy will address all principal threat waste (PTW) by excavation and off-site disposal or, if left in place, with augmented reactive caps to provide in-situ treatment*." PTW thresholds under CERCLA consider two components: (i) highly toxic; and/or (ii) highly mobile contaminants that cannot be reliably contained. These components relative to the Site are discussed in Section 3.6.1.

Additionally, the requirement (based on cap modeling assumptions in the ROD) that a reactive cap is necessary to reliably contain all areas of remaining "highly toxic" PTW exceedance is no longer necessary to meet remedial objectives. More up-to-date modeling conducted using PDI data and more appropriate modeling software (e.g., CapSim, Lampert et al. 2018) demonstrates that unamended/nonreactive caps would be protective at concentrations above ROD PTW levels. Updated cap modeling is discussed in Section 3.6.2 and Appendix K.

3.6.1 PTW Designation

NCP and EPA (1991) guidance indicates that a combination of toxicity and mobility considerations is appropriate for PTW designation.[42] Changes in the understanding of toxicity

[42] Apparent inconsistencies in other passages are a topic of discussion in the ROD Responsiveness Summary.

since the ROD, as well as mobility considerations, require a review and update of PTW designations for the Site. This conclusion is further supported by the media at issue and handling of PTW at other sites.

Toxicity Considerations

Overall, the PDI analyses demonstrate a substantial decline in the estimates of Site risks, such that subsistence fisher pathway risks fall below the 1 x 10^{-3} threshold. Therefore, concentration-driven PTW designations (i.e., highly toxic PTW) should be eliminated.

As discussed in the ROD Responsiveness Summary (EPA 2017b), the estimated baseline carcinogenic risks in the human health fish consumption pathways in the ROD stem from PCBs as the primary indicator of high toxicity. Based on the PDI characterization, the following considerations related to toxicity and the definition of "highly toxic" support the elimination of Site PTW thresholds:

- Updated fish tissue targets and background concentrations rather than the FWM should be used to monitor progress toward achieving RAOs 2 and 6, as discussed in Sections 2.5.3 and 3.3.1 and Appendix H of this report,
- In the 2013 BHHRA, all four fish consumption scenarios (Tribal Whole Body and Fillet, Subsistence, and Recreational) presented baseline cancer risks that exceeded 1 x 10^{-3}. With updated assumptions and 2018 data, the estimated baseline risks have dropped from the 2013 BHHRA estimates by 91% to 99% across the four scenarios, as discussed in Section 2.5.1 and Table 2.6 of this report. Importantly, the Subsistence Fisher Scenario, which was used in the ROD to define the PCB PTW threshold of 200 µg/kg, now provides an estimated carcinogenic risk that is below the 1 x 10^{-3} risk level. Hence, it is no longer necessary to establish a PTW concentration threshold for PCBs.
- The BHHRA did not identify risks greater than 1 x 10^{-3} at the Site for DDx, TCDD-TEQ, or BaP-TEQ for any evaluated scenario. The updated PDI dataset and resultant risk calculations provided by the PDI confirm this finding. Therefore, the ROD definition of highly toxic PTW is not applicable to these COCs.

Mobility Considerations

The following considerations related to mobility support the elimination of Site PTW thresholds:

- PCBs at concentrations substantially higher than the 200 µg/kg ROD PTW threshold can be safely and reliably managed in-place with ENR and/or conventional (unamended) capping technologies. Appendix K and Section 3.6.2 provide this updated evaluation, which draws upon data obtained since the ROD. Impacted sediments such as these are not highly mobile. Hence, dredging or amended capping should not be the default cleanup technologies at these concentrations.
- The "highly mobile" part of the PTW definition can only be applied to certain types of separate phase material in specific environments. The presence of "globules" or "blebs"

of separate phase material or "sticky tar balls" in sediments does not necessarily equate to mobility posing risk of contaminant migration. This also applies to separate phase material including elevated concentrations of chlorobenzene and naphthalene. Proper characterization of mobility has not been completed to date; hence, sediment will only be designated as highly mobile PTW during remedial design if additional pre-design characterization identifies it as mobile separate phase material.

Media Considerations from EPA Guidance

PDI data show that Site-wide sediment concentrations have undergone significant COC recovery in the last decade. Additionally, average sediment concentrations now resemble those of background conditions for multiple COCs. These findings from the PDI show that the Site contains large geographic areas with relatively low concentrations of COCs that are or can be reliably contained in place (see additional discussion in Section 3.6.2). Materials that can be reliably contained should not be treated as PTW.

PTW designation is not appropriate for sediments bearing low to moderate-risk COC impacts, such as 200 µg/kg of PCBs, that are found in numerous locations throughout a 10-mile-long, major river system. Highlight 3 of EPA's guidance (EPA 1991) provides examples of PTW, summarized as follows:

- Liquids (e.g., waste contained in drums, lagoons, or tanks); or NAPL
- Mobile source material (e.g., surface or subsurface soil that bears high concentrations of contaminants)
- Highly toxic source material that is a likely source of uncontained releases (e.g., drums or tanks of wastes or significantly impacted soils)

These examples of PTW from the guidance suggest concentrated and localized, saliently impacted, yet poorly contained, primary and secondary source material in upland sites. In such upland scenarios, it may be feasible to target such localized sources for aggressive source reduction measures, as was the intent of the NCP. However, nothing in the examples provided in the guidance suggests conditions similar to those of the majority of Portland Harbor sediments. In the Site's case, sediments designated in the ROD as PTW (e.g., total PCB concentrations exceeding 200 µg/kg), containing COCs at concentrations far below levels that are visibly present or malodorous, extend over portions of a 10-mile Site footprint. This is not consistent with the intended definition of PTW in the guidance.

Precedent Considerations

A review of PTW designations in RODs for other sediment Superfund Sites released within the last 10 years was performed and is presented in Appendix K. Six RODs (from EPA Regions 2 and 10) were reviewed to assess whether PTW levels were established. While the RODs for many of these sites designate PTW in sediments, none of the RODs presents a PTW threshold concentration level or required remedial technologies to specifically address PTW. This review confirms that the Portland Harbor PTW designations in the ROD should be eliminated.

The following precedents observed at other sediment Superfund sites and in other PCB remediation contexts show that the ROD PTW levels are not appropriate compared to precedent sites:

- The Lower Duwamish Waterway ROD (EPA 2014d) identified tribal seafood consumption risks of 2 x 10^{-3} (excess cancer risk for adult tribal fisher) for PCBs and arsenic. The Lower Duwamish ROD did not identify these risks as highly toxic PTW, nor was dredging technology (removal) required across the site to address these risk levels. The application of dredging versus capping was mostly applied based on site conditions rather than concentration limits. Sediments containing PCBs and arsenic at elevated levels were deemed reliably contained. Thus, EPA's definition of PTW thresholds in the sediments of Portland Harbor is inconsistent with the designation and management of PTW in the Lower Duwamish ROD.
- Sediments at 200 µg/kg PCBs have been designated by EPA as low-level threat wastes at many other sites (see Exhibit A, Appendix K). For example, in Washington State guidance, these levels may pass sediment toxicity tests (bioassay over-ride test) and be left in place to naturally recover.

3.6.2 Cap Amendment Modeling and PTW Considerations

As part of the PTW evaluation, EPA used FS sediment cap modeling to identify which levels of PTW could be reliably contained through conventional (unamended) capping. This was not performed for PTW designation *per se*; instead, it was used to establish remedial requirements for sediments already designated as PTW in the ROD. To update this evaluation, the PDI included a modeling scenario for an unamended cap (i.e., without activated carbon) using a more sophisticated transient cap model and updated parameterization based on more recent studies in the river.

The ROD requires that cap design consider the following:

- *"**Reactive Cap" in "PTW (Highly Toxic)" areas**: "Cap design may require the use of activated carbon and/or other reactive material, as necessary, to meet RAOs [remedial action objectives]."*
- *"Significantly Augmented Cap"* ***in "PTW (NAPL/Not Reliably Contained)" areas****: "Cap design will include organoclay, other reactive material, and/or low permeability material, as necessary, to provide a sufficient chemical isolation layer to reliably contain underlying contamination (i.e., to pore water cleanup values)."*

EPA's cap modeling, as presented in the FS, was developed to confirm that a cap amended with activated carbon (modeled as a 12-inch activated carbon–amended layer overlain by 18 inches of sand) would be protective at the maximum sediment concentration (for PCBs, specified as 14,200 µg/kg in FS Table D7-3). Limited cap modeling was also presented in the FS for benzo(a)pyrene and dichlorodiphenyltrichloroethane (DDT), and for chlorobenzene and naphthalene, to evaluate the need for organoclay or other low permeability material. However, inputs into the cap model (including upwelling/seepage velocities greater than 110 cm/yr) were overly conservative, based in part on recent modeling work performed for the river since the ROD, and no modeling was presented to evaluate whether an unamended cap would be protective for sediments exceeding ROD PTW levels under certain conditions; hence, PDI evaluations included this baseline "no amendment" scenario.

The PDI evaluation included updated cap modeling (see Appendix K) using a more sophisticated transient cap model (Lampert et al. 2018) typically used during remedial design to evaluate cap effectiveness. Updated modeling results show that under certain conditions, unamended capping will provide reliable containment (immobilization), even in areas with elevated PCB concentrations. Updated evaluation of the "containability" of contaminants, rather than concentration levels or PTW designation, should be the determining factor with respect to mapping SMAs and remedial technology selection.

3.6.3 Summary of PTW Considerations

PDI characterization and updated risk estimates show that highly toxic PTW is not present at the Site and should not be considered in the development of SMAs or technology selection. Additionally, the presence of highly mobile material has not been evaluated or confirmed via a mobility study. Lastly, PDI modeling has shown that sediments with elevated PCB concentrations can be reliably contained without carbon amendment. This adds to the ROD Table 7 finding that all focused COCs could be reliably contained at any concentration.

The concentration-based PTW thresholds defined in Table 21 of the ROD have been removed from the updated listing of sediment CULs and RALs in this report. During the remedial design, mobility testing should be performed in areas with separate phase material to evaluate if PTW is present within the Site.

The analyses and discussion presented in Sections 3.5 and 3.6 have important implications for the overall scope of the sediment remedy. Updates to the RALs (Section 3.5) and the removal of concentration-based, highly toxic PTW thresholds (Section 3.6) will reduce the area of sediments requiring management. Figures 3.1a through 3.1f present Natural Neighbor interpolated maps of 2018 PDI sediment data, symbolized using the PDI RALs and no PTW thresholds. The figures show smaller footprints of sediment exceeding PDI RALs than those in Appendix D.2, which maps sediments with respect to ROD RALs and PTW thresholds. Section 4.1 presents the integration of the mapping for multiple focused COCs into a combined footprint of remediation.

3.7 Summary of Updates to Remedial Approaches

The PDI provides a comprehensive, spatially representative, multi-media dataset for updating the Site baseline, illustrating patterns of system recovery, and supporting CSM refinements. With this information, the Site risk estimates, background concentrations, CULs, and RALs have been updated, as summarized below:

- Background concentrations in sediments should be updated with new 2018 data collected from targeted fine-grained sediment in the D/U Reach. For the four focused COCs with background-based CULs (total PCBs and three dioxin/furan congeners), revisions to the background concentrations and resultant CULs are appropriate.
- PDI data for background arsenic and manganese concentrations in porewater are higher than more than 85% of concentrations measured in impacted areas of the Site. Hence, the groundwater CULs for arsenic and manganese need to be removed from the remedy or updated.
- Several COCs, including arsenic, DDx, and dioxins/furans, have watershed-related inputs that should be taken into account during remedial design and source control evaluations, and may need further consideration for determining long-term equilibrium estimates.
- PDI data have demonstrated that sediment-based CULs specifically linked to RAO 2 (protection of human receptors through fish tissue consumption) and RAO 6 (protection of ecological receptors through fish tissue consumption) are not appropriate. Instead, fish tissue targets should be used to evaluate the attainment of these RAOs. Remaining sediment CULs to address other RAOs should be updated to reflect updated background sediment concentrations.
- Updated RALs have been developed to support the delineation of SMAs for sediment remediation. For most of the focused COCs, updated RALs for sediments have increased because of the broad recovery of sediment concentrations since the RI/FS and the current evaluation of background concentrations in the PDI.
- Fish tissue targets need to be established based on Site background tissue concentrations and monitored to measure attainment of RAOs 2 and 6.
- Concentration-based, highly toxic PTW designations should not be used in the development of remedial design plans for sediment cleanup. The presence of highly mobile separate-phase material should be assessed in remedial design. Delineation of SMAs and the selection of remedial technologies (e.g., the use of activated carbon in caps) should be updated based on PDI data and not determined by outdated highly toxic PTW values in the ROD.

4. REMEDY DESIGN CONSIDERATIONS

This section discusses how the updated understanding of current Site conditions, sediment CULs, and sediment RALs should be incorporated into the remedy, specifically:

- Refined SMA footprints using updated RALs,
- A comparison of the level of protectiveness afforded by the Refined SMA footprint relative to the ROD,
- Dioxin/furan data uncertainty and recommendations for future uses, and
- Considerations for technology selection during remedy design and implementation.

The analyses presented in this report demonstrate that this optimized remedial approach remains fully consistent with the RAOs set forth in the ROD and updated CULs described in Section 3.

4.1 Refined Remedial Footprints

The SMA footprint has been refined to reflect the updated RALs provided in this report for total PCBs, total PAHs, and DDx (three focused COCs). The SMA footprint refinements are detailed in Appendix J and summarized in this section. RAL exceedances for the focused COC dioxin/furan congeners are shown as points and not mapped as part of the SMA footprint because of data uncertainties discussed in Section 4.3 and detailed in Appendix E. Figure 4.1 presents the Refined SMA footprint using the PDI SMA mapping dataset for the three focused COCs (total PCBs, total PAHs, and DDx). The footprint totals 111 acres, which is a decrease of 254 acres from the ROD SMA footprint (Table 4.1).

Figure 4.1 includes PDI dioxin/furan sampling points outside of the Refined SMA footprint with reported values or detection limits that exceed the respective RALs. The majority of exceedances are based on non-detect results where the detection limit exceeded the RAL. The validity of exceedances at these locations is highly uncertain and should not be used for SMA mapping (see Section 4.3). While there is uncertainty in the understanding of dioxin/furan presence outside of the Refined SMA footprint, most of the detected dioxin/furan exceedance points are present within the 111-acre SMA footprint (Table 4.2). Areas outside of the Refined SMA footprint may require additional management due to the presence of dioxins/furans; however, decisions about the extent of cleanup of areas with measurable and elevated dioxin/furans will be addressed through further evaluation in the remedial design.

4.1.1 SMA Mapping Method

PDI SMAs are defined as areas where concentrations of one or more of the three focused COCs is above its corresponding RAL. The PDI SMA refinement process is documented in detail in Appendix J and generally follows similar methods used by EPA for development of the ROD SMAs.

The dataset used for delineation of the Refined SMAs includes all Site 2018 surface sediment samples (0 to 30 cm depth), historical samples from the RI/FS, and four validated post-FS surface sediment datasets collected between 2013 and 2016 (described in the PDI Work Plan).[43] Historical results were replaced with PDI 2018 sample results if located within 100 ft of the centroid of a 2018 sample location. While the footprints are primarily based on surface sediment data, the implications of shallow PDI subsurface core data on the footprints are also considered and will be evaluated further during remedial design; in general, the PDI subsurface coring along the boundaries of previously defined SMAs supports the refinement of SMAs (Appendix D.3).

SMA refinement included the following steps:

- Each focused COC was interpolated into a 10-by-10-ft raster grid using the Natural Neighbor algorithm, with separate interpolation domains for east and west nearshore, the navigation channel, and SIL. The spatially interpolated grids were combined to produce a single interpolated map for each focused COC.
- The interpolated maps (one for each of total PCBs, total PAHs, and DDx) were overlaid and merged into a single map that indicates grid cells with one or more exceedances of RALs across the three focused COCs.
- Post-GIS adjustments were made to the interpolated RAL exceedance map to address issues such as contouring artifacts and GIS anomalies (e.g., interpolation through upland areas).
- Dioxin/furan results above the RALs (whether detect or non-detect, with appropriate symbology applied) were shown as data points overlying the SMA boundary.

4.1.2 Other COCs Addressed by Refined SMA Footprint

The Refined SMA footprint is sufficiently addresses remedial objectives for risk from other non-focused sediment COCs listed in ROD Table 17. Excluding the six COCs with background watershed-based influences on the Site,[44] at least 70% of the remaining non-focused COC concentrations above their respective CULs are encompassed within the Refined SMA footprint. Table 4.2 presents the relevant sample counts and statistics; results are grouped based on exceedance factors above the CUL (number of times a concentration is above the CUL) of one, five, and ten. For arsenic and the three focused dioxin/furan COCs, the updated PDI CUL is the basis of comparison; ROD CULs are used for all other COCs. The exceedance factor approach is similar to EPA's approach for mapping benthic toxicity risks at the population scale, which uses an exceedance factor of 10 times the RAO 5 PRG. Using the Refined SMA footprint,

[43] Surface sediment samples from RM 11E (GSI 2014); surface sediment samples collected Site-wide (Kleinfelder 2015) with report updates confirming 30 cm sampling depth; characterization of PAH cores from RM 5-6 (NewFields 2016), and surface sediment sampling in SIL (Geosyntec 2016).

[44] 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, and 2,3,4,7,8-PeCDF (focused COCs) and 1,2,3,4,7,8-hexachlorodibenzofuran [1,2,3,4,7,8-HxCDF] and 2,3,7,8-tetrachlorodibenzofuran [2,3,7,8-TCDF], and arsenic (non-focused COCs).

- At five times the CUL, 94% or more of non-focused COC sample exceedances are addressed, including all arsenic exceedances except for one; and
- At ten times the CUL, 98% of the non-focused COC sample exceedances are addressed.

Two non-focused COC furans (1,2,3,4,7,8-HxCDF and 2,3,7,8-TCDF) are not relevant for post-construction evaluations because of uncertainty associated with the detection limit and qualifier limitations for dioxins/furans (see Section 4.3 and Appendix E). The two non-focused COC furans had 70% or more ROD CUL exceedances remaining outside the Refined SMA footprint, indicating that the ROD CULs are too low and below background concentration levels.

Arsenic concentrations for samples outside of the Refined SMA footprint (95 UCL of 5 mg/kg; N=403) do not appear to be equilibrating to the updated background arsenic CUL of 4 mg/kg. The 95 UCL for arsenic outside the Refined SMA footprint is the same as the 2018 Site-wide 95 UCL (both are approximately 5 mg/kg). ODEQ has identified arsenic as a basin-wide issue and developed a background soil level of 8.8 mg/kg in the Portland Basin (ODEQ 2013). Arsenic CULs for the Site will need additional evaluation during remedial design.

4.1.3 Post-Construction SWACs

SWACs were calculated for the focused COCs to estimate post-construction surface sediment conditions using the Refined SMAs. Estimated post-construction SWACs based on PDI data are presented in Table 4.3. Site-wide SWAC reductions are 41% for total PCBs, 48% for total PAHs, and 78% for DDx after simulated active remediation of the Refined SMA footprint (111 acres). These concentrations are similar to the target SWACs identified on the single-COC-RAL curves (see Appendix I); however, some variation between results is expected because of the higher RALs in the navigation channel and difference in the PDI dataset versus the combined dataset used for SMA mapping, which included some historical results for data coverage. Similar to the ROD, MNR will be applied to areas outside of the SMAs with concentrations above CULs and below RALs that are expected to recover naturally in a reasonable restoration time frame. Ongoing recovery processes in these areas (discussed in Section 2) will continue to further reduce SWACs over time.

4.2 Evaluation of Post-Construction Risk for the Refined SMA Footprint

Post-construction risks and hazards based on the Refined SMA footprint meet EPA's interim risk management targets. Post-construction SWACs were calculated on a Site-wide basis and for each RM (east/west banks separately) to evaluate risk on both spatial scales.

- On a Site-wide basis, post-construction risk and hazard for the tribal fisher (target receptor in FS/ROD for in-water sediment exposure[45]) are approximately 50% to 70%

[45] Consistent with the evaluation of sediment direct contact risk (RAO 1), nearshore sediment SWACs were calculated excluding the navigation channel and including SIL from RM 1.9 up to RM 11.8 (see Appendix J).

lower than pre-remedy (2018) conditions (Table 4.4) and below EPA's long-term direct contact risk management targets for the Site (cancer risk of 10^{-6} and HI of 1) (see Appendix J).

- When sediment exposure is assumed to occur only within 1 RM and along one bank, post-construction risks and hazards are also below EPA's long-term risk management targets (Table 4.5).

Post-construction benthic risks were evaluated by identifying areas where post-construction concentrations for the ecological COCs exceed 10 times RAO 5 PRGs (see Appendix J).

- Of the total RAO 5 benthic risk area, 72% percent (22 of 31 acres) is captured within the Refined SMA footprint. EPA's post-construction interim target of 50% reduction in the area posing unacceptable benthic risk is achieved with the Refined SMA footprint.

Updated post-construction risks from fish consumption (RAO 2) were not calculated due to the lack of a reliable method for predicting fish tissue concentrations from sediment concentrations (see Appendix H). However, the change in COC fish tissue concentrations between the RI and PDI demonstrates that a significant reduction in fish consumption risk has already occurred in the absence of remediation. Upstream and watershed inputs of PCBs, mercury, and other COCs limit the reduction in fish consumption risk that can be achieved at the Site, as acknowledged by EPA in the ROD Responsiveness Summary (EPA 2017b).

The post-construction SWACs and risks are conservative, as they do not take into account ongoing recovery that has been observed at the Site and documented in this report.

4.3 Dioxin/Furan Data Uncertainty and Use

For dioxins and furans, the RI/FS dataset was inadequate to develop a comprehensive CSM and support decision-making in the ROD due to (i) insufficient/lower resolution spatial coverage of the Site, (ii) poor representativeness of the background inputs and sources, and (iii) significant uncertainty in the chemistry data.[46] EPA acknowledged that the sparse RI/FS dataset introduces limitations in understanding how the RALs will perform (EPA 2017b).

The PDI surface sediment dataset provides a much more representative Site-wide understanding of dioxin/furan occurrence than the RI/FS dataset. The PDI Site and D/U Reach data suggest that dioxin/furan CULs should be raised and that the ROD RALs are near the updated background levels (e.g., for 1,2,3,7,8-PeCDD; the ROD RAL [0.0008 μg/kg] is less than two times the updated CUL [0.00049 μg/kg]). Therefore, SMAs should not be delineated with the ROD RALs.

[46] The detection limits in both the RI/FS and PDI work met the criteria from the Quality Assurance Project Plan (QAPP) but varied by laboratory and sample matrix, and the detection limits used to define background in the RI/FS may not consistently be met by certified laboratories.

Additionally, the longer-term remediation goals targeting the ROD CULs cannot be achieved or sustained. ROD CULs for sediment were based on detection limits of the dioxin/furan congeners in the upstream sediment data. Setting cleanup goals to levels below background (i.e., the ROD CULs) does not provide for a sustainable remedy and is not in accordance with EPA policy (2002; 2017c). PDI data demonstrate that an update of the dioxin/furan CULs and RALs is necessary for the remedy to attain sustainable risk reduction given background inputs to the Site. In addition, the ROD RALs were based on spatially limited data but were anticipated to be utilized throughout the Site. The updated CULs and RALs for the three focused dioxin/furan COCs derived in this report are an important step toward achieving that goal and should be adopted.

While PDI data support a better understanding of dioxin/furan conditions throughout and upstream of the Site, both the RI/FS and PDI datasets are characterized by a large percentage of data near detection limits and a substantial proportion of qualified data in the range of the ROD CULs and RALs. The uncertainties generated by these low-level, qualified data extend through all media and include J-flagged values, reported as "estimated," JN-flagged values reported as "estimated, tentatively identified," and elevated detection limits due to matrix interferences (Appendix E). The high proportion of qualified data needs to be considered carefully during data evaluation and decision-making. This is particularly true when comparing Site sediment concentrations to the ROD CULs and RALs. ROD RALs are at or below concentrations that can be quantified with certainty for 2,3,7,8-TCDD and 1,2,3,7,8-PeCDD. Updated CULs, and particularly the updated RALs, can be measured with greater certainty and will provide more assurance that the remedial action will be effective.

The dioxin/furan data have been considered in some PDI analyses. TCDD-TEQ concentrations are used in PDI evaluations for some media (e.g., surface water, fish tissue). Detailed analysis of these results is not a focus of this report because the data are qualified and uncertain. While uncertainty remains, dioxin/furan background values were calculated based on the PDI dataset and updated RALs focused on meeting these background values (or the same Site-wide SWAC identified in the ROD for the selected remedy), but dioxins/furans were not included in the SMA delineation in Section 4.2 because of limited data density relative to other focused COCs and the uncertainty in the dioxin/furan data.[47] While there is increased confidence in dioxin/furan data for concentrations approaching the updated RALs, additional evaluation of the uncertainties inherent in using these data is necessary.

The Site includes selected areas where dioxin/furan concentrations need to be addressed for the Site to meet RAOs. However, the majority (79%) of these areas are included in the Refined SMA footprint due to the other co-located COCs with RAL exceedances and will be addressed (see

[47] The SMA dataset included PDI (SRS and SMA) and historical (RI/FS and post-RI/FS) surface sediment data. Although the PDI dataset has the same number of samples for dioxins/furans as the other focused COCs, the dioxin/furan dataset for SMA mapping is limited due to the paucity of dioxin/furan data in the historical datasets.

Appendix E). Dioxins/furans are also related to watershed inputs (see Appendix F.1). These factors should be considered as the remedial approach for dioxins/furans is refined.

4.4 Considerations for Technology Assignments

The PDI data demonstrate that Site recovery has occurred since the RI, Site-wide patterns are stable, and capping and ENR are viable remedial technologies; together they strongly support providing additional flexibility in technology selection and application during remedial design (and implementation) beyond the selection process included in ROD Figure 28 (Technology Application Decision Tree) and ROD Section 14.2.9 (Design Requirements). An updated decision tree is provided in Appendix L. It allows the screening of additional and potentially applicable technologies in the navigation channel, intermediate region, and shallow areas of the Site. SMA-specific conditions should be considered in identifying appropriate remedial technologies, including COC concentrations, recovery potential, land use and access, implementability, containment potential, and current/wake/propeller wash energy. Recommended updates to the ROD decision tree are summarized below and detailed in Appendix L.

- MNR is an applicable technology outside of SMAs. MNR should be considered for areas outside of SMAs that exceed the CULs. Areas of the Site that meet CULs should be considered for reduced monitoring.
- ENR should not be required outside of SMAs; these areas are below actionable levels. Within SMAs, ENR should be considered in non-erosional areas where natural recovery is occurring but could be accelerated to reduce risks to target levels within an acceptable time frame.
- Dredging should be limited to a depth no greater than an appropriate site-specific cap thickness (partial dredge and cap), except (i) in areas where PTW cannot be reliably contained, or (ii) where dredging to the RAL depth would be more efficient than placing a cap (e.g., full removal of RAL exceedances in the upper few feet). Partial dredging and capping is appropriate in all regions and should be considered after review of depths of impact and effective cap designs.
- Placement of cap on grade (without pre-dredging) should be permitted where consistent with SMA conditions (e.g., bathymetry, land/vessel use or habitat considerations).
- Backfilling may not be necessary or appropriate in dredged areas.
- The decision to amend caps or ENR layers should be SMA-specific based on COC concentrations and other design considerations (see Appendix K).
- Dredge residual layer should only be required where needed, and only if compliance criteria are exceeded (to be determined during design).

Remedial technologies will consider avoiding or minimizing impacts to the aquatic environment and floodway and be evaluated to meet Clean Water Act (Section 404) and federal floodway requirements. Additional evaluation criteria to be considered during the remedial design phase for each technology are described in Appendix L.

Post-construction monitoring plans will be optimized as appropriate to include (i) clear contingency actions for SMAs or portions of SMAs assigned ENR if they do not achieve predicted performance goals, (ii) checking the reliability of capping technologies applied, and (iii) monitoring for recontamination that may be associated with incomplete source control.

4.5 Summary of Remedy Design Considerations

The remedial design will be optimized based on the results of this PDI while still achieving the RAOs of the ROD. The combination of (i) the updated Site data; (ii) refined background characterization, CUL/RAL definition, and SMA delineation; and (iii) technology considerations that reflect an updated understanding of the Site CSM provide a remedial implementation approach that will protect human health and the environment, achieve ARARs, and meet the RAOs, while being streamlined in scope, more quickly implementable and cost-effective.

Specific findings and refinements include the following:

- Demonstrated Site recovery since the RI/FS supports the use of updated RALs and refinements to the SMAs. The Refined SMA footprint encompasses 111 acres, based on PCBs, PAHs, and DDx. The footprint is anticipated to also address the majority of impacts associated with focused dioxins/furans.

- The post-construction risks and hazards calculated using the Refined SMA footprint, with or without the dioxin/furan focused COCs, achieves EPA's interim risk management targets. For RAO 1 (human direct contact with nearshore sediment), EPA's long-term risk management targets are met on both a Site-wide and RM scale. For potential direct contact and fish consumption exposure scenarios, additional post-remedy risk reduction will continue to be achieved as the Site approaches equilibrium with background conditions.

- Post-construction risks will achieve the remedial action objectives and CULs for human health direct-contact receptors (RAO 2), while also allowing an increase in the consumption of fish. However, as recognized by EPA in the ROD, institutional controls in the form of fish consumption advisories will continue to be necessary given watershed background inputs to the Site, especially non-Site related mercury.

- Due to demonstrated Site recovery and refinements in risk estimation methods, highly toxic PTW designations are not necessary. Evaluation of mobility will be conducted during remedial design.

