FINAL

TERMINAL 91 SEDIMENT CLEANUP UNIT FEASIBILITY STUDY WORK PLAN

For submittal to

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ABBREVIATIONS

AO	Agreed Order
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
City	City of Seattle
COC	chemical of concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSL	cleanup screening level
CSM	conceptual site model
CUL	cleanup level
CY	cubic yard
DMM	discarded military munition
DQO	data quality objective
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management
EOD	Explosive Ordinance Disposal
EPA	US Environmental Protection Agency
FSNSD	Former Seattle Navy Supply Depot
FUDS	Formerly Used Defense Site
FS	feasibility study
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
HQ	hazard quotient
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
MC	munitions components
MLLW	mean lower low water
MTCA	Model Toxics Control Act

NSR	net sedimentation rate
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
Port	Port of Seattle
PQL	practical quantification limit
QAPP	quality assurance project plan
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
ROV	remotely operated vehicle
SAP	sampling and analysis plan
SCO	sediment cleanup objective
SCU	Sediment Cleanup Unit
SCUM	Sediment Cleanup User's Manual
SMA	sediment management area
SMS	Washington State Sediment Management Standards
T-91	Terminal 91
TCRA	Time Critical Removal Action
TEQ	toxic equivalent
TOC	total organic carbon
USACE	US Army Corps of Engineers
WAC	Washington Administrative Code

1 Introduction

This work plan presents the approach for the feasibility study (FS) for the Terminal 91 (T-91) Sediment Cleanup Unit (SCU). T-91 is an approximately 210-acre site, owned by the Port of Seattle (Port), that is 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 an SCU that includes about 85 acres of submerged lands around the piers (Map 1-1). The site has hosted a variety of land uses and has played an important role in the City of Seattle's (City's) development since around the turn of the 20th century. The T-91 SCU is the marine water-covered area of the "Terminal 91 Complex" and has been designated as such by the Washington State Department of Ecology (Ecology). Areas of the SCU are owned by either the Port or by Washington State under a Port management agreement with the Department of Natural Resources.

The primary objectives of this FS work plan are to summarize existing information from the remedial investigation (RI) (Windward 2023) regarding the T-91 SCU, present a conceptual site model (CSM), identify FS data gaps, and present a sampling and analysis plan/quality assurance project plan (SAP/QAPP) to fill those data gaps. This FS work plan has been developed in compliance with the requirements of Agreed Order (AO) No. DE 24768 and the *Sediment Cleanup User's Manual – Guidance for Implementing the Cleanup Provisions of the Sediment Management Standards, Chapter 173-204 WAC* (SCUM) (Ecology 2021).

1.1 Site Regulatory Background

T-91 is regulated under both a dangerous waste management permit and two Model Toxics Control Act (MTCA) AOs. The dangerous waste management permit is issued by Ecology and establishes corrective action requirements pursuant to the federal Resource Conservation and Recovery Act (RCRA). RCRA requires corrective action to address releases at permitted hazardous waste treatment, storage, and disposal facilities. Required corrective actions for T-91 are due solely to the former presence of a tenant-operated dangerous waste treatment and storage facility on a 4-acre parcel within T-91 (known as the Tank Farm Lease Parcel). That former facility's regulatory status subjects all contiguous Port-owned properties, including T-91, to corrective action requirements.

Ecology's RCRA corrective action program relies on the Model Toxics Control Act regulations (Chapter 173-340 WAC) to implement corrective action requirements at RCRA facilities. These are the requirements under WAC 173-303-64630 - Use of the Model Toxics Control Act:

1. The department may require the owner/operator of a facility to fulfill his corrective action responsibilities under WAC 173-303-64620 using an enforceable action issued pursuant to the Model Toxics Control Act, as amended, (chapter 70.105D RCW) and its implementing regulations.

2. Corrective action requirements imposed by the department in an action issued pursuant to the Model Toxics Control Act will be in compliance with the requirements of WAC 173-303-64620 and the requirements of chapter 173-303 WAC to the extent required by RCW 70.105D.030(2)(d) and WAC 173-340-710.

3. In the case of facilities seeking or required to have a permit under the provisions of this chapter the department will incorporate corrective action requirements imposed pursuant to the Model Toxics Control Act into permits at the time of permit issuance. Such incorporation will in no way affect the timing or scope of review of the Model Toxics Control Act action.

Under a series of AOs, Ecology and the Port have conducted site investigations and cleanups since 1998, when Ecology took over RCRA corrective action oversight responsibilities for T-91 from the US Environmental Protection Agency (EPA). The upland portion of the site was characterized and remediated under three AOs in 1998 (Ecology 1998), 2010 (Ecology 2010), and 2012 (Ecology 2012); these AOs are summarized in Section 2.3 of the RI (Windward 2023). Specific to the T-91 SCU, Ecology and the Port also executed an AO in 2020 (Ecology 2020), which included the RI, and an amendment to the 2020 AO in 2023 (Ecology 2023a), which included the FS. These two most recent AOs, the amendment to the 2020 AO, and the AOs' requirements are summarized below.

- **2020 AO (Ecology 2020).** In 2020, Ecology and the Port entered into a new AO, under which the Port agreed to conduct an RI for the T-91 SCU. The AO required the Port to complete three tasks:
  - Task 1: RI work plan
  - Task 2: RI
  - Task 3: interim action (if necessary)

The RI work plan was developed and approved by Ecology in 2021 (Windward 2021). The revised draft RI was submitted for Ecology review in December 2023 (Windward 2023). The draft RI will be submitted for public comment along with the draft FS; the two documents will be finalized together.

- **2023 AO Amendment (Ecology 2023a).** In 2023, Ecology and the Port signed an amendment to the 2020 AO (First Amendment), under which the Port agreed to conduct an FS for the T-91 SCU. The First Amendment required the Port to complete six additional tasks:
  - Task 4: FS work plan
  - Task 5: T-91 field investigation data report
  - Task 6: FS
  - Task 7: State Environmental Policy Act compliance
  - Task 8: Public participation
  - Task 9: Preliminary draft cleanup action plan

The two AOs remaining in effect are the 2012 AO (Ecology 2012), which addresses the tank farm affected area and upland area, and the 2020 AO (Ecology 2020), which addresses sediment in the T-91 SCU. This FS work plan is the first deliverable required under Task 4 of the First Amendment to the 2020 AO (Ecology 2023a).

1.2 Site Description and Background

The T-91 SCU is composed of three berth areas: the western berth area to the west of Pier 91, the central berth area between Piers 90 and 91, and the eastern berth area to the east of Pier 90 (Map 1-1). As defined in the 2020 AO (Ecology 2020), the site is a total of 85 acres, 70 acres (82%) of which is subtidal sediment. There are a total of 16 acres of intertidal area (18% of site) in the western portion of the western berth area and the eastern portion of the eastern berth area. Piers 90 and 91 are earthen berms constructed in 1913 and 1919, respectively. These berms function as solid barriers between the berth areas and prevent the transport of water and sediment laterally between adjacent berth areas.

1.2.1 Historical and Current Site Operations

1.2.1.1 Historical Site Operations

The Port owned T-91 from 1913 to 1942, although the extent of the Port-owned property during this period was only a portion of the present-day T-91. Pier 90 was constructed in 1913 and Pier 91 was constructed in 1919; they were designated as Piers 40 and 41, respectively, and were the largest earth-filled commercial piers in the world at that time. Piers 90 and 91 were originally used for loading and unloading materials such as lumber, steel, and coal and for storing vegetable oil (Pinnacle 2006).

The US Navy owned T-91 from 1942 to 1976, making the site a Formerly Used Defense Site (FUDS). During that time, the US Navy enlarged T-91 to encompass all of the property it includes today. During World War II and into the early 1950s, the US Navy conducted extensive operations at T-91, using it as an active naval station (USACE 2013) to conduct extensive naval craft mooring, repair, and deactivation activities that included hull maintenance; sandblasting and painting; and electrical, plumbing, and mechanical repairs (Bureau of Ships 1947, 1950a, b; Clay 1971). The piers were not used as an ammunition resupply facility, but munitions were discarded overboard on occasion during US Navy ownership.

The US Navy transferred ownership of T-91 to the Port in approximately 1976 (Roth Consulting 2007).

1.2.1.2 Current Site Operations

Operations conducted by recent Port tenants at T-91 have included cold storage; maritime services, such as those required for offloading fishing vessels (Pinnacle 2006); and cruise provisioning and

passenger movement. In 2009, the Port began using Pier 91 as a passenger cruise ship terminal for cruises to Alaska, making the pier an important economic feature of Seattle and adding more than $400 million to the local economy (USACE 2013).

1.2.2 History of Dredging Operations

There have been relatively few dredging operations documented within T-91 berths. No documented maintenance dredging events have been conducted, which is consistent with the relatively low sedimentation rates in this area.

Focused dredging has been conducted in the areas where greater depths were required for navigation purposes. There have been two dredging events: the 1992 event in the western berth area, with a dredge volume of 10,000 cubic yards (CY); and the 2007 event in the cruise ship berthing areas,[1] with a dredge volume of 11,500 CY.

In 2016, material along the eastern face of Pier 91 was affecting cruise ship access to the berthing area at low tides. Dredging was not possible due to the potential presence of discarded military munitions (DMMs), which prevented transport of the dredged material to a landfill. Therefore, sediment regrading—the transfer of sediment from one location to another while keeping the sediment underwater—was conducted in the central berth area.

The Port is conducting a redevelopment project at Berths 6 and 8 on the northeastern portion of Pier 90. This project will include replacing the creosote-treated timber pier and apron and the existing slope armoring, as well as removing 25,000 CY of slope armoring and sediment and placing 10,600 CY of slope armoring material. The project will begin in 2024 and be completed in 2026.

1.3 Document Organization

This FS work plan is organized as follows:

- **Section 2 – CSM**: Provides an updated CSM based on the results of the RI, including nature and extent of contamination, sediment characteristics and transport, source control, and exposure pathways and receptors
- **Section 3 – Cleanup Action Goals and Cleanup Level Considerations**: Summarizes the applicable regulations and guidance that may impact the selection and implementation of remedial actions within the T-91 SCU, and presents the project-specific numeric objectives developed for reducing risks to human health and the environment that will be used to evaluate remedial alternatives

[1] Dredging was conducted in the cruise ship berthing areas to provide sufficient navigation depth (-35 ft mean lower low water [MLLW]).

- **Section 4 – Data Gaps Assessment and Investigation Approach**: Discusses the approach for evaluating data gaps and presents the recommended sampling approach to fill those data gaps
- **Section 5 – FS Activities**: Presents the approach to conduct the FS tasks, including managing the FS field investigation and writing the related data report and FS
- **Section 6 – Schedule**: Discusses the project schedule, anticipated sequencing of tasks, and major deliverables
- **Section 7 – References**: Lists the references cited in this document

The following appendices are attached:

- Appendix A – Data Management Plan
- Appendix B – Sampling and Analysis Plan/Quality Assurance Project Plan
- Appendix C – Health and Safety Plan

2 Conceptual Site Model

The preliminary CSM provided in this RI work plan has been updated with the results presented in the RI (Windward 2023).

2.1 Nature and Extent of Contamination

The nature and extent of sediment contamination at the T-91 SCU was characterized through data summaries, spatial evaluations, and comparison to Washington State Sediment Management Standards (SMS). Sediment characterization results are provided in Section 4, including maps illustrating the spatial distributions of contamination in surface and subsurface sediment.

2.1.1 Surface Sediment Quality

The greatest numbers of SMS exceedances in surface sediment were associated with polycyclic aromatic hydrocarbons (PAHs), total polychlorinated biphenyl (PCBs) (sum of Aroclors), mercury, and 1,4-dichlorobenzene. SMS exceedances most frequently occurred in the central berth area; of the 32 surface sediment sampling locations within the central berth area, 28 (88%) had at least one chemical with an SMS exceedance. In the eastern and western berth areas, fewer SMS exceedances were reported, and most of the exceedances were located along the western pier face of Pier 91 and the eastern pier face of Pier 90.

Among the T-91 SCU surface sediment sampling locations, those in the central berth area had the greatest concentrations of PCBs (sum of congeners and sum of Aroclors), PCB toxic equivalents (TEQs), dioxin/furan TEQs, total TEQs, carcinogenic polycyclic aromatic hydrocarbon (cPAH) TEQs, and mercury. In the eastern and western berth areas, concentrations at intertidal sampling locations were less than those at subtidal locations. Dioxin/furan TEQs, total TEQs, and mercury concentrations at the intertidal sampling locations were less than Ecology's natural background concentrations.

2.1.2 Subsurface Sediment Quality

With respect to subsurface sediment within T-91, out of a total of 41 cores, 35 had detected concentrations above their respective chemical sediment cleanup objectives (SCOs), and 25 had detected concentrations above their respective cleanup screening levels (CSLs) in at least one subsurface interval. In general, sediment intervals with concentrations exceeding the SMS had multiple exceedances. The core intervals with detected concentrations exceeding the SMS were generally within the top 4 ft.

2.1.3 *Summary of Former Seattle Naval Supply Depot FUDS Feasibility Study*

During World War II, the US Navy acquired Piers 90 and 91 through condemnation and used them as a naval terminal and for fuel and material storage (USACE 2016). The piers were not used as an ammunition resupply facility, but munitions were discarded overboard on occasion during US Navy ownership. In 1967, the Port and the US National Guard each acquired portions of the site. At present, the Port operates the FUDS as the Smith Cove Cruise Terminal from April through September (i.e., cruise ship season), and as a venue for trade shows and performances the rest of the year. T-91 is also used year-round by commercial fishing fleets, cargo ships, and tug moorage.

In April 2010, Port divers encountered DMMs around Piers 90 and 91 during routine underwater inspections; this discovery led to a US Army and Navy Explosive Ordinance Disposal (EOD). Seven additional EODs were necessary through September of 2010 (USACE 2013). All DMMs encountered were removed by divers. The United States Army Corps of Engineers (USACE) began an RI in September 2010, with the objectives of characterizing the nature and extent of DMMs at the site, and of assessing the risk posed by DMMs and munitions components (MCs) to personnel at the site. The first field season of the RI included surveys conducted using acoustic technology, remotely operated vehicles (ROVs), and an unexploded ordinance dive team.

In December 2010, USACE published an Action Memorandum calling for a Time Critical Removal Action (TCRA) to reduce the hazards posed to individuals, property, and the environment by identifying and removing additional DMMs (USACE 2012). The TCRA was conducted in the first field season of the RI, from January to March 2011. The site was divided into two munitions response sites: the Former Seattle Navy Supply Depot (FSNSD) site, which encompassed a 25.2-acre area where DMMs had previously been found, and the FSNSDa site, which comprised the remaining 61.5 acres of the T-91 SCU (USACE 2013). Both munitions response areas are shown on Map 2-1. Sonar, ROV, and diver surveys were conducted at both sites to identify and remove DMMs. Surface and subsurface DMMs and MCs ranging from 0.75 to 5.00 inches. in length were identified using digital geophysical mapping, ROV surveys, and acoustic surveys and were removed by divers (USACE 2012). In total, 11 DMMs, 212 MCs, and 1 material potentially presenting an explosive hazard were located in the southern half of the central berth and around the south end of Pier 91; all items were identified, classified, and removed from the 25.2 acre area where DMMs had been found (FSNSD). No DMMs were found outside of this area. The TCRA concluded in March 2011 before the start of the 2011 cruise season.

The second field season of the RI began in January 2012; the objectives were to determine the amount of munitions and explosives of concern remaining at the site, characterize MC sediment contamination, conduct human health and ecological risk screening, and determine if further action

was required under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (USACE 2013). During this effort, 13 DMMs were located in the same general areas as those found previously and were removed. Most were on the sediment surface, and two were buried in the sediment at a depth of 10 inches. Twelve sediment samples were collected and analyzed for explosive energetics and munitions-related propellant stabilizers. The samples showed low concentrations of the munitions related chemicals of concern (COCs) within the FSNSD. Human health and ecological risk screenings performed as part of the draft FUDS FS determined that the site posed no risk of adverse effects on human or ecological receptors, based on the USACE exposure assumptions. The final RI was issued in 2013 and recommended a focused FS for the FSNSD (USACE 2013).

The draft FS (USACE 2016) presented four alternatives to reduce or minimize hazards to human health posed by DMMs remaining at the site:

- No action
- Administrative controls
- Dredging the FSNSD to as deep as -40 ft MLLW
- Dredging the FSNSD to as deep as -50 ft MLLW

The first alternative would have no cost and is required for consideration under CERCLA. The second alternative would involve the implementation of administrative controls to protect the health of personnel participating in potential future dredging, sediment sampling, or diving efforts. Administrative controls could include deeds, restrictive covenants, or restrictions on bringing dredged material to the surface prior to screening. The cost of the second alternative was estimated to be $660,000 (USACE 2016).

The third and fourth alternatives differ in the volume of sediment removed and the estimated level of effort: Dredging to -40 ft MLLW would remove approximately 16,000 CY of material, and dredging to -50 ft MLLW would remove approximately 53,200 CY of material (USACE 2016). Both alternatives would require additional engineering services to design dredge areas, perform stability analyses on the piers, design sediment treatment facilities, and perform post-dredging characterization. These alternatives would also require thermal treatment or dewatering of dredged material prior to disposal. The costs of the third and fourth dredging alternatives were estimated to be $3.7 to $4.9 million and $9.7 to $13.5 million, respectively, depending on the dredged material disposal method. The draft FS (PES et al. 2009)evaluated each alternative based on the following criteria:

- Protection of human health and environment
- Compliance with applicable or relevant and appropriate requirements
- Long-term effectiveness

- Short-term effectiveness
- Implementability
- Cost
- Reduction of toxicity, mobility, or volume of DMM

The draft FUDS FS did not recommend a preferred remedial alternative, and USACE did not prepare a final FS.

Since completion of the draft FUDS FS in 2016, Port police divers have found approximately 12 DMMs during routine dive surveys conducted for vessel inspections. The locations of the DMMs were not recorded, but all were found within the FSNSD area characterized in the FUDS FS. The most recent discovery was in April 2024.

2.2 Sediment Characteristics and Sediment Transport

2.2.1 Sediment Characteristics

Subsurface sediment intervals were categorized with upper and lower stratigraphic units, based primarily on density, color, sediment type, and texture, as part of the RI field investigation. T-91 sediment typically includes softer, finer sediments (i.e., sandy silt) overlying coarser sediments (i.e., sand). Several areas where sediment cores were collected experience frequent vessel activity (i.e., propeller wash). Historical dredging and regrading operations in these areas have also altered the depths at which the stratigraphic units appear.

2.2.2 Sediment Transport within T-91

The T-91 site is located at the north end of Elliott Bay and is subject to tidal exchange. Suspended sediments can be transported into or out of the T-91 site with tidal currents, although the spatial extent and degree of any such transport are not well documented. Overall, some exchange of sediments may occur between the T-91 site and Elliott Bay with tidal movement. The vast majority of sediment entering Elliott Bay does so from the Green River/Lower Duwamish Waterway at the south end of the bay (Port of Seattle et al. 2019). The T-91 site differs from locations on the southern shoreline, as the T-91 site is not influenced by river discharge.

Resuspension from vessel propeller wash may move sediments within, into, or out of the T-91 site. The CSM in the RI work plan (Windward 2021) identified propeller wash as the primary mechanism of sediment erosion and mixing near T-91 berths. Propeller wash has the potential to disturb sediments, because propellers generate large velocities under the water during vessel operations. Seabed scour (i.e., erosion) is the result of the large horizontal and vertical velocities caused by propellers. An evaluation of potential scour depths associated with the vessels currently operating at T-91 was

conducted, and the maximum propeller scour depth calculated for berthing for the largest cruise ships was 9 ft. The maximum scour depth calculated for tug operations was less than or equal to 3.5 ft, and fishing vessel operations were calculated to be associated with a maximum scour depth of 1 ft or less.

Excessive mixing or sediment movement can interfere with natural sediment deposition patterns, resulting in episodic and transient erosion and deposition or resuspended sediments, depending on vessel movements. Sediment deposition within the T-91 site is expected to be low due to the absence of large sediment contributions from nearby outside the site. Some small sediment contributions result from the outfalls at the north ends of the western and eastern berth areas, where localized deposition is expected to occur. It is difficult to measure deposition rates in the T-91 site with traditional techniques, such as geochronological cores, as mixing from propeller wash can cause complex radioisotope profiles that cannot be used to calculate average long-term sedimentation rates. One geochronological core was collected in 2018 as part of the T-91 Submerged Lands Preliminary Investigation (Windward 2018a). The sediment profiles for both cesium-137 and lead-210 radioisotopes were evaluated for the core, which was collected near the northeast corner of the T-91 site. Cesium-137 and lead-210 are commonly used to age-date sediments and establish sedimentation rates; however, the results indicated some uncertainty, as neither radioisotope was detected consistently throughout the core intervals. A net sedimentation rate (NSR) could not be estimated for lead-210 due to low correlation, but an NSR of 1.3 cm/year was calculated based on cesium-137 (Windward 2018). However, extrapolating NSRs from data measured at a single geochronological core location to represent the entire area is associated with uncertainty, as NSRs at T-91 are influenced by vessel operations (e.g., resuspension and redistribution of T-91 bed sediments by propeller wash).

2.3 Source Control

Understanding historical sources of contamination and identifying and controlling potential ongoing sources are important components of the overall cleanup effort. Potential sources of contamination evaluated include lateral inputs, spills and leaks, and releases from upland sites.

Throughout the history of operations at T-91, stormwater discharges, combined sewer overflow discharges, and discharges from other outfalls have been potential pathways for contaminants to sediment. Two outfalls are considered the primary sources of ongoing stormwater discharge: Outfall A and Outfall 68 (Map 1-1). Both of these outfalls include areas outside of the T-91 upland site in their drainage basins. Other active outfalls, deck drains, and discharge points also have the potential for lateral inputs of contaminants to sediment.

Surface and subsurface sediment concentrations indicate some potential for ongoing contributions of contaminants common to urban discharge from Outfall A and Outfall 68. Surface and subsurface sediment samples collected in the vicinity of Outfall A have shown elevated concentrations of PAHs and butyl benzyl phthalate, which are contaminants commonly associated with stormwater discharges. Surface and subsurface sediment samples collected in the vicinity of Outfall 68 have had concentrations of total PCBs, PAHs, phthalates (bis[2-ethylhexyl] phthalate and butyl benzyl phthalate), and mercury exceeding SMS. Additional evaluation of the potential for sediment recontamination near Outfall A and Outfall 68 will be conducted as part of the FS.

2.4 Risk Evaluation

The risk evaluation presented in the T-91 RI is summarized herein. As described in SCUM guidance (Ecology 2021), there are two options to address risks to human health and higher-trophic-level ecological receptor health. Based on the criteria described in Chapter 9 of SCUM, T-91 meets the requirements for Option 1: using only sediment data to address and evaluate risks, instead of conducting in-depth ecological and human health risk assessments. This health-protective approach recognizes that for the key bioaccumulative chemicals likely to drive cleanup (e.g., dioxin/furans, PCBs), human health risk-based sediment cleanup standards are expected to be less than Ecology's background concentrations and/or practical quantification limits (PQLs).

Potential receptors and exposure pathways for T-91 include:

- **Human health** – Humans may be exposed to sediment contaminants through both the consumption of contaminated seafood and direct contact with contaminated sediment.
- **Ecological receptors** – Ecological receptors include benthic invertebrates that ingest sediment, those that are filter feeders, and those that are deposit feeders. Benthic invertebrate exposure pathways include direct contact with contaminated sediment and consumption of contaminated prey. Higher-trophic-level species (e.g., benthic fish) exposure pathways include contact with contaminated sediment, accidental ingestion of contaminated sediment, and consumption of contaminated prey.

COCs were identified as any chemical with a concentration greater than its respective SCO. COCs identified for the protection of human health and benthic invertebrates include:

- **Human health COCs:**
  - *Net fishing (SCU-wide exposure)* – cPAH TEQ
  - *Seafood consumption (SCU-wide exposure)* – lead, mercury, silver, zinc, cPAH TEQ, dioxin/furan TEQ, dioxin-like PCB TEQ, and total TEQ
  - *Beach play or clam digging (intertidal exposure)* – none

- **Benthic COCs (point-by-point) (in order of decreasing number of exceedances):** PAHs (16 individual PAHs, total high-molecular-weight polycyclic aromatic hydrocarbons [HPAHs], and total low-molecular-weight polycyclic aromatic hydrocarbons [LPAHs]), total PCBs (Aroclors), mercury, 1,4dichlorobenzene, 2,4-dimethylphenol, bis(2-ethylhexyl)phthalate, zinc, arsenic, butyl benzyl phthalate, lead, and copper

3 Cleanup Action Goals and Cleanup Level Considerations

This section presents cleanup action goals and a summary of cleanup level considerations for the COCs identified in Section 2.4.

3.1 Cleanup Action Goals

Cleanup action goals describe the goals expected to be achieved by the cleanup beyond compliance with SMS (Ecology 2021). Cleanup action goals are used to help focus development and evaluation of remedial alternatives. Cleanup action goals will be finalized in the FS.

The results of the streamlined risk evaluation discussed in the RI (Windward 2023) indicate that remedial action is warranted to reduce unacceptable human health and ecological risks posed by COCs at the T-91 SCU. Unacceptable risks were determined to exist for certain human health exposure scenarios (e.g., seafood consumption and direct contact exposure associated with net fishing) and for certain ecological receptors (e.g., benthic organisms). The cleanup is expected to address unacceptable human health and ecological risks posed by COCs. Washington Administrative Code (WAC) 173-340-351(6) also requires that FS goals include land use plans for the site. The T-91 SCU will continue to be used for commercial shipping purposes, including cruise ship berthing. The intertidal area within the SCU is accessible for clamming, and the SCU is within the usual and accustomed area for tribal net fishing.

3.2 Cleanup Level Approach

This section discusses the approach to developing cleanup levels (CULs) that will be presented in the FS. The approach will consider all applicable regulatory requirements for the cleanup action, including SMS, MTCA, and other potentially applicable regulations. This section presents information relevant to CUL development for the COC list defined in Section 2.1.1, including natural and regional background concentrations, risk-based concentrations, and PQLs under SMS rule.

3.2.1 Cleanup Level Development

Sediment CULs are developed separately for different exposure areas and points of compliance. As described in SCUM (Ecology 2021), sediment CULs (i.e., both the SCO and CSL) for chemicals are defined as follows.

- The SCO is the *highest* of the following values for a given chemical:
  - Natural background value
  - PQL

  - Lowest risk-based value (e.g., 10^{-6} risk level for individual carcinogens or hazard quotient [HQ] of 1 for non-carcinogens)[2]

- The CSL is the *highest* of the following values for a given chemical:
  - Regional background value
  - PQL
  - Lowest risk-based value (e.g., 10^{-5} risk level for individual carcinogens or HQ of 1 for non-carcinogens)[3]

Natural background values and PQLs are provided in SCUM (Ecology 2021). Ecology has not yet developed regional background values for Elliott Bay. If such values are developed during the development of the FS, then they will be included in the FS evaluation.

3.2.2 Cleanup Levels for Human Health Scenarios

This section summarizes the COCs identified in the RI for the human health exposure scenarios (Windward 2023), for which the development of CULs will be necessary. These exposure scenarios include the following:

- Seafood consumption (SCU-wide exposure)
- Net fishing (SCU-wide exposure)
- Beach play and clam digging (intertidal exposure)

Table 3-3 presents the COCs identified for each of these exposure scenarios.

Table 3-3
Summary of Human Health COCs

Human Health Scenario	Exposure Area and Point of Compliance	COCs	Key Considerations
Seafood consumption	SCU-wide, surface sediment (0–10 cm)	lead, mercury, silver, zinc, cPAH TEQ, dioxin/furan TEQ, PCB TEQ[1], and total TEQ	Highest concentrations to be addressed by CULs for benthic community for many of these COCs (e.g., lead, mercury, silver, zinc, and PCBs) Refinement of SCU boundary

[2] As described in Section 2.4, a streamlined approach was used to evaluate risks for the T-91 site, consistent with the Option 1 approach described in Chapter 9 of SCUM. This health-protective approach recognizes that for human health seafood consumption scenarios, risk-based sediment cleanup standards for key bioaccumulative chemicals (e.g., PCBs) are expected to be less than Ecology's background concentrations and/or PQLs. Thus, risk-based values were not developed for seafood consumption pathways.

[3] As noted, risk-based values are not applicable for the seafood consumption pathway.

Human Health Scenario	Exposure Area and Point of Compliance	COCs	Key Considerations
Net fishing	SCU-wide, surface sediment (0–10 cm)	cPAH TEQ	Refinement of surface sediment interpolation for cPAHs Development of regional background
Beach play and clam digging	Intertidal areas, subsurface sediment (0–45 cm)	none	Not applicable (no COCs)

Notes:
1. The CUL for PCB TEQ will require the analysis of PCB congeners in post-remediation monitoring samples to establish that the CUL has been met.
cPAH: carcinogenic polycyclic aromatic hydrocarbon
COC: chemical of concern
cPAH: carcinogenic polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
SCU: sediment cleanup unit
TEQ: toxic equivalent

As noted, CULs for each COC will be developed as part of the FS. This information will be important for the delineation of remedial areas. Key considerations will include:

- Refinement of surface sediment interpolations (particularly for cPAHs)
- Refinement of the SCU boundary
- Consideration of overlap with the development of CULs for benthic COCs
- Spatial evaluation using a range of action levels to estimate post-remediation spatially weighted average concentrations
- Ecology's development of Elliott Bay regional background numbers. If these numbers are developed during the development of the FS, they will be used to evaluate remedial alternatives

3.2.3 Cleanup Levels for Protection of the Benthic Community

As described, the RI (Windward 2023) identified surface sediment with concentrations of arsenic, copper, lead, mercury, zinc, individual PAHs, total HPAHs, total LPAHs, bis[2-ethylhexyl] phthalate, butyl benzyl phthalate, 1,4-dichlorobenzene, 2,4-dimethylphenol, and total PCBs (Aroclors) that exceeded SMS benthic criteria at one or more locations. The FS will establish CULs for all chemicals with concentrations exceeding the benthic SCO.

4 Data Gaps Assessment and Investigation Approach

The purpose of this section is to summarize existing data gaps to support the identification and development of remedial alternatives in the FS. This data gaps assessment considers what is known about the T-91 SCU from previous investigations, the information needed to develop remedial alternatives in the FS, and specific investigation activities that can be used to fill data gaps. Details regarding these investigations are provided in the SAP/QAPP (Appendix B).

Based on the information presented in the RI (Windward 2023), four data quality objectives (DQOs) have been identified for the FS. These DQOs, which are listed below, are discussed further in the SAP/QAPP.

- DQO 1 – Refine surface sediment characterization (primarily for cPAHs) to inform remedial design
- DQO 2 – Refine site boundary of the SCU (primarily for mercury)
- DQO 3 – Characterize berth areas and under-pier slopes for stability
- DQO 4 – Characterize recontamination potential in areas where recontamination may occur (e.g., under-pier sediment in areas where sloughing may occur).

The FS investigations will be conducted using a phased approach. Phase I will include surface sediment sampling to address DQOs 1 and 2, as well as a survey investigation comprising three components (i.e., bathymetric survey, video survey, and diver surveys) to address DQO 3. If needed, a Phase II investigation, which would include the evaluation of subsurface sediment, will be conducted to address DQO 4. The components of these investigations are discussed further in the following subsections.

4.1 Surface Sediment Investigation

The collection of surface sediment samples is planned to address DQOs 1 and 2. For DQO 1, nine surface sediment samples will be collected at specific locations throughout the site to improve data coverage, primarily for cPAHs. For DQO 2, another nine surface sediment samples will be collected from different locations to further refine the southern site cleanup boundary. Three of the DQO 2 samples will be archived for potential mercury analysis, pending results from the other nearby samples. All of these data will be used in the FS to establish the final SCU boundary.

4.2 Survey Investigation

During Phase I of the FS field investigations, three surveys will be conducted to address DQO 3. The bathymetry survey, video survey, and diver survey will provide valuable information regarding under-pier slope stability and the potential for sediment sloughing from the under-pier areas to the pier face.

4.2.1 Bathymetry

A bathymetry survey of the T-91 SCU was last conducted in 2018. An updated multibeam bathymetric survey is needed to inform the understanding of current water depths in berthing areas and under-pier slope areas, as well as any changes caused by sediment shoaling or vessel propeller wash since the 2018 survey. A comparison between the new survey and the 2018 survey will be used to determine where vessel propeller wash has caused erosion and/or where sediment has been redistributed to create higher elevation areas. This comparison will inform design cleanup alternatives that consider the requirements for vessel operations and access.

4.2.2 Video Survey

Following the bathymetric survey, an underwater video survey of the T-91 SCU will be needed to evaluate under-pier conditions. A remote operated underwater vehicle will be used to assess the lateral extent of sediment and exposed rock, search for any visual evidence of debris or DMMs, and verify the presence of pilings as depicted on available drawings. The video survey will be conducted after the bathymetric survey so that any new areas of erosion or accumulation identified in the bathymetry survey can be further investigated.

4.2.3 Diver Surveys

Following the completion of the bathymetry and video surveys, the resultant data will be evaluated to refine the proposed diver survey transect locations, which are planned to characterize sediment thickness on top of the armoring on under-pier slopes. Divers will utilize one of two methods to measure sediment thickness in areas with substantial amounts of sediment on under-pier slopes: In areas without DMM concerns, jet probing will be conducted; in areas with DMM concerns, visual survey methods will be utilized for health and safety reasons.

4.3 Subsurface Sediment Investigation

The need to collect subsurface sediment samples will be determined based on the results of the surveys conducted as part of the Phase I FS field program. If subsurface sediment is determined to be needed, sampling locations will be identified to address DQO 4 after reviewing the results of the surveys discussed in Section 4.2.

Subsurface sediment samples would be collected to provide additional information on the chemical and physical conditions of sediments that may slough downslope into the berth area in the event of dredging. These samples would also provide further information on geotechnical conditions to support the development of volume and timing estimates for any anticipated sloughing associated with a dredge event. Potential supplemental subsurface sediment cores would be collected in under-pier areas and along pier faces in areas with known sediment deposits. If subsurface sediment sampling is conducted in Phase II, details regarding the sampling will be provided in an addendum to the SAP/QAPP.

5 Feasibility Study Activities

The First Amendment to the 2020 AO (Ecology 2023a) lists six major tasks. The first is being addressed through the preparation of this FS work plan. The second will involve preparing the FS field investigation data report following the investigations proposed in this work plan. Upon completion of the FS field investigation data report, the FS will be prepared. The purpose of the FS will be to develop and evaluate cleanup action alternatives for use at the T-91 SCU. The FS will develop cleanup action goals, establish CULs, and fill any data gaps necessary to develop and evaluate cleanup action alternatives. FS requirements are listed in SMS (WAC 173-204-550) and SCUM (Ecology 2021). This section summarizes the additional FS field investigations and reporting required to develop the FS and defines the contents of the FS.

5.1 Feasibility Study Field Investigations

FS field investigations will be conducted in two phases. Phase I will consist of surface sediment sampling (Section 4.1) and survey investigations (Section 4.2). Phase I field investigations are described in the SAP/QAPP (Appendix B).

The need for Phase II of the field investigation will depend on the Phase I results. If needed, Phase II will include the collection of subsurface sediment cores in under-pier and pier face areas where sediment is sufficiently thick (Section 4.3). Details of this investigation will be presented in an addendum to the SAP/QAPP.

5.2 Feasibility Study Field Investigation Data Report

The FS field investigation data report will be prepared using information from the FS field investigation and sampling activities. This report will include the results of all phases of FS field investigations conducted (described in Section 5.1). Validated analytical results will also be submitted in electronic format through Ecology's EIM) System, in accordance with WAC 173-340-840(5) and Ecology's Toxics Cleanup Program Policy 840: Data Submittal Requirements. The final FS data report will address any Ecology comments provided on the draft document.

5.3 Feasibility Study

The FS will include the contents described in the following sections.

5.3.1 Introduction and Objectives of the FS

The first section of the FS will include an introduction and describe the objectives of the document. Reference will be made to previous work completed at the T-91 SCU. Additional work completed to support the FS will also be described.

5.3.1.1 RI Summary

This section will provide a summary of the RI (Windward 2023), including site background, nature and extent of contamination, sediment characteristics and transport, source control, and risk evaluation.

5.3.1.2 FS Field Investigation Data Report Summary

This section will provide a summary of additional data gathered during the FS field investigation.

5.3.2 Cleanup Requirements

This section will identify all applicable regulatory requirements for the cleanup action, including SMS, MTCA, and other potentially applicable regulations. It will also discuss the development of cleanup standards and the cleanup footprint for the T-91 SCU, including cleanup action goals and planned land uses; a summary of exposure pathways, screening levels, and COCs; selection of cleanups standards for COCs; and identification of the cleanup footprint and action levels for remediation. Action levels are contaminant-specific, point-based sediment concentrations that trigger the need for remediation. They may be equivalent to or higher than the CUL (e.g., point-based concentration designed to achieve area average-based cleanup levels).

