Lower Duwamish Waterway Superfund Site

Terminal 117 Early Action Area

TERMINAL 117 ENGINEERING EVALUATION/ COST ANALYSIS

For submittal to:

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Acronyms

Acronym	Definition
AET	apparent effects threshold
ARAR	applicable or relevant and appropriate requirement
BETX	benzene, toluene, ethylbenzene, and xylene
Boeing	The Boeing Company
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)
City	City of Seattle
CSL	Cleanup Screening Level of SMS
CWA	Clean Water Act
KCCWD1	King County Commercial Waterway District No. 1
DMMP	Dredged Material Management Program
DMMU	Dredge material management unit
dw	dry weight
EAA	early action area
Ecology	Washington State Department of Ecology
EE/CA	engineering evaluation/cost analysis
EF	exceedance factor
EPA	US Environmental Protection Agency
ERA	ecological risk assessment
ESA	Endangered Species Act
HHRA	human health risk assessment
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
ICs	institutional controls
IDs	identifiers
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
MLLW	mean lower low water
NAPL	non-aqueous phase liquid
nc	not calculated
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Permit
NTCRA	non-time-critical removal action
OC	organic carbon normalized
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl

Acronym	Definition
Port	Port of Seattle
ppt	part per thousand
PSDDA	Puget Sound Dredged Disposal Agency
QAPP	quality assurance project plan
RAO	removal action objective
RCRA	Resource Conservation and Recovery Act
RD/RA	removal design/removal action
RDC	Regional Disposal Company
RM	river mile
SCWG	Lower Duwamish Waterway Source Control Work Group
SMS	Washington State Sediment Management Standards
SPU	City of Seattle Public Utilities
SQS	Sediment Quality Standards of SMS
SVOC	semivolatile organic compound
T-117	Terminal 117
TBT	tributyltin
TCLP	toxicity characteristic leaching procedure
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TSCA	Toxic Substances Control Act
USACE	US Army Corps of Engineers
USFWS	US Fish and Wildlife Service
VOC	volatile organic compound
WDFW	Washington State Department of Fish and Wildlife

Executive Summary

Terminal 117 (T-117) is one of seven sites within the Lower Duwamish Waterway (LDW) Superfund site that have been identified by the US Environmental Protection Agency (EPA) and the Washington State Department of Ecology as candidate sites for early cleanup because sediments at these sites are associated with greater ecological and/or human health risk. At T-117, the early action area (EAA) is located in the aquatic portion (i.e. sediment) of the site as defined in the LDW early action candidate site memorandum (Windward 2003b). In the time since the T-117 EAA was identified, the Port of Seattle (Port) and the City of Seattle (City) have conducted a series of environmental investigations there to further characterize environmental conditions in the nearshore area and shoreline bank, identify a removal boundary, and to identify potential sources of contamination.

This report is an engineering evaluation/cost analysis (EE/CA) for such a removal action at T-117. It presents background information on the site, discusses available data and the proposed boundary of the removal action, documents the development and evaluation of alternatives for conducting the non-time-critical removal action (NTCRA) and discusses the rationale for the recommended removal action that will be implemented by the Port and the City, subject to EPA approval.

Site Characterization and Risk Assessment

The T-117 EAA owned by the Port is located on the west side of the LDW from approximately RM 3.5 to RM 3.7, as measured from the southern tip of Harbor Island (Figure 2-1). The site is bordered by the South Park Marina to the north and the Boeing South Park Facility to the south.

Polychlorinated biphenyls (PCBs) were identified as the primary risk driver for the removal action at the T-117 EAA (Windward 2003b; Windward et al. 2003b). This finding was based on historical activities and data. After reviewing historical data in the vicinity of T-117, field sampling investigations were conducted to characterize the nature and extent of PCBs in the T-117 EAA in order to determine the removal boundary, establish the general engineering characteristics of the shoreline sediment and bank soils, and identify potential sources of recontamination. The field investigations were iterative events; each additional field effort was based on the results of the preceding effort, ultimately providing the data to further support the removal boundary. The sequence of data collection events undertaken to complete this investigation was as follows:

- **December 2003**—The initial sampling event included the following elements:
  - collecting surface and subsurface sediment samples within the T-117 EAA
  - collecting soil borings along the upland shoreline bank
  - collecting soil samples from the southern drainage ditch and catch basins

- collecting water samples from intertidal seeps, and groundwater samples from shoreline monitoring wells
- a 24-hour tidal study to characterize the groundwater gradient beneath the nearshore T-117 upland area
- a groundwater non-aqueous phase liquid investigation, which was also re-conducted in August 2004

- **March 2004**—Large asphalt deposits and other major debris located in the shoreline bank and south ditch were identified, described, and mapped.
- **March 2004**—Following the initial sample collection effort, the areal extent of PCB contamination in the northern portion of T-117 was still unbounded. Additional surface and subsurface sediment and soil boring samples were collected from the bank in the northern portion of T-117.
- **March 2004**—Soil samples from the roadway along the entrance area of the T-117 property and additional catch basins were collected to evaluate whether these materials are the likely source of elevated PCBs in and around catch basin 5.

These results were summarized and interpreted in the T-117 preliminary boundary technical memorandum (Windward et al. 2004b) and used to delineate the preliminary removal boundary. Following the preliminary removal boundary delineation, there was still some uncertainty about the nature and extent of PCB contamination in the northern portion of the T-117 EAA and other chemicals outside of or below the extent of PCBs. To better define the removal boundary the following sampling events were conducted:

- **June 2004**—Surface sediment samples collected outside the offshore northern portion of the preliminary removal boundary were analyzed for PCBs, and archived samples collected in December 2003 that were either outside of the removal boundary or below the vertical extent of PCB contamination were analyzed for additional chemicals.
- **September 2004**—Surface and subsurface samples were collected in the northern portion of the site that extends into the proposed South Park Marina dredge area. This sampling event was conducted to satisfy both the EPA T-117 EAA boundary definition and the Puget Sound Dredged Disposal Agency (PSDDA) sediment characterization requirements for the South Park Marina. The PSDDA results, which identify sediments that are suitable for open-water disposal, are presented in a separate data report (Windward et al. 2005b).

Based on the results of the iterative sampling and analysis program, a proposed removal boundary was delineated (see Appendix A, T-117 proposed removal boundary technical memorandum). The data to support the rationale for the boundary definition are summarized in Section 2.4 of this EE/CA. With the exception of the PSDDA results, all physical and analytical results from the sampling and analysis activities are discussed above are presented in the T-117 data report (Windward et al. 2005a).

Additional fieldwork was conducted in June 2005 to further address the extent of soil PCB contamination in the vicinity of the upland (west) side of the preliminary removal action boundary and the south ditch area in accordance with an addendum to the QAPP (Windward et al. 2005c). Additional soil boring and push-probe samples were collected to further refine the distribution of PCBs in these areas. Two new shoreline monitoring wells were installed in the northern shoreline area, all wells on T-117 were checked for the occurrence of NAPL, and another round of groundwater sampling was conducted in the shoreline wells. The results of this investigation are pending and will be provided to EPA and shared with the public in a separate technical memorandum. This memorandum will also discuss any needed refinements to the proposed removal action boundary and design of the proposed alternative as may be warranted by the results. If required, refinements may include removal in paved areas inland of the proposed boundary.

Sediments located outside the proposed removal boundary will continue to be evaluated for potential ecological and human health risks through the LDW baseline risk assessment process. If these sediments are found to have unacceptable risks they will be evaluated for remediation in the LDW feasibility study.

The streamlined ecological risk assessment, presented in Section 2.5, supports the appropriateness of the removal action. This risk assessment focused on the benthic invertebrate community by comparing chemical concentrations in surface sediments to Washington State Sediment Management Standards (SMS). PCB concentrations that exceed the SMS Cleanup Screening Level (CSL) are expected to increase the likelihood of adverse biological effects to benthic organisms. More mobile receptors (i.e., fish and wildlife) were assessed during the Phase 1 remedial investigation (RI). The Phase 2 RI will refine the risk estimates for the mobile receptors and for any chemicals in sediment outside of the T-117 removal boundary. The removal action is also supported by a summary of the LDW Phase 1 human health risk assessment that includes a list of potential risks to human health associated with PCBs in the LDW. The proposed removal action at T-117 will indirectly reduce human exposure to chemicals by removing sediment containing bioaccumulative chemicals (i.e., PCBs) that are found in seafood. The removal action is further supported by the potential contamination of sensitive ecosystems, as demonstrated by the presence of PCBs above the CSL in intertidal sediment. These intertidal sediments provide important habitat for benthic invertebrates and juvenile salmonids, as well as other fish and shorebirds.

Scope, Goal, and Objective of the Removal Action

The goal of the removal action is to reduce exposure of ecological receptors and humans to PCBs in LDW surface sediment. The objectives of the removal action are to:

- Reduce the concentrations of contaminants in surface sediment (biological active zone, 0-10 cm) within the removal area boundary to below the SMS Sediment Quality Standard (SQS) for PCBs (12 mg/kg OC).
- Ensure that any remaining bank contamination at T-117 will not be released into the waterway and result in exposure to human and ecological receptors above protective levels by removal and capping of PCB contaminated soils.

The T-117 removal boundary was developed using a weight-of-evidence approach, based on 167 new PCB analysis results from material collected along the T-117 shoreline bank and from offshore sediments and with consideration of available historical data.

As currently proposed, the area left outside of the in-water removal boundary (from the boundary out to the navigation channel line and up to 300 ft north and south of the boundary) has an average PCB concentration (8.4 mg/kg, organic-carbon-normalized [-OC]) below the SQS for PCBs (12 mg/kg-OC). Following the removal action, the average PCB surface sediment concentration within the removal area will also be well below the PCB SQS, because most of the new surface will consist of new material.

REMOVAL AREA PHYSICAL SETTING

The removal area includes the upland unpaved area adjacent the shoreline, the bank extending down to the waterway, and adjacent intertidal to shallow subtidal sediment areas. The area within the boundary has been subdivided into four zones characterized by similar physical characteristics based on the removal action approach that emphasizes using land-based earthwork equipment whenever reasonably possible.

- **Upland**—This is the portion of the site above elevation +14 ft MLLW (approximately 1 ft above the expected highest tide at the site) that is located between the existing paving and the toe of the slope that extends down to the waterway. Removal action in the upland zone would be completed by land-based equipment.
- **Bank—**The bank is adjacent to the upland. It starts at elevation +14 ft MLLW near the top of the slope and extends down to the waterway to the start of the intertidal mudflat at about elevation +5 ft MLLW. The bank is mainly covered with blackberry vegetation, and is composed of a mixture of soil, debris, and creosote-treated timber bulkheads. Removal action in the bank zone would be completed by land-based equipment working when tidal waters are generally not present.
- **Mudflat—**The mudflat zone is adjacent to and offshore of the bank. The mudflat zone starts at the toe of the bank slope and extends out to the existing 0 ft MLLW contour. Removal action in the mudflat zone would be completed by land-based equipment working when tidal waters are generally not present.

- **Submerged—**The submerged zone is adjacent to and offshore of the mudflat zone and extends to the outboard removal boundary, typically near elevation -5 ft to -8 ft MLLW. Removal actions in the submerged zone would be completed with floating equipment working when the tides are high enough to provide the draft required for the barges.

IDENTIFICATION OF REMOVAL ACTION ALTERNATIVES

Two removal action alternatives have been developed for the T-117 removal area, based on options that were carried forward from the initial screening of technologies for the different site zones. The two technologies considered for the removal action are:

1) Removal of the impacted material from the site
2) Capping of the impacted material so that it is isolated from exposure to the public and the environment

Removal and capping actions are considered within two distinct sets of areas according to whether they will be applied from the upland side of the site (land-based removal action) or as in-water (waterway-based removal action). Excavation of the upland, bank, and mudflat sediments is planned to be completed with upland-based earthmoving equipment (excavators, front-end loaders, and dump trucks). Waterway-based work would be completed with a barge-mounted mechanical dredge and sediment haul barges.

- **Alternative 1 –**Combines the options that focus on the removal of PCBs from the site, with capping along the upland/bank, and incorporates backfilling of the mudflat and subtidal zones after dredging to re-establish the original grades.
- **Alternative 2 –**Combines the options that focus on removal of the higher concentration PCBs from the upland/bank and near-bank intertidal sediment, with capping of the lower concentration PCBs in the intertidal and subtidal sediment.

Treatment and disposal technologies were considered for the T-117 removal area and screened based on site-specific conditions. The technology selected for both alternatives is land disposal (landfilling) of PCB-contaminated soil and sediment according to the requirements mandated under the Toxic Substances Control Act (TSCA) and set forth in 40CFR761. All soil and sediment containing less than 50 mg/kg dry weight (dw) PCB would be transferred to a site licensed under the Resource Conservation and Recovery Act (RCRA) as a Subtitle D commercial landfill. Soil from the upland, bank, or mudflat areas determined to contain 50 mg/kg dw or greater PCBs would be loaded and delivered to a TSCA landfill. Two regional landfills have established services to receive dredged sediments and low-concentration

(PCB<50 mg/kg dw) contaminated soil: Roosevelt Regional Landfill near Goldendale, Washington, and Columbia Ridge Landfill near Arlington, Oregon.

In the case of the upland excavation, PCB concentrations in some upland soils are equal to or exceed 50 mg/kg dw and, if landfilled, must be placed in a hazardous waste landfill permitted by EPA under section 3004 of RCRA, or authorized by a State under section 3006 of RCRA, or in a PCB disposal facility approved under the TSCA rule. Landfills meeting these requirements and servicing the northwest include the Chemical Waste Management facility located at Arlington, Oregon, accessible from Seattle by rail, and the US Ecology chemical waste landfills at Grand View, Idaho, and Beatty, Nevada. The selection of specific landfill services will be made as part of the final design and removal action contractor selection process.

A no-action alternative was not considered for the T-117 removal area. Such an alternative would not satisfy the removal action objective of removing or controlling PCB-containing sediment at the T-117 EAA that has the potential to be released to the waterway and result in adverse PCB sediment concentrations in the LDW.

