

Lower Duwamish Waterway Group

City of Seattle / King County / The Boeing Company

PRE-DESIGN INVESTIGATION QUALITY ASSURANCE PROJECT PLAN ADDENDUM NO. 1 FOR THE LOWER DUWAMISH WATERWAY MIDDLE REACH – PHASE II SAMPLING

FINAL

For submittal to

U.S. Environmental Protection Agency
Seattle, WA

June 12, 2024

Prepared by:



1201 3rd Avenue • Suite 2600
Seattle, Washington • 98101

in association
with



200 First Avenue West • Suite 500
Seattle, Washington • 98119

FINAL

TITLE AND APPROVAL PAGE

Remedial Design of Middle Reach

Pre-Design Investigation Quality Assurance Project Plan

Addendum




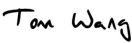



Windward Project Manager	 _____ Name	April 30, 2024 _____ Date
Windward Field Coordinator	 _____ Name	April 30, 2024 _____ Date
Windward QA/QC Manager	 _____ Name	April 30, 2024 _____ Date
Anchor QEA Project Manager	DocuSigned by:  _____ Name <small>E9C2F985081842B...</small>	5/1/2024 _____ Date
Anchor QEA Health and Safety Officer	DocuSigned by:  _____ Name <small>7378A499700B4BB...</small>	5/2/2024 _____ Date
EPA Project Manager	ELLEN HALE  _____ Name <small>Digitally signed by ELLEN HALE Date: 2024.06.12 13:45:56 -07'00'</small>	_____ Date
EPA QA/QC Manager	Don Matheny  _____ Name <small>Digitally signed by Don Matheny Date: 2024.05.02 13:57:41 -07'00'</small>	_____ Date

TABLE OF CONTENTS

1	Introduction	1
2	Project Objectives and Description	2
2.1	Data Quality Objectives	2
2.2	Project Description and Schedule.....	3
3	Project Organization and Responsibilities	5
4	Data Generation and Acquisition for Sediment and Bank Analytical Samples.....	7
4.1	Sampling Design for Sediment and Bank Samples.....	7
4.1.1	General Principles for Identification of Locations	7
4.1.2	Depth Intervals	9
4.1.3	Tiered Sample Analysis.....	12
4.1.4	Analytes.....	13
4.1.5	Toxicity Testing Design	17
4.2	Sample Collection and Processing	20
4.3	Sample Identification.....	21
4.4	Sample Analysis and Toxicity Testing.....	21
4.5	Field-generated Waste Disposal	23
4.6	Sediment Chemistry Quality Assurance/Quality Control.....	24
5	Data Generation and Acquisition of Engineering PDI Elements.....	25
5.1	Topographic Survey and Bank Features.....	25
5.2	Geotechnical Investigation	26
5.2.1	Review of Pre-PDI Geotechnical Data	26
5.2.2	Geotechnical Investigation Design	27
5.3	Other Engineering Data.....	29
5.3.1	Structures.....	29
5.3.2	Sediment Thickness over Armored Banks.....	30
6	Assessment and Oversight	32
7	References	33

FIGURES

Figure 2-1 Design Sampling Phases.....3
 Figure 3-1 Project Organization and Team Responsibilities.....6

TABLES

Table 2-1 DQOs for Phases I and II of the PDI in the Middle Reach.....2
 Table 4-1 Summary of Phase II Middle Reach Sampling Locations and Phase I Archive
 Samples to be Analyzed.....8
 Table 4-2 RAL Exceedance Intervals 10
 Table 4-3 Summary of Vertical Extent Target Depths..... 11
 Table 4-4 Berthing Areas with Vertical Extent Cores..... 12
 Table 4-5 Summary of RAL Exceedances within each RAL Exceedance Area 15
 Table 4-6 Potential Toxicity Testing Locations with Surface Sediment RAL Exceedances for
 Phenol..... 18
 Table 4-7 Toxicity Testing Locations for Chemicals other than Phenol..... 20
 Table 4-8 Sediment Analyses to be Conducted at Each Analytical Laboratory 23
 Table 5-1 Identified Over-water Structures in the Middle Reach and Phase I Observations
 Summary 29

MAPS

Map 1-1. Middle Reach of the Lower Duwamish Waterway
 Map 4-1a. Phase II Sample Locations, RAL Exceedances, and RAL Exceedance Areas Based on the
 Design Dataset, RM 1.6 to RM 1.85
 Map 4-1b. Phase II Sample Locations, RAL Exceedances, and RAL Exceedance Areas Based on the
 Design Dataset, RM 1.85 to RM 2.15
 Map 4-1c. Phase II Sample Locations, RAL Exceedances, and RAL Exceedance Areas Based on the
 Design Dataset, RM 2.15 to RM 2.45
 Map 4-1d. Phase II Sample Locations, RAL Exceedances, and RAL Exceedance Areas Based on the
 Design Dataset, RM 2.45 to RM 2.75
 Map 4-1e. Phase II Sample Locations, RAL Exceedances, and RAL Exceedance Areas Based on the
 Design Dataset, RM 2.75 to RM 3.0
 Map 4-1f. Phase II Sample Locations, RAL Exceedances, and RAL Exceedance Areas Based on the
 Design Dataset, RM 1.9 to RM 2.0

- Map 4-1g. Phase II Sample Locations, RAL Exceedances, and RAL Exceedance Areas Based on the Design Dataset, near Beach 6
- Map 4-1h. Phase II Sample Locations, RAL Exceedances, and RAL Exceedance Areas Based on the Design Dataset, near RM 2.65 to RM 2.85
- Map 4-2a. Phase II Sample Locations, RAL Exceedances, and PCB Interpolation Uncertainty Bands Based on the Design Dataset, RM 1.6 to RM 1.85
- Map 4-2b. Phase II Sample Locations, RAL Exceedances, and PCB Interpolation Uncertainty Bands Based on the Design Dataset, RM 1.85 to RM 2.15
- Map 4-2c. Phase II Sample Locations, RAL Exceedances, and PCB Interpolation Uncertainty Bands Based on the Design Dataset, RM 2.15 to RM 2.45
- Map 4-2d. Phase II Sample Locations, RAL Exceedances, and PCB Interpolation Uncertainty Bands Based on the Design Dataset, RM 2.45 to RM 2.75
- Map 4-2e. Phase II Sample Locations, RAL Exceedances, and PCB Interpolation Uncertainty Bands Based on the Design Dataset, RM 2.75 to RM 3.0
- Map 4-3a. Categories of Vertical Extent Cores, RM 1.6 to RM 2.3
- Map 4-3b. Categories of Vertical Extent Cores, RM 2.3 to RM 3.0
- Map 4-4a. Phase II Sample Locations for Dioxin/Furan Analysis, RM 1.6 to RM 2.3
- Map 4-4b. Phase II Sample Locations for Dioxin/Furan Analysis, RM 2.3 to RM 3.0
- Map 4-5. Toxicity Testing Locations
- Map 4-6. Phase II Sampling Locations, Property Ownership, and Waterfront Operations
- Map 5-1a. Phase II PDI Shoreline Survey Areas Within and Adjacent to RAL Exceedance Areas 29, 30, and 32
- Map 5-1b. Phase II PDI Shoreline Survey Areas Within and Adjacent to RAL Exceedance Areas 25, 26, and 28
- Map 5-1c. Phase II PDI Shoreline Survey Areas Within and Adjacent to RAL Exceedance Area 22 and 23
- Map 5-1d. Phase II PDI Shoreline Survey Areas Within and Adjacent to RAL Exceedance Areas 14, 15, 16, and 19
- Map 5-1e. Phase II PDI Shoreline Survey Areas Within and Adjacent to RAL Exceedance Area 21
- Map 5-1f. Phase II PDI Shoreline Survey Areas Within and Adjacent to RAL Exceedance Areas 11 and 12
- Map 5-1g. Phase II PDI Shoreline Survey Areas Within and Adjacent to RAL Exceedance Area 5
- Map 5-1h. Phase II PDI Shoreline Survey Areas Within and Adjacent to RAL Exceedance Areas 3, 8, and 9

- Map 5-2a. Phase II Geotechnical Investigation Locations, RM 1.6 to RM 2.3
- Map 5-2b. Phase II Geotechnical Investigation Locations, RM 2.3 to RM 3.0

ATTACHMENTS

Attachment A	Phase II Sampling for cPAHs
Attachment B	Sample-specific Details and Rationale
Attachment C	Updated Standard Operating Procedures
Attachment D	Existing Geotechnical Studies
Attachment E	Geotechnical Data Collection Locations and Rationale
Attachment F	Survey QAPP Addendum

ABBREVIATIONS

BBP	butyl benzyl phthalate
BEHP	bis(2-ethylhexyl) phthalate
COC	contaminant of concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
DER	data evaluation report
DMMP	Dredged Material Management Program
DQO	data quality objective
dw	dry weight
EF	exceedance factor
ENR	enhanced natural recovery
EPA	U.S. Environmental Protection Agency
FNC	Federal Navigation Channel
FS	feasibility study
ID	identification
LDW	Lower Duwamish Waterway
MLLW	mean lower low water
MHHW	mean higher high water
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PDI	Pre-Design Investigation
PDIWP	Pre-Design Investigation Work Plan
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RAL	remedial action level
RD	remedial design
RM	river mile
ROD	Record of Decision
SCO	sediment cleanup objective
SM	standard method
SOP	standard operating procedure
SVOC	semivolatile organic compound
TOC	total organic carbon
WUS	waterway user survey

1 Introduction

This document is the first addendum to the Pre-Design Investigation (PDI) quality assurance project plan (QAPP) for the middle reach¹ of the Lower Duwamish Waterway (LDW) (Map 1-1) (Windward and Anchor QEA 2022). The QAPP describes the quality assurance (QA) objectives, methods, and procedures for PDI sampling and analysis. This work will support remedial design (RD) for the middle reach per the Fifth Amendment to the Administrative Order on Consent for the LDW (EPA 2021a), in accordance with the U.S. Environmental Protection Agency's (EPA's) November 2014 Record of Decision (ROD) (EPA 2014).

This QAPP addendum presents a detailed study design for PDI Phase II sampling within the middle reach, including sampling locations, intervals, and analytes, as well as any updates to field collection methods, laboratory analysis methods, data management protocols, and reporting requirements. All aspects of PDI sampling and analysis not addressed herein are the same as those specified in the middle reach PDI QAPP (Windward and Anchor QEA 2022).