5.3.3 Sediment Management Areas

The T-91 SCU can be further divided into sediment management areas (SMAs) that have different current and past uses, contributions to site risk, and chemical and physical conditions. The division of the site into individual SMAs will be presented in this section, per the SMS. SMAs are expected to be based on unique physical characteristics, site use considerations, natural resources, and contaminant distributions.

5.3.4 Screening of Remedial Technologies

This section will present the screening evaluation of remedial technologies for cleanup of the T-91 SMAs. The remedial technologies will be screened for both general applicability and applicability to each SMA. This screening will form the basis for the remedial alternatives. Remedial technologies anticipated to be evaluated include dredging and upland disposal, natural recovery, enhanced natural recovery, in situ treatment, and capping of contaminated sediments. The evaluation of SMAs within the DMM area will address the transport and disposal of sediment that may contain DMMs.

5.3.5 Description of Remedial Alternatives

This section will combine the retained remedial technologies for each SMA into SCU-wide remedial alternatives. The remedial alternatives will be developed to capture the range of potential remedial actions, which will use a range of remedial action levels; these remedial action levels will consider the

different cleanup footprints and concentrations to which the site may equilibrate in the long term. Each remedial alternative will be intended to achieve both significant risk reduction and cleanup standards, either immediately following construction or within a targeted timeframe following construction. Detailed cost estimates will be prepared for each alternative evaluated.

5.3.6 Detailed Evaluation of Alternatives

Remedy selection criteria under SMS regulations are the same as those required under MTCA, with the exception of SMS evaluation criteria specified in WAC 173-204-570. SMS evaluation criteria are specified in WAC 173-204-570. This section will describe the requirements for cleanup action evaluations under SMS, including how alternatives meet minimum requirements and comply with cleanup standards. This section will also present the disproportionate cost analysis.

5.3.7 Preferred Alternative

This section will describe the preferred remedial alternative, the basis for that alternative's identification, and additional considerations for the implementation of site cleanup.

6 Schedule

The schedule for the FS was established in the AO (Ecology 2020). The AO schedule, which is contingent upon the completion of earlier milestones, is provided in Table 6-1. The projected dates for the finalization of the FS work plan and the commencement of fieldwork are based on an assumed Ecology review schedule.

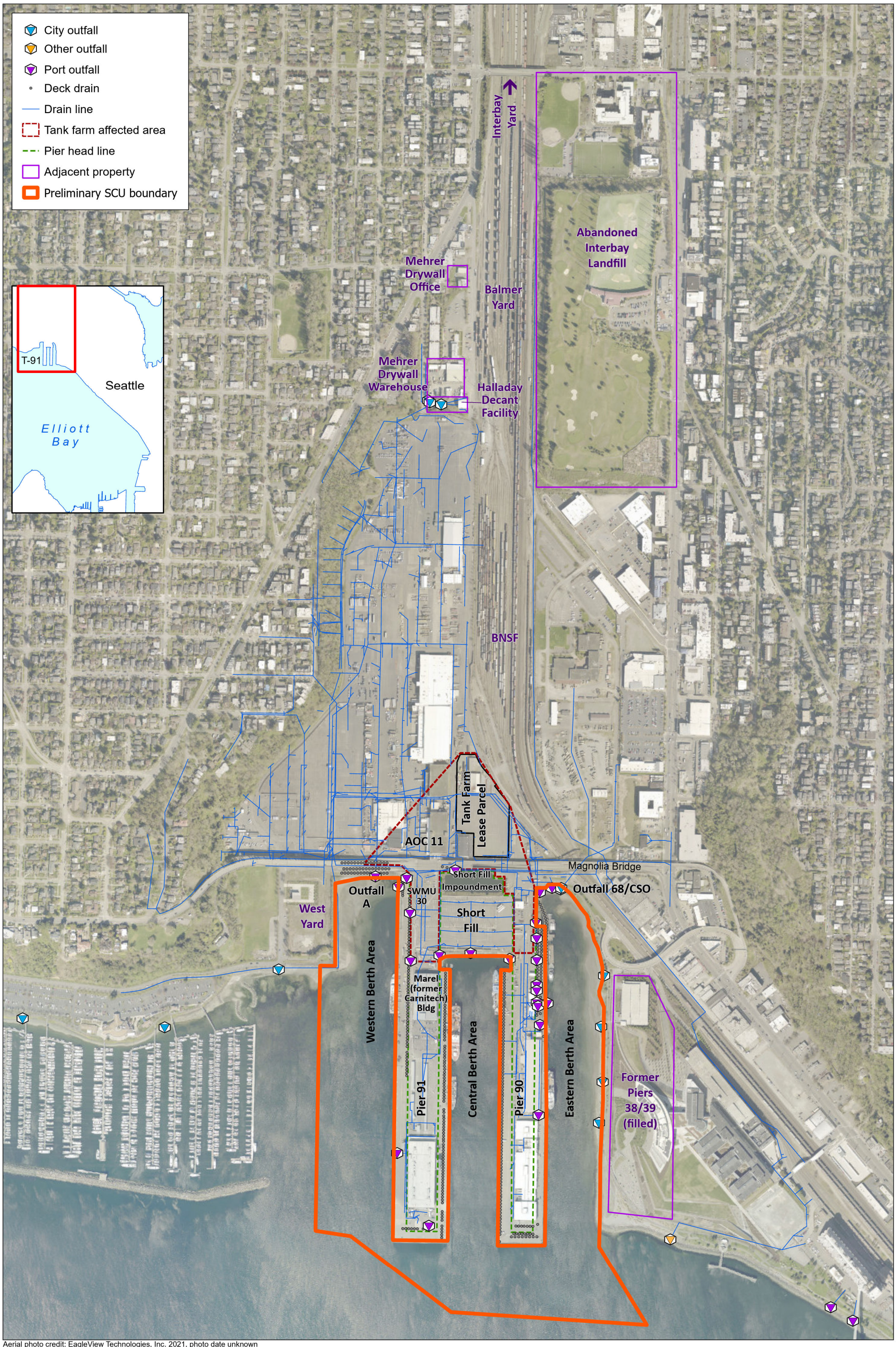
Table 6-1
T-91 FS schedule

Task or Deliverable	Schedule in AO	Date
Service directive approval	NA	January 23 2024
FS planning meeting	Prior to commencing work on the draft FS work plan	February 2024
Agency review draft FS work plan	90 days after approval of service directive	April 22, 2024
Final FS work plan	45 days after receipt of Ecology comments	March 1, 2025
FS fieldwork begins	30 days after FS work plan approval	May 2025
FS fieldwork complete	150 days after FS work plan approval	*October 2025*[1]
Agency review draft FS field investigation data report	60 days after completion of FS field investigations	*January 2026*
Agency review draft FS	90 days after submitting FS field investigation data report	*April 2026*
Public review draft FS	30 days after receipt of Ecology comments	*July 2026*[2]
Agency review preliminary draft cleanup action plan	90 days after approval of FS	TBD

Notes:
Blue italics indicate tentative date.
1. FS field investigations will be considered complete when the FS dataset is finalized.
2. Based on assumption of 30 days for Ecology review.
AO: Agreed Order
Ecology: Washington State Department of Ecology
FS: feasibility study
NA: not applicable
T-91: Terminal 91
TBD: to be determined

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Aerial photo credit: EagleView Technologies, Inc. 2021, photo date unknown

Windward environmental LLC

N

0 100 200 Yards

0 100 200 Meters

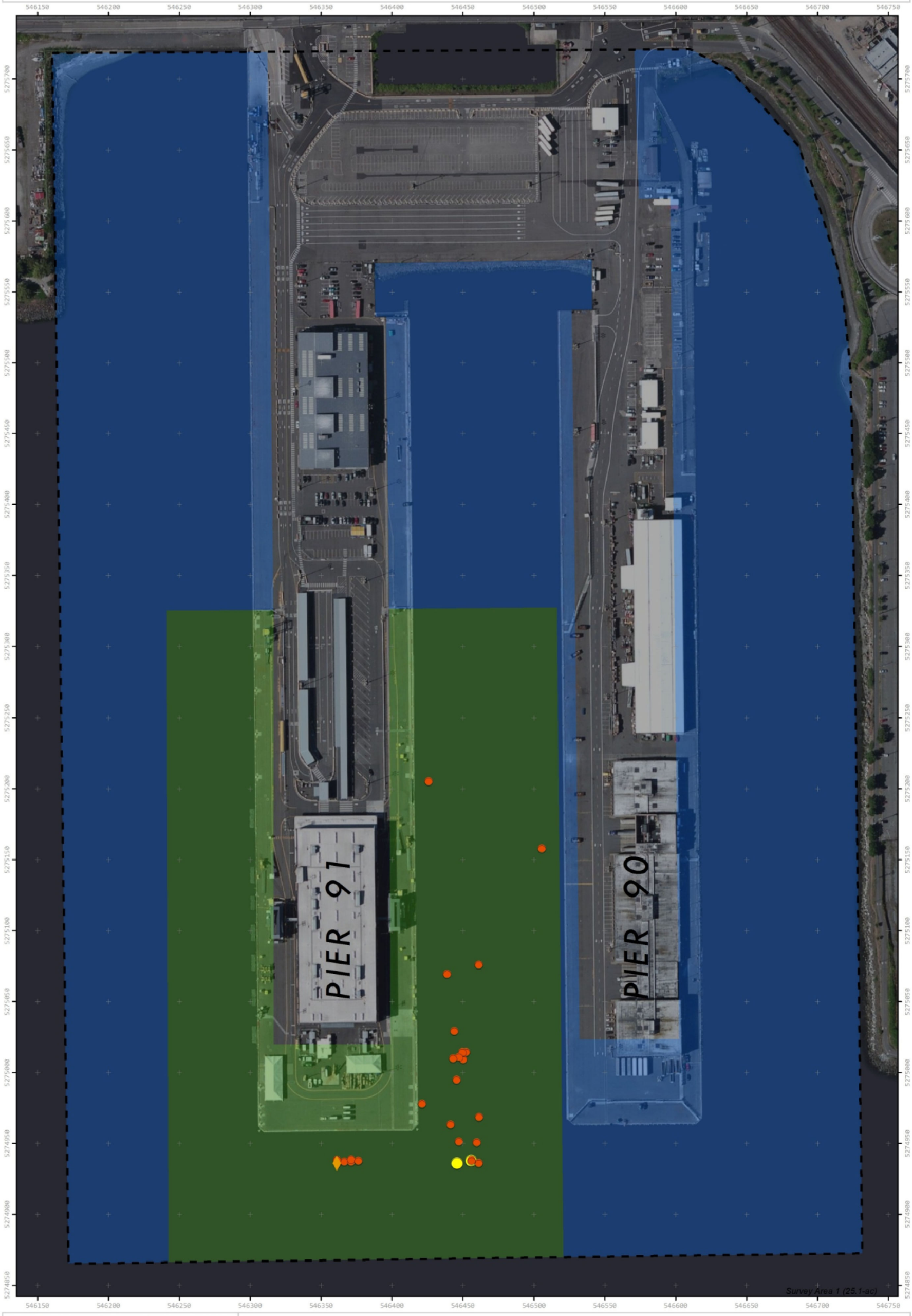
Map 1-1. Site Map

TERMINAL 91 SEDIMENT CLEANUP UNIT:
FEASIBILITY STUDY WORK PLAN

APRIL 14, 2025

Prepared by nicolase, 5/6/2025, W:\Projects\Port of Seattle - T-9\ RIFS\GIS\Maps and Analyses\FS Workplan\Sampling\T91 FS Sampling.aprx

FORMER SEATTLE NAVAL SUPPLY DEPOT MUNITIONS RESPONSE SITES



PORT OF SEATTLE
Piers 90 and 91
Elliott Bay
Seattle, WA

Map Units: Meters | Coordinate System: NAD 1983 UTM Zone 10N

Munitions Response Area (116.1-ac)
Sampling Location above LOQ
DMM Item Found On Surface
DMM Item Found Below Surface
FSNSD MRS (25.2 acres)
FSNSDa MRS (61.5 acres)

0 20 40 60 80 100 Meters
0 100 200 300 Feet

N

Created By	P. Hille	Checked By	GMF	Approved By	D. Jennings
On	04/08/2013	On	04/08/2013	On	04/08/2013

Windward environmental LLC

Source: USACE; Former Seattle Naval Supply Depot Piers 90 and 91–Port of Seattle, Seattle, WA, Formerly Used Defense Site #F10WA012501, Remedial InvestigationDraftFinalReport; May, 2013.

Map 2-1. DMM Locations from USACE (2013)

Prepared by nicolase, 5/6/2025; W:\Projects\Port of Seattle - T-9\ RIFS\GIS\Maps and Analyses\FS Workplan\Sampling\T91 FS Sampling.aprx

APPENDIX A. DATA MANAGEMENT PLAN

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Acronyms

AET	apparent effects threshold
AOC	Administrative Order on Consent
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSL	cleanup screening level
EPA	US Environmental Protection Agency
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
HpCDD	heptachlorodibenzo-*p*-dioxin
HpCDF	heptachlorodibenzofuran
HxCDD	hexachlorodibenzo-*p*-dioxin
HxCDF	hexachlorodibenzofuran
LAET	lowest apparent effects threshold
LDW	Lower Duwamish Waterway
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
OCDD	octachlorodibenzo-*p*-dioxin
OCDF	octachlorodibenzofuran
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PeCDD	pentachlorodibenzo-*p*-dioxin
PeCDF	pentachlorodibenzofuran
PEF	potency equivalency factor
QC	quality control
RL	reporting limit
SCO	sediment cleanup objective
SIM	selected ion monitoring
SMS	Washington State Sediment Management Standards
SQS	sediment quality standards
SVOC	semivolatile organic compound
TCDD	tetrachlorodibenzo-*p*-dioxin
TCDF	tetrachlorodibenzofuran
TEF	toxic equivalency factor

TEQ	toxic equivalent
TOC	total organic carbon
WHO	World Health Organization

Data management rules summarized in this appendix include those for averaging duplicate or replicate samples (Section 3.1), selecting the preferred result if more than one result is reported for a chemical (Section 3.2), handling significant figures and rounding (Section 3.3), calculating totals when results are summed for individual components (Section 3.4), calculating toxic equivalents (TEQs) for polychlorinated biphenyl (PCB) congeners and dioxin/furan congeners (Sections 3.5 and 3.6, respectively), and calculating carcinogenic polycyclic aromatic hydrocarbons (cPAHs) (Section 3.7).

1 Averaging Laboratory Duplicate or Replicate Samples

Contaminant concentrations obtained from the analysis of laboratory duplicates or replicates (i.e., two or more analyses on the same sample) will be averaged for a closer representation of the "true" concentration than that provided by the results of a single analysis. Averaging rules will be dependent on whether the individual results are detected concentrations or reporting limits (RLs) for non-detected analytes. If all concentrations are detected for a given parameter, the values will be simply averaged arithmetically. If all concentrations are non-detected for a given parameter, the minimum RL will be reported. If the concentrations are a mixture of detected concentrations and RLs, any two or more detected concentrations will be averaged arithmetically, and RLs will be ignored. If there is one detected concentration and one or more RLs, the detected concentration will be reported. The latter two rules will be applied regardless of whether the RLs are higher or lower than the detected concentration.

2 Selection of Preferred Results

In some instances, the laboratory will generate more than one result for a chemical for a given sample. Multiple results can occur for several reasons, including:

- The original result does not meet the laboratory's internal quality control (QC) guidelines, and a reanalysis is performed.
- The original result does not meet other project data quality objectives, such as a sufficiently low RL, and a reanalysis is performed.
- Two different analytical methods are used for that chemical.

In each case, a single result will be selected for use. The procedures for selecting the preferred result will differ depending on whether a single or multiple analytical methods are used for that chemical.

For the same analytical method, the results will be selected using the following guidance:

- If the results are detected and not qualified, then the result from the lowest dilution will be selected, unless multiple results from the same dilution are available, in which case the result with the highest concentration will be selected.
- If the results are a combination of estimated and unqualified detected results, then the unqualified result will be selected. This situation most commonly occurs when the original result is outside of the calibration range, thus requiring a dilution. The diluted result within the calibration range will be preferentially selected.
- If the results are all estimated, then the result will be selected using best professional judgment and considering the rationale for qualification. For example, a result qualified based on laboratory replicate results outside of QC objectives for precision will be preferred to a qualified result that is outside the calibration range.
- If the results are a combination of detected and non-detected results, then the detected result will be selected. If there are more than one detected result, the applicable rules for multiple results (as discussed above) will be followed.
- If the results are all non-detected, then the lowest RL will be selected.

For different analytical methods (i.e., when a specific chemical is analyzed in the same sample using different methods), the following rules will be applied:

- For results analyzed using the semivolatile organic compound (SVOC) full-scan (EPA 8270) and selected ion monitoring (SIM) (EPA 8270-SIM) methods, the SIM results will be selected.
- For results analyzed using EPA Method 8081A and any 8270 method (i.e., hexachlorobenzene and hexachlorocyclopentadiene), the 8081A result will be selected.

3 Significant Figures and Rounding

The analytical laboratories report results with various numbers of significant figures depending on the instrument, parameter, and concentration relative to the RL. The reported (or assessed) precision of each observation will be explicitly stored in the project database as a record of the number of significant figures assigned by the laboratory. The tracking of significant figures will become important when calculating averages and performing other data summaries.

When a calculation involves addition, such as totaling PCBs or polycyclic aromatic hydrocarbons (PAHs), the calculation will be only as precise as the least precise number that goes into the calculation. For example (assuming two significant figures):

210 + 19 = 229 will be reported as 230 because 19 is only reported to 2 significant digits, and the enhanced precision of the trailing 0 in the number 210 is not significant.

Then a calculation involves multiplication or division, such as carbon normalization, the original figures for each value are carried through the calculation (i.e., individual values are not adjusted to a standard number of significant figures; instead, the appropriate adjustment is made to the resultant value at the end of the calculation). The result is rounded at the end of the calculation to reflect the value with the fewest significant figures used in the calculation. For example:

59.9 x 1.2 = 71.88 will be reported as 72 because there are 2 significant figures in the number 1.2.

When rounding, if the number following the last significant figure is less than 5, the digit will be left unchanged. If the number following the last significant figure is equal to or greater than 5, the digit will be increased by 1.

4 Calculating Totals

Total PCBs, total PAHs, and total fines will be calculated by summing the detected values for the individual components (e.g., Aroclor mixtures or individual congeners for total PCBs). For samples in which none of the individual components are detected, the total value will be given as the highest RL of any individual component, and assigned a U-qualifier (no detected concentrations). No sum will be calculated in cases where 50% or less of the components are analyzed. Concentrations for analyte sums will be calculated using the following components:

- Total PCBs will be calculated, in accordance with the methods of the SMS, using only detected values for all Aroclor mixtures. For individual samples in which none of the Aroclor mixtures are detected, total PCBs will be given a value equal to the highest RL of the Aroclors and assigned a U-qualifier (no detected concentrations).
- Total low-molecular-weight PAHs (LPAHs), high-molecular-weight PAHs (HPAHs), PAHs, and benzofluoranthenes will also be calculated in accordance with the methods of the SMS. Total LPAHs will be the sum of detected concentrations for naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. Total HPAHs will be the sum of detected concentrations for fluoranthene, pyrene, benzo(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3,-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene. Total benzofluoranthenes will be the sum of the b (i.e., benzo(b)fluoranthene), j, and k isomers.

  Because the j isomer is rarely quantified, the total benzofluoranthenes sum will be typically calculated with only the b and k isomers. In cases where the

laboratory provides total benzofluoranthenes instead of or in addition to the b and k isomers, the laboratory result will be reported, and no sum will be calculated. For samples in which all individual compounds within any of the three groups described above are non-detected, the highest RL for that sample will represent the sum.

- Total fines will be calculated as the sum of clay and silt fractions (i.e. <62.5 µm).

5 Calculation of PCB Congener Toxic Equivalents

PCB congener TEQs will be calculated using the World Health Organization (WHO) consensus toxic equivalency factor (TEF) values for mammals (Van den Berg et al. 1998; Van den Berg et al. 2006), as presented in Table 1. The TEQ will be calculated as the sum of each PCB congener concentration multiplied by the corresponding TEF value. When the PCB congener concentration is reported as non-detected, then the TEF will be multiplied by one-half the RL. The resulting sums will be qualified as estimated consistent with SCUM Section 6.3.3.2 (Ecology 2021).

Table 1. PCB congener TEF values

PCB Congener No.	TEF Value for Mammals (unitless)[a]
77	0.0001
81	0.0003
105	0.00003
114	0.00003
118	0.00003
123	0.00003
126	0.1
156	0.00003
157	0.00003
167	0.00003
169	0.03
189	0.00003

[a] From Van den Berg et al. (2006).
PCB – polychlorinated biphenyl
TEF – toxic equivalency factor

6 Calculation of Dioxin/Furan Congener TEQs

Dioxin/furan congener TEQs will be calculated using the WHO consensus TEF values for mammals (Van den Berg et al. 1998; Van den Berg et al. 2006) as presented in Table 2. The TEQ will be calculated as the sum of each dioxin/furan congener concentration multiplied by the corresponding TEF value. When the dioxin/furan

congener concentration is reported as non-detected, then the TEF will be multiplied by one-half the RL. The resulting sums will be qualified as estimated consistent with SCUM Section 6.3.3.2 (Ecology 2021).

Table 2. Dioxin/furan congener TEF values

Dioxin/Furan Congener	TEF Value for Mammals (unitless)[a]
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,6,7,8-HpCDD	0.01
1,2,3,4,7,8,9-HpCDF	0.01
1,2,3,4,7,8-HxCDF	0.1
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDF	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,7,8-PeCDF	0.03
1,2,3,7,8-PeCDD	1
2,3,4,6,7,8-HxCDF	0.1
2,3,4,7,8-PeCDF	0.3
2,3,7,8-TCDF	0.1
2,3,7,8-TCDD	1
OCDF	0.0003
OCDD	0.0003

[a] From Van den Berg et al. (2006).

HpCDD – heptachlorodibenzo-*p*-dioxin
HpCDF – heptachlorodibenzofuran
HxCDD – hexachlorodibenzo-*p*-dioxin
HxCDF – hexachlorodibenzofuran
OCDD – octachlorodibenzo-*p*-dioxin
OCDF – octachlorodibenzofuran
PeCDD – pentachlorodibenzo-*p*-dioxin
PeCDF – pentachlorodibenzofuran
TCDD – tetrachlorodibenzo-*p*-dioxin
TCDF – tetrachlorodibenzofuran
TEF – toxic equivalency factor

7 Calculation of Carcinogenic Polycyclic Aromatic Hydrocarbons

cPAH values will be calculated using potency equivalency factor (PEF) values (California EPA 2009) based on the individual PAH component's relative toxicity to benzo(a)pyrene. PEF values are presented in Table 3. The cPAH will be calculated as the sum of each individual PAH concentration multiplied by the corresponding PEF value. When the individual PAH component concentration are reported as non-detected, then the PEF will be multiplied by one-half the RL. The resulting sums will be qualified as estimated consistent with SCUM Section 6.3.3.2 (Ecology 2021).

Table 3. cPAH PEF values

cPAH	TEF Value (unitless)[a]
Benzo(a)pyrene	1
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.1
Chrysene	0.01
Dibenz(a,h)anthracene	0.1
Indeno(1,2,3-cd)pyrene	0.1

[a] PEFs for cPAHs are defined by California EPA (2009) by dividing the inhalation unit risk factor for the compound by the inhalation unit risk factor for benzo[a]pyrene.

cPAH – carcinogenic polycyclic aromatic hydrocarbon

EPA – US Environmental Protection Agency

PEF – potency equivalency factor

8 TOC Normalization

For comparison to benthic cleanup goals, sediment samples with TOC content > 0.5% or < 3.5% will be TOC normalized for comparison to the organic carbon-normalized cleanup levels and SMS criteria (Ecology 2021). When TOC is outside the 0.5% and 3.5% ranges, then both dry weight and TOC normalized values should be reported and compared to both the TOC normalized and AET criteria in SCUM, Chapter 8, Table 8-1. An exceedance of either the TOC normalized or AET criteria at the SCO or CSL level is considered an exceedance for that sample.

9 References

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FINAL

TERMINAL 91 SEDIMENT CLEANUP UNIT: FEASIBILITY STUDY WORK PLAN

APPENDIX B – SAMPLING AND ANALYSIS PLAN/QUALITY ASSURANCE PROJECT PLAN

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Acronyms

ARL	Analytical Resources, LLC
ASTM	American Society for Testing and Materials
CFA	Cape Fear Analytical
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CRM	certified reference material
CSL	cleanup screening level
CUL	cleanup level
CV	coefficient of variation
DGPS	differential global positioning system
DMM	discarded military munition
DQI	data quality indicator
DQO	data quality objective
dw	dry weight
Ecology	Washington State Department of Ecology
EDD	electronic data deliverable
EPA	US Environmental Protection Agency
ERA	Waters ERA
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
ID	identification
FS	feasibility study
GPS	global positioning system
LCS	laboratory control sample
LMCL	lower method calibration limit
LOQ	limit of quantitation
LLOQ	lower 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
PAH	polycyclic aromatic hydrocarbon
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
PCB	polychlorinated biphenyl
Port	Port of Seattle
PSEP	Puget Sound Estuary Program
PSR	Puget Sound Reference
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
RI	remedial investigation
RL	reporting limit
ROUV	remote-operated underwater vehicle
RPD	relative percent difference
SAP	sampling and analysis plan
Sayler	Sayler Data Solutions, Inc.
SCO	sediment cleanup objective
SCU	Sediment Cleanup Unit
SCUM	Sediment Cleanup User's Manual
SDG	sample delivery group
SIM	selected ion monitoring
SM	Standard Method
SMS	Washington State Sediment Management Standards
SVOC	semivolatile organic compound
T-91	Terminal 91
TCDD	tetrachlorodibenzo-*p*-dioxin
TOC	total organic carbon
UCT-KED	Universal Cell Technology-kinetic energy discrimination
USCG	US Coast Guard
Windward	Windward Environmental LLC

FINAL

Contractor Signature Sheet

Sampling and Analysis Plan/Quality Assurance Project 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/Quality Assurance Project Plan and agree to follow the methods and quality assurance procedures contained therein.

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Windward

Date April 21, 2025

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Date April 21, 2025

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1 Introduction

This sampling and analysis plan (SAP) and quality assurance project plan (QAPP) for the Sediment Cleanup Unit (SCU)[1] of the Port of Seattle's (Port's) Terminal 91 (T-91) is an appendix to the T-91 feasibility study (FS) work plan. The FS work plan, including this SAP/QAPP, was developed in compliance with the requirements of Ecology/Port Agreed Order (AO) No. DE 24768 (Ecology 2020). Areas of the SCU are owned by either the Port or by Washington State under a Port management agreement with the Department of Natural Resources. This SAP/QAPP covers a phased investigation to collect information related to data needs for the FS.

1.1 SITE DESCRIPTION

T-91 is an approximately 210-acre property, owned by the Port, that is 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 the SCU. The SCU includes about 85 acres of submerged lands around the piers, about 70 acres (82%) of which is subtidal sediment and 16 acres (18%) of which is intertidal sediment (Map 1-1). The SCU is separated into the eastern, central, and western berths by Piers 90 and 91, which are earthen berms constructed in 1913 and 1919, respectively. These berms function as solid barriers between the berth areas and prevent the transport of water and sediment laterally between adjacent berth areas.

The greatest numbers of Washington State Sediment Management Standards (SMS) exceedances in surface and subsurface sediment were associated with polycyclic aromatic hydrocarbons (PAHs), total polychlorinated biphenyl (PCBs) (sum of Aroclors), mercury, and 1,4-dichlorobenzene. SMS exceedances most frequently occurred in the central berth area; among the 32 surface sediment sampling locations within the central berth area, 28 (88%) had at least one chemical with an SMS exceedance. In the eastern and western berth areas, fewer SMS exceedances were reported, and most of the exceedances were located along the western pier face of Pier 91 and the eastern pier face of Pier 90.

Among the T-91 SCU surface sediment sampling locations, those in the central berth area had the greatest concentrations of PCBs (sum of congeners and sum of Aroclors), PCB toxic equivalents (TEQs), dioxin/furan TEQs, total TEQs, carcinogenic polycyclic aromatic hydrocarbon (cPAH) TEQs, and mercury. In the eastern and western berth areas, concentrations at intertidal sampling locations were less than those at subtidal locations. Dioxin/furan TEQs, total TEQs, and mercury concentrations at the intertidal sampling locations were less than Ecology's natural background concentrations.

[1] The T-91 SCU includes the marine water-covered area of the "Terminal 91 Complex," as designated by the Washington State Department of Ecology (Ecology).

1.2 DOCUMENT ORGANIZATION

This plan addresses project management responsibilities; sampling and analytical procedures; assessment and oversight; and data reduction, validation, and reporting. The remainder of this SAP/QAPP is organized as follows:

- Section 2 – Project Objectives and Description
- Section 3 – Project Organization
- Section 4 – Sampling Design
- Section 5 – Field Procedures
- Section 6 – Laboratory Procedures
- Section 7 – References

In addition, this SAP/QAPP is supported by two attachments. Field forms are provided in Attachment B1 and reporting limits (RLs) for dioxins/furans and PCB congeners are provided in Attachment B2.

2 Project Objectives and Description

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

2.1 DATA QUALITY OBJECTIVES

Four DQOs for sediment are identified in the T-91 FS work plan, based on the updated conceptual site model provided in Section 2 of the T-91 FS work plan.

- DQO 1 – Refine surface sediment characterization (primarily for cPAHs) to inform remedial design
- DQO 2 – Refine site boundary of the SCU (primarily for mercury)
- DQO 3 – Characterize berth areas and under-pier slopes for stability
- DQO 4 – Characterize under-pier sediment for recontamination potential in areas where sloughing may occur (e.g., under structures and on slopes)

The DQOs are provided in Table 2-1, with a summary of the investigation sampling design and analytical approach to address each sediment DQO. Descriptions and schedules for each of these investigations are presented in Section 2.2. Details regarding the study designs for each investigation are presented in Section 4.

Table 2-1. Sediment DQOs

Step	DQO 1	DQO 2	DQO 3	DQO 4
STEP 1: State the problem.	What is the horizontal extent of contamination in specific areas?	What is the extent of site-related contamination in specific areas?	What are the extent and thickness of sediment under structures and on slopes? Are there stability concerns related to dredging adjacent to structures or slopes?	What is the potential for sloughing and recontamination adjacent to dredge areas?
STEP 2: Identify the goals of the study.	Refine surface sediment characterization.	Refine site boundary.	Characterize berth areas and under-pier slopes for stability.	Characterize under-pier sediment for recontamination potential in areas where sloughing may occur (e.g., under structures and on slopes).
STEP 3: Identify the information inputs.	The T-91 RI sediment dataset		Limited data are available regarding conditions in under-pier areas. Thus, data are needed regarding sediment presence/thickness both under structures and on slopes.	The survey information obtained for DQO 3
STEP 4: Define the boundaries of the study.	The sediment within the existing SCU boundaries	The vicinity of the revised boundary provided in Section 4.5 of the T-91 RI	The under-pier areas within the SCU	
STEP 5: Develop the analytical approach.	Surface sediment samples will be collected at select locations. Analysis for location-specific analytes will occur (includes PAHs and PCB Aroclors).	Surface sediment samples will be collected at select locations. Analysis for location-specific analytes will occur (includes mercury, dioxins/furans, and PCB congeners).	A phased approach that includes the following components will be used to collect the needed information: 1. Updated bathymetry survey 2. Video survey 3. Diver surveys (jet probe or visual surveys)	Sample locations collected from areas identified based on the bathymetric, video, and diver surveys conducted under DQO 3.
STEP 6: Specify performance or acceptance criteria.	Performance or acceptance criteria are described in Section 6, including those for field QC samples and laboratory QC samples. DQIs for laboratory analyses (i.e., PARCCS) will be met, as described in Table 6-4.		Performance criteria are provided in Section 5.7.	Performance or acceptance criteria are described in Section 6, including those for field QC samples and laboratory QC samples. DQIs for laboratory analyses (i.e., PARCCS) will be met, as described in Table 6-4.

Step	DQO 1	DQO 2	DQO 3	DQO 4
STEP 7: Develop the detailed plan for obtaining data.	Nine surface sediment samples will be collected and analyzed for the analytes identified in Section 4.1. The data will be combined with the existing RI dataset to update the surface sediment interpolation for the FS.	Nine surface sediment samples will be collected and analyzed for the analytes identified in Section 4.1. The data will be combined with the existing RI dataset to define the southern boundary of the SCU.	The surveys will be conducted and the results will be evaluated to identify areas with more than 2 ft of accumulated sediment for potential chemical analysis under DQO 4.	The detailed plan to address DQO 4 will be provided in a QAPP addendum following the evaluation of the survey data.

DQI – data quality indicator
DQO – data quality objective
PAH – polycyclic aromatic hydrocarbon
PARCCS – precision, accuracy, representativeness, completeness, comparability, and sensitivity
PCB – polychlorinated biphenyl
QAPP – quality assurance project plan
QC – quality control
RI – remedial investigation
SCU – Sediment Cleanup Unit

2.2 PROJECT DESCRIPTION AND SCHEDULE

FS sampling activities will be conducted in two phases. Phase I will include the surface sediment investigation and the three components of the survey investigation. Phase II will (if needed) include the collection of subsurface sediment cores. The sampling design for these investigations is provided in Section 4.

2.2.1 Surface sediment investigation

Surface sediment will be collected at locations throughout the site to refine the nature and extent of surface sediment contamination (DQO 1) and refine the site boundary (DQO 2). The surface sediment investigation, which will include the collection of 18 surface sediment samples, is tentatively planned for spring 2025.

2.2.2 Survey investigation

The three components of the phased survey investigation will be conducted sequentially, as described in Section 4.1. The target schedule for these activities is as follows:

- Updated bathymetry survey – summer 2025
- Underwater video survey – fall 2025
- Diver surveys – tentatively spring 2026

Timing of these activities will depend on equipment/crew availability and access to the target areas of the site (i.e., avoiding time periods when vessel presence will limit access to pier faces), and thus is subject to change.

2.2.3 Subsurface sediment investigation

The need to collect subsurface sediment cores will depend on the results of the survey investigations. Locations with more than 2 ft of accumulated sediment will be evaluated as potential core locations. If the collection of subsurface cores are determined to be needed, an addendum to this SAP/QAPP will be prepared to document the rationale for and details of the sampling design for this effort. The schedule for core collection will depend on the timing of the completion of the surveys and approval of the SAP/QAPP addendum, as well as access to the target areas of the site (i.e., avoiding time periods when vessel presence will limit access to pier faces).

3 Project Organization

The overall project organization and individuals responsible for implementing the work elements presented in this SAP/QAPP 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. Key personnel include:

- Susan McGroddy is the Windward project manager and will be responsible for implementation of this SAP.

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

- Amara Vandervort is the Windward QA/QC manager for the project and will provide oversight for both the field sampling and laboratory programs. She is also the laboratory coordinator for chemical analyses, in which role she will confirm that samples are collected and documented appropriately, coordinate with the analytical laboratories, ensure data quality, oversee data validation, and supervise project QA coordination.

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

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 *Sediment Cleanup User's Manual* (SCUM) (Ecology 2021).
- Meet all reporting requirements.
- Deliver electronic data deliverables (EDDs) as specified in this plan.
- Meet turnaround times for deliverables as described in this plan.

Project personnel can be reached as follows:

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4 Sampling Design

This section presents study designs for the elements of the sediment investigations to address the DQOs discussed in Section 2.1. As described, Phase I of FS sampling will include the surface sediment investigation (Section 4.1) and survey investigations (Section 4.2). If needed, Phase II of FS sampling will include the collection of subsurface sediment samples (Section 4.3).

4.1 SURFACE SEDIMENT INVESTIGATION

To address DQOs 1 and 2, a total of 18 surface sediment samples (from a depth of 0 to 10 cm) will be collected as part of the FS (Map 4-1).

- **DQO 1** – To address DQO 1, nine surface sediment samples will be collected at specific locations throughout the site to characterize surface sediment at the site, primarily for cPAHs (Maps 4-2 and 4-3).
- **DQO 2** – To address DQO 2, nine surface sediment samples will be collected to further refine the southern site cleanup boundary (Maps 4-4 and 4-5). Three of these samples will be archived for potential mercury analysis pending results from the other nearby samples. The data from these samples, along with regional background, will be used to establish the final site boundary in the FS.

The rationale for each of the surface sediment locations is provided in Table 4-1.

Table 4-1. Surface sediment sampling locations

Location	Rationale for Location		Rationale Details and Analytes
	Refine Nature and Extent (DQO 1)	Refine Site Boundary (DQO 2)[a]	
T91-FS24-SS100	X		Refine interpolation for cPAHs.
T91-FS24-SS101	X		Refine interpolation for cPAHs and PCB Aroclors.
T91-FS24-SS102	X		Refine interpolation for cPAHs.
T91-FS24-SS103	X		Refine interpolation for cPAHs.
T91-FS24-SS104	X		Refine interpolation for cPAHs.
T91-FS24-SS105	X		Refine interpolation for cPAHs.
T91-FS24-SS106	X		Refine interpolation for cPAHs.
T91-FS24-SS107	X		Refine interpolation for cPAHs.
T91-FS24-SS108	X		Refine interpolation for cPAHs.
T91-FS24-SS109		X	Refine interpolation for dioxins/furans and PCB congeners near southern site boundary.
T91-FS24-SS110		X	Refine interpolation for mercury near southern site boundary.
T91-FS24-SS111		X	Refine interpolation for dioxins/furans and PCB congeners near southern site boundary.
T91-FS24-SS112		X	Refine interpolation for mercury near southern site boundary.
T91-FS24-SS113		X	Refine interpolation for mercury near southern site boundary.
T91-FS24-SS114		X	Refine interpolation for mercury near southern site boundary.