RECOMMENDATIONS

Alternatives 1 and 2 are similar in regard to effectiveness, implementability, and cost. Alternative 1 offers the advantage of increased removal of PCBs and lesser extent of capping, but also has a higher risk for short-term release during excavation and dredging and at a higher initial cost than Alternative 2. Alternative 2 offers the advantage of a lower potential for short-term releases due to a lower volume of in-water removal as well as a lower initial cost, but comes with a higher risk for long-term release from the larger capped area. Both alternatives are considered valid and viable for the T-117 removal action. The Port and City are recommending Alternative 1 because it removes a greater volume of PCBs from the environment with a lesser risk of potential future release of PCBs to the LDW.

1.0 Introduction

The Lower Duwamish Waterway (LDW) was added to the US Environmental Protection Agency's (EPA)'s National Priorities List (the national list of sites for the Comprehensive Environmental Response, Compensation, and Liability Act, or CERCLA, also known as Superfund) on September 13, 2001. The Phase 1 remedial investigation (RI) for the LDW (Windward 2003a) contained a summary of available data for the waterway as well as preliminary estimates of risks to human health and ecological receptors. One of the primary objectives of the Phase 1 RI was to identify areas within the LDW site that might be candidates for early removal action because of their potential for higher levels of risks. Windward (2003b) prepared a technical memorandum that recommended seven areas to EPA and the Washington Department of Ecology (Ecology) for early removal action. Terminal 117 (T-117), located at approximately river mile (RM) 3.6 on the west side of the waterway, was one of the seven recommended early action areas (EAA). EPA has since required that T-117 be investigated and cleaned up as Superfund a non-time-critical removal action (NTCRA).

Investigation of the T-117 EAA is being conducted under the existing Administrative Order on Consent (Cohen 2003) signed by the City, King County, the Port, and The Boeing Company (Boeing)—working together as the Lower Duwamish Waterway Group (LDWG)—as well as EPA and Ecology. Although all four members of LDWG are responsible for the LDW RI documents, work at the T-117 EAA is sponsored by only two of the four LDWG members: the Port and the City.

This report presents an engineering evaluation/cost analysis (EE/CA) for the T-117 removal area. This EE/CA documents site conditions, identification of the proposed boundary of the removal action, and the development and evaluation of various removal alternatives, and discusses the rationale for the recommended removal action that will be implemented by the Port and the City, subject to EPA approval.

The purpose of the EE/CA is to:

- Identify the objectives of the removal action
- Satisfy environmental review requirements for removal actions
- Satisfy administrative record requirements for documentation of removal selection
- Provide a framework for evaluating alternative technologies and making a selection
- Analyze the various alternatives that may be used to satisfy the removal action objectives (RAOs) for their effectiveness, implementability, and cost

The scope of the NTCRA determines the detail of the EE/CA. The NTCRA may be the first and only action at a site, or one of a series of planned response actions. The EE/CA is a flexible document tailored to the scope, goals, and objectives of the removal action. The EE/CA contains only those data necessary to support the selection of a response alternative, and relies on existing documentation whenever possible. This report follows the general format recommended in *Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA* (EPA 1993).

This document is organized into the following sections:

- Section 2 contains site background information, including:
  - description of the site
  - land use information
  - ecological habitats
  - a summary of the sediment chemical analyses conducted within and around the boundary of the removal area
  - source control information
  - streamlined risk assessment
- Section 3 presents the scope, goals, and objectives of the removal action
- Section 4 describes the removal action technologies
- Section 5 describes the removal action alternatives with regard to effectiveness, implementability, and cost
- Section 6 presents a comparative analysis of removal action alternatives
- Section 7 presents the recommended removal alternative
- Section 8 proposes a schedule for the removal action
- A separate map folio contains all figures
- Appendix A, the T-117 Proposed Removal Boundary Technical Memorandum, discusses the rationale and justification for the proposed removal boundary
- Appendix B, a toxicological profile for PCBs
- Appendix C contains predicted tides for 2006, Duwamish Waterway, 8th Ave. S
- Appendix D contains a discussion of how data is calculated

A technical memorandum presenting the rationale used to delineate the removal boundary is provided in Appendix A. The boundary was identified using historical data and recent data collected as part of this early action. Results of the recent field sampling efforts in the T-117 EAA are provided in the field sampling, cruise and data report (Windward et al. 2005a).

2.0 Site Characterization

This section describes the physical features and characteristics, history, land uses, habitat conditions, environmental data, risk assessment findings, and upland source control information for the T-117 EAA.

2.1 SITE DESCRIPTION

The T-117 site is located on the west side of the LDW from approximately RM 3.5 to RM 3.7, as measured from the southern tip of Harbor Island (Figure 2-1). T-117 consists of an aquatic portion that is within the LDW referred to as the EAA and an upland portion adjacent to the EAA that is referred to as the upland property.

2.1.1 T-117 EAA

The T-117 EAA is owned by the Port as successor in interest to the King County Commercial Waterway District No. 1 [(KCCWD1) often referred to as Duwamish Commercial Waterway District No. 1]. This area generally consists of the intertidal zone [from the top of the shoreline bank (+13 ft) to –4 ft mean lower low water (MLLW)] and a subtidal zone (from -4 ft MLLW to the slope of the navigation channel at -9 ft MLLW) and is bordered by the South Park Marina to the north and the Boeing South Park Facility to the south.

2.1.2 T-117 upland property

The upland property (above +13 ft MLLW) of the T-117 site is also owned by the Port. The upland property covers approximately 5.5 ac and is located at 8700 Dallas Ave S in Seattle, Washington. A strip of land adjacent to the shoreline 50-60 ft wide was also obtained by the Port as successor in interest to the KCCWD1. In 1999 the inland parcel between the shoreline KCCWD1 parcel and Dallas Ave S, that was owned by the Malarkey Asphalt Company (Malarkey), was acquired by the Port through a transaction undertaken to provide EPA with a party capable of carrying out the necessary CERCLA Emergency Removal Action, and to provide the Port with value for carrying out that cleanup. These properties were consolidated to form the present-day T-117 upland property.

2.1.3 T-117 adjacent areas

Adjacent properties include parcels owned by Basin Oil on the west side of Dallas Ave S, Boeing to the south, and the South Park Marina to the north/northwest. The City owns the adjacent street rights-of-way, including Dallas Ave S (between the Basin Oil property and T-117) and other streets in the vicinity.

2.1.4 Lower Duwamish Waterway

The Duwamish River originates at the confluence of the Green and Black Rivers near Tukwila, WA, then flows northwest for approximately 13 mi, bifurcating at the southern end of Harbor Island to form the East and West Waterways prior to discharging into Elliott Bay. The LDW consists of the downstream portion of the Duwamish River that is maintained by the US Army Corps of Engineers (USACE) as a federal navigation channel (i.e., the reach downstream from and including Turning Basin 3), excluding the East and West Waterways around Harbor Island (Weston 1999).

The shorelines along most of the LDW have been developed for industrial and commercial operations; the waterway serves as a major shipping route for containerized and bulk cargo. In addition, the LDW is a receiving water body for industrial and municipal stormwater and permitted wastewater. Some of these waste streams have been rerouted or discontinued, but there are still numerous storm drains and combined sewer overflows that currently discharge to the LDW. There are no combined sewer overflows near T-117.

Current shoreline features within the LDW include constructed bulkheads, piers, wharves, buildings extending over the water, and steeply sloped banks armored with riprap or other fill materials (Weston 1999). Intertidal habitats are dispersed in relatively small patches (i.e., generally less than 1 ac in size), with the exception of Kellogg Island, the largest contiguous area of intertidal habitat remaining in the LDW (Windward 2003a). The shoreline features of the T-117 EAA include a riprapped bank and bulkhead.

Over half of the upland areas adjacent to the LDW are industrialized and have been for many decades. Historical and current commercial and industrial operations include cargo handling and storage, marine construction, boat manufacturing, marina operations, concrete manufacturing, paper and metals fabrication, food processing, and airplane parts manufacturing. Thirty-nine percent of the land in the LDW watershed is zoned for residential use. Two residential neighborhoods, Georgetown and South Park, are adjacent to the LDW. South Park is located downstream of the T-117 EAA between RM 3.0 and 3.4. Portions of South Park are also located on land to the west of the T-117 EAA.

There are several public access points where people may enter the LDW for recreational purposes which include: two motorboat launches, three hand boat launches, and nine shoreline public access sites which existed in the LDW as of 1998 (Green-Duwamish Watershed Alliance 1998). Recreational boating and water activities in the LDW occur on a limited basis. Beach play has been observed at Duwamish Waterway Park in the South Park neighborhood. This park is the most likely access point in the LDW for direct contact with sediment. Many other access points and separated from the sediment by steep banks covered by riprap or blackberry bushes.

2.2 SURROUNDING LAND USE

No commercial, industrial, residential or recreational activities occur within the T-117 EAA, but they do occur at the T-117 upland property and nearby areas. The marina, adjacent to T-117 described in more detail below, includes commercial, recreational, and residential activity.

2.2.1 Commercial, industrial and residential activities

Upland property near the T-117 EAA shows a mixed-use pattern that includes residential, commercial, and industrial activities (Figure 2-2). Properties located between the east side of Dallas Ave S and the LDW (northeast and east of the city limits) are located in unincorporated King County and include (from north to south):

- South Park Marina primarily used for boat storage with the exception of 18 live-aboard vessels and some recreational boater use. The upland portion of the property is also used as a boatyard for storage and maintenance.
- T-117 upland property formerly used for manufacturing and industrial activities
- A portion of the Boeing South Park Facility, which is primarily a training center

The area located within the city limits extends from the west up to Dallas Ave S and includes (Figure 2-3):

- Former location of the Basin Oil plant, a used oil and antifreeze processing facility (vacated in 2004)
- Commercial and residential parcels to the west (i.e., located along 16th Ave S and 17th Ave S)
- Seattle Chocolates, chocolate manufacturing company, located in a large building on the north side of S Donovan St, between 16th Ave S and 17th Ave S at 8620 16th Ave S.

Until recently, Basin Oil used the property north of the chocolate company at 8617 17th Ave S for excess drum storage, and several residences are located further north at 8609 and 8601 17th Ave S. Basin Oil also used the west portion of the interior of the south metal building at T-117 for equipment storage and draining of used oil filters, but that use was terminated in 2004. The south metal building is currently used by a construction materials recycling business for storage.

The parcels located at the southwest corner of the intersection of 16th Ave S and Dallas Ave S are used by South Park Marina for additional boat storage. The Basin Oil parcels and those Boeing parcels within the city limits are zoned manufacturing/industrial; the parcels between 16th Ave S and 17th Ave S are zoned industrial buffer. Parcels west of 16th Ave S and north of S Donovan St are zoned residential/commercial which includes approximately 20 houses and one 12 unit apartment complex.

Individuals working or residing near T-117 are not likely to come in direct contact with sediment or water from the T-117 EAA. Individuals from the Treaty Tribes conduct annual commercial netfishing operations in the LDW. Gillnet lead lines may come in contact with sediments during normal operations. Fishers may contact this sediment incidentally upon net retrieval, and may also make incidental contact with surface water and sediment suspended in surface water.

2.2.2 Recreational activities

The LDW is not a major area for recreational use compared to other water bodies in and around Seattle (King County 1999). However, there are several public access points where people may enter the LDW for recreational purposes. Recreational boating in the LDW occurs on a limited basis. The South Park Marina and a public boat launch north of the marina are the closest recreation boating access points to the T-117 EAA. Few data that quantify the frequency with which people use the river for recreational purposes have been located. King County (1999) discussed the human site use of both the Duwamish River and Elliott Bay, but presented quantitative data only for fishing. The King County study assumed that few, if any, people engage in water activities such as swimming, scuba diving, and windsurfing within the LDW.

Anglers are the recreational group most likely to be directly or indirectly exposed to contaminated sediments. Anglers may consume seafood from the LDW that may have been in direct contact with LDW sediments. In the survey of fishing and seafood consumption practices conducted by King County (1999), none of the sites identified in the LDW where recreational fishing occurred were near T-117. Recreational boaters in the vicinity of T-117 (i.e., South Park Marina) are not likely to come in contact with sediment. Kayak and canoe use occurs sporadically in the LDW, but there is no known use of T-117 as a put-in or haul-out location.

2.3 EXISTING HABITAT CONDITIONS

The T-117 EAA is characterized by gently sloping intertidal habitat (mudflat) with a very steep to vertical vegetated riprap bank laden with asphalt deposits and other debris. This section provides an overview of existing data regarding habitat near T-117 and site usage by benthic invertebrates, fish, and wildlife.

2.3.1 Habitat

Estuarine intertidal and nearshore subtidal ecosystems in the LDW provide important habitat for juvenile salmonid growth, physiological transition, and predator avoidance during their outmigration to ocean rearing grounds. The estuarine environment also provides refuge for various marine fish larval stages, and supports an array of preferred prey for all salmonid life stages. The intertidal sediment provides important habitat for benthic invertebrates and juvenile salmonids, as well as other fish and shore birds.

The intertidal habitat of the T-117 EAA extends from the toe of the riprap bank, around +5 ft MLLW, to a depth of approximately -4 ft MLLW (Figure 2-4). The T-117 intertidal habitat includes more than 43,000 ft^2 (4,000 m^2) of gently sloping, fine-grained sediment. This area is potential habitat primarily for benthic communities and secondarily for juvenile salmonids. Recent data indicate the mean percent fines of the nearshore environment in the areas north, south, and adjacent to the T-117 EAA are 87%, 54%, and 64%, respectively. Most of the mid- to lower-intertidal slopes within the T-117 EAA are gradual, increasing in steepness near the northwest site boundary (Figure 2-4).

2.3.2 Site usage

2.3.2.1 Aquatic plants

No historical aquatic plant surveys have been conducted near T-117. In recent site visits, Windward staff observed only the presence of green macro algae.

