TERMINAL 91: REMEDIAL INVESTIGATION WORK PLAN
APPENDIX C – SAMPLING AND ANALYSIS PLAN

DRAFT

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Maps

Acronyms

AFDW	ash-free dry weight
AO	Agreed Order
ARI	Analytical Resources, Inc.
COC	contaminant of concern
COPC	contaminant of potential concern
CRM	certified reference material
CSL	cleanup screening level
CSO	combined sewer overflow
CV	coefficient of variation
CUL	cleanup level
CV	coefficient of variation
DGPS	differential global positioning system
DMM	discarded military munition
DMMP	Dredged Material Management Program
DO	dissolved oxygen
DQI	data quality indicator
DQO	data quality objective
dw	dry weight
EC50	concentration that causes a non-lethal effect in 50% of an exposed population
EcoAnalysts	EcoAnalysts, Inc.
Ecology	Washington State Department of Ecology
EDD	electronic data deliverable
EIM	Environmental Information Management
EPA	US Environmental Protection Agency
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
HSP	health and safety plan
ID	identification
IR	infrared
FS	feasibility study

GPS	global positioning system
LC50	concentration that is lethal to 50% of an exposed population
LCS	laboratory control sample
LMCL	lower method calibration limit
LOQ	limit of quantitation
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
MLLW	mean lower low water
MS	matrix spike
MSD	matrix spike duplicate
NAD83	North American Datum of 1983
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
OC	organic carbon
PACS	Professional Analytical and Consulting Services
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
Port	Port of Seattle
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance/quality control
RI	remedial investigation
RL	reporting limit
RPD	relative percent difference
SAP	sampling and analysis plan
Sayler	Sayler Data Solutions, Inc.
SCO	sediment cleanup objective
SCUM	sediment cleanup user's manual
SDG	sample delivery group
SIM	selected ion monitoring
SLA	Submerged Lands Area
SM	Standard Method
SMS	Washington State Sediment Management Standards

SVOC	semivolatile organic compound
SWAC	spatially weighted average concentration
T-91	Terminal 91
TBT	tributyltin
TCDD	tetrachlorodibenzo-*p*-dioxin
TEQ	toxic equivalent
TOC	total organic carbon
UCT-KED	Universal Cell Technology-kinetic energy discrimination
USCG	US Coast Guard
VOC	volatile organic compound
Windward	Windward Environmental LLC

Contractor Signature Sheet

Sampling and Analysis Plan

Terminal 91 Submerged Lands Area Preliminary Investigation

Terminal 91, Seattle, Washington

By signing below, I acknowledge that I have reviewed the Sampling and Analysis plan and agree to follow the methods and quality assurance procedures contained therein.

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1 Introduction

This sampling and analysis plan (SAP) for the Port of Seattle's (Port's) Terminal 91 (T-91) is required under Exhibit B of Washington State Department of Ecology (Ecology)/Port Agreed Order (AO) No. DE24768, which establishes the scope of work for the T-91 submerged lands area (SLA) remedial investigation (RI). The SAP is designed to address data gaps identified in Section 4 of the T-91 *Remedial Investigation Work Plan* (hereinafter referred to as the T-91 RI Work Plan), to which this document is an appendix. Three sediment investigations are covered by the SAP: a surface sediment investigation, an intertidal sediment investigation, and a subsurface sediment investigation.

This plan addresses project management responsibilities; sampling and analytical procedures; assessment and oversight; and data reduction, validation, and reporting. The field work will follow the health and safety procedures outlined in the health and safety plan (HSP), which is provided as Attachment 1. Field collection forms are provided in Attachment 2. Polychlorinated biphenyls (PCB) congener reporting limits (RLs) are provided in Attachment 3.

1.1 Site Description

T-91 is an approximately 210-acre property owned by the Port, located at 2001 West Garfield Street in the Interbay neighborhood of Seattle, Washington. The property consists of an upland area, two piers (Piers 90 and 91), and about 85 acres of submerged lands around the piers (i.e., SLA) (Map 1).

The T-91 SLA is 85 acres, 70 acres (82%) of which is subtidal sediment. The deepest portions of the berth areas average between -30 and -50 ft mean lower low water (MLLW). There are 8.0 acres of intertidal area in the western portion of the Western Berth Area and 7.3 acres of intertidal area the eastern portion of the Eastern Berth Area. South of the T-91 SLA site boundary specified in the AO (AO boundary), the depths increase towards Elliott Bay (Map 2). T-91 operations include a cruise ship terminal; cargo handling facilities for high-value, high-employment commodities (e.g., fish products); a factory trawler homeport and support facility; a seafood processing plant, distribution, and major cold storage warehouses; an industrial marine fuel distribution facility; and short- and long-term moorage for tugs, barges, and other large vessels.

T-91 was formerly used as the Seattle Naval Supply Depot and by US Navy vessels during World War II. T-91 was not used as an ammunition resupply facility, and there are no records of live-fire actions ever occurring at T-91. However, during a regular underwater inspection of the T-91 SLA by the Port Police Department in April 2010, discarded military munitions (DMMs) were found in the sediments. That same year, the US Army Corps of Engineers initiated the Piers 90 and 91 RI, conducted extensive mapping of the area, and removed all identified munitions (USACE 2013). Field personnel who will perform sampling in the T-91 SLA have been made aware of the potential presence of munitions; safety protocols have been developed in the event that munitions are present in the sediment samples collected. The DMM protocols are provided in the HSP (Attachment 1).

1.2 PREVIOUS SEDIMENT TESTING

Previous sediment investigations of the T-91 SLA were conducted from 2005 to 2018 for a variety of purposes, including regional characterization, dredged material characterization, post-dredge characterization, regrading characterization, Puget Sound and Elliot Bay monitoring programs, and assessment of preliminary remedial action needs (T-91 RI Work Plan, Section 2.4).

Surface sediment samples have been collected at 55 locations distributed throughout the T-91 SLA. Surface sediment samples have been analyzed for metals, tributyltin (TBT), polycyclic aromatic hydrocarbons (PAHs), phthalates, other semivolatile organic compounds (SVOCs), PCB Aroclors, pesticides, volatile organic compounds (VOCs), dioxin/furans, conventional parameters, and grain size (T-91 RI Work Plan, Section 2.4). Washington State Sediment Management Standards (SMS) criteria were exceeded for some contaminants. The majority of SMS exceedances were for PCBs and PAHs (T-91 RI Work Plan, Section 3.6.4). SMS criteria were also exceeded for 1,4-dichlorobenzene, 2,4-dimethyl phenol, phthalates, and metals (T-91 RI Work Plan, Table 3-4).

Subsurface sediment data for the T-91 SLA are limited. Five sediment cores were collected in the Central Berth Area, from which samples were analyzed for PCBs. Two sediment cores were collected in the northern portion of the eastern berth, from which samples were analyzed for SMS chemicals. Available data include metals, TBT, PAHs, phthalates, other SVOCs, PCB Aroclors, pesticides, dioxins/furans, conventional parameters, and grain size (T-91 RI Work Plan, Appendix B).

2 Project Objectives and Description

This section presents an overview of the data quality objectives (DQOs) and the scope of the RI sediment sampling.

2.1 Data Quality Objectives

Five DQOs for sediment are identified in the T-91 RI Work Plan.

- DQO 1 – Characterize the nature and extent of contamination in the sediment.
- DQO 2 – Delineate the cleanup boundary of the SLA.
- DQO 3 – Identify potential sources of contamination or re-contamination to the sediment.
- DQO 4 – Collect sediment for comparison to sediment cleanup levels (CULs).
- DQO 5 – Address feasibility study (FS) data needs for sediment remediation, as possible at this point in the process.

The DQOs are provided in Table 2-1, with a summary of the sampling design and analytical approach to address each sediment DQO.

Detailed study designs for the three sediment investigations (i.e., surface sediment, intertidal sediment, and subsurface sediment) are presented in Section 4 to address the DQOs. Descriptions and schedules for each of the three investigations are presented in Section 2.2.

Table 2-1. Sediment DQOs and data gaps

DQO	Study Question(s)	Existing Data	Sampling Design	Analytical Approach
1 – Nature and extent	What is the horizontal and vertical extent of contamination?	- 49 surface sediment samples (2018) analyzed for full SMS suite - 1 core in Central Berth Area analyzed for full SMS and dioxins/furans - 5 cores in Central Berth Area analyzed for PCBs only - 2 cores in Eastern Berth Area analyzed for full SMS suite	- 31 surface sediment locations[a] throughout the T-91 SLA - subset of surface sediment samples analyzed for dioxins/furans and PCB congeners - 26 subsurface cores[a] located throughout the T-91 SLA (excluding locations south of AO boundary)	- Analyze for full suite of SMS chemicals and conventionals (grain size, TOC). - Analyze subset of samples for dioxins/furans and PCB congeners.
2 – Site cleanup boundary	What is the extent of the site-related contamination?	- a few surface samples and cores near the southern end of the T-91 SLA	- 11 surface sediment locations[b] north and south of the AO boundary - 4 archive surface sediment locations to the south of the AO boundary (analyze if needed) - 6 subsurface cores[b] north and south of AO boundary	- Analyze for full suite of SMS chemicals and conventionals (grain size, TOC). - Analyze subset of samples analyzed for dioxins/furans.
3 – Potential source identification and re-contamination potential	What do the sediment data tell us about potential sources?	- surface sediment samples near Outfall A, Outfall 68/CSO, and primary storm drains, including 2 dioxins/furans composite samples by Outfall 68 - 2 cores collected near Outfall 68/CSO (SMS chemicals)	- 6 surface sediment samples[c] in the vicinity of outfalls - 7 sediment cores[c] in the vicinity of outfalls - 6 under-pier sampling areas, adjacent to areas with elevated sediment concentrations	Analyze for full suite of SMS chemicals, dioxins/furans, and conventionals (grain size, TOC).
4 – CUL derivation and comparison	What sampling design is needed to calculate SWACs for comparison to CULs? Are regional background data needed to establish CULs?	- 49 surface sediment samples analyzed within the T-91 SLA for most COPCs	- 31 surface sediment samples[c] throughout the T-91 SLA - 2 intertidal composites of 2 grab samples collected per intertidal acre	Analyze surface sediment and intertidal composite samples for full suite of SMS chemicals, dioxins/furans, and TOC.
5 – FS data needs	What potential FS data needs can be addressed during RI sampling?	none	Collect geotechnical data in Central and Eastern Berth Areas.	Measure Atterberg limits and bulk density in areas that are likely to require active remediation.

[a] Number excludes locations south of AO boundary.

[b] Number includes locations north of AO boundary, thus double-counting some of the locations enumerated for DQO 1.

[c] Number includes locations within the SLA, thus double-counting some of the locations enumerated for DQO 1.

AO – Agreed Order
COPC – contaminant of potential concern
CSO – combined sewer overflow
CUL – cleanup level
DQO – data quality objective
FS – feasibility study
PCB – polychlorinated biphenyl
RI – remedial investigation
SLA – Submerged Lands Area
SMS – Washington State Sediment Management Standards
SWAC – spatially weighted average concentration
T-91 – Terminal 91
TOC – total organic carbon

2.2 PROJECT DESCRIPTION AND SCHEDULE

2.2.1 Surface sediment investigation

Surface sediment will be collected throughout the T-91 SLA to establish the nature and extent of surface sediment contamination (DQO 1), establish the southern site cleanup boundary (DQO 2), characterize potential source areas (DQO 3), and collect data for comparison to CULs (DQO 4). In addition, surface sediment will be collected to conduct toxicity tests for locations with low SMS exceedance factors and without human health drivers.

The surface sediment investigation will be the first investigation conducted after the finalization of the T-91 RI Work Plan in the spring of 2021.