Location	Rationale for Location		Rationale Details and Analytes
	Refine Nature and Extent (DQO 1)	Refine Site Boundary (DQO 2)[a]	
T91-FS24-SS115		X	Archive sample (potential mercury analysis).
T91-FS24-SS116		X	Archive sample (potential mercury analysis).
T91-FS24-SS117		X	Archive sample (potential mercury analysis).

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

cPAHs – carcinogenic polycyclic aromatic hydrocarbons
CUL – cleanup level
DQO – data quality objective
PCB – polychlorinated biphenyl

Each of the surface sediment samples will be analyzed for select analytes based on the specific questions being answered for each sample, as indicated in Table 4-1. These analytes will include:

- PAHs (nine samples)
- PCB Aroclors (one sample)
- Dioxins/furans and PCB congeners (two samples)
- Mercury (four samples, along with three archive samples)

In addition, archive material will be collected at all locations pending the need for other analytes to be analyzed following the results of the chemistry analyses.

4.2 SURVEY INVESTIGATIONS

Under-pier areas and slopes adjacent to areas with elevated sediment contaminant concentrations will be surveyed to characterize these areas for stability (DQO 3). A phased approach will be used for this investigation and will include the following components:

- Updated bathymetry survey
- Underwater video survey
- Diver surveys (jet probe or visual surveys)

These three components are discussed in Sections 4.2.1 to 4.2.3.

4.2.1 Updated bathymetry survey

An updated multibeam bathymetric survey is planned as the first step of this phased approach. The objectives of this survey are:

- Update the understanding of current water depths in berthing areas and under-pier slope areas.
- Evaluate changes since the 2018 bathymetry survey (Map 4-6) to determine where vessel propeller wash scour has caused erosion and/or where sediment has been

redistributed to create higher-elevation areas. The results of this comparison will inform design cleanup alternatives affecting vessel operations and access.

To the extent feasible, the survey will be conducted at high tide during periods when vessels are not berthed at piers, in order to collect bathymetry information as far under each pier as possible.

4.2.2 Underwater video survey

Following the bathymetric survey, the second step of this phased approach will be to conduct an underwater video survey of the T-91 SCU using a remote-operated underwater vehicle (ROUV). The objectives of this survey are:

- Evaluate under-pier conditions, including lateral extent of sediment and exposed rock and visual presence of debris or discarded military munitions (DMMs).
- Verify piling presence compared to available drawings.

The video survey will be conducted after the bathymetric survey so that any new areas of erosion or accumulation identified based on the comparison of the 2018 and updated bathymetry surveys can be further investigated.

4.2.3 Diver surveys

The third step in this phased approach will be to conduct diver surveys along transects under the structures and at the pier face. Divers will use jet probes to measure the thickness of sediment above rock or other hard substrates. Data gathered via jet probing can also provide important information when evaluating the stability of under-pier slopes and associated structures, especially if armor rock covered by recent sediments extends into berth areas. No jet probe transects are proposed in the DMM area for health and safety reasons. Instead, diver measurements (i.e., visual surveys) are recommended to inform the extent of exposed rock and sediment.

The objectives of the diver surveys are:

- Provide a better understanding of subsurface conditions in the under-pier area and at the pier face of the T-91 SCU. This will include the presence/absence/depth of sediment, rock, clay, and debris.
- Inform potential vertical limits of dredging and associated dredge volume estimates. Understanding sediment thickness at the pier face and in the adjacent under-pier area will help quantify the volume of sediment that may need to be removed during berth dredging, especially considering the volume of sediment that may slough into the dredge area from under-pier areas.
- Inform the need for (and locations of) the collection of subsurface sediment cores.

Preliminary diver survey transects (including 14 jet probing transects and 9 visual diver transects) are presented on Map 4-7. Transect locations may be adjusted pending the results of the updated bathymetric and video surveys.

4.3 SEDIMENT CORE COLLECTION

Depending on the results of the survey investigations conducted in Phase I (i.e., the updated bathymetry survey, underwater video survey, and diver surveys), a second phase of sampling (Phase II) may be needed to characterize under-pier sediment for recontamination potential in areas where sloughing may occur (e.g., under structures and on slopes) (DQO 4). The objectives of the subsurface sediment sampling would include:

- Provide additional information on the chemical and physical conditions of sediments that may slough downslope into the berth area in the event of dredging.
- Provide information on geotechnical conditions to support development of estimates of volume and timing for anticipated sloughing with a dredge event.

If needed, subsurface sediment core locations will be placed in transects in areas with known sediment deposits. Each transect will include three core locations: one under the pier, one at the pier face, and one beyond the pier face on the slope.[2] The proposed core locations, depths, and analytes will be provided in an addendum to this SAP/QAPP.

[2] When possible, an existing sediment core will be used as the third point in these transects.

5 Field Procedures

This section presents the sample identification, collection, processing, and handling procedures that will be followed for the site feasibility study (FS).

5.1 Sample Identification

Unique alphanumeric identifications (IDs) will be assigned to each sample and recorded on the sediment collection forms (Attachment B1). The sampling location IDs will include the following:

- Project area ID (i.e., T91)
- Project phase ID (i.e., FS)
- Sampling year (e.g., 25 for 2025)
- Sample type:
  - Surface sediment samples (0- to 10-cm) will be SS.
  - Subsurface sediment samples will be SC.
- Three-digit location number

For example, a 0- to 10-cm surface sediment sampling location would be T91-FS25-SS001 and a subsurface sediment core sampling location would be T91-FS25-SC005. 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-FS25-SS101).
- Subsurface sediment samples – Sample ID will start the same as the sampling location ID, but a sample identifier will be added to the end of the ID (e.g., T91-FS24-SC105A, B, C). The surface interval of each core (e.g., 0 to 1 ft) will be identified as interval A, after which each subsequent interval will be labeled alphabetically. All cores will be sectioned into 1-ft intervals, so all A intervals will be 0- to 1-ft intervals.

Field duplicates will be indicated by sample IDs starting at 500.

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/QAPP 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 mean lower low water (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, along with mudline depths based on existing bathymetry data.

Table 5-1. Coordinates for proposed surface sediment sampling locations

Sample ID	Mudline Depth (ft MLLW)	Target Coordinates			
		Easting (ft)[a]	Northing (ft)[a]	Latitude	Longitude
T91-FS25-SS100	-2.0	1257920	234124	47.6312774	-122.3847390
T91-FS25-SS101	-36.0	1257966	232996	47.6281869	-122.3844620
T91-FS25-SS102	1.3	1259503	234314	47.6318859	-122.3783346
T91-FS25-SS103	2.2	1259482	233912	47.6307807	-122.3783863
T91-FS25-SS104	-34.3	1259257	233495	47.6296263	-122.3792675
T91-FS25-SS105	-21.8	1259375	233259	47.6289856	-122.3787696
T91-FS25-SS106	0.1	1259501	233220	47.6288857	-122.3782545
T91-FS25-SS107	-18.4	1259385	233057	47.6284342	-122.3787109
T91-FS25-SS108	-8.8	1259465	232634	47.6272775	-122.3783526
T91-FS25-SS109	-64.9	1258190	232035	47.6255664	-122.3834750
T91-FS25-SS110	-80.6	1258501	231772	47.6248635	-122.3821921
T91-FS25-SS111	-70.6	1259010	231911	47.6252706	-122.3801383
T91-FS25-SS112	-44.5	1259768	232114	47.6258682	-122.3770805
T91-FS25-SS113	-54.6	1259847	231855	47.6251650	-122.3767418
T91-FS25-SS114	-74.0	1259778	231620	47.6245169	-122.3770030
T91-FS25-SS115	-14.8	1260063	232192	47.6260992	-122.3758908
T91-FS25-SS116	-68.0	1260073	231855	47.6251774	-122.3758260
T91-FS25-SS117	-81.0	1260040	231524	47.6242660	-122.3759299

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

ID – identification

MLLW – mean lower low water

NAD83 – North American Datum of 1983

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 Puget Sound Estuary Program (PSEP) (1997). Surface sediments will be collected from a sampling vessel at each location using a pneumatic power grab sampler. The 0- to 10-cm sediment interval will be collected to represent the biologically active horizon. All the surface samples will be collected and analyzed as individual samples with no compositing.

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 B1) 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 B1).

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 6 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%. Recovery correction will not be applied to the core intervals.
- 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 on the Sediment Core Collection Form (Attachment B1) 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
- Any deviations from the approved sampling plan on a Protocol Modification Form (Attachment B1)

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

5.7 SURVEY METHODS

This section presents methods for the various survey types planned for the site: a bathymetry survey, underwater video survey, diver visual survey, and diver jet-probe survey.

5.7.1 Bathymetry survey

An updated multibeam bathymetry survey will be conducted using the Port's survey equipment and vessels. The Port's standard practices will be followed when conducting the survey. To the extent feasible, the survey will be conducted at high tide during periods when vessels are not berthed at piers to collect bathymetry information as far under the pier as possible.

5.7.2 Underwater video survey

The Port's ROUV will be used to conduct surveys to evaluate under-pier conditions. The Port's standard practices will be followed when conducting the surveys.

5.7.3 Diver surveys

Two types of diver surveys will be conducted to evaluate conditions under structures. In areas where DMMs are of concern, only a visual survey will be conducted. In other areas, divers will use jet probes to further investigate conditions. Methods for these surveys are described in Sections 5.7.3.1 and 5.7.3.2.

5.7.3.1 Visual survey

Divers will conduct a visual survey to determine the extent of accumulated sediment on the under-pier slope areas. The visual assessment will include an estimated percentage of the slope area that has accumulated sediment. Divers will record a description of the under-pier areas that includes:

- Location

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

5.7.3.2 Jet probe survey

Jet probing comprises 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. The diver will adjust the transect locations as necessary to avoid disturbing existing eelgrass beds, if present. Measurements will be taken at locations 5 to 15 ft apart along each transect. Locations will be verified by the jet probe contractor using a combination of DGPS and sonar-based underwater positioning technology. Diver position will be monitored in real-time by the support crew (connected to the diver via intercom and video) to verify that the transects are in the appropriate locations.

Data will be collected every 5 to 15 feet. Starting at the shoreline/top of slope, each established location will be described by the diver and recorded. Descriptions at each location will include:

- Location
- Water depth measurements in feet
- Time of water depth measurement
- Observed surface substrate type (e.g., rock, sand, silt, shell), color, and consistency
- Debris type and size
- Biological observations
- Estimated surface slope

After the descriptions of surface conditions at the location are completed, a support boat will deliver the diver the jet probe. The jet probe will consist of a galvanized pipe marked with foot graduations and connected to a hose and water pump. The diver 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 diver will characterize the probing observations, typically including:

- 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.

Survey results will include tabulated transect locations and jet probe observations and a series of cross sections summarizing the observations made along each transect.

5.9 SEDIMENT SAMPLE PROCESSING AND HANDLING PROCEDURES

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

5.9.1 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 sediment collected for analysis will be made of glass, stainless steel, or polycarbonate, and they will be cleaned prior to each day's use and between sampling 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 item with aluminum foil.
6. Store the item in a clean, closed container for next use.

5.9.2 Sample containers for analysis

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

5.9.3 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.

5.9.3.1 Procedures for surface sediment grab samples

Sediment processing will be performed on the boat or beach 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 B1); 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 each inside a cooler with ice and/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 following guidance in SCUM Section 4.5.9, which prohibits the return of sediment with visible signs of contamination to the site (Ecology 2021).

5.9.3.3 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 the target depth intervals.[3]
3. Archive all sediment collected below the target depth interval in 1-ft intervals.
3. Record a description of each core on the Sediment Core Collection Form (Attachment B1); 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.
6. Thoroughly check all sample containers for proper ID, analysis type, and lid tightness.
7. Pack each container carefully to prevent breakage, and place each inside a cooler with ice and/or frozen gel packs for storage at the proper temperature (0 to 6°C for all samples).

[3] As described in Section 4.3, the proposed core locations, depths, and analytes will be provided in an addendum to this SAP/QAPP in the event that Phase II sampling occurs.

5.10 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.

5.11 SAMPLE TRANSPORT AND CHAIN OF CUSTODY PROCEDURES

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

1. Each container with sediment samples will be delivered to ARL 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.

6 Laboratory Procedures

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 samples and (if needed) sediment chemistry core samples will be analyzed for specific chemicals of concern based on specific data needs. Analytes may include a subset of SMS chemicals (e.g., PCBs, PAHs, mercury), dioxins/furans, PCB congeners, total organic carbon (TOC), grain size, and/or total solids. Table 6-1 summarizes the parameters for potential 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 RLs

Parameter	Unit	SMS Criteria		Extraction Method	Analysis Method	Target RL[a,b]
		SCO	CSL			
Conventional Parameters						
TOC	%	nc	nc	na	EPA 9060A	0.02
Grain size	%	nc	nc	na	ASTM D-422	0.1
Percent solids	%	nc	nc	na	SM 2540 G-97	0.04
Metals						
Arsenic	mg/kg dw	57	93	na	EPA 6020B UCT-KED	0.2
Cadmium	mg/kg dw	5.1	6.7	na	EPA 6020B UCT-KED	0.1
Chromium	mg/kg dw	260	270	na	EPA 6020B	0.5
Copper	mg/kg dw	390	390	na	EPA 6020B UCT-KED	0.5
Lead	mg/kg dw	450	530	na	EPA 6020B	0.1
Mercury	mg/kg dw	0.41	0.59	na	EPA 7471B	0.025
Silver	mg/kg dw	6.1	6.1	na	EPA 6020B	0.2
Zinc	mg/kg dw	410	960	na	EPA 6020B UCT-KED	6
Organics						
Total LPAH	µg/kg dw	370 mg/kg OC	780 mg/kg OC	na	EPA 8270E (calculated)	20 (2 mg/kg OC)
Naphthalene	µg/kg dw	99 mg/kg OC	170 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Acenaphthylene	µg/kg dw	66 mg/kg OC	66 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Acenaphthene	µg/kg dw	16 mg/kg OC	57 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Fluorene	µg/kg dw	23 mg/kg OC	79 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Phenanthrene	µg/kg dw	100 mg/kg OC	480 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Anthracene	µg/kg dw	220 mg/kg OC	1,200 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)

Parameter	Unit	SMS Criteria		Extraction Method	Analysis Method	Target RL[a,b]
		SCO	CSL			
2-Methylnaphthalene[c]	µg/kg dw	38 mg/kg OC	64 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Total HPAHs	µg/kg dw	960 mg/kg OC	5,300 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E (calculated)	20 (2 mg/kg OC)
Fluoranthene	µg/kg dw	160 mg/kg OC	1,200 mg/kg OC	na	EPA 8270E	20 (2 mg/kg OC)
Pyrene	µg/kg dw	1,000 mg/kg OC	1,400 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Benzo(a)anthracene	µg/kg dw	110 mg/kg OC	270 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Chrysene	µg/kg dw	110 mg/kg OC	460 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Total benzofluoranthenes	µg/kg dw	230 mg/kg OC	450 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E (calculated)	40 (4 mg/kg OC)
Benzo(a)pyrene	µg/kg dw	99 mg/kg OC	210 mg/kg OC	na	EPA 8270E	20 (2 mg/kg OC)
Indeno(1,2,3-cd)pyrene	µg/kg dw	34 mg/kg OC	88 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Dibenz(a,h)anthracene	µg/kg dw	12 mg/kg OC	33 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Benzo(g,h,i)perylene	µg/kg dw	31 mg/kg OC	78 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8720E	20 (2 mg/kg OC)
Chlorinated Hydrocarbons						
1,2-Dichlorobenzene	µg/kg dw	2.3 mg/kg OC	2.3 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)
1,2,4-Trichlorobenzene	µg/kg dw	0.81 mg/kg OC	1.8 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E-SIM[d]	5 (0.5 mg/kg OC)
1,4-Dichlorobenzene	µg/kg dw	3.1 mg/kg OC	9 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E-SIM[d]	5 (0.5 mg/kg OC)
Hexachlorobenzene	µg/kg dw	0.38 mg/kg OC	2.3 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8081B	0.5 (0.05 mg/kg OC)
Phthalates						
Dimethyl phthalate	µg/kg dw	53 mg/kg OC	53 mg/kg OC	EPA 3546 (hexane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Diethyl phthalate	µg/kg dw	61 mg/kg OC	110 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)

Parameter	Unit	SMS Criteria		Extraction Method	Analysis Method	Target RL[a,b]
		SCO	CSL			
Di-n-butyl phthalate	µg/kg dw	220 mg/kg OC	1,700 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Butyl benzyl phthalate	µg/kg dw	4.9 mg/kg OC	64 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E-SIM[d]	5 (0.5 mg/kg OC)
Bis(2-ethylhexyl) phthalate	µg/kg dw	47 mg/kg OC	78 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Di-n-octyl phthalate	µg/kg dw	58 mg/kg OC	4,500 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Phenols						
Phenol	µg/kg dw	420	1,200	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20
2-Methylphenol	µg/kg dw	63	63	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20
4-Methylphenol	µg/kg dw	670	670	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20
2,4-Dimethylphenol	µg/kg dw	29	29	EPA 3546 (dichloromethane/acetone)	EPA 8270E-SIM[d]	20
Pentachlorophenol	µg/kg dw	360 mg/kg OC	690 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8270E	100 (10 mg/kg OC)
Other SVOCs						
Benzyl alcohol	µg/kg dw	57	73	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20
Benzoic acid	µg/kg dw	650	650	EPA 3546 (dichloromethane/acetone)	EPA 8270E	200
Dibenzofuran	µg/kg dw	15 mg/kg OC	58 mg/kg OC[d]	EPA 3546 (dichloromethane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Hexachlorobutadiene	µg/kg dw	3.9 mg/kg OC	6.2 mg/kg OC	EPA 3546 (dichloromethane/acetone)	EPA 8081B	0.5 (0.05 mg/kg OC)
n-Nitrosodiphenylamine	µg/kg dw	11 mg/kg OC	11 mg/kg OC	EPA 3546 (hexane/acetone)	EPA 8270E	20 (2 mg/kg OC)
Total PCB Aroclors	**µg/kg dw**	**12 mg/kg OC**	**65 mg/kg OC**	EPA 3546 (dichloromethane/acetone)	**EPA 8082A**	**20 (2 mg/kg OC)**
Dioxin/Furan congeners	**ng/kg dw**	**nc**	**nc**	EPA 3546 (hexane/acetone)	**EPA 1613b**	**1.0[e]**

Parameter	Unit	SMS Criteria		Extraction Method	Analysis Method	Target RL[a,b]
		SCO	CSL			
PCB congeners	**ng/kg dw**	**nc**	**nc**	EPA 1613b (toluene)	**EPA 1668c**	**12.0[f]**
Specific gravity	none	**nc**	**nc**	EPA 1668c (dichloromethane)	ASTM D854	**nc**
Atterberg Limits	% water	**nc**	**nc**	na	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] EPA 8270-SIM is required when the RLs for EPA 8270 are not sufficient to meet the SCO.

[e] Value listed is ARL's LOQ for 2,3,7,8-TCDD. Individual congener LLOQs are provided in Attachment B2. The LLOQ is ARL'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.

[f] 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 B2. The reported LMCL will be adjusted based on the mass of each sample.

ARL – Analytical Resources, LLC
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
J – estimated concentration
LMCL – lower method calibration limit
LLOQ – lower limit of quantitation
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
na – not applicable
nc – no criteria
OC – organic carbon
PCB – polychlorinated biphenyl
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	60 g	4-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	25 g	
	2 years; 28 days for mercury	freeze, -18ºC		
SVOCs and PCB Aroclors	14 days until extraction	cool/0 to 6ºC	100 g	8-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	100 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

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

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

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 SMS screening levels. When analyzing semivolatile organic compounds (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 triplicate 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 1941b	1 per batch or SDG	1 triplicate 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 D540	1 per batch or SDG	1 per batch or SDG	1 per batch or SDG	1 per batch or SDG	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 – PSR material	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 -– PSR material	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 – PSR	1 per batch or SDG	1 per batch or SDG	na	na	1 per prep batch	every sample

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 ARL and qualified as estimated.

ARL – Analytical Resources, LLC
CRM – certified reference material
ERA – Waters ERA
LCS – laboratory control sample
MS – matrix spike
MSD – matrix spike duplicate
na – not applicable
NIST – National Institute of Standards and Technology
PCB – polychlorinated biphenyl
PSR – Puget Sound Reference
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%	17–197%[c]	95%
PCBs congeners	± 35% RPD	50–150%	15–150%[c]	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, as well as 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 DATA MANAGEMENT PROCEDURES

The laboratory will prepare a detailed report that documents all activities associated with 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 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/QC Summary:** This portion of the report will include the results of all QA/QC analyses, specifically recovery and precision information. LCSs will be reported with each batch, when applicable, as listed in Table 6-3. Additional QA/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.

Data management procedures for the project database are provided in Appendix A of the T-91 FS work plan.

Sediment data will be submitted to Ecology after the data have been validated. Chemistry data will be provided in Environmental Information Management format. The chemical laboratory reports will be provided electronically as appendices.

6.4 DATA VALIDATION

Sayler will conduct Stage 2B data validation, focusing on the results from the analysis of QA/QC samples specified in Table 6-4.

7 References

Ecology. 2020. Agreed Order No. DE 24768. Washington State Department of Ecology.

Ecology. 2021. Sediment cleanup user's manual. Guidance for implementing the cleanup provisions of the sediment management standards, Chapter 173-204 WAC. Third revision December 2021. Pub. No. 12-09-057. Toxics Cleanup Program, Washington State Department of Ecology, Olympia, WA.

PSEP. 1997. Recommended guidelines for sampling marine sediment, water column, and tissue in Puget Sound. Prepared for the Puget Sound Estuary Program, US Environmental Protection Agency, Region 10. King County (METRO) Environmental Laboratory, Seattle, WA.

Preliminary SCU boundary
DNR port management agreement area
Port owned property
Tank farm affected area
Pier head line

Elevation (ft MLLW)
> 0
> -4 and ≤ 0
> -10 and ≤ -4
> -20 and ≤ -10
> -30 and ≤ -20
> -40 and ≤ -30
> -50 and ≤ -40
> -75 and ≤ -50
≤ -75

T-91
Seattle
Elliott Bay

Tank Farm Lease Parcel
Magnolia Bridge
Pier 91
Pier 90

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0 70 140 Meters

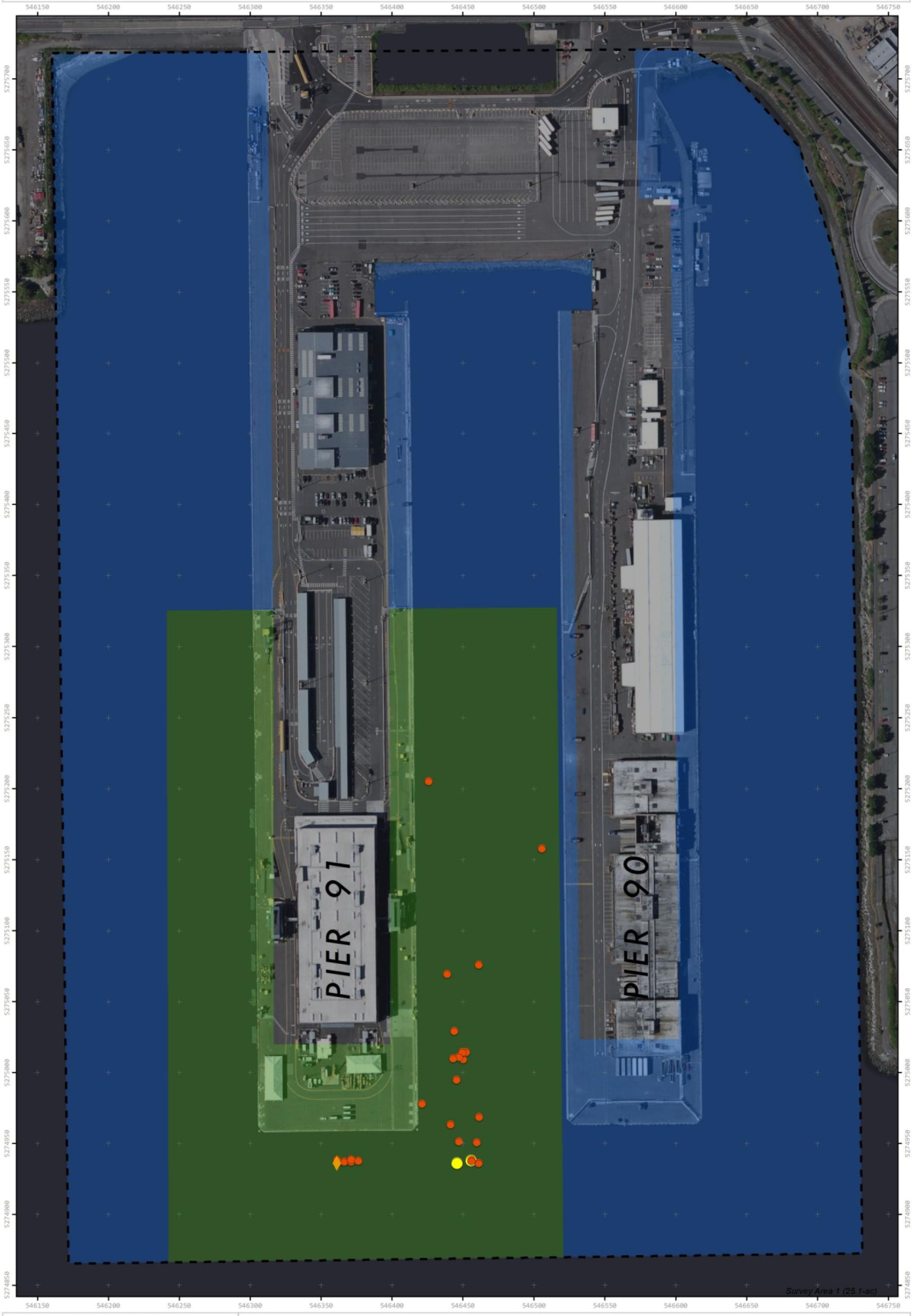
Map 1-1. SCU Map

TERMINAL 91 SEDIMENT CLEANUP UNIT:
FEASIBILITY STUDY WORK PLAN

APRIL 14, 2025

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FORMER SEATTLE NAVAL SUPPLY DEPOT MUNITIONS RESPONSE SITES



PORT OF SEATTLE
Piers 90 and 91
Elliott Bay
Seattle, WA

Map Units: Meters | Coordinate System: NAD 1983 UTM Zone 10N

Munitions Response Area (116.1-ac)
Sampling Location above LOQ
DMM Item Found On Surface
DMM Item Found Below Surface
FSNSD MRS (25.2 acres)
FSNSDa MRS (61.5 acres)

0 20 40 60 80 100 Meters
0 100 200 300 Feet

N

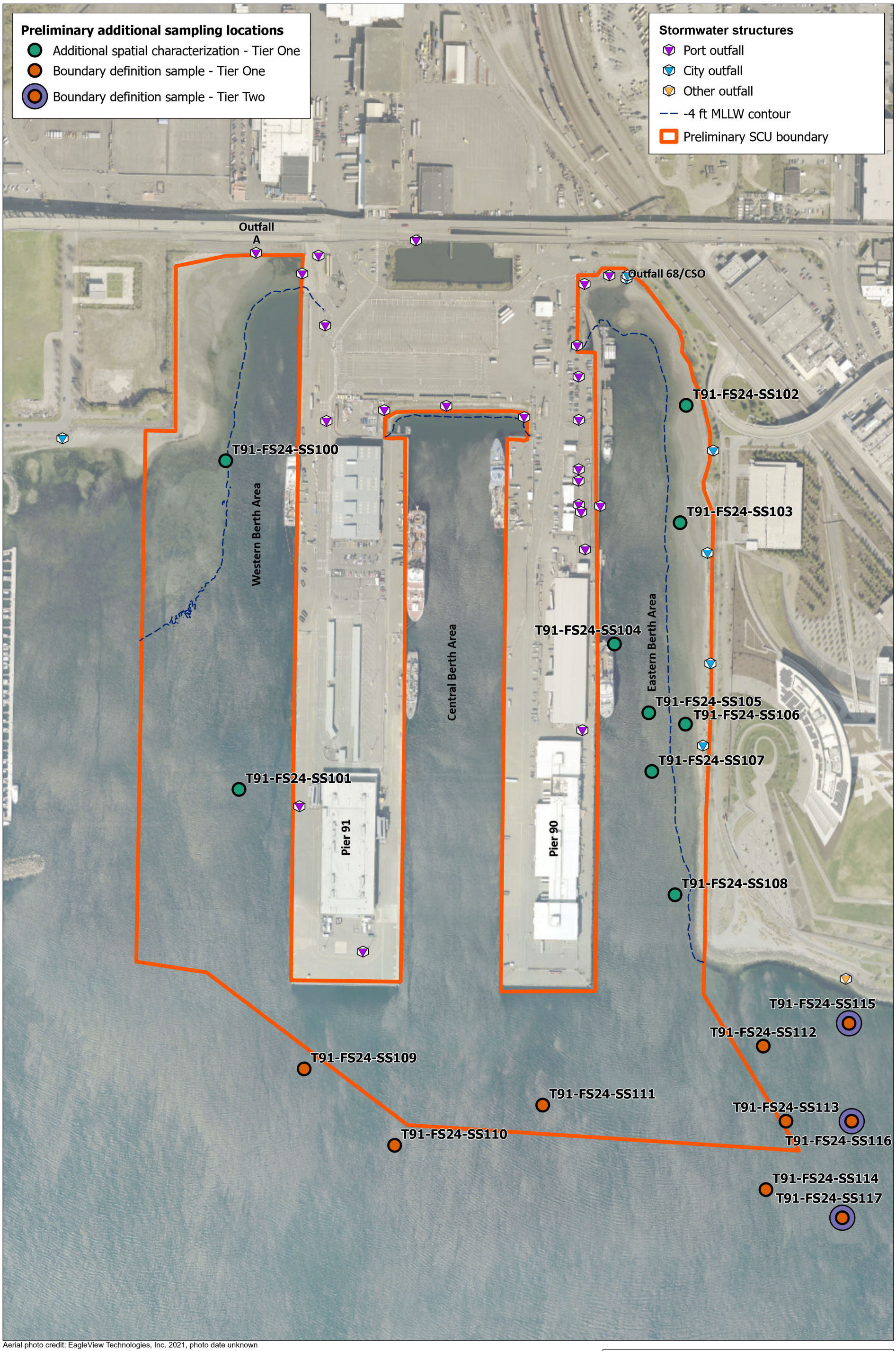
Created By	P. Hille	Checked By	GMF	Approved By	D. Jennings
On	04/08/2013	On	04/08/2013	On	04/08/2013

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Source: USACE; Former Seattle Naval Supply Depot Piers 90 and 91–Port of Seattle, Seattle, WA, Formerly Used Defense Site #F10WA012501, Remedial InvestigationDraftFinalReport; May, 2013.

Map 2-1. DMM Locations from USACE (2013)

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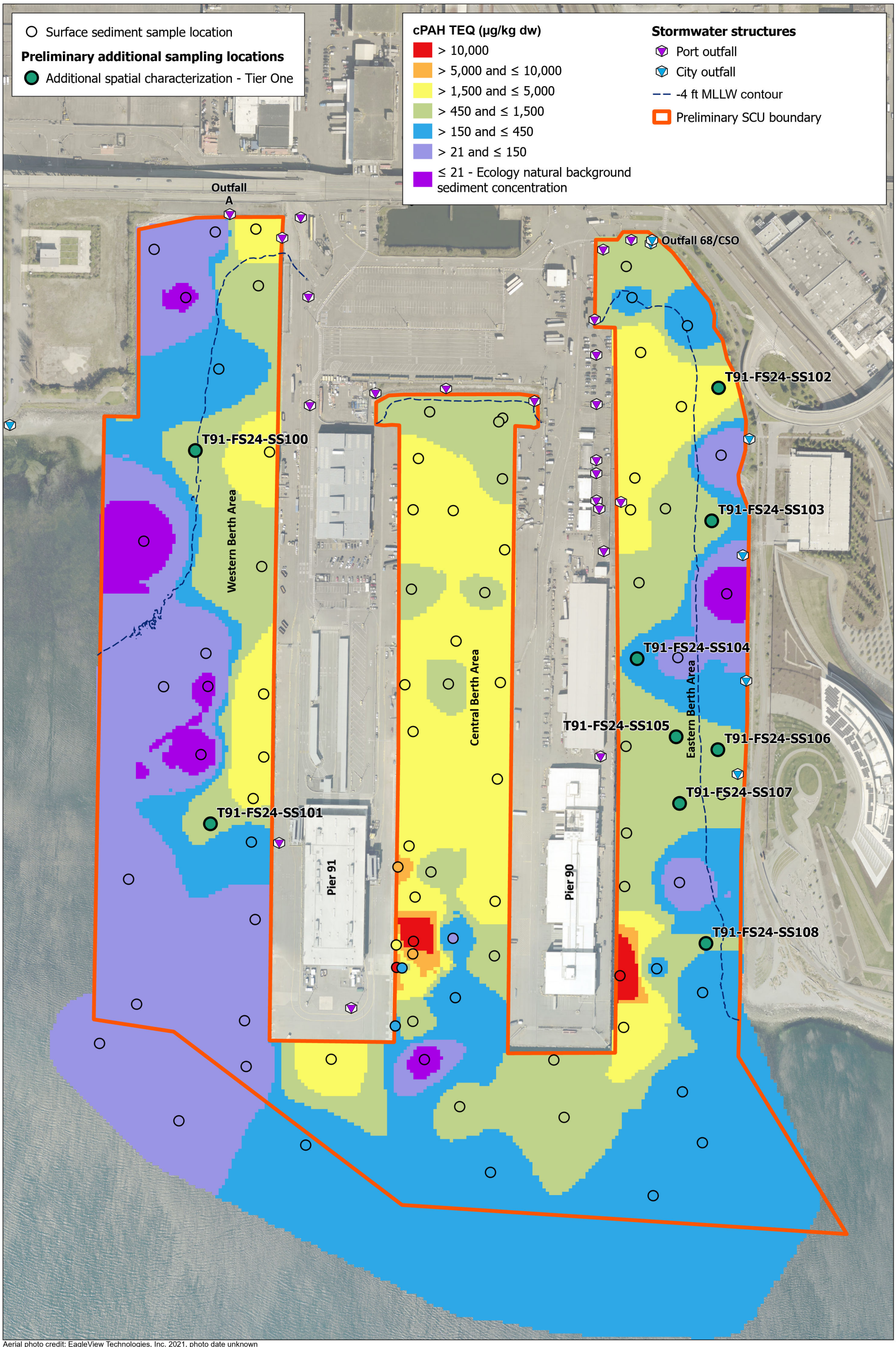
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Map 4-1. Overview of Surface Sediment Sampling Locations

TERMINAL 91 SEDIMENT CLEANUP UNIT:
FEASIBILITY STUDY WORK PLAN

APRIL 14, 2025

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Map 4-2. Surface Sediment Sampling Locations and cPAH TEQ Surface Sediment Interpolation

TERMINAL 91 SEDIMENT CLEANUP UNIT:
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Box Legend

Location Name	
Analyte	**Exceedance Factor**
Total PCBs	2.2
Mercury	1.3

Black text represents SCO exceedance and exceedance factor
Red text represents CSL exceedance and exceedance factor

*Individual PAHs represents the max EF for any individual PAH, in samples where SMS exceedances occur for any individual PAH.

Surface sediment SMS exceedance status
- > CSL exceedances
- > SCO and ≤ CSL exceedances
- No exceedances

Preliminary additional sampling locations
- Additional spatial characterization - Tier One
- Boundary definition sample - Tier One
- Boundary definition sample - Tier Two

Surface sediment total organic carbon
- < 0.5%
- > 3.5%

Stormwater structures
- Port outfall
- City outfall
- Other outfall
- -4 ft MLLW contour
- Preliminary SCU boundary

Site concentrations are OC-normalized where sediment TOC ranges between 0.5 and 3.5% and compared with SMS criteria. In cases where TOC is outside this range (i.e., < 0.5 or > 3.5%), dry weight sediment concentrations are compared to AET marine sediment criteria.