- The Refined SMA footprint developed in this report is protective of human health and the environment and meets CERCLA threshold criteria described in the ROD (Table 4.6).

The updated RALs fall between FS Alternatives D and E for total PCBs and are similar to Alternative C for DDx (no change to PAH RAL). The size of the Refined SMA footprint is also similar to FS Alternative C. All three of these FS Alternatives (C, D, and E) meet threshold criteria, provide long-term effectiveness and permanence, meet ARARs, and reduce benthic risk. The Refined SMA footprint is expected to have the same, or better, performance as these other alternatives because many of the risks have substantially improved with 2018/2019 PDI data.

4.6 Future Long-Term Monitoring

The PDI provides robust data for use in COC screening and establishing a baseline for future long term monitoring (LTM). It also provides recommendations (informed by PDI data and analysis) for COCs that should be eliminated from LTM. Appendix M presents detailed analysis of these LTM considerations.

5. CONCLUSIONS

The PDI program is the most comprehensive, multi-media sampling effort performed at the Site since 2004. The PDI program has met its stated data use objectives and provides EPA and other interested parties with scientifically sound information about current Site conditions and recovery trends. While additional sampling will be necessary during the remedial design phase, as the PDI Statement of Work acknowledges, the "*proposed PDI sampling program is extensive and the data will be used to update the CSM to inform future remedial design activities and future long-term monitoring in accordance with [CERCLA].*"

The PDI generated new data and analyses to refine the Site CSM and provide a more accurate understanding of Site processes, including background influences and risk assumptions. The PDI data and analyses show that Site conditions have improved substantially since the last comprehensive sampling was performed in 2004. Substantial risk reduction has already occurred, and fish consumption risks are at or below EPA's interim targets for recreational fishers and subsistence fishers. The analyses contained in this report support important refinements to the remedial approach outlined in the ROD, including updates to certain background values, CULs, sediment RALs, and fish tissue targets and should be used to inform remedial design decisions.

In addition, the data generated by the PDI can also be used for important additional analyses as the Site cleanup process moves forward. For example, the PDI data will be used to inform ongoing source control studies, support LTM, and evaluate appropriate institutional controls for the Site.

This information will help EPA and the performing parties update and optimize remedial design and implementation at the Site and result in a remedy that is permanent and protective of human health and the environment.

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TABLES

Table 1.1. Summary of PDI Sampling Activities and General Approach

PDI Study Element	Scope
Bathymetric Survey	Site-wide bank-to-bank multibeam bathymetry survey from RM 1.9 to RM 11.8. Current bed elevations to support the CSM, evaluating changes in sediment bed elevation
Surface Sediment Sampling	For Baseline and SMA delineation in the Site: - Total sample count of 655 within Site (424 stratified random, 231 SMA samples) - Upstream sample count of 29 samples from Downtown Reach, 30 samples from Upriver Reach 3-point composite (over small area); 0 to 30 cm target depth; Full ROD Table 17 Sediment COC list including PCB congeners, TOC, and grain size
SMB Fish Tissue Sampling	Smallmouth bass fish tissue sampling at 95 stations in the Site; 40 upstream stations Individual whole body samples, derive fillet values through relationship Full ROD Table 17 Tissue COCs including PCB congeners
Surface Water Sampling	Seven transects (5 within Site, 2 upstream), three seasonal events (low-flow, storm-flow, and high-flow), up to nine subsamples per transect Vertical and horizontal compositing along transect Sample with high volume XAD samplers for low MDLs and peristaltic pump for select analytes Full ROD Table 17 Surface Water COCs, particulate, dissolved, total, and calculated total
Subsurface Sediment Coring	90 sediment cores typically 10 to 15 ft below mudline and 6 ft in nearshore areas to refine remedial footprint boundaries 2-ft sample default increments, unless stratigraphy observed Focused COCs only [(1)], PCB Aroclors, TOC and grain size
Fish Acoustic Tracking Study	Year long acoustic tracking study of SMB fish movement; 40 tagged fish; 34 acoustic receivers within Site
Sediment Trap Sampling	Three seasonal deployments for 3 months each (low-flow, storm-flow, and high-flow) Two sediment traps per transect at RM 11.8 and RM 16.2 (same transects as SW program) Full ROD Table 17 Sediment COCs including PCB congeners, TOC, and grain size
Background Porewater Sampling	Nine locations with three composites per location (one duplicate) Target placement in representative upstream background areas Analyze porewater for naturally occurring arsenic and manganese

General Notes:

1. Focused COCs include Total PCBs, Total PAHs, DDx, 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, and 2,3,4,7,8-PeCDF.

Acronyms:

cm = centimeter
COC = contaminants of concern
CSM = Conceptual Site Model
DDx = dichlorodiphenyltrichloroethane and its derivatives
ft = feet
MDL = method detection limit
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
PDI = Pre-Remedial Design Investigation
PeCDD = pentachlorodibenzo(p)dioxin
PeCDF = pentachlorodibenzofuran
RM = river mile
ROD = Record of Decision
SMA = sediment management area
SMB = smallmouth bass
SW = surface water
TCDD = tetrachlorodibenzo(p)dioxin
TOC = total organic carbon

Table 1.2. Summary of PDI Sample Counts

PDI Study Element	No. of Stations	No. of Primary Samples
Bathymetric Survey	n/a	Site-wide coverage
Surface Sediment	655 (Site) and 59 (upstream)	714
SMB Fish Tissue Sampling	95 (Site) and 40 (upstream)	135
Surface Water Sampling	7 transects	21 composites (all surface water analytes except ethylbenzene) 63 discrete (ethylbenzene only)
Subsurface Sediment Coring	90	423
Fish Acoustic Tracking Study	40	40 tagged fish
Sediment Trap Sampling	4	12
Background Porewater Sampling	9	9

General Notes:

1. All studies completed in 2018/2019. Field duplicates are not included in the sample count.

Acronyms:

n/a = not applicable
PDI = Pre-Remedial Design Investigation
SMB = smallmouth bass

Table 2.1. SWACs and Acres for Depositional, Neutral, and Erosional Areas

Focused COC	Units	PDI 2018 SWACs		
		Net Depositional Area (> 1.2 ft Gain)	Net Neutral Area	Net Erosional Area (>1.2 ft Loss)
Total PCBs	µg/kg	20.6	42.4	58.5
Total PAHs	µg/kg	2,990	11,314	16,569
DDx	µg/kg	28.6	26.0	17.0
2,3,7,8-TCDD	ng/kg	0.28	0.29	0.42
1,2,3,7,8-PeCDD	ng/kg	0.40	1.80	3.70
2,3,4,7,8-PeCDF	ng/kg	3.8	3.6	2.6
Total Acres		**909**	**1,008**	**70**

General Notes:

1. Depositional regime based on 2004-2018 bathymetry elevation change and Site-wide SWACs.
2. The number of acres in each depositional category based on about 1,987 survey acres (Site is 2,203 acres).
3. Net neutral elevation is less than 1.2 ft of elevation change (gain or loss).
4. The ROD states the Site is approximately 2,190 acres and extends from RM 1.9 to RM 11.8. However, when mapped in GIS, the 2,190 acres only covers the area from RM 1.9 to RM 11.6 (at the end of the authorized navigation channel). The acreage from RM 1.9 up to RM 11.8 is more accurately 2,203 acres.

Acronyms:

µg/kg = micrograms per kilogram
ng/kg = nanogram per kilogram
ft = feet
COC = contaminants of concern
DDx = dichlorodiphenyltrichloroethane and its derivatives
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
PDI = Pre-Remedial Design Investigation
PeCDD = pentachlorodibenzo-p-dioxin
PeCDF = pentachlorodibenzofuran
SWAC = spatially weighted average concentration
TCDD = tetrachlorodibenzo-p-dioxin

Table 2.2. Bathymetric Elevation Changes - 2004 to 2018 (SDU Acres and Volumes)

ROD Sediment Decision Unit (SDU)	Bathymetric Elevation Change (2004-2018) within ROD SDUs							
	Sediment Deposition (cy)	Sediment Erosion (cy)	Net Volume Change (cy)	Acres Classified as Depositional	SDU Area (Acres)	Average Change in Elevation within Bathymetric Coverage Area (ft)	Average Rate of Deposition/ Erosion (cm/yr)	2004-2018 Bathymetry Coverage Area
RM2E	357,287	5,109	352,178	57.5	76 (103) [a]	3.2	6.8	90%
RM3.5E	36,646	44,840	-8,193	7.9	51	-0.1	-0.3	83%
RM3.9W	82,392	914	81,479	18.5	49	1.4	3.0	72%
RM4.5E	66,408	38,017	28,391	17.1	43	0.5	1.0	86%
RM5W	54,050	18,530	35,520	11.9	25	1.2	2.6	74%
RM5.5E	9,094	21,589	-12,495	1.6	30	-0.4	-0.9	64%
RM6Nav	152,813	62,284	90,528	21.2	147	0.4	0.8	100%
RM6W	80,695	9,165	71,530	18.3	38	1.5	3.2	77%
RM6.5E	86,960	48,162	38,799	14.1	89	0.3	0.7	88%
RM7W	114,175	27,632	86,543	26.0	68	1.0	2.2	77%
RM9W	175,183	11,056	164,127	29.8	68	2.1	4.4	73%
RM11E	13,148	15,981	-2,833	2.3	29	-0.1	-0.2	86%
SIL	102,125	26,725	75,400	14.4	117	0.5	1.1	80%
SIL West	67,596	21,930	45,667	10.7	79	0.5	1.0	77%
SIL East	34,528	4,795	29,733	3.7	39	0.6	1.2	85%
Totals	**1,344,124**	**345,985**	**998,141**	**243**	**831**	**0.9**	**1.8**	**84%**

General Notes:

1. Deposition is classified as an area where the bed elevation has increased from 2004 to 2018.
2. Erosion is classified as an area where the bed elevation has decreased from 2004 to 2018.
3. Classification as Depositional was identified where >1.2 ft of bathymetric change has occurred from 2004 to 2018 (0.08 ft/year over 14 years). This definition is consistent with RI/FS Figure 3.4-20 - Sediment Deposition Rates. Deposition is considered ≥2.5 cm/yr and erosional is considered ≤-2.5 cm/yr; (2.5 cm/yr = 0.08 ft/yr).
4. Analyses based on ROD acreage (2,190 acres).

Footnotes:

a. RM2E SDU is 103 acres and extends beyond the Site boundary. As a result, 76 acres was used (area of the SDU within the Site boundary).

Acronyms:

cm/yr = centimeter per year
cy = cubic yard
ft = feet
RI/FS = remedial investigation/feasibility study
RM = river mile
ROD = Record of Decision
SDU = Sediment Decision Unit
SIL = Swan Island Lagoon

Table 2.3. Multiple Lines of Evidence Summary of Background Conditions in the D/U Reach

D/U Background Conditions in 2018	Line of Evidence	Focused COC			
		Total PCBs	Total PAHs	DDx	Dioxins/Furans
Lower than CULs/fish tissue targets?	Sediment	No	Yes	Yes (slightly)	No
	Sediment Traps	No	Yes	Yes	No
	Surface Water	No	No	No	No
	Fish	No	n/a	No	No
Decreased since the RI?	Sediment	n/a	n/a	n/a	n/a
	Sediment Traps	Mixed (Low Flow increase only)	No (increase)	Yes (mostly)	No (increase)
	Surface Water	Yes	Yes	Yes	Yes
	Fish	Yes	n/a	Yes	Yes
DR and UR similar?	Sediment	No (DR higher)	Yes	Yes	Yes
	Sediment Traps	No (DR higher)	No (DR higher)	Yes	No (UR higher)
	Surface Water	Yes	Yes	No (DR higher)	No (DR higher)
	Fish	No (DR higher)	n/a	No (DR higher)	Yes
Overall Conclusion		CULs cannot be met in the D/U Reach due to ongoing COC inputs, especially those that enter the Downtown Reach, which have not changed (or have increased) since the RI			

= Negative response to questions, upstream conditions are relatively unchanged (or are higher).

Acronyms:
COC = contaminant of concern
CUL - cleanup level
D/U = Downtown/Upriver Reach
DDx = dichlorodiphenyltrichloroethane and its derivatives
DR = Downtown Reach
n/a = not applicable, not evaluated
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
RI = remedial investigation
UR = Upriver Reach

Table 2.4. Statistics for PDI 2018 Upstream Surface Sediment Data (95 UCL, Median, and UTL)

Focused COC (in µg/kg)	ROD Cleanup Level (Basis)	ROD Background Values	PDI 2018 D/U Surface Sediment Data			
			95 UCL	Median	UTL95-95	Sample Count
Total PCBs	9 (B)	9	20.4	2.54	88.9	58 [a]
Total PAHs	23,000 (R-eco)	113	488	237	1589	58 [a]
DDx	6.1 (R-HH)	3.1	5.6	1.67	14.0	59
2,3,7,8-TCDD	0.0002 (B)	0.0002	0.000253	0.00012	0.00082	59
1,2,3,7,8-PeCDD	0.0002 (B)	0.0002	0.000489	0.00024	0.00177	59
2,3,4,7,8-PeCDF	0.0003 (B)	0.0003	0.00044	0.00017	0.00122	59
TCDD-TEQ	n/a	n/a	0.00036	0.00014	0.01	59

General Notes:

1. Kaplan-Meier (KM) or regression on order (ROS) - based statistics are presented for the analytes with non-detects: Total DDx, 2,3,7,8-TCDD, 1,2,3,7,8,-PeCDD, 2,3,4,7,8- PeCDF. Calculations performed in accordance with ProUCL v5.1 recommendations and methods specified in EPA (2013).

2. 95 UCL values represent the central tendency value of the achievable concentration at the Site.

3. UTL95-95 values represent an upper limit of the upstream sediment dataset.

EPA, 2013. ProUCL Version 5.0.00 Technical Guide. U.S.EPA , Office of Research and Development, Washington, DC. EPA/600/R-07/041. September.

4. Basis for CUL is B = background; R-eco = risk-based, ecological; R-HH = risk-based, human health.

Footnotes:

a. Location B459 excluded for Total PCBs and Total PAHs.

Acronyms:

µg/kg = micrograms per kilogram
COC = contaminants of concern
D/U Reach = Downtown/Upriver Reach
DDx = dichlorodiphenyltrichloroethane and its derivatives
EPA = U.S. Environmental Protection Agency
n/a = not applicable
ng/kg = nanogram per kilogram
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
PDI = Pre-Remedial Design Investigation
PeCDD = pentachlorodibenzo-p-dioxin
PeCDF = pentachlorodibenzofuran
ROD = Record of Decision
TCDD = tetrachlorodibenzo-p-dioxin
TEQ = toxicity equivalency
UCL = upper confidence limit on the arithmetic mean
UTL95-95 = 95% upper tolerance limit with 95% coverage

Table 2.5. Comparison of SMB Tissue Samples Collected in D/U Reach with ROD Tissue Targets

Focused COC for Fish Tissue (in µg/kg-ww)	ROD Tissue Target (fillet)	95 UCL (fillet)
		D/U Reach
Total PCBs	0.25	16
DDx	3	9
2,3,7,8-TCDD	0.000008	0.00005 [a]
1,2,3,7,8-PeCDD	0.000008	0.00009 [a]
2,3,4,7,8-PeCDF	0.00003	0.00006 [a]

General Notes:

1. Fish tissue targets from ROD Table 17 (EPA 2017). Subsistence fisher fish consumption (fillet tissue).

2. 95 UCL of arithmetic mean of smallmouth bass dataset for D/U Reach, converted to fillet using whole-body to fillet ratios (EPA 2016b).

Footnotes:

a. Sample PDI-TF-SMB117 caught in Upriver Reach was excluded from statistics for dioxin/furan focused COCs (see Appendix F.2).

Acronyms:

µg/kg ww = micrograms per kilogram wet weight
COC = contaminant of concern
D/U = Downtown/Upriver Reach
DDx = dichlorodiphenyltrichloroethane and its derivatives
PCB = polychlorinated biphenyl
PDI = Pre-Remedial Design Investigation
PeCDD = pentachlorodibenzo-p-dioxin
PeCDF = pentachlorodibenzofuran
ROD = Record of Decision
SMB = smallmouth bass
TCDD = tetrachlorodibenzo-p-dioxin
UCL = upper confidence limit on the arithmetic mean

Table 2.6. Comparison of Updated Baseline Cancer Risks and Noncancer Hazards to 2013 BHHRA Results

RAO2 Fish Consumption	Fisher Receptor	Tissue Type Consumed	2013 BHHRA	Updated RI/FS Risk Evaluation	Percent Decrease	PDI Risk Evaluation	Percent Decrease
Cancer Risk	Tribal	whole body	2×10^{-2}	6×10^{-3}	70%	2×10^{-3}	91%
	Tribal	fillet	1×10^{-2}	1×10^{-3}	86%	7×10^{-4}	93%
	Subsistence	fillet	1×10^{-2}	6×10^{-4}	94%	2×10^{-4}	98%
	Recreational	fillet	4×10^{-3}	2×10^{-4}	95%	5×10^{-5}	99%
Noncancer Hazard Index	Tribal	whole body	800	158 (91)	80%	46 (26)	94%
	Tribal	fillet	600	42 (23)	93%	11 (5)	98%
	Subsistence	fillet	1,000	38 (16)	96%	16 (7)	98%
	Recreational	fillet	300	13 (5)	96%	4 (2)	99%

General Notes:

1. Parenthetical values for noncancer hazard represent the highest target endpoint based hazard index (see Appendix G).
2. Cancer risks and noncancer hazards for the updated RI/FS risk evaluation were calculated using 2013 BHHRA exposure assumptions including adult fish consumption rates of 175 g/day (tribal), 142 g/day (subsistence), and 49 g/day (recreational), as well as 2018 PDI fish tissue data and current EPA toxicity factors (see Appendix G).
3. Cancer risks and noncancer hazards for the PDI risk evaluation were calculated using updated fish consumption rates based on more recent studies and methods, including 149 g/day (tribal), 81.2 g/day (subsistence), and 21.4 g/day (recreational), updated EPA exposure assumptions and toxicity factors, and PDI fish tissue data (see Appendix G).
4. Percent decreases were calculated as follows: 2013 BHHRA risk or hazard minus updated risk or hazard divided by 2013 BHHRA risk or hazard. Risks and hazards presented in the table above are rounded; percent decreases were calculated prior to rounding (see Appendix G).

Acronyms:

BHHRA = Baseline Human Health Risk Assessment
EPA = U.S. Environmental Protection Agency
g/day = grams per day
PDI = Pre-Remedial Design Investigation
RAO = remedial action objective
RI/FS = remedial investigation/feasibility study

Table 2.7. Background Risks and Hazards from Fish Consumption

Reach	Subsistence Fisher							
	Potential Cancer Risk (Adult/Child)				Potential Noncancer HI (Child)			
	Full Dataset	Background as Percent of Site Risk	Sample SMB117 Removed [a]	Background as Percent of Site Risk	Full Dataset	Background as Percent of Site Hazard	Sample SMB117 Removed [a]	Background as Percent of Site Hazard
Site-Wide	2×10^{-4}				16			
Downtown Reach	6×10^{-5}	32%	6×10^{-5}	32%	9	58%	9	58%
Upriver Reach	2×10^{-4}	B = Site	4×10^{-5}	22%	18	B > Site	7	47%
D/U Reach	1×10^{-4}	75%	5×10^{-5}	26%	13	81%	8	51%

General Notes:

1. Potential risks and hazards were calculated using 2018 PDI fish tissue data for smallmouth bass (estimated fillet concentrations) and updated exposure assumptions for the subsistence fisher (see Appendix G).

2. Site-wide risk/hazard was calculated using exposure point concentrations (e.g., 95 UCL) calculated from 95 samples of SMB caught within the Site during the late summer/early fall 2018 PDI tissue sampling event (see Appendices D.6 and G).

3. Background risk/hazard was calculated separately using exposure point concentrations calculated from 20 SMB samples collected in the Downtown Reach, 20 SMB samples collected in the Upriver Reach, and 40 combined samples from the D/U Reach (see Appendix D.6 and G).

Footnotes:

a. One Upriver Reach SMB sample (PDI-TF-SMB117) with the highest observed concentrations of dioxins/furans was removed (see Appendix F.2).

Acronyms:

B = Background
D/U Reach = Downtown/Upriver Reach
HI = hazard index
PDI = Pre-Remedial Design Investigation
SMB = smallmouth bass
UCL = upper confidence limit on the arithmetic mean

Table 3.1. ROD Sediment PRGs, Background Levels, and CULs Compared to PDI Updated Background and CULs

Focused COC (in µg/kg)	ROD Values							Updated 2018 PDI Values			
	EPA Feasibility Study PRGs				RI Background Sediment Concentration [e]	ROD-Selected Sediment CUL [f]	Basis	Updated D/U Sediment Background 95 UCL [g]	D/U "All Solids" 95 UCL	Updated Sediment CUL	Basis
	Human Direct Contact with In-Water Sediment PRG	Ecological Direct Exposure to Sediment PRG	Human Consumption of Fish PRG	Wildlife Consumption of Fish PRG							
	RAO 1 [a]	RAO 5 [b]	RAO 2 [c]	RAO 6 [d]							
Total PCBs	369	500	0	36	9	9	B	20.4 [h]	19.1	20.4	Updated B
Total PAHs	774 (cPAHs)	23,000	1,076 (cPAHs)	n/a	113	774 (cPAHs) 23,000	R-eco	488 [h]	460	774 (cPAHs) 23,000 (total PAHs)	No change from ESD
DDx	4,262	578	6.1	760	3.1	6.1	R-HH	5.6 [i]	11.8	6.1	No change from ROD [i]
2,3,7,8-TCDD	n/a	n/a	0	0.0008	0.0002	0.0002	B	0.00025	0.0008	0.00025	Updated B
1,2,3,7,8-PeCDD	n/a	n/a	0	0.001	0.0002	0.0002	B	0.00049	0.0009	0.00049	Updated B
2,3,4,7,8-PeCDF	n/a	n/a	0.0002	0.004	0.0003	0.0003	B	0.00044	0.0006	0.00044	Updated B

General Notes:

1. Basis for CUL is B = background; R-eco = risk-based, ecological; R-HH = risk-based, human health.

Footnotes:

a. Table B3-4 of Appendix B of FS and Proposed ESD for cPAHs (EPA 2016b, 2018).
b. Table B4-1 of Appendix B of FS (EPA 2016b).
c. Table B3-5 of Appendix B of FS and Proposed ESD for cPAHs (EPA 2016b, 2018). cPAHs Based on shellfish consumption as calculated in Proposed ESD (EPA 2018).
d. Table B4-2 of Appendix B of FS (EPA 2016b).
e. Table 7.3-1 of RI (EPA 2016a) and Table B2-4 of FS for dioxin/furan COCs (EPA 2016b).
f. Table 17 of ROD and Proposed ESD for cPAHs (EPA 2017, 2018).
g. Upstream data include n=59 samples collected from the Downtown and Upriver Reaches (i.e., river miles ~11.8 to 28.2).
95 UCL values represent the central tendency value of the achievable concentration at the Site.
Calculations performed in accordance with ProUCL v5.1 recommendations and methods specified in EPA (2013).
Kaplan-Meier (KM) or regression on order (ROS) - based statistics are presented for the analytes with non-detects: DDx, 2,3,7,8-TCDD, 1,2,3,7,8,-PeCDD, 2,3,4,7,8- PeCDF.
h. Surface Sediment Location B459 excluded for Total PCBs and Total PAHs (n=58).
i. When all multi-media solids concentrations are evaluated together (bedded sediment, sed traps, surface water particulates) background concentration for DDx is 11.8 µg/kg.

Acronyms:

µg/kg = micrograms per kilogram
COC = contaminant of concern
cPAH = carcinogenic polycyclic aromatic hydrocarbon
CUL = cleanup level
DDx = dichlorodiphenyltrichloroethane and its derivatives
D/U = Downtown/Upriver Reach
EPA = U.S. Environmental Protection Agency
ESD = Explanation of Significant Differences
FS = feasibility study
n/a = not available
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
PDI = Pre-Remedial Design Investigation
PeCDD = pentachlorodibenzo-p-dioxin
PeCDF = pentachlorodibenzofuran
PRG = preliminary remediation goal
RAO = remedial action objective
ROD = Record of Decision
TCDD = tetrachlorodibenzo-p-dioxin
UCL = upper confidence limit on the arithmetic mean
R-eco = risk-based, ecological; R-HH = risk-based, human health

Table 3.2. Background COC Concentrations for Arsenic and Manganese in Porewater

COC (in mg/L)	ROD CUL (Groundwater)[a]	2018 Background Porewater Concentrations		
		Mean	95 UCL	USL[b]
Arsenic	0.000018	0.03	0.039	0.058
Manganese	0.43	12.03	17.9	32

General Notes:

1. Upstream data include n=10 samples collected from the Downtown and Upriver Reaches. One duplicate was averaged.

Footnotes:

a. Basis for ROD CUL was applied without Site-specific data to establish the CUL.

b. Background threshold values are based on 95% USLs and were calculated using ProUCL v5.1 in accordance with EPA (2013).

Acronyms:

COC = contaminant of concern
CUL = cleanup level
mg/L= milligram per liter
ROD = Record of Decision
UCL = upper confidence limit on the arithmetic mean
USL = upper simultaneous limit

Table 3.3. Updated Fish Tissue Targets for Focused COCs

Focused COC for Fish Tissue (in µg/kg-ww)	ROD Tissue Target [a]	Updated Risk-based Fish Tissue Targets Adult/Child Subsistence Fisher (fillet) [d]				Background Concentrations (fillet) [e,f]		Background Concentrations (whole body) [e]	
		Risk = 10^{-6}	Risk = 10^{-5}	Risk = 10^{-4}	HQ = 1	95 UCL Range	UTL Range	95 UCL Range	UTL Range
Total PCBs	0.25 [c]	--	--	--	0.9	16 - 25	37 - 70	125 - 200	300 - 560
Total PCBs	0.5 [b]	1.3	12.5	125	12	16 - 25	37 - 70	125 - 200	300 - 560
DDx	3 [b]	7.1	71	712	282	7 - 11	13 - 19	50 - 80	100 - 140
2,3,7,8-TCDD	0.000008 [b]	2E-05	2E-04	2E-03	5E-04	5E-05 - 1E-03	7E-05 - 3E-03	3E-04 - 7E-03	4E-04 - 2E-02
1,2,3,7,8-PeCDD	0.000008 [b]	2E-05	2E-04	2E-03	5E-04	8E-05 - 3E-03	2E-04 - 1E-02	5E-04 - 2E-02	1E-03 - 7E-02
2,3,4,7,8-PeCDF	0.00003 [b]	8E-05	8E-04	8E-03	2E-03	5E-05 - 8E-05	1E-04 - 2E-04	3E-04 - 5E-04	7E-04 - 1E-03

Footnotes:

a. EPA 2017 (ROD Table 17). Based on subsistence angler fish consumption (fillet-based).

b. Based on subsistence fisher (adult/child) consumption of fish (142 grams per day) at a cancer risk level of 10^{-6}.

c. Based on nursing infant of adult subsistence fisher at an HQ of 1.

d. Updated risk-based target tissue concentrations calculated using updated exposure assumptions including FCR of 81.2 grams/day (adult) & 29.6 grams/day (child), body weight, and exposure duration (EPA 2014b,c). See Appendix G, Exhibit A for basis of updated exposure assumptions for subsistence fisher. Appendix G also provides fish tissue targets for TCDD-TEQ.

e. See Appendix F.2 for derivation of background threshold values for fish tissue. Range reflects analysis by Downtown Reach only, Upriver Reach only, and D/U combined, also with and without one UR sample with elevated concentrations of dioxin and furan congeners (PDI-TF-SMB117).

f. Fillet tissue concentrations calculated from whole body concentrations by dividing by whole body-to-fillet ratios (EPA 2016b): PCBs = 8.02; DDx = 7.17; dioxin/furan congeners = 6.13.

Acronyms:

µg/kg ww= micrograms per kilogram wet weight
COC = contaminant of concern
CUL = cleanup level
DDx = dichlorodiphenyltrichloroethane and its derivatives
EPA = U.S. Environmental Protection Agency
ESD = Explanation of Significant Differences
FCR = fish consumption rate
HQ = hazard quotient
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
PeCDD = pentachlorodibenzo-p-dioxin
PeCDF = pentachlorodibenzofuran
PRG = preliminary remediation goal
RAO = remedial action objective
ROD = Record of Decision
TCDD = tetrachlorodibenzo-p-dioxin
TEQ = toxicity equivalence
UCL = upper confidence limit on the arithmetic mean
UR = Upriver Reach
UTL = upper tolerance limit (95% with 95% coverage)

Table 3.4. Updated RALs Compared to ROD RALs

Focused COC (in µg/kg)	ROD RALs		Updated RAL Based on 2018 PDI Data		
	Site-Wide RAL	Navigation Channel RAL	Updated Site-wide RAL	Basis for Update to Site-wide RAL	Navigation Channel RAL (No Change)
Total PCBs	75	1,000	350	Same target SWAC as post-Alternative F Modified SWAC reported in ROD	1,000
Total PAHs	30,000 (proposed ESD)	170,000	30,000	Proposed ESD RALs (direct contact with in-water sediment)	170,000
DDx	160 [a]	650	578	ROD RAO 5	650
2,3,7,8-TCDD	0.0006 [a]	0.002	0.0011	95 UCL of PDI D/U data	0.002
1,2,3,7,8-PeCDD	0.0008 [a]	0.003	0.025	95 UCL of PDI D/U data	0.025 [b]
2,3,4,7,8-PeCDF	0.2 [a]	1	0.35	Same target SWAC as post-Alternative F Modified SWAC reported in ROD	1

General Notes:

1. PDI SWACs determined using natural neighbor 10x10 foot interpolation grids.
2. See Appendix I for RAL curve selection details.
3. In the PDI Work Plan, the term spatially weighted average concentration (SWAC) is used. In previous Site documents including the ROD, the SWAC term is also defined as surface area weighted average concentrations. For surface sediments, these terms can be used interchangeably. For this report, the term spatially weighted average concentration is used to remain consistent with the PDI Work Plan.