2.3.2.2 Benthic invertebrates

The T-117 EAA provides intertidal and subtidal habitat for benthic invertebrates. Clams have been observed and collected in the intertidal zone of the T-117 EAA as part of LDW RI investigations (Windward 2004e). No other benthic invertebrate surveys, neither epibenthic nor infaunal, have been conducted at T-117. However, the habitat is similar to other intertidal and subtidal habitats within the LDW. The general habitat characteristics, and the potential benthic organisms that reside within these habitat types, are discussed below.

Most of the data regarding benthic macrofauna[1] are from surveys conducted in the vicinity of Kellogg Island, which is approximately 2.7 mi downstream of T-117 (King County 1999; Leon 1980). Both intertidal and subtidal macrofauna were collected in these studies, in substrates ranging from sand to mud. Studies by Cordell et al. (1996; 1997; 1999; 2001) included a site closer to T-117 in Turning Basin 3 (approximately 1.5 mi upstream of T-117). In this study, macrofauna were collected on intertidal mudflats at 0 ft elevation.

Similar numbers of taxa, ranging between 14 and 21 per site, were found at Kellogg Island and Turning Basin 3 in 1997 (Cordell et al. 1996; 1997; 1999; 2001). In 1995, relatively more taxa (27) were found at Kellogg Island than at Turning Basin 3 (16). In the years studied, the total density of organisms was generally higher at Kellogg Island than at Turning Basin 3. Other benthic invertebrate surveys have found the number of taxa at Kellogg Island to range from 27 to 68 per site (King County 1999; Leon 1980). Cordell et al. (1996; 1997; 1999; 2001) found the benthic invertebrate macrofauna community at Turning Basin 3 dominated by nematodes, oligochaetes, and *Corophium* spp. (amphipods) which are reflective of lower salinity, and the Kellogg Island community dominated by nematodes, oligochaetes, polychaetes, and crustaceans which are reflective of higher salinity. The lower salinity of T-117 EAA suggests that benthic community structure is likely to be more similar to that of Turning Basin 3 than that of Kellogg Island.

No epibenthic community survey has been conducted near T-117. The epibenthic community around Kellogg Island was surveyed in 1989 using a plankton pump, which is a standard epibenthic sampling device (Williams 1990). The survey examined seven transects and identified a total of 80 taxa. The community was dominated by small harpacticoid copepods, cumaceans, small annelids, and nematodes.

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[1] Invertebrates retained on a 0.5-mm sieve.

A clam survey was conducted in August 2003 in the T-117 EAA and southern vicinity by Windward as part of LDW RI investigations (Windward 2004e). Bivalves were most abundant at Kellogg Island and less abundant in T-117 EAA vicinity. Five different species were identified at Kellogg Island (M*acoma balthica, Macoma nasuta, Macoma secta, inconspicuous macoma, and Mya arenaria*), whereas only the *Macoma balthica,* inconspicuous macoma, *and Mya arenaria* clams were found at the T-117 EAA. Diversity differences within the LDW are not uncommon due to various salinity tolerances among clam species. A benthic invertebrate tissue and co-located sediment sampling event was also conducted by Windward in August 2004 as part of the LDW RI investigations (Windward 2005a). During this investigation 36 *Mya arenaria* and 4 *Macoma nasuta* clams were obtained from two beach samples taken with the T-117 EAA. Common larger epibenthic organisms in the LDW include crustaceans and mussels. Adult Dungeness and red rock crabs were collected at multiple locations near Kellogg Island (ESG 1999), but were not collected upstream of this area. Juvenile Dungeness crabs were found up to the First Avenue South Bridge (RM 3.4). Quarterly crab and shrimp surveys conducted as part of the LDW RI in 2003 and 2004 (Windward 2004a, b, c, d) found mostly slender crabs, few Dungeness crab, and no red rock crabs in the vicinity of T-117. Mussels were observed in large numbers on pilings and other structures in the lower, more saline end of the LDW and have been reported to occur to and slightly upstream of Turning Basin 3. Crabs were collected for tissue residue analysis in the offshore subtidal zone in the vicinity of T-117 as part of LDW RI investigations. From 6 traps 7 Dungeness and 21 slender crabs were caught. Analytical results from this study are available in *LDW RI Fish and Crab Tissue Collection and Chemical Analyses* (Windward 2005b).

2.3.2.3 Fish

Most LDW fish community surveys have been conducted in the vicinity of Harbor Island or Kellogg Island (Meyer et al. 1981; Taylor et al. 1999; Weitkamp and Campbell 1980; West et al. 2001). Sampling gear used to capture the fishes included beach seine, otter trawl, purse seine, and gill nets. The number of reported species from the Kellogg Island area ranged from 18 to 26 (Matsuda et al. 1968; Miller et al. 1975; Weitkamp and Campbell 1980). The dominant species were chinook, coho, and chum salmon, English sole, snake prickleback, sculpin spp., shiner perch, starry flounder, and three-spined stickleback. Other reported species from the area included Pacific herring, longfin smelt, Pacific cod and tomcod, sole spp., and perch spp. Three surveys sampled fishes near the T-117 area (Miller et al. 1975; 1977; Warner and Fritz 1995). However, only Miller et al. (1975) listed the species caught near T-117. A total of 19 fish species were caught, including longfin smelt, starry flounder, soles, sculpin spp., snake prickleback, Pacific tomcod, Pacific herring, perch spp., and chinook and coho salmon.

Fish were collected for tissue residue analysis in the offshore subtidal zone in the vicinity of T-117 as part of LDW RI investigations. The following were collected from 5 trawl sets: 55 sculpin spp (primarily pacific staghorn), 35 English sole, 466 shiner surfperch, 10 pile perch, 6 striped perch, 13 pacific tomcod,65 starry flounder, 3 longfin smelt, 2 sea pen, 12 snake prickleback and 23 cragon shrimp. Analytical results from this study are available in *LDW RI Fish and Crab Tissue Collection and Chemical Analyses* (Windward 2005b).

2.3.2.4 Wildlife

Formal studies, field observations, and anecdotal reports indicate that up to 87 species of birds and six species of mammals use the LDW at least part of the year to feed, rest, or reproduce (Canning et al. 1979; Cordell et al. 2001; Walker 1999). Monitoring of birds and mammals has not been conducted in the immediate vicinity of T-117. General use of the LDW by birds and mammals is discussed separately in the following sections.

Birds

Cordell et al. (2001) observed bird species during extensive monitoring of four sites (two at Turning Basin 3, one on Kellogg Island, and one at Terminal 105) in the LDW between 1995 and 2001. At these four sites, Cordell et al. (2001) reported 75 species of birds: 32 passerine/upland birds, 7 raptors, 8 shorebirds/waders, 16 waterfowl, and 12 seabirds. Diversity and abundance were highest at the Kellogg Island site, but other areas of the LDW were also consistently used by a wide variety of birds. Birds were most abundant in the spring and least abundant in the summer. A complete list of birds documented to use the LDW is presented in the LDW Phase 1 RI (Windward 2003a).

The presence of a gently sloping intertidal habitat offshore from the site suggests that the T-117 area may be used by shorebirds. In addition, fish and benthic invertebrates present in this area may serve as prey for eagle, osprey, great blue heron, and some waterfowl and seabird species.

The bald eagle is listed under the Endangered Species Act (ESA) as a threatened species, but is currently under review for delisting. In Washington, it is also listed as a state threatened species (WDFW 2003). There are five bald eagle nests within 5 mi of the LDW that were occupied in 1999 (King County 1999). The closest nest is located in West Seattle within 1 mi of T-117. One or two pairs of resident eagles may be found in the LDW vicinity during the summer (King County 1999). Overwintering migrant eagles are routinely observed in the vicinity of the LDW from the beginning of October through late March.

Common waterfowl and seabirds using the LDW include mallards, gadwalls, canvasbacks, mergansers, cormorants, gulls, and western grebes. Common shorebirds observed in the LDW include great blue heron, sandpipers, and killdeer. Spotted, least, and western sandpipers are reported to use the LDW in substantial numbers. A consistent, sizeable population of great blue herons is present in the waterway. Two nesting colonies can be found in the vicinity of the LDW: one 6.8 mi to the northwest (the Kiwanis Ravine colony), and the other 7.5 mi to the southeast in Renton (the Black River colony). A colony of up to 37 active nests was located in West Seattle a few hundred meters from Kellogg Island until 1999, but no successful nesting occurred there in 2000 or 2001 (Norman 2002).

Mammals

Three semi-aquatic terrestrial mammals use the LDW (river otter, muskrats, and raccoons), and three marine mammals may occasionally enter the LDW (harbor seal, California sea lion, and harbor porpoise) (Tanner 1991).

Anecdotal information indicates that a river otter family lives year-round on Kellogg Island in the LDW, approximately 3 mi downstream from T-117, although otters were not observed by Cordell et al. (2001) during their wildlife surveys. River otters are almost exclusively aquatic and prefer food-rich habitats such as the lower portions of streams and rivers, estuaries, and lakes and tributaries that feed rivers (Mowbray et al. 1979; Tabor and Wight 1977). Muskrat populations are reported to exist at Terminal 107 and at Turning Basin 3 (Canning et al. 1979). Raccoons are reported to be common along the forested ridge slopes to the west of the LDW and are known to adapt to urban settings such as the T-117 EAA. Raccoons are generally less dependent on the aquatic environment for food and habitat than river otters and muskrats.

Harbor seals and sea lions are commonly seen in Elliott Bay and have been observed in the LDW as far upstream as T-117. During a survey conducted by Washington State Department of Fish and Wildlife (WDFW) from December 1998 to June 1999, with observations occurring over 307 hours on 52 days, sea lions were observed on 16 occasions and seals on 17 occasions (Walker 1999). Most observations for both species occurred downstream of the First Avenue South Bridge. Harbor seals have been shown to forage over large distances ranging from 3.1 mi (Stewart et al. 1989) to 34.2 mi (Beach et al. 1985). Recent information on use of the LDW by harbor porpoises was not available, although Dexter et al. (1981) noted that they occasionally enter the LDW.

2.3.2.5 Endangered and threatened species

Fourteen species reported in the LDW are listed under either the ESA or by the WDFW as candidate species, threatened species, endangered species, or species of concern (Table 2-1).

Table 2-1. Species listed under ESA or by WDFW

COMMON NAME	SCIENTIFIC NAME	STATUS
Fish		
Chinook salmon	*Oncorhynchus tshawytscha*	FT, SC
Coho salmon	*Oncorhynchus kisutch*	FC
River lamprey	*Lampetra ayresi*	FSC, SC
Bull trout	*Salvelinus confluentes*	FT, SC
Pacific herring	*Clupea herengus pallasi*	SC
Pacific cod	*Gadus macrocephalus*	SC
Walleye pollock	*Theragra chalcogrammus*	SC
Rockfish species	*Sebastes* spp.	SC
Birds		
Bald eagle	*Haliaeetus leucocephalus*	FT[a], ST

COMMON NAME	SCIENTIFIC NAME	STATUS
Peregrine falcon	*Falco peregrinus*	FSC, SS[b]
Merlin	*Falco columbarius*	SC
Common murre	*Uria aalge*	SC
Common loon	*Gavia Immer*	SS
Western grebe	*Aechmophorus occidentalis*	SC

Source – WDFW (2003)

FT – Federal threatened species
FC – Federal candidate species
FSC – Federal species of concern
ST – State threatened species
SC – State candidate species
SS – State sensitive species

[a] Listing currently under review for removal

[b] Downlisted from state endangered to state sensitive, April 2002

With the exception of chinook salmon, coho salmon, bull trout, bald eagle, western grebe, and perhaps Pacific herring, use of the LDW by the species in Table 2-1 is rare or incidental, so they are not likely to have frequent exposure to sediment-associated chemicals from the LDW. Reports of these rare or incidental species in the LDW are as follows: loons (Canning et al. 1979, rare), merlin (Cordell et al. 1997, rare), common murre (believed to be rare[2]), rockfish (Malins et al. 1980, present; Matsuda et al. 1968, rare), river lamprey (Matsuda et al. 1968, rare; Warner and Fritz 1995, rare) walleye pollock (Matsuda et al. 1968, rare; Miller et al. 1975, rare), and Pacific cod (Miller et al. 1975, 1977; Weitkamp and Campbell 1980). Reports of peregrine falcon are anecdotal (Anderson 2002). These species share life history traits with species more common in the LDW; the analysis of exposure and effects due to sediment-associated chemicals for the more common species should be protective of these species of concern. The National Marine Fisheries Service (NMFS) ruled on November 22, 2000 that ESA listing of Pacific cod and walleye pollock was not warranted (65FR227, Friday, November 24, 2000). NMFS ruled on April 3, 2001 that ESA listing of Pacific herring, brown rockfish, copper rockfish, and quillback rockfish was not warranted (66FR64, Docket No. 010312061–1061–01; I.D. 061199B]).

2.4 SUMMARY OF ENVIRONMENTAL DATA

2.4.1 Historical data

The initial step in the process to delineate a removal boundary was to compile and summarize existing environmental data for the T-117 EAA and to identify any remaining data gaps (Windward et al. 2003b). Based on this summary, PCBs were identified as the primary chemical of potential concern for the removal action and supporting source control activities at the T-117 EAA. PCBs were initially detected in surface and subsurface soil during several investigations in the 1990's. A CERCLA removal emergency removal action was conducted in 1999 (Onsite 2000) remove the

[2] Common murre was observed by Canning et al. (1979) on only two occasions during the year-long survey; only one bird was seen on each occasion

PCB contaminated soil. Samples which represent soil that were removed are no longer applicable and contaminated soils remaining in the T-117 upland property were capped with asphalt.

Other contaminants and related sources within the greater drainage area and adjoining river reach identified during implementation of the Lower Duwamish Waterway Source Control Workgroup (SCWG) Source Control Action Plan (Ecology 2005) may also require control and will, if necessary, be addressed under the broader source control strategy for the LDW. Additional upland source control investigations are discussed below in section 2.4.4.

Figure 2-5 (see map folio) presents the locations of historical sediment samples for which PCB was an analyzed constituent. Table 2-2 presents the historical PCB chemistry data from stations located offshore of T-117 that were used to assist in identifying this EAA and support the boundary delineation. All historical results from locations presented on Figure 2-5 can be found in *Summary of Existing Information and Data Needs Analysis* (Windward et al. 2003b).