Following submittal of the Phase I PDI data evaluation report (DER) and QAPP, EPA, the Washington State Department of Ecology, and the Lower Duwamish Waterway Group² agreed that characterization of the Inlet at river mile (RM) 2.2W should be included as part of the middle reach PDI. A separate PDI QAPP addendum (i.e., QAPP Addendum No. 2) presents existing data collected from the Inlet at RM 2.2W and the resulting PDI Phase II sampling design for that area.

¹ The middle reach includes river mile (RM) 1.6 to RM 3.0 of the LDW.

² The members of the Lower Duwamish Waterway Group are The City of Seattle, King County, and The Boeing Company. These three entities are working collaboratively to implement the Fifth Amendment to the Administrative Order on Consent.

2 Project Objectives and Description

2.1 Data Quality Objectives

PDI sampling is being conducted in phases in the middle reach. Phase II sampling is being conducted to meet the Phase II data quality objectives (DQOs) outlined in Table 2-1. Phase I DQOs were met by Phase I sampling, and Phase I results are presented herein and in the Phase I DER (Anchor QEA and Windward 2023).

**Table 2-1
DQOs for Phases I and II of the PDI in the Middle Reach**

Phase I	Phase II
DQO1 – Delineate 0–10-cm RAL exceedances in Recovery Category 2/3	DQO10 – Further delineate RAL exceedances, as needed for unbounded areas ¹
DQO2 – Delineate 0–10-cm RAL exceedances in Recovery Category 1	DQO11 – Assess chemical and physical characteristics of sediment in banks, as needed, depending on remedial technology selected and whether or not the bank is erosional
DQO3 – Delineate 0–45-cm intertidal RAL exceedances in Recovery Category 2/3	DQO12 – Delineate vertical elevation of RAL exceedances in dredge (and partial dredge and cap) areas and collect vertical contamination information in cap areas where deeper contamination under caps may be located ²
DQO4 – Delineate 0–45-cm intertidal RAL exceedances in Recovery Category 1	DQO13 – Collect geotechnical data as needed depending on technology proposed and/or physical characteristics of remedial action areas
DQO5 – Delineate 0–60-cm PCB RAL exceedances in potential vessel scour areas in Recovery Category 2/3	DQO14 – Collect other engineering-applicable data as needed (e.g., structures inspection, utility location verification, thickness of sediment on top of riprap layers)
DQO6 – Delineate 0–60-cm RAL exceedances in Recovery Category 1	
DQO7 – Delineate RAL exceedances in shoaling areas	
DQO8 – Conduct a visual inspection of the structures and banks in the middle reach to identify features relevant to RD, such as the presence/absence of bank armoring, and to plan how to access banks and areas under structures for sampling purposes	
DQO9 – Sample areas under structures, if feasible, safe, and appropriate, to delineate RAL exceedances	

Notes:

1. Benthic toxicity testing may be used to override chemical data in RAL delineation (DQO 10), per the ROD (EPA 2014).
2. Vertical delineation includes an assessment of whether an additional 1 foot of dredging in partial dredge and cap areas would be sufficient to achieve complete removal, as shown in ROD Figure 20 (EPA 2014).

DQO: data quality objective

PCB: polychlorinated biphenyl

PDI: pre-design investigation

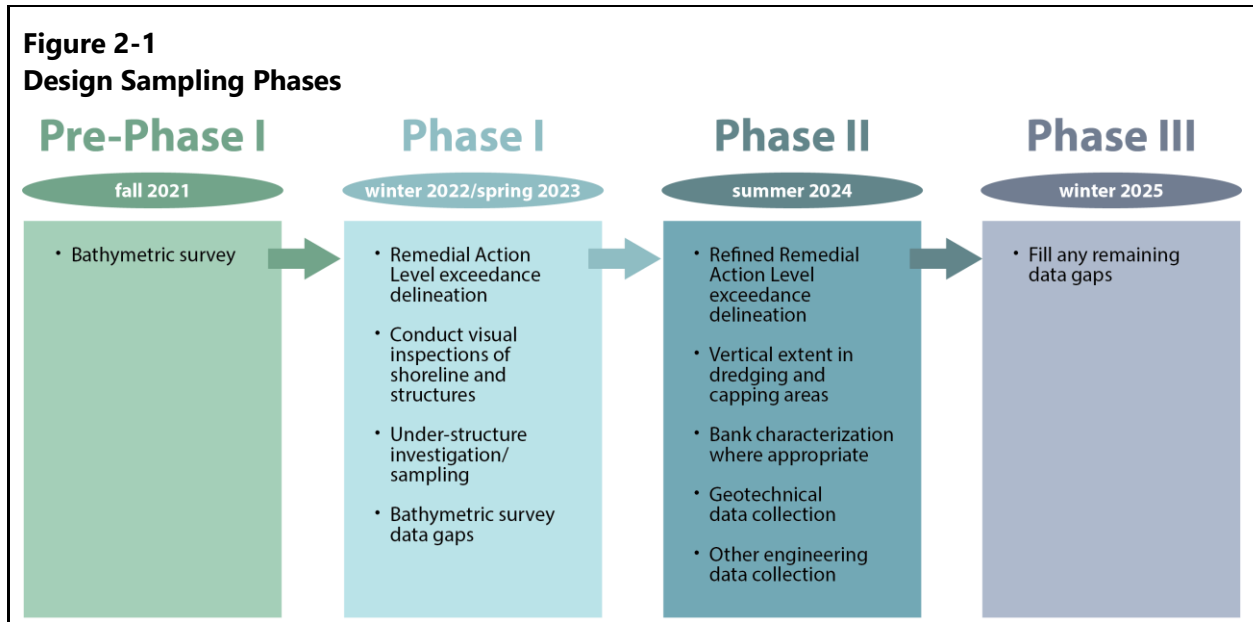
RAL: remedial action level

RD: remedial design

ROD: Record of Decision

2.2 Project Description and Schedule

Phase II sampling, as presented in this addendum, will involve the collection and chemical analysis of sediment and bank samples to refine the delineation of remedial action level (RAL)³ exceedances, assess the vertical extent of contamination in dredging or partial dredging and cap areas, and acquire area-specific engineering information needed for design (Figure 2-1). Following Phase II sampling, a Phase II DER will be prepared to interpret the results and guide the development of subsequent RD activities.



The Tier 1 and Tier 2 results of the Phase I PDI sediment sampling have been uploaded to <https://ldwg.org/> as a data package with backup documentation. The complete Phase I design dataset⁴ is provided in Appendix I of the middle reach Phase I DER (Anchor QEA and Windward 2023).

Results of the Phase I bank visual inspection, structures visual inspection, bathymetric surveys, and recovery category assessment are attached to the Phase I DER; these results are used in this PDI

³ As stated in the ROD (EPA 2014), a RAL is a contaminant concentration above which active remediation is required. RALs for the LDW are defined in ROD Table 28, titled *Remedial Action Levels, ENR Upper Limits, and Areas and Depths of Application*. EPA has updated the carcinogenic polycyclic aromatic hydrocarbon (cPAH) RALs, target tissue levels, and cleanup levels presented in ROD Table 28 in an explanation of significant differences for the LDW (EPA 2021b). The explanation of significant differences RALs are used in this addendum.

⁴ The design dataset, which is Appendix I to the middle reach DER (Anchor QEA and Windward 2023), contains data from the remedial investigation/feasibility study (FS), post-FS data, and Phase I PDI data. Phase II (and, if collected, Phase III) data will be added to the design dataset when available.

QAPP Addendum and will be supplemented with any additional information gathered during Phase II.

An archaeological monitoring and inadvertent discovery plan describing the actions to be performed during Phase II investigations related to any unanticipated discovery of cultural resources, artifacts, or other archaeological features is available upon request. The monitoring and inadvertent discovery plan describes the locations where archaeological monitoring will take place and provides direction, contact information, and guidance for the proper procedures to follow should an inadvertent discovery occur. In addition, all data collection and sampling activities will be conducted in conformance with the health and safety plan for the middle reach PDI QAPP (Attachment A) (Windward and Anchor QEA 2022).

Phase II sampling will begin in May 2024 upon approval of this QAPP addendum. Sampling and analysis are anticipated to be complete by the end of October 2024.

3 Project Organization and Responsibilities

Details regarding overall project organization, individuals responsible for various tasks required for PDI sampling and analysis, and documentation and records keeping are provided in Section 3 of the middle reach PDI QAPP (Windward and Anchor QEA 2022).