2.2.2 Intertidal sediment investigation

The intertidal areas in the Eastern and Western Berth Areas will be characterized by one composite sample each, the results from which will be compared to direct contact CULs (DQO 4).

The intertidal sediment investigation (including a reconnaissance survey described in Section 4.2.3) will be conducted in the spring/summer of 2021 to take advantage of the low daylight tides of -3.0 ft or lower during that period. The reconnaissance survey will take place in late April/May and the sediment collection work will occur in late June/July (Table 2-2).

Table 2-2. Daylight low tides of -3.0 ft or lower in 2021

Month	Date	Time	Low Tide
April 2021	Thursday, April 29	1:19 pm	-3.0 ft
May 2021	Wednesday, May 26	11:27 am	-3.3 ft
	Thursday, May 27	12:11 pm	-3.9 ft
	Friday, May 28	12:58 pm	-3.9 ft
	Saturday, May 29	1:47 pm	-3.3 ft
June 2021	Wednesday, June 23	10:22 am	-3.2 ft
	Thursday, June 24	11:08 am	-3.9 ft
	Friday, June 25	11:54 am	-4.0 ft
	Saturday, June 26	12:41 pm	-3.7 ft
	Sunday, June 27	1:29 pm	-3.0 ft
July 2021	Thursday, July 22	10:05 am	-3.0 ft
	Friday, July 23	10:53 am	-3.3 ft
	Saturday, July 24	11:40 am	-3.2 ft

Source: 2021 NOAA tide predictions for Seattle, Washington
NOAA – National Oceanic and Atmospheric Administration

2.2.3 Subsurface sediment investigation

The subsurface sediment investigation will be conducted to establish the nature and extent of deeper contamination (DQO 1), establish the southern site cleanup boundary (DQO 2), characterize potential source areas (DQO 3), and address FS data needs (DQO 5).

The subsurface sediment investigation will be conducted after a review of the preliminary results from the surface sediment investigation to finalize the locations for sediment cores. For example, if the surface sediment results identify new areas of concern or new potential sources of contamination, then cores for the subsurface sediment investigation may be relocated or added to characterize these areas.

In addition, a diver survey of six under-pier areas will be conducted. Under-pier sediment samples will be collected from locations within these areas if sufficient accumulated sediment exist to represent a potential source of recontamination.

The subsurface sediment investigation will occur in the summer of 2021 following the review of the preliminary results from the surface sediment investigation.

3 Project Team and Responsibilities

The overall project organization and individuals responsible for implementing the work elements presented in this SAP are described in this section.

The Port will be ultimately responsible for the implementation of the project. Windward Environmental LLC (Windward) will be responsible for sample collection, laboratory coordination, appropriate quality assurance/quality control (QA/QC) review, and preparation of the final sampling and analysis report. Susan McGroddy the Windward project manager, responsible for implementation of this SAP; Kathy Godtfredsen is the RI Lead and Suzanne Replinger is the Risk Assessment Lead.

Thai Do is the Windward field coordinator, responsible for day-to-day technical and QA/QC oversight. He will ensure that appropriate protocols for sample collection, preservation, and holding times are observed, and he will submit environmental samples to the designated laboratories for chemical and physical analyses.

Amara Vandervort is the Windward QA/QC manager for the project, providing oversight for both the field sampling and laboratory programs. She is also the laboratory coordinator for chemical analyses, confirming that samples are collected and documented appropriately, coordinating with the analytical laboratories, ensuring data quality, overseeing data validation, and supervising project QA coordination.

Independent third-party data review and validation will be performed by Sayler Data Solutions, Inc. (Sayler). Analytical Resources, Inc. (ARI) and Cape Fear Analytical will perform all chemical analyses of the sediment samples. EcoAnalysts, Inc. will perform toxicity testing.

The analytical testing laboratory will be responsible for the following:

- Perform the methods outlined in this plan, including those methods referenced for each analytical procedure.
- Follow documentation, custody, and sample logbook procedures.
- Implement QA/QC procedures required by the Puget Sound Estuary Program (PSEP).
- Meet all reporting requirements.
- Deliver electronic data deliverables (EDDs) as specified in this plan.
- Meet turnaround times for deliverables as described in this plan.

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4 Study Design

This section presents study designs for the three sediment investigations to address the DQOs discussed in Section 2.1.

4.1 Surface Sediment

Surface sediment samples will be collected to fill data gaps to address DQO1, DQO 2, DQO 3, and DQO 4. This section presents the rationale for sampling locations and analytes.

4.1.1 Surface sediment sampling locations

The 39 surface sediment locations identified are provided on Map 3. The rationale for each of the surface sediment locations is provided in Table 4-1. Data from all locations within the T-91 SLA will be used to address nature and extent (DQO 1) and CUL comparison (DQO 4), because all samples will be compared to SMS and used in spatially weighted average concentration (SWAC) calculations. Locations near the AO boundary will be used to delineate the SLA cleanup boundary (DQO 2) through the comparison to sediment CULs, which may not be finalized until the FS (depending on when regional background is developed). Data from locations near potential sources of contamination or re-contamination will be used to address DQO 4.

Table 4-1. Surface sediment sampling locations

Location	Rationale for Location				Comments
	Nature and Extent (DQO 1)	Cleanup Boundary (DQO 2)[a]	Potential Source ID (DQO 3)	CUL Comparison (DQO 4)[b]	
RI-SS01	X			X	western intertidal near West Yard property, potential toxicity test location
RI-SS02	X		X	X	re-occupy SS01, potential toxicity test location, vicinity of Outfall A, and stormwater outfall
RI-SS03	X			X	
RI-SS04	X			X	re-occupy SS05, potential toxicity test location.
RI-SS05	X			X	potential toxicity test location
RI-SS06	X			X	re-occupy T91-2018-SS33, potential toxicity test location.
RISS07	X			X	re-occupy SS-06, potential toxicity test location.
RI-SS08	X		X	X	stormwater outfall, potential toxicity test location
RI-SS09	X	X		X	potential toxicity test location
RI-SS10	X	X		X	potential toxicity test location
RI-SS11		X			
RI-SS12		X			

Location	Rationale for Location				Comments
	Nature and Extent (DQO 1)	Cleanup Boundary (DQO 2)[a]	Potential Source ID (DQO 3)	CUL Comparison (DQO 4)[b]	
RI-SS13		X			archive boundary sample to analyze if CUL exceedances in samples just south of AO boundary
RI-SS14	X	X		X	
RI-SS15		X			
RI-SS16		X			archive boundary sample to analyze if CUL exceedances in samples just south of AO boundary
RI-SS17		X			archive boundary sample to analyze if there are CUL exceedances in samples just south of AO boundary
RI-SS18		X			
RI-SS19	X	X		X	
RI-SS20	X			X	re-occupy T91-16-SS11[c]
RI-SS21	X			X	re-occupy T91-16-SS8[c]
RI-SS22	X			X	
RI-SS23	X			X	re-occupy T91-16-SS14[c]
RI-SS24	X			X	
RI-SS25	X			X	
RI-SS26	X			X	
RI-SS27	X			X	
RI-SS28	X			X	
RI-SS29	X			X	
RI-SS30	X		X	X	re-occupy SS10; potential toxicity test in the vicinity of stormwater outfall
RI-SS31	X		X	X	vicinity of stormwater outfall, potential toxicity test location
RI-SS32	X			X	re-occupy SS19, potential toxicity test location
RI-SS33	X			X	potential toxicity test location
RI-SS34	X		X	X	vicinity of stormwater outfall, potential toxicity test location
RI-SS35	X		X	X	re-occupy SS30, vicinity of stormwater outfall, potential toxicity test location
RI-SS36	X			X	re-occupy SS24, potential toxicity test location
RI-SS37	X			X	re-occupy SS32, potential toxicity test location
RI-SS38	X	X		X	potential toxicity test location
RI-SS39		X			

Location	Rationale for Location				Comments
	Nature and Extent (DQO 1)	Cleanup Boundary (DQO 2)[a]	Potential Source ID (DQO 3)	CUL Comparison (DQO 4)[b]	
RI-SS40		X			
RI-SS41		X			archive boundary sample to analyze if CUL exceedances in samples just south of AO boundary

[a] All boundary samples will also be compared to CULs to help establish the boundary.

[b] All surface sediment sampling locations in the Eastern and Western Berth Areas have been identified as potential toxicity test locations based on existing data in these berth areas.

[c] Location was sampled immediately after the completion of the 2016 regrading operation prior to the resumption of cruise ship berthing operations.

AO – Agreed Order
CUL – cleanup level
DQO – data quality objective
ID – identification
SMS – Washington State Sediment Management Standards

A subset of 11 locations are re-occupations of existing surface sediment locations. Eight re-occupation locations (SS02, SS04, SS06, SS07, SS32, SS35, SS36, and SS37) that are located in the Eastern and Western Berth Areas have existing data that exceed only the SMS for chemicals unlikely to be contaminants of potential concern (COPCs) for human health seafood ingestion. Therefore, toxicity tests may be conducted at these locations to potentially override chemical criteria. All surface sediment samples that meet these criteria may be toxicity tested.

The remaining three re-occupation locations (SS20, SS21, and SS23) were identified to provide temporal information in an area affected by a regrading operation in 2016. This area may be subject to propeller scour from cruise ship berthing operations. Data from these locations were collected following regrading and before cruise ship berthing operations resumed after the regrading. Comparison of these data with RI data from these sampling locations may indicate changes in chemical concentrations due to sediment disturbance caused by propellor scour.

In order to define the southern site cleanup boundary (DQO 2), 10 surface sediment locations have been established in the vicinity of the AO boundary. In addition, four locations south of the AO boundary locations have been identified to provide archive boundary samples. These samples will be analyzed if the sediment concentrations in the 10 initial boundary samples suggest that the site contamination extends beyond those locations. The sediment concentrations at the boundary locations will be used to define a boundary based on a comparison with CULs, which may be revised based on the development of Elliott Bay regional background. If these background concentrations are not developed before the RI is final, the RI will establish a sediment cleanup boundary, and a final site boundary will be established in the FS.

In order to characterize potential sources of contamination or recontamination (DQO 3), six surface sediment samples will be collected in the vicinity of stormwater outfalls

(SS02, SS08, SS30, SS31, SS34, and SS35). In combination with existing data, the RI data will be used to evaluate these outfalls as potential sources of COPCs to the sediment.

4.1.2 Analytes

All of the surface sediment samples will be analyzed for the full suite of SMS chemicals (e.g., metals, SVOCs, PCBs, PAHs). In addition, 15 samples will be analyzed for dioxins/furans in order to have sufficient site-wide dioxin/furan toxic equivalent (TEQ) values to calculate a SWAC for dioxin/furan TEQ.

The samples identified as potential toxicity test samples will require expedited chemistry results that will be reviewed to determine whether or not the toxicity test will be run. Toxicity testing will be considered for samples with low SMS exceedance factors and no exceedances associated with human health COPCs. If the sediment concentrations in the chemistry results are below the sediment cleanup objective (SCO) or there is an exceedance of a human health COPC, then the toxicity test will not be conducted.

The preliminary data for PCBs and dioxins/furans will be reviewed to identify samples for the analysis of PCB congeners. The samples will be selected to evaluate the relationship between total PCBs and PCB TEQ.

4.2 Intertidal Sediment

This section presents the study design for the intertidal sediment samples that will be collected to support the evaluation of human health risks associated with direct contact with sediment during beach play and clam digging activities (DQO 4).[1] Per the sediment cleanup user's manual (SCUM) (Ecology 2019), risk estimates should be based on an area-averaged sediment concentration; thus, a composite sample approach will be used to determine concentrations in the intertidal sediment.

The intertidal area is defined as extending from the shoreline to -4 ft MLLW. This area includes a total of approximately 15.3 acres: approximately 8.0 acres in the western berth and 7.3 acres in the eastern berth. The small amount of intertidal area in the central berth (0.3 acres) is an armored rip-rap slope that is not suitable for beach play or clamming (i.e., there is no exposed sediment), so no intertidal samples will be collected from this area.