Table 2-2. Historical (1997-1998) total PCB sediment results compared to SMS

Location	Sample ID	Total PCBs (µg/kg dw)	TOC %	Total PCBs (mg/kg-OC)	Q	SQS EF	CSL EF
Surface							
WIT265	WIT07-01	2,600	0.31	***840***		70	13
WIT267	WIT07-02	550	0.67	***82***		6.8	1.3
WST323	WST09-02	7,850	1.9	***410***		34	6.3
DR206	SD-DR206-0000	205	3.0	6.9	J	0.58	0.11
DR207	SD-DR207-0000	12,000	3.2	***380***		32	5.8
DR208	SD-DR208-0000	388	1.3	**30**	J	2.5	0.46
DR218	SD-DR218-0000	87	2.6	3.4	J	0.28	0.052
R16	SD0011	2,400	1.1	***210***		18	3.2
R17	SD0010	177	1.2	**15**		1.3	0.23
R18	SD0018	201	1.0	**20**		1.7	0.31
R19	SD0019	193	1.3	**15**		1.3	0.23
Subsurface							
SD-DR206	SD-DR206-0000A (0-2ft)	1,250	0.79	***160***		13	2.5
	SD-DR206-0020 (2-4ft)	40	2.5	1.6	U	0.13	0.025

SQS – Sediment Quality Standards (12 mg/kg-OC) **bold** indicates SQS exceedance

CSL – Cleanup Screening Level (65 mg/kg-OC) ***bold and italicized*** indicates CSL exceedance

dw – dry weight OC – organic carbon normalized

EF – exceedance factor (concentration in mg/kg-OC/SQS [SQS EF] or CSL [CSL EF])

Q – qualifier: J – estimated value U – undetected

2.4.2 T-117 EAA recent investigation

Multiple field efforts to fill data gaps were conducted as necessary to determine the nature and extent of PCB contamination, assist engineering design, and identify potential sources of sediment contamination. Figure 2-6 (see map folio) presents all sampling locations associated with the multiple field efforts that are described below. A discussion of the rationale for sample locations and analyses was provided in the quality assurance project plan (QAPP, Windward et al. 2003a). All data are presented in the field sampling, cruise and data report (Windward et al. 2005a).

- In December 2003, surface sediment grab samples and subsurface sediment core samples were collected from the T-117 EAA and analyzed primarily for PCBs. A subset of the surface sediment samples near potential source discharge areas were also analyzed for all SMS chemicals. One sediment sample near the South Park Marina was analyzed for tributyltin (TBT).
- In December 2003, soil samples were collected from catch basin 1, catch basin 5, and the southern drainage ditch, and analyzed for SMS analytes. Soil boring locations along the shoreline bank were analyzed for PCBs and polycyclic aromatic hydrocarbons (PAHs).
- In December 2003, a 24-hour tidal study was conducted to characterize the groundwater gradient beneath the T-117 upland area, characterize the influence of tides in the LDW on water levels in the wells, establish appropriate tide ranges for monitoring well sampling, and check for the occurrence of NAPL in wells. A follow-up well check for the presence of NAPL was conducted in August 2004.
- In late December 2003 and early January 2004, water samples were collected from four shoreline bank monitoring wells and three seep locations along the toe of the bank and analyzed for SMS analytes.
- In March 2004, locations of large concentrated roofing/shingle asphalt outcrops in the shoreline bank and south ditch were mapped.

Following this initial sample collection effort, the areal extent of PCB contamination at northern portion of T-117 was still unbounded. To better define the potential cleanup boundary the following samples were collected in March 2004. A discussion of the rationale for sample locations and analyses are provided in a QAPP addendum (Windward et al. 2004a).

- Surface sediment grabs and subsurface sediment cores from the northern intertidal zone were analyzed for PCBs.
- Shallow soil boring samples along the northern shoreline bank were analyzed for PCBs.

In March 2004, additional soil sampling was also conducted to estimate the concentrations of PCBs in the roadway along the entrance area of the T-117 property and evaluate whether these materials are the likely source of elevated PCBs in and around catch basin 5. A discussion of the rationale for sample locations and analyses are provided in the upland roadway soil sampling work plan (Onsite 2004). Roadway soil samples and additional catch basin samples were analyzed for PCBs.

All of these results were used to determine a preliminary removal boundary (Windward et al. 2004b). Following the preliminary boundary delineation, there was still some uncertainty about the nature and extent of PCB contamination and the extent of other contaminants beyond or below the PCB-delineated boundary. The following samples were collected in June 2004. A discussion of the rationale for sample locations and analyses was provided in a second QAPP addendum (Windward et al. 2004d):

- Surface sediment samples were collected to determine the nature and extent of PCB sediment contamination outside of the offshore northern portion of the preliminary removal boundary to better define the proposed removal boundary.
- Archived samples collected in December 2003 that were either outside the preliminary cleanup boundary or below the vertical extent of PCB contamination were also analyzed for metals and semivolatile organic compounds (SVOCs) to assess whether chemicals other than PCBs would influence placement of the boundary.

Surface and subsurface samples were collected in the northern portion of the site that extends into the proposed South Park Marina dredge area to determine the nature and extent of PCBs in sediment to better define the proposed removal boundary. This sampling event was conducted to satisfy both the EPA T-117 EAA boundary definition and the Puget Sound Dredged Disposal Agency (PSDDA) sediment characterization requirements for the South Park Marina. The PSDDA results, which are suitable for open water disposal, are presented in a separate data report (Windward et al. 2005b). A discussion of the rationale for sample locations and analyses was provided in a third QAPP addendum (Windward et al. 2004c).

2.4.3 Results of T-117 field efforts

The T-117 field sampling, cruise and data report (Windward et al. 2005a) contains the results of all T-117 field surveys conducted as part of this early action, including the contents of the three drafts submitted earlier this year, the results of the roadway soil samples, and additional supplemental sediment samples as discussed above. All analytical results were validated by an independent data validator and reviewed by EPA, and were found to be acceptable for use in establishing the removal area boundary. Results of the independent validation process are also contained in field sampling, cruise and data report. Results of the chemical analyses applicable to the delineation of the proposed removal boundary are summarized below. Supplemental information on upgradient sources includes ongoing work by the City of Seattle Public Utilities (SPU), Ecology, and others. This work and additional sources are described in Section 2.4.1.

In the tables referenced, field duplicate results are presented independently from the sample from which the field duplicate came. For mapping purposes, however, field duplicate results were averaged. Significant figure rules were applied when summing and during carbon normalizing. For carbon normalized averages, results from the two samples were averaged before normalizing (average value in dry weight [dw]/average total organic carbon [TOC] value). A detailed discussion of the hierarchical approach used in averaging laboratory replicates and field duplicates, calculating totals, carbon normalizing, and the application of significant figures, is presented in Appendix D. The location identifiers (IDs) shown on several figures are abbreviations for the locations shown in the following tables in this document, as indicated in the map legend. An abbreviated ID format is also used in this discussion, omitting the initial T-117 from sample IDs for brevity.

2.4.3.1 Sediment

Surface Sediment

PCBs

Fifty-seven individual surface grab samples, including six field duplicates, were analyzed for total PCBs during the recent investigation. One composite sample was also collected along the north bank. Total PCB results compared to SMS criteria are presented in Table 2-3. The PCB concentrations for initial surface grab samples are shown on Figure 2-7 (see map folio) and for the supplemental samples are shown on Figure 2-8 (see map folio). The surface sediment sampling data show a spatial trend of PCB concentrations decreasing from the bank out towards the navigation channel. Sediment samples with PCB concentrations above the PCB CSL are found within 100 ft of the top of the bank. PCB concentrations were generally higher and the frequency of CSL exceedances was greater in the northern portion of the EAA relative to the southern portion. The historical data supports the spatial trend of PCB concentrations ascertained by the recent data.

Table 2-3. T-117 EAA investigation total PCB surface sediment results compared to SMS

LOCATION	SAMPLE ID	TOTAL PCBS (µg/kg dw)	TOC%	TOTAL PCBS (mg/kg-OC)	Q	SQS EF	CSL EF
Initial Sampling December 2003							
T-117-SE-7-G	T-117-SE07-SG	87	3.2[b]	2.7		0.23	0.042
T-117-SE-8-G	T-117-SE08-SG	1,000	2.2	**45**		3.8	0.70
T-117-SE-10-G	T-117-SE10-SG	1,200	2	**60**		5.0	0.92
T-117-SE-13-G	T-117-SE13-SG	870	2.8	**31**		2.6	0.48
T-117-SE-15-G	T-117-SE15-SG	132	2.3[b]	5.7		0.48	0.088
T-117-SE-16-G	T-117-SE16-SG	2,800	1.8	***160***		13	2.4
T-117-SE-17-G	T-117-SE17-SG	12,000	2.2	***550***		45	8.4
T-117-SE-18-G	T-117-SE18-SG	5,900	1.7	***350***		29	5.3
T-117-SE-19-G	T-117-SE19-SG	270	1.2	**23**	J	1.9	0.35

Location	Sample ID	Total PCBs (µg/kg dw)	TOC%	Total PCBs (mg/kg-OC)	Q	SQS EF	CSL EF
T-117-SE-20-G	T-117-SE20-SG	1,300	1.3	***100***		8.3	1.5
T-117-SE-21-G	T-117-SE21-SG	38,000	1.7	***2,200***		186	34
T-117-SE-22-G	T-117-SE22-SG	16,000	1.8	***890***		74	14
T-117-SE-23-G	T-117-SE23-SG	80	1.7	4.7		0.39	0.072
T-117-SE-24-G	T-117-SE24-SG	3,500	1.5	***230***		19	3.6
T-117-SE-25-G	T-117-SE25-SG	4,000	1.4	***290***		24	4.4
T-117-SE-26-G	T-117-SE26-SG	1,900	1.7	***110***		9.3	1.7
T-117-SE-27-G	T-117-SE27-SG	83	1.8	4.6		0.38	0.071
T-117-SE-28-G	T-117-SE28-SG	910	1.2	***76***		6.3	1.2
T-117-SE-29-G	T-117-SE29-SG	170	2.6	6.5		0.54	0.10
	T-117-SE52-SG[a]	102	2.3	4.3		0.36	0.066
T-117-SE-30-G	T-117-SE30-SG	320	1.7	**19**		1.6	0.29
T-117-SE-31-G	T-117-SE31-SG	3,400	2.3	***150***		12	2.3
T-117-SE-32-G	T-117-SE32-SG	250	2.2	11		0.95	0.17
T-117-SE-33-G	T-117-SE33-SG	9,400	3	***310***	J	26	4.8
	T-117-SE60-SG[a]	1,300	1	***130***		11	2.0
T-117-SE-34-G	T-117-SE34-SG	4,900	1.5	***330***		27	5.0
T-117-SE-35-G	T-117-SE35-SG	47	2.2[b]	2.1	J	0.18	0.033
T-117-SE-36-G	T-117-SE36-SG	230	2.2	10		0.87	0.16
T-117-SE-37-G	T-117-SE37-SG	4,300	1.9	***230***		19	3.5
T-117-SE-38-G	T-117-SE38-SG	86	1.8	4.8		0.40	0.074
T-117-SE-39-G	T-117-SE39-SG	11,000	2.6	***420***		35	6.5
T-117-SE-40-G	T-117-SE40-SG	3,200	1.6	***200***		17	3.1
T-117-SE-41-G	T-117-SE41-SG	127	2.8	4.5		0.38	0.070
T-117-SE-42-G	T-117-SE42-SG	136	2.3	5.9		0.49	0.091
T-117-SE-43-G	T-117-SE43-SG	540	0.98	**55**	J	4.6	0.85
T-117-SE-44-G	T-117-SE44-SG	320	1.5	**21**		1.8	0.33
T-117-SE-45-G	T-117-SE45-SG	520	1.2	**43**	J	3.6	0.66
	T-117-SE53-SG[a]	910	1.1	***83***	J	6.9	1.3
T-117-SE-46-G	T-117-SE46-SG	210	1.6	**13**		1.1	0.20
T-117-SE-47-G	T-117-SE-SGComp1	4,000	2.3	***170***		14	2.7
Supplemental Sampling							
March 2003							
T-117-SE-73-G	T-117-SE73-SG	263	3.3[b]	8.0	J	0.66	0.12
	T-117-SE75-SG[a]	223	3.2	7.0		0.58	0.11
T-117-SE-74-G	T-117-SE74-SG	123	2.7	4.6		0.38	0.070
June 2003							
T-117-SE-76-G	T-117-SE76-SG	1,400	1.88[b]	***77***	J	6.4	1.2
T-117-SE-77-G	T-117-SE77-SG	1,100	3.29	**40**	J	3.3	0.62
T-117-SE-78-G	T-117-SE78-SG	508	1.29	**33**	J	2.8	0.51
	T-117-SE83-SG[a]	310	3.36	9.2	J	0.77	0.14

LOCATION	SAMPLE ID	TOTAL PCBS (µg/kg dw)	TOC%	TOTAL PCBS (mg/kg-OC)	Q	SQS EF	CSL EF
T-117-SE-79-G	T-117-SE79-SG	150	1.7	8.8	J	0.73	0.14
T-117-SE-80-G	T-117-SE80-SG	143	2.18	6.6	J	0.55	0.10
T-117-SE-81-G	T-117-SE81-SG	400	1.16	34	J	2.8	0.52
T-117-SE-82-G	T-117-SE82-SG	109	2.47	4.4	J	0.37	0.068
September 2004							
T-117-SE-84-G	T-117-SE84-SG	88	1.26[b]	7.2		0.60	0.11
T-117-SE-85-G	T-117-SE85-SG	117	3.23	3.6		0.30	0.055
T-117-SE-86-G	T-117-SE86-SG	102	3.08	3.3		0.28	0.051
T-117-SE-89-G	T-117-SE89-SG	700	0.762	***92***		7.7	1.4
	T-117-SE95-SG[a]	620	1.28	48		4.0	0.75
T-117-SE-91-G	T-117-SE91-SG	128	3.04	4.2		0.35	.065
T-117-SE-93-G	T-117-SE93-SG	203	2.71	7.5		0.62	0.12

SQS – Sediment Quality Standards (12 mg/kg-OC) **bold** indicates SQS exceedance

CSL – Cleanup Screening Level (65 mg/kg-OC) ***bold and italicized*** indicates CSL exceedance

dw – dry weight OC – organic carbon normalized

EF – exceedance factor (concentration in mg/kg-OC/SQS [SQS EF] or CSL [CSL EF])

nc – not calculated because %TOC is either ≤0.2 or ≥5.0%. Dry weight concentration compared to apparent effects threshold (AET) equivalents of SQS (lowest AET: 130 µg/kg dw) and CSL (second lowest AET: 1,000 µg/kg dw).