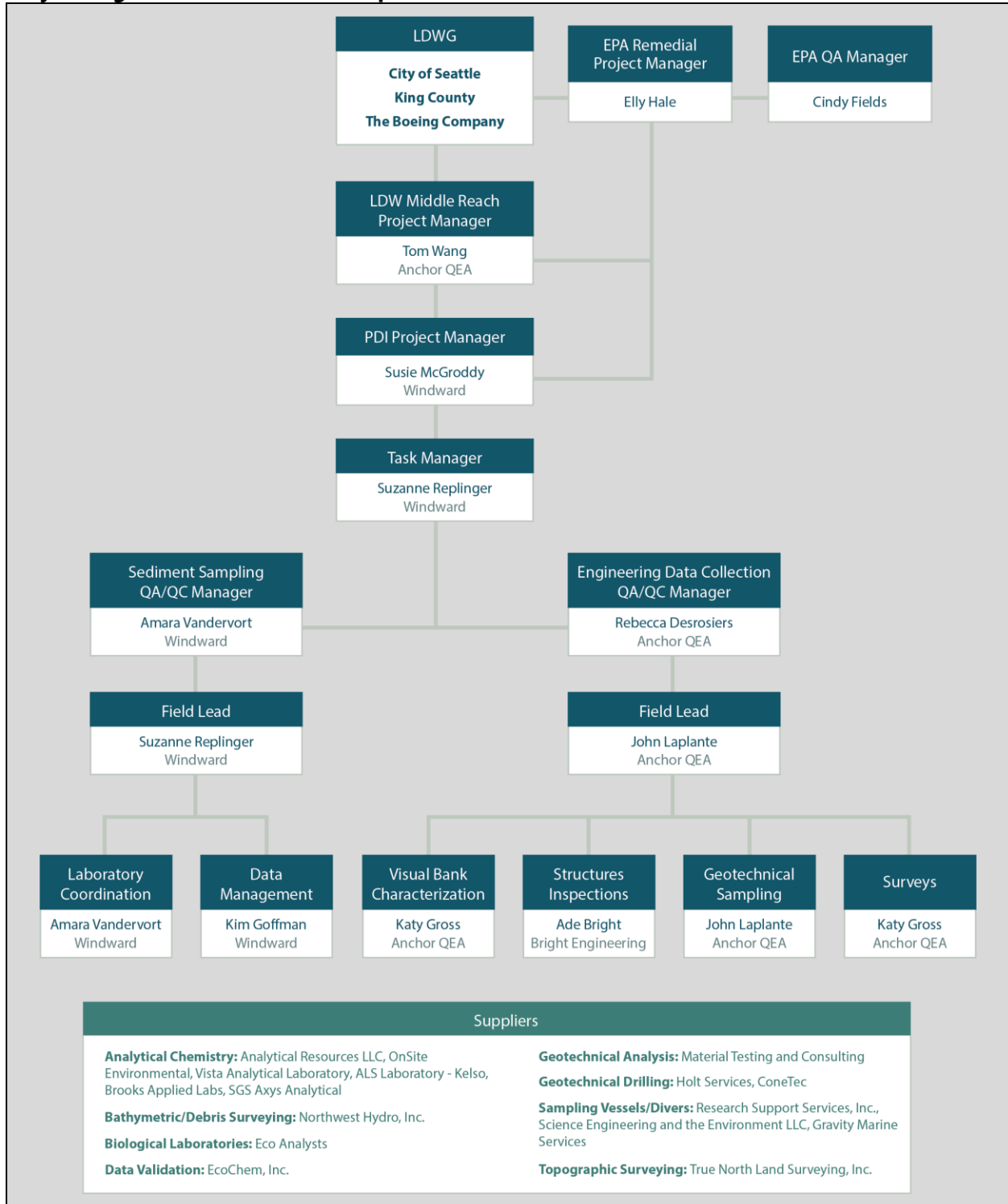
Cindy Fields is the new EPA QA Manager. Don Matheny works on behalf of the QA manager and is the EPA contact for the middle reach of the LDW.

The data validation firm has changed from the firm identified in the PDI QAPP. The firm identified in the PDI QAPP, LDC Inc., was not able to validate the Phase I data; the validation was conducted by EcoChem Inc. For Phase II, EcoChem Inc. will provide independent third-party chemical data review and validation. The Project Manager at EcoChem Inc. can be reached as follows:

Ms. Alison Bodkin
EcoChem, Inc.
500 Union Street, Suite 1010
Seattle, WA 98101
206.508.2104

Project organization and team responsibilities are shown in Figure 3-1.

**Figure 3-1
Project Organization and Team Responsibilities**



4 Data Generation and Acquisition for Sediment and Bank Analytical Samples

This section presents the design and methodology for Phase II sediment sampling, analysis, and toxicity testing.

4.1 Sampling Design for Sediment and Bank Samples

To address DQOs 9 to 12, Phase II sediment sampling will be conducted in the middle reach, including sampling under structures and on banks as needed. The sampling design discussed in this section includes an overall approach as well as the rationale for sampling locations, depth intervals, analytes, and tiering.

Information regarding sample custody and shipping requirements; decontamination procedures; field-generated waste disposal; laboratory methods; sediment chemistry analytical DQOs and criteria and QA/quality control (QC); sediment benthic toxicity testing methods and QA/QC; instrument/equipment testing, inspection, maintenance, and calibration; and analytical data management is presented in the middle reach PDI QAPP (Windward and Anchor QEA 2022) and is not repeated herein.

4.1.1 General Principles for Identification of Locations

To determine specific sediment and bank sampling locations for Phase II sampling, the following five principles were applied based on the existing design dataset for the middle reach. Table B-4 in Attachment B provides a discussion of the key Phase II sampling objectives for each RAL exceedance area.

- **Refine horizontal boundaries of Phase I RAL exceedance areas:** Collect additional sediment and bank data around the boundaries of areas with RAL exceedances to refine the horizontal extents of RAL exceedance areas (i.e., to reduce uncertainties in the polychlorinated biphenyl [PCB] data interpolation or refine Thiessen polygon shapes for other contaminants of concern [COCs]). Sampling locations were selected based on area-specific considerations, including spatial distribution of data, potential upland sources, conceptual site model, bank type, presence of in-water structures, and bathymetric elevations and grades.
- **Gather data in RAL exceedance areas defined only by interpolation:** Collect samples in or adjacent to RAL exceedance areas that are based on interpolated concentrations only (herein referred to as interpolation-only RAL exceedance areas). These areas do not have any sample locations with RAL exceedances but are included as RAL exceedance areas because interpolated concentrations exceed RALs as they cross recovery category or shoaling area boundaries that have different RALs.

- **Bound vertical extent:** Collect samples within RAL exceedance areas where needed for RD (e.g., dredging or partial dredging and cap areas) to determine the vertical extent of contamination. In addition, archive vertical extent cores from areas where vertical extent data may be needed, but specific intervals are not yet known (e.g., for side slope characterization).
- **Collect sediment for benthic toxicity testing:** Reoccupy locations that only exceed benthic RALs for toxicity testing and that, if they were to pass benthic toxicity tests, would affect area boundaries and/or eliminate the need for remediation.
- **Collect bank samples at locations adjacent to RAL exceedance areas:** For RAL exceedance areas located along the shorelines, sample collection will target bank areas when they are sampleable (see Attachment B).

Using these principles, Phase II sediment sampling is proposed at 301 locations, many of which will have more than 1 sample depth interval (Table 4-1). In addition, Table 4-1 summarizes the 13 locations where archived Phase I sediment samples will be analyzed as part of Phase II (for 6 of these 13 locations, samples were analyzed for all other applicable COCs during Phase I, and thus will be analyzed only for dioxins/furans in Phase II). These locations are shown on Maps 4-1a through 4-1e; Maps 4-1f through 4-1h show Phase II locations near RM 1.9E, Beach 6 (RM 2.8E), and RM 2.7 to RM 2.8W in more detail. The locations are shown with PCB interpolation probability bands on Maps 4-2a through 4-2e. At most of the Phase II locations, at least one sample will be analyzed as part of Tier 1 (i.e., upon collection); the remaining samples will be archived and analyzed, if needed, as part of Tier 2 (see Section 4.1.3).

Table 4-1
Summary of Phase II Middle Reach Sampling Locations and Phase I Archive Samples to be Analyzed

Sample Type	Count of Design Dataset Locations ¹				Map 4-1 Series Symbology
	No. Prior to Phase II	No. Phase I Archives for Analysis ²	No. of Phase II Locations		
			Tier 1	Tier 2	
Sediment Samples					
Surface (0–10 cm)	473	2	135	14	Indicated on maps by blue or gray circles (or pink if potential toxicity testing location)
Intertidal subsurface (0–45 cm) ³	70	2	62	21	Indicated on maps by blue or gray pentagons
Subtidal subsurface (0–60 cm) (not shoaling areas) ⁴	155	7	40	62	Indicated on maps by blue or gray squares (or pink if potential toxicity testing location)
Shoaling area subsurface (variable) ^{4,5}	47	2	9	30	Indicated on maps by blue or gray squares with yellow rims in dark green shoaling areas

Sample Type	Count of Design Dataset Locations ¹				Map 4-1 Series Symbology
	No. Prior to Phase II	No. Phase I Archives for Analysis ²	No. of Phase II Locations		
			Tier 1	Tier 2	
Vertical extent cores	0	0	73	116	Indicated on maps by blue or gray Vs; core profiles provided in Attachment B provide details regarding which intervals will be analyzed in Tier 1 vs. archived.
Upland Samples					
Upland soils ⁶	NA	0	1	0	Indicated on maps by brown hexagons

Notes:

1. This table presents the location counts by sample type for Phase II; it includes the samples to be collected at the 14 under-structure locations. The sample counts are greater than the location counts because many locations have multiple sample intervals. See Attachment B tables for details. The location counts do not include the sample locations for cPAH-only areas discussed in Attachment A.
2. This count describes the 13 locations where archived Phase I samples will be analyzed as part of Phase II (note that 6 of these samples were analyzed during Phase I for all applicable COCs other than dioxins/furans). No sample collection is needed at these locations (see Attachment B).
3. At each vertical extent location in an intertidal area where only a V is shown on the Map 4-1 series, a 0–45-cm archive sample will also be collected as part of that core. These locations are included in the Tier 2 counts in this table.
4. At each vertical extent location in a subtidal area where only a V is shown on the Map 4-1 series, a 0–60-cm archive sample (or shoaling interval archive sample) will also be collected as part of that core. These locations are included in the Tier 2 counts in this table.
5. Sampling depths for shoaling area cores vary depending on the thickness of shoal material at each location (see Figure 4-1 in the middle reach PDI QAPP (Windward and Anchor QEA 2022)).
6. The one upland soil sample is not included in the Phase II sediment sample count but is shown the Map 4-1 series. Data from this sample will not be included in the sediment design dataset.

COC: contaminant of concern

cPAH: carcinogenic polycyclic aromatic hydrocarbon

MHHW: mean higher high water

NA: not available

PDI: pre-design investigation

QAPP: quality assurance project plan

RAL: remedial action level

ROD: Record of Decision

4.1.2 Depth Intervals

4.1.2.1 Horizontal Delineation

Sediment depth intervals sampled to delineate RAL exceedances were described in the middle reach PDI QAPP (Windward and Anchor QEA 2022). In Phase II, samples will be collected from these depth intervals to refine the horizontal extent of RAL exceedances in sediment. The applicable RAL intervals are summarized in Table 4-2.

**Table 4-2
RAL Exceedance Intervals**

Area Type	Applicable RAL Intervals	
	Surface	Subsurface
Intertidal	0–10 cm	0–45 cm
Subtidal	0–10 cm	0–60 cm (in Recovery Category 1 and potential vessel scour areas ¹)
Shoaled areas in the FNC	0–10 cm	Shoaled material (depth and number of samples varies, depending on the depth of shoal) ²
		2 feet of over dredge

Notes:

1. The only segment of the FNC with the potential for vessel scour is RM 2.8 to RM 3.0, with an authorized navigation depth of -15 feet MLLW, which is shallower than the vessel scour depth of -18 feet MLLW. Between RM 1.6 and RM 2.8, the authorized depths (-20 feet MLLW and -30 feet MLLW) are deeper than the corresponding potential vessel scour depths (-18 feet MLLW and -24 feet MLLW, respectively).