Outfall A

Outfall 68/CSO

Western Berth Area

Central Berth Area

Eastern Berth Area

Pier 91

Pier 90

T91-FS24-SS100
T91-FS24-SS101
T91-FS24-SS102
T91-FS24-SS103
T91-FS24-SS104
T91-FS24-SS105
T91-FS24-SS106
T91-FS24-SS107
T91-FS24-SS108
T91-FS24-SS109
T91-FS24-SS110
T91-FS24-SS111
T91-FS24-SS112
T91-FS24-SS113
T91-FS24-SS114
T91-FS24-SS115
T91-FS24-SS116
T91-FS24-SS117

T91-RI-SS03	
Individual PAHs*	2.7
Total HPAHs	1.4

T91-RI-SS04	
Individual PAHs*	1.7
Total HPAHs	1.9
BBP	2.5

T91-2017-SS-17	
Total PCBs	2.4
Individual PAHs*	2.4
Total HPAHs	1.4
BBP	2.2
BEHP	4.5

T91-RI-SS39	
Individual PAHs*	1.2
Mercury	1.4

T91-RI-SS40	
Individual PAHs*	3.6
Total HPAHs	4.8
Total LPAHs	3.9

T91-2017-SS-10	
Individual PAHs*	1.2

T91-RI-SS37	
Individual PAHs*	1.4
Mercury	1.1

T91-2017-SS-21	
Total PCBs	2.1
Individual PAHs*	2.2
Total HPAHs	1.7

T91-RI-SS05	
Individual PAHs*	1.8

T91-RI-SS36	
Mercury	1

T91-RI-SS35	
Total PCBs	1.1
Mercury	1.3

T91-RI-SS42	
Individual PAHs*	1.1
Total HPAHs	2
Total LPAHs	1.3

T91-2017-SS-11	
Total PCBs	1
Individual PAHs*	2.3
Total HPAHs	1
Mercury	1.4

T91-RI-SS34	
Mercury	2.8

T91-RI-SS41	
Individual PAHs*	1.6

T91-2017-SS-12	
Total PCBs	1.5
Individual PAHs*	1.2
Mercury	1.5

T91-RI-SS06	
Individual PAHs*	1.5

T91-RI-SS32	
Mercury	1.8

T91-RI-SS33	
Total PCBs	1.1
Mercury	1.3

T91-2017-SS-13	
Total PCBs	2.6
Individual PAHs*	1.8
Mercury	4.9
1,4-Dichlorobenzene	1.2

T91-RI-SS30	
Total PCBs	1.3
Individual PAHs*	1.1
Mercury	1.1

T91-RI-SS08	
Individual PAHs*	1
Total HPAHs	1.5

T91-RI-SS31	
Individual PAHs*	1.1
Total HPAHs	1.1
Mercury	1.3
2,4-Dimethylphenol	1.4

T91-2017-SS-14	
Total PCBs	2.5
Individual PAHs*	2.4
Mercury	1.4
2,4-Dimethylphenol	2

T91-RI-SS29	
Total PCBs	2.5
Individual PAHs*	1.1
Mercury	1.5
1,4-Dichlorobenzene	1.3

T91-RI-SS09	
Individual PAHs*	1.8
Total HPAHs	1.6

T91-2017-SS-06	
Total PCBs	1.8
Individual PAHs*	1.4
Total HPAHs	1.9
1,4-Dichlorobenzene	1

T91-2017-SS-15	
Total PCBs	1.7
Individual PAHs*	2.2
Total HPAHs	1.6

T91-RI-SS28	
Total PCBs	1.9
Individual PAHs*	1.2
Total HPAHs	1.5
1,4-Dichlorobenzene	1.9

T91-16-SS10	
Total PCBs	2.2
Individual PAHs*	1.2
Total HPAHs	2.2
Mercury	1.3
1,4-Dichlorobenzene	2.8
BEHP	1.2

T91-RI-SS45	
Individual PAHs*	1.5

T91-16-SS15	
Total PCBs	1.4
Individual PAHs*	1.3
Total HPAHs	1.3
1,4-Dichlorobenzene	1.2

T91-RI-SS10	
Total PCBs	3.7

T91-16-SS16	
Total PCBs	2.3
Individual PAHs*	1.3
1,4-Dichlorobenzene	1.5

T91-16-SS13	
Total PCBs	2
Individual PAHs*	11
Total HPAHs	3.6
Total LPAHs	2
Mercury	2
1,4-Dichlorobenzene	1.1
BEHP	1.6

T91-RI-SS27	
Total PCBs	1.1
Individual PAHs*	1.8
Total HPAHs	2

T91-2018-SS31	
Total PCBs	1.4
Individual PAHs*	1.5
Total HPAHs	1
1,4-Dichlorobenzene	2.6

T91-16-SS8	
Total PCBs	1.3
Individual PAHs*	20
Total HPAHs	11
Total LPAHs	3.3
Mercury	2.1
1,4-Dichlorobenzene	22
2,4-Dimethylphenol	2.9

T91-2017-SS-16	
Total PCBs	1.2
Individual PAHs*	1.6

T91-16-SS12	
Total PCBs	4.4
Individual PAHs*	5.5
Total HPAHs	2.6
Arsenic	1.2
Lead	1.5
Mercury	2.9
Zinc	2
1,4-Dichlorobenzene	5.4
2,4-Dimethylphenol	1.5

T91-2017-SS-28	
Individual PAHs*	5.4
Total HPAHs	2
Total LPAHs	1.6

T91-RI-SS25	
Arsenic	1.1

T91-RI-SS24	
Mercury	3.1

T91-16-SS7	
Total PCBs	1.2

T91-16-SS9	
Individual PAHs*	1.1
1,4-Dichlorobenzene	1.3

T91-RI-SS47	
Total PCBs	1.3
Individual PAHs*	2.1
Total HPAHs	1.1

T91-RI-SS13	
Zinc	3

T91-RI-SS17	
Individual PAHs*	1.2
Mercury	1.4

T91-RI-SS14	
Mercury	1.4

T91-RI-SS21	
Mercury	1.2

T91-RI-SS20	
Individual PAHs*	1.7

T91-RI-SS19	
Mercury	1.7
Total PCBs	1.1

T91-RI-SS18	
Total PCBs	1.1

T91-RI-SS50	
Mercury	1.3

T91-RI-SS54	
Mercury	1.4

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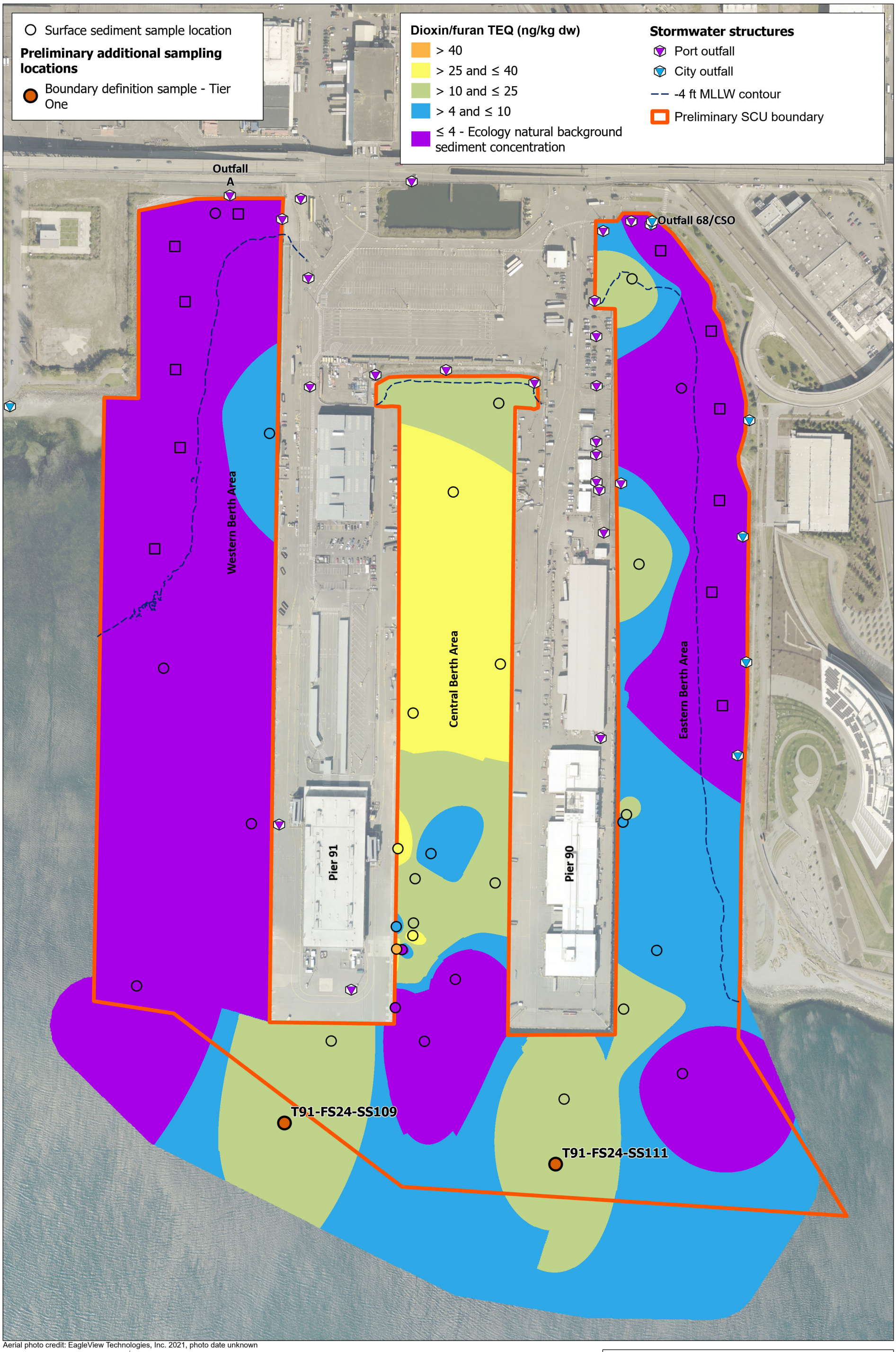
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Map 4-3. Surface Sediment Sampling Locations and Benthic SMS Exceedances in Surface Sediment

TERMINAL 91 SEDIMENT CLEANUP UNIT:
FEASIBILITY STUDY WORK PLAN

APRIL 14, 2025

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Windward environmental LLC

N

0 50 100 Yards

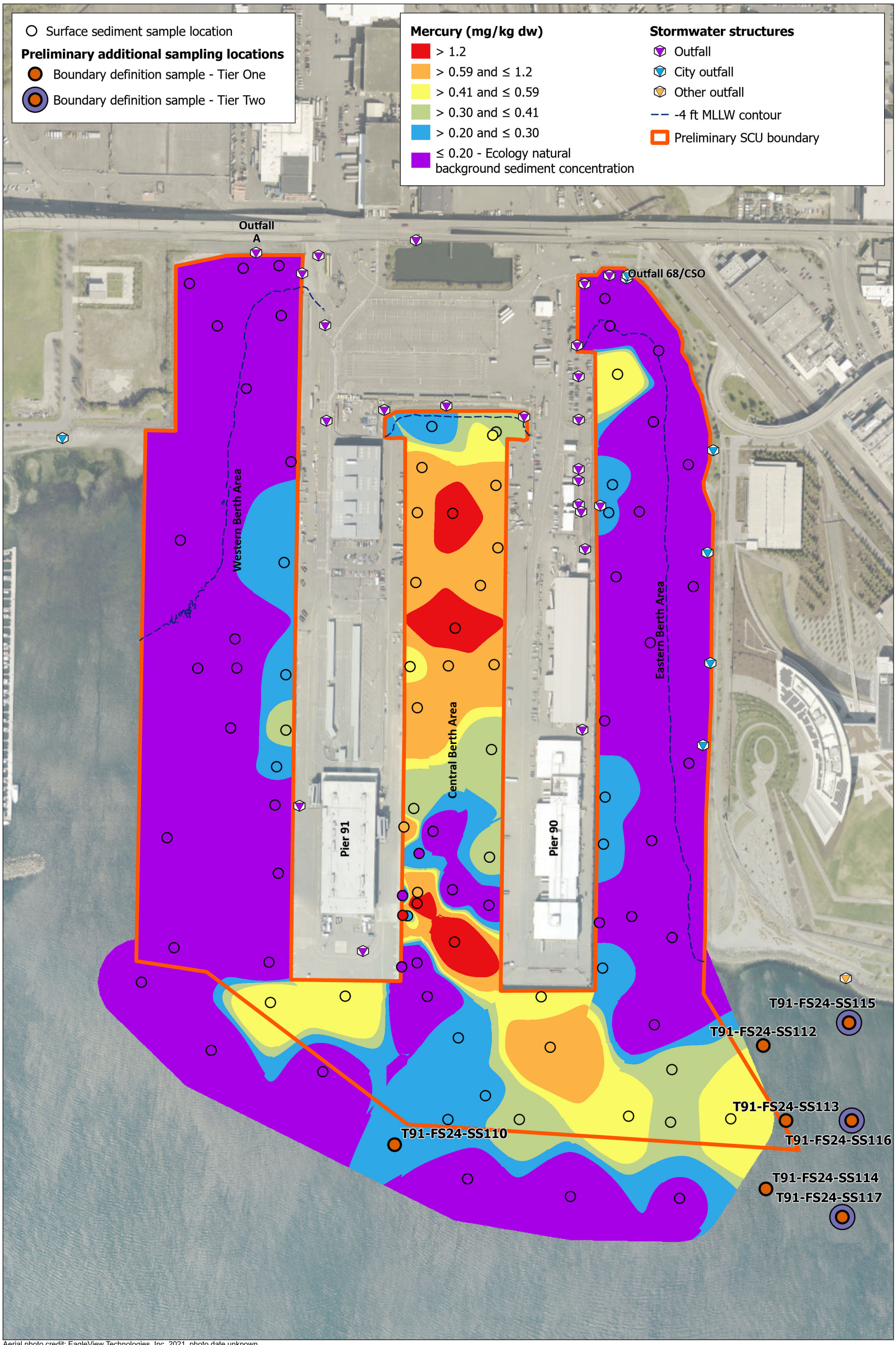
0 50 100 Meters

Map 4-4. Surface Sediment Sampling Locations and Dioxin/Furan TEQ Surface Sediment Interpolation

TERMINAL 91 SEDIMENT CLEANUP UNIT: FEASIBILITY STUDY WORK PLAN

APRIL 14, 2025

Prepared by nicolase, 5/6/2025; W:\Projects\Port of Seattle - T-9' RIFS\GIS\Maps and Analyses\FS Workplan\Sampling\T91 FS Sampling.aprx



Aerial photo credit: EagleView Technologies, Inc. 2021, photo date unknown

Windward environmental LLC

N

0 50 100 Yards

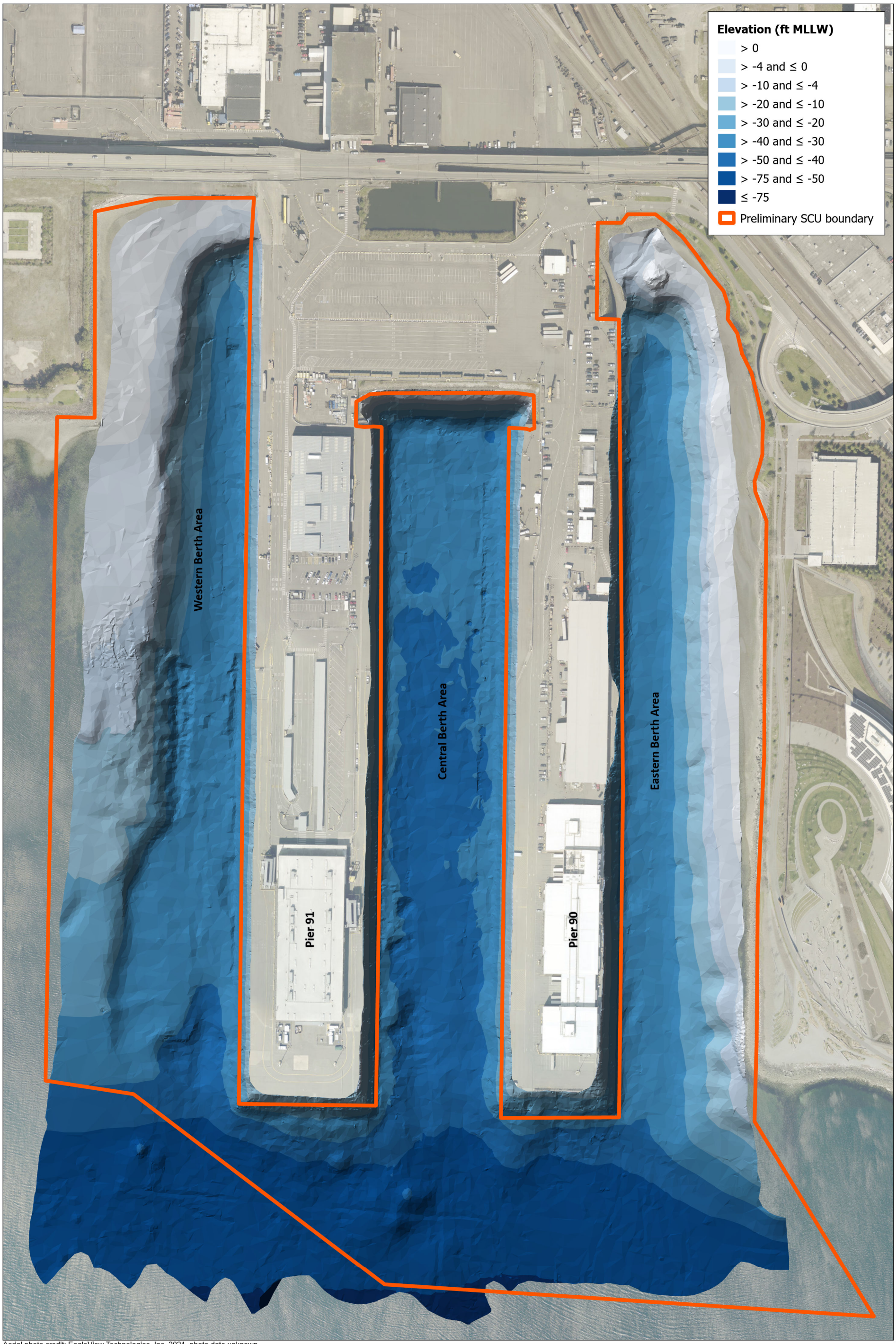
0 50 100 Meters

Map 4-5. Surface Sediment Sampling Locations and Mercury Surface Sediment Interpolation

TERMINAL 91 SEDIMENT CLEANUP UNIT:
FEASIBILITY STUDY WORK PLAN

APRIL 14, 2025

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Windward environmental LLC

N

0 50 100 Yards

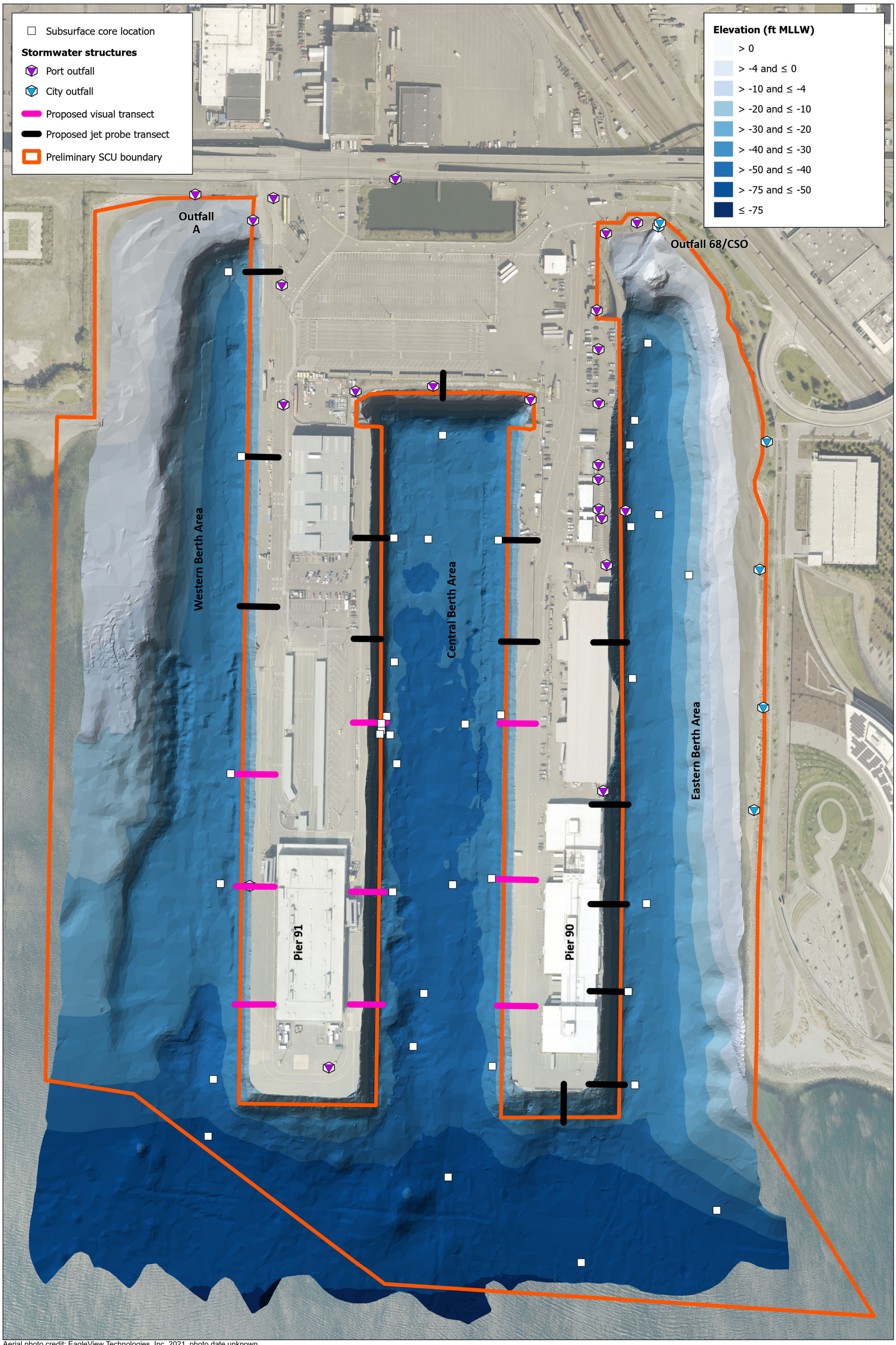
0 50 100 Meters

Map 4-6. T-91 Bathymetry

TERMINAL 91 SEDIMENT CLEANUP UNIT:
FEASIBILITY STUDY WORK PLAN

APRIL 14, 2025

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Aerial photo credit: EagleView Technologies, Inc. 2021, photo date unknown

Windward environmental LLC

N

0 40 80 Yards

0 40 80 Meters

Map 4-7. Preliminary Transects for Diver Surveys

TERMINAL 91 SEDIMENT CLEANUP UNIT:
FEASIBILITY STUDY WORK PLAN

APRIL 14, 2025

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Attachment B1. Field Forms

- Form 1 – Surface Sediment Collection Form
- Form 2 – Protocol Modification Form
- Form 3 – Sediment Core Collection Form
- Form 4 – Sediment Core Processing Form

FORM 1. SURFACE SEDIMENT COLLECTION FORM

SURFACE SEDIMENT COLLECTION FORM

Project Name: _____ **Project no.:** _____

Date: _____ **Weather:** _____

Sampling Method: _____ **Crew:** _____

GRAB DATA	**Location ID:**				
Latitude/Northing(Y):				**Longitude/Easting(X):**	
Grab time	**Bottom depth (m or ft)**	**Penetration depth (cm)**	**Acceptable grab (Y/N)**	**Benthic Community Subsample ID**	**Comments**
SAMPLE DATA	**Sample ID:**				
Pre-homogenization analyses (circle): VOC Sulfides Ammonia AVS/SEM TPH-P Other:					

Sediment type	**Sediment color**	**Sediment odor**		**Comments:**
cobble	brown surface	none	H_2S	
gravel	drab olive	slight	petroleum	
sand (F M C)	brown	moderate	other:	
silt	gray	strong		
clay	black			

FORM 2: PROTOCOL MODIFICATION FORM

Project Name and Number: _____

Material to be Sampled: _____

Measurement Parameter: _____

Standard Procedure for Field Collection & Laboratory Analysis (cite reference):

Reason for Change in Field Procedure or Analysis Variation: _____

Variation from Field or Analytical Procedure: _____

Special Equipment, Materials or Personnel Required: _____

Initiator's Name: _____ Date: _____

Project Officer: _____ Date: _____

QA Officer: _____ Date: _____

FORM 3

Windward environmental LLC

Sediment Core Collection Form

Page ___ of ___

Project: | **Location ID:**
Date: | **Attempt No.:**
Weather: | **Core Type:** Intertidal Subtidal Shoaling
Logged By: | **Field Staff:**

Field Collection Coordinates:
Lat/Northing: | Long/Easting:

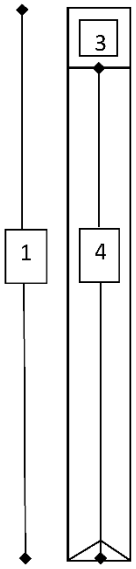
A. Water Depth
DTM Depth Sounder:
DTM Lead Line:

B. Water Level Measurements
Time:
Height:
Source:

C. Mudline Elevation (ft MLLW)

Core Collection Recovery Details:
1. Core Tube Length:
2. Penetration Depth:
3. Headspace Measurement:
4. Recovery Depth:
5. Recovery Percentage:
6. Core Accepted: Yes / No

Recovery Measurements (prior to cuts)



Core Sections To Process:
A:
B:
C:
D:

Drive Notes:

Shoe Description:

Core Field Observations and Description:	Sediment type, moisture, color, minor modifier, MAJOR modifier, other constituents, odor, sheen, layering, anoxic layer, debris, plant matter, shells, biota

Notes:

FORM 4

Windward environmental LLC

Sediment Core Processing Form

Project:	**Core Type:** Intertidal Subtidal Shoaling
Date:	**Penetration Depth:**
Processed By:	**Compacted Depth:**
Location ID:	**Compaction-Correction Factor:**
Attempt No.:	

Recovery Depth	Correction Depth	Sample ID		**Sample Description and Notes** (Sediment type, moisture, color, minor modifier, MAJOR modifier, other constituents, odor, sheen, layering, anoxic layer, debris, plant matter, shells, biota)

Page_____ of _____

FINAL

Attachment B2. PCB and Dioxin/Furan Reporting Limits

Table 1. PCB reporting limits

Analyte	EPA Method 3540C/1668C Sediment (ng/kg dw) Based on 10-g dw Sample	
	MDL	LOQ
PCB-1	0.667	2.00
PCB-2	0.667	4.00
PCB-3	0.667	2.00
PCB-4	0.667	4.00
PCB-5	0.667	4.00
PCB-6	0.667	4.00
PCB-7	0.667	4.00
PCB-8	0.667	4.00
PCB-9	0.667	4.00
PCB-10	0.667	4.00
PCB-11	1.98	25.0
PCB-12/13	1.41	8.00
PCB-14	0.667	4.00
PCB-15	0.667	4.00
PCB-16	0.667	2.00
PCB-17	0.667	2.00
PCB-19	0.667	2.00
PCB-21/33	1.33	4.00
PCB-22	0.667	2.00
PCB-23	0.667	2.00
PCB-24	0.667	2.00
PCB-25	0.667	2.00
PCB-26/29	1.33	4.00
PCB-27	0.667	2.00
PCB-28/20	1.33	4.00
PCB-30/18	1.33	4.00
PCB-31	0.667	2.00
PCB-32	0.667	2.00
PCB-34	0.667	2.00
PCB-35	0.667	2.00
PCB-36	0.667	2.00
PCB-37	0.667	2.00
PCB-38	0.667	2.00
PCB-39	0.667	2.00
PCB-40/71	1.33	4.00

Table 1. PCB reporting limits

Analyte	EPA Method 3540C/1668C Sediment (ng/kg dw) Based on 10-g dw Sample	
	MDL	LOQ
PCB-41	0.667	2.00
PCB-42	0.667	2.00
PCB-43	0.667	2.00
PCB-44/47/65	0.846	2.00
PCB-45/51	1.33	4.00
PCB-46	0.667	2.00
PCB-48	0.667	2.00
PCB-50/53	1.33	4.00
PCB-52	0.667	2.00
PCB-54	0.667	2.00
PCB-55	0.667	2.00
PCB-56	0.667	2.00
PCB-57	0.667	2.00
PCB-58	0.667	2.00
PCB-59/62/75	2.00	6.00
PCB-60	0.667	2.00
PCB-61/70/74/76	2.67	8.00
PCB-63	0.667	2.00
PCB-64	0.667	2.00
PCB-66	0.667	2.00
PCB-67	0.667	2.00
PCB-68	1.33	4.00
PCB-69/49	1.33	4.00
PCB-72	0.667	2.00
PCB-73	0.667	2.00
PCB-77	0.667	2.00
PCB-78	0.667	2.00
PCB-79	0.667	2.00
PCB-80	0.667	2.00
PCB-81	0.667	2.00
PCB-82	0.667	2.00
PCB-83	0.667	2.00
PCB-84	0.667	2.00
PCB-88/91	1.33	4.00
PCB-89	0.667	2.00

Table 1. PCB reporting limits

Analyte	EPA Method 3540C/1668C Sediment (ng/kg dw) Based on 10-g dw Sample	
	MDL	LOQ
PCB-92	0.667	2.00
PCB-93/100	1.33	4.00
PCB-94	0.667	2.00
PCB-95	0.667	2.00
PCB-96	0.667	2.00
PCB-98/102	1.33	4.00
PCB-99	0.667	2.00
PCB-103	0.667	2.00
PCB-104	0.667	2.00
PCB-105	0.667	2.00
PCB-106	0.667	2.00
PCB-107	0.667	2.00
PCB-108/124	1.33	4.00
PCB-109/119/86/97/125/87	4.00	12.0
PCB-110/115	1.33	4.00
PCB-111	0.667	2.00
PCB-112	0.667	2.00
PCB-113/90/101	2.00	6.00
PCB-114	0.667	2.00
PCB-117/116/85	2.00	6.00
PCB-118	0.667	2.00
PCB-120	0.667	2.00
PCB-121	0.667	2.00
PCB-122	0.667	2.00
PCB-123	0.667	2.00
PCB-126	0.667	2.00
PCB-127	0.667	2.00
PCB-128/166	1.33	4.00
PCB-130	0.667	2.00
PCB-131	0.667	2.00
PCB-132	0.667	2.00
PCB-133	0.667	2.00
PCB-134	0.667	2.00
PCB-136	0.667	2.00
PCB-137	0.667	2.00

Table 1. PCB reporting limits

Analyte	EPA Method 3540C/1668C Sediment (ng/kg dw) Based on 10-g dw Sample	
	MDL	LOQ
PCB-138/163/129	2.00	6.00
PCB-139/140	1.33	4.00
PCB-141	0.667	2.00
PCB-142	0.667	2.00
PCB-143	0.667	2.00
PCB-144	0.667	2.00
PCB-145	0.667	2.00
PCB-146	0.667	2.00
PCB-147/149	1.33	4.00
PCB-148	0.667	2.00
PCB-150	0.667	2.00
PCB-151/135	1.33	4.00
PCB-152	0.667	2.00
PCB-153/168	1.33	4.00
PCB-154	0.667	2.00
PCB-155	0.667	2.00
PCB-156/157	1.33	4.00
PCB-158	0.667	2.00
PCB-159	0.667	2.00
PCB-160	0.667	2.00
PCB-161	0.667	2.00
PCB-162	0.667	2.00
PCB-164	0.667	2.00
PCB-165	0.667	4.00
PCB-167	0.667	2.00
PCB-169	0.667	2.00
PCB-170	0.667	2.00
PCB-171/173	1.33	4.00
PCB-172	0.667	2.00
PCB-174	0.667	2.00
PCB-175	0.667	2.00
PCB-176	0.667	2.00
PCB-177	0.667	2.00
PCB-178	0.667	2.00
PCB-179	0.667	2.00

Table 1. PCB reporting limits

Analyte	EPA Method 3540C/1668C Sediment (ng/kg dw) Based on 10-g dw Sample	
	MDL	LOQ
PCB-180/193	1.33	4.00
PCB-181	0.667	2.00
PCB-182	0.667	2.00
PCB-183/185	1.33	4.00
PCB-184	0.667	2.00
PCB-186	0.667	2.00
PCB-187	0.667	2.00
PCB-188	0.667	2.00
PCB-189	0.667	2.00
PCB-190	0.667	2.00
PCB-191	0.667	2.00
PCB-192	0.667	2.00
PCB-194	0.667	2.00
PCB-195	0.667	2.00
PCB-196	0.667	2.00
PCB-197/200	1.33	4.00
PCB-198/199	1.33	4.00
PCB-201	0.667	2.00
PCB-202	0.667	2.00
PCB-203	0.667	2.00
PCB-204	0.667	2.00
PCB-205	0.667	2.00
PCB-206	0.667	2.00
PCB-207	0.667	2.00
PCB-208	0.667	2.00
PCB-209	0.667	2.00

dw – dry weight
EPA – US Environmental Protection Agency
LOQ – limit of quantification
MDL – method detection limit
PCB – polychlorinated biphenyl

Table 2. Dioxin/furan reporting limits

Analyte	EPA Method 1613B			
	Sediment (ng/kg dw) Based on 10-g Sample		TEQ (ng/kg)	
	EDL[a]	LOQ[b]	TEF	TEQ[c]
2,3,7,8-TCDD	0.1	1.0	1	0.5
1,2,3,7,8-PeCDD	0.1	1.0	1	0.5
1,2,3,4,7,8-HxCDD	0.1	1.0	0.1	0.05
1,2,3,6,7,8-HxCDD	0.1	1.0	0.1	0.05
1,2,3,7,8,9-HxCDD	0.1	1.0	0.1	0.05
1,2,3,4,6,7,8-HpCDD	0.1	2.5	0.01	0.0125
OCDD	01	5.0	0.0003	0.0015
2,3,7,8-TCDF	0.1	1.0	0.1	0.05
1,2,3,7,8-PeCDF	01	1.0	0.03	0.015
2,3,4,7,8-PeCDF	0.1	1.0	0.3	0.15
1,2,3,4,7,8-HxCDF	0.1	1.0	0.1	0.05
1,2,3,6,7,8-HxCDF	0.1	1.0	0.1	0.05
1,2,3,7,8,9-HxCDF	0.1	1.0	0.1	0.05
2,3,4,6,7,8-HxCDF	0.1	1.0	0.1	0.05
1,2,3,4,6,7,8-HpCDF	0.1	1.0	0.01	0.005
1,2,3,4,7,8,9-HpCDF	0.1	1.0	0.01	0.005
OCDF	0.1	2.5	0.0003	0.000375

[a] EDL is a sample-specific DL. The value provided here is an estimate, and the sample-specific values will vary based on sample mass and the analytical conditions at the time of analysis.

[b] LOQ is ARL'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

[c] TEQ calculated using ½ RL value multiplied by the 2005 WHO TEF.

ARL – Analytical Resources, LLC.
DL – detection limit
dw – dry weight
EDL – estimated detection limit
EPA – US Environmental Protection Agency
J – estimated
LOQ – limit of quantitation
HpCDF – heptachlorodibenzofuran
HxCDF – hexachlorodibenzofuran
HpCDD – heptachlorodibenzo-*p*-dioxin
HxCDD – hexachlorodibenzo-*p*-dioxin
LMCL – lower method calibration limit
OCDD – octachlorodibenzo-*p*-dioxin
OCDF – octachlorodibenzofuran
PeCDD – pentachlorodibenzo-*p*-dioxin
PeCDF – pentachlorodibenzofuran
RL – reporting limit
TCDD – tetrachlorodibenzo-*p*-dioxin
TCDF – tetrachlorodibenzofuran
TEF – toxic equivalency factor
TEQ – toxic equivalent
WHO – World Health Organization

STANDARD OPERATING PROCEDURE

FOR

THE ANALYSIS OF POLYCHLORINATED BIPHENYLS (PCBs)

BY

HIGH-RESOLUTION GAS CHROMATOGRAPHY/HIGH-RESOLUTION MASS SPECTROMETRY (HRGC/HRMS)

(CF-OA-E-003)

APPLICABLE TO METHOD:
EPA Method 1668A and C

PROPRIETARY INFORMATION

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Process Owner	(Sign)	Walter M. Larkins (Print Name)
Quality Review	(Sign)	Coleman Corzine (Print Name)
Laboratory Director	(Sign)	Christopher K. Cornwell (Print Name)

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1.0 STANDARD OPERATING PROCEDURE FOR THE ANALYSIS OF POLYCHLORINATED BIPHENYLS (PCB) BY HIGH-RESOLUTION GAS CHROMATOGRAPHY/HIGH-RESOLUTION MASS SPECTROMETRY (HRGC/HRMS)

2.0 METHOD OBJECTIVE, PURPOSE, CODE AND SUMMARY

This standard operating procedure (SOP) covers the analytical determination of PCBs according to EPA Method 1668, Revisions A & C.

3.0 APPLICABLE MATRICES

Applicable matrices include groundwater, wastewater, surface water, leachate, soil, sediment, sludge, oil, and tissue.