Q – qualifier: J – estimated value U – undetected

[a] Field duplicate

[b] result averaged with laboratory replicates

PAHs

Fourteen surface sediment samples (SE08-SG, SE15-SG, SE21-SG, SE25-SG, SE27-SG, SE33-SG, SE36-SG, SE37-SG, SE39-SG, SE40-SG, SE43-SG, SE44-SG, SE45-SG, and SE46-SG) were analyzed for PAHs during the recent investigation. Sample SE25-SG (within the proposed boundary) exceeded the applicable SQS for three PAHs. Sample SE37-SG (within the proposed boundary) had 13 individual PAH SQS exceedances, 10 of which also exceeded the applicable CSL. Total high-molecular-weight PAHs (HPAHs) in this sample exceeded the SQS, and total low-molecular-weight PAHs (LPAHs) in this sample exceeded both the SQS and CSL. Detection limits were typical for relatively uncontaminated sediment samples, ranging from 19 to 40 µg/kg dw. The two locations with PAH exceedances also contained PCBs above the CSL, and were thus within the proposed removal boundary. PAH exceedances are presented in Table 2-4.

Table 2-4. Exceedances of polycyclic aromatic hydrocarbons in surface sediment

Sample ID	Chemical	Concentration		Q	SQS	CSL	SQS EF	CSL EF
		µg/kg dw	mg/kg-OC					
T-117-SE25-SG[a]	Indeno(1,2,3-cd)pyrene	520	**37**		34	88	1.1	0.42
	Acenaphthene	250	**18**	J	16	57	1.1	0.31
	Phenanthrene	1,900	**140**		100	480	1.4	0.29
T-117-SE37-SG[b]	2-Methylnaphthalene	1,400	***74***		38	64	1.9	1.2
	Acenaphthene	3,900	***210***		16	57	13	3.7
	Anthracene	4,300	**230**		220	1,200	1.0	0.19
	Benzo(a)anthracene	8,400	***440***		110	270	4.0	1.6
	Benzo(a)pyrene	7,900	***420***		99	210	4.2	2.0
	Benzo(g,h,i)perylene	1,200	**63**		31	78	2.0	0.81
	Chrysene	7,700	**410**		100	460	4.1	0.89
	Dibenzo(a,h)anthracene	640	***34***		12	33	2.8	1.0
	Dibenzofuran	4,200	***220***		15	58	15	3.8
	Fluoranthene	24,000	***1,260***		160	1,200	7.9	1.1
	Fluorene	5,500	***290***		23	79	13	3.7
	Indeno(1,2,3-cd)pyrene	1,900	***100***		34	88	2.9	1.1
	Phenanthrene	28,000	***1,500***		100	480	15	3.1
	Total HPAHs	85,000	**4,500**		960	5,300	4.7	0.8
	Total LPAHs	43,000	***2,300***		370	780	6.2	2.9

SQS – Sediment Quality Standards (12 mg/kg-OC) **bold** indicates SQS exceedance

CSL – Cleanup Screening Level (65 mg/kg-OC) ***bold and italicized*** indicates CSL exceedance

dw – dry weight OC – organic carbon normalized

EF – exceedance factor (concentration in mg/kg-OC/SQS [SQS EF] or CSL [CSL EF])

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon

Q – qualifier: J – estimated value

Surface samples with no PAH exceedance of the SQS: T-117-SE08-SG, SE15-SG, SE21-SG, SE27-SG, SE33-SG, SE36-SG, SE39-SG, SE44-SG, SE45-SG, and SE46-SG

[a]- TOC = 1.4%

[b]- TOC = 2.6%

Other Analytes

Twelve surface sediment samples (SE08-SG, SE15-SG, SE21-SG, SE25-SG, SE27-SG, SE33-SG, SE36-SG, SE37-SG, SE39-SG, SE44-SG, SE45-SG, and SE46-SG) were analyzed during the recent investigation for eight trace metals: arsenic, cadmium, chromium, copper, lead, mercury, silver, and zinc. There were no exceedances of SQS or CSL for metals. Fourteen surface sediment samples (SE08-SG, SE15-SG, SE21-SG, SE25-SG, SE27-SG, SE33-SG, SE36-SG, SE37-SG, SE39-SG, SE40-SG, SE43-SG, SE44-SG, SE45-SG, and SE46-SG) were analyzed during the recent investigation for SVOCs. The hexachlorobenzene detection limit (0.44 mg/kg-OC) for sample SE21-SG (within the proposed boundary) exceeded the SQS. There were no other SVOC exceedances. Sample SE08-SG was analyzed for bulk TBT. TBT (as ion) was not detected at a detection limit of 5.0 µg/kg dw. Three volatile organic compounds (VOCs: 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, and 1,4-dichlorobenzene) were analyzed in fourteen surface sediment samples (SE08-SG, SE15-SG, SE21-SG, SE25-SG, SE27-SG, SE33-SG, SE36-SG, SE37-SG, SE39-SG, SE40-SG, SE43-SG, SE44-SG, SE45-SG, and SE46-SG). There were no exceedances of SQS or CSL for these compounds.

Subsurface Sediment

Twenty-one sediment cores[3] from the T-117 EAA investigations, most of which were divided into six or seven sampling intervals, were analyzed for PCBs. A total of 109 subsurface sediment samples were tested and evaluated for PCBs. Total PCB results are presented in Table 2-5. The PCB concentrations for each initial core location are shown on Figure 2-9 (see map folio) and supplemental core location results are on Figure 2-8 (see map folio).

The subsurface sediment sampling data also show a spatial trend of PCB concentrations that decrease from the bank out towards the navigation channel. Sediment samples with PCB concentrations above the PCB CSL are found within 100 ft of the top of the bank and were typically confined to the upper 1-2 ft of sediment in the nearshore cores. PCB concentrations were also generally higher and the frequency of CSL exceedances was greater at corresponding depths in the northern portion of the EAA than in the southern portion.

Table 2-5. Total PCB subsurface results compared to SMS

LOCATION	SAMPLE ID	DEPTH BELOW MUDLINE (ft)	TOC %	TOTAL PCBS (µg/kg dw)	TOTAL PCBS (mg/kg-OC)	Q	SQS EF	CSL EF
Initial Sampling December 2003								
T-117-SE-15-SC	T-117-SE15-SC-01	0-1	2.0	310	**16**		1.3	0.24
	T-117-SE15-SC-12	1-2	1.9	320	**17**		1.4	0.26
	T-117-SE15-SC-24	2-4	1.5	216	**15**		1.3	0.23
	T-117-SE49-SC-24[a]	2-4	1.6	175	11		0.92	0.17
	T-117-SE15-SC-46	4-6	1.0	46	4.6	J	0.38	0.071
	T-117-SE15-SC-68	6-8	1.3	130	10		0.83	0.15
	T-117-SE15-SC-810	8-10	1.8	104	5.8		0.48	0.089

[3] Three of the cores (SE89, SE91, SE93) were collected along the northern boundary under the Dredge Material Management Program (DMMP) for the adjacent South Park Marina dredging project. These adjacent cores were collected to meet the needs of both EPA and DMMP in defining the boundary of the T-117 EAA and in determining the suitability of the sediments for disposal at the Elliott Bay open-water dredged material disposal site.

LOCATION	SAMPLE ID	DEPTH BELOW MUDLINE (ft)	TOC %	TOTAL PCBS (µg/kg dw)	TOTAL PCBS (mg/kg-OC)	Q	SQS EF	CSL EF
T-117-SE-16-SC	T-117-SE16-SC-0-0.9	0-0.9	2.1	3,400	***200***		17	3.1
	T-117-SE16-SC-0.9-1.3	0.9-1.3	1.7	2,900	***140***		12	2.1
	T-117-SE16-SC-1.3-2	1.3-2	1.4[b]	590	**42**		3.5	0.65
	T-117-SE16-SC-24	2-4	2.4	1,900	***79***		6.6	1.2
	T-117-SE16-SC-46	4-6	1.5	129	8.6		0.72	0.13
	T-117-SE16-SC-68	6-8	1.4	430	**31**		2.6	0.47
	T-117-SE16-SC-810	8-10	1.6	69	4.3		0.36	0.066
T-117-SE-17-SC	T-117-SE17-SC-01	0-1	1.9	3,700	***200***		16	3.0
	T-117-SE17-SC-12	1-2	2.2	3,200	***150***		12	2.2
	T-117-SE17-SC-24	2-4	2.2	280	**13**		1.1	0.20
	T-117-SE17-SC-46	4-6	0.83	67	8.1		0.67	0.12
	T-117-SE17-SC-68	6-8	1.4	100	**13**	J	1.1	0.2
	T-117-SE47-SC-68[a]	6-8	0.56	34	6.1		0.51	0.094
	T-117-SE17-SC-810	8-10	0.27	20	7.4	U	0.62	0.11
T-117-SE-20-SC	T-117-SE20-SC-01	0-1	1.1	2,800	***260***		21	3.9
	T-117-SE20-SC-12	1-2	1.5[b]	420	**28**		2.3	0.43
	T-117-SE20-SC-24	2-4	1.1	145	**13**		1.1	0.20
	T-117-SE20-SC-46	4-6	1.3	60	4.6		0.38	0.071
	T-117-SE20-SC-68	6-8	2.3	18	0.78	J	0.065	0.012
	T-117-SE20-SC-810	8-10	2.8	118	4.2		0.35	0.065
T-117-SE-21-SC	T-117-SE21-SC-01	0-1	2.1	16,000	***760***		63	12
	T-117-SE21-SC-12	1-2	1.8	280	**16**		1.3	0.24
	T-117-SE21-SC-24	2-4	1.0	20	2.0	U	0.17	0.031
	T-117-SE21-SC-46	4-6	1.2	20	1.7	U	0.14	0.026
	T-117-SE21-SC-68	6-8	0.63	20	3.2	U	0.26	0.049
	T-117-SE21-SC-810	8-10	0.28	20	7.1	U	0.60	0.110
T-117-SE-23-SC	T-117-SE23-SC-01	0-1	1.6	51	3.2	J	0.27	0.049
	T-117-SE23-SC-12	1-2	1.8	21	1.2		0.097	0.018
	T-117-SE23-SC-24	2-4	2.8	158	5.6		0.47	0.087
	T-117-SE23-SC-46	4-6	1.3	220	**17**		1.4	0.26
	T-117-SE23-SC-68	6-8	1.8	210	12		0.97	0.18
	T-117-SE23-SC-810	8-10	1.9	68	3.6		0.30	0.055
T-117-SE-24-SC	T-117-SE24-SC-01	0-1	1.2	1,300	***110***		9.0	1.7
	T-117-SE24-SC-12	1-2	1.2	122	10		0.85	0.16
	T-117-SE24-SC-24	2-4	1.1	98	8.9		0.74	0.14
	T-117-SE24-SC-46	4-6	2.2	77	3.5		0.29	0.054
	T-117-SE24-SC-68	6-8	1.7	68	4.0	J	0.33	0.062
	T-117-SE24-SC-810	8-10	1.4	45	3.2	J	0.27	0.049

LOCATION	SAMPLE ID	DEPTH BELOW MUDLINE (ft)	TOC %	TOTAL PCBs (µg/kg dw)	TOTAL PCBs (mg/kg-OC)	Q	SQS EF	CSL EF
T-117-SE-25-SC	T-117-SE25-SC-01	0-1	0.76	2,000	***260***		22	4.0
	T-117-SE25-SC-12	1-2	2.0	380	**19**		1.6	0.29
	T-117-SE25-SC-24	2-4	2.1	97	4.6	J	0.38	0.071
	T-117-SE25-SC-46	4-6	1.7	64	3.8		0.31	0.058
	T-117-SE25-SC-68	6-8	0.74	45	6.1		0.51	0.094
	T-117-SE25-SC-810	8-10	0.34	19	5.6	U	0.47	0.086
T-117-SE-30-SC	T-117-SE30-SC-01	0-1	1.2[b]	990	***83***		6.9	1.3
	T-117-SE30-SC-12	1-2	1.3	158	12		1.0	0.19
	T-117-SE30-SC-24	2-4	0.068	20	nc	U	0.15	0.02
	T-117-SE30-SC-46	4-6	0.99	19	1.9	U	0.16	0.030
	T-117-SE30-SC-68	6-8	0.58	19	3.3	U	0.27	0.050
	T-117-SE30-SC-810	8-10	0.81	20	2.5	U	0.21	0.038
T-117-SE-31-SC	T-117-SE31-SC-01	0-1	2.0	51,000	***2,600***		213	39
	T-117-SE31-SC-12	1-2	1.5	26	1.7		0.14	0.027
	T-117-SE31-SC-24	2-4	1.3	19	1.5	U	0.12	0.022
	T-117-SE31-SC-46	4-6	0.68[b]	19	2.8	U	0.23	0.043
	T-117-SE31-SC-68	6-8	0.74	20	2.7	U	0.23	0.042
	T-117-SE31-SC-810	8-10	0.5	20	4.0	U	3.0	0.062
	T-117-SE48-SC-810[a]	8-10	0.52	19	3.7	U	0.31	0.057
T-117-SE-35-SC	T-117-SE35-SC-01	0-1	2.1	135	6.4		0.54	0.099
	T-117-SE35-SC-12	1-2	1.9	480	**25**	J	2.1	0.39
	T-117-SE35-SC-24	2-4	2.0	920	**46**		3.8	0.71
	T-117-SE50-SC-24[a]	2-4	2.3	1140	**48**		4.0	0.74
	T-117-SE35-SC-46	4-6	2.6	480	**18**	J	1.5	0.28
	T-117-SE35-SC-68	6-8	1.5	210	**14**		1.2	0.22
	T-117-SE35-SC-810	8-10	0.65	14	2.2	J	0.18	0.033
T-117-SE-36-SC	T-117-SE36-SC-01	0-1	1.4	168	12	J	1.0	0.18
	T-117-SE36-SC-12	1-2	0.52	19	3.7	U	0.30	0.056
	T-117-SE36-SC-24	2-4	1.2	19	1.6	U	0.13	0.024
	T-117-SE36-SC-46	4-6	0.67	19	2.8	U	0.24	0.044
	T-117-SE36-SC-68	6-8	1.3	19	1.5	U	0.12	0.022
	T-117-SE36-SC-810	8-10	0.38	19	5.0	U	0.42	0.077
T-117-SE-37-SC	T-117-SE37-SC-01	0-1	0.48	3,100	***650***		54	9.9
	T-117-SE37-SC-12	1-2	0.45	19	4.2	U	0.35	0.065
	T-117-SE37-SC-24	2-4	0.16	19	nc	U	0.15	0.019
	T-117-SE37-SC-46	4-6	0.064	20	nc	U	0.15	0.02
	T-117-SE37-SC-68	6-8	0.17	18	nc	J	0.88	0.16
	T-117-SE37-SC-810	8-10	0.13	20	nc	U	0.15	0.020