Footnotes:

a. The ROD RAL curves cover a small area of the site where there was adequate data coverage, then the RAL was applied Site-wide. For the PDI data evaluation, Site-wide RAL curves were developed with the Site-wide 2018 dataset.

b. 1,2,3,7,8-PeCDD navigation channel RAL is different from the ROD navigation channel RAL, as a result of the updated Site-wide RAL being higher than the ROD navigation channel RAL.

Acronyms:

µg/kg = microgram per kilogram
COC = contaminant of concern
D/U = Downtown/Upriver
DDx = dichlorodiphenyltrichloroethane and its derivatives
ESD = Explanation of Significant Differences
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
PDI = pre-remedial design investigation
PeCDD = pentachlorodibenzo-p-dioxin
PeCDF = pentachlorodibenzofuran
RAL = remedial action level
RAO = remedial action objective
ROD = Record of Decision
SWAC = spatially weighted average concentration
TCDD = tetrachlorodibenzo-p-dioxin
UCL = upper confidence limit on the arithmetic mean

Table 3.5. SWACs Outside of SMAs and Comparison to Other Average Concentrations

Focused COC and Arsenic	Units	PDI 2018/2019 Average Sediment Concentrations					
		SWAC Outside of ROD SMAs	SWACs in Depositional Areas of Site	Average D/U Sediment Trap	95 UCL D/U Sediment Trap	Average D/U Surface Water Particulate	95 UCL D/U Surface Sediment
Total PCBs	µg/kg	20.0	20.6	9.68	19.1	20.2	20.4
Total PAHs	µg/kg	3,660	2,990	148	194	671	488
DDx	µg/kg	7.9	28.6	2.89	3.45	34.5	5.6
2,3,7,8-TCDD	ng/kg	0.2	0.28	0.63	0.64	3.5	0.25
1,2,3,7,8-PeCDD	ng/kg	0.4	0.40	0.72	0.52	3.4	0.49
2,3,4,7,8-PeCDF	ng/kg	0.9	3.8	0.60	0.43	2.8	0.44
Arsenic	mg/kg	5.1 [a]	n/c	6.8	7.8	n/c	4.0

General Notes:

1. Depositional area defined as > 1.2 feet of elevation changed (2004-2018 bathymetry).
2. 95 UCL calculated for PCBs and PAHs with one upstream sample removed.
3. Surface water particulate fraction converted to particulate per unit of mass based on total solids results.
4. Surface water and sediment trap average values calculated for three rounds of sampling.
5. SWACs based on ROD interpolation area of 2,190 acres.

Footnotes:

(a) 95 UCL of samples outside of Refined SMA is presented; SWACs were not calculated for Arsenic

Acronyms:

µg/kg = micrograms per kilogram
COCs = contaminants of concern
D/U = Downtown/Upriver Reach
DDx = dichlorodiphenyltrichloroethane and its derivatives
n/c = not calculated
ng/kg = nanograms per kilogram
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
PDI = Pre-Remedial Design Investigation
PeCDD = pentachlorodibenzo-p-dioxin
PeCDF = pentachlorodibenzofuran
ROD = Record of Decision
SMA = sediment management area
SWAC = spatially weighted average concentration
TCDD = tetrachlorodibenzo-p-dioxin
UCL = upper confidence limit on the arithmetic mean
UTL95-95 = 95% upper tolerance limit with 95% coverage

Table 4.1. Comparison of Refined and ROD SMA Acres and Volumes

Report	SMA (acres)	Volume (cy) [b]
EPA Portland Harbor Proposed Plan (June 2016)	290	1,885,000
ROD Alternative F modified [a]	365	3,666,427
ESD Alternative F modified	348	3,622,627
Preliminary Refined SMA	320	2,219,820 (to 5 ft)
Refined SMA (Evaluation Report)	111	895,000 (to 5 ft)

General Notes:

1. The ROD Alternative F Modified and ESD Alternative F Modified used the same dataset, but the ESD used an updated RAL for Total PAHs.
2. The ROD and ESD RALs (for PAHs) were used for the ESD and the Preliminary Refined SMAs, but the latter used the PDI SMA dataset (which added 2018 and post-FS data from the ROD/FS dataset). The PDI Footprint Report (AECOM and Geosyntec 2018) included updated 2018 data.
3. The Preliminary Refined SMA and Refined SMAs were delineated with the same dataset (the PDI SMA mapping dataset); however, the Refined SMAs were drawn with the updated RALs.
4. The refined SMAs are based on updated RAL exceedances for three COCs (Total PCBs, Total PAHs, DDx). Contaminated sediment volume calculated for the upper 5 ft of sediment.

Footnotes:

a. Value was taken from the EPA ROD Table D2.d. Page 12. Volume presents the dredge volume and not riverbank excavation or capping.

b. Volume contaminated above ROD RALs for the EPA documents. Volume inventory to 5 ft depth for the Preliminary Refined SMA and Refined SMA.

Acronyms:

COC = contaminant of concern
cy = cubic yards
DDx = dichlorodiphenyltrichloroethane and its derivatives
EPA = U.S. Environmental Protection Agency
ESD = Explanation of Significant Differences
FS = Feasibility Study
ft = feet
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
PDI = pre-remedial design investigation
RAL = remedial action level
ROD = Record of Decision
SMA = sediment management area

Table 4.2. Site COCs Addressed by Refined SMA Footprint

COC	ROD CUL River Bank Soil/Sediment		# of PDI sample locations	PDI Sample Locations with Concentration above ROD CUL			PDI Sample Locations with Concentration above 5x ROD CUL			PDI Sample Locations with Concentration above 10x ROD CUL		
	Unit	Concentration		Total # of locations	# within Refined SMA	% of samples inside SMA	Total # of locations	# within Refined SMA	% of samples inside SMA	Total # of locations	# within Refined SMA	% of samples inside SMA
Aldrin	µg/kg	2	424	0	0	100%	0	0	100%	0	0	100%
Arsenic [a]	mg/kg	4.0	424	348	17	22%	1	0	100%	0	0	100%
BEHP	µg/kg	135	424	72	10	85%	13	2	97%	3	0	99%
Cadmium	mg/kg	0.51	424	7	2	99%	0	0	100%	0	0	100%
Chlordanes	µg/kg	1.4	424	135	13	71%	7	3	99%	3	3	100%
Copper	mg/kg	359	424	1	0	100%	0	0	100%	0	0	100%
DDD	µg/kg	114	655	11	11	100%	2	2	100%	1	1	100%
DDE	µg/kg	226	655	2	2	100%	0	0	100%	0	0	100%
DDT	µg/kg	246	655	6	6	100%	2	2	100%	2	2	100%
Dieldrin	µg/kg	0.07	424	28	4	94%	28	4	94%	11	4	98%
Lindane	µg/kg	5	424	0	0	100%	0	0	100%	0	0	100%
Lead	mg/kg	196	424	0	0	100%	0	0	100%	0	0	100%
Mercury	mg/kg	0.085	424	85	10	82%	3	1	100%	1	0	100%
1,2,3,4,7,8-HxCDF	µg/kg	0.0004	655	573	54	21%	299	47	62%	174	41	80%
1,2,3,7,8-PeCDD [a]	µg/kg	0.00049	655	229	30	70%	20	4	98%	5	1	99%
2,3,4,7,8-PeCDF [a]	µg/kg	0.00044	655	350	52	55%	106	30	88%	53	22	95%
2,3,7,8-TCDD [a]	µg/kg	0.00025	655	264	32	65%	27	8	97%	11	2	99%
2,3,7,8-TCDF	µg/kg	0.00041	655	531	54	27%	148	34	83%	73	24	93%
TPH-Diesel	mg/kg	91	424	87	14	83%	12	7	99%	6	5	100%
Tributyltin	µg/kg	3080	424	2	0	100%	0	0	100%	0	0	100%
Zinc	mg/kg	459	424	0	0	100%	0	0	100%	0	0	100%

General Notes:

1. Only 2018 PDI samples were analyzed for PDI CUL exceedances. SMA footprint based on 111-acre 3-focused COCs.
2. Values taken from FS Tables 2.2-8 and 2.2-12.
3. This table does not show the three focused COCs (Total PCBs, Total PAHs, or DDx).

Footnotes:

a. Arsenic and dioxin background-based CULs have been updated based on 95 UCL of PDI upstream data. See Appendix F.1.

Acronyms:

= number (count)
µg/kg = micrograms per kilogram
B = background-based number
BEHP = bis(2-ethylhexyl)phthalate
COC = contaminant of concern
Conc. = concentration
CUL = cleanup level
DDD = dichlorodiphenyldichloroethane
DDE = dichlorodiphenyldichloroethylene
DDT = dichlorodiphenyltrichloroethane
DDx = dichlorodiphenyltrichloroethane and its derivatives
FS = feasibility study
GIS = geographic information system
HxCDF = hexachlorodibenzofuran
mg/kg = milligram per kilogram
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
PDI = Pre-Remedial Design Investigation
ROD = Record of Decision
TPH = total petroleum hydrocarbon
SMA = sediment management area

Table 4.3. Estimated Post-Construction Site-wide SWACs for the Focused COCs

Focused COC (in µg/kg)	ROD Site-wide SWAC	2018 PDI Data	
		2018 Pre-Remedy Site-Wide SWAC	Estimated Post-Construction (Time 0) Site-wide SWAC
Total PCBs	92	44	26
Total PAHs	36,000	7,710	3,980
DDx	52	36	8.1
2,3,7,8-TCDD	0.0009	0.0003	0.0003
1,2,3,7,8-PeCDD	0.0005	0.0014	0.0013
2,3,4,7,8-PeCDF	0.017	0.0051	0.0014

General Notes:

1. ROD SWAC values were taken from Figures 10 through 15.
2. 2018 SWACs were calculated using Natural Neighbor interpolation. More detail discussing the Site-wide SWAC calculation is provided in Appendix D.2.
3. Post-remedy SWACs were calculated by replacing grid cells located within the 111-acre 3-focused COC SMA footprint with bed replacement value. Bed replacement values are discussed in Appendix I.
4. 2018 pre-remedy baseline SWAC and the estimated post-construction SWAC use 2018 PDI data.

Acronyms:

µg/kg = micrograms per kilogram
COC = contaminant of concern
DDx = dichlorodiphenyltrichloroethane and its derivatives
PAH = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyl
PDI = pre-remedial design investigation
PeCDD = pentachlorodibenzo-p-dioxin
PeCDF = pentachlorodibenzofuran
ROD = Record of Decision
SMA = sediment management area
SWAC = spatially weighted average concentration
TCDD = tetrachlorodibenzo-p-dioxin

Table 4.4. Pre- and Post-Construction (Time 0) Nearshore Sediment Site-Wide Cancer Risks and Noncancer Hazards
Direct Contact RAO 1 - Tribal Fisher

Focused COC	Cancer Risk - Nearshore Sediment Direct Contact - Tribal Fisher						
	2018 Pre-Remedy	Estimated Time 0 Post-Construction					
	Cancer Risk	Nearshore SWAC [a] Three Focused COCs (µg/kg)	Cancer Risk	Risk Reduction	Nearshore SWAC [b] Six Focused COCs (µg/kg)	Cancer Risk	Risk Reduction
Total PCBs	4.65E-08	39.2	2.32E-08	50%	36.7	2.18E-08	53%
BaP-TEQ	1.39E-07	234	6.62E-08	52%	217	6.15E-08	56%
DDx	3.68E-09	12.4	6.36E-10	83%	11.6	5.95E-10	84%
2,3,7,8-TCDD	7.97E-09	0.000358	7.03E-09	12%	0.000284	5.57E-09	30%
1,2,3,7,8-PeCDD	4.99E-08	0.00242	4.75E-08	5%	0.00061	1.20E-08	76%
2,3,4,7,8-PeCDF	9.78E-08	0.0025	2.34E-08	76%	0.0022	2.10E-08	79%
Total	**3.45E-07**		**1.68E-07**	**51%**		**1.22E-07**	**64%**

Focused COC	Noncancer Hazard - Nearshore Sediment Direct Contact - Tribal Fisher						
	2018 Pre-Remedy	Estimated Time 0 Post-Construction					
	Noncancer Hazard Index	Nearshore SWAC [a] Three Focused COCs (µg/kg)	Noncancer Hazard Index	HI Reduction	Nearshore SWAC [b] Six Focused COCs (µg/kg)	Noncancer Hazard Index	HI Reduction
Total PCBs	1.16E-03	39.2	5.81E-04	50%	36.7	5.44E-04	53%
BaP-TEQ	4.62E-04	234	2.21E-04	52%	217	2.05E-04	56%
DDx	2.16E-05	12.4	3.74E-06	83%	11.6	3.50E-06	84%
2,3,7,8-TCDD	8.76E-05	0.000358	7.72E-05	12%	0.000284	6.13E-05	30%
1,2,3,7,8-PeCDD	5.48E-04	0.00242	5.22E-04	5%	0.00061	1.31E-04	76%
2,3,4,7,8-PeCDF	6.04E-03	0.0025	1.44E-03	76%	0.0022	1.30E-03	79%
Total	**8.32E-03**		**2.85E-03**	**66%**		**2.24E-03**	**73%**

General Notes:

1. Nearshore sediment SWACs (excluding the navigation channel and including SIL from RM 1.9 up to RM 11.8, both sides of river) were calculated using PDI SRS and SMA data and Natural Neighbor interpolation.
2. Post-construction SWACs were calculated by replacing Site data located within the Refined SMA footprint with the associated bed replacement value, as discussed in Appendix I.
3. BaP-TEQ SWACs were calculated from total PAH SWACs using regression equation presented in the Feasibility Study (Appendix D, Section D5) (EPA 2016b).
4. Pre-and Post-Construction cancer risk and noncancer hazard were calculated in Appendix J.

Footnotes:

a. Nearshore sediment SWACs were calculated from Refined SMA footprint based on PDI SRS and SMA data for three focused COCs (Total PCBs, Total PAHs, and DDx).

b. Nearshore sediment SWACs were calculated from Refined SMA footprint based on PDI SRS and SMA data for all six focused COCs (Total PCBs, Total PAHs, DDx, 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, and 2,3,4,7,8-PeCDF).

Acronyms:

µg/kg = micrograms per kilogram
BaP-TEQ = benzo(a)pyrene toxicity equivalence
COC = contaminant of concern
DDx = dichlorodiphenyltrichloroethane and its derivatives
EPA = U.S. Environmental Protection Agency
HI = hazard index
PAH = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyl
PeCDD = pentachlorodibenzo-p-dioxin
PeCDF = pentachlorodibenzofuran
RAO = remedial action objective
RM = river mile
ROD = Record of Decision
SMA = sediment management area
SRS = stratified random sampling
SWAC = spatially weighted average concentration
TCDD = tetrachlorodibenzo-p-dioxin

Table 4.5. Post-Construction (Time 0) Nearshore Sediment River Mile Cancer Risks and Noncancer Hazards - Direct Contact RAO 1 - Tribal Fisher

River Reach	SMA Footprint Based on Total PCBs, DDx, and Total PAHs		SMA Footprint Based on Six Focused COCs	
	Total Potential Cancer Risk	Total Potential HI	Total Potential Cancer Risk	Total Potential HI
River Mile 1.9 to 3 East	8.47E-08	1.09E-03	8.47E-08	1.09E-03
River Mile 1.9 to 3 West	5.60E-08	4.27E-04	5.60E-08	4.27E-04
River Mile 3 to 4 East	9.22E-08	1.07E-03	9.22E-08	1.07E-03
River Mile 3 to 4 West	1.48E-07	1.03E-03	1.48E-07	1.03E-03
River Mile 4 to 5 East	2.17E-07	1.95E-03	2.03E-07	1.83E-03
River Mile 4 to 5 West	2.58E-07	1.52E-03	2.53E-07	1.47E-03
River Mile 5 to 6 East	1.84E-07	1.88E-03	1.48E-07	1.58E-03
River Mile 5 to 6 West	1.69E-07	1.24E-03	1.69E-07	1.24E-03
River Mile 6 to 7 East	4.34E-07	1.59E-02	1.62E-07	2.25E-03
River Mile 6 to 7 West	2.63E-07	2.20E-03	2.54E-07	2.10E-03
River Mile 7 to 8 East	1.39E-07	1.88E-03	1.17E-07	1.53E-03
River Mile 7 to 8 West	5.13E-07	5.80E-03	4.61E-07	5.23E-03
River Mile 8 to 9 East	3.62E-08	6.19E-04	3.62E-08	6.19E-04
River Mile 8 to 9 West	9.87E-08	1.71E-03	9.01E-08	1.58E-03
River Mile 9 to 10 East	3.78E-08	6.37E-04	3.78E-08	6.37E-04
River Mile 9 to 10 West	4.74E-08	7.08E-04	4.61E-08	6.91E-04
River Mile 10 to 11 East	4.79E-08	8.63E-04	4.79E-08	8.63E-04
River Mile 10 to 11 West	5.55E-08	7.41E-04	5.35E-08	7.10E-04
River Mile 11 to 11.8 East	9.36E-08	2.01E-03	9.36E-08	2.01E-03
River Mile 11 to 11.8 West	2.33E-08	3.61E-04	2.33E-08	3.61E-04
Swan Island Lagoon	1.67E-07	2.89E-03	1.58E-07	2.74E-03

General Notes:

1. Post-Construction cancer risk and noncancer hazard were calculated in Appendix J.

Acronyms:

COC = contaminant of concern
DDx = dichlorodiphenyltrichloroethane and its derivatives
HI = hazard index
PAH = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyl
RAO = remedial action objective
SMA = sediment management area

Table 4.6. Comparison of Updated RALs and SMAs to FS Alternatives

Focused COC	FS/ROD Alternatives			ROD Selected Remedy Alternative F Modified	PDI Refined SMA Footprint
	Alt C	Alt D	Alt E		
Remedial Action Levels (µg/kg) (Site-wide)					
Total PCBs	750	500	200	75	350
Total PAHs	130,000	69,000	35,000	30,000 (ESD)	30,000
DDx	550	450	300	160	578
2,3,7,8-TCDD	0.002	0.002	0.0006	0.0006	0.001 (n/i)
1,2,3,7,8-PeCDD	0.002	0.0008	0.0008	0.0008	0.025 (n/i)
2,3,4,7,8-PeCDF	1	1	0.2	0.2	0.35 (n/i)
Other Parameters					
SMA Footprint Size (Acres) [a]	117	177	269	365	111
Meets CERCLA Threshold Criteria [b]	n/a	Yes	Yes	Yes	Yes
Long-term Effectiveness and Permanence [b]	n/a	Low	Moderate	Better	Better
Estimated Construction Years [c]	5	6	7	13	n/c
RAO 2 Post-Construction Risk Reduction	n/a	70%	74%	78%	n/c
Percent of Area Exceeding 10x Benthic Risk addressed [d]	n/a	64%	73%	72%	72%

General Notes:

1. Dioxins/furans were not included in delineation of Refined SMA footprint.

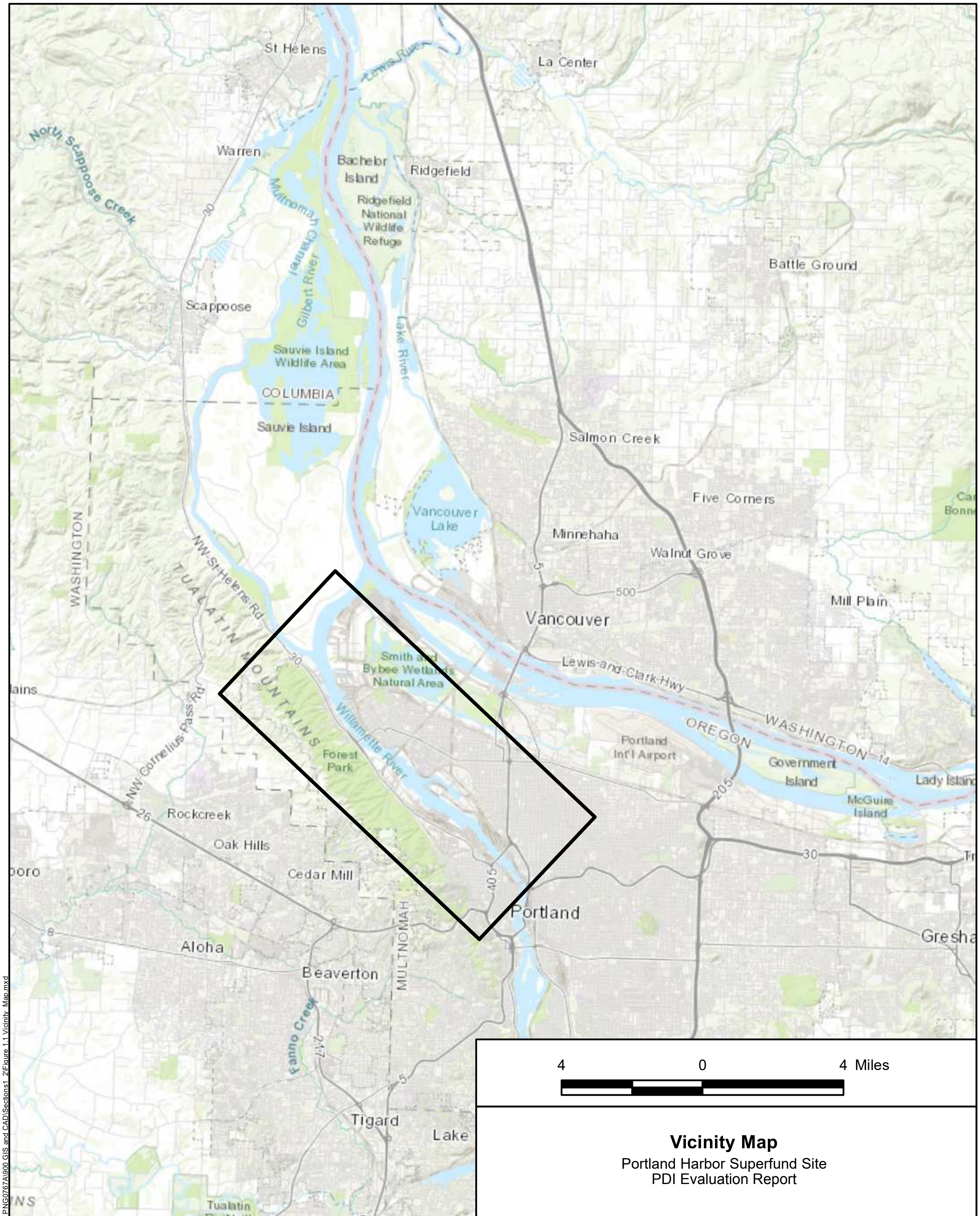
Footnotes:

a. ROD Table 20.
b. ROD Table 23.
c. ROD Table 26.
d. ROD Table 4.2-7, 1,289 acres within the Site using RI/FS dataset.

Acronyms:

µg/kg = micrograms per kilogram
Alt = alternative
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
DDx = dichlorodiphenyltrichloroethane and its derivatives
ESD = Explanation of Significant Differences
FS = feasibility study
n/c = not calculated
n/i = not included in delineation of Refined SMA footprint
PAH = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyl
PDI = Pre-Remedial Design Investigation
PeCDD = pentachlorodibenzo-p-dioxin
PeCDF = pentachlorodibenzofuran
RAL = remedial action level
RAO = remedial action objective
RI = remedial investigation
ROD = Record of Decision
SMA = sediment management area
TCDD = tetrachlorodibenzo-p-dioxin

FIGURES



4 0 4 Miles

Vicinity Map
Portland Harbor Superfund Site
PDI Evaluation Report

Legend

Site Location

N

Notes:
1. Topographical map provided by ESRI Basemaps 2016

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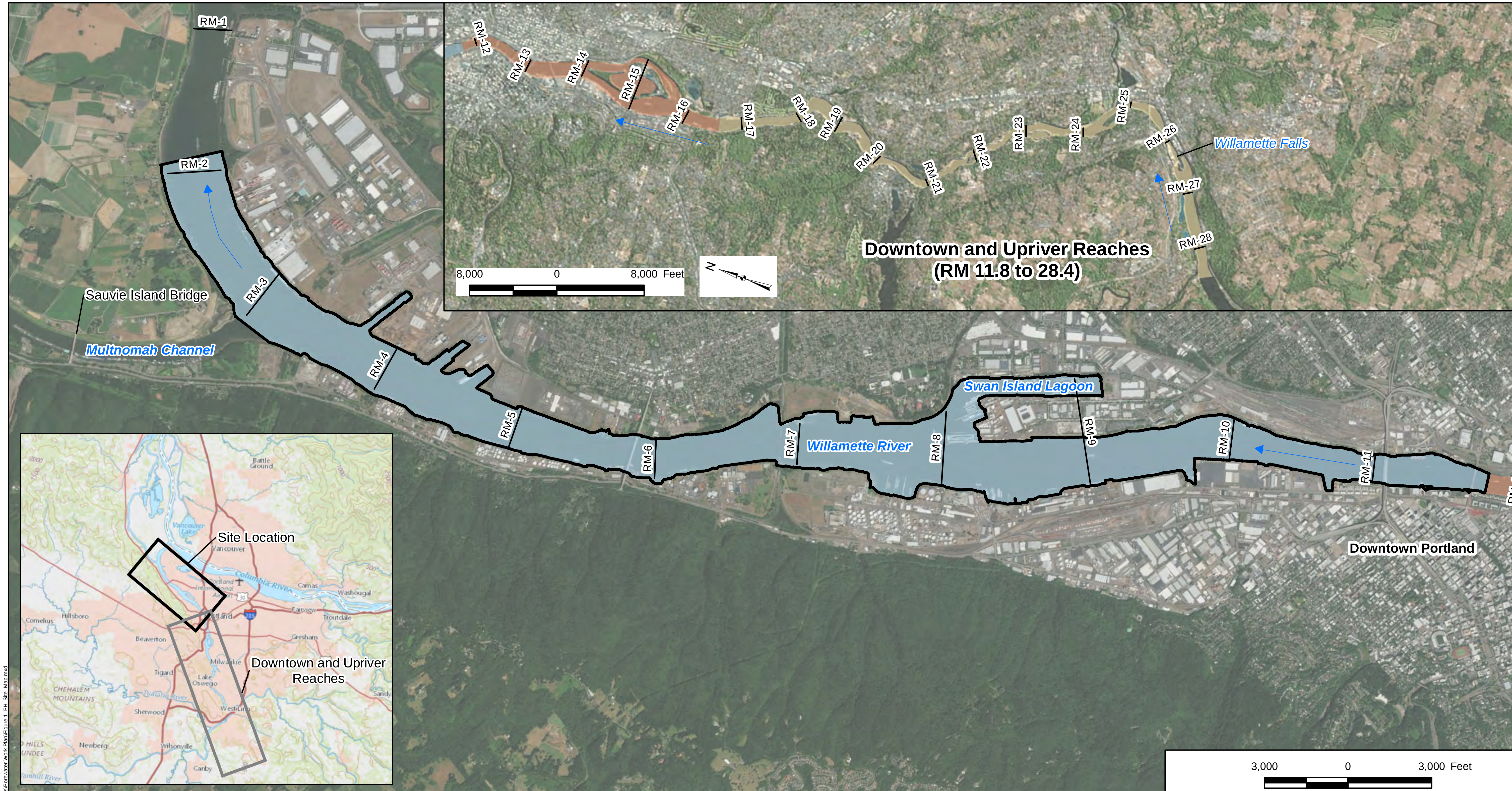
Figure **1.1**

Path: P:\Projects\Portland Pre-Design P\NG0767A\900 GIS and CAD\Sections1_2\Figure 1.1 Vicinity_Map.mxd



Legend

- Flow Direction
- River Mile Marker
- Superfund Site Boundary (RM 1.9 to 11.8)

Study Area

- Site Area (RM 1.9 to 11.8)
- Downtown Reach (RM 11.8 to 16.6)
- Upriver Reach (RM 16.6 to 28.4)

Note:
1. Aerial Imagery provided by ESRI Basemaps 2016

N

Portland Harbor Site Map

Portland Harbor Superfund Site
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Figure