An overview of the design to estimate chemical concentrations in the intertidal area of the T-91 SLA is presented in Table 4-2.

[1] Risks associated with netfishing will be assessed using surface sediment data discussed in Section 4.1.

Table 4-2. Overview of intertidal surface sediment sampling approach

Design Component	Approach
Sample type	composite samples
Number of composite samples	2 samples (one each in the Western and Eastern Berth intertidal areas)
Sample density	approximately 2 samples per acre
Number of samples per composite	Western Berth Area – 16 locations (based on an approximate intertidal area of 8.0 acres) Eastern Berth Area – 15 locations (based on an approximate intertidal area of 7.3 acres)
Sample depth	to be determined based on the results of the intertidal survey to be conducted during the low tides in late April/May
Analytes	all SMS chemicals, dioxins/furans, and TOC

SMS – Washington State Sediment Management Standards
TOC – total organic carbon

4.2.1 Sampling locations

Target sampling locations to be included in each composite are located throughout the intertidal area such that they cover the range of intertidal elevations and provide good spatial coverage of each intertidal area. As described, target sampling locations occur at a density of approximately 2 per acre, for a total of 16 locations in the Western Berth Area and 15 locations in the Eastern Berth Area (Map 4). Locations will be adjusted as needed by the field crew based on whether the target location can be sampled successfully.

A jar of archive sediment from each sampling location included in the composite will be retained prior to compositing. If a more spatially explicit understanding of the intertidal sediment concentrations is needed (i.e., if composite concentrations result in human health risks above the acceptable risk threshold), these archived samples may be analyzed.

4.2.2 Sample depth

Intertidal composite samples are intended to characterize individuals' potential exposure to sediment in the T-91 SLA intertidal area during beach play (for young children) or clam digging (for adults). The depth of exposure for young children (i.e., up to six years of age) playing at the beach is expected to be less than that for adult clam diggers. Thus, as a health-protective approach, the sample depth will be based on primarily expected exposure during clam digging. The sample depth to be used for the collection of the composite samples will be determined in consultation with Ecology and the Tribes prior to initiation of the intertidal sediment sampling effort. The types of clams present in the intertidal areas will help inform the appropriate sample depth. Insufficient information is currently available about the type(s) of clams present in the T-91 SLA, so an intertidal survey will be conducted to obtain additional information.

4.2.3 Intertidal reconnaissance survey

Prior to initiating the intertidal sediment sampling effort, a reconnaissance survey of the intertidal area will be conducted to provide important information regarding several key elements of the sampling design: sample depth, boundary of the intertidal area, potential beach access points, and best sampling methods for intertidal sediment collection. This survey will take place during the daylight low tides that will occur in late April/May. Survey activities will include the following:

- **Sample depth** – As part of determining the relevant exposure depth, a survey of the types of clams present in the T-91 SLA and their depths will be investigated.
- **Shoreline survey** – Based on a review of available aerial photographs and the bathymetry layer, a reconnaissance of the upper boundary of the intertidal area will be conducted to better define the extent of the intertidal area. In addition, the shoreline survey will include documentation of potential beach access points.
- **Sampling methods** – As part of the intertidal reconnaissance survey, conditions throughout intertidal areas will be noted to better inform intertidal sampling methods (i.e., hand-collection from the beach during low tide and/or collection from a boat during high tide).

Details regarding the methods for conducting this survey are discussed in Section 5.4.

4.3 Subsurface Sediment

Sediment cores will be collected to characterize subsurface sediment to support DQO 1, DQO 2, DQO 3, and DQO 5. To supplement existing data, cores will be collected at 28 locations throughout the T-91 SLA to provide data on the vertical extent of contamination in all three berth areas (Map 5). Sediment core locations were identified based on the surface sediment data and potential sources; the locations were co-located with surface sediment sampling locations, where possible, to provide data throughout the sediment horizon in many areas (Map 6).

4.3.1 Sediment core locations

Sediment core locations and the DQOs associated with each location are summarized in Table 4-3. Thirty-one sediment core locations have been identified, primarily to provide coverage for nature and extent throughout the site (DQO 1). In addition, six core locations (SC05, SC06, SC07, SC08, SC28, and SC29) have been identified in the vicinity of the southern boundary of the SLA, to support the establishment of an interim boundary if regional background data are not available prior to finalizing the RI.

Table 4-3. Sediment core locations

Location	Nature and Extent (DQO 1)	Boundary (DQO 2)	Potential Source ID (DQO 3)	FS Data Needs (DQO 5)	Comments
RI-SC01	X		X		Characterize subsurface in the vicinity of Outfall A.
RI-SC02	X				
RI-SC03	X				
RI-SC04	X		X		vicinity of stormwater outfall
RI-SC05	X	X			propeller scour area near AO boundary
RI-SC06	X	X			
RI-SC07	X	X			
RI-SC08	X	X			propeller scour area near AO boundary and regrade area
RI-SC09	X			X	propeller scour area near regrade area
RI-SC10	X				
RI-SC11	X			X	propeller scour area near regrade area
RI-SC12	X				propeller scour area
RI-SC13	X			X	propeller scour area
RI-SC14	X				
RI-SC15	X				
RI-SC16	X				
RI-SC17	X			X	
RI-SC18	X				
RI-SC19	X		X		vicinity of stormwater outfall
RI-SC20	X		X		vicinity of stormwater outfall
RI-SC21	X		X		vicinity of stormwater outfall
RI-SC22	X		X		vicinity of stormwater outfall
RI-SC23	X		X		vicinity of stormwater outfall
RI-SC24	X				
RI-SC25	X				vicinity of stormwater outfall
RI-SC26	X				
RI-SC27	X				
RI-SC28	X	X		X	
RI-SC29		X			

AO – Agreed Order
DQO – data quality objective
FS – feasibility study
ID – identification

Eight core locations have been identified in the vicinity of stormwater outfalls. The analysis of subsurface sediment intervals at these locations will provide information on historical inputs from these outfalls.

Subsurface sediment for geotechnical index testing will be collected in five locations adjacent to areas with elevated COC concentrations within the Central and the Eastern Berth Areas.

The preliminary surface sediment data will be reviewed in consultation with Ecology and the Tribes to determine if the surface sediment concentrations support adjusting the locations or number of core samples. Any changes in the core locations will be documented in an approved addendum to this SAP prior to sampling.

4.3.2 Subsurface sediment core depths and intervals

Within the preliminary areas of propeller scour where scour depths greater than 5 ft have been observed (T-91 RI Work Plan, Section 3.2.6), the target depth for sediment cores will be 10 ft. Outside of these areas, the target depth will be 6 ft. The deeper cores in the propeller scour areas will allow for the collection of sediment below the sediment affected by mixing due to propeller scour (RI Work Plan, Section 3.2.6).

Cores collected outside of preliminary propeller scour areas will be sampled in 1-ft intervals for the top 2 ft (0 to 1 and 1 to 2 ft) and in 2-ft intervals below 2 ft (i.e., 2 to 4 and 4 to 6 ft). The top three intervals of each core will be analyzed, and the preliminary results will be reviewed to determine if analysis of the 4- to 6-ft core interval is necessary. If the COPC concentrations are below the SMS in the 2- to 4-ft interval, then the 4- to 6-ft interval will not be analyzed.

In the preliminary propeller scour area, cores will be sampled in 2-ft intervals. Three intervals will be selected for analysis in each core, including the uppermost interval (0 to 2 ft), an interval within the potential scour depth (based on core stratigraphy and modeling), and an interval below the potential scour depth. All other intervals will be logged and archived.

From the cores collected for FS data needs, geotechnical index samples will be collected from up to two intervals for each core. One sample will be collected from the shallower surface material, and one sample will be collected from a lower lithological layer. At least one geotechnical index test sample will be collected from the native sediment.

4.3.4 Analytes

Subsurface sediment will be analyzed for SMS chemicals, total organic carbon (TOC), and grain size. A subset of samples from nearby areas with elevated dioxin/furan TEQs in surface sediment will also be analyzed for dioxins/furans.

4.4 UNDER-PIER SEDIMENT

Under-pier areas adjacent to areas with elevated sediment contaminant concentrations will be surveyed and potentially sampled to support source identification and the evaluation of potential re-contamination (DQO 3). This investigation will require divers to survey the accumulated sediment in the under-pier areas and collect samples in areas with sufficient accumulated sediment to be a potential recontamination risk.

4.4.1 Under-pier sampling areas

Six potential under-pier sampling areas have been identified (Map 7, Table 4-4) based on the presence of elevated COPCs in the adjacent surface or subsurface sediment. The under-pier sediment areas represent a potential source of re-contamination if there is contamination associated with accumulated sediment under the piers that could be resuspended and deposited in adjacent areas after remediation.

Table 4-4. Potential under-pier sampling areas

Location	Rationale
UP01	adjacent to elevated surface sediment PCB concentrations
UP02	adjacent to elevated subsurface sediment PCB concentrations
UP03	adjacent to elevated surface sediment PCB concentrations
UP04	adjacent to elevated surface sediment PCB concentrations
UP05	adjacent to elevated surface and subsurface sediment PCB concentrations
UP06	adjacent to elevated surface sediment PAH concentrations

PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl

These under-pier areas will be surveyed by divers during the subsurface investigation. If there is sufficient accumulated sediment under the piers to represent a concern for recontamination, then sediment samples will be collected by the diver for analysis. Samples will be collected if there is accumulated sediment covering at least 50% of the under-pier area slope to a thickness of at least 30 cm.

4.4.2 Analytes

Under-pier samples will be analyzed for TOC and COPCs with concentrations exceeding SMS in adjacent sediment. These samples will also be analyzed for grain size to assess mobility.

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5 Field Sampling and Processing

This section presents the sample identification, collection, processing, and handling procedures that will be followed for the T-91 SLA RI.

5.1 Sample Identification

Unique alphanumeric identifications (IDs) will be assigned to each sample and recorded on the sediment collection forms (Attachment 2). The sampling location IDs will include the following:

- Project area ID (i.e., T91)
- Project phase ID (i.e., RI)
- Sample type:
  - Surface sediment samples (0 to 10-cm) will be SS.
  - Intertidal sediment samples will be ITW or ITE (to designate intertidal samples in the western or eastern berth, respectively).
  - Subsurface sediment samples will be SC.
  - Under-pier samples will be UP.
- Two digit location number

For example, a 0 to 10-cm surface sediment sampling location would be labeled T91-RI-SS07, an intertidal grab sampling location would be labeled T91-RI-ITW05, and a subsurface sediment core sampling location would be labeled T91-RI-SC15.

Sample IDs will be the same as or similar to sampling location IDs:

- Surface sediment samples – Sample ID will be the same as the sampling location ID (e.g., T91-RI-SS07).
- Intertidal sediment samples – Sample ID for archive samples will be the same as the location ID (e.g., T91-RI-ITW05). Intertidal composite sample IDs will be T91-RI-ITWComp1 and T91-RI-ITEComp2 for the two intertidal areas.
- Subsurface sediment samples – Sample ID will start the same as the location ID, but a sample identifier will be added to the end of the ID (e.g., T91-RI-SC15A, B, C). The surface interval of each core (0 to 1 ft or 0 to 2 ft) will be identified as interval A, then each subsequent interval will be labeled alphabetically.

5.2 Station Positioning

On the day of sampling, US Coast Guard (USCG) personnel will be contacted and advised that the sampling operations outlined in this SAP will be occurring within their

Vessel Traffic Service area. During sampling, VHF-FM channels 13 and 14 will be monitored by Windward staff.