2. The depth intervals for the shoaled material are shown on Figure 4-1 of the middle reach PDI QAPP (Windward and Anchor QEA 2022).

DMMP: Dredged Material Management Program

FNC: Federal Navigation Channel

MLLW: mean lower low water

RAL: remedial action level

RM: river mile

4.1.2.2 Vertical Extent Delineation

Cores extending below the RAL intervals (referred to herein as vertical extent cores) will be collected to determine the depth of contamination below the sediment surface where needed for remedy design. Vertical extent cores are needed in areas with RAL exceedances that have the potential for dredging or partial dredging and capping technology remedies. The target elevations or depths for the vertical cores are discussed in Section 4.1.6 in the middle reach PDI QAPP (Windward and Anchor QEA 2022) and are further described in Table 4-3. Any sediment collected below the target elevation (or target core depth), including native material, will be archived in 30-cm (approximately 1-foot) intervals.

**Table 4-3
Summary of Vertical Extent Target Depths**

Area Type	Target Core Elevation or Core Depth	Summary of Rationale
Within the FNC	Target elevation: 11 feet below the authorized depth ^{1,2}	ROD requires top of cap to be 4 feet below authorized depth; thus, assuming a maximum potential cap thickness of 5 feet and a need to characterize an additional 2 feet below the cap, 11 feet below the authorized depth must be characterized
Outside the FNC – in berthing areas	Target elevation: 9 feet below operating depth ²	See Table 4-4
Outside the FNC – in habitat areas (defined as areas above -10 ft MLLW in the ROD)	Target core depths: 7.5 ft in intertidal ³ 10 ft in subtidal	Intertidal: 6 feet below RAL interval Subtidal: 8 feet below RAL interval
Outside the FNC – other subtidal areas	Target core depth: 10 ft (minimum)	At least 8 feet below the 2-foot RAL interval (e.g., possibly deeper in side slope areas)

Notes:

1. Within the FNC, the vertical extent cores will be collected to target elevations of -26 feet MLLW (between RM 2.8 and RM 3.0), -31 feet MLLW (between RM 2.0 and RM 2.8), and -41 feet MLLW (between RM 1.6 and RM 2.0), allowing for characterization of at least 2 feet of sediment below the maximum cap thickness.
 2. If, based on the target elevation, the target depth for a core is less than 6 feet, the field crew will attempt to collect a core with a minimum length of 6 feet.
 3. When hand collection of vertical extent cores is necessary, the core length will be as long as feasible but will be less than 7.5 feet.
- FNC: federal navigation channel
 MLLW: mean lower low water
 RM: river mile
 ROD: record of decision

As shown in Table 4-3, target elevations are defined both for cores collected within the Federal Navigation Channel (FNC) (as well as those within a 10-foot buffer on either side of the FNC boundary) and for cores within berthing areas.

Outside the FNC and berthing areas, 10-foot cores will be collected in subtidal areas (i.e., the 0- to 60-cm RAL interval plus 8 feet) and 7.5-foot cores will be collected in intertidal areas (i.e., the 0- to 45-cm RAL interval plus 6 feet). The core depths are based on an assumed maximum potential cap thickness of 5 feet and the need to characterize an additional 2 feet below the cap, resulting in a minimum core depth of 7 feet. The subtidal core target depth includes an additional 2 feet because these areas may not require backfill after dredging, and additional vertical information may be useful in design. In intertidal areas where collecting vertical extent cores from a vessel is not feasible (e.g., due to accessibility of the area), cores will be hand collected as described in the subsurface sediment standard operating procedure (SOP) (Attachment C). In these cases, a shorter core (< 7.5 feet) will be collected based on method limitations or depth of refusal. A maximum core length of 4.5 to 5 feet is anticipated. In addition, based on an evaluation of potential side slopes, deeper cores will be targeted

at some locations along the FNC, as specified in Attachment B. The types of vertical cores are shown on Maps 4-3a and 4-3b.

Where vertical extent delineation is required within a berthing area outside of the FNC, the target elevation will be at least 9 feet below the operating depth, providing the data necessary to design a cap as thick as 5 feet. The operating depth and target depth for each berthing area with a vertical extent core are provided in Table 4-4.

**Table 4-4
Berthing Areas with Vertical Extent Cores**

RM (side)	Berthing Area ¹	Depth (feet MLLW)	
		Operating Depth ¹	Vertical Core Target Depth ²
1.65 (east)	Certainteed Pier	-31	-40
1.8–1.9 (east)	Samson Tug	-12	-21
1.9–2.0 (east)	Duwamish Marine Center ³	Not defined	10-foot core
1.8–1.9 (west)	Lineage Logistics (Terminal 115)	-20	-29
2.2 (west)	Alaska Marine ⁴	Not defined	10-foot core
2.3 (west)	Boyer Alaska Barge Line North Lay Berth ⁵	Not defined	10-foot core
2.2–2.3 (east)	Transient moorage used by Manson and AML ⁶	Not defined	10-foot core
2.4–2.55 (east)	Seattle Iron & Metals Wharves	-16	-25
2.6 (west)	Pacific Pile and Marine Mooring	-12	-21
2.7–2.8 (west)	Pacific Pile and Marine Wharf	-20	-29

Notes:

1. Berthing areas and operating depths obtained from the LDW FS (AECOM 2012).
2. Vertical core target depths may be adjusted based on information obtained during access agreement discussions.
3. Area identified as a berthing area in the LDW FS. It is used as a marina and has no maintained operating depth.
4. Alaska Marine area used as a lay berth with no defined operating depth.
5. Boyer lay berth with no defined operating depth.
6. Area identified as a berthing area in the LDW FS, but is not maintained and there is no defined operating depth. The presence of barges is consistent with the use of this area for transient moorage.

FS: feasibility study

LDW: Lower Duwamish Waterway

MLLW: mean lower low water

RM: river mile

TBD: to be determined

4.1.3 Tiered Sample Analysis

Like Phase I sampling, Phase II sediment sampling will involve the collection of two tiers of samples:

- Tier 1 – Locations sampled for immediate analysis
- Tier 2 – Locations sampled for sample archival, with analyses and analytes dependent on the results of Tier 1 analyses

Tier 1 and Tier 2 samples will be collected during the same sampling effort. The majority of the RAL interval samples will be analyzed in Tier 1. Whether or not analysis is needed for the Tier 2 RAL interval samples will depend on the need for additional bounding, which will be based on nearby Tier 1 sample results.

Of the 189 vertical extent core locations, approximately 40% (73 of 189 core locations) are characterized as Tier 1, meaning that some of the intervals will be analyzed in Tier 1. In these cores, the first two 30-cm sample intervals below the RAL interval(s) will be analyzed in Tier 1. Then, each subsequent, alternating interval will be archived or analyzed, until the end of the core, native sediment, or target depth is reached (see Attachment B for interval details). Alternating intervals will be analyzed as part of Tier 1 to help define the vertical extent of contamination (defined as concentrations above surface RALs). The remaining intervals will be archived for potential analysis in Tier 2 if further refinement of the vertical extent of contamination is necessary.

Among the other 116 vertical extent cores, many intervals will be analyzed as part of Tier 2. Tier 2 vertical extent cores will generally fall into the following three categories:

- **Side slope cores:** Vertical extent cores placed to characterize the side slopes of anticipated dredge areas (e.g., along the side of the FNC for RAL exceedance area 28) will be collected and archived. The Tier 1 data from nearby vertical cores within the RAL exceedance area boundary will be used to inform the intervals and analytes for analysis of these side slope cores as part of Tier 2.
- **Bounding locations:** Where RAL exceedance areas are being bounded horizontally in Phase II, vertical extent cores will be collected and archived. These cores will be analyzed if RAL exceedance area boundaries are extended and additional vertical data are needed for design. An example of this is location 1323 at the downstream end of RAL exceedance area 28.
- **Other Tier 2 coring locations:** In areas where vertical extent core locations have been placed more densely based on anticipated needs for RD (e.g., at RM 1.9E [Map 4-1f], Beach 6 [Map-4 1g], and RM 2.7 to RM 2.8W), some cores will be collected and analyzed in Tier 1, while others will be collected and archived. Given that limited information is available to inform the depth of contamination in these areas, tiering the associated vertical extent cores will allow for the use of Tier 1 data to better inform the intervals and analytes for analysis in Tier 2.

4.1.4 Analytes

In general, the analyte list for each Phase II sample is dependent on nearby RAL exceedances in the design dataset and on which RALs are applicable at a given location. Locations where RALs apply are

summarized in Figure 4-2 of the middle reach PDI QAPP (Windward and Anchor QEA 2022) and in Table 28 in the ROD (EPA 2014). The locations where RALs apply are based on bathymetry (e.g., intertidal or subtidal), sample interval, recovery category, shoaling areas, and other location-specific factors.

For the vertical extent cores, analytes will be determined based on nearby RAL exceedances and whether vertical extent information is needed for design. In general, analytes are limited to those contaminants with subsurface RALs at that location; however, in some instances, vertical extent information for other analytes is needed (e.g., location 1390 in RAL exceedance area 27, where a surface sediment exceedance for butyl benzyl phthalate [BBP] [which does not have a subsurface RAL] is above the ENR upper limit) because dredging may be required in this area.

To meet the objective of the Phase II sampling and analysis (i.e., to refine the areas with RAL exceedances), analyte lists for Phase II samples include COCs with applicable RALs for a given area with nearby RAL exceedances (or exceedance factors [EFs] of > 0.9). Table 4-5 provides a summary of COCs with RAL exceedances by RAL exceedance area (see Maps 4-1a through 4-1e). Guidelines for selecting analytes for each of the Phase II samples are as follows:

- **PCBs:** PCBs will be analyzed in nearly all Phase II samples; the following situations will be the exceptions:
 - PCBs will not be analyzed in Phase II samples from Phase I PDI locations reoccupied for potential toxicity testing, because PCBs were analyzed in Phase I at these locations.
 - PCBs will not be analyzed when an area's only exceedance is for a COC other than PCBs (e.g., dioxins/furans), and PCBs have already been analyzed in the area without detecting any exceedances of the RAL or PCB EFs greater than 0.9.
- **Dioxins/furans:** Dioxins/furans will be analyzed in Phase II samples from areas with dioxin/furan toxic equivalent RAL exceedances (Maps 4-4a and 4-4b). A tiered approach will be used. In areas where there are dioxin/furan RAL exceedances, **there are gaps in spatial coverage, or there is reason to expect dioxins/furans may be present**, a subset of samples will be analyzed for dioxins/furans in Tier 1. The Tier 1 data for all analytes will be reviewed and samples will be selected for dioxin/furan analysis in Tier 2 to confirm that the horizontal and vertical extents of dioxin/furan contamination do not extend beyond areas with concentrations below RALs for other COC(s).
- **Metals:** In areas where arsenic is the only metal with concentrations above RALs, arsenic will be analyzed in RAL intervals and vertical cores. In areas with RAL exceedances for metals (including mercury) other than arsenic, metals and mercury will be analyzed in the RAL intervals listed in Table 28 of ROD, and analytes for vertical cores will be determined based on the analytes that exceed the RAL in the associated RAL interval.