1.2

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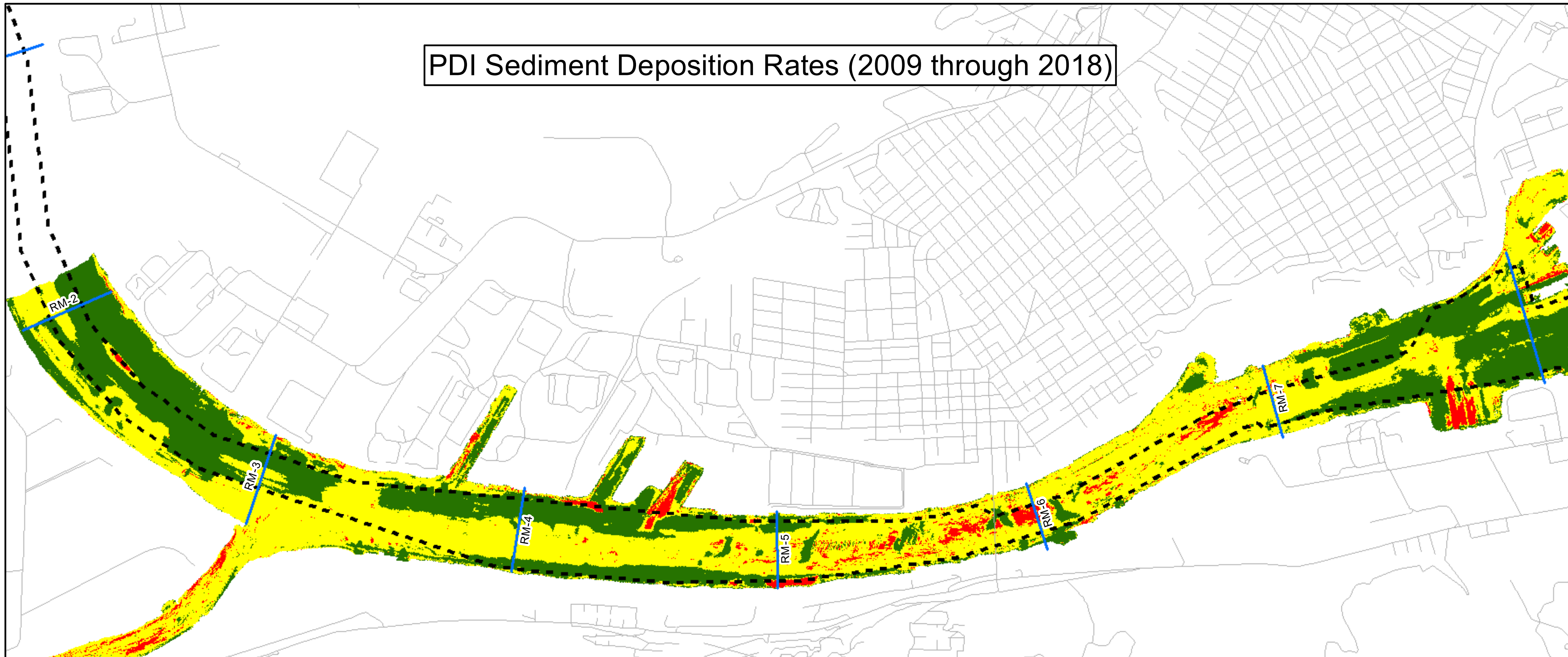

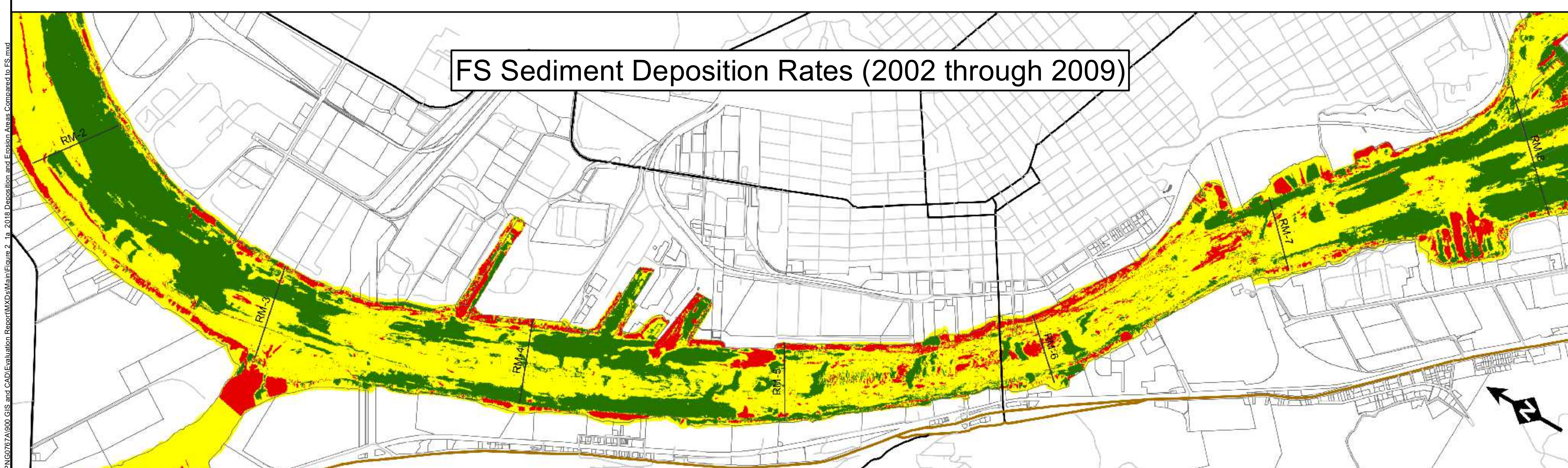

Legend

- Erosional: -2.5 cm/yr or more
- Neutral: -2.5 to 2.5 cm/yr
- Depositional: 2.5 cm/yr or more
- Navigation Channel
- River Mile Marker

Note:
1. FS Sediment Deposition Rates for 2002 to 2009, taken from FS Figure 3.4-20

N

1,200 600 0 1,200 2,400 Feet

2018 Deposition and Erosion Areas Compared to FS RM 1.9 to 8.0

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Figure **2.1a**

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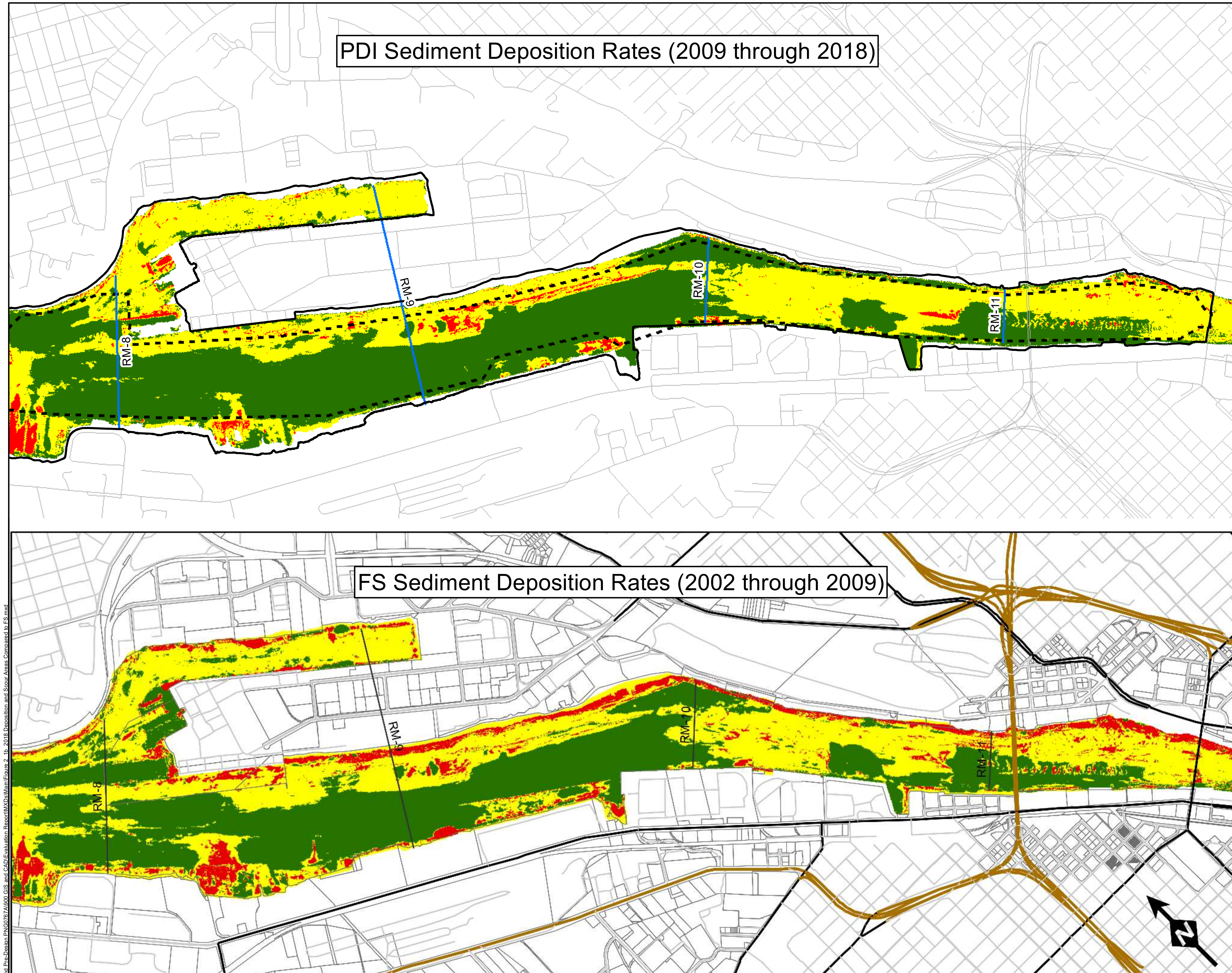

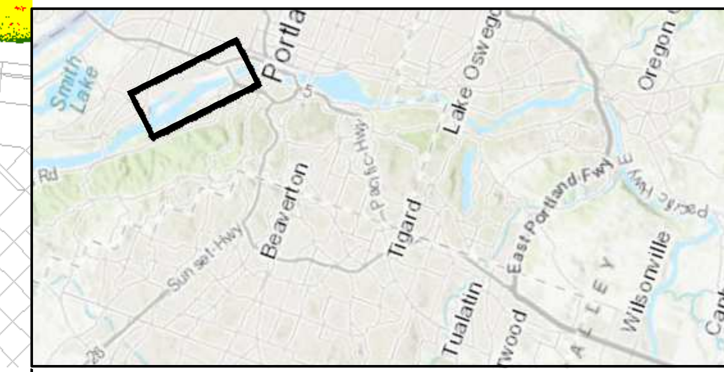

Legend

- Erosional: -2.5 cm/yr or more
- Neutral: -2.5 to 2.5 cm/yr
- Depositional: 2.5 cm/yr or more
- Navigation Channel
- River Mile Marker

Note:
1. FS sediment Deposition Rates for 2002 to 2009, taken from FS Figure 3.4-20

1,200 600 0 1,200 2,400 Feet

2018 Deposition and Erosion Areas Compared to FS RM 8.0 to 11.8

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Figure **2.1b**

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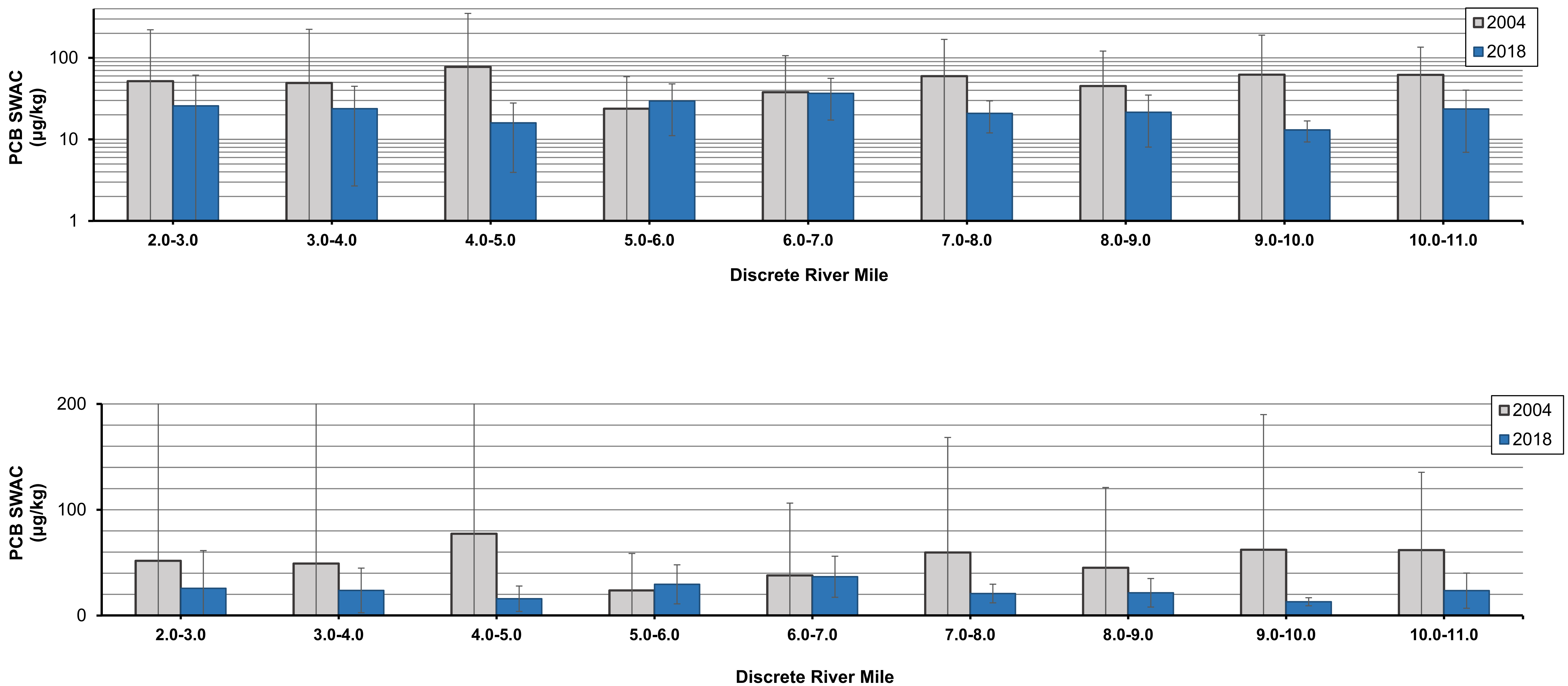

Notes:
1. SWAC calculations based on ROD Site acreage estimate of 2,190 acres.
2. Insufficient PCB data available to support 2004 SWAC calculation in RM 11.0 – 11.8.

Comparison of 2004 and 2018 Surface Sediment SWACs by River Mile for PCBs

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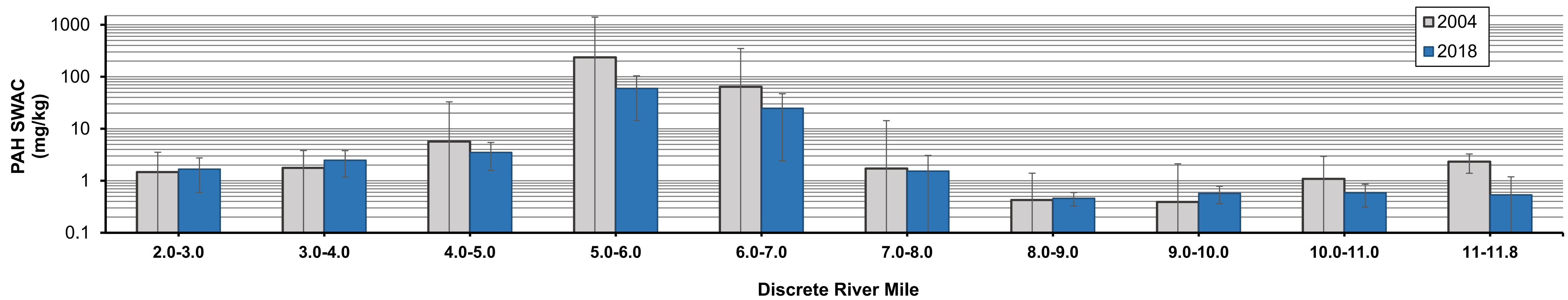
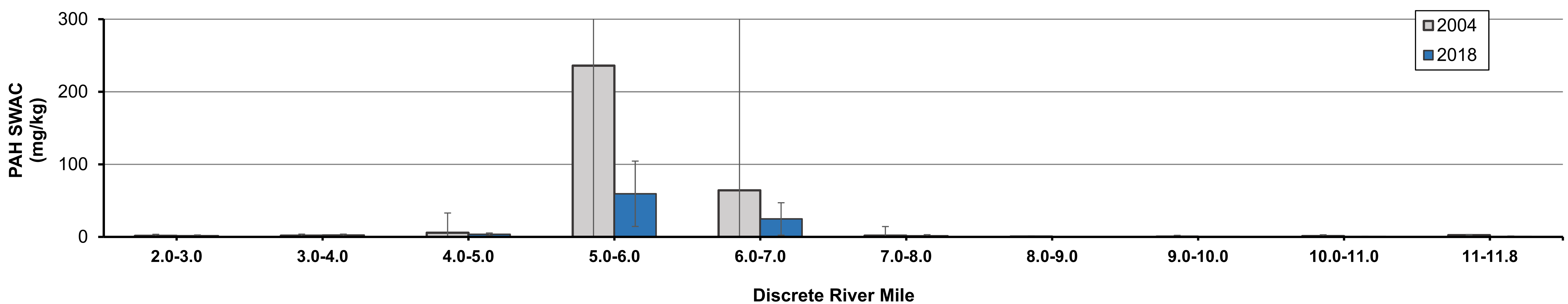
Figure 2.2a





Notes:
1. SWAC calculations based on ROD Site acreage estimate of 2,190 acres.

Comparison of 2004 and 2018 Surface Sediment SWACs by River Mile for TPAHs

Portland Harbor Superfund Site
PDI Evaluation Report

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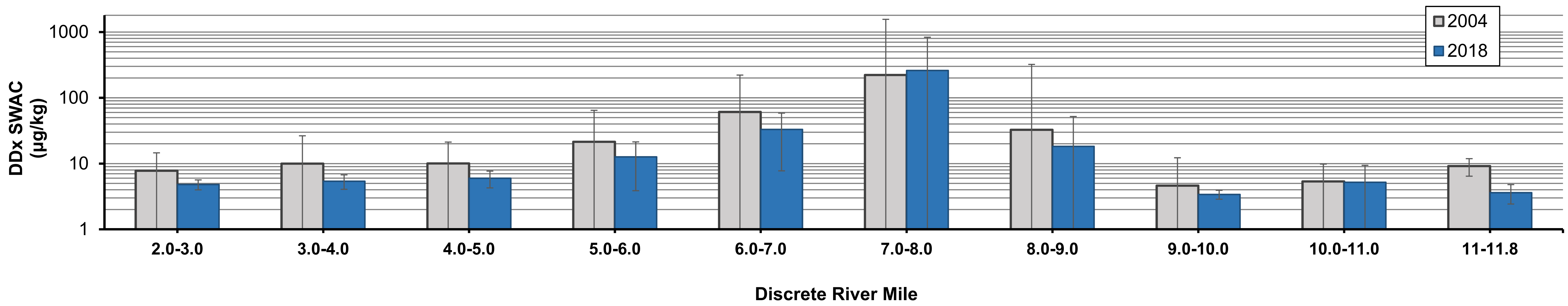

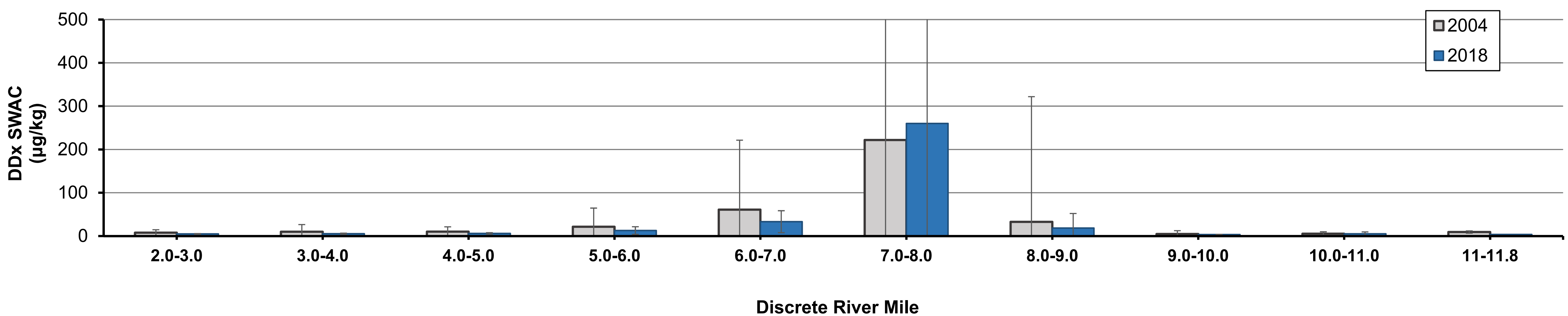

Notes:
1. SWAC calculations based on ROD Site acreage estimate of 2,190 acres.

Comparison of 2004 and 2018 Surface Sediment SWACs by River Mile for DDx

Portland Harbor Superfund Site
PDI Evaluation Report

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Figure 2.2c

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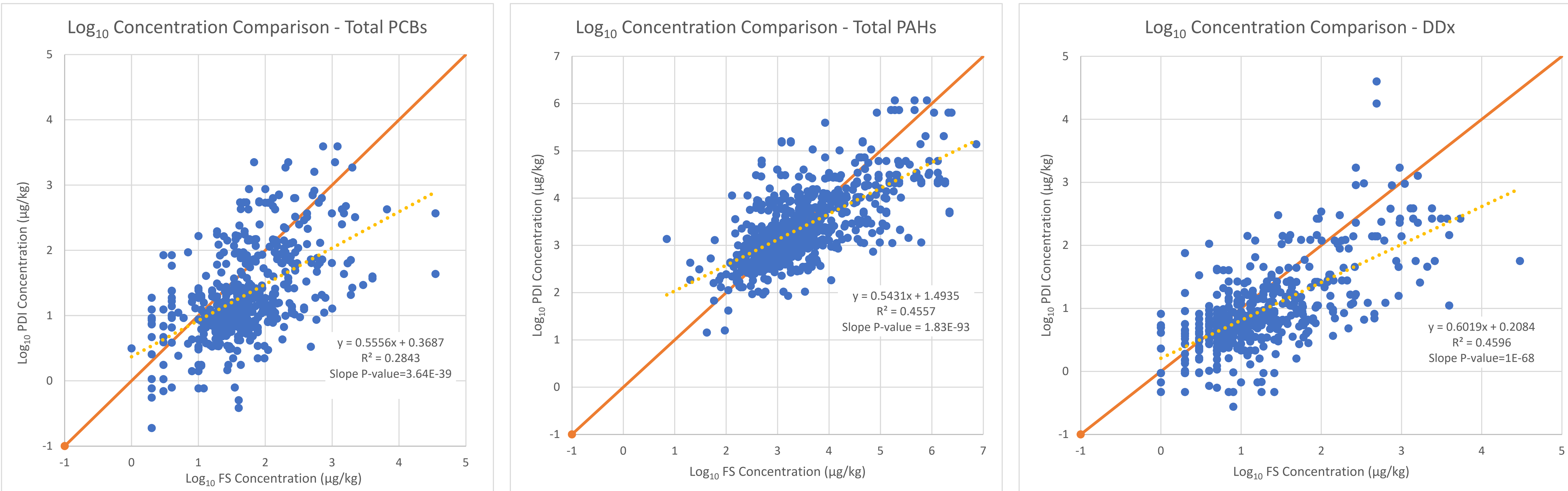
\\seattle-01\data\Projects\Portland Pre-Design PNG0767A\600 Deliverables (AECOM&Geosyntec)\z_PDI Evaluation Report\Main Text\Figures\v4 (6.10.19)\Fig 2.2 SWAC RMs\[ttest (2004 vs 2018) TP SWACs-Rolling RM (060719)_MJ.xlsx]Figure 2.2a



Notes:
1. Plotted concentrations are from surface samples collected in the FS and the PDI that are within 100 ft of each other.
2. A p-value of <0.05 indicates statistical significance.

- Proximate Surface Samples
- 1:1 Line
- Best Fit Linear Relationship

Comparison of RI and PDI Surface Sediment Sample Concentrations in Proximate Locations for PCBs, PAHs, and DDx

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Figure 2.3

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Notes:
1. Ratio labels represent the upper end of the range (e.g., "0.6" represents range from 0.3-0.6).
2. Recovery ratio represents the ratio of the top interval concentration to the maximum concentration within a single core.
3. Data displayed only include cores where maximum concentrations within a core exceed Site-wide ROD RALs. Site-wide ROD RALs were applied regardless of core location within or outside of the navigational channel: PCBs: 75 μg/kg, Total PAHs: 30,000 μg/kg; DDx: 160 μg/kg.

Distribution of COC Recovery Ratios in PDI Cores with ROD RAL Exceedances
Top Interval to Maximum Concentration Interval
Portland Harbor Superfund Site
PDI Evaluation Report

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Figure 2.4

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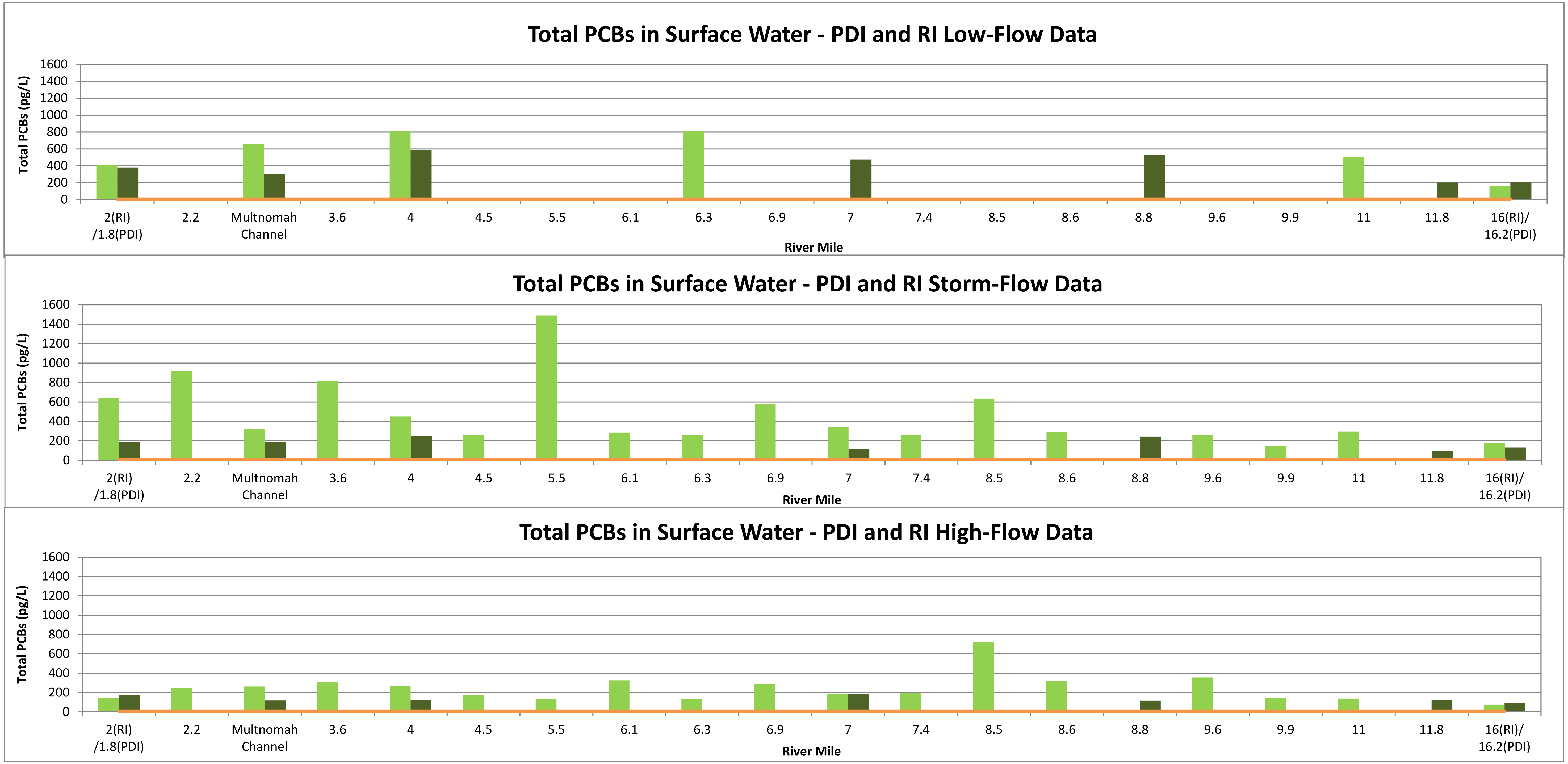

Notes:
1. Whole water refers to the calculated sum of particulate and dissolved fractions.
2. Locations with no data were not sampled during this program.
3. X-axis sampling locations are not equally spaced throughout the Site. Some river miles contain more sampling locations than other river miles.