Horizontal positioning will be determined using a differential global positioning system (DGPS) receiver on the sampling vessel. The DGPS will include a global positioning system (GPS) receiver unit affixed to the end of the sampling vessel's deployment boom and a USCG beacon differential receiver. The GPS unit will receive radio broadcasts of GPS signals from satellites, and the USCG beacon receiver will acquire corrections to the GPS signals to accurately determine positioning within 1 to 2 m. The vertical elevation of each core will be measured using a fathometer or lead line and will be converted to MLLW with the National Oceanic and Atmospheric Administration's (NOAA's) tide prediction data from the Seattle tide gauge station. Target coordinates for sampling locations are presented in Table 5-1. Mudline depths are listed for those locations covered by existing bathymetry data.

Table 5-1. Coordinates for proposed sampling locations

Sample ID	Mudline Depth (ft)	Easting (ft)[a]	Northing (ft)[a]	Latitude	Longitude
Surface sediment					
T91-RI-SS01	nd	1257796	234735	47.632939	-122.385279
T91-RI-SS02	-0.2	1258107	234795	47.633121	-122.384021
T91-RI-SS03	-33.5	1258146	234122	47.631279	-122.383809
T91-RI-SS04	-35.6	1258131	233775	47.630326	-122.383840
T91-RI-SS05	-8.5	1257826	233408	47.629303	-122.385046
T91-RI-SS06	-39.1	1258128	233388	47.629265	-122.383821
T91-RI-SS07	-38.1	1258095	233072	47.628397	-122.383929
T91-RI-SS08	-37.4	1258093	232939	47.628033	-122.383927
T91-RI-SS09	-42.6	1258077	232406	47.626570	-122.383947
T91-RI-SS10	-36.2	1257743	232449	47.626672	-122.385305
T91-RI-SS11	-44.8	1257629	232330	47.626337	-122.385759
T91-RI-SS12	-51.8	1258073	232262	47.626176	-122.383950
T91-RI-SS13	-59.5	1257873	232095	47.625708	-122.384748
T91-RI-SS14	-28.7	1258432	232305	47.626315	-122.382500
T91-RI-SS15	-43.1	1258338	232229	47.626100	-122.382874
T91-RI-SS16	-64.9	1258253	232022	47.625529	-122.383202
T91-RI-SS17	-69.5	1258816	231944	47.625346	-122.380915
T91-RI-SS18	-58.5	1258719	232140	47.625878	-122.381323
T91-RI-SS19	-46.7	1258824	232269	47.626237	-122.380909
T91-RI-SS20	-39.3	1258571	232395	47.626568	-122.381944
T91-RI-SS21	-34.8	1258529	232561	47.627021	-122.382127
T91-RI-SS22	-35.7	1258847	232765	47.627599	-122.380856
T91-RI-SS23	-38.0	1258567	232929	47.628032	-122.382003
T91-RI-SS24	-39.7	1258571	233276	47.628982	-122.382016

Sample ID	Mudline Depth (ft)	Easting (ft)[a]	Northing (ft)[a]	Latitude	Longitude
T91-RI-SS25	-40.6	1258687	233418	47.629378	-122.381556
T91-RI-SS26	-37.9	1258852	233422	47.629399	-122.380889
T91-RI-SS27	-39.1	1258571	233705	47.630158	-122.382051
T91-RI-SS28	-39.2	1258701	233941	47.630812	-122.381543
T91-RI-SS29	-37.4	1258576	234100	47.631243	-122.382063
T91-RI-SS30	-32.3	1258850	234222	47.631591	-122.380961
T91-RI-SS31	-4.1	1259243	234589	47.632620	-122.379399
T91-RI-SS32	-30.7	1259264	234418	47.632151	-122.379299
T91-RI-SS33	-17.0	1259387	234257	47.631716	-122.378788
T91-RI-SS34	-34.8	1259236	233946	47.630856	-122.379375
T91-RI-SS35	-35.4	1259263	233724	47.630249	-122.379246
T91-RI-SS36	-37.0	1259223	233230	47.628893	-122.379368
T91-RI-SS37	-39.0	1259215	232381	47.626565	-122.379331
T91-RI-SS38	-35.6	1259395	232182	47.626030	-122.378584
T91-RI-SS39	-56.3	1259031	232109	47.625810	-122.380056
T91-RI-SS40	-49.7	1259453	232032	47.625621	-122.378338
T91-RI-SS41	-65.3	1259310	231868	47.625164	-122.378903
Intertidal sediment					
T91-RI-ITW01	-0.6	1258135	234789	47.633105	-122.383908
T91-RI-ITW02	-1.7	1258024	234686	47.632817	-122.384347
T91-RI-ITW03	4.1	1257916	234772	47.633046	-122.384792
T91-RI-ITW04	3.8	1257800	234653	47.632715	-122.385252
T91-RI-ITW05	1.3	1257899	234595	47.632560	-122.384846
T91-RI-ITW06	4.4	1257804	234442	47.632137	-122.385219
T91-RI-ITW07	-0.7	1257931	234449	47.632162	-122.384708
T91-RI-ITW08	1.7	1257859	234316	47.631794	-122.384987
T91-RI-ITW09	-2.1	1257916	234204	47.631490	-122.384746
T91-RI-ITW10	1.4	1257787	234183	47.631426	-122.385267
T91-RI-ITW11	nd	1257728	234087	47.631159	-122.385502
T91-RI-ITW12	-2.5	1257782	233996	47.630912	-122.385272
T91-RI-ITW13	-2.9	1257889	233953	47.630800	-122.384836
T91-RI-ITW14	nd	1257702	233856	47.630525	-122.385588
T91-RI-ITW15	-2.8	1257854	233789	47.630348	-122.384965
T91-RI-ITW16	-3.1	1257721	233641	47.629936	-122.385492
T91-RI-ITE17	-0.6	1259184	234694	47.632903	-122.379647
T91-RI-ITE18	1.9	1259326	234673	47.632854	-122.379069
T91-RI-ITE19	-1.6	1259394	234553	47.632528	-122.378782
T91-RI-ITE20	nd	1259481	234431	47.632200	-122.378420
T91-RI-ITE21	1.5	1259451	234237	47.631666	-122.378527
T91-RI-ITE22	3.7	1259504	234087	47.631258	-122.378300

Sample ID	Mudline Depth (ft)	Easting (ft)[a]	Northing (ft)[a]	Latitude	Longitude
T91-RI-ITE23	nd	1259551	233931	47.630833	-122.378093
T91-RI-ITE24	-1.6	1259453	233790	47.630441	-122.378482
T91-RI-ITE25	nd	1259524	233675	47.630129	-122.378182
T91-RI-ITE26	-0.6	1259470	233514	47.629684	-122.378391
T91-RI-ITE27	nd	1259526	233372	47.629298	-122.378152
T91-RI-ITE28	-1.2	1259480	233255	47.628974	-122.378327
T91-RI-ITE29	nd	1259528	233063	47.628452	-122.378116
T91-RI-ITE30	-2.3	1259507	232818	47.627780	-122.378181
T91-RI-ITE31	nd	1259536	232587	47.627146	-122.378046
Sediment cores					
T91-RI-SC01	-0.2	1258107	234795	47.633121	-122.384021
T91-RI-SC02	-33.5	1258146	234122	47.631279	-122.383809
T91-RI-SC03	-37.4	1257992	233387	47.629256	-122.384370
T91-RI-SC04	-37.4	1258093	232939	47.628033	-122.383927
T91-RI-SC05	-42.6	1258077	232406	47.626570	-122.383947
T91-RI-SC06	-51.8	1258073	232262	47.626176	-122.383950
T91-RI-SC07	-58.5	1258719	232140	47.625878	-122.381323
T91-RI-SC08	-39.3	1258571	232395	47.626568	-122.381944
T91-RI-SC09	-34.8	1258529	232561	47.627021	-122.382127
T91-RI-SC10	-35.7	1258847	232765	47.627599	-122.380856
T91-RI-SC11	-38.0	1258567	232929	47.628032	-122.382003
T91-RI-SC12	-40.6	1258705	233024	47.628299	-122.381453
T91-RI-SC13	-39.7	1258571	233276	47.628982	-122.382016
T91-RI-SC14	-40.6	1258687	233418	47.629378	-122.381556
T91-RI-SC15	-37.9	1258852	233422	47.629399	-122.380889
T91-RI-SC16	-39.2	1258573	233554	47.629744	-122.382032
T91-RI-SC17	-35.8	1258558	233898	47.630686	-122.382119
T91-RI-SC18	-36.5	1258856	233896	47.630698	-122.380909
T91-RI-SC19	-27.8	1258591	234229	47.631597	-122.382012
T91-RI-SC20	-32.3	1258850	234222	47.631591	-122.380961
T91-RI-SC21	-30.7	1259264	234418	47.632151	-122.379299
T91-RI-SC22	-31.9	1259223	234207	47.631571	-122.379446
T91-RI-SC23	-34.8	1259236	233946	47.630856	-122.379375
T91-RI-SC24	-34.5	1259241	233510	47.629661	-122.379318
T91-RI-SC25	-37.0	1259223	233230	47.628893	-122.379368
T91-RI-SC26	-35.2	1259299	232807	47.627738	-122.379024
T91-RI-SC27	-36.3	1259209	232647	47.627295	-122.379376
T91-RI-SC28	-39.0	1259215	232381	47.626565	-122.379331
T91-RI-SC29	-49.7	1259453	232032	47.625621	-122.378338

[a] Washington North Zone, NAD83 geographic and state plane coordinates – US survey feet.

ID – identification
NAD83 – North American Datum of 1983
nd – no data

5.3 SURFACE SEDIMENT COLLECTION

Surface sediment collection and processing will follow standardized procedures for the Puget Sound area that have been developed by the PSEP (1997). Surface sediments will be collected at each location using a pneumatic power grab sampler from a sampling vessel. The 0- to 10-cm sediment interval will be collected to represent the biologically active horizon.

The surface sediment samples will be collected as described in the following steps:

1. Using GPS, maneuver the sampling vessel to the approximate pre-identified sampling location.
2. Open the grab sampler jaws to the deployment position.
3. Guide the sampler overboard until it is clear of the vessel.
4. Using GPS, position the sampling vessel such that the GPS receiver, mounted on the winch arm directly over the grab sampler, is within 1 to 2 m of the intended sampling location.
5. Lower the sampler through the water column to the bottom at approximately 0.3 m/sec.
6. Record the GPS location of the boat when the sampler reaches bottom.
7. Record the water depth and time.
8. Retrieve the sampler and raise it at approximately 0.3 m/sec.
9. Guide the sampler aboard the vessel and place it on the work stand on the deck, using care to avoid jostling that might disturb the integrity of the sample.
10. Examine the sample using the following sediment acceptance criteria:
    - Sediment is not extruding from the upper face of the sampler.
    - Overlying water is present (indicating minimal leakage).
    - The sediment surface is relatively flat (indicating minimal disturbance or winnowing).
    - A penetration depth of at least 11 cm has been achieved.

If these sample acceptance criteria are not achieved, the sample will be rejected. If an acceptable grab sample cannot be obtained in three attempts, the target sampling location will be moved while remaining as close as possible to the original location. If the sampling location needs to be moved more than 10 ft from the original location, Ecology will be notified to approve the new sampling location.

After sample acceptance, the following observations will be noted on the Surface Sediment Collection Form (Attachment 2, Form 1) or in the field logbook:

- GPS location
- Depth as read by the boat's depth sounder or lead line
- Gross characteristics of the surficial sediment, including texture, color, biological structures, odor, and presence of debris or oily sheen
- Gross characteristics of the vertical profile (i.e., changes in sediment characteristics and redox layer, if visible)
- Maximum penetration depth (nearest 0.5 cm)
- Comments relative to sample quality

Any deviations from the approved sampling plan will be noted on a Protocol Modification Form (Attachment 2, Form 2).