LOCATION	SAMPLE ID	DEPTH BELOW MUDLINE (ft)	TOC %	TOTAL PCBS (µg/kg dw)	TOTAL PCBS (mg/kg-OC)	Q	SQS EF	CSL EF
T-117-SE-42-SC	T-117-SE42-SC-01	0-1	1.3[b]	470	**36**		3.0	0.56
	T-117-SE42-SC-12	1-2	1.6	47	2.9		0.24	0.045
	T-117-SE42-SC-24	2-4	1.4	20	1.4	U	0.12	0.022
	T-117-SE42-SC-46	4-6	0.99	19	1.9	U	0.16	0.030
	T-117-SE42-SC-68	6-8	0.53	20	3.8	U	0.31	0.058
	T-117-SE51-SC-68 [a]	6-8	0.53	20	3.8	U	0.31	0.058
	T-117-SE42-SC-810	8-10	0.49	19	3.9	U	0.32	0.060
T-117-SE-43-SC	T-117-SE43-SC-0-0.3	0-0.3	0.49[b]	310	**63**		5.3	0.97
	T-117-SE43-SC-0.3-1	0.3-1	0.49	20	4.1	U	0.34	0.063
	T-117-SE43-SC-12	1-2	0.25	19	7.6	U	0.63	0.12
	T-117-SE43-SC-24	2-4	0.48	19	4.0	U	0.33	0.061
	T-117-SE43-SC-46	4-6	0.56	20	3.6	U	0.30	0.055
	T-117-SE43-SC-68	6-8	0.65	19	2.9	U	0.24	0.045
	T-117-SE43-SC-810	8-10	0.50	19	3.8	U	0.32	0.058
Supplemental Sampling								
March 2004								
T-117-SE-70-SC	T-117-SE70-SC-0-0.5	0-0.5	2.4	34,000	***1,400***		120	22
	T-117-SE70-SC-0.5-1	0.5-1	2.0	11,000	***550***		46	8.5
	T-117-SE70-SC-12	1-2	1.9	1,380	***73***		6.1	1.1
T-117-SE-71-SC	T-117-SE71-SC-01	0-1	1.3	730	**56**		4.7	0.86
	T-117-SE71-SC-12	1-2	0.14	19	nc	U	0.15	0.019
	T-117-SE71-SC-2-2.7	2-2.7	0.079	20	nc	U	0.15	0.020
T-117-SE-72-SC	T-117-SE72-SC-01	0-1	2.2[b]	540	**25**		2.0	0.38
	T-117-SE72-SC-12	1-2	1.9	1,410	***74***		6.2	1.1
	T-117-SE72-SC-2-2.4	2-2.4	2.0	2,200	***110***		9.2	1.7
September 2004								
T-117-SE-89-SC	T-117-SE89-SC-02	0-2	2.06[b]	380	**17.1**		1.4	0.26
T-117-SE-91-SC	T-117-SE91-SC-02	0-2	2.51	142	5.7		0.47	0.087
T-117-SE-93-SC	T-117-SE93-SC-02	0-2	2.41	150	6.2		0.52	0.096

SQS – Sediment Quality Standards (12 mg/kg-OC) **bold** indicates SQS exceedance

CSL – Cleanup Screening Level (65 mg/kg-OC) ***bold and italicized*** indicates CSL exceedance

dw – dry weight OC – organic carbon normalized

EF – exceedance factor (concentration in mg/kg-OC/SQS [SQS EF] or CSL [CSL EF])

Q – qualifier: J – estimated value U – undetected

nc – not calculated because %TOC is either ≤0.2 or ≥5.0%. Dry weight concentration compared to AET equivalents of SQS (lowest AET: 130 µg/kg dw) and CSL (second lowest AET: 1,000 µg/kg dw).

[a] Field duplicate

[b] result averaged with laboratory replicates

Archived core samples from locations 17-SC, 21-SC, 25-SC, 31-SC, and 37-SC, located within the proposed removal boundary, were also analyzed for metals and SVOCs. The top samples (0-1 ft) from the cores previously collected from these locations had total PCB concentrations above the CSL, but concentrations in samples collected at lower depths were at or below the SQS. Consequently, the archived samples from the 1-2 or 2-4 ft intervals, depending on the location, were analyzed for metals and SVOCs to determine if the vertical extent of contamination for chemicals other than PCBs is deeper than the top 1-2 ft. At location 17-SC, the total PCB concentration in the 2-4 ft interval (13 mg/kg-OC) was slightly above the SQS, so this interval and the interval below it (4-6 ft) were analyzed for metals and SVOCs. The only exceedance of SQS was in core sample SE-25-SC-24 where acenaphthene was 29 mg/kg-OC (SQS = 16 mg/kg-OC).

2.4.3.2 Soil

PCBs

Table 2-6 summarizes the PCB results compared to SMS for soil samples collected from two drainage ditch locations (DS-1 and DS-2) and fourteen soil boring locations. Soils data were compared to SMS values because soils have the potential to be a source to the sediments. This does not, however, preclude other criteria that are identified in the future as being applicable and important to the overall site-wide source control perspective and in agreement with the SCWG's Source Control Strategy (Ecology 2004). As the RI/FS process for the LDW site progresses, the SCWG and Ecology have the option of implementing additional source control actions as necessary to prevent sediment recontamination at any time prior to, during and after implementation of the early action.

The six soil boring locations included in the initial phase of this investigation (SB-1 to SB-6) were sampled using a hollow-stem auger drill deployed from a drill rig. Each soil boring was divided into six samples at 2.5-ft intervals. Eight additional shallow soil boring samples (SB-7 to SB-14) were collected during a supplemental sampling event to a depth of 1.5 ft and analyzed for PCBs. The PCB concentrations for initial soil samples are shown on Figure 2-10 (see map folio) and the supplemental results shown are on Figure 2-8 (see map folio).

Table 2-6. Total PCBs in soil samples

Location	Sample ID	Depth Below Ground Surface (ft)	TOC %	Total PCBs (µg/kg dw)	Total PCBs (mg/kg-OC)	Q	SQS EF	CSL EF
Initial Sampling December 2003								
T-117-DS-1	T-117-DS1	0-0.5	15	***2,200***	nc	J	17	2.2
	T-117-DS1-D[a]	0-0.5	32	***1,600***	nc	J	12	1.6
T-117-DS-2	T-117-DS2	0-0.5	26	***4,600***	nc		35	4.6
T-117-SB-1	T-117-SB1-01	0-1.5	1.2	85,000	***7,100***		590	110
	T-117-SB1-02	2.5-4	1.6	33,000	***2,100***		180	32
	T-117-SB1-03	5-6.5	3.9	56	1.4		0.12	0.022
	T-117-SB1-04	7.5-9	0.94	2,700	***290***		24	4.5
	T-117-SB1-05	10-11.5	3.5	130	3.7		0.31	0.057
	T-117-SB1-06	12.5-14	0.12	20	nc	U	0.15	0.02
T-117-SB-2	T-117-SB2-01	0-1.5	2.4	150,000	***6,300***		530	97
	T-117-SB2-02	2.5-4	2.5	120,000	***4,800***		400	74
	T-117-SB2-03	5-6.5	0.61	5,600	***920***		77	14
	T-117-SB2-06	12.5-14	0.39	33	8.5		0.71	0.13
T-117-SB-3	T-117-SB3-01	0-1.5	0.84	29,000	***3,500***		290	54
	T-117-SB3-02	2.5-4	0.88	28,000	***3,200***		270	49
	T-117-SB3-03	5-6.5	1.0	6,700	***670***		56	10
	T-117-SB3-04	7.5-9	0.82	5,600	***680***		57	10
	T-117-SB3-05	10-11.5	0.34[b]	19	5.6	U	0.47	0.086
	T-117-SB3-06	12.5-14	0.55	20	3.6	U	0.30	0.055
T-117-SB-4	T-117-SB4-01	0-1.5	0.84	20	2.4	U	0.20	0.037
	T-117-SB4-02	2.5-4	0.28	20	7.1	U	0.59	0.11
	T-117-SB4-03	5-6.5	1.2	4,000	***330***		28	5.1
	T-117-SB4-04	7.5-9	1.1	20	1.8	U	0.15	0.028
	T-117-SB4-05	10-11.5	0.17	16	nc	J	0.12	0.016
	T-117-SB4-06	12.5-14	0.14	20	nc	U	0.15	0.02
T-117-SB-5	T-117-SB5-01	0-1.5	3.0	15,000	***500***		42	7.7
	T-117-SB5-02	2.5-4	0.66	6,800	***1,000***		83	15
	T-117-SB5-03	5-6.5	0.30[b]	18	6.0	J	0.50	0.092
	T-117-SB5-04	7.5-9	0.93	20	2.2	U	0.18	0.034
	T-117-SB5-05	10-11.5	0.54	140	**26**		2.2	0.40
	T-117-SB5-06	12.5-14	0.34	180	**53**		4.4	0.82
T-117-SB-6	T-117-SB6-01	0-1.5	0.52	5,100	***980***		82	15
	T-117-SB6-02	2.5-4	1.3	99	7.6		0.63	0.12
	T-117-SB6-03	5-6.5	0.70	20	2.9	U	0.24	0.045
	T-117-SB6-05	10-11.5	0.56	20	3.6	U	0.30	0.055

LOCATION	SAMPLE ID	DEPTH BELOW GROUND SURFACE (ft)	TOC %	TOTAL PCBS (µg/kg dw)	TOTAL PCBS (mg/kg-OC)	Q	SQS EF	CSL EF
	T-117-SB6-06	12.5-14	0.55	20	3.6	U	0.30	0.055
Supplemental sampling March 2003								
T-117-SB-7	T-117-SB7-01	0-1.5	2.0[b]	200,000	***10,000***	J	830	150
T-117-SB-8	T-117-SB8-01	0-1.5	3.9	15,000	***380***		32	5.9
	T-117-SB15-01[a]	0-1.5	3.0	11,000	***370***		31	5.6
T-117-SB-9	T-117-SB9-01	0-1.5	2.3	100,000	***4,300***	J	360	67
T-117-SB-10	T-117-SB10-01	0-1.5	2.6	100,000	***3,800***	J	320	59
T-117-SB-11	T-117-SB11-01	0-1.5	4.4	70,000	***1,600***	J	130	24
T-117-SB-12	T-117-SB12-01	0-1.5	3.2	37,000	***1,200***		96	18
T-117-SB-13	T-117-SB13-01	0-1.5	2.0	5,000	***250***		21	3.8
T-117-SB-14	T-117-SB14-01	0-1.5	5.2	31,000	nc		240	31

SQS –Sediment Quality Standards (12 mg/kg-OC) **bold** indicates SQS exceedance

CSL – Cleanup Screening Level (65 mg/kg-OC) ***bold and italicized*** indicates CSL exceedance

dw – dry weight

OC – organic carbon normalized

EF – exceedance factor (concentration in mg/kg-OC/SQS [SQS EF] or CSL [CSL EF])

Q – qualifier J – estimated value U – undetected

nc – not calculated because %TOC is either ≤0.2 or ≥5.0%. Dry weight concentration compared to AET equivalents of SQS (lowest AET: 130 µg/kg dw) and CSL (second lowest AET: 1,000 µg/kg dw).

[a] Field duplicate

In boreholes SB-1 through SB-6, PCB concentrations in soils typically exceeded the CSL in the shallower samples (surface to 9 ft deep) with much lower concentrations (<SQS) in deeper soils. Generally, PCB concentrations in SB-1, SB-2, and SB-3 were higher than those observed in SB-4, SB-5, and SB-6 at corresponding depths, indicating a tendency for PCBs to decrease toward the south end of the shoreline bank. At SB-6, for example, only the 0-1.5 ft interval contained PCBs exceeding the CSL. Only relatively shallow soil samples were obtained from the northern portion of the shoreline bank (SB-7 through SB-14). All soil samples from these boreholes contained PCBs at levels exceeding the CSL. Soil samples from the south drainage ditch (DS-1 and DS-2) also exceeded the CSL for PCBs.

Other Analytes

Table 2-7 summarizes the detected exceedances of metals and SVOCs from the two drainage ditch sample locations.