Whole Water RI
Whole Water PDI
ROD CUL = 6.4 pg/L

Comparison of RI and PDI PCB Surface Water Concentrations in Whole Water at Various Flow Conditions

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Figure 2.5a

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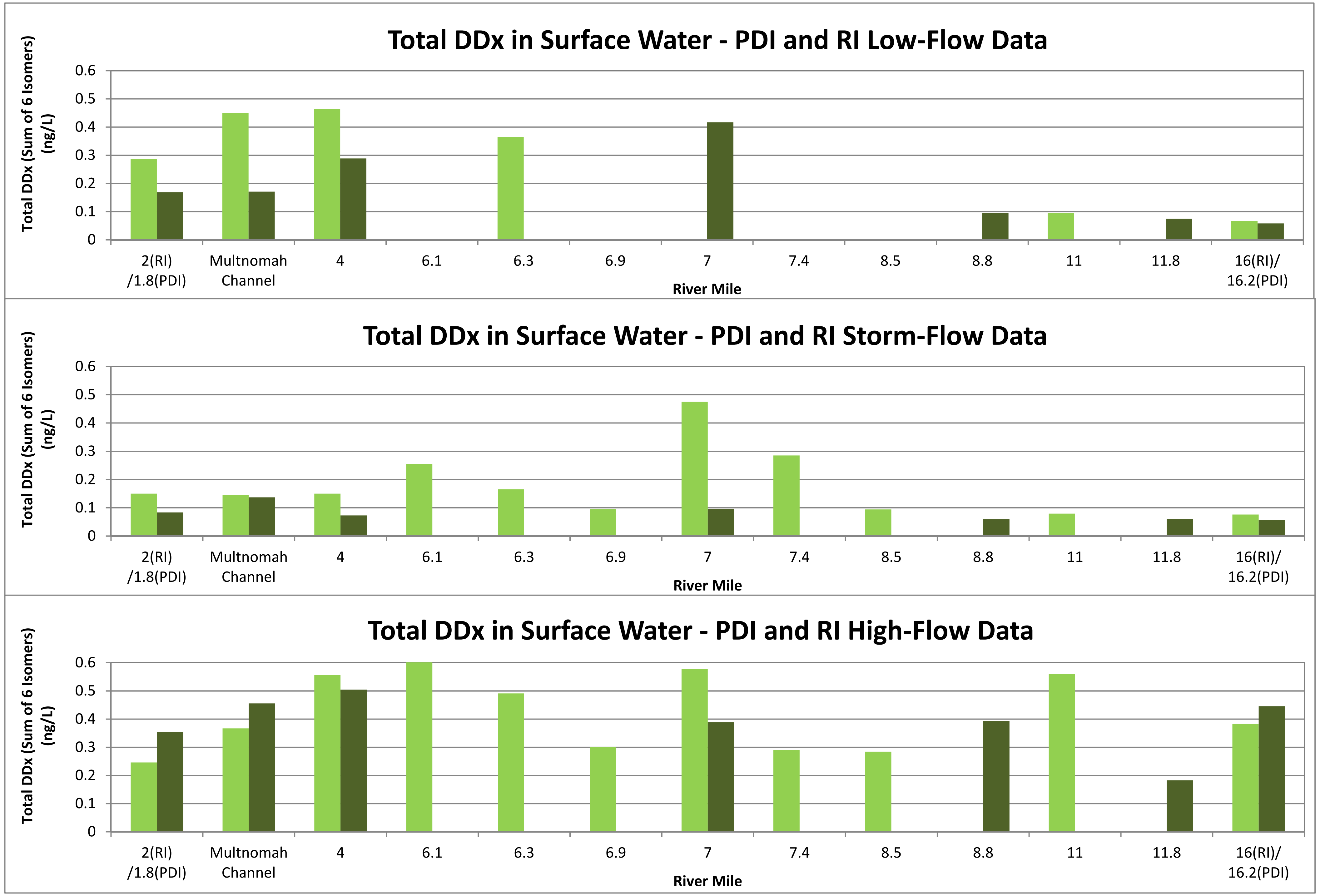

Notes:
1. Whole water refers to the calculated sum of particulate and dissolved fractions.
2. Locations with no data were not sampled during this program.
3. The ROD CUL for DDx is 10 ng/L, which is not shown on these figures because it is greater than the maximum y-axis value.
4. X-axis sampling locations are not equally spaced throughout the Site. Some river miles contain more sampling locations than other river miles.

Comparison of RI and PDI DDx Surface Water Concentrations in Whole Water at Various Flow Conditions

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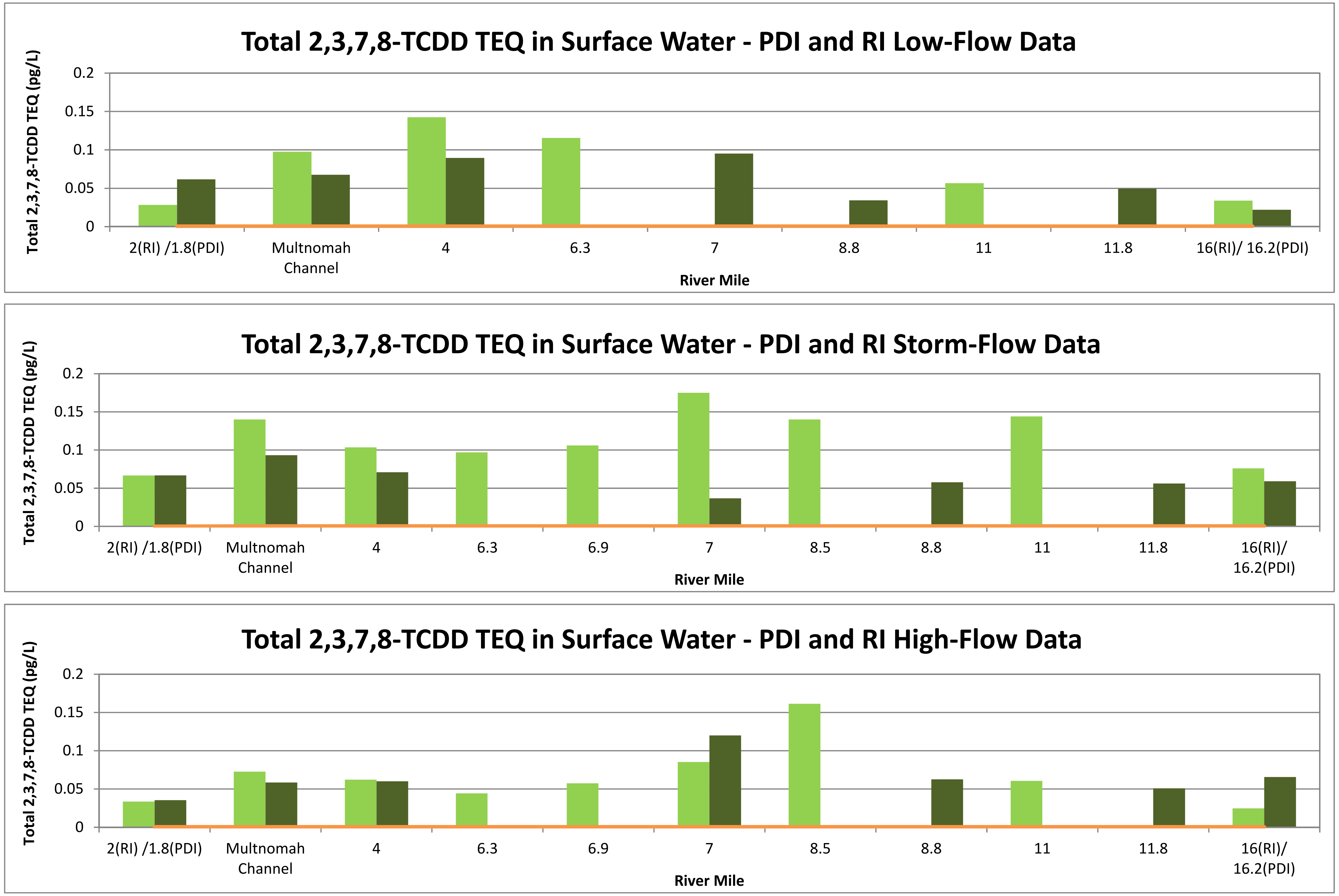
Figure 2.5b

MI/SEA

June 2019



Notes:
1. Whole water refers to the calculated sum of particulate and dissolved fractions.
2. Locations with no data were not sampled during this program.
3. X-axis sampling locations are not equally spaced throughout the Site. Some river miles contain more sampling locations than other river miles.

Whole Water RI
Whole Water PDI
ROD CUL = 0.0005 pg/L

Comparison of RI and PDI 2,3,7,8-TCDD Surface Water Concentrations in Whole Water at Various Flow Conditions

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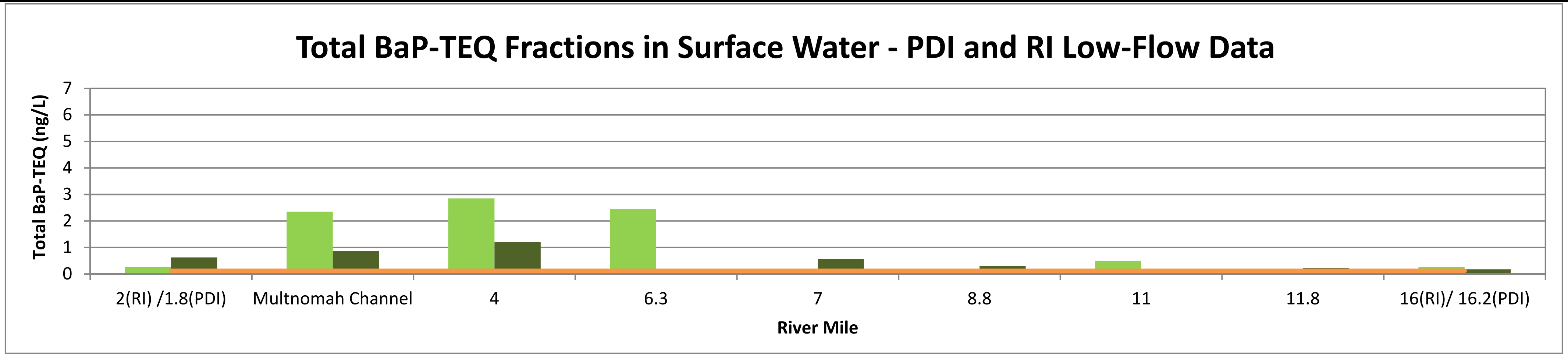
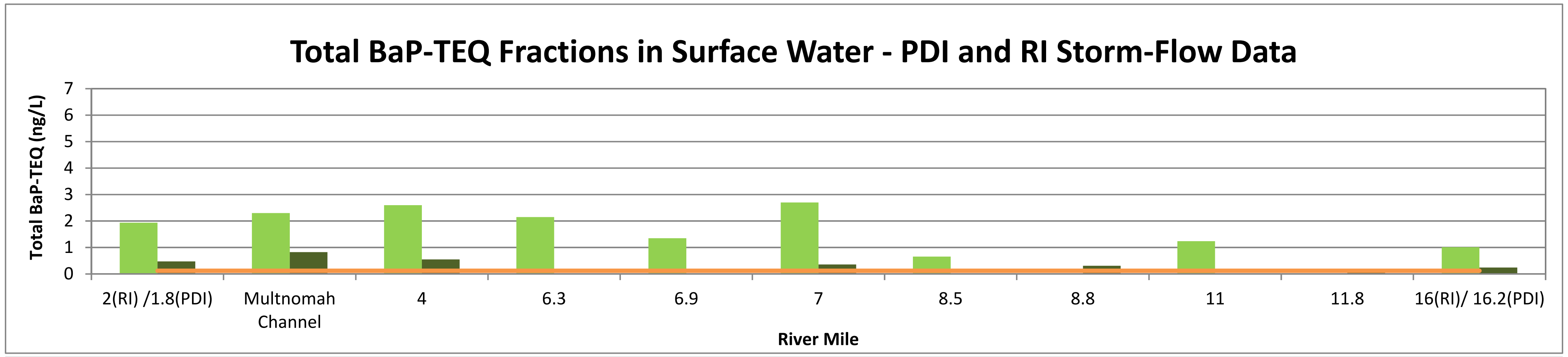
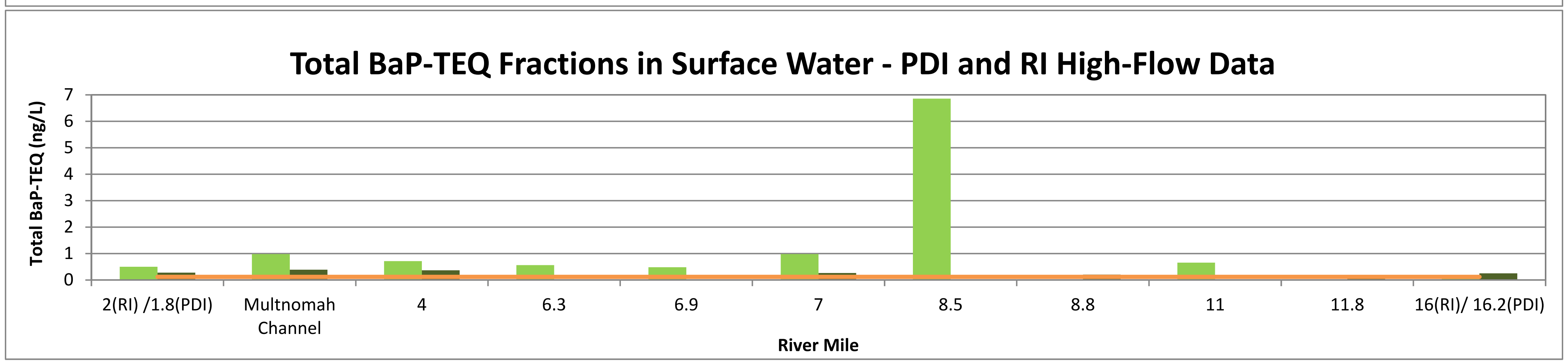
Figure 2.5c

MI/SEA | June 2019







Notes:
1. Whole water refers to the calculated sum of particulate and dissolved fractions.
2. Locations with no data were not sampled during this program.
3. X-axis sampling locations are not equally spaced throughout the Site. Some river miles contain more sampling locations than other river miles.

Comparison of RI and PDI BaP-TEQ Surface Water Concentrations in Whole Water at Various Flow Conditions

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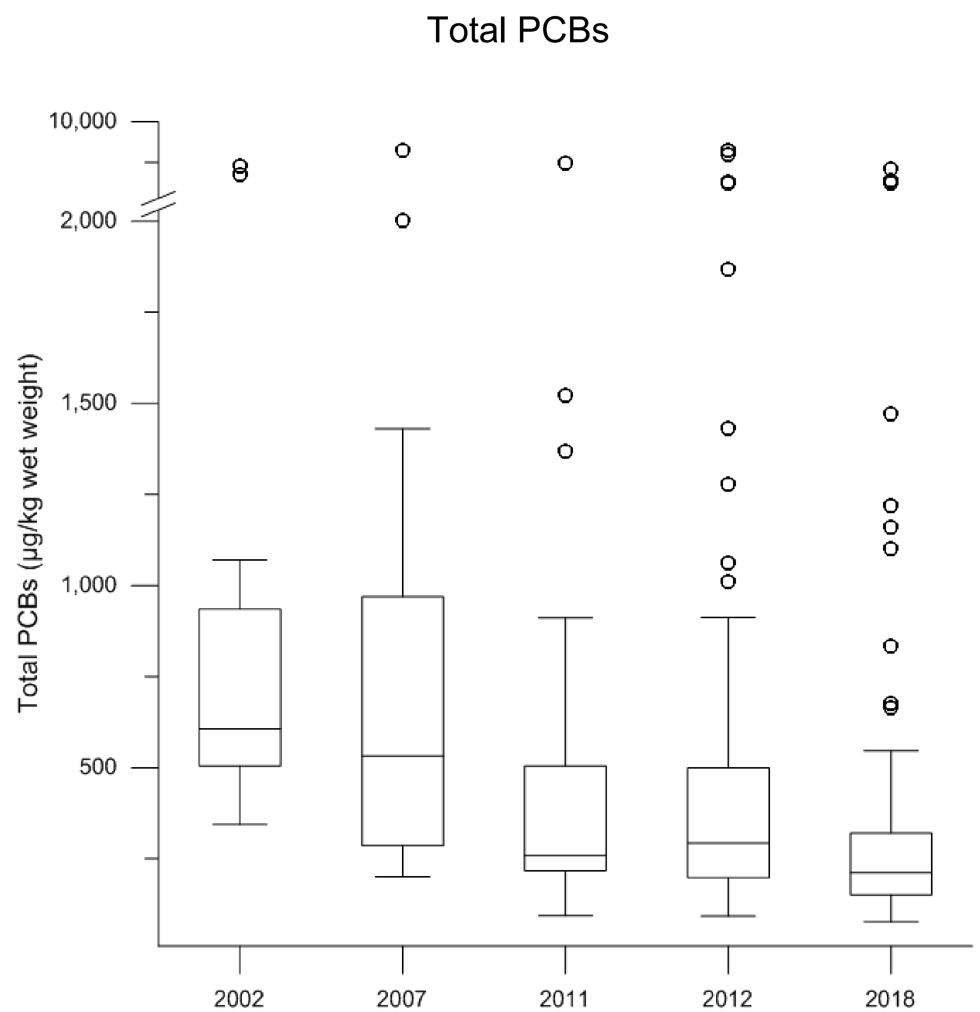
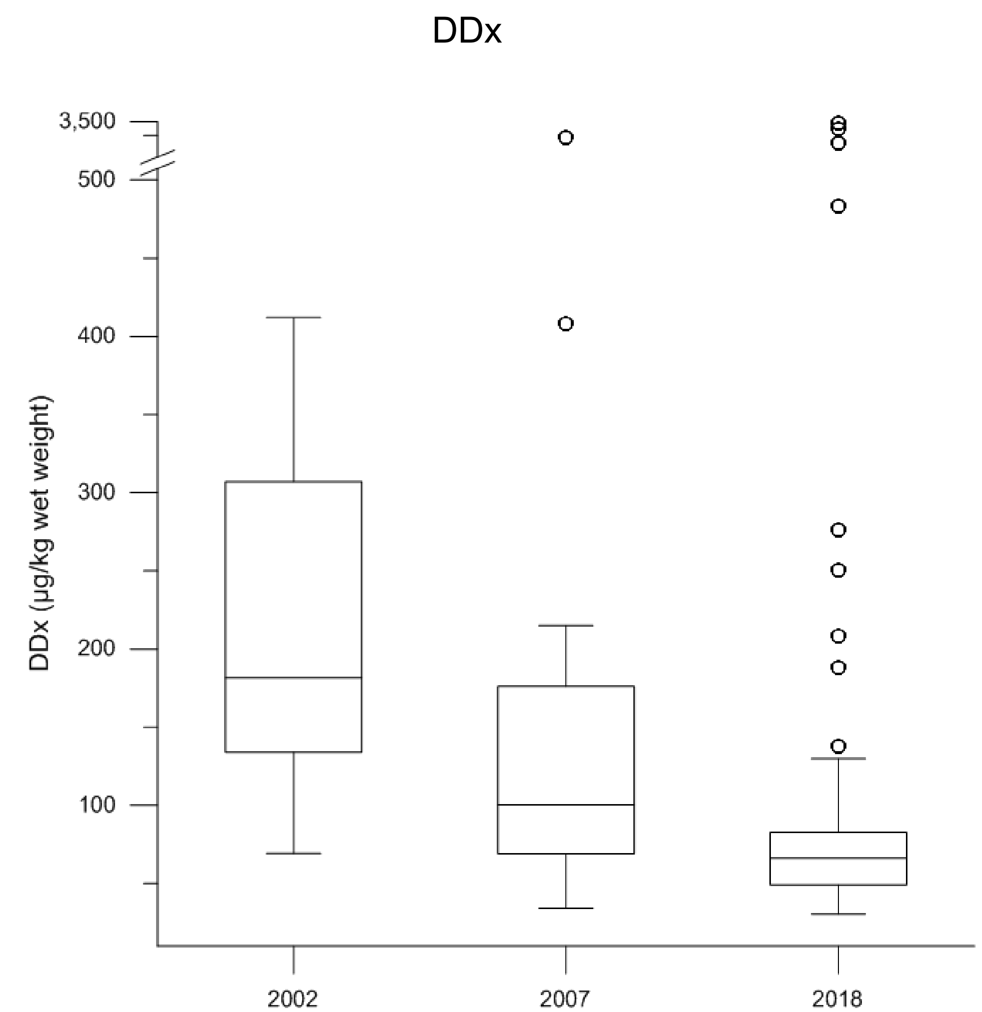
Figure
2.5d

MI/SEA
June 2019





Notes:
1. The box represents the interquartile range, where the top of the box corresponds to the upper quartile or the 75th percentile, and the bottom of the box corresponds to the lower quartile or the 25th percentile, and the horizonal line in the middle corresponds to the median. The whiskers represent 1.5 times the upper and lower quartiles, and very high or low values are shown as points outside the whiskers.
2. Box plots are based on Site samples of smallmouth bass (whole body).

Distribution of Smallmouth Bass Whole Body Concentrations
2002 - 2018 for Total PCBs and DDx

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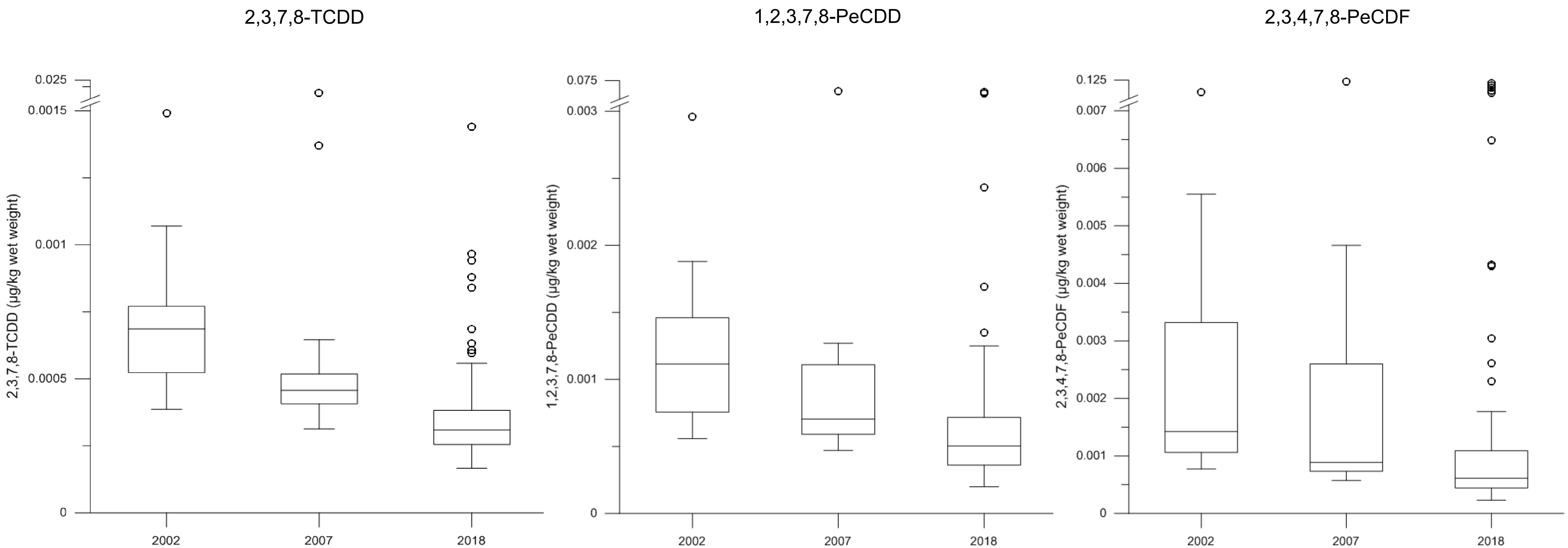
Figure
2.6a

LW/RAL | June 2019

\\seattle-01\data\Projects\Portland Pre-Design PNG0767A\600 Deliverables (AECOM&Geosyntec)\z_PDI Evaluation Report\Figures (main text)\Section 2 Figures\v4\Fig 2.6 Fish B+W\[Fig 2.6 Fish Bar Charts.xlsx]Figure 2.6a



Notes:
1. The box represents the interquartile range, where the top of the box corresponds to the upper quartile or the 75th percentile, and the bottom of the box corresponds to the lower quartile or the 25th percentile, and the horizonal line in the middle corresponds to the median. The whiskers represent 1.5 times the upper and lower quartiles, and very high or low values are shown as points outside the whiskers.
2. Box plots are based on Site samples of smallmouth bass (whole body).

Distribution of Smallmouth Bass Whole Body Concentrations
2002 - 2018 for Dioxin/Furan Focused COCs

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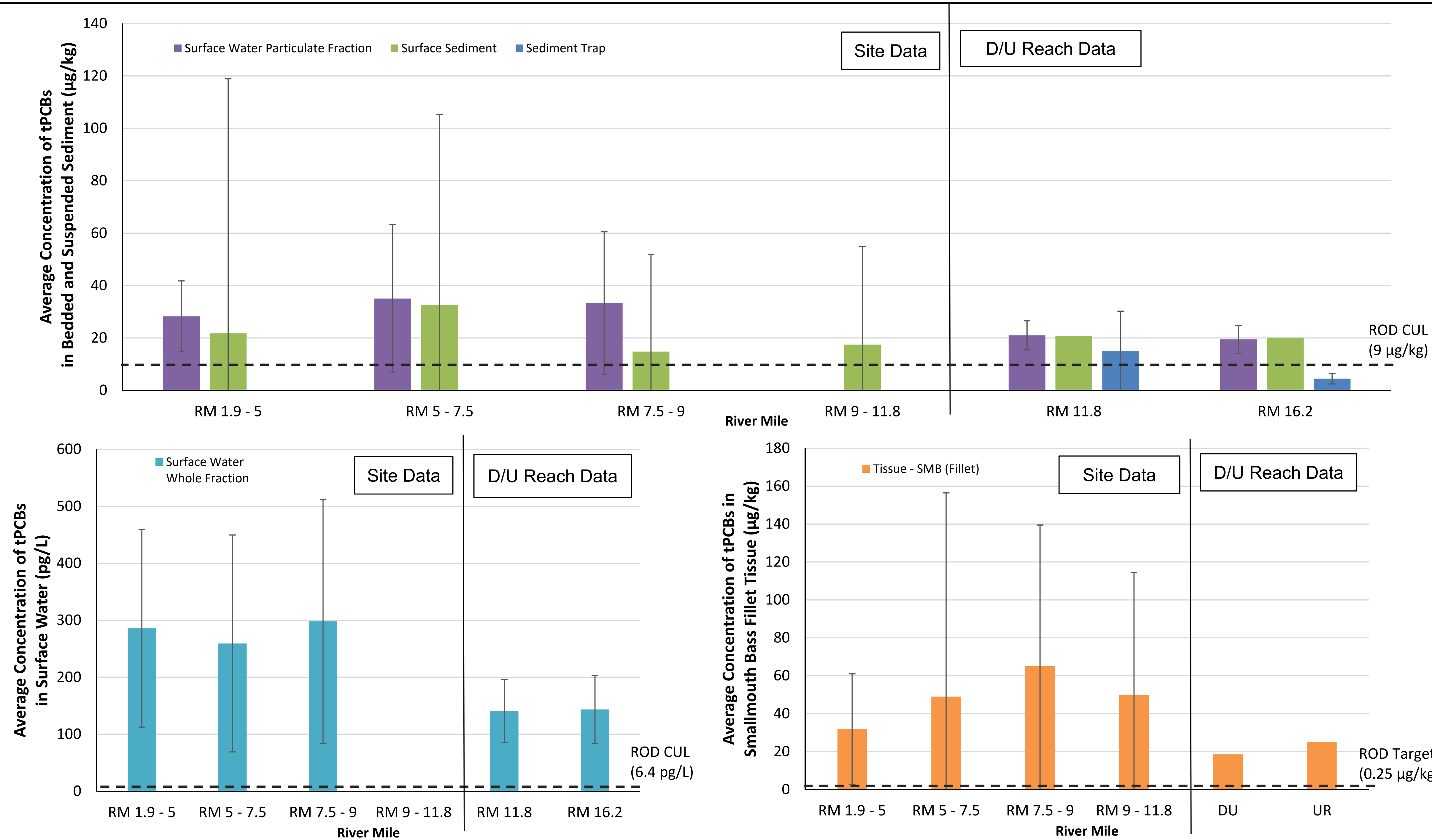
Figure
2.6b

LW/RAL | June 2019

\\seattle-01\data\Projects\Portland Pre-Design PNG0767A\600 Deliverables (AECOM&Geosyntec)\z_PDI Evaluation Report\Figures (main text)\Section 2 Figures\v4\Fig 2.6 Fish B+W\[Fig 2.6 Fish Bar Charts.xlsx]Figure 2.6a



Notes:
1. Surface water particulate fraction, surface water whole water, and sediment trap data are presented as the average of the low-flow, storm-flow, and high-flow events. Where more than one transect location is present wtihin a RM span, the average of all captured transect values is presented.
2. Site surface sediment data is presented as the SWAC calculated for the specified RM span (see Appendix D2). D/U Reach surface sediment data is presented as the 95% UCL of the data with Station B459 removed as discussed in Appendix F1.
3. Site fish tissue (calculated smallmouth bass fillet) data is presented as the average for the specified RM span. D/U Reach tissue data is presented as the 95% UCL of the data (see Appendix F2).
4. Not all matrices were sampled at each location during the PDI (e.g., sediment trap data was not collected within the Site boundaries).
5. Error bars represent 1 standard deviation of the mean and are presented when n = 3 or greater.