5.4 Intertidal Reconnaissance Survey

The intertidal reconnaissance survey will include two main parts: a clam survey and a survey of the shoreline boundary. In addition, the field team will take notes regarding the intertidal substrate to help inform the methods to be used for the collection of intertidal sediment. Survey methods are described in the subsections below.

After the intertidal survey is complete, a memorandum documenting the results of the survey and information regarding the collection methods for intertidal sediment will be submitted to Ecology and the Tribes.

5.4.1 Clam survey

The objective of the clam survey will be to understand the clam species present in the T-91 SLA and the approximate depths of those clams. This information will be used to determine the depth of the intertidal sediment samples.

To conduct the survey, the field team will walk the intertidal area during low tide and will opportunistically look for clam shows. Efforts will be focused along the low tide water line during the time of the lowest tide and will then continue progressively higher on the beach.

Team members will dig for clams when shows are observed and record the following information:

- Clam species (identified to lowest possible taxonomic level)
- Length measurement (e.g., anterior to posterior length)
- Approximate location (drawn on map)
- Depth of sediment at which clam was encountered

In addition, the field team will select three subareas that capture the range of intertidal conditions (i.e., spatial extent, tidal elevation, and substrate) and will systematically dig for clams in these areas (regardless of whether shows are observed). The information described above will be recorded for each of these subareas.

5.4.2 Shoreline survey

Based on a review of the available aerial photographs and bathymetry layer, a reconnaissance of the boundary of the intertidal area will be conducted to better define the shoreline boundary. The field crew will accomplish this survey by walking the shoreline (i.e., upper) boundary of the intertidal area with a hand-held GPS unit and recording a line feature that can be used to improve map accuracy. In addition, notes will be taken regarding potential beach access points. This exercise will be conducted in both the western and eastern berth intertidal areas. Photographs will also be taken to document conditions and access points along the shoreline boundary.

5.5 Intertidal Sediment Collection

Intertidal sediment samples will be collected in both the western and eastern berth intertidal areas at the locations shown on Map 4 and in Table 5-1. The primary intertidal sampling method will be to collect sediment by hand using a shovel (or hand-core tube) during low tide. However, pending the evaluation of sediment conditions during the intertidal reconnaissance survey, intertidal sediment may also be collected from a boat using the methods described for surface and/or subsurface sediment collection (Section 5.3 and 5.6, respectively).

The following steps will be used to collect intertidal sediment by hand during low tide:

1. Identify target location using a hand-held GPS unit. For target locations at lower elevations (i.e., near the low tide water line), the field crew will collect samples during the time when the tide is lowest to ensure that the samples are successfully collected.
2. If a target location cannot be sampled (e.g., due to the presence of debris), the sampling location will be moved to the nearest available location.
3. Using a shovel or trowel, the field crew will dig a hole to the specified depth. The field crew will make up to three attempts to reach the target depth; if unsuccessful, the deepest of the three holes will be used.[2]
4. Collect sediment using a spoon such that the vertical extent of sediment from the hole is equally represented in the sample. Collect sufficient sediment to fill a

[2] As an alternate collection option, the field crew may elect to use a hand-driven core tube to collect a sample, depending on the substrate and sampling conditions. If this method is utilized, the core tube will be driven to the target depth, extracted from the sediment, and the contents extruded onto a piece of foil to collect sediment.

16-oz jar (i.e., sufficient material for inclusion in the composite and to fill an archive jar at each location).

5. Label the jar, place it in resealable plastic bag, and store it in a cooler on ice for transport to ARI for further processing.

After collection, the following observations will be noted on the Intertidal Sediment Collection Form (Attachment 2, Form 3) or in the field logbook:

- GPS location
- Gross characteristics of the surficial sediment, including texture, color, biological structures, odor, and presence of debris or oily sheen
- Gross characteristics of the vertical profile (i.e., changes in sediment characteristics and redox layer, if visible)
- Maximum penetration depth (nearest 0.5 cm)
- Comments relative to sample quality

Any deviations from the approved sampling plan will be noted on a Protocol Modification Form (Attachment 2, Form 2).

5.6 SEDIMENT CORE COLLECTION

Subsurface sampling will be conducted using a vibracorer deployed from the research vessel. The RIC-3500 vibracoring system consists of a vibrating power head attached to a 6-ft-long, 4-in.-diameter core barrel with a check valve and core catcher to create suction and retain sediment within the core tube. Sediment core samples will be collected according to the following procedures:

1. Maneuver the sampling vessel to the targeted sampling location.
2. Deploy the vibracorer and a decontaminated core tube.
3. Collect continuous core samples to a depth of 10 ft or until refusal.
4. Measure and record the depth of core penetration. Measure the depth of the drive from the sediment surface to refusal depth using a lead line attached to the vibracoring unit.
5. Extract the sample core tube and retrieve the assembly aboard the vessel.
6. Evaluate the core sample at the visible ends of the core tube to verify retention of the sediment in the core tube. If the sediment core is acceptable (see criteria below), begin processing the core on the boat.

Sediment core logging and processing will be done on the boat. Acceptance criteria for a sediment core sample are as follows:

- Material is collected to an acceptable depth.
- Recovery (determined by measuring the headspace and subtracting that measurement from the length of the core tube upon retrieval) is greater than 75%.
- The core tube appears to be intact without obstructions or blocking.

If sample acceptance criteria are not achieved, the sample will be rejected. If repeated deployment (i.e., maximum three attempts) as close as possible to the original target location does not result in a sample that meets the appropriate acceptance criteria, a different sampling location may be selected based on consultation and coordination with the Port and Ecology.

Logs and field notes of all core samples will be maintained as samples are collected and correlated to the sampling location map. The following information will be included noted on the Sediment Core Collection Form (Attachment 2, Form 4) or in the field logbook:

- Water depth and tide elevation at the time of sampling for each sediment core location relative to MLLW
- Location of each sediment core as determined using DGPS measurements
- Date and time of collection of each sediment core
- Names of field supervisor and person(s) collecting and logging the sample
- Observations made during sample collection, including weather conditions, complications, ship traffic, and other details associated with the sampling effort
- Core ID (see Section 5.2)
- Depth of sediment recovered using the vibracorer or hammer corer
- Any deviations from the approved sampling plan on a Protocol Modification Form (Attachment 2, Form 2)

Additionally, photographs of sediment cores will be taken with a digital camera.

5.7 Under-pier Area Diver Survey

Under-pier sediment surveys will be conducted adjacent to the five under-pier areas shown in Map 6. These surveys will be conducted by divers to map the extent and thickness of sediment. Sediment extent will be determined in transects extending from the bulkhead alignment to the face of the pier structure. Divers will use jet probing to measure sediment thickness. Jet probing involves the penetration of unconsolidated sediment in shallow water using a thin, hollow probe, assisted by water or air flow out of the probe tip. A jet probe can be used to estimate sediment type and stratigraphy, including the depth of hard objects or hard bottom.

The jet probe surveys will be conducted in a series of transects extending perpendicular to each shoreline. Measurements will be taken at locations 5 to 15 ft apart along each transect. Measurement locations will be verified by the jet probe contractor using a combination of a DGPS and sonar-based underwater positioning technology. Diver position will be monitored in real-time by the support crew (connected to the divers via intercom and video) to verify that the transects are in the appropriate locations.

Starting at the shoreline/top of slope, each established measurement location will be described by the divers and recorded. Descriptions will include the following:

- Location
- Water depth measurement in feet
- Time of water depth measurement
- Observed surface substrate type
- Debris type and size
- Biological observations
- Estimated surface slope

After the divers have described the surface conditions at a location, a support boat will deliver the jet probe to the divers. The jet probe will consist of a galvanized pipe marked with foot graduations and connected to a hose and water pump. The divers will advance the probe into the sediment without additional water pressure (i.e., hand-probe) to obtain an approximate depth and consistency of the surface substrate (surficial sediment depth), until resistance or refusal is encountered. The boat-supported water pump will then be engaged to assist the probe's penetration through the sediment substrate layers. The divers will characterize the probing observations, typically including the following:

- Depth of layers penetrated
- Debris encountered
- Resistance levels
- Vibration
- Refusal depth
- Sediment plume color and density (if applicable)

Some locations may require multiple passes of the jet probe to properly characterize the area. The jet probing methods should remain flexible and be modified as necessary to ensure a safe work environment for the divers and support crew.

The divers will verify the X and Y locations, water depth, and time of each measurement. A final depth-corrected table of elevation measurements will be provided, documenting the position and water depth for each measurement. In under-pier areas exposed at low tide and where rip-rap is present, the average diameter of the rip-rap stone will be recorded, and the elevation recorded will represent the average condition of the slope at that location. Survey results will include tabulated transect locations and jet probe observations, as well as a series of cross sections summarizing the observations made along each transect.

5.8 Sediment Sample Processing and Handling Procedures

This section describes the equipment decontamination procedures, sample containers, and processing procedures.

5.8.1 Equipment decontamination procedures

Sample containers, instruments, working surfaces, technician protective gear, and other items that may come into contact with sediment sample material must meet high standards of cleanliness. All equipment and instruments that come into direct contact with the sediment collected for analysis must be made of glass, stainless steel, or polycarbonate, and they will be cleaned prior to each day's use and between sampling or compositing events. Decontamination of all items will follow PSEP protocols (1997). The decontamination procedure is as follows:

1. Pre-wash and rinse the item with site or tap water.
2. Wash the item with a solution of site or tap water and Alconox® soap (brush).
3. Rinse the item with site or tap water.
4. Rinse the item with distilled water.
5. Cover (no contact) all decontaminated items with aluminum foil.
6. Store the item in a clean, closed container for next use.

5.8.2 Sample containers for analysis

The laboratory will provide certified, pre-cleaned, EPA-approved containers for all samples. Prior to shipping, the analytical laboratory will add preservative, as required, according to PSEP protocols (1997).

5.8.3 Sample processing procedures

All working surfaces and instruments will be thoroughly cleaned, decontaminated, and covered with aluminum foil to minimize outside contamination between sampling events. Disposable gloves will be discarded after processing the samples at each sampling location, and new gloves will be donned prior to handling decontaminated instruments or work surfaces.

Sample containers (i.e., jars and bottles) will be kept in the original packaging as received from the analytical laboratory (i.e., coolers and/or boxes) until they are used to collect the samples. A sample container will be removed from the original packaging only when a sample is to be collected and placed within. The container will immediately be labeled and placed in a sturdy, plastic cooler containing ice and/or frozen gel packs.

5.8.3.1 Procedures for surface sediment grabs

Sediment grab processing will be performed on the boat immediately after sample collection. The steps for processing the samples are as follows:

1. Record a description of the grab sample on the Surface Sediment Collection Form (Attachment 2, Form 1) for surface sediment; note the following parameters, as appropriate:
    - Elevation of bed at sampling location
    - Penetration depth
    - Sediment color, density, consistency, and stratification
    - Odor (e.g., hydrogen sulfide, petroleum)
    - Vegetation
    - Debris
    - Biological activity (e.g., detritus, shells, tubes, bioturbation, live or dead organisms)
    - Presence of oil sheen
    - Any other distinguishing characteristics or features
2. Transfer material that will make up the sample for laboratory analysis into a single clean stainless steel bowl and homogenize until textural and color homogeneity are achieved.
3. Using a clean stainless steel spoon, completely fill pre-labeled sample containers.
4. Thoroughly check all sample containers for proper ID, analysis type, and lid tightness.
5. Pack each container carefully to prevent breakage, and place it inside a cooler with ice or frozen gel packs for storage at the proper temperature (0 to 6°C for all samples).
6. Return excess sediment to the sampling location.