- **Semivolatile organic compounds (SVOCs):** SVOCs include PAHs, phthalates, and other SVOCs.⁵
 - All phthalates will be analyzed in areas with one or more phthalate RAL exceedance.
 - All PAHs will be analyzed in areas with one or more PAH RAL exceedance.
 - All other SVOCs will be analyzed in areas with one or more other SVOC RAL exceedance.
 - If there are RAL exceedances for more than one of these groups (i.e., PAHs, phthalates, or other SVOCs), all SVOCs will be analyzed.
- **Full Suite:** The full suite of COCs with RALs (other than dioxins/furans, unless there are nearby exceedances) will be analyzed in the following situations:
 - A reoccupation of a pre-PDI location that was not re-occupied during Phase I
 - A wide range of COCs with RAL exceedances in an area
- **Total organic carbon (TOC):** TOC will be analyzed in all Phase II samples analyzed for one or more chemical.
- **Archive samples:** No analytes will be identified for Phase II Tier 2 (archive) samples, as these analytes will be proposed and discussed with EPA following review of Tier 1 results.

**Table 4-5
Summary of RAL Exceedances within each RAL Exceedance Area**

RAL Exceedance Area	Description of Area	Analytes with RAL Exceedances Other than Phenol ¹ in the Design Dataset	
		Surface (0–10 cm)	Subsurface (0–45 cm, 0–60 cm, or shoaling interval)
1	RM 2.95 W	PCBs, mercury	No exceedances
2	RM 2.9–RM 3.0	No exceedances (PCB EF of 0.95)	PCBs
3	Slip 4 (under-structure)	PCBs, dioxins/furans	No exceedances
4	RM 2.85 W	PCBs	No exceedances
5	RM 2.65–RM 2.85 W (including under-structure)	PCBs, dioxins/furans, mercury, PAHs, other SVOCs	PCBs, dioxins/furans, PAHs, other SVOCs
6	RM 2.8	No exceedances	PCBs
7	RM 2.8 E	No exceedances	PCBs
8	RM 2.8 E	PCBs	No exceedances
9	RM 2.6–RM 2.85 E, including Beach 6	PCBs, metals, PAHs	PCBs, metals, dioxins/furans
10	RM 2.5–RM 2.7 FNC	PCBs	PCBs

⁵ Other SVOCs (i.e., those that are not PAHs or phthalates) with RALs, as listed in Table 27 of the ROD (EPA 2014), include 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, dibenzofuran, hexachlorobenzene, n-nitrosodiphenylamine, pentachlorophenol, and phenol.

RAL Exceedance Area	Description of Area	Analytes with RAL Exceedances Other than Phenol ¹ in the Design Dataset	
		Surface (0–10 cm)	Subsurface (0–45 cm, 0–60 cm, or shoaling interval)
11	RM 2.6–RM 2.7 E	PCBs, BBP, benzoic acid (arsenic, chromium, zinc in bank samples)	Hexachlorobenzene, fluoranthene
12	RM 2.5 W	Dioxins/furans	No exceedances (limited data)
13	RM 2.5 FNC/W	PCBs	No exceedances
14	RM 2.4 E	PAHs	No exceedances
15	RM 2.35 E (Myrtle)	PCBs, zinc, BBP, BEHP (benzoic acid EF of 0.92)	PCBs, dioxins/furans, BBP, BEHP
16	RM 2.3–RM 2.4 W	PCBs, dioxins/furans	PCBs
17	RM 2.1–RM 2.4 in FNC	No exceedances	PCBs, mercury
18/19/22	RM 2.25–RM 2.35 E	PCBs (chrysene EF of 0.99)	PCBs ³
20 ²	Inlet at RM 2.2 W	See separate QAPP Addendum	
21	RM 2.1–RM 2.25 W	PCBs	PCBs
23	RM 2.1 E (under-structure)	PCBs	No exceedances
24	Slip 3 (SE corner)	PCBs, dioxins/furans, zinc, PAHs, BBP, BEHP (bank samples)	No exceedances (limited data)
25	Slip 3	Zinc	No exceedances
26	RM 2.05 W	BEHP	No exceedances
27	RM 2.05 E	PCBs, BBP	No exceedances
28	RM 1.75–RM 2.1 in FNC	PCBs	PCBs, dioxins/furans, mercury
29	RM 1.9–RM 2.0 E	PCBs, dioxins/furans, BEHP	PCBs
30	RM 1.85 E	PCBs	Arsenic
31	Slip 2	PCBs	No exceedances
32	RM 1.75	No exceedances	PCBs
33	Slip 2	PCBs	No exceedances
34	Slip 2	No exceedances	No exceedances (PCB interpolation)

Notes:

1. Phenol RAL exceedances are not listed in this table. See Section 4.1.5 for a discussion of the approach for phenol in Phase II.
2. Data from within RAL Exceedance Area 20 (Inlet at RM 2.2W) are summarized along with the Phase II sampling approach in a separate QAPP Addendum.
3. The recovery category in this area was revised to Recovery Category 1 following Phase 1 sampling. The subsurface samples in this area were analyzed for only PCBs in Phase I; archives will be analyzed for the ROD benthic COCs in Phase II.

BBP: butyl benzyl phthalate

BEHP: bis(2-ethylhexyl) phthalate

COC: contaminant of concern

EF: exceedance factor

EPA: U.S. Environmental Protection Agency

FNC: Federal Navigation Channel

PAH: polycyclic aromatic hydrocarbon

PCB: polychlorinated biphenyl

PDI: Pre-Design Investigation

QAPP: quality assurance project plan
RAL: remedial action level
RM: river mile
ROD: Record of Decision
SVOC: semivolatile organic carbon

Analytes and sample-specific details are summarized in Table B-1 of Attachment B. In addition, Section 4.1.5 contains details regarding analyte lists and the approach for areas where chemistry will be expedited for benthic toxicity testing.

4.1.5 Toxicity Testing Design

Per the ROD (EPA 2014), benthic toxicity testing can be used to help delineate remedial action areas if there are no human health RAL exceedances.⁶ If sediment is not toxic at a location based on benthic sediment cleanup objective (SCO) biological criteria evaluated through site-specific sediment toxicity testing, then that toxicity result overrides the benthic RAL chemistry result (in areas without human health RAL exceedances).

As part of Phase II, benthic toxicity testing will be considered for the following three conditions:

- 1) **Condition 1: Phase I locations with phenol-only RAL exceedances** (Section 4.1.5.1) – For these locations, sediment will be collected for potential toxicity testing depending on the chemistry results for the Phase II sample (which will be analyzed only for phenol).
- 2) **Condition 2: Other Phase I locations with only benthic RAL exceedances** (Section 4.1.5.2) – For these locations, sediment will be collected for toxicity testing (no chemical analysis will be conducted).
- 3) **Condition 3: Post-feasibility study (FS) locations with only benthic RAL exceedances** (Section 4.1.5.2) – For these locations, sediment will be collected for potential toxicity testing depending on Phase II chemistry results (i.e., toxicity testing will be conducted if Phase II results have only benthic RAL exceedances).

For conditions 1 and 3 (i.e., Phase I phenol-only locations and post-FS locations), sediment for chemistry and benthic toxicity testing will be collected simultaneously; chemical analysis at these locations will be expedited so that benthic toxicity tests can be initiated within holding times (see Section 4.2.5 in the middle reach PDI QAPP (Windward and Anchor QEA 2022)). For condition 2 (i.e., other Phase I locations with benthic RAL exceedances), no chemical analysis will be conducted prior to initiating toxicity testing. At least two surface sediment grabs and at least three 0- to 45-cm or 0- to 60-cm cores will be required to collect sufficient volume for benthic toxicity testing (see middle

⁶ ROD Table 20 has a footnote that states “Benthic SCO biological criteria (WAC 173-204-562, Table IV) may be used to override benthic SCO chemical criteria where human health-based RALs are not also exceeded” (EPA 2014).

reach PDI QAPP Attachments J1 and J2). Map 4-5 shows the locations where Phase II toxicity testing may be conducted.

4.1.5.1 Toxicity Testing at Locations with Phenol-only RAL Exceedances

Phenol, which is discussed in Section 3.4.1.1.2 of the Phase I DER (Anchor QEA and Windward 2023), is an aromatic organic alcohol that is a natural product of the decomposition of organic matter and the burning of wood and petroleum products (ATSDR 2008). In Phase I, phenol concentrations above the RAL were reported in subtidal surface sediment samples from 30 locations throughout the middle reach (Table 4-6). In Phase II, surface sediment will be collected at each of the 23 locations⁷ listed in Table 4-6 that do not have a PCB exceedance and are not under a structure. These samples will be analyzed for phenol to confirm the phenol RAL exceedances. If the phenol concentration is less than the RAL, the new result will replace the Phase I result for phenol for that location. If the phenol concentration is greater than the RAL, the sample will be considered for toxicity testing. The locations with confirmed phenol RAL exceedances will be reviewed, and those with the highest phenol concentrations within an area with phenol exceedances will be selected for toxicity testing in consultation with EPA. If the location with the highest phenol concentration passes the toxicity test, the surrounding locations with lower phenol concentrations will also be considered to have passed.