Comparison of PDI Total PCB Concentrations to ROD CULs and Targets by Matrix

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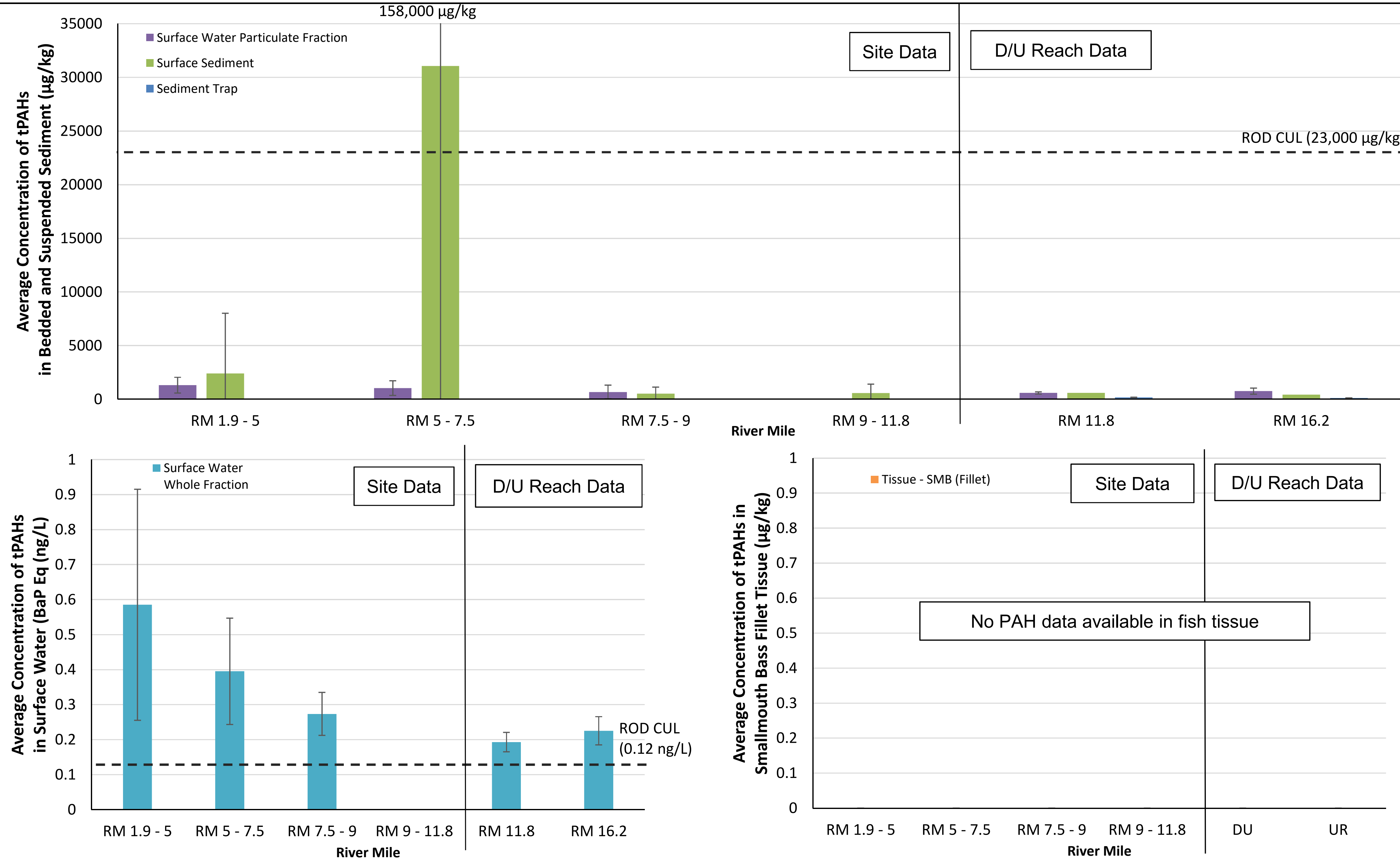
Figure **2.7a**

MI/SEA | June 2019



Notes:
1. Surface water particulate fraction, surface water whole water, and sediment trap data are presented as the average of the low-flow, storm-flow, and high-flow events. Where more than one transect location is present wtihin a RM span, the average of all captured transect values is presented.
2. Site surface sediment data is presented as the SWAC calculated for the specified RM span (see Appendix D2). D/U Reach surface sediment data is presented as the 95% UCL of the data with Station B459 removed as discussed in Appendix F1.
3. Site fish tissue (calculated smallmouth bass fillet) for PAHs is not available (see Appendix F2).
4. Not all matrices were sampled at each location during the PDI (e.g., sediment trap data was not collected within the Site boundaries).
5. Error bars represent 1 standard deviation of the mean and are presented when n = 3 or greater.
6. Surface water particulate fraction total PAHs are calculated from benzo[a]pyrene toxicity equivalents (BaP-TEQ) as: total PAH = (BaP-TEQ ^ 0.984) x (10 ^ 0.996) (ESD, EPA 2018)

Comparison of PDI Total PAH Concentrations to ROD CULs and Targets by Matrix

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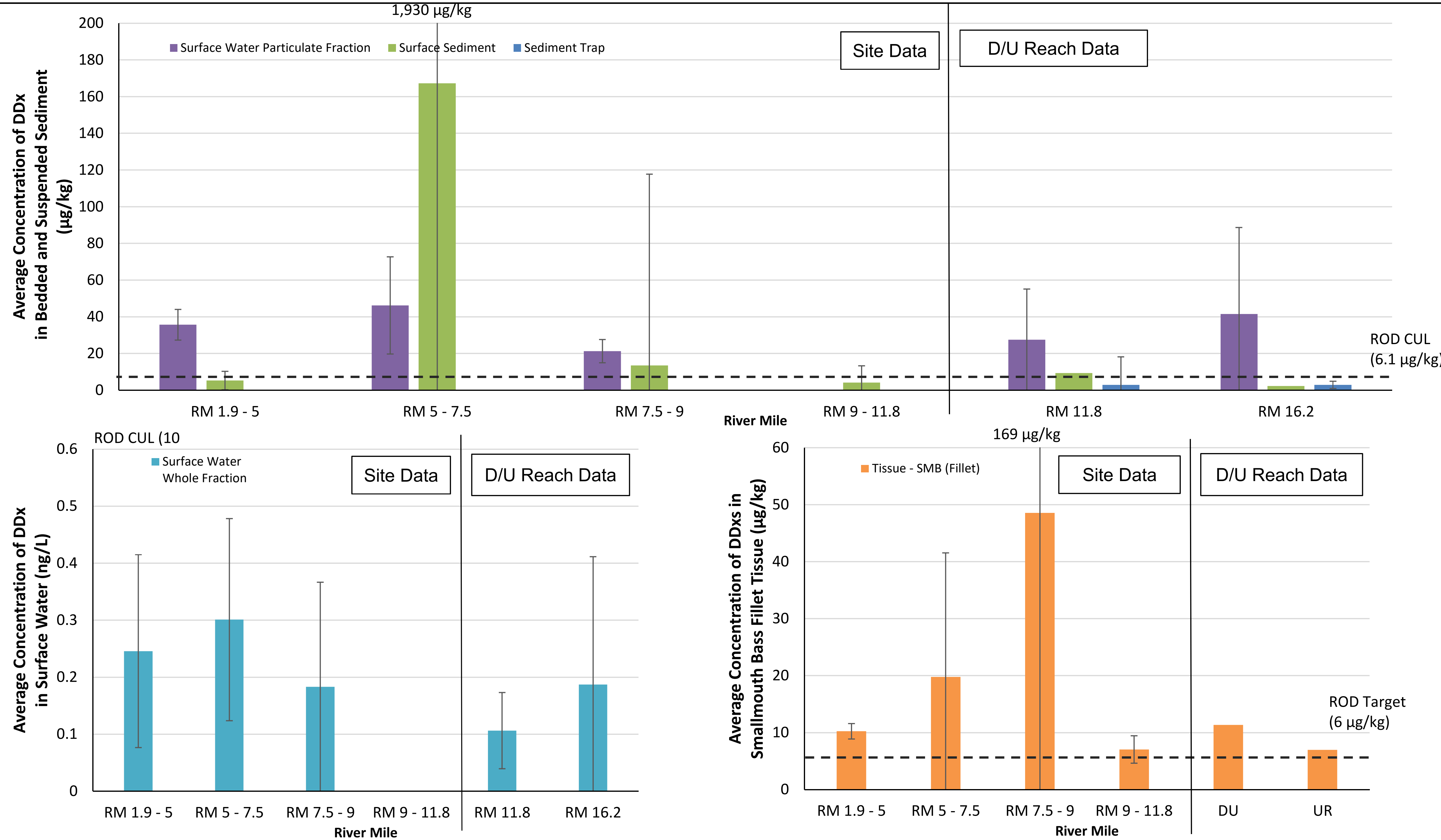
Figure 2.7b

MI/SEA

June 2019



Notes:
1. Surface water particulate fraction, surface water whole water, and sediment trap data are presented as the average of the low-flow, storm-flow, and high-flow events. Where more than one transect location is present wtihin a RM span, the average of all captured transect values is presented.
2. Site surface sediment data is presented as the SWAC calculated for the specified RM span (see Appendix D2). D/U Reach surface sediment data is presented as the 95% UCL of the data (see Appendix F1).
3. Site fish tissue (calculated smallmouth bass fillet) data is presented as the average for the specified RM span. D/U Reach tissue data is presented as the 95% UCL of the data (see Appendix F2).
4. Not all matrices were sampled at each location during the PDI (e.g., sediment trap data was not collected within the Site boundaries).
5. Error bars represent 1 standard deviation of the mean and are presented when n = 3 or greater.

Comparison of PDI DDx Concentrations to ROD CULs and Targets by Matrix

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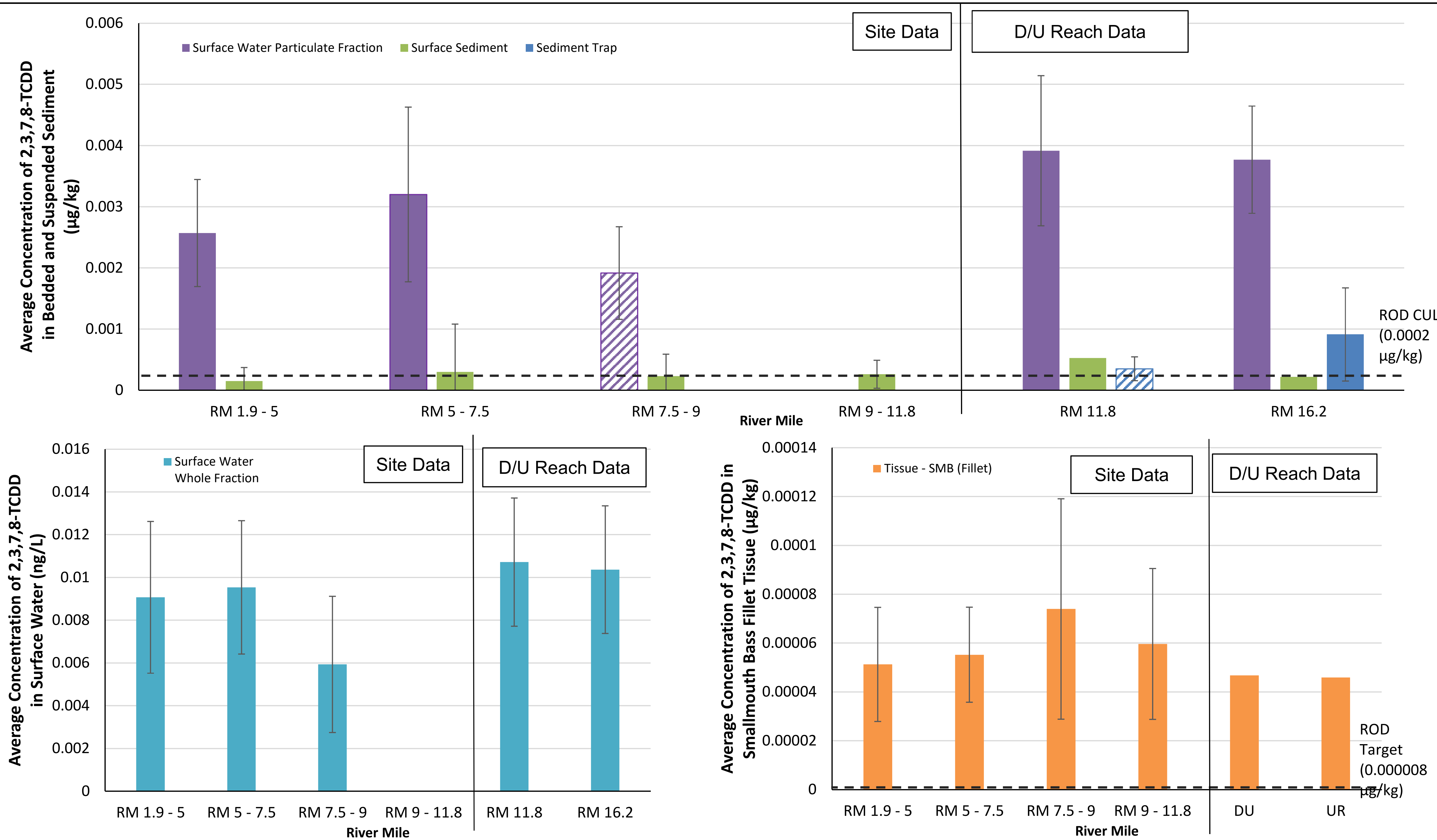
Figure **2.7c**

MI/SEA | June 2019



Notes:
1. Surface water particulate fraction, surface water whole water, and sediment trap data are presented as the average of the low-flow, storm-flow, and high-flow events. Where more than one transect location is present wtihin a RM span, the average of all captured transect values is presented.
2. D/U Reach surface sediment data is presented as the 95% UCL of the data (see Appendix F1).
3. Site fish tissue (calcuated smallmouth bass fillet) data is presented as the average for the specified RM span. D/U Reach tissue data is presented as the 95% UCL of the data with SMB117 removed (see Appendix F2).
4. Not all matrices were sampled at each location during the PDI (e.g., sediment trap data was not collected within the Site boundaries).
5. Error bars represent 1 standard deviation of the mean and are presented when n = 3 or greater.
6. When all samples were non-detect, bars are shown in hashed lines at the average MDL.

Comparison of PDI 2,3,7,8-TCDD Concentrations to ROD CULs and Targets by Matrix

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PDI Evaluation Report

Figure **2.7d**

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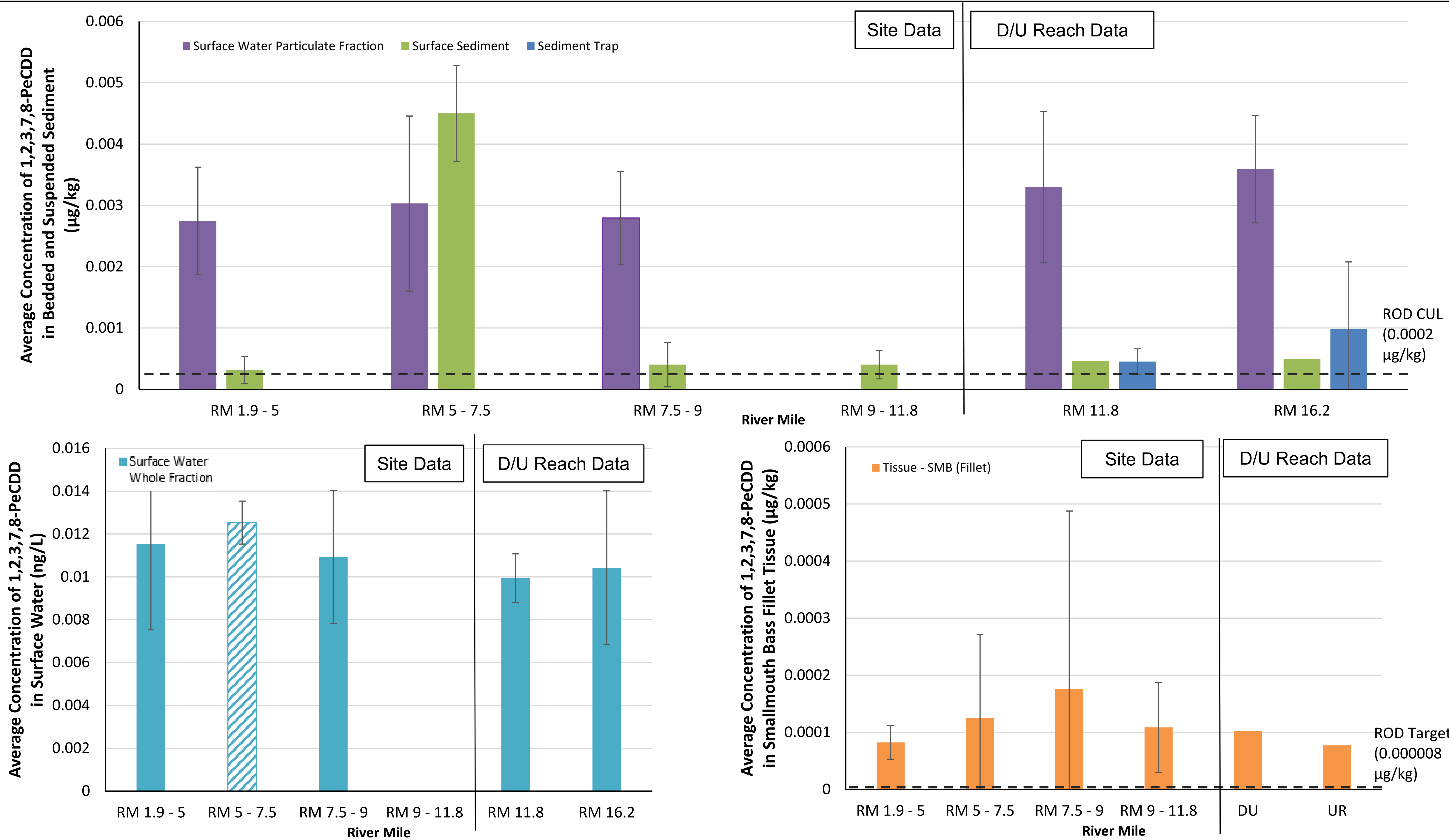

Notes:
1. Surface water particulate fraction, surface water whole water, and sediment trap data are presented as the average of the low-flow, storm-flow, and high-flow events. Where more than one transect location is present wtihin a RM span, the average of all captured transect values is presented.
2. D/U Reach surface sediment data is presented as the 95% UCL of the data (see Appendix F1).
3. Site fish tissue (calculated smallmouth bass fillet) data is presented as the average for the specified RM span. D/U Reach tissue data is presented as the 95% UCL of the data with SMB117 removed (see Appendix F2).
4. Not all matrices were sampled at each location during the PDI (e.g., sediment trap data was not collected within the Site boundaries).
5. Error bars represent 1 standard deviation of the mean and are presented when n = 3 or greater.
6. When all samples were non-detect, bars are shown in hashed lines at the average MDL.

Comparison of PDI 1,2,3,7,8-PeCDD Concentrations to ROD CULs and Targets by Matrix

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Figure 2.7e

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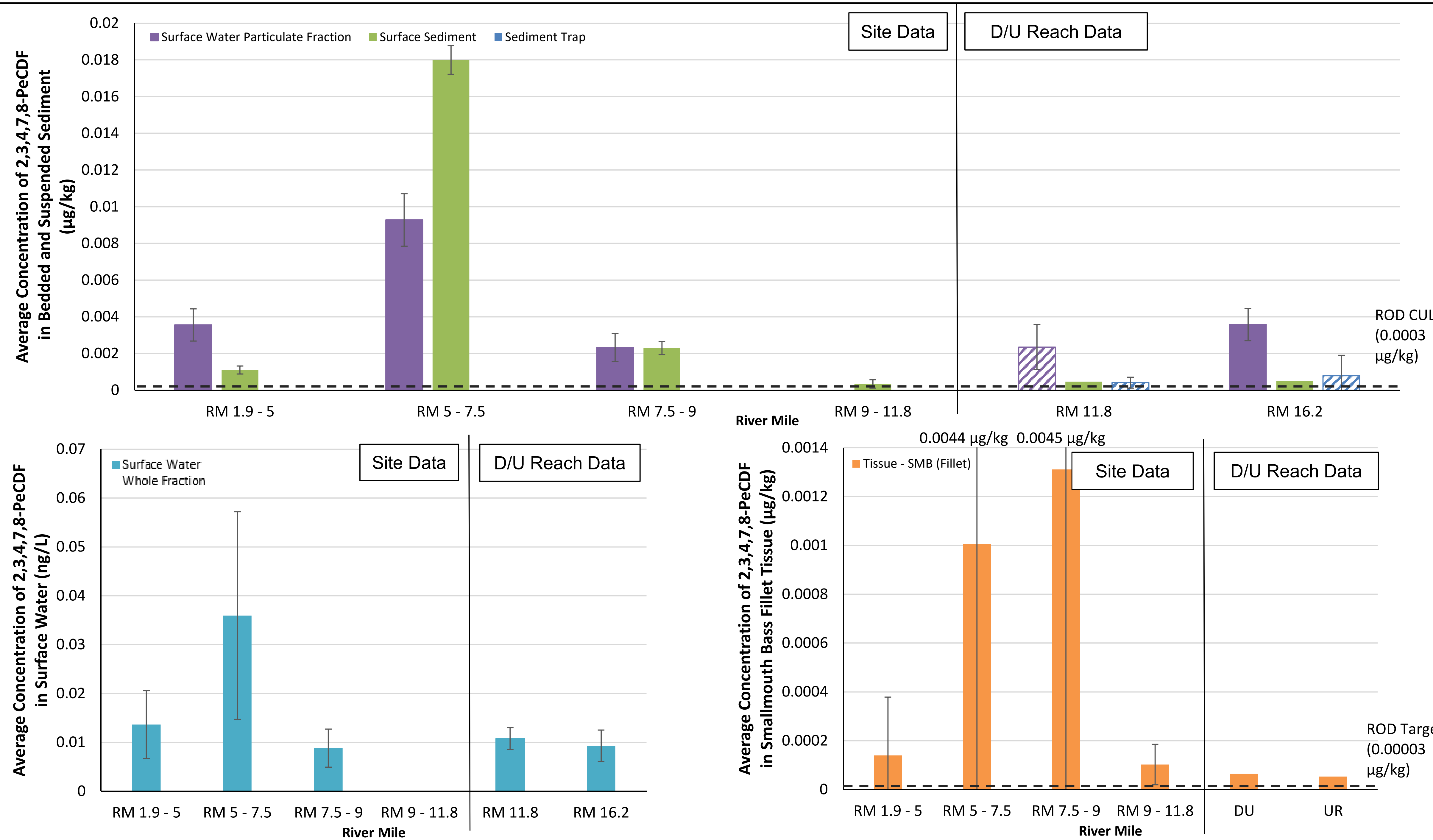
June 2019



Notes:
1. Surface water particulate fraction, surface water whole water, and sediment trap data are presented as the average of the low-flow, storm-flow, and high-flow events. Where more than one transect location is present wtihin a RM span, the average of all captured transect values is presented.
2. D/U Reach surface sediment data is presented as the 95% UCL of the data (see Appendix F1).
3. Site fish tissue (calculated smallmouth bass fillet) data is presented as the average for the specified RM span. D/U Reach tissue data is presented as the 95% UCL of the data with SMB117 removed (see Appendix F2).
4. Not all matrices were sampled at each location during the PDI (e.g., sediment trap data was not collected within the Site boundaries).
5. Error bars represent 1 standard deviation of the mean and are presented when n = 3 or greater.
6. When all samples were non-detect, bars are shown in hashed lines at the average MDL.

Comparison of PDI 2,3,4,7,8-PeCDF Concentrations to ROD CULs and Targets by Matrix

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Figure 2.7f

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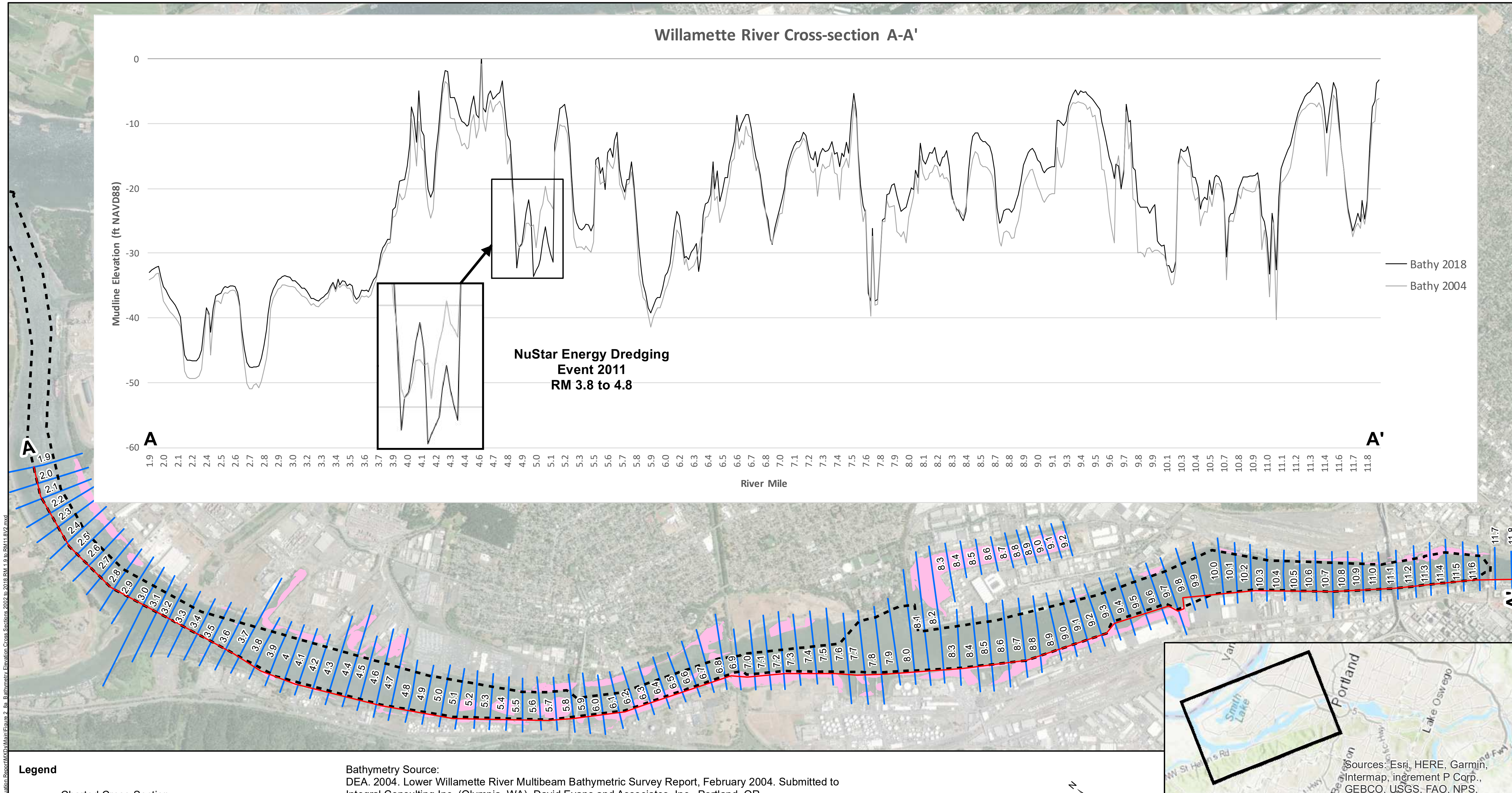

Legend

- Charted Cross-Section
- ROD SMA Footprint
- River Mile Marker
- Navigation Channel

Bathymetry Source:
DEA. 2004. Lower Willamette River Multibeam Bathymetric Survey Report, February 2004. Submitted to Integral Consulting Inc. (Olympia, WA). David Evans and Associates, Inc., Portland, OR.

1 0.5 0 1 Miles

Notes:
1. Aerial Imagery provided by ESRI Basemaps 2017.
2. Cross-section A and C based on east and west edges of navigation channel, adjusted as needed to intersect ROD SMA footprint.
3. Cross-section B based on midpoint of east and west edges.
4. ROD Navigation channel provided by USACE.
5. River miles shown in chart are approximate.

Bathymetry Elevation Cross Section 2004 to 2018
Transect Location A- A'
RM 1.9 to RM 11.8
Portland Harbor Superfund Site
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Figure **2.8a**

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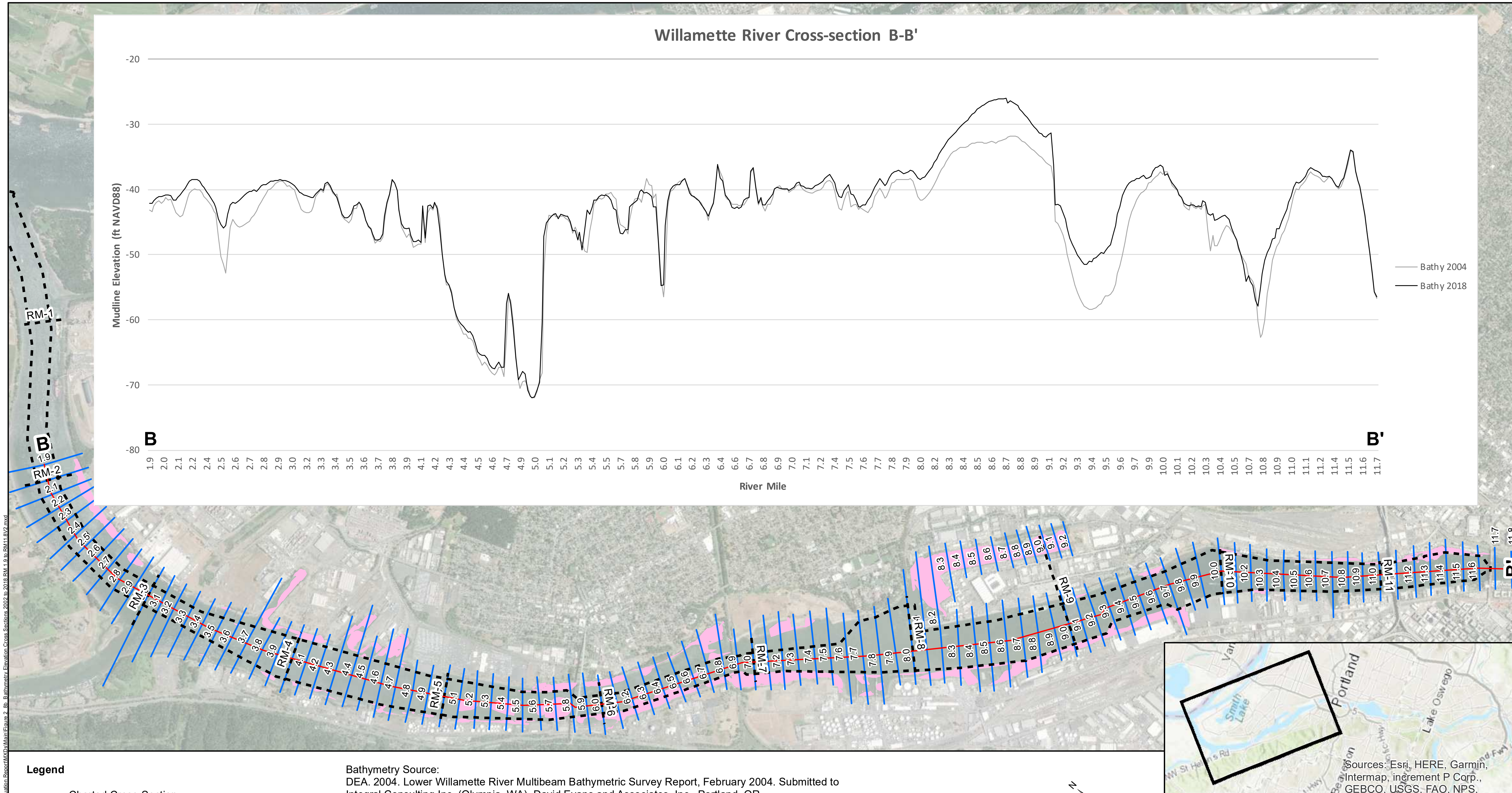

Legend

- Charted Cross-Section
- ROD SMA Footprint
- River Mile Marker
- Navigation Channel

Bathymetry Source:
DEA. 2004. Lower Willamette River Multibeam Bathymetric Survey Report, February 2004. Submitted to Integral Consulting Inc. (Olympia, WA). David Evans and Associates, Inc., Portland, OR.