4.0 METHOD SCOPE, APPLICABILITY AND DETECTION LIMIT

4.1 Method 1668 may be used to quantify PCBs that are soluble in methylene chloride and/or toluene. The compounds are separated using a gas chromatograph (GC) and detected using a high-resolution double focusing mass spectrometer (HRMS). Appendix 1 lists the analytes currently analyzed using these methods and their practical quantitation limits.

4.2 The practical quantitation limit (PQL) is the lowest level in the calibration curve. The PQL is the lowest level at which compounds may be accurately quantitated and is compound dependent. The calibration curve typically ranges from 0.5 ng/mL to 2000 ng/mL. These ranges reflect instrument readings, which are in ng/mL (ppb). It should be noted that the calibration range may vary between calibrations and instruments.

4.3 Method detection limit studies (MDLs) are performed and/or verified on an annual basis. MDLs are done for aqueous, solid, and tissue matrices. For more information regarding MDLs, refer to The Determination of Method Detection Limits, CF-LB-E-001.

4.4 Qualified analysts must demonstrate proficiency initially and annually thereafter with an IDOC, CDOC or PT study. Acceptability criteria may be found in the analytical method.

4.4.1 To establish the ability to generate acceptable accuracy and precision, the analyst should perform an "analyst validation study" or Initial Demonstration of Capability. Four LCS standards are extracted and analyzed. Calculate the average recovery and the standard deviation of the recovery for each analyte of interest using the four results. Then compare the average and the standard deviation with the corresponding criteria found in Table 6 of Method 1668A or C as appropriate. If the average and the standard deviation for all analytes of interest meet the acceptance criteria, then the analyst may begin work on actual samples. If the validation study fails for one or more of the compounds, then the study must be repeated for those compounds which failed.

5.0 METHOD VARIATIONS

5.1 Sample extracts are stored at room temperature to avoid analyte loss. Many of the target analytes in these methods form a strong cohesive bond with solids such as glass in cold temperatures; this type of analyte loss is not addressed in the method. (This is a variance from the following method recommendations: -10° to -20° C per DoD QSM.)

5.2 The analytical method does not address the reporting of EDL and EMPC. These values are reported only when requested by the client.

5.3 Project specific modifications are allowed to meet the data quality objectives of the Delaware River Basin Commission.

6.0 DEFINITIONS

6.1 Accuracy: The degree of agreement between an observed value and an accepted reference value.

6.2 AlphaLIMS: The Laboratory Information Management System used at CFA, LLC.

6.3 Blank: An aliquot of reagent water or other blank matrix that is treated exactly as a sample including exposure to all glassware, equipment, solvents, reagents, and standard additions that are used with other samples. The LMB (Lab Method Blank) is used to determine if method analytes or other interferences are present in the laboratory environment, the reagents, or the apparatus. Contamination may be derived during sampling, transportation, storage or analysis. The blank may be used to establish a background value.

6.4 Calibration Standard (CAL): An aliquot of a primary standard solution or stock standard solution. The CAL solutions are used to calibrate the instrument response with respect to analyte concentration.

6.5 Calibration Verification Standard (CVS, CCAL): A solution of target analytes with a concentration near the mid-point of the calibration range. It should be obtained from a second source vendor and is used to verify the initial calibration on a basis described in the determinative method.

6.6 Cleanup Standards: Isotopes added prior to cleanup that are used to measure the efficiency of the fractionation step alone. Method 1668 uses three compounds as the Cleanup Standards.

6.7 Duplicate Analysis: The analysis or measurement of the variable of interest performed identically on two field subsamples of the same sample. The results from duplicate analyses are used to evaluate analytical or measurement precision of sample, preservation, or storage internal to the laboratory.

6.8 Estimated Detection Limit (EDL): A calculation of the concentration of a given analyte required to produce a signal with a peak height of at least 2.5 times the background signal level. The EDL is calculated for each congener that is not identified.

6.9 Estimated Maximum Possible Concentration (EMPC): A calculation for a peak characterized by a response with a signal-to-noise ratio of at least 2.5 for both the quantitation ions, and meeting all identification criteria except ion ratio. EMPC is a worst-case estimate of the concentration.

6.10 Extraction Standards: Isotopes added prior to extraction that serve as internal standards for many PCB congeners. In addition, to measure the overall extraction and fractionation efficiencies. Method 1668 names them Labeled Compounds.

6.11 Injection Standards: Isotopes added prior to injection to determine the recoveries of the Extraction and Cleanup Standards. Method 1668 calls them Internal Standards.

6.12 Internal Standard (ISTD): A known amount of standard added to a test portion of a sample as a reference for evaluating the retention time and concentration of dependent analytes and controlling the precision and bias of the applied analytical method.

6.13 Laboratory Control Standard/Duplicate (LCS/LCSD): Aliquots of reagent water or other blank matrix to which known quantities of the method analytes are added in the

laboratory. The LCS/LCSD are analyzed exactly like a sample, and the purpose is to determine whether the methodology is in control, and whether the laboratory is capable of making accurate and precise measurements.

6.14 Laboratory Duplicate (DUP): Aliquots of a sample taken from the same container and processed in the same manner under identical laboratory conditions. The aliquot is analyzed independently from the parent sample and the results are compared to measure precision and accuracy.

6.15 Matrix Spike and Matrix Spike Duplicate (MS and MSD): Two separate aliquots of an environmental sample to which known quantities of the method analytes are added in the laboratory. The MS and MSD are analyzed exactly like a sample, and their purpose is to determine whether the sample matrix contributes bias to the analytical results. The concentrations of the analytes in the sample matrix must be determined in a separate aliquot and the measured values in the MS/MSD adjusted. Percent recovery is calculated for both aliquots, and RPD is calculated between the two.

6.16 Method Detection Limit (MDL): The minimum concentration of an analyte that can be identified, measured and reported with 99% confidence that the analyte concentration is greater than zero.

6.17 Precision: The degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves, a data quality indicator. Precision is usually expressed as standard deviation, variance or range in either absolute or relative terms.

6.18 Quantitation Limits (also PQL, RL): The value at which an instrument can accurately measure an analyte at a specific concentration (i.e., a specific numeric concentration can be quantified). These points are primarily established by the upper and lower limits of the linear calibration range, but may be elevated as needed.

7.0 INTERFERENCES/LIMITATIONS

7.1 Contaminants found in extraction glassware, solvents, and other sample processing hardware may jeopardize the integrity of this method.

7.2 Glassware must be scrupulously cleaned as soon as possible after extraction.

7.3 Contamination may also occur in the GC/MS system. High boiling materials tend to build up in the injection port and the front end of the column. The analyst should maintain a thorough working knowledge of keeping the injection port free of contamination, including changing out the septum, injection port liner, O-ring, ferrule, and gold seal.

7.4 Contamination by carryover can occur whenever high-level and low-level samples are sequentially analyzed. To reduce carryover, the sample syringe must be rinsed with solvent between samples. If carryover is suspected, potentially impacted samples should be re-analyzed after any needed maintenance, solvent replacement, and/or cleaning has been done.

8.0 SAFETY PRECAUTIONS AND WARNINGS

METHYLENE CHLORIDE IS A SUSPECTED CARCINOGEN AND A KNOWN SKIN IRRITANT.

PCBs HAVE BEEN TENTATIVELY CLASSIFIED AS KNOWN OR SUSPECTED MAMMALIAN CARCINOGENS.

CONTACT WITH OXIDIZERS MAY GENERATE EXPLOSIVE MIXTURES.

PREVENT SKIN AND EYE CONTACT BY USING SPECIFIED PERSONAL PROTECTIVE EQUIPMENT WHEN MAKING STOCK REAGENTS.

WORK UNDER A HOOD TO PREVENT INHALATION WHEN MAKING STOCK REAGENTS FROM SOLIDS.

8.1 Eye protection should be worn when handling samples, reagents, or standards. NOTE: Contact lenses pose a special problem; soft lenses may absorb irritants and all lenses concentrate them. DO NOT wear contact lenses in the laboratory.

8.2 Treat all chemicals and samples as potential health hazards and reduce exposure to these chemicals to the lowest level possible. CFA maintains a reference file of Material Safety Data Sheets (MSDS) for each chemical and standard. These documents and individual sample MSDS provided by clients are maintained in the laboratory.

8.3 Personal Protective Equipment (PPE)

8.3.1 Gloves and eye protection should be worn when handling reagents, solvents, standards and samples.

8.3.2 Analysts should prepare samples and standards under the hood.

8.4 All samples, chemicals, extracts, and extraction residues must be transferred, delivered, and disposed of safely according to all related SOPs.

8.5 Never leave gas cylinders unchained or untied.

8.6 In the event of an accident or medical emergency, call for help immediately. When time and safety permit, management should be notified of all accidents.

8.7 Fire escape routes are posted in the lab, and all personnel should be familiar with them. In addition, fire safety equipment such as fire extinguishers and fire blankets are located in the lab. Training is available on the proper operation of this equipment.

8.8 The analyst must use care when assembling and operating instrumentation. Check to see that the gas chromatograph equipment is properly assembled and hooked up to the proper gas cylinder and power, referencing the appropriate manual. Analytical equipment must only be operated by qualified personnel.

8.9 For further safety instructions, consult the Safety, Health and Chemical Hygiene Plan, CF-LB-N-001.

9.0 APPARATUS, EQUIPMENT AND INSTRUMENTATION

9.1 Equipment associated with this method includes:

9.1.1 Gas tight syringes

9.1.2 2 mL high recovery (conical) autosampler vials and storage racks

9.1.3 Teflon crimp tops

9.1.4 Crimper/De-crimper

9.1.5 GC Column (SPB-Octyl or equivalent; 30m, 0.25 mm, 0.25 um)

9.1.6 Quartz/Glass injection port liners

9.1.7 Injection port liner O-ring seals

9.1.8 Gold seals

9.1.9 Ferrules

9.1.10 Column cleaving tool

9.1.11 Septa (thermogreen)

9.1.12 0.5-10 uL adjustable air displacement pipette with disposable tips

9.2 Instrumentation

9.2.1 Waters Autospec Premier high resolution mass spectrometer

9.2.1.1 The MassLynx workstation software is used for instrument control and data acquisition of the AutoSpec-NT SIOS hardware embedded PC based system running the industry standard VxWorks real-time. The workstation operating system used is Windows XP SP2 or SP3 to support Masslynx v4.1.

9.2.1.2 The TargetLynx Application Manager is used for post-acquisition processing and general data manipulation. The workstation operating system used is Windows XP SP2 or SP3 to support Targetlynx v4.1. Post-acquisition processing and general data manipulation can be carried out by an additional computer workstation and software installation.

9.2.2 Agilent 7890 Gas Chromatograph

9.2.2.1 A suggested temperature program follows:

Temperature 1	150° C
Time 1	2.0 min.
Rate	5° C/min.
Temperature 2	180° C
Time 2	1.5°/min
Final Temperature	265° C
Run Time:	55 minutes (may vary due to column length or flow rate)
Solvent Delay:	6.0 min.
Splitless Valve Time:	2.0 min.
Flow:	1.0 mL/min.
Mass Range:	See descriptor definitions (Table 2)

NOTE: These instrument conditions and rates are guidelines which may change.

9.2.3 LEAP Technologies GC PAL Autosampler

9.2.3.1 Suggested parameters:

Sample volume – 1 µL
Air volume – 0.5 µL
Solvent push volume – 1 µL
Number of sample washes - 0
Solvent washes - 30
Sample viscosity wait – 1 second
Number of sample pumps - 0
Injection mode - Fast

10.0 REAGENTS AND STANDARDS

10.1 Reagents and standards

10.1.1 Nonane

10.1.2 Source Standards: Source Standards are purchased directly from vendors and may be diluted to make stock, intermediate, or working standards. These may include extraction standard, matrix spiking standard, cleanup standard, injection standard, as well as others. Source standards expire per the vendor expiration date or after five years from the date opened, whichever is shorter. Please reference CF-LB-E-007 for further information regarding standards and their preparation.

10.1.3 Initial Calibration (ICAL) Standards: Certified calibration standards are purchased from commercial vendors at a minimum of five concentration levels. One of the calibration standards is at a concentration near, but above, the method detection limit; the others should correspond to the expected range of compounds found in samples. Calibration standards expire after a maximum of five years and should be monitored frequently for signs of degradation.

10.1.4 Calibration Verification Standards (CVS, CCAL, CS3): A certified CVS is purchased from a second source commercial vendor at a concentration that is near to the midpoint of the calibration curve.

10.1.5 Window Defining Mix and Column Performance Mix (WDM and CPM): A standard containing the first and last eluters for each homolog group, as well as the isomers used to demonstrate isomer specificity on the GC column in use. Usually contained in the daily 209 injection mix.

11.0 SAMPLE HANDLING AND PRESERVATION

11.1 Samples have a one year holding time from the date of collection, and a one year holding time from the date of extraction.

11.2 Sample extracts are delivered from the prep lab to the instrument lab and are stored in a darkened hood at room temperature. The extracts are usually grouped according to batches and are accompanied by the batch pull sheet and other pertinent paperwork.

11.3 Custody of samples is monitored using the AlphaLIMS sample tracking system. Each analyst should scan the samples planned to run into their custody prior to analysis.

11.4 All sample extracts should be treated with caution as potential health hazards. Refer to Section 8.0 on safety.

12.0 SAMPLE PREPARATION

12.1 Before extracts can be analyzed on the instrument, they must first be evaporated to 18 uL nonane (added after cleanup steps) under nitrogen and then spiked with injection standard to set the final volume nominally at 20 µL. A determination must also be made as to whether the extract should be diluted. The decision to dilute a sample extract is based on several factors: sample screening, historical data about the sample or sample site, the appearance of the extract (color, viscosity, incidental odor, turbidity, etc.), or regulatory considerations. The experience of the analyst is invaluable in making this determination.

NOTE: Sample extracts may contain multiple layers or sediment. Samples that contain sediment are returned to cleanup. Multiple layers are treated on a case-by-case basis. If the extract can be homogenized, then a uniform sample is achieved. If the extract remains bi-phasic, the PM and client are contacted for further guidance.

12.2 Witness: Check the vial labeling, standards, and pipet settings. When witnessing is complete, please initial the injection prep logbook with LIMS.

12.3 If a sample is to be analyzed without dilution ('neat'), 2 nanograms of injection standard solution is added to the extract using a pipette (2 µL of a 1.0 ng/µL = 100 pg/µL extract concentration). A cap is then placed on the vial and secured by crimping before vortexing the sample to ensure complete mixing and vial wall washing.

12.4 If samples require dilution, the dilution is made using nonane or appropriate solvent. If not previously added, 2 nanograms of JS is added to the autosampler vial. Dilution prep may involve the addition of supplemental extraction standard (ES) and is documented in the injection prep logbook.

12.5 Once samples are prepped, they are ready to be injected onto the instrument. An autosampler is used to inject standards and sample extracts on the instrument.

12.6 The need for dilution may also be determined after analysis is performed, and may still be performed as above. Under normal circumstances, a sample would be diluted if any chromatographic peaks saturate the detector.

13.0 QUALITY CONTROL SAMPLES AND REQUIREMENTS

Typically a blank (LMB), laboratory control sample (LCS) and laboratory control sample duplicate (LCSD) are extracted and analyzed with each prep batch. Other client requirements may include a matrix spike (MS) and matrix spike duplicate (MSD) or sample duplicate (DUP).

13.1 Blanks

13.1.1 A blank is extracted with each batch of 20 or fewer samples to demonstrate that interferences from glassware, reagents and the analytical system are under control. Blanks are carried through all stages of sample preparation and analysis. An acceptable blank must be below the minimum levels listed in Table 2 of the method for all analytes.

13.1.2 The percent recovery of each labeled standard (extraction and cleanup) is calculated as shown in Sec. 19.1.3. Recoveries must be within the limits in Table 5.

13.2 Laboratory Control Samples and Matrix Spikes

13.2.1 The spiking standard for LCS/LCSDs and MS/MSDs contains all analytes listed in Table 4. For each LCS, LCSD, MS and MSD, the concentration of each analyte and its percent recovery are calculated as shown in Sec.19.1.1 and 19.1.3. Recovered concentrations should be within the limits in Table 5.

13.2.2 If recovery is not within these limits, the data may need to be re-checked for errors, or the samples and QC may need to be re-analyzed. In addition, the instrumentation may need to be checked for performance problems. If the LCS fails to meet acceptance criteria due to low recovery, the associated samples may have to be re-extracted and re-analyzed when possible. If one or more recoveries are high in the LCS and these analytes are not detected in the samples, the event should be documented and data may be reported. If the MS and MSD both fail due to matrix interference and/or dilution, data may be reported provided the associated LCS passes acceptance criteria.

NOTE: Many clients have contract specific criteria that must be considered when evaluating recovery of the Quality Control samples.

13.2.3 The percent recovery of each labeled standard (extraction and cleanup) is calculated as shown in Sec. 19.1.3. Recoveries must be within the limits in Table 5.

13.3 Samples

13.3.1 The percent recovery of each labeled standard (as outlined in SOP CF-OA-E-001) is calculated as shown in Sec. 19.1.3. Recoveries must be within the limits in Table 5.

13.3.2 Calculated EDLs should be below the PQLs. Any reported EDLs above the PQLs should be noted in the case narrative.

14.0 INSTRUMENT CALIBRATION, STANDARDIZATION AND PERFORMANCE

14.1 Mass spectrometer performance

14.1.1 The mass spectrometer is operated in electron ionization mode. A static resolving power of at least 10,000 (10 percent valley definition) must be demonstrated at appropriate masses before any analysis is performed. Static resolving power checks must be performed at the beginning and at the end of each 12-hr period of operation. Corrective action must be implemented whenever the resolving power does not meet the requirement.

14.1.1.1 Chromatography time for PCBs exceeds the long term mass stability of the mass spectrometer. Because the instrument is operated in the high-resolution mode, mass drifts of a few ppm (e.g., 5 ppm in mass) can have serious adverse effects on instrument performance. Therefore, a mass drift correction is mandatory. A lock-mass ion from the reference compound PFK is used for tuning the mass spectrometer. The selection of the lock-mass ion is dependent on the masses of the ions monitored within each descriptor. Lock mass ions may be found in the descriptor table, Table 2. The level of the reference compound (PFK) metered into the ion chamber during HRGC/HRMS analyses should be adjusted so that the amplitude of the most intense selected lock-mass ion signal (regardless of the descriptor number) does not exceed 10 percent of the full scale deflection for a given set of detector parameters. Under these conditions, sensitivity changes that might occur during the analysis can be more effectively monitored. NOTE: Excessive PFK (or any other reference substance) may cause noise problems and contamination of the ion source resulting in an increase in downtime for source cleaning.

14.1.2 Documentation of the instrument resolving power must be accomplished by recording the peak profile of the high-mass reference signal (m/z 380.9760) obtained during the above peak matching experiment by using the low mass PFK ion at m/z 304.9824 as a reference. The minimum resolving power of 10,000 must be demonstrated on the high-mass ion while it is transmitted at a lower accelerating voltage than the low-mass reference ion, which is transmitted at full sensitivity. The format of the peak profile representation must allow manual determination of the resolution, i.e., the horizontal axis must be a calibrated mass scale (amu or ppm per division). The result of the peak width measurement (performed at 5 percent of the maximum, which corresponds to the 10 percent valley definition) must appear on the hard copy and cannot exceed 100 ppm at m/z 380.9760 (or 0.038 amu at that particular mass).

14.2 System Performance

System performance criteria are presented below. The laboratory may use the recommended GC column described in Sec. 9.1.5. The laboratory must document that all applicable system performance criteria were met before sample analysis begins. Sec. 9.2.2.1 provides recommended GC conditions that may be used to satisfy the required criteria. A GC column performance check is required at the beginning of each 12-hr period during which samples are analyzed. A continuing calibration must be performed at the beginning of the sequence.

14.2.1 Daily 209 injection mix

14.2.1.1 Inject 1 uL of the daily 209 injection mix solution and acquire selected ion monitoring (SIM) data within a total cycle time of $\leq$ 1.5 second. The chromatographic separation between congeners 34-TrCB and 23-TrCB, and between congeners 187-HxCB and 182-HxCB, must be resolved with a valley of $\leq$ 40 percent, where:

Valley percent = (x/y) × 100

x = the height of the valley

y = the peak height of the shorter of the two peaks

Congeners 156-HxCB and 157-HxCB must also co-elute within 2 seconds.

14.2.1.2 The daily 209 injection mix contains all 209 PCB congeners, and may thus be used to identify the first and last PCB eluters in each congener group, and in each analytical descriptor. Their retention times are used to determine the seven homologue retention time windows that are used for qualitative (Sec. 15.4.1.1) and quantitative purposes.

14.3 Initial Calibration

14.3.1 Prior to running a multi-level calibration, take precautions to ensure that the instrument meets system performance criteria. The analyst must document that all system performance criteria are met before analyzing an initial calibration.

14.3.2 Initial calibration is required before any samples are analyzed for PCBs and must meet the acceptance criteria in this section. Initial calibration is also required if any routine calibration does not meet the required criteria listed in Sec. 15.3, and at a minimum, annually.

14.3.3 At a minimum, all five high-resolution concentration calibration solutions listed in Table 4 must be used for the initial calibration. A lower calibration point of 0.5pg/ul is used for DRBC.

14.3.4 Tune the instrument with PFK to meet the above-specified system performance criteria.

14.3.5 Inject the daily 209 injection mix solution and acquire SIM mass spectral data. The laboratory must not perform any further analysis until it is demonstrated and documented that the criteria listed in Sec. 14.2.1 are met.

14.3.6 By using the same conditions (GC and MS) that produced acceptable results with the 209 injection mix solution, analyze each of the five concentration calibration solutions. Each injection must meet the following ion ratio and signal-to-noise (S/N) requirements:

14.3.6.1 The ratio of integrated ion current for the ions appearing in Table 2 (homologous series quantitation ions) must be within the indicated control limits (set for each homologous series) in Table 3. These ion ratio requirements must be within the specified control limits simultaneously in one run. It is the analyst's responsibility to take corrective action if the ion abundance ratios are outside the limits.

14.3.6.2 For each selected ion current profile (SICP) and for each GC signal corresponding to the elution of a target analyte and of its labeled standards, the S/N ratio must be better than or equal to 10. Manual measurement of S/N is required for any GC peak that has an apparent S/N of less than 15:1. The result of the measurement must appear on the SICP above the GC peak in question. NOTE: An interference with PFK m/z 223.9872 may preclude meeting this requirement for DiCB congeners. Suspected column bleed interference may preclude meeting this requirement in other congeners groups. These interferences are noted in the low calibration levels, CS1 and below. If interference occurs, 10:1 S/N must be met at the CS2 level. The lower calibration points are still included in the initial calibration.

14.3.6.3 Manual integrations, if required, are performed and documented according to SOP CF-LB-E-017.

14.3.7 Calculate the relative response factors (RF) for unlabeled target analytes relative to their appropriate internal standards. Also calculate the RFs for the ESs and CSs relative to the appropriate injection standards according to the following formula:

$$RF = \frac{A_x C_{is}}{A_{is} C_x}$$

Where:

Ax = Sum of the Areas of the two characteristic ions for the compound being measured.

Ais = Sum of the Areas of the two characteristic ions for the specific internal standard.

Cis = Concentration of the specific internal standard.

Cx = Concentration of the compound being measured.

The RF is a dimensionless quantity; the units used to express Cis and Cx must be the same.

14.3.8 Because more than five calibration levels may be analyzed, the analyst may choose to deactivate one or more levels. The low standard representing the PQL cannot be deactivated. CFA only includes calibration points below the PQL at the request of the client (drinking water states, TMDL, etc.). If warranted, a mid-level standard is deactivated for all analytes (globally) in that calibration mixture. An upper level(s) standard may be deactivated to meet method criteria for single compounds. This practice results in a narrower calibration range. The analyst must get supervisory approval before deactivating any calibration levels within the method calibration range. Following approval, management will document the situation,

including reasonable cause for calibration level removal. Calibrations with rejected mid-level points are not used for DOE clients. Please note that this practice does not represent "cherry picking," which is acknowledged as an unacceptable laboratory practice.

14.3.9 The average RF must be calculated for each compound as follows:

$$RF_{avg} = \frac{\sum_{i=1}^{n} X}{n}$$

Where:

N = number of calibration levels
X_i; i=1 to n, are the compounds RF values for each calibration point

14.3.10 Criteria for acceptable initial calibration

The criteria listed below for acceptable calibration must be met before sample analyses are performed.

14.3.10.1 The percent relative standard deviations for the mean response factors from the unlabeled standards must not exceed ±20 percent.

$$\%RSD = \frac{SD}{\bar{x}} \times 100$$

Where:

RSD = relative standard deviation
$\bar{x}$ = mean of 5 or more initial RFs for a compound
SD = standard deviation of average RFs for a compound

$$SD = \sqrt[2]{\frac{\sum_{i=1}^{n}(X - A)}{n-1}}$$

where:

n = number of calibration levels
X_i; i=1 to n, are the compounds RF values for each calibration point
A = average of the RFs from above

14.3.10.2 The percent relative standard deviations for the mean response factors from the labeled standards must not exceed ±30 percent.

15.0 PROCEDURE FOR ANALYSIS AND INSTRUMENT OPERATION

15.1 Resolution check

15.1.1 At the beginning and end of each 12-hour window, mass resolution must be tuned and/or verified. A static resolving power of at least 10,000 must be demonstrated at appropriate masses before analysis is performed.

15.1.2 Using a PFK molecular leak, tune the instrument to the minimum required resolving power of 10,000 at m/z 330.9792 (for day to day operations, the instrument may be tuned to approximately 11,000). Verify that the exact mass of m/z 380.9760 is within 5 ppm of the required value. Due to the

wide mass ranges required for PCB analysis, resolution may drop to 8000 at either end of the descriptor, but should be >10,000 at the midpoint.

15.2 Daily 209 injection mix

Inject 1 uL of the daily 209 mix. Verify that all column performance and window defining criteria in Section 14.2.1 have been met.

15.3 Continuing Calibration

15.3.1 The initial calibration curve for each compound of interest must be verified once every 12 hours. Inject 1 uL of the CS3 standard. For 1668C, the Daily 209 injection mix is used to satisfy the calibration verification criteria.

Calculate the percent difference using:

$$\% \text{ Difference} = \frac{\left|\overline{RF}_i - RF_c\right|}{\overline{RF}_i} \times 100$$

Where:

$\overline{RF}_i$ = average response factor from initial calibration

RF_c = response factor from current CS3

15.3.1.1 For Method 1668A, if the percent difference for each native analyte is $\leq$ 30%, and for each labeled analyte is $\leq$ 50%, the calibration is assumed to be valid. Method 1668C criteria are listed in Table 7. If the criteria are not met, corrective action should be taken. If no source of the problem can be determined after corrective action has been taken, a new initial calibration may need to be generated.

15.3.1.2 All ion ratios must be within the limits in Table 3.

15.4 Sample Analysis

15.4.1 Data Interpretation

15.4.1.1 Qualitative Analysis

For a peak to be identified as a PCB, it must meet all of the criteria listed below.

15.4.1.1.1 The signals for the two m/z's being monitored must be present and maximize within the same two scans.

15.4.1.1.2 The signal-to-noise ratio between the two m/z's must be $\geq$ 2.5 for each PCB detected in a sample extract, and $\geq$10 for all PCBs in the calibration and verification standards. (DiCBs suffer from PFK interference and are not required to meet 10:1 until the CS2. Other PCBs suffer from suspected column bleed interference and are only required to meet 2.5:1 in calibration points below the CS1.)

15.4.1.1.3 Ion ratios must be within the limits in Table 3.

15.4.1.1.4 The relative retention time of the peak for a PCB must be within the RRT limits calculated as specified in Table 8 based on the RT limits provided.

15.4.1.1.5 Congener overlap, interfering substances, or the loss of chlorine from a higher chlorinated congener may make

it difficult to meet all identification criteria. In these cases, an experienced spectrometrist must determine the presence or absence of the congener.

15.4.1.2 Calibration Limit Exceedance

15.4.1.2.1 If a compound in a sample exceeds the upper calibration limit, all subsequent samples must be checked for carryover contamination.

15.4.1.2.2 When a subsequent sample is non-detect for the compound in question, the sequence is again considered acceptable for reporting.

15.4.1.2.3 All affected samples between the exceeding sample and the non-detect sample must be re-analyzed.

16.0 EQUIPMENT AND INSTRUMENT MAINTENANCE

16.1 Preventive maintenance on a HRGC/HRMS system involves the following basic areas:

16.1.1 Vacuum pumps for the inlets, source, and analyzer need a change of oil about every year or when system performance indicates it is needed.

16.1.2 The GC injection port is cleaned as needed, approximately once a week. It is recommended that the septum and injection port liner be replaced at the time of cleaning. Additionally, the gold-plated seal should be cleaned or replaced.

16.1.3 Ion source maintenance is usage dependent. The type and quantity of samples that have been injected determine the frequency of ion source cleaning and filament replacement.

16.1.4 Autosampler maintenance is primarily that of cleanliness. Most autosamplers need their moving parts to be clean and lightly lubricated. The most frequent corrective maintenance is that of changing the syringe, usually about once per month.

16.1.5 Instrument maintenance logs are kept with each instrument and serve as a record of all the maintenance that has been done on the instrument.

16.2 Non-Routine Maintenance Procedures (Special, Operational or Failure Mode Maintenance)

16.2.1 Service is provided to the instrument via the analyst, the in-house instrument service engineer, or a technical support specialist from the manufacturer. When instrument failure occurs, different parts of the instrument are isolated to determine the root cause. For example, the injection port may be capped off if a leak is suspected to prove the leak is/is not coming from that source. Instrument maintenance logbooks are kept for each instrument detailing the type of maintenance performed on the instrument and when it was performed. Preventive maintenance visits are scheduled annually for the mass spectrometers.

16.2.2 Analytical GC columns are clipped or replaced when the existing column shows signs of excessive degradation or the inability to properly resolve chromatographic peaks. Excessive peak tailing, poor responses, and baseline disturbances may also indicate that the column needs to be replaced.

17.0 DATA RECORDING, CALCULATION AND REDUCTION METHODS

17.1 Data are evaluated qualitatively and quantitatively using a software program such as Waters MassLynx, or equivalent data system.

17.2 Data are reviewed, and a hard copy is generated. If manual integrations are made, a hard copy of the manual integration is printed and initialed by the analyst and included with the raw data.

17.3 Additional supporting documentation, such as totals pages generated by the software may be included with the data.

17.4 Quantitative Analysis

17.4.1 The concentration (ng/L for aqueous, ng/g for solids) of each identified compound in the sample is calculated as follows:

$$[PCB] = \frac{\left(A_{unk}^{ion1} + A_{unk}^{ion2}\right)}{\left(A_{ES}^{ion1} + A_{ES}^{ion2}\right)} \times \frac{Q_{ES}}{W_{unk} \times D \times \overline{RF}}$$

Where:

A_{unk} and A_{ES} = the integrated area for each ion monitored.
Q_{ES} = the amount of extraction standard added to the sample in nanograms
W_{unk} = the initial sample aliquot size, in liters for waters and in grams for solids.
D = (% moisture in sample)/100, or 1 for waters
$\overline{RF}$ = Average RF from the ICAL for the compound

17.4.2 The concentration of each extraction and cleanup standard is calculated as follows:

$$[ES_{ng}] = \frac{\left(A_{ES}^{ion1} + A_{ES}^{ion2}\right)}{\left(A_{JS}^{ion1} + A_{JS}^{ion2}\right)} \times \frac{Q_{JS}}{\overline{RF}}$$

Where:

A_{ES} and A_{JS} = the integrated area for each ion monitored.
Q_{JS} = the amount of injection standard added to the sample in nanograms
$\overline{RF}$ = Average RF from the ICAL for the compound

The cleanup standard concentration is calculated as above, substituting the area of the individual cleanup standard ions for the extraction standard ions.

17.4.3 Percent recovery is calculated as follows:

$$\%R = \frac{R_{ng}}{S_{ng}} \times 100$$

Where:

R_{ng} = the amount of standard recovered in nanograms.
S_{ng} = the amount of standard spiked in nanograms.

18.0 POLLUTION/CONTAMINATION

18.1 Work area should be maintained free of dust and dirt accumulations.

18.2 Fume hoods are utilized to remove fumes and reduce the risk of airborne contaminants to ensure personnel safety. Hoods are monitored in accordance with CF-FC-E-003 for Fume Hood Face Velocity Performance Checks.

18.3 The laboratory area is restricted to authorized personnel.

19.0 DATA REVIEW, APPROVAL AND TRANSMITTAL

19.1 A review process is used to insure the quality of the data. Raw data are reviewed first by the analyst, then by a second (peer) analyst or a data validator. When the analyst is satisfied that the data have been correctly processed and uploaded to the LIMS, a data report is generated from AlphaLIMS. The AlphaLIMS report along with the raw data and supporting documentation, such as a run log and case narrative, are submitted for review to the data validator or another experienced analyst. The reviewer goes through the raw data as if he/she was working it up for the first time and verifies that they are correct. In addition, he/she must make sure that the data have been correctly entered into AlphaLIMS. AlphaLIMS reports may be self-reviewed. If errors are discovered in either the raw data or the AlphaLIMS report, then the two analysts should discuss the differences and how best to resolve them. In some cases, the peer review process may uncover errors that lead to a sample being re-extracted or re-run. In cases such as these, a nonconformance report (NCR) should be completed and submitted to the Quality department. It is recommended that a copy of the NCR be given to the prep analyst if it involves a re-extraction and that a copy be kept with the original data.

19.2 Once the data review has been completed by the reviewer, the batch is returned to the analyst for corrections (if applicable) and the status is updated from REVW to DONE in AlphaLIMS.

19.3 Data may be transmitted automatically to AlphaLIMS. This automatic "upload" procedure may be activated prior to data review or after data review is complete. In either case, the data recorded in AlphaLIMS are checked by the analyst for accuracy and completeness.

20.0 CORRECTIVE ACTION FOR OUT-OF-CONTROL OR UNACCEPTABLE DATA

Corrective action for out-of-control data may require instrument maintenance, re-analysis, re-extraction, or a more complex set of actions. When troubleshooting measures fail to bring an analytical process or data into control, a nonconformance report and/or corrective action should be initiated in accordance with CF-QS-E-004 for the Documentation of Nonconformance Reporting and Dispositioning and Control of Nonconforming Items, and CF-QS-E-002 for Conducting Corrective Action.

21.0 CONTINGENCIES FOR HANDLING THESE SITUATIONS

Troubleshooting is used to determine the appropriate action to take when an initial or continuing calibration, blank and/or laboratory control sample fails to meet the acceptance criteria defined for the method. Troubleshooting may involve one or more of the following actions:

21.1 If analytes in a multi-point calibration fail to meet specified criteria, additional standards for the failing compounds may need to be reanalyzed. If they still do not meet specifications, instrument maintenance or new standards may be required before work is continued.

21.2 If a continuing calibration fails to meet specified criteria, instrument tuning or inlet maintenance may be required. If these attempts fail, a new initial calibration must be analyzed.

21.3 If a method blank fails to meet defined criteria, the source of contamination should be found and eliminated before proceeding with analysis.

21.4 If a LCS fails to meet specified criteria, the process should be reviewed to identify potential areas for failure. Any problem areas should be corrected before re-extraction or re-analysis is performed.

21.5 If a sample fails to meet recovery or detection limit criteria, the data should be reviewed to determine whether matrix interferences are present, and if further cleanup or a smaller volume extraction might improve recoveries.

22.0 RECORDS MANAGEMENT

22.1 Run logs are generated for each instrument each day that the instrument is run. These run logs serve as records of what is run on the instrument, including samples, QC, calibrations, tunes, etc. Additional information is provided in the run log, including the analyst's initials, run date and time, and file name.

22.2 Raw data are stored in the lab in filing cabinets and/or boxes as long as there is space available. When space runs out, the data are boxed and sent to storage.

22.3 All records generated as a result of this procedure are maintained as quality documents in accordance with CF-QS-E-008 for Quality Records Management and Disposition.

23.0 LABORATORY WASTE HANDLING AND DISPOSAL

Sample extracts that have been run are temporarily stored in case they have to be reanalyzed. Once space is no longer available to keep them in the lab, they are moved to Waste Disposal where they are handled and disposed in accordance with the Laboratory Waste Management Plan, CF-LB-G-001.

24.0 REFERENCES

Method 1668, Revision A, “Chlorinated Biphenyl Congeners in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS” with corrections and changes through August 20, 2003

Method 1668C Chlorinated Biphenyl Congeners in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS April 2010

DELAWARE RIVER ESTUARY STAGE 2 PCB TMDL Polychlorinated Biphenyls - EPA Method 1668A Project Quality Control Requirements 02/03/05

25.0 HISTORY

Revision 1: Section 15.4.1.2 added.

Revision 2: Calibration upper limit exceedance clarified.

Revision 3: Tables 1, 4, 5, and 6 updated. Table 8 added. 1668A references added. Tridecane use removed. 1668C references and limits added.

Revision 4: Removed references to Version B.

Revision 5: Comments regarding DRBC modifications and references. Additions for DRBC ICAL exceptions.

Revision 6: Added holding timetable.