Table 2-7. Detected SVOCs and metals exceeding SMS criteria in ditch samples

Location	Sample ID	Chemical	Result	Unit	SQS	CSL	SQS EF	CSL EF
T-117-DS-1	T-117-DS1	zinc	**454**	mg/kg dw	410	960	1.1	0.47
		benzoic acid	***2,000 J***	µg/kg dw	650	650	3.1	3.1
		benzyl alcohol	***860***	µg/kg dw	57	73	15	12
	T-117-DS1-D[a]	zinc	**430**	mg/kg dw	410	960	1.0	0.45
		benzoic acid	***4,500 J***	µg/kg dw	650	650	6.9	6.9
		benzyl alcohol	***1,000***	µg/kg dw	57	73	18	14
T-117-DS-2	T-117-DS2	benzoic acid	***1,300***	µg/kg dw	650	650	2.0	2.0
		benzyl alcohol	***190***	µg/kg dw	57	73	3.3	2.6

SQS – Sediment Quality Standard

CSL – Cleanup Screening Level

dw – dry weight

EF – exceedance factor (concentration/SQS [SQS EF] or CSL [CSL EF])

J – estimated value

[a] field duplicate

bold indicates SQS exceedance

bold and italicized indicates CSL exceedance

Thirty-three soil boring samples were analyzed for PAHs, with 31 samples having no SQS exceedances. Two soil boring samples, SB-4-03 and SB-3-02, had elevated PAH concentrations above the SQS or CSL criteria (Table 2-8). At both of these locations the sample also exceeded the PCB CSL.

Table 2-8. PAHs in soil borings exceeding SMS criteria

Chemical	Concentration (mg/kg-OC)		SQS	CSL
	T-117-SB4-03[a]	T-117-SB3-02[b]		
Acenaphthene	16	**25**	16	57
Acenaphthylene	***100***	3.0	66	66
Benzo(a)anthracene	**180**	**180**	110	270
Benzo(a)pyrene	***320***	**180**	99	210
Benzo(g,h,i)perylene	***92***	***83***	31	78
Benzofluoranthenes (total-calculated)	***760***	**350**	230	450
Chrysene	**330**	**220**	100	460
Dibenzo(a,h)anthracene	**33**	**32**	12	33
Dibenzofuran	**39**	13	15	58
Fluoranthene	**780**	**440**	160	1,200
Fluorene	**64**	23	23	79
Indeno(1,2,3-cd)pyrene	***100***	**88**	34	88
Phenanthrene	***750***	**280**	100	480
Total HPAH (calculated)	**3,300**	**1,900**	960	5,300
Total LPAH (calculated)	***1,100***	**430**	370	780

SQS – Sediment Quality Standard — **bold** indicates SQS exceedance

CSL – Cleanup Screening Level — ***bold and italicized*** indicates CSL exceedance

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon

OC – organic carbon normalized

EF – exceedance factor (concentration in mg/kg-OC/SQS [SQS EF] or CSL [CSL EF])

[a]- TOC = 1.2%

[b]- TOC = 0.88%

2.4.3.3 Potential upland sources

Catch Basins

Table 2-9 summarizes the PCB results compared to SMS for soil samples collected from four catch basins at T-117 during the initial and supplemental field efforts. An additional soil sample not proposed in the QAPP, identified as CB-5-OUT, was collected from the outside margins around catch basin 5 to evaluate whether soil from outside the catch basin was a source of PCBs to soil within the catch basin. Catch basins 4 and 6 were sampled as part of the supplemental work to evaluate potential off-site sources. Table 2-10 summarizes the detected exceedances of metals and SVOCs from two catch basin locations. Zinc slightly exceeded the SQS in one sample. Silver also exceeded the SQS but is not a sediment contaminant of concern in the LDW. The organic exceedances will be addressed by actions targeting PCBs. Pentachlorophenol exceedances of the SQS and CSL observed in interior catch basin 1 are likely the result of past nearby wood storage at the site (no longer occurring). Storage of wood was limited to a small portion of the paved area and only occurred for a brief period of time.

Since the pentachlorophenol exceedance was an isolated occurrence and has not been detected in any other soil or sediment it does not appear to be an ongoing source.

Soil samples from catch basins 4 and 6 were only analyzed for PCBs. The PCB concentrations for catch basins 1 and 5 (initial sampling) are shown on Figure 2-10 (see map folio), and concentrations for catch basins 4 and 6 (supplemental sampling) are shown on Figure 2-11 (see map folio).

Table 2-9. Total PCBs in catch basin soil samples

Location	Sample ID	TOC %	Total PCBs (µg/kg dw)	Total PCBs (mg/kg-OC)	Q	SQS EF	CSL EF
Catch basin 1	T-117-CB1-SU	5.0	2,600	**52**	J	4.3	0.80
	T-117-CB1-SU-D[a]	4.3	3,000	***70***	J	5.8	1.1
Catch basin 4	T-117-CB4-01	-	**620**	nc		4.8	0.62
	T-117-CB4-02[a]	-	**890**	nc		6.8	0.89
Catch basin 5	T-117-CB5	4.3	50,000	***1,200***		100	18
	T-117-CB5-OUT	4.3	1,400	**33**		2.8	0.51
Catch basin 6	T-117-CB6-SU	-	**140**	nc		1.1	0.14

SQS – (Sediment Quality Standards) 12 mg/kg-OC **bold** indicates SQS exceedance

CSL – (Cleanup Screening Level) 65 mg/kg-OC ***bold and italicized*** indicates CSL exceedance

dw – dry weight

OC –organic carbon normalized

EF – exceedance factor (concentration in mg/kg-OC/SQS [SQS EF] or CSL [CSL EF])

Q – qualifier J – Estimated value

nc – not calculated because no TOC data were collected; dry weight value compared to AET equivalents of SQS (lowest AET: 130 µg/kg dw) and CSL (second lowest AET: 1,000 µg/kg dw).

[a] Field duplicate

Table 2-10. Detected metals and SVOCs exceeding SMS criteria in catch basin soil samples

Location	Sample ID	Chemical	Result	Unit	SQS	CSL	SQS EF	CSL EF
Catch basin 1	T-117-CB1-SU	Butyl benzyl phthalate	**44**	mg/kg-OC	4.9	64	9.0	0.69
		Pentachlorophenol	**480 J**	µg/kg dw	360	690	1.3	0.70
		Silver	***26.9***[a]	mg/kg dw	6.1	6.1	4.4	4.4
	T-117-CB1-SU-D[b]	Butyl benzyl phthalate	**56**	mg/kg-OC	4.9	64	11	0.88
		Pentachlorophenol	***3,500 J***	µg/kg dw	360	690	9.7	5.1
		Silver	***27.6***	mg/kg dw	6.1	6.1	4.5	4.5
Catch basin 5	T-117-CB5	Bis(2-ethylhexyl)phthalate	***280***	mg/kg-OC	47	78	6.0	3.6
	T-117-CB5-OUT	Benzyl alcohol	***87***	µg/kg dw	57	73	1.5	1.2
		Bis(2-ethylhexyl)phthalate	***150***	mg/kg-OC	47	78	3.2	1.9
		Butyl benzyl phthalate	**10**	mg/kg-OC	4.9	64	2.0	0.16
		Zinc	**664**[a] **J**	mg/kg dw	410	960	1.6	0.69

SQS – Sediment Quality Standard

CSL – Cleanup Screening Level

bold indicates SQS exceedance

bold and italicized indicates CSL exceedance

EF – exceedance factor (concentration divided by applicable SQS or CSL)

J – estimated value

[a] Result averaged with laboratory duplicate

[b] Field duplicate

Catch basins 2 and 3 drain directly to catch basin 4 (which subsequently flows to catch basin 5), so sediment in catch basin 4 is presumed to be representative of the inputs from the small upstream basins. The PCB concentrations in catch basin 4 was slightly less than 1 mg/kg dw. An OC-normalized concentration was not calculated because TOC was not analyzed. PCB concentrations in catch basin 1, which discharges directly to the river, ranged from 2.6 to 3.0 mg/kg dw and only slightly exceeded the SQS based on OC-normalized concentrations. Catch basin 6 is located near the northwest corner of the south building, on the shoulder of Dallas Ave S. PCBs were detected at 0.14 mg/kg dw. All catch basins (excluding small interconnecting culverts between catch basins 3, 4, and 5) at T-117 were cleaned after the samples were analyzed and the data validated. All culverts and catch basins on T-117 will be thoroughly cleaned prior to initiation of the removal action as part of the upland source control measures.

Groundwater and Seep Water

Groundwater samples were collected from four monitoring wells (MW-2, MW-4, MW-5, and MW-6) in January 2004. These monitoring wells are immediately adjacent to the shoreline bank (Figure 2-6). No NAPL was observed in the well water during the development, at the initiation and termination of the tidal study, or during purging. No PCBs, PAHs, or other chemicals were detected in monitoring well groundwater samples. Additional NAPL measurements were conducted on August 15, 2004, and no product was observed. Previous site-specific groundwater studies (Windward et al. 2003b) and monitoring results to date for the wells adjacent to the shoreline indicate:

- The net discharge of tidally-influenced groundwater beneath the site is toward the river from the upland area
- Groundwater in the vicinity of the shoreline does not contain any contaminants of concern or indicate any source-related problems
- Groundwater discharge from the upland area of T-117 to the LDW appears not to be a source of contaminants of concern to the sediment

Two additional monitoring wells (MW-7 and MW-8) were installed in June 2005 at the north end of the site to augment the shoreline monitoring well network in accordance with the addendum to the QAPP (Windward et al. 2005c). Groundwater samples were obtained from the six shoreline monitoring wells during a receding tide and submitted for analysis of total PCBs, TOC, and total suspended solids. All wells at T-117, including the inland well MW-3, were checked for the presence of NAPL during and after a high tide event. The analytical results are pending and will be provided to EPA in a separate technical memorandum.

These findings and pending results will be re-evaluated after completion of the early action by an additional round of monitoring in wells to be re-established as feasible upgradient of the removal area. Monitoring results will be used in evaluating the need for additional monitoring and/or source control measures in conjunction with the SCWG and/or as part of post construction monitoring.

Water samples were collected from three seeps along the shoreline. One difference between seep and groundwater samples is that seep samples can also include surface sediment that is eroded by the seepage force of the water. Seep water may also contain contaminants from the river introduced into the nearshore groundwater by recharge during high tide. Results of the chemical analysis of seep water are presented in Table 2-11. Both total and dissolved metals data were developed from seep samples, but only the total metals data are shown because of quality control concerns associated with the relatively long period of time that elapsed before samples analyzed for dissolved metals were filtered. No separate-phase product or product sheens were observed in the seep water.

The original total PCB result from an uncentrifuged sample from seep 3 (SW-3) was detected at 0.94 J µg/L. It was possible that PCBs detected at SW-3 were associated with contaminated solids present in the shoreline where the seep sample was obtained. SW-3 was resampled to determine whether the detected PCBs were associated with suspended solids in the water sample. The sample was centrifuged before analysis as set forth in the QAPP (Windward et al. 2003a) and as described in the field sampling, cruise and data report (Windward et al. 2005a). PCBs were not detected (detection limit was 0.033 µg/L) in the water sample following centrifugation. A low estimated concentration of bis(2-ethylhexyl)phthalate was detected in one sample from seep 2 and low levels of chromium and copper were detected in samples from seep 2 and 3. Seep monitoring data to date indicate that seep discharges from the T-117 upland to the LDW do not appear to be a current source of potential recontamination for contaminants of concern to the sediment. Based on the results of the 2005 groundwater sampling program, an additional round of seep sampling may be conducted before final design of the removal action to further evaluate these findings as part of the SCWG's longer–term measures under the T-117 Action Plan (Ecology 2005) and/or as part of post construction monitoring.

Table 2-11. Chemicals detected in seep water samples

LOCATION	SAMPLE ID	CHEMICAL	RESULT	UNIT
T-117-SW-1	T-117-SW1	copper (total)	0.003 [a]	mg/L
		zinc (total)	0.007	mg/L
T-117-SW-2	T-117-SW2	bis(2-ethylhexyl)phthalate	2.7 J	µg/L
		chromium (total)	0.006	mg/L
		copper (total)	0.002	mg/L
	T-117-SW4 [b]	bis(2-ethylhexyl)phthalate	15 J	µg/L
		chromium (total)	0.006	mg/L
		copper (total)	0.003	mg/L
T-117-SW-3	T-117-SW3	chromium (total)	0.007	mg/L
		copper (total)	0.004	mg/L
		total PCBs (non-centrifuged) [c]	0.94 J	µg/L
		total PCBs (centrifuged) [cd]	0.033 U	µg/L

J – estimated value

[a] Result averaged with laboratory duplicate

[b] Field duplicate

[c] Based on detection of Aroclor 1260

[d] Non-detected result presented for T-117 SW-3 centrifuged sample

2.4.3.4 Roadway soil samples

Six soil samples were collected from the roadway near the south entrance of T-117. This work was performed to further evaluate the area as a possible source of the elevated soil PCB concentrations observed in and around catch basin 5. Concentrations of total PCBs observed in the samples were significantly less than the 50,000 µg/kg dw observed in catch basin 5. The soils in the roadway do not appear to be a potential source of PCBs to the sediments. The results are presented in Table 2-12 and shown on Figure 2-11 (see map folio).

Table 2-12. Total PCBs in roadway soil samples

LOCATION	SAMPLE ID	TOTAL PCBS (µg/kg dw)
T-117-RW-01	T-117-RW-01-01	380
T-117-RW-02	T-117-RW-02-01	630
	T-117-RW-02-02[a]	660
T-117-RW-03	T-117-RW-03-01	620
T-117-RW-04	T-117-RW-04-01	330
T-117-RW-05	T-117-RW-05-01	520
T-117-RW-06	T-117-RW-06-01	320

dw – dry weight

[a] Field duplicate

2.4.4 Potential upland sources from other investigations

Environmental data for potential upland sources have been obtained by the Port and City and through other investigations. Sampled upgradient features and locations include:

- T-117 interior monitoring well 3
- T-117 utility corridor and south building planter soil
- Former Basin Oil facility and monitoring well 1
- Upland street dust and road right–of–way sampling
- Neighborhood yard sampling

2.4.4.1 T-117 interior monitoring well 3

The original monitoring well at this location was installed by Ecology in May 1991 to monitor former contaminant sources associated with the Malarkey operations. This included a partially buried railcar tank in the immediate vicinity of the original well, which was used as an oil-water separator and removed by Malarkey before vacating the site. During initial sampling of MW-03 in 1991, Ecology observed approximately 1/8 in. of floating product in the well, and noted that there was insufficient volume to provide a sample (Parametrix 1991). Subsequent sampling of MW-03 and other monitoring wells in 1994 did not detect the presence of floating product (URS 1994). The surrounding area was subsequently excavated during the PCB-removal action in 1999, and the original monitoring well at this location was replaced with MW-03 (Figure 2-6, see map folio), a well of identical construction, after the removal area was backfilled and paved. NAPL has not been detected in the reconstructed MW-03.