1 0.5 0 1 Miles

Notes:
1. Aerial Imagery provided by ESRI Basemaps 2017.
2. Cross-section A and C based on east and west edges of navigation channel, adjusted as needed to intersect ROD SMA footprint.
3. Cross-section B based on midpoint of east and west edges.
4. ROD Navigation channel provided by USACE.
5. River miles shown in chart are approximate.

Bathymetry Elevation Cross Section 2004 to 2018
Transect Location B- B'
RM 1.9 to RM 11.8
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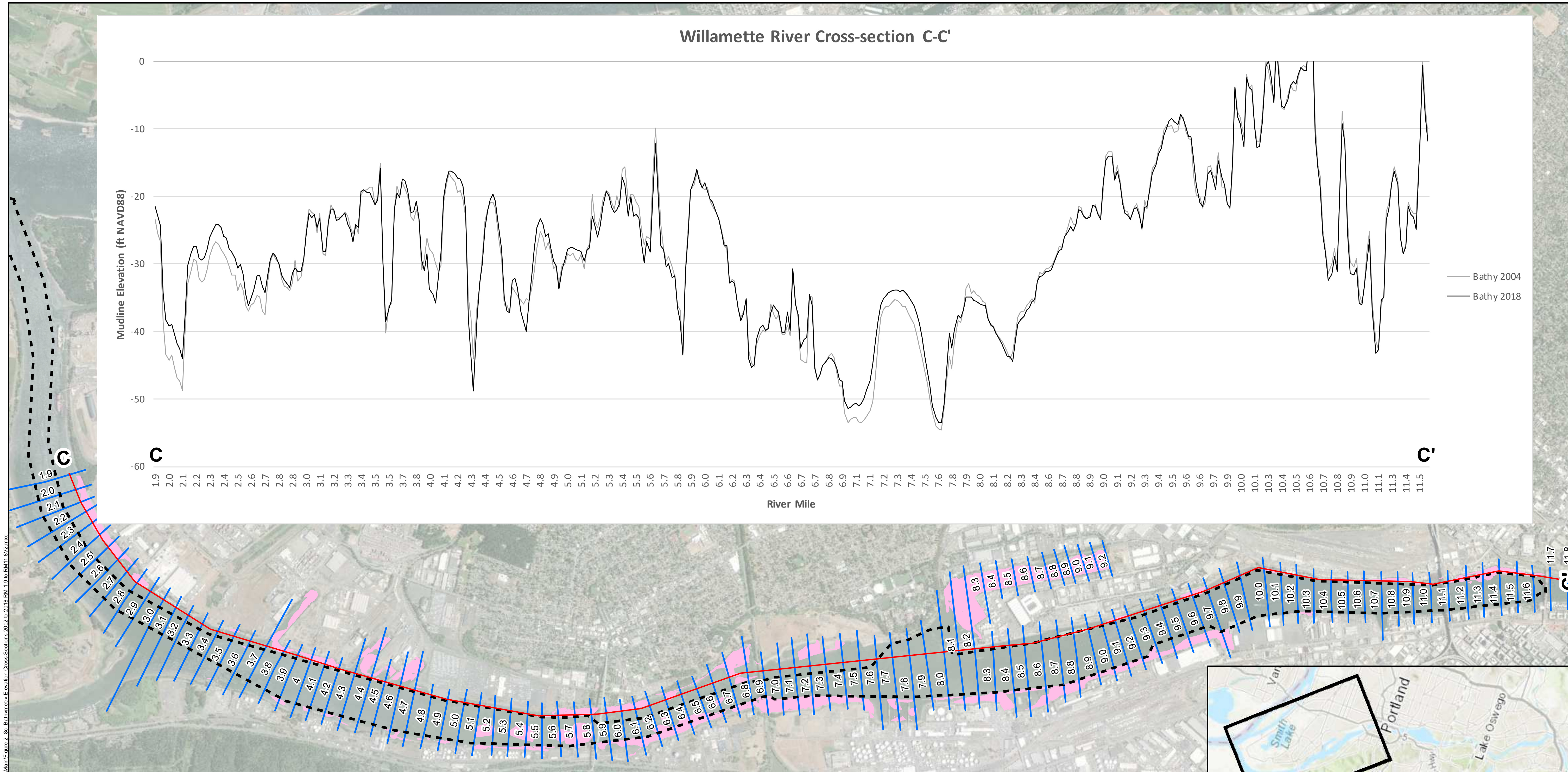
Figure **2.8b**

MI/SEA | June 2019



Legend

- Charted Cross-Section
- ROD SMA Footprint
- River Mile Marker
- Navigation Channel

Bathymetry Source:
DEA. 2004. Lower Willamette River Multibeam Bathymetric Survey Report, February 2004. Submitted to Integral Consulting Inc. (Olympia, WA). David Evans and Associates, Inc., Portland, OR.

1 0.5 0 1 Miles

Notes:
1. Aerial Imagery provided by ESRI Basemaps 2017.
2. Cross-section A and C based on east and west edges of navigation channel, adjusted as needed to intersect ROD SMA footprint.
3. Cross-section B based on midpoint of east and west edges.
4. ROD Navigation channel provided by USACE.
5. River miles shown in chart are approximate.

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS,

Bathymetry Elevation Cross Section 2004 to 2018
Transect Location C- C'
RM 1.9 to RM 11.8

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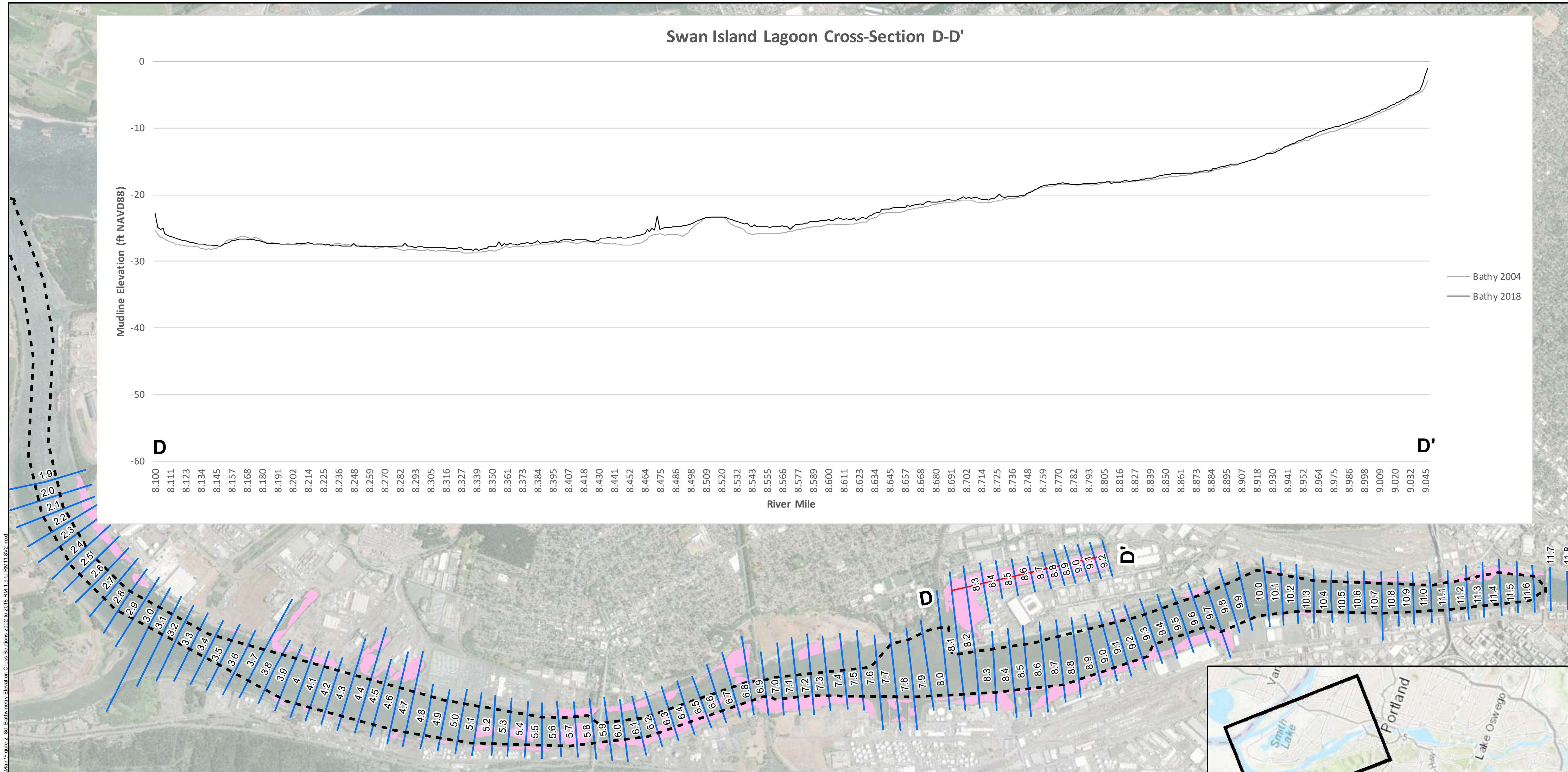
Figure **2.8c**

MI/SEA | June 2019



Legend

- Charted Cross-Section
- ROD SMA Footprint
- River Mile Marker
- Navigation Channel

Bathymetry Source:
DEA. 2004. Lower Willamette River Multibeam Bathymetric Survey Report, February 2004. Submitted to Integral Consulting Inc. (Olympia, WA). David Evans and Associates, Inc., Portland, OR.

1 0.5 0 1 Miles

Notes:
1. Aerial Imagery provided by ESRI Basemaps 2017.
2. Cross-section A and C based on east and west edges of navigation channel, adjusted as needed to intersect ROD SMA footprint.
3. Cross-section B based on midpoint of east and west edges.
4. ROD Navigation channel provided by USACE.
5. River miles shown in chart are approximate.

Bathymetry Elevation Cross Section 2004 to 2018
Transect Location D- D'
RM 8.1 to RM 9.2
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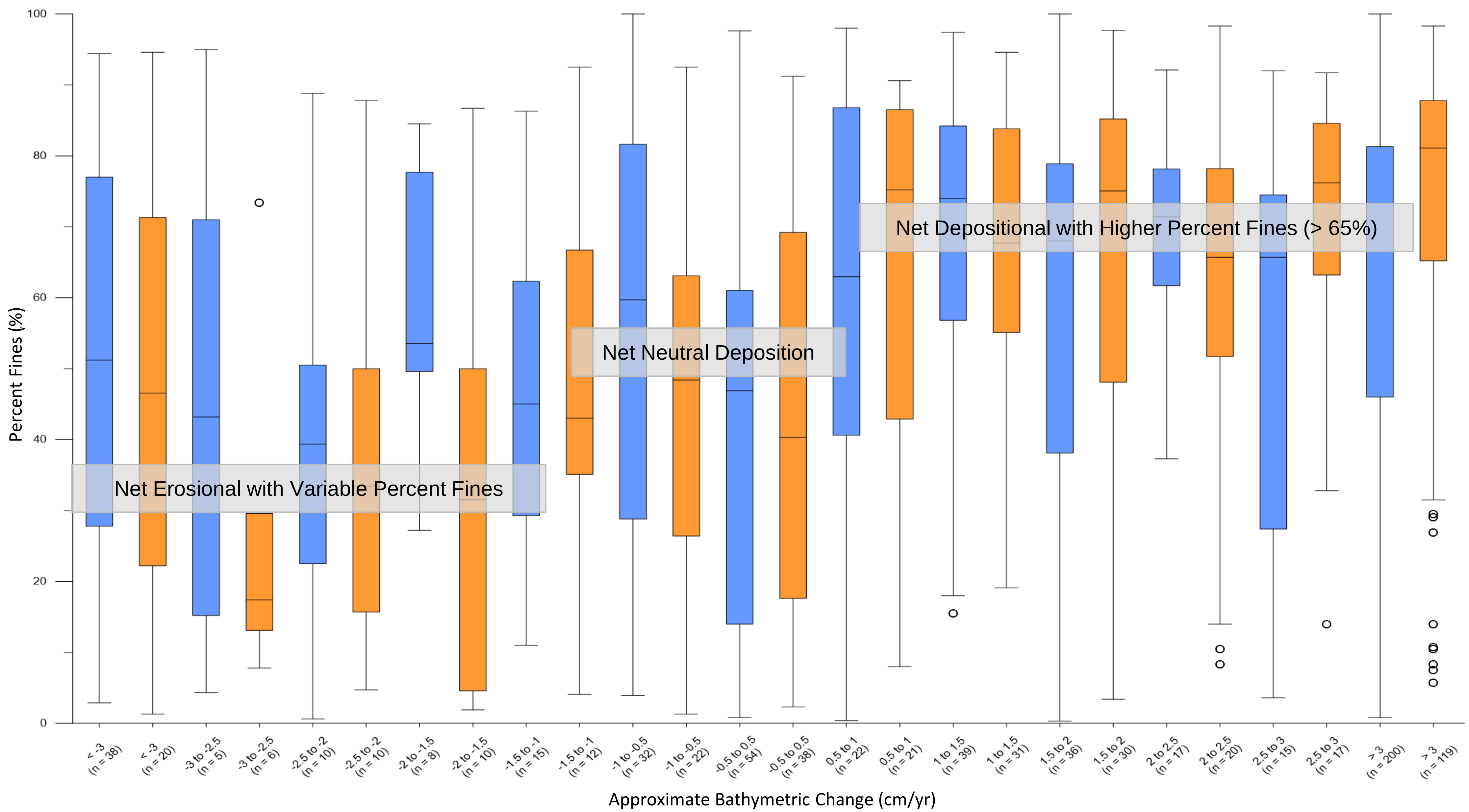
Figure **2.8d**

MI/SEA	June 2019



Notes:
1. The box represents the interquartile range, where the top of the box corresponds to the upper quartile or the 75th percentile, and the bottom of the box corresponds to the lower quartile or the 25th percentile, and the horizonal line in the middle corresponds to the median. The whiskers represent 1.5 times the upper and lower quartiles, and outliers (open circles) are outside of 1.5 times the interquartile range.
2. Approximate net sediment deposition rates are calculated as the change in bathymetry at the FS sample location divided by the time between the collection of the FS and the PDI sample.

FS Samples
PDI Samples

Comparison of Percent Fines in Proximate Surface Sediment Samples by Sedimentation Rate
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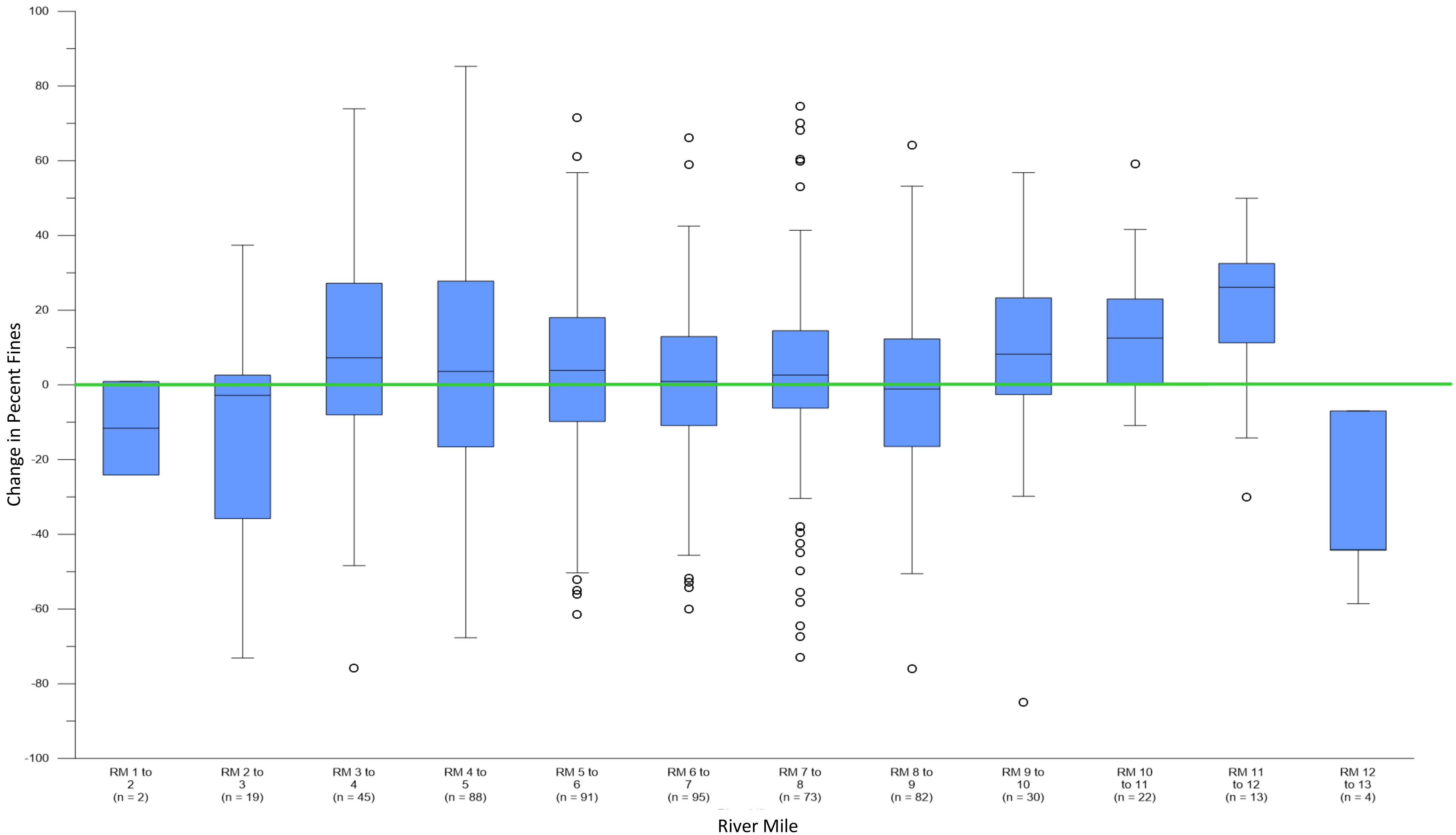
Figure 2.9a

JS/SEA | June 2019



Notes:
1. The box represents the interquartile range, where the top of the box corresponds to the upper quartile or the 75th percentile, and the bottom of the box corresponds to the lower quartile or the 25th percentile, and the horizontal line in the middle corresponds to the median. The whiskers represent 1.5 times the upper and lower quartiles, and outliers (open circles) are outside of 1.5 times the interquartile range.
2. A positive change means that the 2018 PDI sample has higher percent fines than its proximal RI sample.

Distribution of Change in Percent Fines Between PDI and FS Proximate Samples by River Mile

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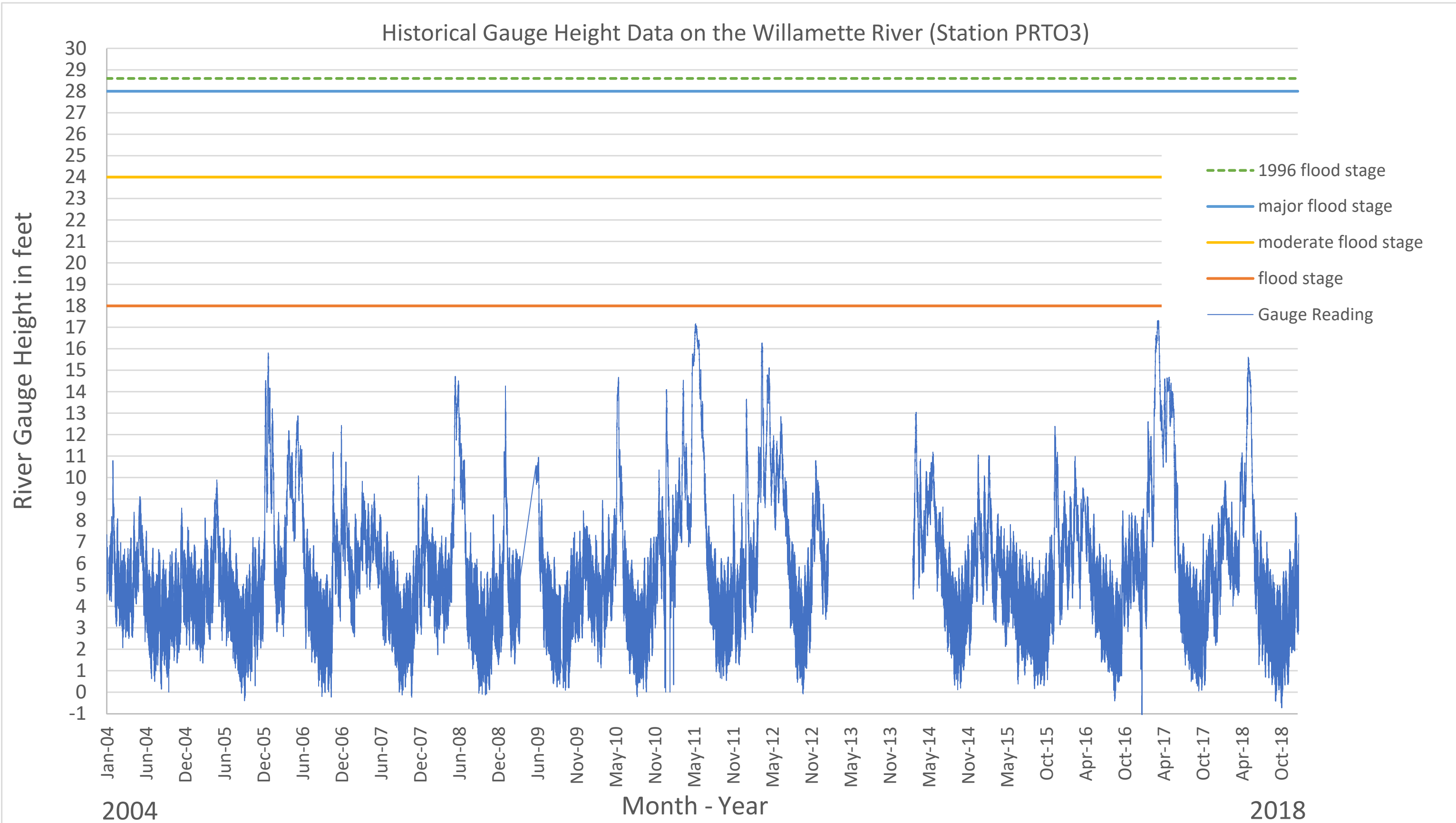
Figure **2.9b**

JS/SEA

June 2019



\\seattle-01\data\Projects\Portland Pre-Design PNG0767A\600 Deliverables (AECOM&Geosyntec)\z_PDI Evaluation Report\Main Text\Figures\v4 (6.10.19)\Fig 2.10 Hydrograph\[Fig 2.10.xlsx]Figure 2.10

General Notes:

1) Water levels are taken from the US Army Corps of Engineers Willamette River gauge station PRTO3.
2) Water levels are an instantaneous point collected every 15 minutes from December 3, 2004 to April 29, 2019. Data missing in 2013.
3) Water levels were collected on an hourly basis between January 1 and December 3, 2004.
4) 1996 flood crested at 28.6 ft in downtown Portland, approximately 11 feet above flood stage.

References:

http://www.nwd-wc.usace.army.mil/dd/common/dataquery/www/
https://www.nwrfc.noaa.gov/river/station/flowplot/flowplot.cgi?lid=PRTO3
https://multco.us/file/57184/download

Willamette River Hydrograph Gauge Height Data
2004 through 2018

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Figure 2.10

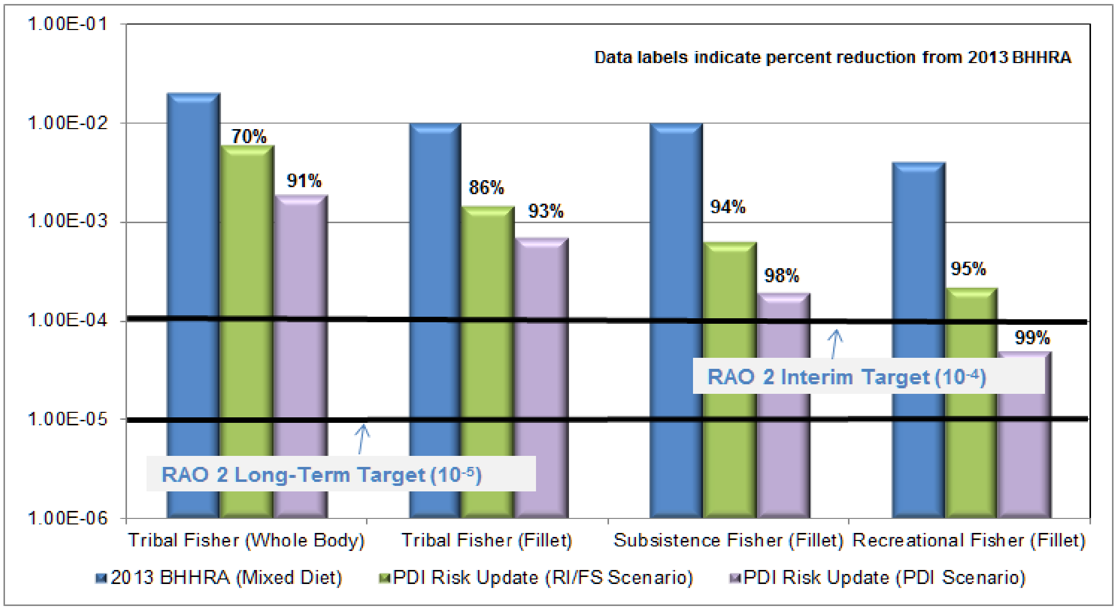


Figure 2.11a. Comparison of 2013 BHHRA and Updated Site-wide Cancer Risk For Fishers (Adult/Child) - Fish Consumption

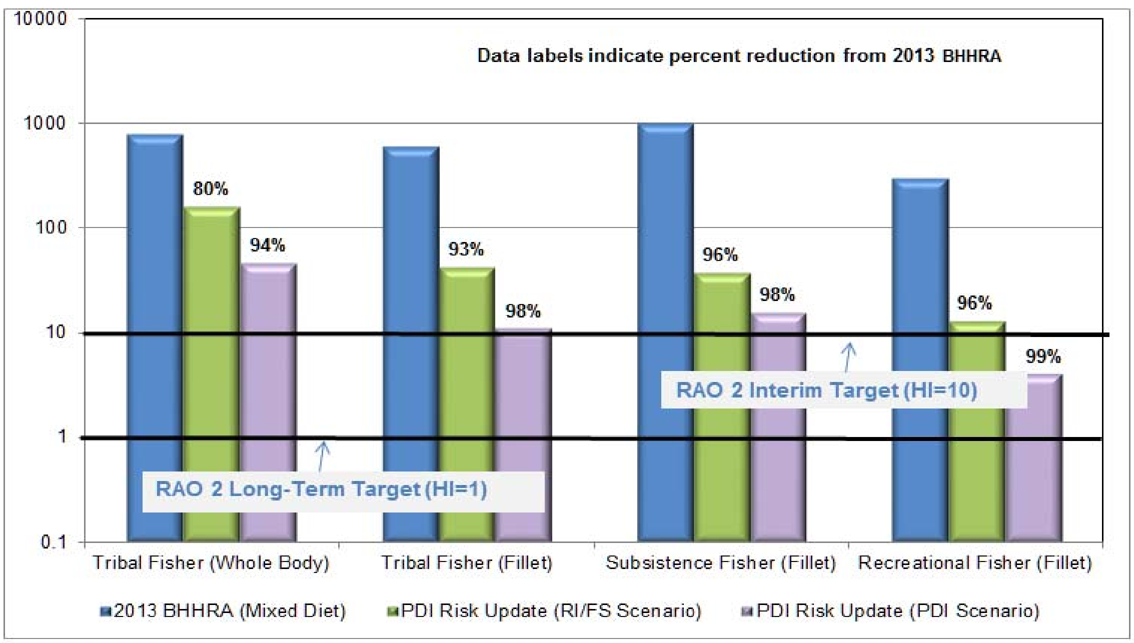


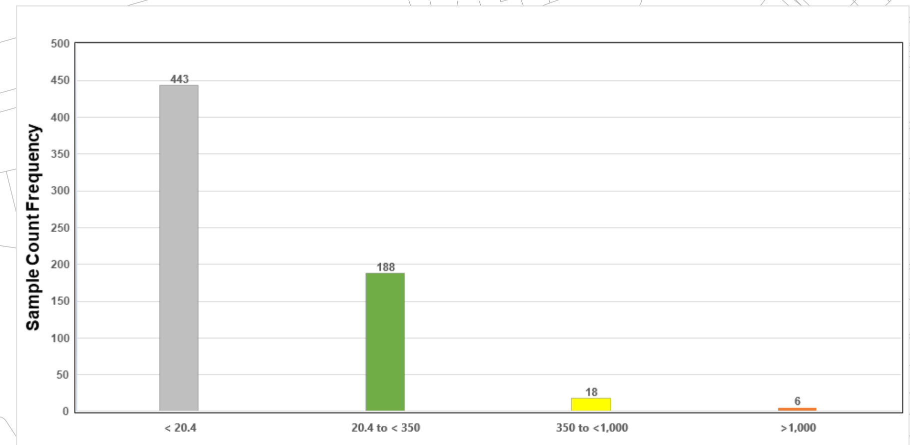
Figure 2.11b. Comparison of 2013 BHHRA and Updated Site-wide Noncancer Hazard For Fishers (Child) - Fish Consumption

Notes:

1. Percent decreases were calculated in as follows: 2013 BHHRA risk or hazard minus updated risk or hazard divided by 2013 BHHRA risk or hazard. The percent decreases were calculated from the values in Tables 5 and 6 of Appendix G.