Revision 7: Removing PQLs from and adding CAS numbers to SOP.

Revision 8: Updated section 9 to include hardware and software requirements. Updated 14.3.8 to clarify calibration level deactivation protocol.

Revision 9: Improved 14.3.8.

Revision 10: Added JS witnessing.

TABLE 1: METHOD ANALYTES

2-Chlorobiphenyl (1)	2051-60-7	2,3,3',4-Tetrachlorobiphenyl (55)	74338-24-2
3-Chlorobiphenyl (2)	2051-61-8	2,3,3',4'-Tetrachlorobiphenyl (56)	41464-43-1
4-Chlorobiphenyl (3)	2051-62-9	2,3,3',5-Tetrachlorobiphenyl (57)	70424-67-8
2,2'-Dichlorobiphenyl (4)	13029-08-8	2,3,3',5'-Tetrachlorobiphenyl (58)	41464-49-7
2,3-Dichlorobiphenyl (5)	16605-91-7	2,3,3',6-Tetrachlorobiphenyl (59)	74472-33-6
2,3'-Dichlorobiphenyl (6)	25569-80-6	2,3,4,4'-Tetrachlorobiphenyl (60)	33025-41-1
2,4-Dichlorobiphenyl (7)	33284-50-3	2,3,4,5-Tetrachlorobiphenyl (61)	33284-53-6
2,4'-Dichlorobiphenyl (8)	34883-43-7	2,3,4,6-Tetrachlorobiphenyl (62)	54230-22-7
2,5-Dichlorobiphenyl (9)	34883-39-1	2,3,4',5-Tetrachlorobiphenyl (63)	74472-34-7
2,6-Dichlorobiphenyl (10)	33146-45-1	2,3,4',6-Tetrachlorobiphenyl (64)	52663-58-8
3,3'-Dichlorobiphenyl (11)	2050-67-1	2,3,5,6-Tetrachlorobiphenyl (65)	33284-54-7
3,4-Dichlorobiphenyl (12)	2974-92-7	2,3',4,4'-Tetrachlorobiphenyl (66)	32598-10-0
3,4'-Dichlorobiphenyl (13)	2974-90-5	2,3',4,5-Tetrachlorobiphenyl (67)	73575-53-8
3,5-Dichlorobiphenyl (14)	34883-41-5	2,3',4,5'-Tetrachlorobiphenyl (68)	73575-52-7
4,4'-Dichlorobiphenyl (15)	2050-68-2	2,3',4,6-Tetrachlorobiphenyl (69)	60233-24-1
2,2',3-Trichlorobiphenyl (16)	38444-78-9	2,3',4',5-Tetrachlorobiphenyl (70)	32598-11-1
2,2',4-Trichlorobiphenyl (17)	37680-66-3	2,3',4',6-Tetrachlorobiphenyl (71)	41464-46-4
2,2',5-Trichlorobiphenyl (18)	37680-65-2	2,3',5,5'-Tetrachlorobiphenyl (72)	41464-42-0
2,2',6-Trichlorobiphenyl (19)	38444-73-4	2,3',5',6-Tetrachlorobiphenyl (73)	74338-23-1
2,3,3'-Trichlorobiphenyl (20)	38444-84-7	2,4,4',5-Tetrachlorobiphenyl (74)	32690-93-0
2,3,4-Trichlorobiphenyl (21)	55702-46-0	2,4,4',6-Tetrachlorobiphenyl (75)	32598-12-2
2,3,4'-Trichlorobiphenyl (22)	38444-85-8	2',3,4,5-Tetrachlorobiphenyl (76)	70362-48-0
2,3,5-Trichlorobiphenyl (23)	55720-44-0	3,3',4,4'-Tetrachlorobiphenyl (77)	32598-13-3
2,3,6-Trichlorobiphenyl (24)	55702-45-9	3,3',4,5-Tetrachlorobiphenyl (78)	70362-49-1
2,3',4-Trichlorobiphenyl (25)	55712-37-3	3,3',4,5'-Tetrachlorobiphenyl (79)	41464-48-6
2,3',5-Trichlorobiphenyl (26)	38444-81-4	3,3',5,5'-Tetrachlorobiphenyl (80)	33284-52-5
2,3',6-Trichlorobiphenyl (27)	38444-76-7	3,4,4',5-Tetrachlorobiphenyl (81)	70362-50-4
2,4,4'-Trichlorobiphenyl (28)	7012-37-5	2,2',3,3',4-Pentachlorobiphenyl (82)	52663-62-4
2,4,5-Trichlorobiphenyl (29)	15862-07-4	2,2',3,3',5-Pentachlorobiphenyl (83)	60145-20-2
2,4,6-Trichlorobiphenyl (30)	35693-92-6	2,2',3,3',6-Pentachlorobiphenyl (84)	52663-60-2
2,4',5-Trichlorobiphenyl (31)	16606-02-3	2,2',3,4,4'-Pentachlorobiphenyl (85)	65510-45-4
2,4',6-Trichlorobiphenyl (32)	38444-77-8	2,2',3,4,5-Pentachlorobiphenyl (86)	55312-69-1
2',3,4-Trichlorobiphenyl (33)	38444-86-9	2,2',3,4,5'-Pentachlorobiphenyl (87)	38380-02-8
2',3,5-Trichlorobiphenyl (34)	37680-68-5	2,2',3,4,6-Pentachlorobiphenyl (88)	55215-17-3
3,3',4-Trichlorobiphenyl (35)	37680-69-6	2,2',3,4,6'-Pentachlorobiphenyl (89)	73575-57-2
3,3',5-Trichlorobiphenyl (36)	38444-87-0	2,2',3,4',5-Pentachlorobiphenyl (90)	68194-07-0
3,4,4'-Trichlorobiphenyl (37)	38444-90-5	2,2',3,4',6-Pentachlorobiphenyl (91)	68194-05-8
3,4,5-Trichlorobiphenyl (38)	53555-66-1	2,2',3,5,5'-Pentachlorobiphenyl (92)	52663-61-3
3,4',5-Trichlorobiphenyl (39)	38444-88-1	2,2',3,5,6-Pentachlorobiphenyl (93)	73575-56-1
2,2',3,3'-Tetrachlorobiphenyl (40)	38444-93-8	2,2',3,5,6'-Pentachlorobiphenyl (94)	73575-55-0
2,2',3,4-Tetrachlorobiphenyl (41)	52663-59-9	2,2',3,5',6-Pentachlorobiphenyl (95)	38379-99-6
2,2',3,4'-Tetrachlorobiphenyl (42)	36559-22-5	2,2',3,6,6'-Pentachlorobiphenyl (96)	73575-54-9
2,2',3,5-Tetrachlorobiphenyl (43)	70362-46-8	2,2',3',4,5-Pentachlorobiphenyl (97)	41464-51-1
2,2',3,5'-Tetrachlorobiphenyl (44)	41464-39-5	2,2',3',4,6-Pentachlorobiphenyl (98)	60233-25-2
2,2',3,6-Tetrachlorobiphenyl (45)	70362-45-7	2,2',4,4',5-Pentachlorobiphenyl (99)	38380-01-7
2,2',3,6'-Tetrachlorobiphenyl (46)	41464-47-5	2,2',4,4',6-Pentachlorobiphenyl (100)	39485-83-1
2,2',4,4'-Tetrachlorobiphenyl (47)	2437-79-8	2,2',4,5,5'-Pentachlorobiphenyl (101)	37680-73-2
2,2',4,5-Tetrachlorobiphenyl (48)	70362-47-9	2,2',4,5,6'-Pentachlorobiphenyl (102)	68194-06-9
2,2',4,5'-Tetrachlorobiphenyl (49)	41464-40-8	2,2',4,5',6-Pentachlorobiphenyl (103)	60145-21-3
2,2',4,6-Tetrachlorobiphenyl (50)	62796-65-0	2,2',4,6,6'-Pentachlorobiphenyl (104)	56558-16-8
2,2',4,6'-Tetrachlorobiphenyl (51)	68194-04-7	2,3,3',4,4'-Pentachlorobiphenyl (105)	32598-14-4
2,2',5,5'-Tetrachlorobiphenyl (52)	35693-99-3	2,3,3',4,5-Pentachlorobiphenyl (106)	70424-69-0
2,2',5,6'-Tetrachlorobiphenyl (53)	41464-41-9	2,3,3',4',5-Pentachlorobiphenyl (107)	70424-68-9
2,2',6,6'-Tetrachlorobiphenyl (54)	15968-05-5	2,3,3',4,5'-Pentachlorobiphenyl (108)	70362-41-3

(Continued)

2,3,3',4,6-Pentachlorobiphenyl (109)	74472-35-8	2,3,3',4',5,6-Hexachlorobiphenyl (163)	74472-44-9
2,3,3',4',6-Pentachlorobiphenyl (110)	38380-03-9	2,3,3',4',5',6-Hexachlorobiphenyl (164)	74472-45-0
2,3,3',5,5'-Pentachlorobiphenyl (111)	39635-32-0	2,3,3',5,5',6-Hexachlorobiphenyl (165)	74472-46-1
2,3,3',5,6-Pentachlorobiphenyl (112)	74472-36-9	2,3,4,4',5,6-Hexachlorobiphenyl (166)	41411-63-6
2,3,3',5',6-Pentachlorobiphenyl (113)	68194-10-5	2,3',4,4',5,5'-Hexachlorobiphenyl (167)	52663-72-6
2,3,4,4',5-Pentachlorobiphenyl (114)	74472-37-0	2,3',4,4',5',6-Hexachlorobiphenyl (168)	59291-65-5
2,3,4,4',6-Pentachlorobiphenyl (115)	74472-38-1	3,3',4,4',5,5'-Hexachlorobiphenyl (169)	32774-16-6
2,3,4,5,6-Pentachlorobiphenyl (116)	18259-05-7	2,2',3,3',4,4',5-Heptachlorobiphenyl (170)	35065-30-6
2,3,4',5,6-Pentachlorobiphenyl (117)	68194-11-6	2,2',3,3',4,4',6-Heptachlorobiphenyl (171)	52663-71-5
2,3',4,4',5-Pentachlorobiphenyl (118)	31508-00-6	2,2',3,3',4,5,5'-Heptachlorobiphenyl (172)	52663-74-8
2,3',4,4',6-Pentachlorobiphenyl (119)	56558-17-9	2,2',3,3',4,5,6-Heptachlorobiphenyl (173)	68194-16-1
2,3',4,5,5'-Pentachlorobiphenyl (120)	68194-12-7	2,2',3,3',4,5,6'-Heptachlorobiphenyl (174)	38411-25-5
2,3',4,5',6-Pentachlorobiphenyl (121)	56558-18-0	2,2',3,3',4,5',6-Heptachlorobiphenyl (175)	40186-70-7
2',3,3',4,5-Pentachlorobiphenyl (122)	76842-07-4	2,2',3,3',4,6,6'-Heptachlorobiphenyl (176)	52663-65-7
2',3,4,4',5-Pentachlorobiphenyl (123)	65510-44-3	2,2',3,3',4',5,6-Heptachlorobiphenyl (177)	52663-70-4
2',3,4,5,5'-Pentachlorobiphenyl (124)	70424-70-3	2,2',3,3',5,5',6-Heptachlorobiphenyl (178)	52663-67-9
2',3,4,5,6'-Pentachlorobiphenyl (125)	74472-39-2	2,2',3,3',5,6,6'-Heptachlorobiphenyl (179)	52663-64-6
3,3',4,4',5-Pentachlorobiphenyl (126)	57465-28-8	2,2',3,4,4',5,5'-Heptachlorobiphenyl (180)	35065-29-3
3,3',4,5,5'-Pentachlorobiphenyl (127)	39635-33-1	2,2',3,4,4',5,6-Heptachlorobiphenyl (181)	74472-47-2
2,2',3,3',4,4'-Hexachlorobiphenyl (128)	38380-07-3	2,2',3,4,4',5,6'-Heptachlorobiphenyl (182)	60145-23-5
2,2',3,3',4,5-Hexachlorobiphenyl (129)	55215-18-4	2,2',3,4,4',5',6-Heptachlorobiphenyl (183)	52663-69-1
2,2',3,3',4,5'-Hexachlorobiphenyl (130)	52663-66-8	2,2',3,4,4',6,6'-Heptachlorobiphenyl (184)	74472-48-3
2,2',3,3',4,6-Hexachlorobiphenyl (131)	61798-70-7	2,2',3,4,5,5',6-Heptachlorobiphenyl (185)	52712-05-7
2,2',3,3',4,6'-Hexachlorobiphenyl (132)	38380-05-1	2,2',3,4,5,6,6'-Heptachlorobiphenyl (186)	74472-49-4
2,2',3,3',5,5'-Hexachlorobiphenyl (133)	35694-04-3	2,2',3,4',5,5',6-Heptachlorobiphenyl (187)	52663-68-0
2,2',3,3',5,6-Hexachlorobiphenyl (134)	52704-70-8	2,2',3,4',5,6,6'-Heptachlorobiphenyl (188)	74487-85-7
2,2',3,3',5,6'-Hexachlorobiphenyl (135)	52744-13-5	2,3,3',4,4',5,5'-Heptachlorobiphenyl (189)	39635-31-9
2,2',3,3',6,6'-Hexachlorobiphenyl (136)	38411-22-2	2,3,3',4,4',5,6-Heptachlorobiphenyl (190)	41411-64-7
2,2',3,4,4',5-Hexachlorobiphenyl (137)	35694-06-5	2,3,3',4,4',5',6-Heptachlorobiphenyl (191)	74472-50-7
2,2',3,4,4',5'-Hexachlorobiphenyl (138)	35065-28-2	2,3,3',4,5,5',6-Heptachlorobiphenyl (192)	74472-51-8
2,2',3,4,4',6-Hexachlorobiphenyl (139)	56030-56-9	2,3,3',4',5,5',6-Heptachlorobiphenyl (193)	69782-91-8
2,2',3,4,4',6'-Hexachlorobiphenyl (140)	59291-64-4	2,2',3,3',4,4',5,5'-Octachlorobiphenyl (194)	35694-08-7
2,2',3,4,5,5'-Hexachlorobiphenyl (141)	52712-04-6	2,2',3,3',4,4',5,6-Octachlorobiphenyl (195)	52663-78-2
2,2',3,4,5,6-Hexachlorobiphenyl (142)	41411-61-4	2,2',3,3',4,4',5,6'-Octachlorobiphenyl (196)	42740-50-1
2,2',3,4,5,6'-Hexachlorobiphenyl (143)	68194-15-0	2,2',3,3',4,4',6,6'-Octachlorobiphenyl (197)	33091-17-7
2,2',3,4,5',6-Hexachlorobiphenyl (144)	68194-14-9	2,2',3,3',4,5,5',6-Octachlorobiphenyl (198)	68194-17-2
2,2',3,4,6,6'-Hexachlorobiphenyl (145)	74472-40-5	2,2',3,3',4,5,5',6'-Octachlorobiphenyl (199)	52663-75-9
2,2',3,4',5,5'-Hexachlorobiphenyl (146)	51908-16-8	2,2',3,3',4,5,6,6'-Octachlorobiphenyl (200)	52663-73-7
2,2',3,4',5,6-Hexachlorobiphenyl (147)	68194-13-8	2,2',3,3',4,5',6,6'-Octachlorobiphenyl (201)	40186-71-8
2,2',3,4',5,6'-Hexachlorobiphenyl (148)	74472-41-6	2,2',3,3',5,5',6,6'-Octachlorobiphenyl (202)	2136-99-4
2,2',3,4',5',6-Hexachlorobiphenyl (149)	38380-04-0	2,2',3,4,4',5,5',6-Octachlorobiphenyl (203)	52663-76-0
2,2',3,4',6,6'-Hexachlorobiphenyl (150)	68194-08-1	2,2',3,4,4',5,6,6'-Octachlorobiphenyl (204)	74472-52-9
2,2',3,5,5',6-Hexachlorobiphenyl (151)	52663-63-5	2,3,3',4,4',5,5',6-Octachlorobiphenyl (205)	74472-53-0
2,2',3,5,6,6'-Hexachlorobiphenyl (152)	68194-09-2	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (206)	40186-72-9
2,2',4,4',5,5'-Hexachlorobiphenyl (153)	35065-27-1	2,2',3,3',4,4',5,6,6'-Nonachlorobiphenyl (207)	52663-79-3
2,2',4,4',5,6'-Hexachlorobiphenyl (154)	60145-22-4	2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl (208)	52663-77-1
2,2',4,4',6,6'-Hexachlorobiphenyl (155)	33979-03-2	2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl (209)	2051-24-3
2,3,3',4,4',5-Hexachlorobiphenyl (156)	38380-08-4	Total Monochlorobiphenyl PCBs	27323-18-8
2,3,3',4,4',5'-Hexachlorobiphenyl (157)	69782-90-7	Total Dichlorobiphenyl PCBs	25512-42-9
2,3,3',4,4',6-Hexachlorobiphenyl (158)	74472-42-7	Total Trichlorobiphenyl PCBs	25323-68-6
2,3,3',4,5,5'-Hexachlorobiphenyl (159)	39635-35-3	Total Tetrachlorobiphenyl PCBs	26914-33-0
2,3,3',4,5,6-Hexachlorobiphenyl (160)	41411-62-5	Total Pentachlorobiphenyl PCBs	25429-29-2
2,3,3',4,5',6-Hexachlorobiphenyl (161)	74472-43-8	Total Hexachlorobiphenyl PCBs	26601-64-9
2,3,3',4',5,5'-Hexachlorobiphenyl (162)	39635-34-2	Total Heptachlorobiphenyl PCBs	28655-71-2

TABLE 2: MASS DESCRIPTORS

F1	Description*	Mass	Ion
1	13C-MoCB 1	200.0795	M
2	13C-MoCB 2	202.0766	M+2
3	13C-DiCB 1	234.0406	M
4	13C-DiCB 2	236.0376	M+2
5	MoCB 1	188.0393	M
6	MoCB 2	190.0363	M+2
7	DiCB 1	222.0003	M
8	DiCB 2	223.9974	M+2
9	Lock Mass	218.9856	PFK
F2	**Description**	**Mass**	**Ion**
1	13C-DiCB 1	234.0406	M
2	13C-DiCB 2	236.0376	M+2
3	13C-TrCB 1	268.0016	M
4	13C-TrCB 2	269.9986	M+2
5	13C-TeCB 1	301.9626	M
6	13C-TeCB 2	303.9597	M+2
7	DiCB 1	222.0003	M
8	DiCB 2	223.9974	M+2
9	TrCB 1	255.9613	M
10	TrCB 2	257.9584	M+2
11	TeCB 1	289.9224	M
12	TeCB 2	291.9194	M+2
-	DiCB 35 IC	255.9613	M
13	DiCB 35 ICQ	220.9924	M-35Cl
-	TrCB 35 IC	289.9224	M
14	TrCB 35 ICQ	254.9535	M-35Cl
15	Lock Mass	230.9856	PFK
F3	**Description**	**Mass**	**Ion**
1	13C-TrCB 1	268.0016	M
2	13C-TrCB 2	269.9986	M+2
3	13C-TeCB 1	301.9626	M
4	13C-TeCB 2	303.9597	M+2
5	13C-PeCB 1	337.9207	M+2
6	13C-PeCB 2	339.9178	M+4
7	TrCB 1	255.9613	M
8	TrCB 2	257.9584	M+2
9	TeCB 1	289.9224	M
10	TeCB 2	291.9194	M+2
11	PeCB 1	325.8804	M+2
12	PeCB 1	323.8834	M
13	PeCB 2	327.8775	M+4
-	TrCB 35 IC	289.9224	M
14	TrCB 35 ICQ	254.9535	M-35Cl
-	TeCB 35 IC	325.8804	M+2
15	TeCB 35 ICQ	288.9145	M-35Cl
-	TrCB 70 IC	325.8804	M+2
16	TrCB 70 ICQ	253.9457	M-35Cl2
17	Lock Mass	330.9792	PFK
F4	**Description**	**Mass**	**Ion**
1	13C-TeCB 1	301.9626	M
2	13C-TeCB 2	303.9597	M+2
3	13C-PeCB 1	337.9207	M+2
4	13C-PeCB 2	339.9178	M+4
5	13C-HxCB 1	371.8817	M+2
6	13C-HxCB 2	373.8788	M+4
7	TeCB 1	289.9224	M
8	TeCB 2	291.9194	M+2
9	PeCB 1	323.8834	M
10	PeCB2	325.8804	M+2
11	PeCB 3	327.8775	M+4
12	HxCB 1	359.8415	M+2
13	HxCB 2	361.8385	M+4
-	TeCB 35 IC	325.8804	M
14	TeCB 35 ICQ	288.9145	M-35Cl
-	PeCB 35 IC	359.8415	M+2
15	PeCB 35 ICQ	322.8756	M-35Cl
-	TeCB 70 IC	359.8415	M+2
16	TeCB 70 ICQ	287.9067	M-35Cl2
17	Lock Mass	330.9792	PFK
F5	**Description**	**Mass**	**Ion**
1	13C-PeCB 1	337.9207	M+2
2	13C-PeCB 2	339.9178	M+4
3	13C-HxCB 1	371.8817	M+2
4	13C-HxCB 2	373.8788	M+4
5	13C-HpCB 1	405.8428	M+2
6	13C-HpCB 2	407.8398	M+4
7	PeCB 1	323.8834	M
8	PeCB 2	325.8804	M+2
9	PeCB 3	327.8775	M+4
10	HxCB 1	359.8415	M+2
11	HxCB 2	361.8385	M+4
12	HpCB 1	393.8025	M+2
13	HpCB 2	395.7995	M+4
-	PeCB 35 IC	359.8415	M+2
14	PeCB 35 ICQ	322.8756	M-1
-	HxCB 35 IC	393.8025	M+2

15	HxCB 35 ICQ	356.8366	M-35Cl
-	PeCB 70 IC	393.8025	M+2
16	PeCB 70 ICQ	321.8677	M-35Cl2
17	Lock Mass	330.9792	PFK
F6	**Description**	**Mass**	**Ion**
1	13C-HxCB 1	371.8817	M+2
2	13C-HxCB 2	373.8788	M+4
3	13C-HpCB 1	405.8428	M+2
4	13C-HpCB 2	407.8398	M+4
5	13C-OcCB 1	439.8038	M+2
6	13C-OcCB 2	441.8008	M+4
7	HxCB 1	359.8415	M+2
8	HxCB 2	361.8385	M+4
9	HpCB 1	393.8025	M+2
10	HpCB 2	395.7995	M+4
11	OcCB 1	427.7635	M+2
12	OcCB 2	429.7606	M+4
-	HxCB 35 IC	393.8025	M+2
13	HxCB 35 ICQ	356.8366	M-35Cl
-	HpCB 35 IC	427.7635	M+2
14	HpCB 35 ICQ	390.7976	M-35Cl
-	HxCB 70 IC	427.7635	M+2
15	HxCB 70 ICQ	355.8288	M-35Cl2
16	Lock Mass	380.9760	PFK
F7	**Description**	**Mass**	**Ion**
1	13C-HpCB 1	405.8428	M+2
2	13C-HpCB 2	407.8398	M+4
3	13C-OcCB 1	439.8038	M+2
4	13C-OcCB 2	441.8008	M+4
5	13C-NoCB 1	473.7648	M+2
6	13C-NoCB 2	475.7619	M+4
7	13C-DeCB 1	509.7229	M+4
8	13C-DeCB 2	511.7199	M+6
9	HpCB 1	393.8025	M+2
10	HpCB 2	395.7995	M+4
11	OcCB 1	427.7635	M+2
12	OcCB 2	429.7606	M+4
13	NoCB 1	461.7246	M+2
14	NoCB 2	463.7216	M+4
15	DeCB 1	497.6826	M+4
16	DeCB 2	499.6797	M+6
17	Lock Mass	430.9728	PFK

* IC – Interference Check ion
ICQ – Interference Check Quantitation ion

TABLE 3: THEORETICAL ION RATIOS AND CONTROL LIMITS

Homolog Group	M/Z Forming Ratio	Theoretical Ratio	Lower Limit	Upper Limit
Mono	M/M+2	3.13	2.66	3.60
Di	M/M+2	1.56	1.33	1.79
Tri	M/M+2	1.04	0.88	1.20
Tetra	M/M+2	0.77	0.65	0.89
Penta	M/M+2	0.61	0.52	0.71
Penta	M+2/M+4	1.55	1.32	1.78
Hexa	M+2/M+4	1.24	1.05	1.43
Hepta	M+2/M+4	1.05	0.89	1.21
Octa	M+2/M+4	0.89	0.76	1.02
Nona	M+2/M+4	0.77	0.65	0.89
Deca	M+4/M+6	1.16	0.99	1.33

TABLE 4: INITIAL CALIBRATION CONCENTRATIONS

Congener (#)	CS0.5	CS1	CS2	CS3	CS4	CS5
Native Analytes						
2-MoCB (1)	0.5	1	5	50	400	2000
4-MoCB (3)	0.5	1	5	50	400	2000
2,2'-DiCB (4)	0.5	1	5	50	400	2000
4,4'-DiCB (15)	0.5	1	5	50	400	2000
2,2',6'-TrCB (19)	0.5	1	5	50	400	2000
3,4,4'-TrCB (37)	0.5	1	5	50	400	2000
2,2',6,6'-TeCB (54)	0.5	1	5	50	400	2000
3,3',4,4'-TeCB (77)	0.5	1	5	50	400	2000
3,4,4',5-TeCB (81)	0.5	1	5	50	400	2000
2,2',4,6,6'-PeCB (104)	0.5	1	5	50	400	2000
2,3,3',4,4'-PeCB (105)	0.5	1	5	50	400	2000
2,3,4,4',5-PeCB (114)	0.5	1	5	50	400	2000
2,3',4,4',5-PeCB (118)	0.5	1	5	50	400	2000
2',3,4,4',5-PeCB (123)	0.5	1	5	50	400	2000
3,3',4,4',5-PeCB (126)	0.5	1	5	50	400	2000
2,2',4,4',6,6'-HxCB (155)	0.5	1	5	50	400	2000
2,3,3',4,4',5-HxCB (156)	0.5	1	5	50	400	2000
2,3,3',4,4',5'-HxCB (157)	0.5	1	5	50	400	2000
2,3',4,4',5,5'-HxCB (167)	0.5	1	5	50	400	2000
3,3',4,4',5,5'-HxCB (169)	0.5	1	5	50	400	2000
2,2',3,4',5,6,6'-HpCB (188)	0.5	1	5	50	400	2000
2,3,3',4,4',5,5'-HpCB (189)	0.5	1	5	50	400	2000
2,2',3,3',5,5',6,6'-OcCB (202)	0.5	1	5	50	400	2000
2,3,3',4,4',5,5',6-OcCB (205)	0.5	1	5	50	400	2000
2,2',3,3',4,4',5,5',6-NoCB (206)	0.5	1	5	50	400	2000
2,2',3,3',4',5,5',6,6'-NoCB (208)	0.5	1	5	50	400	2000
DeCB (209)	0.5	1	5	50	400	2000
Extraction Standards						
13C12-2-MoCB (1L)	100	100	100	100	100	100
13C12-4-MoCB (3L)	100	100	100	100	100	100
13C12-2,2'-DiCB (4L)	100	100	100	100	100	100
13C12-4,4'-DiCB (15L)	100	100	100	100	100	100
13C12-2,2',6'-TrCB (19L)	100	100	100	100	100	100
13C12-3,4,4'-TrCB (37L)	100	100	100	100	100	100
13C12-2,2',6,6'-TeCB (54L)	100	100	100	100	100	100
13C12-3,3',4,4'-TeCB (77L)	100	100	100	100	100	100
13C12-3,4,4',5-TeCB (81L)	100	100	100	100	100	100
13C12-2,2',4,6,6'-PeCB (104L)	100	100	100	100	100	100
13C12-2,3,3',4,4'-PeCB (105L)	100	100	100	100	100	100
13C12-2,3,4,4',5-PeCB (114L)	100	100	100	100	100	100
13C12-2,3',4,4',5-PeCB (118L)	100	100	100	100	100	100
13C12-2',3,4,4',5-PeCB (123L)	100	100	100	100	100	100
13C12-3,3',4,4',5-PeCB (126L)	100	100	100	100	100	100
13C12-2,2',4,4',6,6'-HxCB (155L)	100	100	100	100	100	100
13C12-2,3,3',4,4',5-HxCB (156L)	100	100	100	100	100	100
13C12-2,3,3',4,4',5'-HxCB (157L)	100	100	100	100	100	100
13C12-2,3',4,4',5,5'-HxCB (167L)	100	100	100	100	100	100
13C12-3,3',4,4',5,5'-HxCB (169L)	100	100	100	100	100	100
13C12-2,2',3,4',5,6,6'-HpCB (188L)	100	100	100	100	100	100
13C12-2,3,3',4,4',5,5'-HpCB (189L)	100	100	100	100	100	100
13C12-2,2',3,3',5,5',6,6'-OcCB (202L)	100	100	100	100	100	100

(CONTD)

13C12-2,3,3',4,4',5,5',6-OcCB (205L)	100	100	100	100	100	100

13C12-2,2',3,3',4,4',5,5',6-NoCB (206L)	100	100	100	100	100	100
13C12-2,2',3,3',4',5,5',6,6'-NoCB (208L)	100	100	100	100	100	100
13C12-DeCB (209L)	100	100	100	100	100	100
Cleanup Standards						
13C12-2,4,4'-TrCB (28L)	100	100	100	100	100	100
13C12-2,3,3',5,5'-PeCB (111L)	100	100	100	100	100	100
13C12-2,2',3,3',5,5',6-HpCB (178L)	100	100	100	100	100	100
Injection Standards						
13C12-2,5-DiCB (9L)	100	100	100	100	100	100
13C12-2,2',5,5'-TeCB (52L)	100	100	100	100	100	100
13C12-2,2',4',5,5'-PeCB (101L)	100	100	100	100	100	100
13C12-2,2',3',4,4',5'-HxCB (138L)	100	100	100	100	100	100
13C12-2,2',3,3',4,4',5,5'-OcCB (194L)	100	100	100	100	100	100

TABLE 5: LCS LIMITS

Method 1668A

Native Analytes	Lower %	Upper %
2-MoCB (1)	50	150
4-MoCB (3)	50	150
2,2'-DiCB (4)	50	150
4,4'-DiCB (15)	50	150
2,2',6'-TrCB (19)	50	150
3,4,4'-TrCB (37)	50	150
2,2',6,6'-TeCB (54)	50	150
3,3',4,4'-TeCB (77)	50	150
3,4,4',5-TeCB (81)	50	150
2,2',4,6,6'-PeCB (104)	50	150
2,3,3',4,4'-PeCB (105)	50	150
2,3,4,4',5-PeCB (114)	50	150
2,3',4,4',5-PeCB (118)	50	150
2',3,4,4',5-PeCB (123)	50	150
3,3',4,4',5-PeCB (126)	50	150
2,2',4,4',6,6'-HxCB (155)	50	150
2,3,3',4,4',5-HxCB (156)	50	150
2,3,3',4,4',5'-HxCB (157)	50	150
2,3',4,4',5,5'-HxCB (167)	50	150
3,3',4,4',5,5'-HxCB (169)	50	150
2,2',3,4',5,6,6'-HpCB (188)	50	150
2,3,3',4,4',5,5'-HpCB (189)	50	150
2,2',3,3',5,5',6,6'-OcCB (202)	50	150
2,3,3',4,4',5,5',6-OcCB (205)	50	150
2,2',3,3',4,4',5,5',6-NoCB (206)	50	150
2,2',3,3',4',5,5',6,6'-NoCB (208)	50	150
DeCB (209)	50	150

Extraction Standards	Lower %	Upper %
13C12-2-MoCB (1L)	15	140
13C12-4-MoCB (3L)	15	140
13C12-2,2'-DiCB (4L)	30	140
13C12-4,4'-DiCB (15L)	30	140
13C12-2,2',6'-TrCB (19L)	30	140
13C12-3,4,4'-TrCB (37L)	30	140
13C12-2,2',6,6'-TeCB (54L)	30	140
13C12-3,3',4,4'-TeCB (77L)	30	140
13C12-3,4,4',5-TeCB (81L)	30	140
13C12-2,2',4,6,6'-PeCB (104L)	30	140
13C12-2,3,3',4,4'-PeCB (105L)	30	140
13C12-2,3,4,4',5-PeCB (114L)	30	140
13C12-2,3',4,4',5-PeCB (118L)	30	140
13C12-2',3,4,4',5-PeCB (123L)	30	140
13C12-3,3',4,4',5-PeCB (126L)	30	140
13C12-2,2',4,4',6,6'-HxCB (155L)	30	140
13C12-2,3,3',4,4',5-HxCB (156L)	30	140
13C12-2,3,3',4,4',5'-HxCB (157L)	30	140
13C12-2,3',4,4',5,5'-HxCB (167L)	30	140
13C12-3,3',4,4',5,5'-HxCB (169L)	30	140
13C12-2,2',3,4',5,6,6'-HpCB (188L)	30	140
13C12-2,3,3',4,4',5,5'-HpCB (189L)	30	140
13C12-2,2',3,3',5,5',6,6'-OcCB (202L)	30	140
13C12-2,3,3',4,4',5,5',6-OcCB (205L)	30	140
13C12-2,2',3,3',4,4',5,5',6-NoCB (206L)	30	140
13C12-2,2',3,3',4',5,5',6,6'-NoCB (208L)	30	140
13C12-DeCB (209L)	30	140
Cleanup Standards		
13C12-2,4,4'-TrCB (28L)	40	125
13C12-2,3,3',5,5'-PeCB (111L)	40	125
13C12-2,2',3,3',5,5',6-HpCB (178L)	40	125

Method 1668C (LCS Limits)

Native Analytes	Lower %	Upper %
2-MoCB (1)	60	135
4-MoCB (3)	60	135
2,2'-DiCB (4)	60	135
4,4'-DiCB (15)	60	135
2,2',6'-TrCB (19)	60	135
3,4,4'-TrCB (37)	60	135
2,2',6,6'-TeCB (54)	60	135
3,3',4,4'-TeCB (77)	60	135
3,4,4',5-TeCB (81)	60	135
2,2',4,6,6'-PeCB (104)	60	135
2,3,3',4,4'-PeCB (105)	60	135
2,3,4,4',5-PeCB (114)	60	135
2,3',4,4',5-PeCB (118)	60	135
2',3,4,4',5-PeCB (123)	60	135
3,3',4,4',5-PeCB (126)	60	135
2,2',4,4',6,6'-HxCB (155)	60	135
2,3,3',4,4',5-HxCB (156)	60	135
2,3,3',4,4',5'-HxCB (157)	60	135
2,3',4,4',5,5'-HxCB (167)	60	135
3,3',4,4',5,5'-HxCB (169)	60	135
2,2',3,4',5,6,6'-HpCB (188)	60	135
2,3,3',4,4',5,5'-HpCB (189)	60	135
2,2',3,3',5,5',6,6'-OcCB (202)	60	135
2,3,3',4,4',5,5',6-OcCB (205)	60	135
2,2',3,3',4,4',5,5',6-NoCB (206)	60	135
2,2',3,3',4',5,5',6,6'-NoCB (208)	60	135
DeCB (209)	60	135

Extraction Standards	Lower %	Upper %
13C12-2-MoCB (1L)	15	145
13C12-4-MoCB (3L)	15	145
13C12-2,2'-DiCB (4L)	15	145
13C12-4,4'-DiCB (15L)	15	145
13C12-2,2',6'-TrCB (19L)	15	145
13C12-3,4,4'-TrCB (37L)	15	145
13C12-2,2',6,6'-TeCB (54L)	15	145
13C12-3,3',4,4'-TeCB (77L)	40	145
13C12-3,4,4',5-TeCB (81L)	40	145
13C12-2,2',4,6,6'-PeCB (104L)	40	145
13C12-2,3,3',4,4'-PeCB (105L)	40	145
13C12-2,3,4,4',5-PeCB (114L)	40	145
13C12-2,3',4,4',5-PeCB (118L)	40	145
13C12-2',3,4,4',5-PeCB (123L)	40	145
13C12-3,3',4,4',5-PeCB (126L)	40	145
13C12-2,2',4,4',6,6'-HxCB (155L)	40	145
13C12-2,3,3',4,4',5-HxCB (156L)	40	145
13C12-2,3,3',4,4',5'-HxCB (157L)	40	145
13C12-2,3',4,4',5,5'-HxCB (167L)	40	145
13C12-3,3',4,4',5,5'-HxCB (169L)	40	145
13C12-2,2',3,4',5,6,6'-HpCB (188L)	40	145
13C12-2,3,3',4,4',5,5'-HpCB (189L)	40	145
13C12-2,2',3,3',5,5',6,6'-OcCB (202L)	40	145
13C12-2,3,3',4,4',5,5',6-OcCB (205L)	40	145
13C12-2,2',3,3',4,4',5,5',6-NoCB (206L)	40	145
13C12-2,2',3,3',4',5,5',6,6'-NoCB (208L)	40	145
13C12-DeCB (209L)	40	145
Cleanup Standards		
13C12-2,4,4'-TrCB (28L)	15	145
13C12-2,3,3',5,5'-PeCB (111L)	40	145
13C12-2,2',3,3',5,5',6-HpCB (178L)	40	145