**Table 4-6
Potential Toxicity Testing Locations with Surface Sediment RAL Exceedances for Phenol**

RM	Phase I Location	Phase II Location	Recovery Category	Phenol Concentration (µg/kg dw)	RAL EF
1.6–1.8	SS1003	SS1300	1	856	2.0
	SS1015	SS1305	2/3	1,100	1.3
	SS1021	SS1306	2/3	1,130	1.3
	SS1018	SS1308	1	596	1.4
	SS1032	SS1322	1	431	1.0
1.9–2.0	SS1061	SS1349	2/3	987	1.2
2.0–2.2	SS1096	SS1398	2/3	1,100	1.3
	SS1103	SS1392	2/3	1,480	1.8
	SS1104	SS1394	2/3	1,660	2.0
	SS1105	SS1400	2/3	1,800	2.1
	SS1107	SS1393	2/3	1,480	1.8
	SS1111	SS1410	2/3	991	1.2

⁷ At 5 of the 30 locations, PCBs also exceeded the RAL in surface or subsurface sediment samples, and zinc also exceeded the RAL at location SS1100. The location 1804 sample was collected under a structure; that location will not be re-occupied in Phase II because of safety concerns associated with diver-collected samples. The results for the other phenol re-occupied locations will be used to determine the status of this exceedance.

RM	Phase I Location	Phase II Location	Recovery Category	Phenol Concentration (µg/kg dw)	RAL EF
2.3–2.6	SS1151	SS1471	1	627	1.5
	SS1158	SS1472	1	614	1.5
	SS1164	SS1474	1	723	1.7
	SS1173	SS1481	1	451	1.1
	SS1188	SS1494	1	462	1.1
2.6–2.7	SS1204	SS1517	2/3	1,620	1.9
	SS1205	SS1518	2/3	857	1.0
2.7–3.0	SS1247	SS1572	1	530	1.3
	SS1249	SS1574	1	438	1.0
	SS1265	SS1578	1	492	1.3
	SS1270	SS1580	1	1,060	2.5

Notes:
 dw: dry weight
 EF: exceedance factor
 RAL: remedial action level
 RM: river mile

4.1.5.2 Toxicity Testing at Locations with Benthic RAL Exceedances Other than Phenol

Locations with benthic RAL exceedances for COCs other than phenol are summarized in Table 4-7. Based on Phase I PDI data, there are six Phase II toxicity testing locations associated with benthic RAL exceedances⁸ and no human health RAL exceedances (four surface sediment sampling locations and two subsurface sediment sampling locations). In addition, there are three Phase II bioassay locations associated with benthic RAL exceedances in post-FS samples (all from 2011) that may be submitted for toxicity testing. Phase II samples will be collected at each of these locations. As described, the samples from the six 2023 Phase I locations will not be chemically analyzed prior to toxicity testing because of the recency of the Phase I data (Attachment B). Samples from the locations last characterized in 2011 will be analyzed for the full suite of COCs with benthic RALs (Attachment B), with toxicity testing dependent on Phase II chemistry results. If benthic RAL exceedances (and no exceedances of human health RALs) persist at any of these 2011 locations, the associated samples will be toxicity tested.

⁸ One Phase II surface sediment sample will be collected to re-occupy LDW-SS2037-D and LDW-SS2037-A, as these locations are 12 ft apart.

**Table 4-7
Toxicity Testing Locations for Chemicals other than Phenol**

Existing Location (Year)	Depth Interval	RM	Phase II Location	RAL Exceedance (EF)
Phase I PDI Locations with only Benthic RAL Exceedances				
LDW23-SS1100 (2023)	0–10 cm	2.1	SS1396	Zinc (1.5), phenol (1.7)
LDW23-SS1813 (2023)	0–10 cm	2.4	SS1827	Acenaphthene (4.1), dibenzofuran (2.3), phenanthrene (1.8), fluorene (1.7), fluoranthene (1.5)
LDW23-SS1174 (2023)	0–10 cm	2.5	SS1484	BBP (1.4)
LDW23-SC1188 (2023)	0–60 cm		SC1494	Hexachlorobenzene (3.2)
LDW23-SC1186 (2023)	0–60 cm		SC1495	Fluoranthene (2.4)
LDW23-SS1276 (2023)	0–10 cm	2.95	SS1584	Mercury (1.3)
Post-FS Locations with only Benthic RAL Exceedances²				
LDW-SS2506-D (2011)	0–10 cm	2.0	SS1379	BEHP (4.3)
LDW-SS2506-A (2011)	0–10 cm		SS1380	BEHP (1.4)
LDW-SS2037-D (2011) ¹	0–10 cm	2.5	SS1497	Benzoic acid (1.5)
LDW-SS2037-A (2011) ¹	0–10 cm			Benzoic acid (1.4)

Notes:

1. Because of the close proximity of these two 2011 samples (samples located approximately 12 feet apart), a single Phase II sample will be used to reoccupy these two pre-PDI locations.

2. These locations are potential toxicity test locations, The chemistry results for these samples will determine whether or not the toxicity testing is conducted.

BBP: butyl benzyl phthalate

BEHP: bis(2-ethylhexyl) phthalate

EF: exceedance factor

FS: feasibility study

PDI: Pre-Design Investigation

RAL: remedial action level

RM: river mile

4.2 Sample Collection and Processing

Methods to locate, collect, and process surface and subsurface sediment samples as part of PDI sampling efforts are described in the middle reach PDI QAPP and its SOPs in Appendix E (Windward and Anchor QEA 2022). The Subsurface Sediment Collection SOP (E19) was revised for Phase II to include additional methods to collect deeper vertical extent cores from intertidal locations that are inaccessible or not suitable for collection from a vessel. All updated SOPs are included in Attachment C.

As during Phase I, Phase II sampling activities will be coordinated with other activities occurring within the middle reach. These activities will include tribal fishing, waterfront operations at active facilities, and potential construction activities. Phase II sampling locations and current waterfront operations are shown on Map 4-6.

4.3 Sample Identification

Unique alphanumeric identifications (IDs) will be assigned to each sample and recorded on the collection and processing forms (Appendix C of the middle reach PDI QAPP (Windward and Anchor QEA 2022)). The sample IDs for Phase II samples will be consistent with the identification rules for the Phase I samples provided in Section 4.4 of the middle reach PDI QAPP.

The sample IDs for individual sediment samples will include the following:

- Project area ID (i.e., LDW) and two-digit year (i.e., 24 will be used for all Phase II samples to indicate that sample collection occurred in 2024).
- Sample type:
 - SS – surface sediment (0 to 10 cm)
 - IT – intertidal sediment (0 to 45 cm)
 - SC – subsurface core (depths variable)
 - UP – upland bank soil (depths variable)
 - GT – geotechnical sample
- Location number, beginning with 1300 for locations not under structures, 1821 for under-structure locations, and 1 for upland bank soils locations.
- For all subsurface cores, a sequential letter (e.g., A, B, C) will be used to identify the interval. The letter A will be used to indicate the targeted surface interval, with B, C, etc. being used to indicate each subsequent interval.

For example, a surface sediment sample from location 1357 would be labeled LDW24-SS1357. The subtidal sediment core samples from that location would be labeled LDW24-SC1357A for the first core interval (e.g., the 0- to 60-cm sample) and LDW24-SC1357B for the next core interval sample (if applicable), and so forth.

Any field duplicate sample collected will have the same sample ID as its parent sample but will be appended with “-FD” to identify it as a field duplicate.

4.4 Sample Analysis and Toxicity Testing

Analytical laboratory and benthic toxicity testing methods will be the same as those provided in Sections 4.8 and 4.11 of the middle reach PDI QAPP (Windward and Anchor QEA 2022). Updated SOPs are provided in Attachment C for two bioassay tests and for chemistry data validation.

The laboratories for analytical chemistry and toxicity testing, the methods to be used, and the containers in which to submit samples to the laboratories are provided in Table 4-8. The analytical requirements for each analysis are provided in Section 4.8 of the middle reach PDI QAPP (Windward

and Anchor QEA 2022). Bioassay testing requirements are provided in Section 4.11 of the middle reach PDI QAPP. See Attachment B for a detailed analyte list for each location.

**Table 4-8
Sediment Analyses to be Conducted at Each Analytical Laboratory**

Laboratory	Analyses to be Conducted	Methods	Container
Analytical Resources Laboratory	TOC, percent solids	EPA 9060A, SM 2540G	4-oz glass jar
	Metals	EPA 3050B, EPA 6020B universal cell technology-kinetic energy discrimination	4-oz glass jar
	Mercury	EPA 7471B	
	PAHs/SVOCs	EPA 3546/ EPA 8270E and 8270E-selected ion monitoring	16-oz glass jar
	Hexachlorobenzene	EPA 3546/ EPA 8081B	
	PCB Aroclors	EPA 3546, Mod EPA 8082A	
	Dioxin/furan congeners	EPA 1613b	8-oz amber glass jar
	Ammonia	SM 4500-NH3 H-97	4-oz glass jar
	Total sulfides ¹	SM 4500-S2 D-0 Puget Sound Estuary Program prep	4-oz glass jar
Archive	NA	8-oz glass jar	
Materials Testing and Consulting, Inc.	Grain size	American Society for Testing and Materials D7913 and D7928	16-oz high-density polyethylene
EcoAnalysts	Benthic toxicity testing	Acute amphipod 10-day mortality test, acute 48-hour bivalve larvae combined mortality and abnormality test, and chronic 20-day juvenile polychaete survival and growth test	6 32-oz high-density polyethylene wide-mouth jars

Notes:

1. Ammonia and total sulfide analyses will be conducted only on the sediment locations targeted for possible toxicity testing.

EPA: US Environmental Protection Agency

NA: not applicable

PAH: polycyclic aromatic hydrocarbon

PCB: polychlorinated biphenyl

SM: Standard Method

SVOC: semivolatile organic carbon

TOC: total organic carbon

4.5 Field-generated Waste Disposal

Phase I investigation data have been reviewed to identify areas with COC concentrations that may exceed thresholds for hazardous wastes under Washington State regulations and the federal Toxic Substances Control Act. The excess sediment associated with samples from these areas will be segregated in drums and labelled as potentially hazardous waste or potentially Toxic Substances Control Act-regulated material, as appropriate. Representative samples of materials from the drums

will be tested as appropriate to complete the final waste profiles. Containers will be secured for off-site disposal via a licensed waste disposal company.

Outside of the areas with potential exceedances in hazardous waste or other regulated material, excess surface sediment will be returned to each sampling location after sampling has been completed at that location. Excess subsurface sediment will be contained in drums. A waste profile based on the Phase I sediment data will be submitted to the disposal company for the disposal of this material. Containers will be secured for off-site disposal via a licensed waste disposal company.