5.8.3.2 Procedures for intertidal sediment composites

After the completion of the intertidal sediment sampling effort, intertidal sediment samples will be processed and composite samples will be created at ARI. The steps for processing the intertidal sediment samples and creating composites are as follows:

1. Separate jars into groups for the western and eastern berth intertidal areas; process each group separately.
2. For each individual location, adhere to the following steps:
    a. Remove sediment from jar used for sample collection and place sediment in a clean stainless steel bowl; homogenize sediment until textural and color homogeneity are achieved.
    b. Using a clean stainless steel spoon, measure an equal amount from each location sample into a clean stainless steel measuring cup and add the resulting mixture to the stainless steel bowl to be used to homogenize the composite sample.
    c. Use the stainless steel spoon to fill an 8-oz archive jar using the remaining homogenized sediment.
    d. Record processing information on the Intertidal Composite Form (Attachment 2, Form 5)
3. Once all samples from locations in a given area (west or east) have been processed, homogenize until textural and color homogeneity are achieved.
4. Using a clean stainless steel spoon, completely fill pre-labeled sample containers.
5. Thoroughly check all sample containers for proper ID, analysis type, and lid tightness.

5.8.3.3 Procedures for sediment cores

Sediment core processing will be performed on the boat. The steps for processing the samples are as follows:

1. Carefully cut along the butyl acetate or polycarbonate core liner to expose the sediment core for processing.
2. Slice each core into target depth intervals as described in Section 4.3.
3. Record a description of each core on the Sediment Core Collection Form (Attachment 2, Form 4); note the following parameters, as appropriate:
    - Elevation of bed at sampling location
    - Penetration depth
    - Length of recovered core (in inches)
    - Sediment core sample depth intervals and excess material
    - Sediment color, density, consistency, and stratification
    - Odor (e.g., hydrogen sulfide, petroleum)
    - Vegetation
    - Debris

- Biological activity (e.g., detritus, shells, tubes, bioturbation, live or dead organisms)
- Presence of oil sheen
- Any other distinguishing characteristics or features

4. Place the collected sediment samples into separate stainless steel containers, homogenize, label, subsample for archive, and store on ice.
5. Using a clean stainless steel spoon, completely fill pre-labeled sample containers for the remaining analyses.
7. Thoroughly check all sample containers for proper ID, analysis type, and lid tightness.
8. Pack each container carefully to prevent breakage, and place it inside a cooler with ice or frozen gel packs for storage at the proper temperature (0 to 6°C for all samples).

5.9 Surface Sediment Field Quality Assurance Samples

Field duplicate surface sediment samples will be collected to evaluate variability attributable to sample homogenization and subsequent sample handling. Field duplicate samples will be collected from the same homogenized material as the original samples and analyzed as separate samples; this type of field QA /QC sample is also referred to as a field split sample (PSEP 1997). A minimum of 1 field duplicate will be analyzed for every 20 samples.

Although data validation guidelines have not been established for field QC samples, the data resulting from the analyses of these kinds of samples are useful in identifying possible problems caused by sample collection or processing in the field. All field QC samples will be documented in the field logbook and verified by the project QA/QC manager or a designee.

5.10 Sample Transport and Chain of Custody Procedures

Following sample processing, samples will be transferred into ARI's custody. Specific sample transport procedures are as follows:

1. Each container with the sediment samples will be delivered to ARI or to the Windward storage area within 24 hours of being sealed.
2. A sufficient amount of ice, double-bagged in sealed plastic bags, or frozen gel packs will be placed within each container. Chain of custody forms will be enclosed in a sealed plastic bag and taped to the inside lid of each container.
3. Signed and dated chain of custody seals will be placed on all containers prior to shipping.

The persons who transfer custody of the sediment sample containers and archival samples will sign the chain of custody form upon transfer of sample possession to the analytical laboratory. The shipping container seal will be broken upon receipt of samples at the laboratory, at which time the receiver will record the condition of the samples. Chain of custody procedures will be used internally by the laboratory to track sample handling and final disposition.

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6 Chemical/Conventional Analyses

Laboratory methods, QA/QC procedures, laboratory sample handling, and data quality indicators (DQIs) for the sediment samples collected for chemistry testing are described in this section.

6.1 METHODS AND SAMPLE HANDLING

Surface sediment and sediment chemistry core samples will be analyzed for all SMS chemicals, TOC, grain size, and total solids. Dioxins/furans and PCB congeners will be analyzed in a subset of samples. Table 6-1 summarizes the parameters for analysis, analysis methods, and target RLs for the collected sediment samples. All samples will be maintained according to the appropriate holding times and temperatures for each analysis, as presented in Table 6-2.

Table 6-1. SMS criteria, analysis methods, and target detection limits

Parameter	Unit	SMS Criteria		Analysis Method	Target RL[a,b]
		SCO	CSL		
Conventional Parameters					
TOC	%	nc	nc	Plumb (1981) combustion IR	0.02
Grain size	%	nc	nc	PSEP 1986	0.1
Percent solids	%	nc	nc	SM 2540 G-97	0.04
Metals					
Arsenic	mg/kg dw	57	93	EPA 6020A UCT-KED	0.2
Cadmium	mg/kg dw	5.1	6.7	EPA 6020A UCT-KED	0.1
Chromium	mg/kg dw	260	270	EPA 6020A	0.5
Copper	mg/kg dw	390	390	EPA 6020A UCT-KED	0.5
Lead	mg/kg dw	450	530	EPA 6020A	0.1
Mercury	mg/kg dw	0.41	0.59	EPA 7471B	0.025
Silver	mg/kg dw	6.1	6.1	EPA 6020A	0.2
Zinc	mg/kg dw	410	960	EPA 6020A UCT-KED	4
Organics					
Total LPAH	µg/kg dw	370 mg/kg OC	780 mg/kg OC	EPA 8270D (calculated)	20 (2 mg/kg OC)
Naphthalene	µg/kg dw	99 mg/kg OC	170 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Acenaphthylene	µg/kg dw	66 mg/kg OC	66 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Acenaphthene	µg/kg dw	16 mg/kg OC	57 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Fluorene	µg/kg dw	23 mg/kg OC	79 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Phenanthrene	µg/kg dw	100 mg/kg OC	480 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Anthracene	µg/kg dw	220 mg/kg OC	1,200 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
2-Methylnaphthalene[c]	µg/kg dw	38 mg/kg OC	64 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Total HPAHs	µg/kg dw	960 mg/kg OC	5,300 mg/kg OC	EPA 8270D (calculated)	20 (2 mg/kg OC)
Fluoranthene	µg/kg dw	160 mg/kg OC	1,200 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Pyrene	µg/kg dw	1,000 mg/kg OC	1,400 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Benzo(a)anthracene	µg/kg dw	110 mg/kg OC	270 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Chrysene	µg/kg dw	110 mg/kg OC	460 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Total benzofluoranthenes	µg/kg dw	230 mg/kg OC	450 mg/kg OC	EPA 8270D (calculated)	40 (4 mg/kg OC)

Parameter	Unit	SMS Criteria		Analysis Method	Target RL[a,b]
		SCO	CSL		
Benzo(a)pyrene	µg/kg dw	99 mg/kg OC	210 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Indeno(1,2,3-cd)pyrene	µg/kg dw	34 mg/kg OC	88 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Dibenz(a,h)anthracene	µg/kg dw	12 mg/kg OC	33 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Benzo(g,h,i)perylene	µg/kg dw	31 mg/kg OC	78 mg/kg OC	EPA 8720D	20 (2 mg/kg OC)
Chlorinated Hydrocarbons					
1,2-Dichlorobenzene	µg/kg dw	2.3 mg/kg OC	2.3 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
1,2,4-Trichlorobenzene	µg/kg dw	0.81 mg/kg OC	1.8 mg/kg OC	EPA 8270D-SIM	5 (0.5 mg/kg OC)
1,4-Dichlorobenzene	µg/kg dw	3.1 mg/kg OC	9 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Hexachlorobenzene	µg/kg dw	0.38 mg/kg OC	2.3 mg/kg OC	EPA 8081B	1 (0.1 mg/kg OC)
Phthalates					
Dimethyl phthalate	µg/kg dw	53 mg/kg OC	53 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Diethyl phthalate	µg/kg dw	61 mg/kg OC	110 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Di-n-butyl phthalate	µg/kg dw	220 mg/kg OC	1,700 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Butyl benzyl phthalate	µg/kg dw	4.9 mg/kg OC	64 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Bis(2-ethylhexyl) phthalate	µg/kg dw	47 mg/kg OC	78 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Di-n-octyl phthalate	µg/kg dw	58 mg/kg OC	4,500 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Phenols					
Phenol	µg/kg dw	420	1,200	EPA 8270D	20
2-Methylphenol	µg/kg dw	63	63	EPA 8270D	20
4-Methylphenol	µg/kg dw	670	670	EPA 8270D	20
2,4-Dimethylphenol	µg/kg dw	29	29	EPA 8270D-SIM	25
Pentachlorophenol	µg/kg dw	360 mg/kg OC	690 mg/kg OC	EPA 8270D	100 (10 mg/kg OC)
Other SVOCs					
Benzyl alcohol	µg/kg dw	57	73	EPA 8270D	20
Benzoic acid	µg/kg dw	650	650	EPA 8270D	200
Dibenzofuran	µg/kg dw	15 mg/kg OC	58 mg/kg OCe	EPA 8270D	20 (2 mg/kg OC)
Hexachlorobutadiene	µg/kg dw	3.9 mg/kg OC	6.2 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
n-Nitrosodiphenylamine	µg/kg dw	11 mg/kg OC	11 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Total PCB Aroclors	**µg/kg dw**	**12 mg/kg OC**	**65 mg/kg OC**	**EPA 8082A**	**20 (2 mg/kg OC)**

Parameter	Unit	SMS Criteria		Analysis Method	Target RL[a,b]
		SCO	CSL		
Dioxin/Furan congeners	**ng/kg dw**	**nc**	**nc**	**EPA 1613b**	**1.0**[d]
PCB congeners	**ng/kg dw**	**nc**	**nc**	**EPA 1668c**	**12.0**[e]
Ammonia[f]	mg/kg dw	**nc**	**nc**	SM 4500-NH3 H-97	**0.4**
Total sulfides[f]	mg/kg dw	**nc**	**nc**	SM 4500-S2 D-0 PSEP prep	**1**
Specific gravity	none	**nc**	**nc**	ASTM D854	**nc**
Atterberg Limits	% water	**nc**	**nc**	ASTM D4318	**nc**

a Actual RLs will vary based on the amount of sample analyzed, the analytical dilution, and the percent solids of the sample.

b Non-normalized RLs were converted to OC-normalized values using 1% TOC.

c 2-Methylnapthalene is not included in the sum of LPAHs.

d Value listed is ARI's LOQ for 2,3,7,8 -TCDD. Individual congener LOQs are provided in Attachment 3. The LOQ is ARI's lowest concentration, at or above the LMCL, at which test accuracy (precision and bias) has been demonstrated. Values below the LOQ are J-qualified. The reported LOQ will be adjusted based on the sample mass of each sample.

e The PCB RL is based on the LMCL from CFA and represents the maximum value for an individual PCB congener. Individual congener LMCLs are listed in Attachment 3. The reported LMCL will be adjusted based on the mass of each sample.

f Ammonia and total sulfide analysis will be conducted only on sediment targeted for toxicity testing.