TABLE 6: SAMPLE AND LMB RECOVERY LIMITS

Method 1668A

Extraction Standards	Lower %	Upper %
13C12-2-MoCB (1L)	15	150
13C12-4-MoCB (3L)	15	150
13C12-2,2'-DiCB (4L)	25	150
13C12-4,4'-DiCB (15L)	25	150
13C12-2,2',6'-TrCB (19L)	25	150
13C12-3,4,4'-TrCB (37L)	25	150
13C12-2,2',6,6'-TeCB (54L)	25	150
13C12-3,3',4,4'-TeCB (77L)	25	150
13C12-3,4,4',5-TeCB (81L)	25	150
13C12-2,2',4,6,6'-PeCB (104L)	25	150
13C12-2,3,3',4,4'-PeCB (105L)	25	150
13C12-2,3,4,4',5-PeCB (114L)	25	150
13C12-2,3',4,4',5-PeCB (118L)	25	150
13C12-2',3,4,4',5-PeCB (123L)	25	150
13C12-3,3',4,4',5-PeCB (126L)	25	150
13C12-2,2',4,4',6,6'-HxCB (155L)	25	150
13C12-2,3,3',4,4',5-HxCB (156L)	25	150
13C12-2,3,3',4,4',5'-HxCB (157L)	25	150
13C12-2,3',4,4',5,5'-HxCB (167L)	25	150
13C12-3,3',4,4',5,5'-HxCB (169L)	25	150
13C12-2,2',3,4',5,6,6'-HpCB (188L)	25	150
13C12-2,3,3',4,4',5,5'-HpCB (189L)	25	150
13C12-2,2',3,3',5,5',6,6'-OcCB (202L)	25	150
13C12-2,3,3',4,4',5,5',6-OcCB (205L)	25	150
13C12-2,2',3,3',4,4',5,5',6-NoCB (206L)	25	150
13C12-2,2',3,3',4',5,5',6,6'-NoCB (208L)	25	150
13C12-DeCB (209L)	25	150
Cleanup Standards		
13C12-2,4,4'-TrCB (28L)	30	135
13C12-2,3,3',5,5'-PeCB (111L)	30	135
13C12-2,2',3,3',5,5',6-HpCB (178L)	30	135

Method 1668C (Sample and LMB Recovery Limits)

Extraction Standards	Lower %	Upper %
13C12-2-MoCB (1L)	5	145
13C12-4-MoCB (3L)	5	145
13C12-2,2'-DiCB (4L)	5	145
13C12-4,4'-DiCB (15L)	5	145
13C12-2,2',6'-TrCB (19L)	5	145
13C12-3,4,4'-TrCB (37L)	5	145
13C12-2,2',6,6'-TeCB (54L)	5	145
13C12-3,3',4,4'-TeCB (77L)	10	145
13C12-3,4,4',5-TeCB (81L)	10	145
13C12-2,2',4,6,6'-PeCB (104L)	10	145
13C12-2,3,3',4,4'-PeCB (105L)	10	145
13C12-2,3,4,4',5-PeCB (114L)	10	145
13C12-2,3',4,4',5-PeCB (118L)	10	145
13C12-2',3,4,4',5-PeCB (123L)	10	145
13C12-3,3',4,4',5-PeCB (126L)	10	145
13C12-2,2',4,4',6,6'-HxCB (155L)	10	145
13C12-2,3,3',4,4',5-HxCB (156L)	10	145
13C12-2,3,3',4,4',5'-HxCB (157L)	10	145
13C12-2,3',4,4',5,5'-HxCB (167L)	10	145
13C12-3,3',4,4',5,5'-HxCB (169L)	10	145
13C12-2,2',3,4',5,6,6'-HpCB (188L)	10	145
13C12-2,3,3',4,4',5,5'-HpCB (189L)	10	145
13C12-2,2',3,3',5,5',6,6'-OcCB (202L)	10	145
13C12-2,3,3',4,4',5,5',6-OcCB (205L)	10	145
13C12-2,2',3,3',4,4',5,5',6-NoCB (206L)	10	145
13C12-2,2',3,3',4',5,5',6,6'-NoCB (208L)	10	145
13C12-DeCB (209L)	10	145
Cleanup Standards		
13C12-2,4,4'-TrCB (28L)	5	145
13C12-2,3,3',5,5'-PeCB (111L)	10	145
13C12-2,2',3,3',5,5',6-HpCB (178L)	10	145

TABLE 7: CONTINUING CALIBRATION LIMITS (VER)

Methods 1668A

Native Analytes	Lower %	Upper %
2-MoCB (1)	70	130
4-MoCB (3)	70	130
2,2'-DiCB (4)	70	130
4,4'-DiCB (15)	70	130
2,2',6'-TrCB (19)	70	130
3,4,4'-TrCB (37)	70	130
2,2',6,6'-TeCB (54)	70	130
3,3',4,4'-TeCB (77)	70	130
3,4,4',5-TeCB (81)	70	130
2,2',4,6,6'-PeCB (104)	70	130
2,3,3',4,4'-PeCB (105)	70	130
2,3,4,4',5-PeCB (114)	70	130
2,3',4,4',5-PeCB (118)	70	130
2',3,4,4',5-PeCB (123)	70	130
3,3',4,4',5-PeCB (126)	70	130
2,2',4,4',6,6'-HxCB (155)	70	130
2,3,3',4,4',5-HxCB (156)	70	130
2,3,3',4,4',5'-HxCB (157)	70	130
2,3',4,4',5,5'-HxCB (167)	70	130
3,3',4,4',5,5'-HxCB (169)	70	130
2,2',3,4',5,6,6'-HpCB (188)	70	130
2,3,3',4,4',5,5'-HpCB (189)	70	130
2,2',3,3',5,5',6,6'-OcCB (202)	70	130
2,3,3',4,4',5,5',6-OcCB (205)	70	130
2,2',3,3',4,4',5,5',6-NoCB (206)	70	130
2,2',3,3',4',5,5',6,6'-NoCB (208)	70	130
DeCB (209)	70	130

Extraction Standards	Lower %	Upper %
13C12-2-MoCB (1L)	50	150
13C12-4-MoCB (3L)	50	150
13C12-2,2'-DiCB (4L)	50	150
13C12-4,4'-DiCB (15L)	50	150
13C12-2,2',6'-TrCB (19L)	50	150
13C12-3,4,4'-TrCB (37L)	50	150
13C12-2,2',6,6'-TeCB (54L)	50	150
13C12-3,3',4,4'-TeCB (77L)	50	150
13C12-3,4,4',5-TeCB (81L)	50	150
13C12-2,2',4,6,6'-PeCB (104L)	50	150
13C12-2,3,3',4,4'-PeCB (105L)	50	150
13C12-2,3,4,4',5-PeCB (114L)	50	150
13C12-2,3',4,4',5-PeCB (118L)	50	150
13C12-2',3,4,4',5-PeCB (123L)	50	150
13C12-3,3',4,4',5-PeCB (126L)	50	150
13C12-2,2',4,4',6,6'-HxCB (155L)	50	150
13C12-2,3,3',4,4',5-HxCB (156L)	50	150
13C12-2,3,3',4,4',5'-HxCB (157L)	50	150
13C12-2,3',4,4',5,5'-HxCB (167L)	50	150
13C12-3,3',4,4',5,5'-HxCB (169L)	50	150
13C12-2,2',3,4',5,6,6'-HpCB (188L)	50	150
13C12-2,3,3',4,4',5,5'-HpCB (189L)	50	150
13C12-2,2',3,3',5,5',6,6'-OcCB (202L)	50	150
13C12-2,3,3',4,4',5,5',6-OcCB (205L)	50	150
13C12-2,2',3,3',4,4',5,5',6-NoCB (206L)	50	150
13C12-2,2',3,3',4',5,5',6,6'-NoCB (208L)	50	150
13C12-DeCB (209L)	50	150
Cleanup Standards		
13C12-2,4,4'-TrCB (28L)	60	130
13C12-2,3,3',5,5'-PeCB (111L)	60	130
13C12-2,2',3,3',5,5',6-HpCB (178L)	60	130

Method 1668C Continuing Calibration Limit (VER)

Native Analytes	Lower %	Upper %
2-MoCB (1)	75	125
4-MoCB (3)	75	125
2,2'-DiCB (4)	75	125
4,4'-DiCB (15)	75	125
2,2',6'-TrCB (19)	75	125
3,4,4'-TrCB (37)	75	125
2,2',6,6'-TeCB (54)	75	125
3,3',4,4'-TeCB (77)	75	125
3,4,4',5-TeCB (81)	75	125
2,2',4,6,6'-PeCB (104)	75	125
2,3,3',4,4'-PeCB (105)	75	125
2,3,4,4',5-PeCB (114)	75	125
2,3',4,4',5-PeCB (118)	75	125
2',3,4,4',5-PeCB (123)	75	125
3,3',4,4',5-PeCB (126)	75	125
2,2',4,4',6,6'-HxCB (155)	75	125
2,3,3',4,4',5-HxCB (156)	75	125
2,3,3',4,4',5'-HxCB (157)	75	125
2,3',4,4',5,5'-HxCB (167)	75	125
3,3',4,4',5,5'-HxCB (169)	75	125
2,2',3,4',5,6,6'-HpCB (188)	75	125
2,3,3',4,4',5,5'-HpCB (189)	75	125
2,2',3,3',5,5',6,6'-OcCB (202)	75	125
2,3,3',4,4',5,5',6-OcCB (205)	75	125
2,2',3,3',4,4',5,5',6-NoCB (206)	75	125
2,2',3,3',4',5,5',6,6'-NoCB (208)	75	125
DeCB (209)	75	125

Extraction Standards	Lower %	Upper %
13C12-2-MoCB (1L)	50	145
13C12-4-MoCB (3L)	50	145
13C12-2,2'-DiCB (4L)	50	145
13C12-4,4'-DiCB (15L)	50	145
13C12-2,2',6'-TrCB (19L)	50	145
13C12-3,4,4'-TrCB (37L)	50	145
13C12-2,2',6,6'-TeCB (54L)	50	145
13C12-3,3',4,4'-TeCB (77L)	50	145
13C12-3,4,4',5-TeCB (81L)	50	145
13C12-2,2',4,6,6'-PeCB (104L)	50	145
13C12-2,3,3',4,4'-PeCB (105L)	50	145
13C12-2,3,4,4',5-PeCB (114L)	50	145
13C12-2,3',4,4',5-PeCB (118L)	50	145
13C12-2',3,4,4',5-PeCB (123L)	50	145
13C12-3,3',4,4',5-PeCB (126L)	50	145
13C12-2,2',4,4',6,6'-HxCB (155L)	50	145
13C12-2,3,3',4,4',5-HxCB (156L)	50	145
13C12-2,3,3',4,4',5'-HxCB (157L)	50	145
13C12-2,3',4,4',5,5'-HxCB (167L)	50	145
13C12-3,3',4,4',5,5'-HxCB (169L)	50	145
13C12-2,2',3,4',5,6,6'-HpCB (188L)	50	145
13C12-2,3,3',4,4',5,5'-HpCB (189L)	50	145
13C12-2,2',3,3',5,5',6,6'-OcCB (202L)	50	145
13C12-2,3,3',4,4',5,5',6-OcCB (205L)	50	145
13C12-2,2',3,3',4,4',5,5',6-NoCB (206L)	50	145
13C12-2,2',3,3',4',5,5',6,6'-NoCB (208L)	50	145
13C12-DeCB (209L)	50	145
Cleanup Standards		
13C12-2,4,4'-TrCB (28L)	65	135
13C12-2,3,3',5,5'-PeCB (111L)	75	125
13C12-2,2',3,3',5,5',6-HpCB (178L)	75	125

TABLE 8: RETENTION TIME LIMITS (and example relative retention time limits)

Reference 209 Mix Analyte	Example RT (min)	RT Ref	Example RT Ref (min)	Window (sec) low	Window (sec) high	Example Resulting RRT Limits
MoCB-1	6.99	1L	6.98	-3	3	0.994 - 1.009
MoCB-2	8.64	3L	8.77	-3	3	0.979 - 0.991
MoCB-3	8.78	3L	8.77	-3	3	0.995 - 1.007
DiCB-4	8.99	4L	8.97	-3	3	0.997 - 1.008
DiCB-10	9.13	4L	8.97	-3	3	1.012 - 1.023
DiCB-9	10.65	4L	8.97	-3	3	1.182 - 1.193
DiCB-7	10.80	4L	8.97	-3	3	1.198 - 1.210
DiCB-6	11.01	4L	8.97	-3	3	1.222 - 1.233
DiCB-5	11.27	4L	8.97	-3	3	1.251 - 1.262
DiCB-8	11.38	4L	8.97	-3	3	1.263 - 1.274
DiCB-14	12.87	15L	14.25	-3	3	0.900 - 0.907
DiCB-11	13.66	15L	14.25	-3	3	0.955 - 0.962
DiCB-13/12	13.98	15L	14.25	-3	3	0.978 - 0.985
DiCB-15	14.26	15L	14.25	-3	3	0.997 - 1.004
TrCB-19	11.66	19L	11.65	-3	3	0.997 - 1.005
TrCB-18/30	13.35	19L	11.65	-3	3	1.142 - 1.150
TrCB-17	13.77	19L	11.65	-3	3	1.178 - 1.186
TrCB-27	13.96	19L	11.65	-3	3	1.194 - 1.203
TrCB-24	14.11	19L	11.65	-3	3	1.207 - 1.215
TrCB-16	14.22	19L	11.65	-3	3	1.216 - 1.225
TrCB-32	14.72	19L	11.65	-3	3	1.259 - 1.268
TrCB-34	15.98	19L	11.65	-3	3	1.367 - 1.376
TrCB-23	16.16	19L	11.65	-3	3	1.383 - 1.391
TrCB-26/29	16.49	19L	11.65	-5	5	1.408 - 1.423
TrCB-25	16.71	37L	21.93	-3	3	0.760 - 0.764
TrCB-31	17.04	37L	21.93	-3	3	0.775 - 0.779
TrCB-20/28	17.38	37L	21.93	-5	5	0.789 - 0.796
TrCB-21/33	17.61	37L	21.93	-5	5	0.799 - 0.807
TrCB-22	18.06	37L	21.93	-3	3	0.821 - 0.826
TrCB-36	19.81	37L	21.93	-3	3	0.901 - 0.906
TrCB-39	20.23	37L	21.93	-3	3	0.920 - 0.925
TrCB-38	20.93	37L	21.93	-3	3	0.952 - 0.957
TrCB-35	21.47	37L	21.93	-3	3	0.977 - 0.981
TrCB-37	21.96	37L	21.93	-3	3	0.999 - 1.004
TeCB-54	14.58	54L	14.55	-3	3	0.999 - 1.005
TeCB-50/53	16.77	54L	14.55	-5	5	1.147 - 1.158
TeCB-45/51	17.56	54L	14.55	-5	5	1.201 - 1.213

TeCB-46	17.82	54L	14.55	-3	3	1.221	-	1.228
TeCB-52	19.38	54L	14.55	-3	3	1.329	-	1.335
TeCB-73	19.54	54L	14.55	-3	3	1.340	-	1.346
TeCB-43	19.67	54L	14.55	-3	3	1.348	-	1.355
TeCB-69/49	19.92	54L	14.55	-5	5	1.363	-	1.375
TeCB-48	20.29	54L	14.55	-3	3	1.391	-	1.398
TeCB-44/65/47	20.59	54L	14.55	-5	5	1.409	-	1.421
TeCB-59/62/75	20.93	54L	14.55	-5	5	1.433	-	1.444
TeCB-42	21.17	54L	14.55	-3	3	1.452	-	1.458
TeCB-41	21.63	54L	14.55	-5	5	1.481	-	1.492
TeCB-40/71	21.76	54L	14.55	-5	5	1.490	-	1.501
TeCB-64	22.03	54L	14.55	-3	3	1.511	-	1.518
TeCB-72	23.04	81L	30.73	-3	3	0.748	-	0.751
TeCB-68	23.40	81L	30.73	-3	3	0.760	-	0.763
TeCB-57	23.93	81L	30.73	-3	3	0.777	-	0.780
TeCB-58	24.23	81L	30.73	-3	3	0.787	-	0.790
TeCB-67	24.45	81L	30.73	-3	3	0.794	-	0.797
TeCB-63	24.79	81L	30.73	-3	3	0.805	-	0.808
TeCB-61/76/70/74	25.20	81L	30.73	-6	6	0.817	-	0.823
TeCB-66	25.63	81L	30.73	-3	3	0.832	-	0.836
TeCB-55	25.84	81L	30.73	-3	3	0.839	-	0.842
TeCB-56	26.49	81L	30.73	-3	3	0.860	-	0.864
TeCB-60	26.78	81L	30.73	-3	3	0.870	-	0.873
TeCB-80	27.34	81L	30.73	-3	3	0.888	-	0.891
TeCB-79	29.39	81L	30.73	-3	3	0.955	-	0.958
TeCB-78	30.16	81L	30.73	-3	3	0.980	-	0.983
TeCB-81 WHO	30.76	81L	30.73	-3	3	0.999	-	1.003
TeCB-77 WHO	31.54	77L	31.51	-3	3	0.999	-	1.003
PeCB-104	20.51	104L	20.48	-3	3	0.999	-	1.004
PeCB-96	20.93	104L	20.48	-5	5	1.018	-	1.026
PeCB-103	23.28	104L	20.48	-3	3	1.134	-	1.139
PeCB-94	23.55	104L	20.48	-3	3	1.147	-	1.152
PeCB-95	24.09	104L	20.48	-5	5	1.172	-	1.180
PeCB-93/100	24.39	104L	20.48	-5	5	1.187	-	1.195
PeCB-102/98	24.57	104L	20.48	-5	5	1.196	-	1.204
PeCB-88/91	25.19	104L	20.48	-6	6	1.225	-	1.235
PeCB-84	25.47	104L	20.48	-3	3	1.241	-	1.246
PeCB-89	26.10	104L	20.48	-3	3	1.272	-	1.277
PeCB-121	26.67	104L	20.48	-3	3	1.300	-	1.305
PeCB-92	27.15	123L	34.37	-3	3	0.788	-	0.791
PeCB-113/90/101	27.91	123L	34.37	-5	5	0.810	-	0.814
PeCB-83	28.55	123L	34.37	-6	6	0.828	-	0.834
PeCB-99	28.72	123L	34.37	-5	5	0.833	-	0.838

PeCB-112	28.87	123L	34.37	-3	3	0.839	-	0.841
PeCB-86/87/97/109/119/125	29.38	123L	34.37	-8	8	0.851	-	0.859
PeCB-117/116/85	30.38	123L	34.37	-5	5	0.881	-	0.886
PeCB-110/115	30.73	123L	34.37	-5	5	0.892	-	0.897
PeCB-82	31.05	123L	34.37	-3	3	0.902	-	0.905
PeCB-111	31.62	123L	34.37	-3	3	0.919	-	0.921
PeCB-120	32.28	123L	34.37	-3	3	0.938	-	0.941
PeCB-108/124	33.88	123L	34.37	-8	8	0.982	-	0.990
PeCB-107	34.23	123L	34.37	-5	5	0.994	-	0.998
PeCB-123 WHO	34.40	123L	34.37	-3	3	0.999	-	1.002
PeCB-106	34.56	123L	34.37	-3	3	1.004	-	1.007
PeCB-118 WHO	34.86	118L	34.85	-3	3	0.999	-	1.002
PeCB-122	35.36	118L	34.85	-3	3	1.013	-	1.016
PeCB-114 WHO	35.64	114L	35.60	-3	3	1.000	-	1.003
PeCB-105 WHO	36.57	105L	36.54	-3	3	0.999	-	1.002
PeCB-127	38.78	105L	36.54	-3	3	1.060	-	1.063
PeCB-126 WHO	41.17	126L	41.14	-3	3	1.000	-	1.002
HxCB-155	27.64	155L	27.61	-3	3	0.999	-	1.003
HxCB-152	27.88	155L	27.61	-3	3	1.008	-	1.012
HxCB-150	28.12	155L	27.61	-3	3	1.017	-	1.020
HxCB-136	28.58	155L	27.61	-3	3	1.033	-	1.037
HxCB-145	29.00	155L	27.61	-3	3	1.049	-	1.052
HxCB-148	31.10	155L	27.61	-3	3	1.125	-	1.128
HxCB-151/135	31.94	155L	27.61	-5	5	1.154	-	1.160
HxCB-154	32.29	155L	27.61	-5	5	1.166	-	1.173
HxCB-144	32.72	155L	27.61	-3	3	1.183	-	1.187
HxCB-147/149	33.22	155L	27.61	-5	5	1.200	-	1.206
HxCB-134	33.48	155L	27.61	-5	5	1.210	-	1.216
HxCB-143	33.64	155L	27.61	-5	5	1.215	-	1.221
HxCB-139/140	34.08	155L	27.61	-5	5	1.231	-	1.237
HxCB-131	34.35	155L	27.61	-3	3	1.242	-	1.246
HxCB-142	34.58	155L	27.61	-3	3	1.251	-	1.254
HxCB-132	35.01	155L	27.61	-5	5	1.265	-	1.271
HxCB-133	35.77	155L	27.61	-3	3	1.294	-	1.297
HxCB-165	36.36	167L	44.03	-3	3	0.825	-	0.827
HxCB-146	36.73	167L	44.03	-3	3	0.833	-	0.835
HxCB-161	36.92	167L	44.03	-3	3	0.837	-	0.840
HxCB-153/168	37.68	167L	44.03	-5	5	0.854	-	0.858
HxCB-141	37.89	167L	44.03	-3	3	0.859	-	0.862
HxCB-130	38.49	167L	44.03	-3	3	0.873	-	0.875
HxCB-137	38.85	167L	44.03	-3	3	0.881	-	0.883
HxCB-164	39.00	167L	44.03	-3	3	0.885	-	0.887

HxCB-138/163/129	39.48	167L	44.03	-7	7	0.894 - 0.899
HxCB-160	39.71	167L	44.03	-5	5	0.900 - 0.904
HxCB-158	40.06	167L	44.03	-3	3	0.909 - 0.911
HxCB-128/166	41.31	167L	44.03	-5	5	0.936 - 0.940
HxCB-159	42.90	167L	44.03	-3	3	0.973 - 0.975
HxCB-162	43.33	167L	44.03	-3	3	0.983 - 0.985
HxCB-167 WHO	44.06	167L	44.03	-3	3	1.000 - 1.002
HxCB-156/157 WHO	45.81	156L	45.76	-3	3	1.000 - 1.002
HxCB-169 WHO	50.88	169L	50.83	-3	3	1.000 - 1.002
HpCB-188	35.64	188L	35.61	-3	3	0.999 - 1.002
HpCB-179	36.11	188L	35.61	-3	3	1.013 - 1.015
HpCB-184	36.92	188L	35.61	-3	3	1.035 - 1.038
HpCB-176	37.41	188L	35.61	-3	3	1.049 - 1.052
HpCB-186	38.08	188L	35.61	-3	3	1.068 - 1.071
HpCB-178	40.17	188L	35.61	-3	3	1.127 - 1.129
HpCB-175	41.12	188L	35.61	-3	3	1.153 - 1.156
HpCB-187	41.54	188L	35.61	-3	3	1.165 - 1.168
HpCB-182	41.86	188L	35.61	-3	3	1.174 - 1.177
HpCB-183/185	42.48	188L	35.61	-3	3	1.192 - 1.194
HpCB-174	42.80	188L	35.61	-3	3	1.201 - 1.203
HpCB-177	43.47	188L	35.61	-3	3	1.219 - 1.222
HpCB-181	44.09	188L	35.61	-3	3	1.237 - 1.240
HpCB-173/171	44.41	188L	35.61	-5	5	1.245 - 1.249
HpCB-172	46.99	189L	54.86	-3	3	0.856 - 0.857
HpCB-192	47.42	189L	54.86	-3	3	0.863 - 0.865
HpCB-193/180	47.93	189L	54.86	-3	3	0.873 - 0.875
HpCB-191	48.55	189L	54.86	-3	3	0.884 - 0.886
HpCB-170	49.94	189L	54.86	-3	3	0.909 - 0.911
HpCB-190	50.77	189L	54.86	-3	3	0.925 - 0.926
HpCB-189 WHO	54.89	189L	54.86	-3	3	1.000 - 1.001
OcCB-202	43.68	202L	43.65	-3	3	1.000 - 1.002
OcCB-201	45.11	202L	43.65	-5	5	1.032 - 1.035
OcCB-204	46.16	202L	43.65	-3	3	1.056 - 1.059
OcCB-197/200	46.51	202L	43.65	-3	3	1.064 - 1.067
OcCB-198/199	51.05	202L	43.65	-5	5	1.168 - 1.171
OcCB-196	52.12	205L	58.97	-3	3	0.883 - 0.885
OcCB-203	52.44	205L	58.97	-3	3	0.888 - 0.890
OcCB-195	54.48	205L	58.97	-3	3	0.923 - 0.925
OcCB-194	58.26	205L	58.97	-3	3	0.987 - 0.989
OcCB-205	59.00	205L	58.97	-3	3	1.000 - 1.001
NoCB-208	54.14	208L	54.11	-3	3	1.000 - 1.001
NoCB-207	55.63	208L	54.11	-3	3	1.027 - 1.029
NoCB-206	61.88	206L	61.85	-3	3	1.000 - 1.001

DeCB-209	64.86	209L	64.81	-3	3	1.000	-	1.002
MoCB-1L	6.98	9L	10.63	-15	15	0.633	-	0.680
MoCB-3L	8.77	9L	10.63	-15	15	0.802	-	0.849
DiCB-4L	8.97	9L	10.63	-15	15	0.820	-	0.867
DiCB-15L	14.25	9L	10.63	-10	10	1.325	-	1.356
TrCB-19L	11.65	9L	10.63	-15	15	1.072	-	1.119
TrCB-37L	21.93	52L	19.37	-15	15	1.119	-	1.145
TeCB-54L	14.55	52L	19.37	-10	10	0.743	-	0.760
TeCB-81L	30.73	52L	19.37	-10	10	1.578	-	1.595
TeCB-77L	31.51	52L	19.37	-10	10	1.618	-	1.635
PeCB-104L	20.48	101L	27.90	-10	10	0.728	-	0.740
PeCB-123L	34.37	101L	27.90	-10	10	1.226	-	1.238
PeCB-118L	34.85	101L	27.90	-10	10	1.243	-	1.255
PeCB-114L	35.60	101L	27.90	-10	10	1.270	-	1.282
PeCB-105L	36.54	101L	27.90	-10	10	1.304	-	1.316
PeCB-126L	41.14	101L	27.90	-10	10	1.469	-	1.481
HxCB-155L	27.61	138L	39.43	-10	10	0.696	-	0.704
HxCB-167L	44.03	138L	39.43	-10	10	1.112	-	1.121
HxCB-156L/157L	45.76	138L	39.43	-10	10	1.156	-	1.165
HxCB-169L	50.83	138L	39.43	-10	10	1.285	-	1.293
HpCB-188L	35.61	194L	58.23	-10	10	0.609	-	0.614
HpCB-189L	54.86	194L	58.23	-10	10	0.939	-	0.945
OcCB-202L	43.65	194L	58.23	-10	10	0.747	-	0.752
OcCB-205L	58.97	194L	58.23	-15	15	1.008	-	1.017
NoCB-208L	54.11	194L	58.23	-10	10	0.926	-	0.932
NoCB-206L	61.85	194L	58.23	-15	15	1.058	-	1.066
DeCB-209L	64.81	194L	58.23	-15	15	1.109	-	1.117
TrCB-28L CU	17.35	9L	19.37	-10	10	0.887	-	0.904
PeCB-111L CU	31.59	101L	27.90	-10	10	1.126	-	1.138
HpCB-178L CU	40.12	138L	39.43	-10	10	1.013	-	1.022
DiCB-9L IS	10.63	138L	39.43	-12.5	12.5	0.264	-	0.275
TeCB-52L IS	19.37	138L	39.43	-12.5	12.5	0.486	-	0.497
PeCB-101L IS	27.90	138L	39.43	-12.5	12.5	0.702	-	0.713
HxCB-138L IS	39.43	138L	39.43	-50	50	0.979	-	1.021
OcCB-194 IS	58.23	138L	39.43	-12.5	12.5	1.472	-	1.482

The retention time limits are applied to the daily 209 mix resulting in RRT limits for calibrations and samples, including QC samples.
OcCB-194 IS upper limit example: (58.23+(12.5/60))/39.43=1.482

TABLE 9: METHOD HOLDING TIMES

Method	Collection to Extraction	Extraction to Analysis
8290A *	30 days	45 days
1613B	365 days	365 days
DLM02.2	365 days	365 days
M23	30 days	45 days
TO-9a	7 days	40 days
CBC01.2	35 days collect to analysis	
1668A/C	365 days	365 days

* NOTE: The holding times listed in method 8290 are recommendations. PCDDs and PCDFs are very stable in a variety of matrices and holding times under the conditions listed in this section may be as long as a year for certain matrices.

TERMINAL 91: SEDIMENT CLEANUP UNIT: FEASIBILITY STUDY WORK PLAN

APPENDIX C – HEALTH AND SAFETY PLAN

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For submittal to:

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October 2024

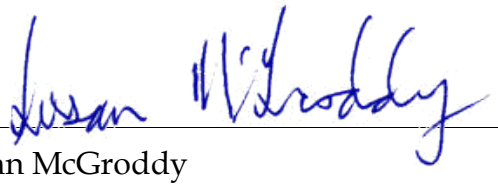
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Health and Safety Plan Signature Page

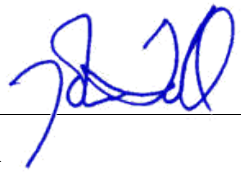
By their signature, the undersigned certify that this health and safety plan is approved and that it will be used to govern health and safety aspects of fieldwork described in the quality assurance project plan to which it is attached.



April 14, 2025

Susan McGroddy — Date

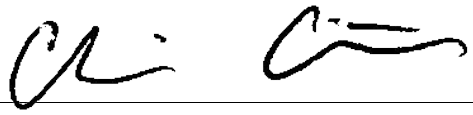
Project Manager



April 14, 2025

John Toll — Date

Corporate Health and Safety Manager



April 14, 2025

Claire Christensen — Date

Field Coordinator/Health and Safety Officer

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Acronyms

CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
COVID-19	Coronavirus Disease 2019
CPR	cardiopulmonary resuscitation
DDESB	Department of Defense Explosives Safety Board
DMM	discarded military munitions
EOD	Explosive Ordnance Disposal
EPA	US Environmental Protection Agency
FC	field coordinator
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSM	health and safety manager
HSO	health and safety officer
HSP	health and safety plan
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEC	project emergency coordinator
PFD	personal flotation device
Port	Port of Seattle
PPE	personal protective equipment
PM	project manager
QAPP	quality assurance project plan
RI	remedial investigation
T-91	Terminal 91
TCDD	tetrachlorodibenzo-*p*-dioxin
USACE	US Army Corps of Engineers
USCG	US Coast Guard
UXO	unexploded ordnances
WAC	Washington Administrative Code

1 Introduction

This site-specific health and safety plan (HSP) describes safe working practices for conducting field activities at potentially hazardous sites and for handling potentially hazardous materials or waste products. This HSP covers elements as specified in 29 Code of Federal Regulations (CFR) 1910§120 as well as Washington Administrative Code (WAC) 173-340-810. The goal of the HSP is to establish procedures for safe working practices for all field personnel.

This HSP addresses all activities associated with the collection and handling of surface and subsurface sediment samples in the Port of Seattle's (Port's) Terminal 91 (T-91). During site work, this HSP will be implemented by the field coordinator (FC), who is also the designated site health and safety officer (HSO), in cooperation with the corporate health and safety manager (HSM) and the project manager (PM).

All personnel involved in fieldwork on this project will be required to comply with this HSP. The content of this HSP reflects the types of activities that are anticipated to be performed, knowledge of the physical characteristics of the site, and consideration of preliminary chemical data from previous investigations at the site. The HSP may be revised based on new information and/or changed conditions during site activities. Revisions will be documented in the project records.

2 Site Description and Project Scope

2.1 Site Description

T-91 is an approximately 210-acre property, owned by the Port, that is 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 the SCU. The SCU includes about 85 acres of submerged lands around the piers, about 70 acres (82%) of which is subtidal sediment and 16 acres (18%) of which is intertidal sediment (Map 1-1). The SCU is separated into the eastern, central, and western berths by Piers 90 and 91, which are earthen berms constructed in 1913 and 1919, respectively. These berms function as solid barriers between the berth areas and prevent the transport of water and sediment laterally between adjacent berth areas.

2.2 Scope and Duration of Work

FS sampling activities will be conducted in two phases. Phase I will include a surface sediment investigation and the three components of a survey investigation. Phase II will (if needed) include the collection of subsurface sediment cores.

Field work is anticipated to occur starting in the spring/summer of 2024. The exact timing of field activities is will depend on equipment/crew availability and access to the target areas of the site (i.e., avoiding time periods when vessel presence will limit access to pier faces). The duration of the field work is dependent on whether Phase II is determined to be necessary.

The T-91 sampling and analysis plan (SAP)/quality assurance protocol plan (QAPP), which is Appendix B of this FS WP, contains the details of all the sampling protocols for all types of sampling activities. A site-specific dive HSP will be developed prior to the initiation of any fieldwork that involves divers (i.e., diver surveys and subsurface sampling in underpier areas).

3 Health and Safety Personnel

Key health and safety personnel and their responsibilities are described below. These individuals are responsible for the implementation of this HSP.

Project Manager: The PM will have overall responsibility for the successful outcome of the project. The PM will ensure that adequate resources and budget are provided for the health and safety staff to carry out their responsibilities during fieldwork. The PM, in consultation with the HSM, will make final decisions concerning the implementation of the HSP.

Field Coordinator/Health and Safety Officer: Because of the limited scope and duration of fieldwork, the FC and HSO will be the same individual. The FC/HSO will direct field sampling activities, coordinate the technical components of the field program with health and safety components, and ensure that work is performed according to the quality assurance project plan (QAPP). The FC/HSO will implement this HSP at the work location and will be responsible for all health and safety activities and the delegation of duties to a health and safety technician in the field, if appropriate. The FC/HSO will also have stop-work authority, to be used if there is an imminent safety hazard or potentially dangerous situation. The FC/HSO or designee shall be present during sampling and operations.

Corporate Health and Safety Manager: The HSM will have overall responsibility for the preparation, approval, and revision of this HSP. The HSM will not necessarily be present during fieldwork but will be readily available, if required, for consultation regarding health and safety issues during fieldwork.

Field Crew: All field crew members must be familiar and comply with the information in this HSP. They also will have the responsibility to report any potentially unsafe or hazardous conditions to the FC/HSO immediately.

UXO Technician: Although discarded military munitions (DMM) are not expected to be encountered during this field work, an unexploded ordnance (UXO) Technician III

will escort the sediment sampling crew and will be responsible for performing anomaly avoidance, described in Section 4.1.8.2 of this HSP. The UXO Technician will be qualified in accordance with Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP) 18, *Minimum Qualifications for Personnel Conducting Munitions and Explosives of Concern-Related Activities* (DDESB 2020)and implement all necessary protective measures related to safeguarding the health and well-being of the sampling crews, should DMM inadvertently be recovered.

4 Hazard Evaluation and Control Measures

This section discusses potential physical and chemical hazards that may be associated with the proposed project activities and presents control measures for addressing these hazards. The activity hazard analysis (Section 4.5) lists the potential hazards associated with each site activity and the recommended site control. Confined space entry will not be necessary for this project. Therefore, hazards associated with this activity are not discussed in this HSP.

4.1 PHYSICAL HAZARDS

For this project, it is anticipated that physical hazards present a greater risk of injury than do chemical hazards.

4.1.1 Slips, trips, and falls

As with all fieldwork sites, caution should be exercised to prevent slips on slick surfaces. In particular, sampling from a boat or other floating platform requires careful attention to minimize the risk of falling down or falling overboard. The same care should be used in rainy conditions or on the shoreline where there are slick rocks. Slips can be minimized through the use of boots with good treads, made of material that does not become overly slippery when wet.

Trips are always a hazard on the uneven deck of a boat, in cluttered work areas, or in the intertidal zone where uneven substrate is common. Personnel will keep work areas as free as possible from obstacles that could interfere with walking.

Falls can also be a hazard. Personnel can avoid falls by working as far from exposed edges as possible, erecting railings, and using fall protection when working on elevated platforms. For this project, no work that would present a fall hazard is anticipated.

4.1.2 Sampling equipment

Sediment grab and core samplers will be deployed from the boat to collect surface sediment and sediment core samples. Hard hats will be worn and care will be taken to ensure that the samplers are safely guided over the railing and into and out of the

water during deployment and retrieval. Before sampling activities begin, there will be a training session for all field personnel for the equipment that will be onboard the sampling vessel.

4.1.3 Falling overboard

Most of the sampling activities will be done from a boat. As with any work from a floating platform, there will be a chance of falling overboard. Personal flotation devices (PFDs) will be worn by all personnel while working from the boat.