Decontamination water (i.e., an Alconox®/water solution) will be contained for disposal via the sanitary sewer. All disposable sampling materials and personal protective equipment used in sample processing, such as disposable coveralls, gloves, and paper towels, will be placed in heavyweight garbage bags or other appropriate containers. Disposable supplies will be removed from the site by sampling personnel and placed in a normal refuse container for disposal as solid waste.

4.6 Sediment Chemistry Quality Assurance/Quality Control

The types of samples to be analyzed and the procedures to be conducted for QA/QC in the field and laboratory are described in Section 4.10 of the PDI QAPP, with the exception of the field duplicates described below.

Field QA/QC samples, such as field duplicate samples, are generally used to evaluate the variability attributable to sample handling and processing. Field duplicates are prepared by collecting twice as much volume as necessary to fill the sample containers. Following homogenization, aliquots of a sample for which a field duplicate is needed are equally distributed into two sets of sample containers. Field duplicate results are used to measure and document the repeatability of sample handling procedures and heterogeneity of the sample matrix (PSEP 1997). For Phase II Tier 1 surface and subsurface samples, a minimum of 1 duplicate sample for every 20 samples will be collected. The proportion of field duplicates will be the same for surface and subsurface samples. Field duplicate samples will be analyzed for the same analytes as the parent sample. Additional field duplicates will be collected to be analyzed with Tier 2 samples, based on the assumption that 30% of the Tier 2 samples will be analyzed.⁹ The additional field duplicates will be collected for Tier 1 samples and archived. The archived field duplicates will be analyzed for the analytes in the parent sample when Tier 2 samples are analyzed.

⁹ In Phase II of the PDI characterization of the upper reach, approximately 30% of the Tier 1 samples were analyzed.

5 Data Generation and Acquisition of Engineering PDI Elements

This section discusses the study design and procedures for collecting, handling, and managing data that will be acquired in support of the engineering PDI elements including, methods for the following PDI elements:

- Focused topographic surveys and bank features (DQO 11)
- Geotechnical data collection for use in RD; material behavior assessment; and stability modeling for banks, structures, and dredging or capping areas (DQO 13)
- Inspections and evaluations of existing structures within or adjacent to RAL exceedance areas to develop design criteria for remedial activities that may impact existing structures (DQO 14)
- Collection of other engineering-applicable data (e.g., sediment thickness overlying the armor layer in bank areas and debris location and extents) as necessary to adequately characterize site conditions for engineering design and construction bid documents (DQO 14)

5.1 Topographic Survey and Bank Features

The Phase II PDI will build upon the Phase I visual bank inspection in the areas with RAL exceedances. To address DQO 11, Phase II will include focused topographic surveys to obtain elevation data and detailed observations of bank features that may impact the design and construction of remedial actions. To partially address DQO 14, the survey work will also be used to delineate surface debris deposits within the intertidal area, and to verify the locations of existing structures and outfalls.

The Phase II focused topographic survey will be performed by True North in the 17 RAL exceedance areas with banks that may require remedial action (Maps 5-1a through 5-1h). Detailed topographic survey extents, methods, and procedures are included in the Survey QAPP Addendum (Attachment F). The topographic survey will overlap with the bathymetric survey to provide full elevation coverage of the middle reach in RAL exceedance areas and, where feasible, will extend approximately 50 feet landward of the mean higher high water elevation line (+11.3 feet MLLW) to capture the top of bank.

In addition to topographic survey elevation data, oblique and ortho-aerial photographs will be obtained during surveying activities and used to identify locations and extents of bank features found within the 17 RAL exceedance areas with banks, including the following:

- Woody vegetation extents
- Extent and other ascertainable features of bank armoring
- Aboveground utilities (e.g., outfalls, storm drains, groundwater monitoring wells)

- Underground or submerged utility corridors that run through banks or cross the waterway (if they can be located)
- Large surface debris
- Structures (e.g., corner points of existing structures, fence lines, paved surfaces adjacent to top of bank)

After review of the topographic survey, detailed bank features will be identified by the field crew via upland access (or by boat if upland access is restricted). The inspection activities will occur coincident with a tide level that allows for the entire bank area (i.e., toe of bank to top of bank) to be observed. The approximate toe of bank elevations in the RAL exceedance areas are identified on Maps 5-1a through 5-1h. In some cases, the toe of bank may be below the available low tide elevation during the field investigation period. In such instances, observations will occur at as low a tidal elevation (e.g., 0 ft MLLW or lower) as is available during the field investigation period. The field crew will describe the features noted in the bullets above in their field summaries, as well as in the topographic survey data summary (to be prepared as part of the Phase II DER); the features will be incorporated into RD.

Vegetation and habitat information relevant to development of the biological assessment will also be collected during the Phase II investigation. This investigation will include a desktop review of high-resolution photographs taken in 2024 during late spring/early summer field work, when vegetation is most visible. The photographs will be reviewed to identify areas that require site visits. The photographs and the areas identified for site visits will be discussed with EPA prior to initiating the site visits. Site visits will be conducted to verify the extent of vegetation and the species at bank areas within or adjacent to RAL exceedance areas where vegetation is present. Vegetation in the area will be documented, including vegetation type, percent cover, and plant communities.

Detailed bank features will be located by the topographic surveyor and by other field crew members using differential GPS equipment. Results of the detailed identification of bank features will be documented by RAL exceedance area in a tabular format and summarized in the Phase II DER, along with photographs of bank features taken by drone. Relevant photographs from Phase I are provided in Appendix A of the Phase I DER (Anchor QEA and Windward 2023).

5.2 Geotechnical Investigation

5.2.1 *Review of Pre-PDI Geotechnical Data*

Pre-PDI geologic and geotechnical data for bank and in-water areas were compiled from several sources, as summarized in Attachment D. These data were used to inform the geotechnical investigation design and locations for geotechnical data collection as part of the Phase II PDI. The

locations of historical geotechnical investigations in the LDW middle reach are shown on Maps 5-2a and 5-2b.

5.2.2 Geotechnical Investigation Design

An overview of the types of geotechnical data that will be collected during Phase II is presented in Section 5.3 of the middle reach PDI QAPP (Windward and Anchor QEA 2022), which also discusses the field data collection and laboratory methods that will be used to generate geotechnical data for the project.

This section presents an overview of the general principles discussed in Section 4.3.3 of the PDIWP (Windward and Anchor QEA 2019) that have been used to identify specific sampling locations for geotechnical data collection, *in situ* testing procedures for geotechnical properties, and *ex situ* geotechnical laboratory analyses; this work will address DQO 13. Like the Phase II sediment sampling described in Section 4.1, geotechnical sampling activities will be coordinated with other actions occurring within the middle reach, including collection of Phase II sediment samples.

The general stratigraphy of the Duwamish Valley includes anthropogenic fill material within bank areas and recently deposited sediments (organic silt and sand), both overlying a sequence of upper alluvium (silt and sand) and lower alluvium (sand and sand with silt interbeds) (Windward 2010). Remedial actions in the LDW middle reach will generally involve dredging, partial dredging/capping, capping, ENR, and area-specific technologies within recently deposited sediments and the upper alluvium. Depths for geotechnical data collection as part of the geotechnical investigation design will focus within these geologic units and consider the vertical extent of potential remedial actions. Geotechnical data will be collected within these units to characterize the materials for dredgeability, bearing capacity, consolidation (settlement characteristics), and slope stability. The experienced geotechnical engineer leading this effort will review boring log information and *in situ* data and assign laboratory testing to characterize the lithologic units encountered.

Following appropriate review and consideration of risks, safety factors, and variations in site conditions, geotechnical characteristics can be more broadly interpolated and extrapolated than can sediment chemistry. Therefore, fewer geotechnical sampling locations are typically required to characterize a site sufficiently for RD. Phase II geotechnical data collection locations were identified for each of the following areas: adjacent to the FNC, within the intertidal/subtidal area (i.e., between the FNC and the toe of bank), and at the top of the upland bank when access by water is not feasible. The study designs for each of these areas are as follows:

- **Adjacent to the FNC:** FNC-adjacent geotechnical data collection will occur at locations spaced approximately 500 feet from each other along portions of the FNC with RAL exceedance areas. To target the collection of geotechnical samples above and within the

native alluvium subsurface unit, geotechnical sampling adjacent to the FNC will be to an elevation approximately 10 feet below the authorized navigation depth. These data will be used to evaluate potential dredging and capping designs within and adjacent to the FNC.

- **Intertidal and Subtidal:** Intertidal and subtidal geotechnical data collection will occur within RAL exceedance areas at locations spaced up to 250 feet from each other and adjacent to existing structures. These data will inform the engineering design within and adjacent to structure footprints. Geotechnical sampling in the area between the FNC and toe of bank will be approximately 20 to 40 feet below ground surface, allowing for an evaluation of potential dredging and capping designs adjacent to existing structures.
- **Top of upland banks:** Geotechnical data will be collected at the top of upland banks adjacent to RAL exceedance areas that cannot be accessed by water. These locations will be targeted to supplement the in-water geotechnical locations. The depth of geotechnical sampling at the tops of upland banks will be approximately 40 feet below ground surface. These data will be used evaluate dredging/excavation or capping designs on banks and adjacent to existing structures.

In order to evaluate local and global static and seismic slope stability, geotechnical investigation locations will be oriented along profiles placed generally perpendicular to the shoreline; this orientation will support the development of geotechnical data from the top of bank into the FNC. Maps 5-2a and 5-2b show all Phase II geotechnical investigation locations in relationship to RAL exceedance areas and existing geotechnical data locations. Each data collection location is presented in Table E-1 in Attachment E. Geotechnical field collection and laboratory testing methods are described in Sections 5.3.2 and 5.3.3 of the middle reach PDI QAPP (Windward and Anchor QEA 2022).

An experienced field geologist or geotechnical engineer will be responsible for overseeing the logging of geotechnical borings in the field (using soil boring log forms found in Appendix D of the upper reach PDI QAPP (Windward and Anchor QEA 2020)). That individual will determine the appropriate types and numbers of samples to be assigned for testing, based on observed field conditions and best professional judgement. In addition, this individual may determine that depths of sampling and/or data collection locations need to be modified in the field based on observed conditions encountered during exploration.