Acronyms:

BHHRA = Baseline Human Health Risk Assessment. Final.
PCB = polychlorinated biphenyls
RAO = remedial action objective
RI/FS = remedial investigation/feasibility study
PDI = pre-remedial design investigation
TEQ = toxicity Equivalence



Legend

total PCBs (SRS/SMA) - Natural Neighbor

- ≤ PDI CUL (20.4 μg/kg)
- > PDI CUL and ≤ PDI RAL (350 μg/kg)
- > PDI RAL and ≤ PDI Nav RAL (1,000 μg/kg)
- > PDI Nav RAL (1,000 μg/kg)

PDI Sample Type

- Sediment Management Area (n=231)
- Stratified Random Sample (n=424)
- Navigation Channel
- Existing Cap
- Superfund Site Boundary (RM 1.9 to 11.8)

N

1,200 0 1,200 2,400 Feet

Notes:
1. SMA:Sediment Management Area, SRS:Stratified Random Sample.
2. Figure shows the centroid location of 2018 PDI actual grab locations (0 to 30 cm depth).
3. Site boundary based on EPA ROD and extends from RM 1.9 to RM 11.8.
4. Natural Neighbor interpolation using 10-ft by 10-ft grid.
5. Natural Neighbor interpolation area based on 4 site regions provided by EPA on 6 Nov. 2018

Natural Neighbor Interpolated Surface Sediment total PCBs Map (SRS and SMA)

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PDI Evaluation Report

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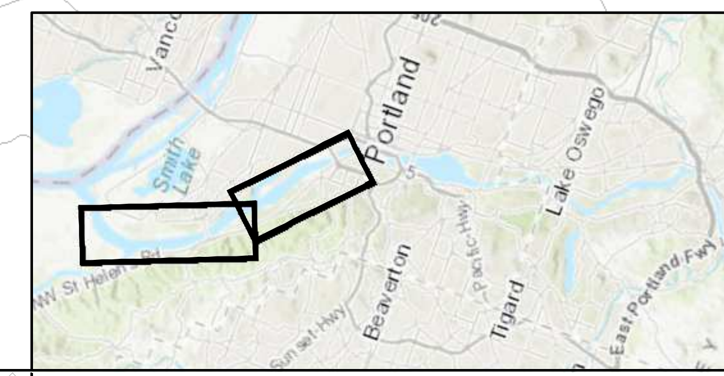
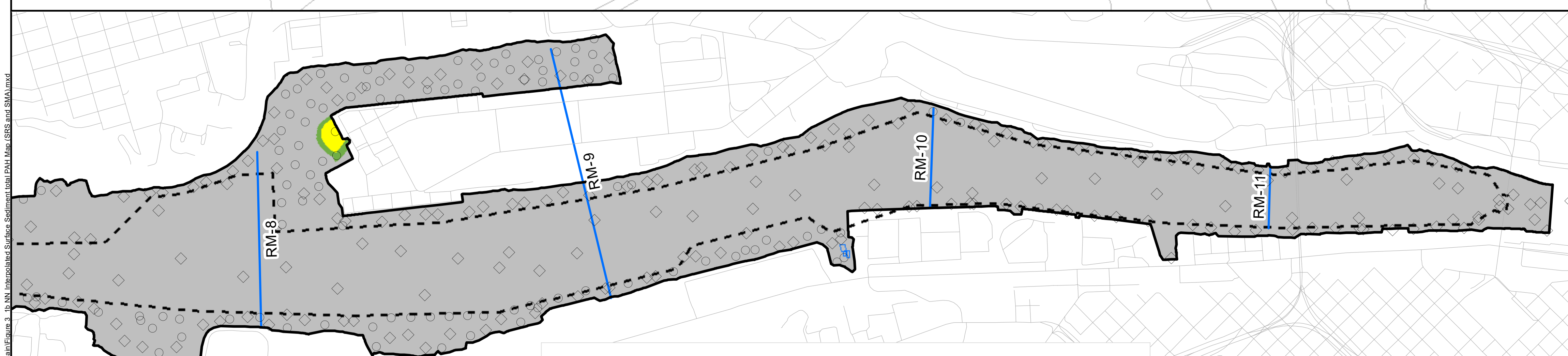
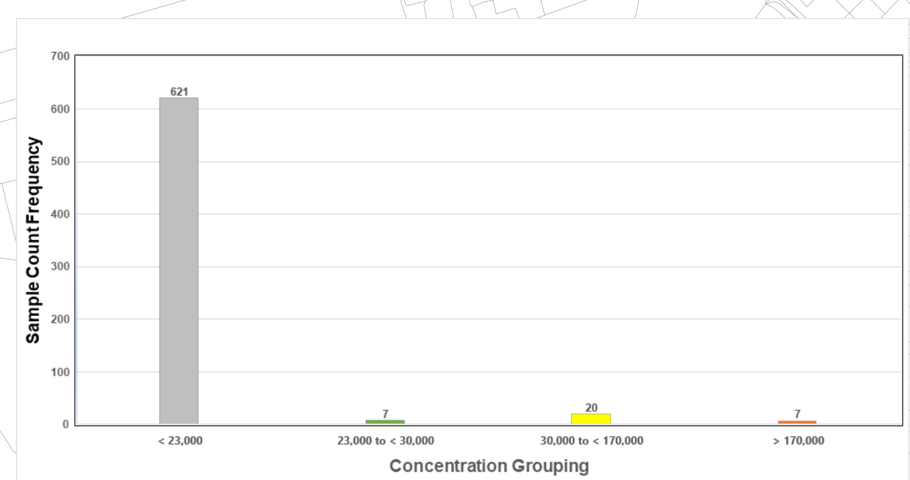
Figure 3.1a

MI/SEA June 2019







Legend

total PAHs (SRS/SMA) - Natural Neighbor

- ≤ PDI CUL (23,000 µg/kg)
- > PDI CUL and ≤ PDI RAL (30,000 µg/kg)
- > PDI RAL and ≤ PDI Nav RAL (170,000 µg/kg)
- > PDI Nav RAL (170,000 µg/kg)

Sample Type

- SMA Delineation Sample Location (n=231)
- Stratified Random Sample Location (n=424)
- Navigation Channel
- Existing Cap
- Superfund Site Boundary (RM 1.9 to 11.8)

N

1,200 0 1,200 2,400 Feet

Notes:
1. SMA:Sediment Management Area, SRS:Stratified Random Sample.
2. Figure shows the centroid location of 2018 PDI actual grab locations (0 to 30 cm depth).
3. Site boundary based on EPA ROD and extends from RM 1.9 to RM 11.8.
4. Natural Neighbor interpolation using 10-ft by 10-ft grid.
5. Natural Neighbor interpolation area based on 4 site regions provided by EPA on 6 Nov. 2018.

Natural Neighbor Interpolated Surface Sediment total PAHs Map (SRS and SMA)

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PDI Evaluation Report

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Figure **3.1b**

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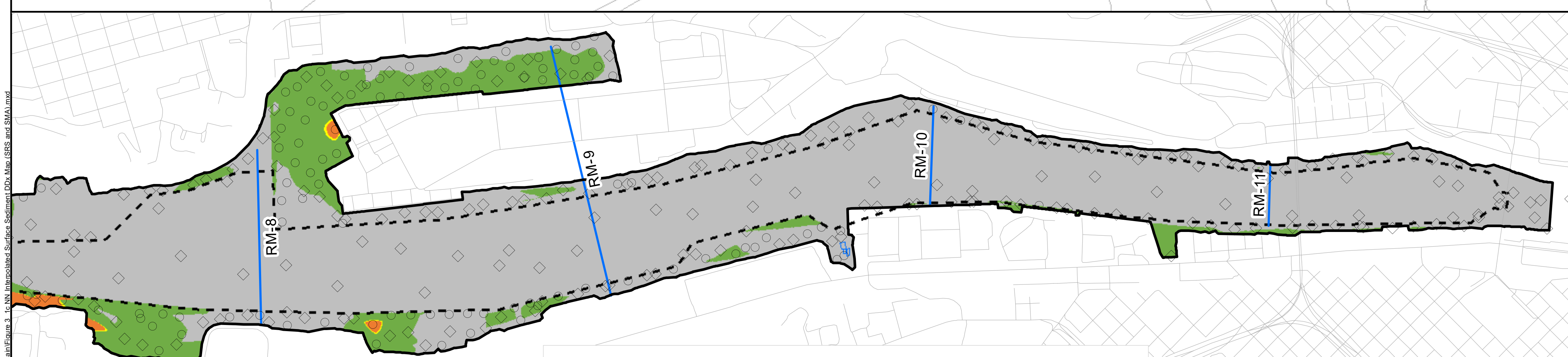
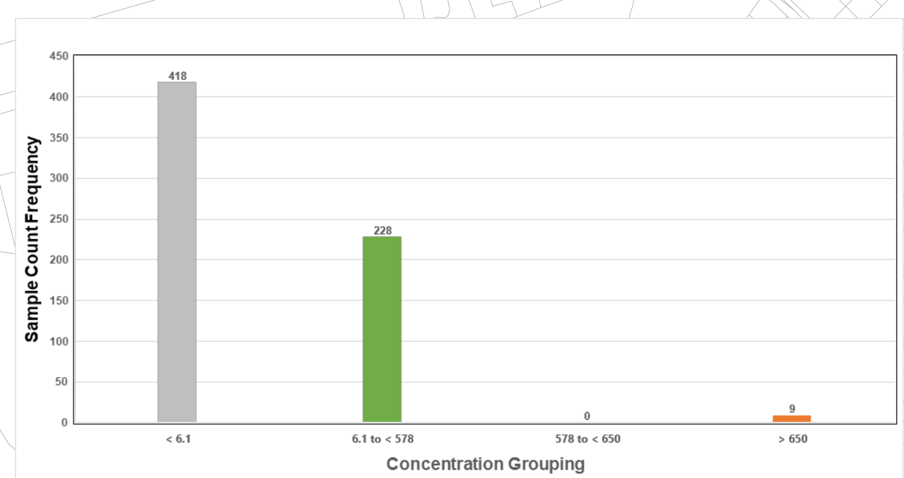
Path: P:\Projects\Portland Pre-Design PNG0767A\900 GIS and CAD\Evaluation Report\MXDs\Main\Figure 3_1b NN Interpolated Surface Sediment total PAH Map (SRS and SMA).mxd





Legend

DDx (SRS/SMA) - Natural Neighbor

- ≤ PDI CUL (6.1µg/kg)
- > PDI CUL and ≤ PDI RAL (578 µg/kg)
- > PDI RAL and ≤ PDI Nav RAL (650 µg/kg)
- > PDI Nav RAL (650 µg/kg)

PDI Sample Type

- SMA Delineation Sample Location (n=231)
- Stratified Random Sample Location (n=424)
- Navigation Channel
- Existing Cap
- Superfund Site Boundary (RM 1.9 to 11.8)

N

1,200 0 1,200 2,400 Feet

Notes:
1. SMA:Sediment Management Area, SRS:Stratified Random Sample.
2. Figure shows the centroid location of 2018 PDI actual grab locations (0 to 30 cm depth).
3. Site boundary based on EPA ROD and extends from RM 1.9 to RM 11.8.
4. Natural Neighbor interpolation using 10-ft by 10-ft grid.
5. Natural Neighbor interpolation area based on 4 site regions provided by EPA on 6 Nov. 2018

Natural Neighbor Interpolated Surface Sediment DDx Map (SRS and SMA)

Portland Harbor Superfund Site
PDI Evaluation Report

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Figure **3.1c**

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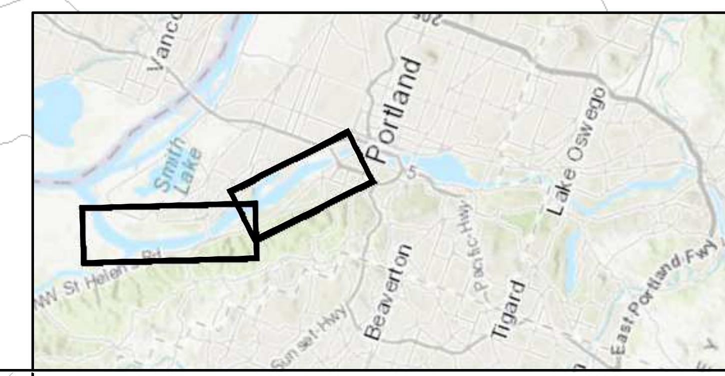

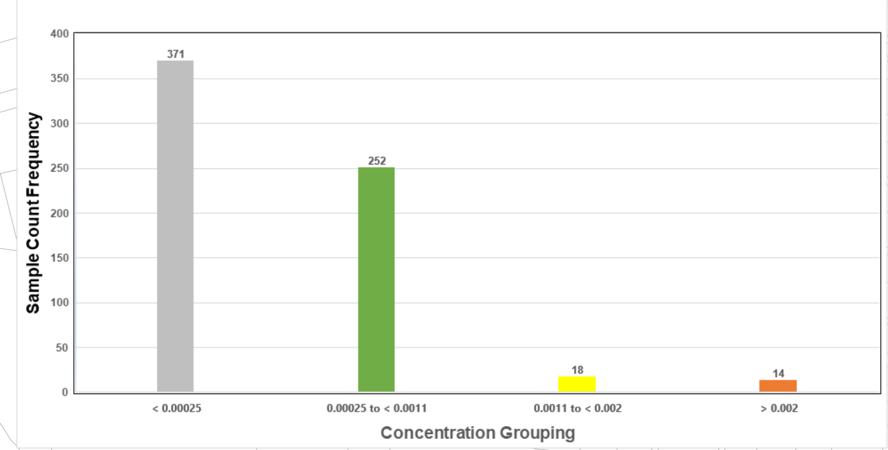

Legend

2,3,7,8-TCDD (SRS/SMA) - Natural Neighbor

- ≤ PDI CUL (0.00025 µg/kg)
- > PDI CUL and ≤ PDI RAL (0.0011 µg/kg)
- > PDI RAL and ≤ PDI Nav RAL (0.002 µg/kg)
- > PDI Nav RAL (0.002 µg/kg)

PDI Sample Type

- SMA Delineation Sample Location (n=231)
- Stratified Random Sample Location (n=424)
- Navigation Channel
- Existing Cap
- Superfund Site Boundary (RM 1.9 to 11.8)

N

1,200 0 1,200 2,400 Feet

Notes:
1. SMA:Sediment Management Area, SRS:Stratified Random Sample.
2. Figure shows the centroid location of 2018 PDI actual grab locations (0 to 30 cm depth).
3. Site boundary based on EPA ROD and extends from RM 1.9 to RM 11.8.
4. Natural Neighbor interpolation using 10-ft by 10-ft grid.
5. Natural Neighbor interpolation area based on 4 site regions provided by EPA on 6 Nov. 2018

Natural Neighbor Interpolated Surface Sediment 2,3,7,8-TCDD Dioxin Map (SRS and SMA)

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Figure **3.1d**

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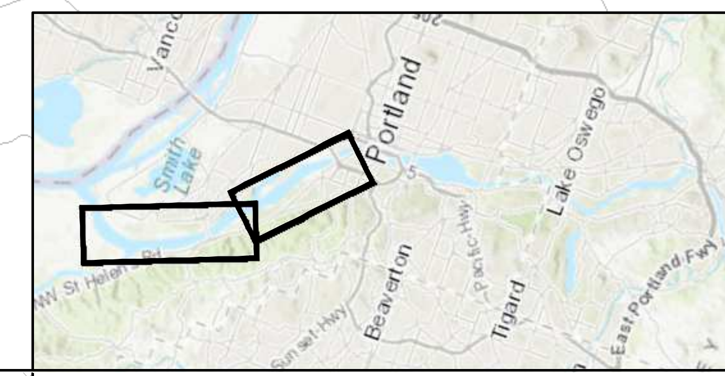

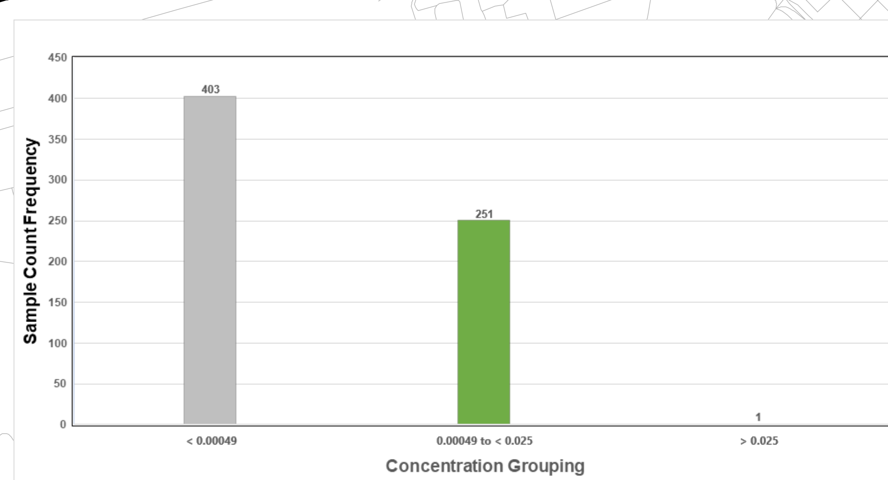

Legend

1,2,3,7,8-PeCDD (SRS/SMA) - Natural Neighbor

- ≤ PDI CUL (0.00049 µg/kg)
- > PDI CUL and < PDI/Nav RAL (0.025 µg/kg)
- > PDI/Nav RAL (0.025 µg/kg)

PDI Sample Type

- SMA Delineation Sample Location (n=231)
- Stratified Random Sample Location (n=424)
- Navigation Channel
- Existing Cap
- Superfund Site Boundary (RM 1.9 to 11.8)

N

1,200 0 1,200 2,400 Feet

Notes:
1. SMA:Sediment Management Area, SRS:Stratified Random Sample.
2. Figure shows the centroid location of 2018 PDI actual grab locations (0 to 30 cm depth).
3. Site boundary based on EPA ROD and extends from RM 1.9 to RM 11.8.
4. Natural Neighbor interpolation using 10-ft by 10-ft grid.
5. Natural Neighbor interpolation area based on 4 site regions provided by EPA on 6 Nov. 2018

Natural Neighbor Interpolated Surface Sediment 1,2,3,7,8-PeCDD Dioxin Map (SRS and SMA)

Portland Harbor Superfund Site
PDI Evaluation Report

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Figure **3.1e**

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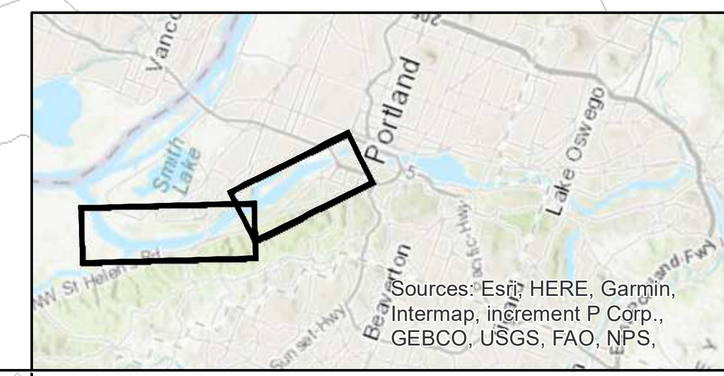
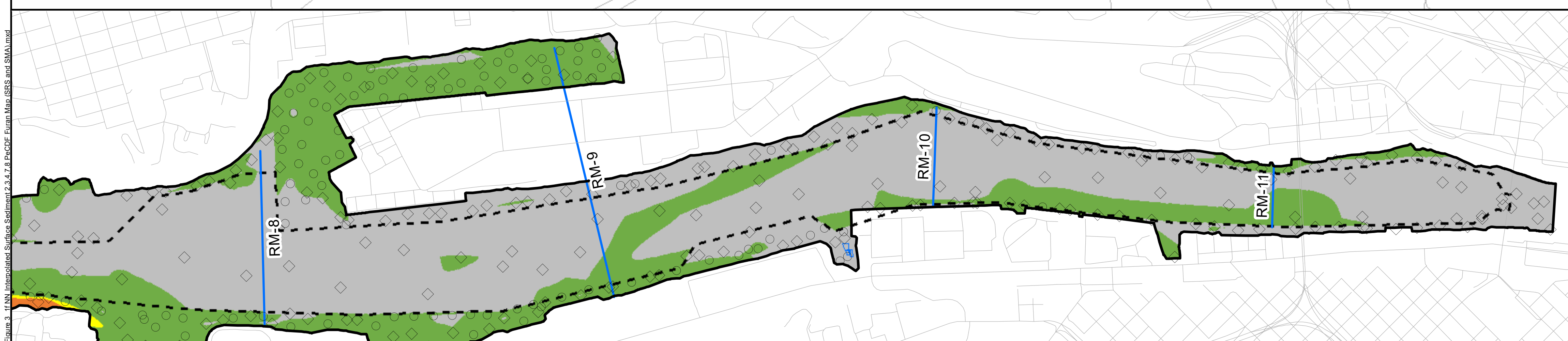
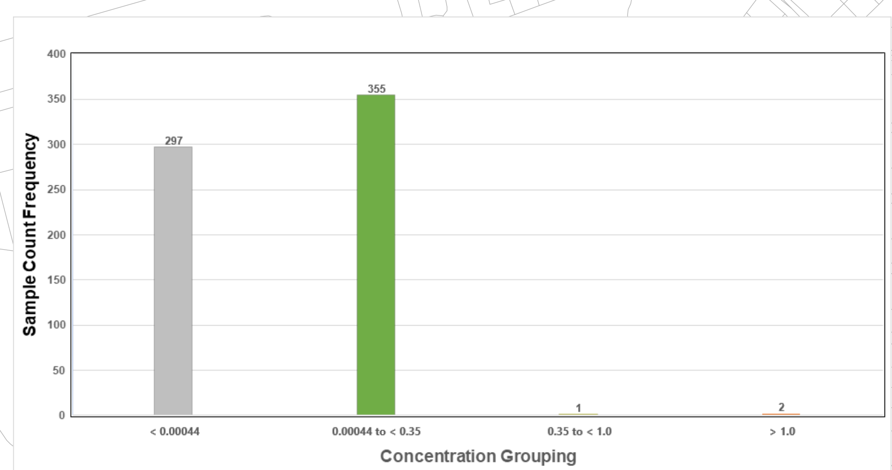
Path: P:\Projects\Portland Pre-Design PNG0767A\900 GIS and CAD\Evaluation Report\MXDs\Main\Figure 3_1e NN Interpolated Surface Sediment 1,2,3,7,8-PeCDD Dioxin Map (SRS and SMA).mxd







Notes:
1. SMA:Sediment Management Area, SRS:Stratified Random Sample.
2. Figure shows the centroid location of 2018 PDI actual grab locations (0 to 30 cm depth).
3. Site boundary based on EPA ROD and extends from RM 1.9 to RM 11.8.
4. Natural Neighbor interpolation using 10-ft by 10-ft grid.
5. Natural Neighbor interpolation area based on 4 site regions provided by EPA on 6 Nov. 2018

Legend

2,3,4,7,8-PeCDF (SRS/SMA) - Natural Neighbor

- ≤ PDI CUL (0.00044 µg/kg)
- > PDI CUL and ≤ PDI RAL (0.35 µg/kg)
- > PDI RAL 0.35 and ≤ PDI Nav RAL (1 µg/kg)
- > ROD Nav RAL (1 µg/kg)

PDI Sample Type

- SMA Delineation Sample Location (n=231)
- Stratified Random Sample Location (n=424)
- Navigation Channel
- Existing Cap
- Superfund Site Boundary (RM 1.9 to 11.8)

N

1,200 0 1,200 2,400 Feet

Natural Neighbor Interpolated Surface Sediment 2,3,4,7,8 PeCDF Furan Map (SRS and SMA)

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Figure **3.1f**

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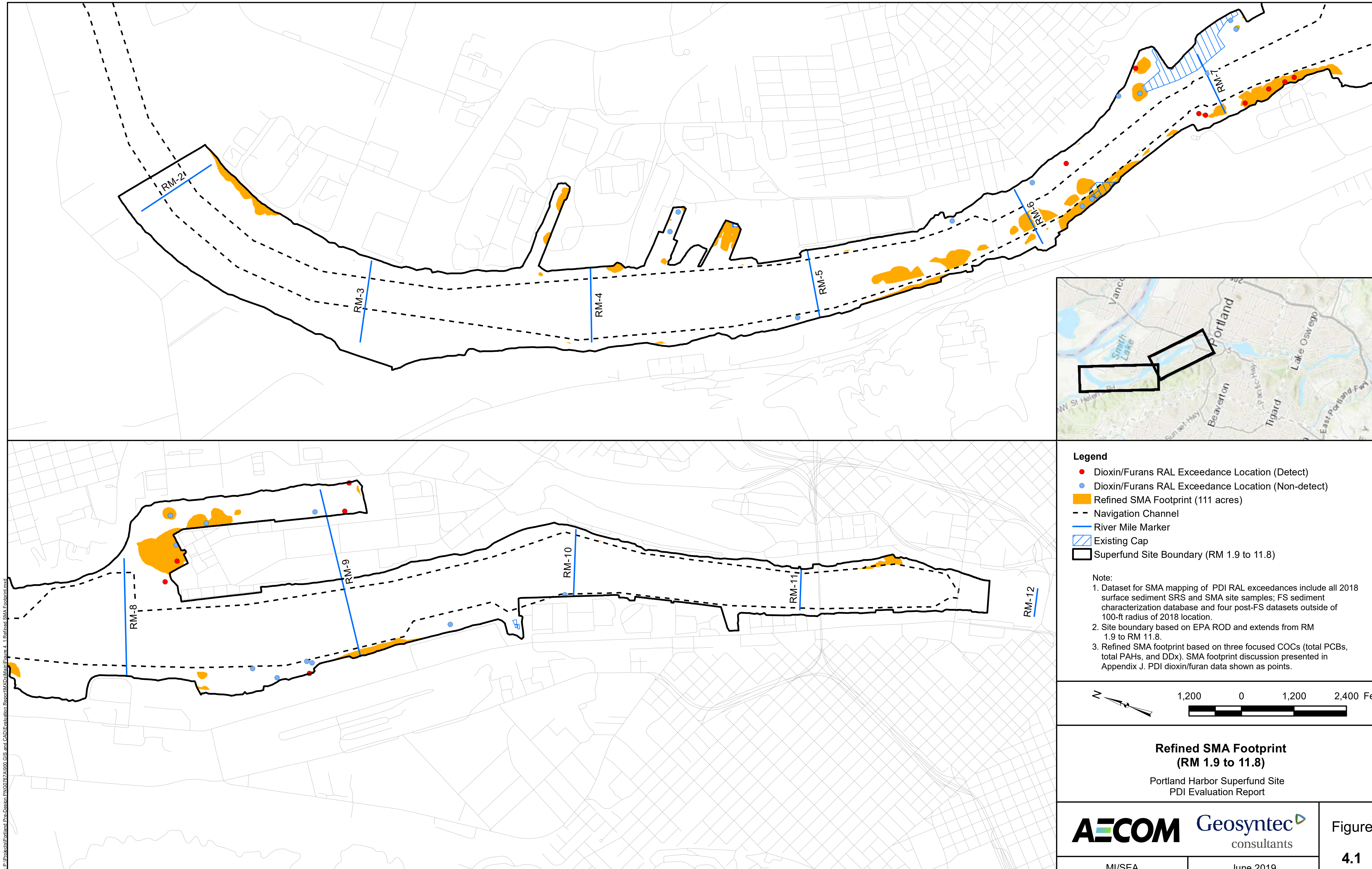
Path: P:\Projects\Portland Pre-Design PNG0767A\900 GIS and CAD\Evaluation Report\MXDs\Main\Figure 3_1f NN Interpolated Surface Sediment 2,3,4,7,8 PeCDF Furan Map (SRS and SMA).mxd



Legend

- Dioxin/Furans RAL Exceedance Location (Detect)
- Dioxin/Furans RAL Exceedance Location (Non-detect)
- Refined SMA Footprint (111 acres)
- Navigation Channel
- River Mile Marker
- Existing Cap
- Superfund Site Boundary (RM 1.9 to 11.8)

Note:
1. Dataset for SMA mapping of PDI RAL exceedances include all 2018 surface sediment SRS and SMA site samples; FS sediment characterization database and four post-FS datasets outside of 100-ft radius of 2018 location.
2. Site boundary based on EPA ROD and extends from RM 1.9 to RM 11.8.
3. Refined SMA footprint based on three focused COCs (total PCBs, total PAHs, and DDx). SMA footprint discussion presented in Appendix J. PDI dioxin/furan data shown as points.

Refined SMA Footprint
(RM 1.9 to 11.8)

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Figure **4.1**

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