4.1.4 Manual lifting

Equipment and samples must be lifted and carried. Back strain can result if lifting is done improperly. During any manual lifting tasks, personnel should lift with the load supported by their legs, not their backs. For heavy loads, an adequate number of people, or if possible, a mechanical lifting/handling device, will be used.

4.1.5 Heat stress, hypothermia, or frostbite

Sampling operations and conditions that might result in the occurrence of heat stress, hypothermia ,or frostbite are not anticipated.

4.1.6 Weather

In general, field team members will be equipped for the normal range of weather conditions. The FC/HSO will be aware of current weather conditions and of the potential for those conditions to pose a hazard to the field crew. Some conditions that might force work stoppage are electrical storms, high winds, or high waves resulting from winds.

4.1.7 Sharp objects

Sampling operations might result in the exposure of field personnel to sharp objects on top of or buried within the sediment. If these objects are encountered, field personnel should not touch them. Also, field personnel should not dig in the sediment by hand.

4.1.8 Discarded military munitions

4.1.8.1 Site Background

The former Seattle Naval Supply Depot is a Formerly Used Defense Site #F10WA012501 facility that was used during the World War II-era as a loading and offloading facility for US Navy warships. It was not an ammunition depot, and no records exist of live firing ever occurring at the site. During this period, DMM were infrequently jettisoned overboard without documentation while ships were in port.

The site is presently operated by the Port as T-91 and encompasses Piers 90 and 91. Pier 91 is presently used during a portion of the year as the Smith Cove Cruise

Terminal. The cruise terminal is a point of embarkation for cruise trips to Alaska. During routine security sweeps by Port Police Department divers on April 22, 2010, several DMM were discovered. These discoveries led to a series of six subsequent active US Army and Navy Explosive Ordnance Disposal (EOD) responses to T-91. Prior to these events, there is no record of encounters with DMM at the facility.

In 2010, the US Army Corps of Engineers (USACE) initiated the Piers 90 and 91 RI, conducted extensive mapping of the area, and removed all identified munitions. Safety protocols have been developed in this HSP to addresses the unlikely event that DMM are encountered in a sediment sample. Possible DMM types at T-91 are:

- 0.50 Cal
- 20-mm cartridges
- 30-mm cartridges
- 40-mm projectile
- 3-in. projectile
- 4-in. projectile
- 5-in. projectile

4.1.8.2 DMM avoidance

A UXO Technician III will accompany the sampling crews aboard the sampling vessel. Within the portion of the site identified as the DMM Area (Map 1)—based on the presence of DMM in this area during previous investigations—the UXO Technician will perform anomaly avoidance techniques at each location prior to sampling, in accordance with USACE's *Explosives Safety and Health Requirements Manual, EM 385-1-97* (USACE 2013). This procedure will include the UXO Technician's use of a magnetometer to survey each location prior to the collection of a sediment sample. If an anomaly is detected at a sediment sampling location, that location will be abandoned and a new sampling location will be chosen.

When sampling is conducted outside of the DMM Area, a magnetometer survey of each sampling location will not be required. The UXO Technician will be present to perform magnetometer and visual surveys on samples after collection.

All samples that are successfully gathered will be brought aboard the sampling vessel and visually inspected, as well as screened with a magnetometer. If a potential DMM is found in a sediment sample, the UXO Technician will secure the DMM and immediately contact:

- Port Police Department dispatch: 206.787.3490
- Port Bomb Disposal Unit, Sgt. Pat Addison: 206.787.7690

- CPT Greg McClendon, Assistant Operations Officer, Third Ordnance Battalion EOD, US Army (Fort Lewis):
  - 619.791.4280, cell
  - 253.967.1971, S3 duty phone
  - 253.548.5344, EOD team leader on duty
- Tom Mackie, Site Manager, Hazardous Waste & Toxics Reduction Program, Washington State Department of Ecology:
  - 509.575.2803

Once notified, a representative of the Third Ordnance Battalion (EOD) will respond to the site to take custody of the DMM from the UXO Technician or Port Bomb Disposal Unit personnel. The EOD representative will contact the US Environmental Protection Agency (EPA) per standard operating procedures, to ensure that transport and disposal of the DMM is lawfully permitted. The UXO Technician will not conduct disposal operations.

The Port Bomb Disposal Unit will be notified at least two days prior to the sampling date so that they can alert the Port Police Dispatch of the work and prepare to lend assistance if needed.

Prior to sampling, the UXO Technician will review the DMM avoidance procedures with all essential personnel. This review will include familiarization with and hazards of DMM that may be encountered, and the procedures that will be followed should DMM be inadvertently brought aboard the vessel.

The UXO Technician will also perform morning safety briefings that will be required for all personnel involved in sampling. These briefings will cover expected weather for the day, normal safe practice measures to prevent accidents or injury, a review of possible DMM discovery procedures, and any additional safety information needed or drawn from previously performed activities. The morning safety briefings will also include a review of emergency procedures in the unlikely event of an accident.

4.2 BIOLOGICAL HAZARDS

This section describes basic steps to reduce the risk of worker exposure to COVID-19[1] and other viruses/common illnesses during field operations. These recommendations may be updated or amended as often as necessary to remain in compliance with changing local, state, and federal guidelines.

[1] COVID-19 is a contagious respiratory disease caused by the SARS-CoV-2 virus (OSHA 2020). Symptoms typically include fever (>100.4°F), coughing, and shortness of breath, but some people have reported experiencing other non-respiratory symptoms—such as chills, repeated shaking with chills, muscle pain, headache, sore throat, and a loss of taste or smell—while still others have been asymptomatic and experienced no symptoms at all.

COVID-19 and other sicknesses may be transmitted via inhalation or by touching a surface or object and then one's own mouth, nose, or eyes. As appropriate, site workers will implement good hygiene and infection control practices, including:

- Staying home when sick or showing symptoms (consistent with Washington State and CDC guidelines)
- Following respiratory etiquette, including covering coughs and sneezes
- Washing hands frequently and thoroughly. If soap and running water are not immediately available, alcohol-based sanitizer containing at least 60% alcohol will be used.
- Maintaining regular housekeeping practices, including routine cleaning and disinfecting of surfaces, equipment, and other elements of the work environment

4.3 VESSEL HAZARDS

Because of the high volumes of vessel and barge traffic in and around T-91, precautions and safe boating practices will be implemented to ensure that the field boat does not interrupt vessel traffic. Additional potential vessel emergency hazards and responses are listed in Table 1.

Table 1. Potential vessel emergency hazards and responses

Potential Emergency or Hazard	Response
Fire or explosion	If manageable, personnel should attempt to put out a small fire with a fire extinguisher. Otherwise, personnel should call USCG or 911, evacuate the area (by rescue boat or swimming), and meet at a designated area. The FC/HSO will take roll call to make sure everyone evacuated safely. Emergency meeting places will be determined in the field during the daily safety briefing.
Medical emergency or injury	At least one person with current first aid and CPR training will be aboard the vessel at all times. This person will attempt to assess the nature and severity of the injury, immediately call 911, and perform CPR if necessary. Personnel should stop work and wait for medical personnel to arrive. Once the emergency has passed, the FC/HSO should fill out a site accident report.
Person overboard	All personnel aboard the sampling vessel will wear PFDs at all times. One person should keep an eye on the individual who fell overboard and shout the distance (boat lengths) and direction (o'clock) of the individual from the vessel. Personnel should stop work and use the vessel to retrieve the individual in the water.
Sinking vessel	Personnel should call USCG immediately. If possible, personnel should wait for a rescue boat to arrive to evacuate vessel personnel. See fire or explosion (above) for emergency evacuation procedures. The FC/HSO will take a roll call to make sure everyone is present.
Lack of visibility	If navigation visibility or personal safety is compromised because of smoke, fog, or other unanticipated hazards, personnel should stop work immediately. The vessel operator and FC/HSO will assess the hazard and, if necessary, send out periodic horn blasts to mark vessel location to other vessels potentially in the area, move to a secure location (i.e., berth), and wait for the visibility to clear.

Potential Emergency or Hazard	Response
Loss of power	Personnel should stop work and call the USCG for assistance. Personnel should use oars to move the vessel towards the shoreline. Other vessel personnel should watch for potential collision hazards and notify the vessel operator if hazards exist. Personnel should secure the vessel to a berth, dock, or mooring as soon as possible.
Collision	Personnel should stop work and call the USCG for assistance. The FC/HSO and vessel operator will assess damage and potential hazards. If necessary, the vessel will be evacuated and secured until repairs can be made.

CPR – cardiopulmonary resuscitation
FC – field coordinator
HSO – health and safety officer
PFD – personal flotation device
USCG – US Coast Guard

4.4 CHEMICAL HAZARDS

Previous investigations have shown that some chemical substances are present at higher-than-background concentrations in the sampling areas. For the purpose of discussing potential exposure to substances in sediments, the contaminants of concern are metals, tributyltin, dioxins/furans, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs).

4.4.1 Exposure routes

Potential routes of chemical exposure include inhalation, dermal contact, and ingestion. Exposure will be minimized by using safe work practices and by wearing the appropriate PPE. Further discussion of PPE requirements is presented in Section 7.

Inhalation — Inhalation is not expected to be an important route of exposure for this project.

Dermal exposure — Dermal exposure to hazardous substances associated with sediments, surface water, or equipment decontamination will be controlled through the use of PPE and adherence to detailed sampling and decontamination procedures.

Ingestion — Ingestion is not considered to be a major route of exposure for this project. Accidental ingestion of surface water is possible. However, careful handling of equipment and containers aboard the boat should prevent the occurrence of water splashing or spilling during sample collection and handling activities.

4.4.2 Chemical hazards

Metals and tributyltin — Exposure to metals may occur via ingestion or skin contact. As mentioned, neither is likely as an exposure route. Metal fumes or metal-contaminated dust will not be encountered during field and sample handling activities. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for the passage of any of the

metals into the body. Field procedures require the immediate washing of sediments from exposed skin.

Polycyclic aromatic hydrocarbons — Exposure to PAHs may occur via ingestion or skin contact. The most important human health exposure pathway for this group of chemicals, inhalation, is not expected to occur at this site. Animal studies have shown that PAHs can have harmful effects on skin, body fluids, and ability to fight disease after both short- and long-term exposure, but these effects have not been documented in people. Some PAHs may reasonably be expected to be carcinogens. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for the passage of any of the compounds into the body. Field procedures require the immediate washing of sediments from exposed skin.

Polychlorinated biphenyls — Prolonged skin contact with PCBs may cause acne-like symptoms known as chloracne. Irritation to eyes, nose, and throat may also occur. Acute and chronic exposure can damage the liver and cause symptoms of edema, jaundice, anorexia, nausea, abdominal pains, and fatigue. PCBs are a suspected human carcinogen. Skin absorption may substantially contribute to the uptake of PCBs. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for the passage of any of these compounds into the body. Field procedures require the immediate washing of sediments from exposed skin.

Dioxins/furans — Prolonged skin contact with dioxins/furans may cause acne-like symptoms known as chloracne. Other effects on the skin, such as red skin rashes, have been reported to occur in people following exposure to high concentrations of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD). Acute and chronic exposure can damage the liver, result in an increase in the risk of diabetes and abnormal glucose tolerance, and may increase the risk for reproductive and developmental effects. 2,3,7,8-TCDD is a possible human carcinogen, and a mixture of dioxins/furans with six chlorine atoms (four of the six chlorine atoms at the 2, 3, 7, and 8 positions) is a probable human carcinogen. Skin absorption may substantially contribute to the uptake of dioxins/furans. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for the passage of any of the compounds into the body. Field procedures require the immediate washing of sediments from exposed skin.

4.5 ACTIVITY HAZARD ANALYSIS

The activity hazard analysis summarizes the field activities to be performed during the project, outlines the hazards associated with each activity, and presents controls that can reduce or eliminate the risk of the hazard occurring. Table 2 presents the activity hazard analysis for sampling from a boat and scuba diving.

Table 2. Activity hazard analysis

Activity	Hazard	Control
Sampling from a boat	falling overboard	Use care in boarding and departing from vessel. Wear a PFD.
	head injury	Wear a hard hat and watch for overhead hazards, particularly during deployment/retrieval of sampling equipment
	skin contact with contaminated sediments or liquids	Wear modified Level D PPE.
	DMMs	Risk will be evaluated by UXO Technician and Port Police will dispose of DMM.
	back strain	Use appropriate lifting techniques when transporting equipment and supplies to or from the boat or seek help.
	COVID-19 and other illnesses	Stay at home if sick or exhibiting symptoms, practice good hygiene.

COVID-19 – coronavirus disease 2019
DMM – discarded military munitions
PFD – personal flotation device
PPE – personal protective equipment
UXO – unexploded ordnance

5 Work Zones and Shipboard Access Control

During sampling and sample handling activities, work zones will be established to identify where sample collection and processing are actively occurring. The intent of the zones is to limit the migration of sample material out of the zones and to restrict access to active work areas by defining work zone boundaries.

5.1 Work Zone

The work zone on the boat will encompass the area where sample collection and handling activities are performed. The work zone in the sample processing area will include the immediate area surrounding the samples and the jar labeling area. Only persons with appropriate training, PPE, and authorization from the FC/HSO will be allowed to enter the work zone while work is in progress.

5.2 Decontamination Station

A decontamination station will be set up, and personnel will clean soiled boots or PPE prior to leaving the work zone. The station will have the buckets, brushes, soapy water, rinse water, or wipes necessary to clean boots, PPE, or other equipment leaving the work zones. Plastic bags will be provided for expendable and disposable materials. If the location does not allow for the establishment of a decontamination station, the FC/HSO will provide alternatives to prevent the spread of contamination.

Decontamination of the boat will also be completed at the end of each work day. Cockpit and crew areas will be rinsed down with site water to minimize the accumulation of sediment.

5.3 ACCESS CONTROL

Boat security and access control will be the responsibility of the FC/HSO and boat captain. Boat access will be granted only to essential project personnel and authorized visitors. Any security or access control problems will be reported to the PM or appropriate authorities.

6 Safe Work Practices

Following common sense rules will minimize the risk of exposure or accident at the work site. The general safety rules listed below will be followed on-site:

- Do not climb over or under obstacles of questionable stability.
- Do not eat, drink, smoke, or perform other hand-to-mouth transfers in the work zone.
- Work only in well-lighted spaces.
- Never enter a confined space without the proper training, permits, and equipment.
- Make eye contact with equipment operators when moving within the range of their equipment.
- Be aware of the movements of shipboard equipment when not in the operator's range of vision.
- Get immediate first aid for all cuts, scratches, abrasions, or other minor injuries.
- Use the established sampling and decontamination procedures.
- Always use the buddy system.
- Be alert to your own and other workers' physical condition.
- Report all accidents, no matter how minor, to the FC/HSO.
- Do not do anything dangerous or unwise even if ordered by a supervisor.

7 Personal Protective Equipment and Safety Equipment

Appropriate PPE will be worn as protection against potential hazards. In addition, a PFD will be required for all personnel when working aboard the boat. A hard hat will be required when working on the boat deck, where overhead hazards are present during sampling equipment deployment and retrieval. Prior to donning PPE, personnel will inspect their PPE for any defects that might render the equipment ineffective.

Fieldwork will be conducted in Level D or modified Level D PPE, as discussed in Sections 7.1 and 7.2. Situations that would require PPE beyond modified Level D are not anticipated. Should the FC/HSO determine that PPE beyond modified Level D is necessary, the HSM will be notified and alternative PPE selected.

7.1 LEVEL D PERSONAL PROTECTIVE EQUIPMENT

Individuals performing general activities in which skin contact with contaminated materials is unlikely will be required to wear Level D PPE. Level D PPE includes the following:

- Cotton overalls or lab coats
- Chemical-resistant steel-toed boots
- Chemical-resistant gloves
- Safety glasses

7.2 MODIFIED LEVEL D PERSONAL PROTECTIVE EQUIPMENT

Individuals performing activities in which skin contact with contaminated materials is possible but inhalation risks are not expected will be required to wear an impermeable outer suit. The type of outerwear will be chosen according to the types of contaminants that might be encountered. Modified Level D PPE includes the following:

- Impermeable outer garb, such as rain gear or waders
- Chemical-resistant steel-toed boots
- Chemical-resistant outer gloves
- Protective face mask (as needed)

7.3 SAFETY EQUIPMENT

In addition to the above-identified PPE, basic emergency and first aid equipment will be provided. Equipment for the field team will include:

- A copy of this HSP
- First aid kit adequate for the number of personnel in the field crew
- Emergency eyewash

The FC/HSO will ensure that the safety equipment is available. Equipment will be checked daily to ensure its readiness for use.

8 Monitoring Procedures for Site Activities

A monitoring program that addresses the potential site hazards will be implemented. For this project, air, dust, and noise monitoring will not be necessary. The sampled media will be wet and will not pose a dust hazard, and equipment emitting high-amplitude (>85 dBA) sound will be not be used. Because sampling is occurring outdoors on a boat, air monitoring is not anticipated to be necessary.

For this project, the monitoring program will include all individuals monitoring themselves and their co-workers for signs of potential physical stress or illness. All personnel will be instructed to look for and inform each other of any deleterious changes in their physical or mental conditions during the performance of all field activities. Examples of such changes are as follows:

- Headaches
- Dizziness
- Nausea
- Fever
- Coughing
- Shortness of breath (difficulty breathing)
- Muscle pain
- Sore throat
- Loss of sense of taste or smell
- Symptoms of heat stress
- Blurred vision
- Cramps
- Irritation of eyes, skin, or respiratory system
- Changes in complexion or skin color
- Changes in apparent motor coordination
- Increased frequency of minor mistakes
- Excessive salivation or changes in papillary response
- Changes in speech ability or speech pattern
- Shivering
- Blue lips or fingernails

If any of these conditions develop, work will be halted immediately and the affected person(s) evaluated. If further assistance is needed, personnel at the local hospital will be notified, and an ambulance will be summoned if the condition is thought to be serious. If the condition is the direct result of sample collection or handling activities, procedures will be modified to address the problem.

9 Decontamination

Decontamination is necessary to prevent the migration of contaminants from the work zone(s) into the surrounding environment and to minimize the risk of exposure of personnel to contaminated materials that might adhere to PPE. The following subsections discuss personnel and equipment decontamination. The following supplies will be available to perform decontamination activities:

- Wash buckets
- Rinse buckets
- Long-handled scrub brushes
- Clean water sprayers
- Paper towels
- Plastic garbage bags
- Alconox® or similar decontamination solution

9.1 Minimization of Contamination

The first step in addressing contamination is to prevent or minimize exposure to existing contaminated materials and the spread of those materials. During field activities, the FC/HSO will enforce the following measures:

Personnel

- Limit field staff to minimum number required to safely complete the work.
- Wash hands frequently and thoroughly. Use alcohol-based sanitizer with at least 60% alcohol if soap and running water are not readily available.
- Follow proper coughing and sneezing etiquette.
- Do not walk through areas of obvious or known contamination.
- Do not handle, touch, or smell contaminated materials directly.
- Make sure PPE has no cuts or tears prior to use.
- Fasten all closures on outer clothing, covering with tape if necessary.
- Protect and cover any skin injuries.

- Stay upwind of airborne dusts and vapors.
- Do not eat, drink, chew tobacco, or smoke in the work zones.

Sampling equipment and boat

- Avoid or minimize handling of equipment, tools, and supplies by multiple people.
- Clean or disinfect touch surfaces, handheld equipment, tools, and supplies frequently.
- Place clean equipment on a plastic sheet or aluminum foil to avoid direct contact with contaminated media.
- Keep contaminated equipment and tools separate from clean equipment and tools.
- Clean boots before entering the boat.

9.2 PERSONNEL DECONTAMINATION

The FC/HSO will ensure that all site personnel are familiar with personnel decontamination procedures. Personnel will perform decontamination procedures, as appropriate, before eating lunch, taking a break, or leaving the work location. Decontamination procedures for field personnel include:

1. Rinse off the outer suit if it is heavily soiled.
2. Wash and rinse outer gloves and boots with water.
3. Remove and inspect outer gloves and discard them if damaged.
4. Wash hands if taking a break.
5. Don necessary PPE before returning to work.
6. Dispose of soiled, disposable PPE before leaving for the day.

9.3 SAMPLING EQUIPMENT DECONTAMINATION

Sampling equipment will be decontaminated to minimize sample contamination and worker exposure to contamination from samples. The following practices will be followed:

- Safety glasses and face shields (if needed) will be assigned to a single user, will be disinfected frequently, at the end of the day or between uses, and be stored in a clean sealable bag.
- All utensils or equipment used directly in handling sediment (e.g., such as the grab sampler, hand corers, shovels, spoons and bowls) will be scrubbed

with Alconox® detergent, rinsed with deionized water, and stored wrapped in aluminum foil until use, as necessary.

- Sample processing surfaces will be cleaned and lined with aluminum foil to prevent direct contact with samples.
- Ice chests will be scrubbed with Alconox® detergent and rinsed with deionized water prior to any sampling activities. Lids and handles will be cleaned frequently throughout each day.
- Wet ice used for sample storage during field activities will be contained in separate plastic bags, and samples will be placed in resealable, waterproof plastic bags to avoid contamination from melting ice.
- Sampling equipment will be free from contaminants such as oils, grease, and fuels.

9.4 VESSEL DECONTAMINATION

Most sampling will be conducted from a boat. Care will be taken to minimize the amount of sediment spilled on the vessel. The vessel deck will be hosed off regularly to remove sediment from the cockpit and crew areas to minimize slipping hazards and the transport of sediment on boots through work zones.

10 Disposal of Contaminated Materials

Contaminated materials that may be generated during field activities include PPE, decontamination fluids, and excess sample material. These contaminated materials will be disposed of as an integral part of the project.

10.1 PERSONAL PROTECTIVE EQUIPMENT

Gross surface contamination will be removed from PPE. All disposable sampling materials and PPE, such as disposable coveralls, gloves, and paper towels used in the sample processing, will be placed in heavyweight garbage bags. Filled garbage bags will be placed in a normal refuse container for disposal as solid waste.

10.2 EXCESS SAMPLE MATERIALS

At each sampling location, excess sediment collected will be returned to the collection location.

11 Training Requirements

Individuals who perform work at locations where potentially hazardous materials and conditions may be encountered must meet specific training requirements. It is not

anticipated that hazardous concentrations of contaminants will be encountered in sampled material, so training will consist of site-specific instruction for all personnel and the oversight of inexperienced personnel by an experienced person for one working day. The following subsections describe the training requirements for this fieldwork.

11.1 PROJECT-SPECIFIC TRAINING

In addition to Hazardous Waste Operations and Emergency Response (HAZWOPER) training, field personnel will undergo training specifically for this project. All personnel must read this HSP and be familiar with its contents before beginning work. Personnel will acknowledge reading the HSP by signing the Field Team Health and Safety Plan Review Form (Attachment 1). The completed form will be kept in the project files.

The boat captain and FC/HSO or a designee will provide project-specific training prior to the first day of fieldwork and whenever new workers arrive. Field personnel will not be allowed to begin work until project-specific training has been completed and documented by the FC/HSO. Training will address the HSP and all health and safety issues and procedures pertinent to field operations. Training will include, but not be limited to, the following topics:

- Activities with the potential for chemical exposure
- Activities that pose physical hazards and actions to control the hazards
- Ship access control and procedure
- Use and limitations of PPE
- Decontamination procedures
- Emergency procedures
- Use and hazards of sampling equipment
- Location of emergency equipment
- Vessel safety practices
- Emergency evacuation and emergency procedures

11.2 DAILY SAFETY BRIEFINGS

The FC/HSO or a designee and the boat captain will present safety briefings before the start of each day's activities. These safety briefings will outline the activities expected for the day, update work practices and hazards, address any specific concerns associated with the work location, and review emergency procedures and routes. The FC/HSO or designee will document safety briefings in the logbook.

11.3 FIRST AID AND CPR

At least one member of the field team must have first-aid and cardiopulmonary resuscitation (CPR) training. The diver and dive tender will also be trained in first aid and CPR as required by Research Support Services' *Safe Practices Manual for Diving Operations*. Documentation of which individuals possess first aid and CPR training will be kept in the project health and safety files.

12 Medical Surveillance

A medical surveillance program conforming to the provisions of 29CFR1910§120(f) will not be necessary for field team members, because the field team members do not meet any of the four criteria outlined in the regulations for the implementation of a medical surveillance program:

- Employees who are or may be exposed to hazardous substances or health hazards at or above permissible exposure levels for 30 days or more per year (1910.120(f)(2)(I)
- Employees who must wear a respirator for 30 days or more per year (1910.120(f)(2)(ii))
- Employees who are injured or become ill due to possible overexposures involving hazardous substances or health hazards from an emergency response or hazardous waste operation (1910.120(f)(2)(iii))
- Employees who are members of HAZMAT teams (1910.120(f)(2)(iv))

As described in Section 8, employees will monitor themselves and each other for any deleterious changes in their physical or mental condition during the performance of all field activities.

13 Reporting and Record Keeping

Each member of the field crew will sign the HSP review form (see Attachment 1). If necessary, accident/incident report forms and Occupational Safety and Health Administration (OSHA) Form 200s will be completed by the FC/HSO.

The FC/HSO or a designee will maintain a health and safety field logbook that records health-and-safety-related details of the project. Alternatively, entries may be made in the field logbook, in which case a separate health and safety field logbook will not be required. The logbook must be bound and the pages must be numbered consecutively. Entries will be made with indelible blue ink. At a minimum, each day's entries must include the following information:

- Project name or location

- Names of all personnel
- Weather conditions
- Type of fieldwork being performed

The individual maintaining the entries will initial and date the top or bottom of each completed page. Blank space at the bottom of an incompletely filled page will be lined out. Each day's entries will begin on the first blank page after the previous workday's entries.

14 Emergency Response Plan

As a result of the hazards and conditions under which operations will be conducted, the potential exists for an emergency situation to occur. Emergencies may include personal injury, exposure to hazardous substances, fire, explosion, or release of toxic or non-toxic substances (i.e., spills). OSHA regulations require that an emergency response plan be available to guide actions in emergency situations.

Onshore organizations will be relied upon to provide response in emergency situations. The local fire department and ambulance service can provide timely response. Field personnel will be responsible for identifying emergency situations, providing first aid, if applicable, notifying the appropriate personnel or agency, and evacuating any hazardous area. Shipboard personnel will attempt to control only very minor hazards that could present an emergency situation, such as a small fire, and will otherwise rely on outside emergency response resources.

The following subsections identify the individual(s) who should be notified in case of emergency, provide a list of emergency telephone numbers, offer guidance for particular types of emergencies, and provide directions for getting from any sampling location to a hospital.

14.1 Pre-Emergency Preparation

Before the start of field activities, the FC/HSO will ensure that preparation has been made in anticipation of emergencies. This preparation will include the following:

- Meeting with equipment handlers concerning emergency procedures to be followed in the event of an injury
- Conducting a training session informing all field personnel of emergency procedures, locations of emergency equipment and their use, and proper evacuation procedures
- Conducting a training session (led by senior staff responsible for operating field equipment) to apprise field personnel of operating procedures and specific risks associated with field equipment

- Ensuring that field personnel are aware of the existence of the emergency response plan in the HSP and ensuring that a copy of the HSP accompanies the field team

14.2 PROJECT EMERGENCY COORDINATOR

The FC/HSO will serve as the project emergency coordinator (PEC) in the event of an emergency. He will designate a replacement for times when he is not available or is not serving as the PEC. The designation will be noted in the logbook. The PEC will be notified immediately when an emergency is recognized. The PEC will be responsible for evaluating the emergency situation, notifying the appropriate emergency response units, coordinating access with those units, and directing onboard interim actions before the arrival of emergency response units. The PEC will notify the HSM and the PM as soon as possible after initiating an emergency response action. The PM will have responsibility for notifying the client.

14.3 EMERGENCY RESPONSE CONTACTS

All personnel must know whom to notify in the event of an emergency situation, even though the FC/HSO has primary responsibility for notification. Table 3 lists the names and phone numbers for emergency response services and individuals.

Table 3. Emergency response contacts

Contact	Telephone Number
Emergency Numbers	
Ambulance	911
Police	911
Fire	911
Harborview Medical Center	206.323.3074
US Coast Guard Office Emergency General information	 206.286.5400 206.442.5295 UHF Channel 16
National Response Center	800.424.8802
US Environmental Protection Agency	908.321.6660
Washington State Department of Ecology Northwest Region Spill Response (24-hour emergency line)	206.649.7000
Port of Seattle Police Dispatch	206.787.5401
Project Management Emergency Contacts	
Susan McGroddy, Project Manager and Corporate Health and Safety Manager	206.812.5421
Thai Do, Field Coordinator/Health and Safety Officer	206.812.5407

14.4 RECOGNITION OF EMERGENCY SITUATIONS

Emergency situations will generally be recognizable through observation. An injury or illness will be considered an emergency if it requires treatment by a medical professional and cannot be treated with simple first aid techniques.

14.5 DECONTAMINATION

In the case of evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. If an injured individual is also heavily contaminated and must be transported by emergency vehicle, the emergency response team will be informed of the type of contamination. To the extent possible, contaminated PPE will be removed but only if doing so does not exacerbate the injury. Plastic sheeting will be used to reduce the potential for spreading contamination to the inside of the emergency vehicle.

14.6 FIRE

Field personnel will attempt to control only small fires. If an explosion appears likely, personnel will follow evacuation procedures specified during the training session. If a fire cannot be controlled with the onboard fire extinguisher that is part of the required safety equipment, personnel will either withdraw from the vicinity of the fire or evacuate the site as specified during the training session.

14.7 PERSONAL INJURY

In the event of serious personal injury, including unconsciousness, possibility of broken bones, severe bleeding or blood loss, burns, shock, or trauma, the first responder will immediately do the following:

- Administer first aid, if qualified.
- If not qualified, seek out an individual who is qualified to administer first aid, if time and conditions permit.
- Notify the PEC of the incident, the name of the individual, the location, and the nature of the injury.

The PEC will immediately do the following:

- Notify the boat captain, FC/HSO, and the appropriate emergency response organization.
- Assist the injured individual.
- Follow the emergency procedures for retrieving or disposing of equipment and leave the site and proceed to the predetermined land-based emergency pick-up.
- Designate someone to accompany the injured individual to the hospital.

- If a life-threatening emergency occurs (i.e., injury in which death is imminent without immediate treatment), the FC/HSO or boat captain will call 911 and arrange to meet the emergency responder at the nearest accessible location or dock. For injuries or emergencies that are not life-threatening (e.g., broken bones, minor lacerations), the PEC will follow the procedures outlined above and proceed to the Harbor Island Marina or to an alternative location if that would be more expedient.
- Notify the HSM and the PM.

If the PEC determines that emergency response is not necessary, he or she may direct someone to decontaminate and transport the individual by vehicle to the nearest hospital. Directions describing the route to the hospital are provided in Section 14.10.

If a worker leaves the site to seek medical attention, another worker should accompany them to the hospital. When in doubt about the severity of an injury or exposure, always seek medical attention as a conservative approach and notify the PEC.

The PEC will be responsible for completing all accident/incident field reports, OSHA Form 200s, and other required follow-up forms.

14.8 Overt Personal Exposure or Injury

If an overt exposure to toxic materials occurs, the first responder to the victim will initiate actions to address the situation. The following actions should be taken, depending on the type of exposure.

14.8.1 Skin contact

- Wash/rinse the affected area thoroughly with copious amounts of soap and water.
- If eye contact has occurred, rinse eyes for at least 15 minutes using the eyewash that is part of the onboard emergency equipment.
- After initial response actions have been taken, seek appropriate medical attention.

14.8.2 Inhalation

- Move victim to fresh air.
- Seek appropriate medical attention.

14.8.3 Ingestion

- Seek appropriate medical attention.

14.8.4 Puncture wound or laceration

- Seek appropriate medical attention.

14.9 Spills and Spill Containment

No bulk chemicals or other materials subject to spillage are expected to be used during this project. Accordingly, no spill containment procedure is required for this project.

14.10 Emergency Route to the Hospital

The name, address, and telephone number of the hospital that will be used to provide medical care is as follows:

Harborview Medical Center
325 9th Avenue
Seattle, WA
206.323.3074

Directions from T-91 to Harborview Medical Center (Figure 1) are as follows:

- From 16th Ave. N., turn right toward Elliott Ave. W.
- Turn left onto Elliott Ave. W.
- Turn left onto W. Mercer Pl.
- Slight right onto Mercer St.
- Take the ramp to I-5 S
- Keep right at the fork, follow signs for I-5 S and merge onto I-5 S
- Take exit 165A toward James Street
- Merge onto 6th Ave.
- Turn left onto James St.
- Turn right onto 9th Ave.
- Destination is on the right

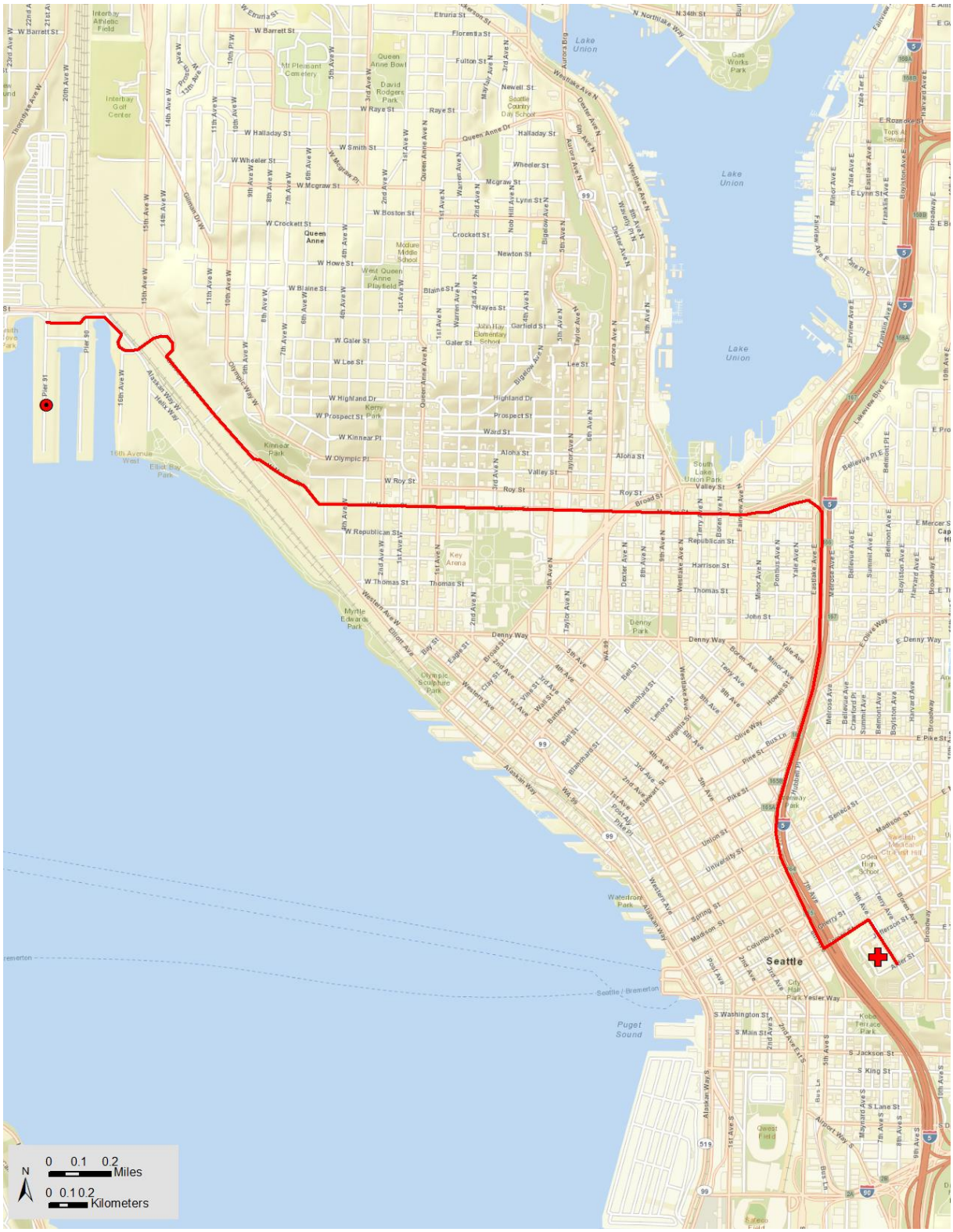


Figure 1. Directions to Harborview Medical Center from T-91

15 References

DDESB. 2020. Minimum qualifications for personnel conducting munitions and explosives of concern-related activities. Department of Defense Explosives Safety Board, Alexandria, VA.

OSHA. 2020. Guidance on preparing workplaces for COVID-19. OSHA 3990-03 2020. US Department of Labor, Occupational Safety and Health Administration, Washington, DC.

USACE. 2013. Explosives safety and health requirements manual, EM 385-1-97. US Army Corps of Engineers, Washington, DC.

Attachment 1. Field Team Health and Safety Plan Review

I have read a copy of the health and safety plan, which covers field activities that will be conducted to investigate potentially contaminated areas in T-91. I understand the health and safety requirements of the project, which are detailed in this health and safety plan.

Signature	Date
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