ASTM – American Society for Testing and Materials
CFA – Cape Fear Analytical
CSL – cleanup screening level
dw – dry weight
EPA – US Environmental Protection Agency
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
IR – infrared
J – estimated concentration
LMCL – lower method calibration limit
LOQ – limit of quantitation
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
nc – no criteria
OC – organic carbon
PCB – polychlorinated biphenyl
PSEP – Puget Sound Estuary Program
RL – reporting limit
SCO – sediment cleanup objective
SIM – selected ion monitoring
SM – Standard Method
SMS – Washington State Sediment Management Standards
SVOC – semivolatile organic compound
TCDD – tetrachlorodibenzo-*p*-dioxin
TOC – total organic carbon
UCT-KED – Universal Cell Technology-kinetic energy discrimination

Table 6-2. Guidelines for sample handling and storage of sediment samples

Parameter	Holding Time	Preservative	Sample Size	Container Size and Type[a]
Grain size	6 months	cool/0 to 6ºC	600 g	16-oz plastic
Percent solids	14 days	cool/0 to 6ºC	55 g	8-oz glass
	6 months	freeze, -18ºC		
TOC	14 days	cool/0 to 6ºC		
	6 months	freeze, -18ºC		
Total metals	6 months; mercury sample must be frozen	cool/0 to 6ºC	5 g	
	2 years; 28 days for mercury	freeze, -18ºC		
SVOCs and PCB Aroclors	14 days until extraction	cool/0 to 6ºC	100 g	16-oz glass
	1 year until extraction	freeze, -18ºC		
	40 days after extraction	cool/0 to 6ºC, or freeze, -18ºC		
Dioxins/furan congeners	1 year until extraction	cool to ≤ 0 to 6°C	40 g	8-oz amber glass
	1 year after extraction if stored in the dark at ≤ -10°C	freeze to ≤ -18°C		
PCB congeners	collection to lab receipt	cool to ≤ 0 to 6°C	40 g	4-oz glass
	1 year until extraction	freeze to ≤ -18°C		
	1 year after extraction if stored in the dark at ≤ -10°C			
Specific gravity	na	na	50g	8 oz jar
Atterberg Limits				
Archive material[b]	na	freeze, -18ºC	na	8-oz glass
Amphipod and polychaete toxicity testing	56 days until test initiation	cool/0 to 6ºC	2,400 g	32-oz glass (6)
Bivalve larvae toxicity testing	56 days until test initiation	cool/0 to 6ºC		
Ammonia[c]	7 days	cool/0 to 6ºC	25 g	4-oz glass
Total sulfides[c]	7 days	2 mL 2 N zinc acetate; cool/0 to 6ºC	25 g	4-oz glass

[a] All sample containers will have lids with Teflon® inserts.

[b] Material from the individual samples will be archived, as possible.

[c] Ammonia and total sulfide analysis will be conducted only on sediment targeted for toxicity testing.

na – not applicable
PCB – polychlorinated biphenyl
SVOC – semivolatile organic compound
TOC – total organic carbon

6.2 QUALITY ASSURANCE/QUALITY CONTROL AND DATA QUALITY INDICATORS

The frequency of analysis for laboratory QA/QC samples is summarized in Table 6-3. Project-specific DQIs are summarized in Table 6-4. All RLs must be below the SMS screening levels. When analyzing SVOCs, PCB Aroclors, dioxin/furan congeners, PCB congeners, metals, and conventional parameters, initial calibrations will be required before any samples are analyzed, after each major disruption of equipment, and when ongoing calibration fails to meet acceptance criteria. Ongoing calibration will be required before and after the collection of every 10 samples or every 12 hours (depending on the test method).

Table 6-3. Laboratory QA/QC sample analysis summary

Analysis Type	Initial Calibration	Initial Calibration Verification (second source)	Continuing Calibration Verification	CRM[a]	LCS	Laboratory Replicate[b]	MS[c]	MSD[c]	Method Blank	Internal Standards/ Surrogate Spike
Grain size	na	na	na	na	na	triplicate per 20 samples	na	na	na	na
Percent solids	na	na	na	na	na	1 per 20 samples or per batch	na	na	na	na
TOC	prior to analysis	after initial calibration	1 per 10 samples	1 per 20 samples – NIST 1944	1 per batch or SDG	1 per batch or SDG[d]	1 per batch or SDG	na	1 per prep batch	na
Metals	prior to analysis and as needed[e]	after initial calibration	1 per 10 samples	1 per 20 samples – ERA DO95-540	1 per batch or SDG	1 per batch or SDG	1 per batch or SDG	na	1 per prep batch	na
Semivolatile organics	prior to analysis and as needed[e]	after initial calibration	prior to analytical batch, 1 per 10–20 samples, or every 12 hours	1 per 20 samples – CRM-143	1 per batch or SDG	na	1 per batch or SDG	1 per batch or SDG	1 per prep batch	every sample
PCB Aroclors[f]	prior to analysis and as needed[e]	after initial calibration	prior to analytical batch, 1 per 10–20 samples, or every 12 hours	1 per 20 samples – CRM-911	1 per batch or SDG	na	1 per batch or SDG	1 per batch or SDG	1 per prep batch	every sample
Dioxin/furan congeners	prior to analysis and as needed[e]	after initial calibration	prior to analytical batch or every 12 hours	1 per batch or SDG – NIST 1944	1 per batch or SDG	1 per batch or SDG	na	na	1 per prep batch	every sample
PCB congeners	prior to analysis and as needed[e]	after initial calibration	prior to analytical batch, 1 per 10–20 samples, or every 12 hours	1 per 20 samples – SRM09 WMS-01	1 per batch or SDG	1 per batch or SDG	na	na	1 per prep batch	every sample
Ammonia	prior to analysis	after initial calibration	every 10 samples	na	1 per batch or SDG	1 per batch or SDG	1 per batch or SDG	na	1 per prep batch	na
Total sulfides	prior to analysis	after initial calibration	every 10 samples	na	1 per batch or SDG	1 per prep batch or SDG	1 per batch or SDG	na	1 per prep batch	na

Note: A batch is a group of samples of the same matrix analyzed or prepared at the same time, not exceeding 20 samples.

a An LCS may be used to assess accuracy when a CRM is unavailable.

[b] Laboratory replicate sample(s) will be analyzed only if sufficient sample volume is available. Non-project-specific results may also be available to satisfy this QA/QC requirement.

[c] An LCS duplicate sample may be analyzed in lieu of MS/MSD. Non-project-specific MS/MSD results may also be available to satisfy this QA/QC requirement.

[d] TOC analysis includes a triplicate per batch or SDG.

[e] Initial calibrations are considered valid until the ongoing continuing calibration no longer meets method specifications. At that point, a new initial calibration is performed.

[f] PCB Aroclors will have all detects confirmed via second column confirmation. The second column must be of a dissimilar stationary phase from the primary column and meet all method requirements for acceptance. The primary column is considered the column that results in the highest value with the least interference. Values should have RPDs less than 40%, or they will be P1-flagged by ARI and qualified as estimated.

ARI – Analytical Resources, Inc.
CRM – certified reference material
LCS – laboratory control sample
MS – matrix spike
MSD – matrix spike duplicate
na – not applicable
NIST – National Institute of Standards and Technology
PACS – Professional Analytical and Consulting Services
PCB – polychlorinated biphenyl
QA/QC – quality assurance/quality control
RPD – relative percent difference
SDG – sample delivery group
TOC – total organic carbon

Table 6-4. DQIs for chemical analyses

Parameter	Precision[a,b]	Accuracy		Completeness
		CRM/LCS[a,b]	MS/MSD[a,b]	
Grain size	± 20% RPD	na	na	95%
Percent solids	± 20% RPD	na	na	95%
TOC	± 30% CV	75–125%	75–125%	95%
Total metals	± 30% RPD	80–120%	75–125%	95%
SVOCs	± 35% RPD	50–150%	50–150%	95%
PCB Aroclors	± 35% RPD	50–150%	50–150%	95%
Dioxin/furan congeners	± 35% RPD	50-150%	63-170%[c]	95%
PCBs congeners	± 35% RPD	50–150%	15–150%[c]	95%
Ammonia	± 20% RPD	90-110%	75-125%	95%
Total sulfides	± 20% RPD	75-125%	75-125%	95%

[a] Values listed are performance-based limits provided by the laboratories.
[b] Values represent a range for all parameters.
[c] Labelled compound percent recovery range.

CRM – certified reference material
CV – coefficient of variation
DQI – data quality indicator
LCS – laboratory control sample
MS – matrix spike
MSD – matrix spike duplicate
na – not applicable
PCB – polychlorinated biphenyl
RPD – relative percent difference
SVOC – semivolatile organic compound
TOC – total organic carbon

Surrogates will be required (organics only) for every sample, including matrix spike (MS) samples, blanks, laboratory control samples (LCSs), and certified reference materials (CRMs). All samples analyzed for dioxin/furan and PCB congeners will be spiked with a known amount of labeled surrogate compounds, as defined in the analytical method. MS samples and matrix spike duplicates (MSDs) will be required for SVOCs, and for PCBs for every 20 samples received or at the request of the client. An MS sample and a laboratory duplicate sample will be analyzed for every 20 samples for metals. Matrix triplicates will be analyzed for conventional parameters (e.g., grain size).

All samples will be diluted and re-analyzed if target compounds are detected at levels that exceed their respective established calibration ranges. Re-analyses will be performed if surrogate or internal standard recoveries exceed the control limits to demonstrate matrix effects. QC samples may be re-analyzed once if results are not within control limits, and it cannot be determined that the sample matrix is the cause.

6.3 LABORATORY DATA REPORT

The laboratory will prepare a detailed report that documents all activities associated with the sample analyses. Included in this report will be:

- **Project Narrative:** This portion of the report will detail the samples received, analyses performed, and corrective actions taken.
- **Chain-of-Custody Documentation:** Chain of custody documentation must be available for all samples at all laboratories. The chain of custody will document basic sample identifiers such as client and project name, sample name, sample collection date and time, analyses requested, sampler's name or initials, and special instructions.
- **Data Summary Forms:** These forms will include a tabular listing of concentrations and RLs for all target analytes. The data summary report forms or other supplemental forms will also list other pertinent information, such as amount of sample analyzed, dilution factors, sample processing dates, extract cleanups, and surrogate recoveries.
- **QA Summary:** This portion of the report will include the results of all QC analyses, specifically recovery and precision information. LCSs will be reported with each batch, when applicable, as listed in Table 6-3 Additional QC analyses will include laboratory replicates, MSs, and CRMs.
- **Instrument Calibration Forms and Raw Data:** This portion of the report will include initial and continuing calibration summaries, instrument tuning data for mass spectroscopy analyses, laboratory bench sheets, quantitation reports, chromatograms, preparatory log book pages, and instrument log book pages.

The laboratory will also provide electronic deliverables in standard EDD format as specified by the project QA/QC manager.

6.4 DATA VALIDATION

Sayler will conduct summary-level data validation, focusing on the results from the analysis of QA/QC samples specified in Table 6-4.

7 Sediment Toxicity Tests

This section describes the sediment toxicity test procedures, including sediment collection, methods, sample handling, test evaluation criteria, DQIs, QC criteria, and the laboratory data report.

7.1 Sediment Collection

7.1.1 T-91 sediment

For locations identified for potential toxicity testing, additional sediment will be collected during the collection of surface sediment grabs (Section 4.3). A total of 200 oz (6 L) of sediment will be collected at the surface sediment sampling locations; multiple grabs will be collected from the same location until sufficient volume has been obtained for both chemistry and toxicity testing samples. Sediment from all grabs will be thoroughly homogenized prior to distribution into the appropriate sample containers for both chemistry and toxicity testing. The sediment from locations identified for toxicity testing will be submitted for expedited analysis of all analytes, in order to determine if toxicity testing is required and to identify appropriate reference sediments. The expedited data will be available within two weeks of sample collection in order to initiate the toxicity tests within the holding time (56 days).

7.1.2 Reference Area Sediment

Reference area sediment will be collected by EcoAnalysts, Inc. from locations in Carr Inlet with grain size and TOC similar to that of the T-91 samples being tested. In order to obtain a suitable reference sample and to best match the T-91 samples, five locations will be sampled from the reference area, following the reference area sediment sampling protocols in SCUM (Ecology 2019) and the Dredged Material Management Program (DMMP) user manual (USACE et al. 2018). Field measurements of grain size will be used to inform the selection of the five locations.