All geotechnical samples will be shipped to the laboratory and archived. A representative subset of samples will be assigned for *ex situ* testing (e.g., grain size, moisture content, Atterberg limits, strength and consolidation testing) so that the range of geotechnical characteristics within the LDW middle reach can be characterized for RD. The specific assignment of *ex situ* testing will be

determined collaboratively between the geotechnical field team and the experienced geotechnical engineer upon review of the field boring logs.

5.3 Other Engineering Data

5.3.1 Structures

During the Phase II PDI, inspection and evaluation activities will be conducted for structures within RAL exceedance areas. Table 5-1 includes the list of structures that will be inspected. Because unsound structures (e.g., waterway user survey [WUS] Structure #32) could be further destabilized during remedial construction, RAL exceedance areas near such structures will be evaluated for construction accessibility during Phase II data collection. These evaluations may include more detailed condition inspections, potential structure materials sampling, and additional equipment accessibility evaluation. Phase II inspection activities will be conducted in accordance with American Society of Civil Engineers manual of practice No. 130. The results of these inspections will be documented in the Phase II DER.

**Table 5-1
Identified Over-water Structures in the Middle Reach and Phase I Observations Summary**

Approximate RM	Property or Overwater Structure Name (WUS ID)	Description ¹
1.8–1.9E	Samson Tug (23)	Facility composed of three waterfront structures: one T-head pier (75 feet wide; on the mouth of Slip 2) and two single-span piers (25 feet wide each)
1.9–2.0E	Duwamish Marine Center (53)	Central structure is a floating dock with several integrated boat houses
2.1W	Alaska Marine Lines Yard No. 2 (25 and 28)	Concrete wharf (95 feet wide)
2.1–2.2E	SeaTac Marine (26)	In Slip 3, a configuration of concrete wharfs, aprons, and a long finger pier (600 feet long and 40 feet wide) make up a vessel slip; wharf (400 feet long) exists on the main waterway
2.35W	Boyer Alaska Barge Line North Lay Berth (29)	Plastic float system (less than 10 feet wide) with steel raised decking and timber guide piles
2.4–2.55E	Seattle Iron & Metals Wharves (30 and 32)	Two timber wharves (one 135 feet long and one 315 feet long); south structure is not in use and is unsafe
2.6W	Pacific Pile and Marine Mooring (33 and 34)	One timber pier (25 feet wide)
2.75W	Pacific Pile and Marine Wharf (35)	Triangular timber pile wharf (265 feet long and <10 feet deep along waterway and 125 feet wide and >10 feet deep towards shore)
2.8E	8 th Avenue Terminal Wharf (36)	Segmented concrete pile-supported wharf (600 feet long in total)

Notes:

1. Description modified from the *Waterway User Survey and Assessment of In-Water Structures – Data Report* (Integral et al. 2018). Only structures with notable overwater coverage are included in this table. Other structures (e.g., bridge abutments, mooring dolphins, private docks, and floats) have been omitted. General dimensions of structures are approximate.

ID: identification

RM: river mile

WUS: waterway user survey

5.3.2 Sediment Thickness over Armored Banks

Some areas with RAL exceedances were classified as armored banks during the Phase I PDI. In these areas, measuring the thickness of sediment over the armor layer will be necessary in Phase II to determine the location of the toe of the armored bank, and to be able to calculate the volume of sediment overlying the armor layer. Measuring sediment thickness will be needed in portions of 14 RAL exceedance areas: 5, 9, 11, 12, 14, 15, 16, 21, 23, 24, 26, 30, 31, and 33. Additionally, two RAL exceedance areas (27 and 29) classified as unarmored (i.e., discontinuous armoring) based on Phase I visual observations will be field inspected in Phase II to determine if sediment thickness probing would be appropriate to assess whether there is more continuous armoring present under the mudline; such armoring may result in reclassification of the bank type.

The method for determining sediment thickness and toe of bank armoring location is described in SOP E27 in Appendix E of the middle reach PDI QAPP (Windward and Anchor QEA 2022). It will be employed for areas that are accessible by foot at low tide. This method involves hand probing the sediment in coordination with recording measurements and locations using differential GPS equipment. For this method, a rod marked with measurement ticks will be used to determine the thickness of sediment over the armor layer.

Sediment probing will occur along transects extending perpendicular to the shoreline and spaced between 50 and 100 feet from each other; data will be collected approximately every 5 feet along the transect from the top to the toe of the armored bank. Prior to probing at each location along the transect, descriptions will be recorded that will include the following (as applicable):

- Location ID
- Water depth measurement in feet and time of measurement (if applicable)
- Coordinates of each probe point
- Observed surface substrate type (e.g., rock, sand, silt, shell) and color
- Other observations of note (e.g., description of visible surface debris)

After documenting the surface conditions at the location, probing will commence. The field crew performing probing will document the probing observations, typically including the following:

- Sediment thickness/depth of layers penetrated/refusal depth
- Subsurface debris or obstructions encountered during probing

- Any other important observations noted during probing, such as the extent of breaks in the armoring
- Observations will be documented on field forms included in Appendix C to the middle reach PDI QAPP (Windward and Anchor QEA 2022).

6 Assessment and Oversight

Protocols outlined in Sections 7.1 and 7.2 of the middle reach PDI QAPP (Windward and Anchor QEA 2022) for compliance assessments and response actions and reports will be followed.

A Phase II PDI DER will be prepared that will document all activities associated with the Phase II PDI, including the collection, handling, and analysis of Phase II samples, as specified in Fifth Amendment to the Administrative Order on Consent (EPA 2021a). The DER will document the sampling events and present and interpret the analytical results.

The following base information will be included in the Phase II DER:

- Summary of all field activities, including descriptions of any deviations from the approved QAPP
- Sampling locations reported in latitude and longitude to the nearest one-tenth of a second and in northing and easting to the nearest foot
- Sample collection elevations (feet MLLW) and depths below mudline
- Summary of the chemical data QA/QC review
- Summary of field QC result evaluation
- Results of focused topographic surveys and additional shoreline/bank survey data collected
- Results of structure inspections and sediment thickness probing surveys, including field inspection forms and structure condition ratings from the Phase II PDI
- Results of the analyses of sediment and geotechnical samples and an updated table with the results from reoccupied locations

A data package will be posted to <https://ldwg.org/> with Phase II sediment collection, analysis, and toxicity testing details. The package will include Phase II data and sampling locations, copies of field logs and photographs, chain of custody forms, and laboratory and data validation reports.

Once the data in the Phase II DER have been approved by EPA, toxicity testing results and chemistry database exports will be created from the project SQL Server database and submitted to the Washington State Department of Ecology (EIM). Chemistry exports will be submitted to EPA (Scribe), as specified in Section 7.3 of the middle reach PDI QAPP (Windward and Anchor QEA 2022).

As described in Section 6.1.4 of the RD work plan and Section 4.1 of the PDIWP (Windward and Anchor QEA 2023; Anchor QEA and Windward 2022), the Phase II DER will contain an interpretation of the data in order to define RAL exceedance area boundaries, general vertical extent depths, the range of remedial technologies, and remaining data needs for Phase III (if any).

7 References

- AECOM. 2012. Final feasibility study, Lower Duwamish Waterway. Prepared for Lower Duwamish Waterway Group. AECOM, Seattle, WA.
- Anchor QEA, Windward. 2022. Remedial design work plan for the Lower Duwamish Waterway - Middle Reach. Final. Delivered to EPA December 2, 2022. Anchor QEA Inc and Windward Environmental LLC, Seattle, WA.
- Anchor QEA, Windward. 2023. Phase I pre-design investigation data evaluation report for the Lower Duwamish Waterway - middle reach. Draft. Submitted to EPA December 18, 2023. Anchor QEA and Windward Environmental LLC, Seattle, WA.
- ATSDR. 2008. Toxicological profile for phenol. US Department of Health and Human Services Agency for Toxic Substances and Disease Registry, Atlanta, GA.
- EPA. 2014. Record of Decision. Lower Duwamish Waterway Superfund Site. US Environmental Protection Agency.
- EPA. 2021a. Fifth Amendment to the Administrative Order on Consent for remedial investigation/feasibility study (AOC) for the Lower Duwamish Waterway (LDW), CERCLA-10-2001-0055. US Environmental Protection Agency, Region 10, Olympia, WA.
- EPA. 2021b. Proposed explanation of significant differences. September 2021. Lower Duwamish Waterway Superfund site. US Environmental Protection Agency Region 10, Seattle, WA.
- Integral, Moffat & Nichol, Windward. 2018. Waterway user survey and assessment of in-water structures - data report. Integral Consulting Inc., Moffan & Nichol, and Windward Environmental LLC, Seattle, WA.
- PSEP. 1997. Recommended guidelines for sampling marine sediment, water column, and tissue in Puget Sound. Prepared for the Puget Sound Estuary Program, US Environmental Protection Agency, Region 10. King County (METRO) Environmental Laboratory, Seattle, WA.
- Windward. 2010. Lower Duwamish Waterway remedial investigation. Remedial investigation report. Final. Prepared for Lower Duwamish Waterway Group. Appendix I. Source control area-related facility information. Windward Environmental LLC, Seattle, WA.
- Windward, Anchor QEA. 2022. Pre-design investigation quality assurance project plan for the Lower Duwamish Waterway - Middle Reach. Final. Submitted to EPA November 21, 2022. Windward Environmental LLC and Anchor QEA, Seattle, WA.
- Windward, Anchor QEA. 2019. Pre-design investigation work plan for the Lower Duwamish Waterway upper reach. Final. Submitted to EPA December 16, 2019. Windward Environmental LLC and Anchor QEA, Seattle, WA.
- Windward, Anchor QEA. 2020. Lower Duwamish Waterway quality assurance project plan for remedial design of Upper Reach: pre-design investigation. Final. Submitted to EPA May 19, 2020. Windward Environmental LLC and Anchor QEA, Seattle, WA.
- Windward, Anchor QEA. 2023. Pre-design investigation work plan for the Lower Duwamish Waterway - Middle Reach. Final. Submitted to EPA February 14, 2023. Windward Environmental LLC and Anchor QEA, Seattle, WA.

Attachment A

Phase II Sampling for cPAHs

Attachment B

Sample-specific Details and Rationale

FINAL

Attachment C

Updated Standard Operating Procedures

Attachment D

Existing Geotechnical Studies

Attachment E

Geotechnical Data Collection Locations and Rationale

FINAL

Attachment F

Survey QAPP Addendum