At each reference area location, multiple grab samples will be combined and homogenized thoroughly to create a composite sample with sufficient volume for toxicity testing and analysis of TOC, grain size, ammonia, and total sulfides. Additional sediment from the reference locations will be archived in case chemical analyses are needed at a later date.

In order to review reference area grain size and TOC data prior to initiating toxicity testing, these analyses will be expedited. The grain size and TOC data for the five composite reference samples will be reviewed, and the toxicity test reference will be selected. The reference sediment percent fines should be within 20% of the test sediment percent fines, and the TOC should be similar. If there is no single sample with TOC and grain size comparable to that of the T-91 samples, then combining reference area samples to create a composite reference sample will be considered.

7.2 Methods and Sample Handling

Sediment submitted for toxicity testing will be obtained from the same field homogenate as the sediment submitted for chemical analyses. The homogenized sediment will be placed in six I-Chem™ 32-oz high-density polyethylene wide-mouth jars with zero headspace. These samples will be refrigerated after nitrogen purging of the headspaces in the jars at ARI, after which they will be shipped to EcoAnalysts, as needed. The sediment samples will be stored in the dark at 4 ± 2°C. The toxicity tests will be initiated within eight weeks of sample collection.

Three standard PSEP sediment toxicity tests will be conducted on each sample collected from the locations identified for toxicity testing. These tests are:

- Acute 10-day amphipod mortality test (*Rhepoxynius abronius*, *Ampelisca abdita*, or *Eohaustorius estuarius*)
- Acute 48-hr bivalve larvae combined mortality and abnormality test (*Mytilus galloprovincialis* or Dendraster excentricus)
- Chronic 20-day juvenile polychaete survival and growth test (*Neanthes arenaceodentata*)

Toxicity testing will be conducted according to *Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments* (PSEP 1995), consistent with the updated protocols in (Ecology 2019).

7.2.1 Acute 10-day amphipod mortality test

Short-term adverse effects of sediments will be evaluated by measuring the survival of adult amphipods. The appropriate test species will be selected based on sediment grain size data (Table 7-1). Amphipods will be exposed to T-91 sediment and reference sediment from Carr Inlet for a 10-day period. The test will be performed according to the procedures and QA/QC performance standards described by Ecology (2019), with survival as the primary endpoint.

Table 7-1. Sediment conditions and preferred amphipod test species

Sediment Condition	Grain Size	Preferred Amphipod Test Species
Coarse	< 60% fines	*R. abronius*
Fine-grained	> 60% fines	*A. abdita or E. estuarius*
High clay	> 20% clay	*A. abdita*
Low salinity[a] and clay	< 20% clay	*E. estuarius*

[a] Interstitial salinity below 25 ppt.
ppt – parts per thousand

7.2.2 Acute 48-hr bivalve larvae combined mortality and abnormality test

The endpoint assessed in bivalve larvae after a 48-hr exposure period is normal survivorship, which is a combined assessment of mortality and abnormality. Larvae of

M. galloprovincialis are the preferred test organisms for this study. If *M. galloprovincialis* in spawning condition are unavailable, the echinoderm *D. excentricus* will be used. Test protocols and QA/QC performance standards will be in accordance with guidance (USACE et al. 2018; Ecology 2019).

7.2.3 Chronic 20-day juvenile polychaete survival and growth

The juvenile polychaete sublethal toxicity test is used to characterize the toxicity of marine sediments based on worm growth. The target initial worm weight for test organisms is between 0.5 and 1.0 mg. Parameters measured after the 20-day sediment exposure are survival and growth in juvenile polychaetes (*N. arenaceodentata*). The test will be performed according to the procedures described in PSEP protocols (1995) and Johns et al. (1990), as well as the most recent *N. arenaceodentata* protocol adjustments presented in the 2013 clarification paper regarding the use of ash-free dry weights (AFDWs) (DMMP 2013) and the QA/QC guidance provided by Ecology (2019).

7.3 Toxicity Test Evaluation Criteria

The results of the toxicity tests will be evaluated relative to the marine biological criteria in SCUM (Ecology 2019). The evaluation criteria are provided in Table 7-2. Benthic SCO biological criteria (Ecology 2013) may be used to override benthic SCO chemical criteria where human health-based remedial action levels are not also exceeded.

Table 7-2 SMS marine biological criteria

Toxicity Test	Test Endpoint	SCO	CSL
Amphipod	10-day mortality	test mortality > 25% and statistical difference between test mortality and reference mortality ($p < 0.05$)	test mortality-reference mortality ≥ 30% and statistical difference between test mortality and reference mortality ($p < 0.05$)
Larval	bivalve or echinoderm abnormality/mortality	test normal survivorship/reference normal survivorship < 0.85 and statistical difference between test and reference response ($p < 0.10$)	test normal survivorship/reference normal survivorship < 0.70 and statistical difference between test and reference response ($p < 0.10$)
Polychaete	*N. arenaceodentata* 20-day growth	test mean individual growth/reference mean individual growth < 0.70 and statistical difference between test response and reference response ($p < 0.05$)	test mean individual growth/reference mean individual growth <0.50 and statistical difference between test response and reference response ($p < 0.05$)

CSL – cleanup screening level
SCO – sediment cleanup objective
SMS – Washington State Sediment Management Standards

7.4 Data Quality Indicators

DQIs for sediment toxicity tests (Table 7-3) are based on guidelines provided by Ecology (2019). Compliance with these indicators will be confirmed by EcoAnalysts and Windward.

Table 7-3 DQIs for sediment toxicity testing

Toxicity Test	DQI
Acute 10-day amphipod mortality test with *R. abronius, E. estuarius,* and *A. abdita*	• Mean mortality in the negative control is ≤10%. • Mean mortality in reference sediments is ≤ 25% • All organisms in a test must be from the same source. • The mean of the daily test temperature must be within ± 1°C of 15°C (20°C for *A. abdita*) • Test must be conducted under continuous light. • DO, pH, and salinity must be within the acceptable ranges established by the protocol. • Test chambers must be identical and contain the same volume of sediment and overlying water. • The LC50 for a positive control test should be within the mean LC50 ± 2 standard deviations of the control chart.
Acute 48-hr bivalve larvae combined mortality and abnormality test with *M. galloprovincialis*	• Normal survivorship expressed as actual counts is ≥ 0.70 for the control sediment and ≥ 0.65 for the reference sediment. • All organisms in a test must be from the same source. • The mean of the daily test temperature must be within ± 1°C of 16°C (15°C for echinoderm *D. excentricus*). • Test must be conducted under a light cycle of 14 hrs light to 10 hrs dark. • DO, pH, and salinity must be within the acceptable ranges established by the protocol. • Test chambers must be identical and contain the same volume of sediment and overlying water. • The EC50 for a positive control test should be within the mean EC50 ± 2 standard deviations of the control chart.
Chronic 20-day juvenile polychaete survival and growth test with *N. arenaceodentata*	• Mean juvenile polychaete weight must be between 0.5 and 1.0 mg dw at test initiation. • Mean mortality in the negative control must be ≤ 10%. • Mean individual growth rate must be ≥ 0.38 mg/individual/day dw in the control. • Mean individual growth rate in reference sediment divided by mean individual growth rate in negative control must be ≥ 0.80 as AFDW. • All organisms in a test must be from the same source. • The mean of the daily test temperature must be within ± 1°C of 20°C. • Test must be conducted under continuous light. • DO, pH, and salinity must be within the acceptable ranges established by the protocol. • Test chambers must be identical and contain the same volume of sediment and overlying water. • The EC50 for a positive control test should be within the mean EC50 ± 2 standard deviations of the control chart.

AFDW – ash-free dry weight
DO – dissolved oxygen
DQI – data quality indicator
dw – dry weight
EC50 – concentration that causes a non-lethal effect in 50% of an exposed population
LC50 – concentration that is lethal to 50% of an exposed population

7.5 Quality Control Criteria

All three sediment toxicity tests will incorporate standard QA/QC procedures to ensure that the test results are valid. Standard QA/QC procedures include the use of a negative control, a positive control, and reference sediment samples, as well as the measurement of water quality during testing.

The negative control will be a test using a clean, inert material and the same diluent seawater used in testing sediment toxicity. For the amphipod and polychaete tests, the negative control will be native sediment from the organism collection site. For the polychaete test, the negative control will be sand collected from Yaquina Bay (*Eohaustorius* home sediment) or other clean amphipod control sediment. For the bivalve larvae test, the negative control seawater will be ambient seawater from North Hood Canal.

For the positive control, a reference toxicant will be used to establish the relative sensitivity of the test organism. The positive control for sediment tests is typically conducted with diluent seawater and without sediment. Reference toxicants are often used in positive controls. In addition, positive controls using ammonia (water exposure only) will be performed.

Reference sediment will also be included with each toxicity test series. Reference sediments provide toxicity data that can be used to separate toxicant effects from unrelated effects, such as those of sediment grain size. Reference sediments are also used in statistical comparisons to determine whether test sediments are toxic. Sediment samples selected to be test reference sediment should represent the range of important natural, physical, and chemical characteristics of the test sediments, specifically sediment grain size and TOC. Sediments to be used as reference sediment for the three toxicity tests will be collected from Carr Inlet (PSEP 1995).

Toxicity tests require that proper water quality conditions be maintained to ensure that organisms survive and do not experience undue stress unrelated to test sediments. Salinity, dissolved oxygen (DO), pH, ammonia, total sulfides, and temperature will be regularly measured during testing. Temperature, salinity, DO, and pH will be measured daily for all three tests.

Interstitial porewater will be analyzed for ammonia and total sulfides at test initiation and termination for both the amphipod and polychaete tests. Ammonia and total sulfides will be measured in overlying water in all three tests at test initiation and test termination.

DMMP (USACE et al. 2018) protocols will be followed for samples with unacceptable ammonia, sulfides, wood waste, or grain size.

7.6 LABORATORY DATA REPORT

The toxicity testing laboratory, EcoAnalysts, will be responsible for internal checks on sample handling and toxicity test data reporting and will correct errors identified during the QA review. EcoAnalysts will submit its laboratory data packages electronically, including the following as applicable:

- **Project Narrative:** This summary, in the form of a cover letter, will present any problems encountered during any aspect of sample analyses. The summary will include, but not be limited to, summary of test methods, discussion of QC, sample shipment, sample storage, and analytical difficulties. This summary will document any problems encountered by the laboratory and their resolutions, and it will provide definitions of laboratory qualifiers.

- **Records:** The data package will include legible copies of the chain of custody forms. This documentation will include the time of receipt and the condition of each sample received by the laboratory, as well as additional internal tracking of sample custody by the laboratory.
- **Sample Results:** The data package will summarize the toxicity test results and replicate data for each sample analyzed. The summary will include the following information, as applicable:
  - Field sample ID code and the corresponding laboratory ID code
  - Toxicity test and test species
  - Test start and end dates and times
  - Weight of a representative subsample of organisms at the start of sediment exposures
  - Test acceptability requirements and discussion of any deviations from these requirements
- **QA/QC Summaries:** These summaries will contain the results of all QA/QC checks, including the following as applicable:
  - Serial dilutions
  - LCS and reference toxicant tests
  - Any additional QC procedures required by applicable method protocols and laboratory standard operating procedures
- **Original Data:** The data package will include legible copies of the original data generated by the laboratory, including the following:
  - Source of control sediment and associated measurements
  - Water quality monitoring results
  - Measured light intensity during testing
  - Laboratory worksheets

EcoAnalysts will submit data electronically, in a Microsoft™ Excel spreadsheet format to be provided by Windward.

8 Reporting

Sediment data will be submitted to Ecology after the data have been validated. Chemistry and toxicity data will be provided in Environmental Information Management (EIM) format. The chemical and toxicity laboratory reports will be provided electronically on CD-ROM as appendices.

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9 References

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