Because the groundwater sampling event in May 2003 preceded the T-117 early action investigation, it was not subject to the same quality control and data validation standards established in the T-117 QAPP (Windward et al. 2003a). Nevertheless, the results do provide some indication of the nature of groundwater contaminants encountered at this particular location within T-117.

A groundwater sample was obtained from MW-03 using low-flow micropurge methods during a one-time sampling event by the Port in May 2003 (Onsite 2003). The following analyses were performed for total petroleum hydrocarbons (TPH; gasoline and diesel ranges); benzene, toluene, ethylbenzene and xylene (BTEX); PAHs; and PCBs.

No NAPL was observed in the well at the time of sampling, and detected contaminants included diesel–range TPH (0.70mg/L), lube oil-range TPH (1.4 mg/L), xylene (1.4 µg/L), and six PAHs ranging from 0.013 to 1.6 µg/L. PCBs (undetected at 0.049 µg/L for each Aroclor), gasoline-range TPH, benzene, toluene and ethylbenzene were not detected. Based on location and contaminant level, this data does not indicate a groundwater source concern for TPH and PAHs to the LDW.

None of these contaminants were detected in water from downgradient wells and seeps (centrifuged samples) along the shoreline (Section 2.4.3.3).

2.4.4.2 T-117 utility corridor and south building planter soil sampling

Structurally unsuitable fill materials, debris, and waste were removed by the Port from approximately 150 ft of a narrow, shallow, concrete-lined below-grade utility corridor at T-117 in September 2004 (Windward and Onsite 2004). The corridor extends north-northeast from north side of the south building at the terminal (Figure 2-12, map folio).The work was conducted to prevent further settling of the pavement surface immediately above the corridor and to stem the extrusions of undesirable black, sticky asphalt material appearing at several locations along the alignment. These extrusions occurred when heavy truck traffic (high surface loading) during warm weather caused soft asphalt to extrude up through the pavement asphalt in the traffic areas. There was concern that this material, together with PAHs and oil, could be tracked and spread by vehicles or come into contact with stormwater.

Contaminants, including PCBs and PAHs, are known to have been associated with former tenant operations. Four composite samples of soil excavated from the corridor were therefore submitted for analysis of these contaminants and for the toxicity characteristic leaching procedure (TCLP) for metals. The purpose of the sampling was to obtain necessary profiling information for waste disposal. Total PCB concentrations detected in the four samples were 3.6, 2.3, 2.8, and 8.1 mg/kg dw. PAH concentrations and TCLP results were below those requiring the soil to be designated as hazardous waste. TPH concentrations (primarily heavy-end lube-oil hydrocarbons) ranged from 7,600 mg/kg dw in the soil removed from the north portion of the corridor to 19,000 mg/kg dw in soil from the south portion of the corridor.

Two narrow planter areas along the north side of the south metal-frame building at T-117 were noted by Ecology in 2004 as a potential source of erodible soil in close proximity to stormwater flowing toward catch basin 5. Four surface soil grab samples were collected from the alignment and analyzed for PCBs, resulting in measured concentrations of 0.22, 0.26, 0.07, and 0.03(J) mg/kg dw. The east planter, level with the pavement, was subsequently paved by SPU. The west planter, elevated from pavement and enclosed by a concrete rim, is covered with pea gravel.

2.4.4.3 Former Basin Oil facility and monitoring well 1

Ecology obtained two samples of soil/sludge from two locations in the interior of the Basin Oil facility in July 2004 prior to facility demolition. One grab sample (CB41) was obtained from a settling basin in the east end of the oil-water separator that formerly discharged onto Dallas Ave S. The detected total PCB concentration was 350 µg/kg dw or 2.59 mg/kg-OC. Another grab sample (CB42) obtained from a drain in the southwest containment area, contained a total PCB concentration of 140 µg/kg dw or 2.42 mg/kg-OC (Cargill 2004a). The sampled materials also exceeded the SQS criteria for arsenic (98 and 248 mg/kg), zinc (711 and 830 mg/kg), and bis(2-ethylhexyl)phthalate (622 and 708 mg/kg-OC). Ecology currently has no plans to conduct additional sampling on the Basin Oil parcels, although the agency has indicated it intends to formally list the site as a location of interest due to its active or potential impact upon the environment.

No NAPL or detectable groundwater contaminants were observed in monitoring well 1 (MW-01) during a one-time sampling event by the Port in May 2003 (Onsite 2003). Analyses were performed on groundwater samples obtained using low-flow micropurge techniques for the following analytes: TPH (gasoline and diesel ranges), BTEX, PAHs, and PCBs. None of the analytes were detected at or above the detection limits specified in the report.

The results of sampling events for MW-01 from 1991 to 2003 are summarized in the data summary report (Windward et al. 2003b). Groundwater sampling during Ecology's 1991 site hazard assessment (Parametrix 1991) and subsequent 1994 site inspection (URS 1994) detected 1.8 µg/L and 1.2 µg/L (value qualified as "an estimate") PCBs, respectively, in MW-01, although it's not clear whether low-flow purge techniques were used or whether the PCBs may have been associated with contaminated silt in the surrounding formation of the newly installed well.

2.4.4.4 Upland street dust and road right-of-way sampling

Surface soil sampling locations for street dust samples obtained by SPU in July through December 2004 are shown in Figure 2-13. Results have been validated and are available, together with a map of sampling locations, on the SPU internet site: www.seattle.gov/util/southpark. Results indicate that concentrations of PCBs exceeding the state Model Toxics Control Act soil cleanup level for unrestricted use (1 mg/kg PCBs) were detected in a number of the street dust, catch basin and roadway samples. In December 2004, the City implemented extensive interim source control measures and is now working with the EPA and Ecology to develop longer-term solutions. Interim measures included removing contaminated soil from roadway shoulders and replacing with clean gravel along Dallas Ave S; grading and paving the 17th Ave S, S Donovan St, and Dallas Ave S roadways; and installing a temporary stormwater collection and treatment system to control stormwater runoff from the newly paved roadways.

For up-to-date information on additional work in the T-117 neighborhood by the City and concerned agencies please check the above-mentioned internet address.

2.4.4.5 Neighborhood yard sampling

As above, soil sampling in residential yards adjacent to contaminated street areas identified by SPU was performed by the King County Department of Public Health and Ecology, and results are also listed and mapped on the SPU-sponsored internet site. Results for samples from yards abutting S Cloverdale St, S Donovan St, and 17^{th} Ave S indicated PCB concentrations ranging from non-detect to 46 mg/kg dw. Of thirty six samples collected in residential yard areas, only four exceeded the state cleanup level. The City is working with King County Department of Public Health and Ecology to develop a plan to clean up PCBs in the 2 affected yards. Runoff from these two yards is collected in onsite drainage systems and directed to the City combined sewer.

2.5 STREAMLINED RISK ASSESSMENT

As described in the EE/CA guidance (EPA 1993), a streamlined risk assessment is intermediate in scope between the limited risk assessment conducted for emergency removal actions and the conventional baseline assessment normally conducted for removal actions. The purpose of a streamlined risk assessment is to justify taking a removal action and to identify current or potential exposure pathways which should be prevented.

A protective approach was used in this streamlined risk assessment, which relied, in part, on the results of the Phase 1 ecological and human health risk assessments that have been completed for the LDW (Windward 2003a). The final LDW risk assessments will include all sediments outside of the T-117 removal area.

Consistent with EE/CA guidance, this streamlined risk assessment identifies the potential for risk if no removal action is taken which will assist in the removal action decisions by addressing the exposures. The streamlined risk assessment will focus on the human health risk and on the ecological risk to benthic communities associated with elevated PCB concentrations in the removal area.

2.5.1 Exposure pathways

The risk assessment presented in this document is designed to identify risk from potential exposure pathways if no action is taken within the proposed removal boundary. An exposure pathway is considered complete if a chemical can travel from a source to a human or ecological receptor and is available to the receptor via one or more exposure routes (EPA 1997a, b). The principal human exposure pathways are characterized in Section 2.2.

The exposure pathways for benthic invertebrates are direct and include ingestion of contaminated sediment, direct contact with contaminated sediment, and contact with porewater associated with contaminated sediment. Exposure pathways for fish, birds, and marine mammals are both direct and indirect. Direct exposure pathways include incidental ingestion of contaminated sediment and direct contact with contaminated sediment. Indirect exposure is primarily through the ingestion of marine organisms.

2.5.2 Risk characterization

2.5.2.1 Ecological risk

Site-wide risks for the LDW were evaluated as part of the LDW Phase 1 RI (Windward 2003a). Site-wide risks from PCBs identified in the Phase 1 ecological risk assessment (ERA) include risks to piscivorous fish and wildlife. Risks to the benthic community were area-specific within the LDW based primarily on a comparison of select chemical concentrations to state promulgated SMS criteria. T-117 was one of the areas identified with potential risk to the benthic community.

While many of these ecological receptors (e.g., fish, birds, mammals) are mobile and could be exposed to PCBs throughout the LDW, benthic communities are composed of small individuals that are largely sessile in comparison to other receptors. While ecological risk to mobile receptors will be conducted in the Phase 2 LDW ERA, risks to benthic organisms specifically associated with T-117 were estimated by comparing sediment concentrations of PCBs and other chemicals to the SMS criteria.

Under the provisions of the SMS, when no detailed bioassay data are available, surface sediments are categorized in one of three ways:

- Sediments with chemical concentrations equal to or less than SQS are designated as having no adverse effects on biological resources (WAC 173-204-301[1][a])
- Sediments with chemical concentrations above the SQS but below the CSL have potential for adverse effects on biological resources
- Sediments with chemical concentrations above the CSL have a greater potential for adverse effects on biological resources requiring evaluation of cleanup alternatives

Risks to the benthic community were assessed by comparing sediment chemical concentrations to the SMS. This streamlined risk assessment estimates risks associated with accepting the no-action alternative and not conducting the NTCRA within the removal boundary. In the absence of bioassay data, results of chemical analyses of sediment were used to estimate risks associated with the no-action alternative.

2.5.2.2 Risk characterization using sediment chemistry

Sediment chemistry data described in Section 2.4.1 were compared to SMS SQS and CSL values. Table 2-2 presents PCB results in surface sediment compared to SQS and CSL standards. Figures 2-5 and 2-7 (see map folio) show the distribution of total PCBs that exceeded SMS in surface sediment. Detected SQS and CSL exceedances were predominantly associated with PCBs.

PAHs were the only other detected analytes to exceed SQS and CSL; only two of the 14 surface sediment samples exceeded the applicable SQS and CSL for PAHs (Table 2-3). These two samples also exceed the CSL for PCBs.

Table 2-4 presents the subsurface PCB results compared to SQS and CSL. Figures 2-8 and 2-9 (see map folio) show the PCB concentrations in subsurface sediment. With the exception of one acenaphthene result above the SQS, total PCBs were the only detected exceedance of SQS or CSL.

Overall, SMS were exceeded primarily for PCBs, with several samples having concentrations greater than 10 times their respective SQS or CSL. PCB concentrations within the proposed removal boundary indicate that these sediments may pose a risk to benthic community health.

2.5.2.3 Human health risk

Overview of the Phase 1 LDW HHRA applicable to T-117

This section briefly describes the site-wide human health risks associated with sediment contamination in the LDW, as previously summarized in the Phase 1 HHRA for the LDW Superfund Site (Windward 2003a). The Phase 1 HHRA established that humans could be exposed to chemicals found in LDW sediments, estimated the potential extent of such exposures, and grouped exposure pathways into exposure scenarios. The primary exposure scenarios identified were direct contact with sediments during commercial netfishing or beach play in the LDW and consumption of seafood from the LDW. These scenarios were determined to be the most applicable to areas within the LDW, including T-117, based on data from a variety of sources: the Muckleshoot and Suquamish Tribes, thorough review of prior risk assessments conducted in the LDW and Harbor Island, and thorough review of other relevant reports and studies conducted in the vicinity of the LDW, including a study of seafood consumption habits of Asian and Pacific Islanders. Some of these scenarios are unlikely to apply to the T-117 EAA since access is limited by a fence and locked gate surrounding the upland property and a steep riprap and overgrown shoreline bank. The Human Access Survey Results (Windward 2005c) conducted as part of the LDW RI also noted that shoreline access was difficult and no human use was identified.

Quantitative risk estimates for swimming were taken from an analysis done by King County (King County 1999). Swimming risks were in the 1 in a million range and were two orders of magnitude lower than risks posed by seafood consumption. Surveys of beaches for clams and clam harvest per unit effort exercised indicated that harvestable numbers of clams are present in the LDW. The LDW phase 1 RI risk assessment (Windward 2003a) did not examine direct contact exposure for individuals engaged in clam harvest, but this will be done in the LDW phase 2 RI risk assessment. A clam reconnaissance survey identified the intertidal habitat in the vicinity of T-117 as high quality clam habitat, though clam densities in the vicinity of T-117 were generally lower relative to other beaches surveyed.

Consistent with EPA risk assessment guidance, reasonable maximum exposure estimates were calculated in the Phase 1 HHRA for all exposure scenarios to avoid underestimating risks. Consequently, risk estimates may be overestimated for many individuals.

Once the exposure scenarios were selected, chemical concentrations in samples from surface sediments and in fish and shellfish tissue were screened by comparing the maximum detected concentration, or the maximum detection limit for chemicals that were not detected, to risk-based concentrations. Using this screening procedure, PCBs were identified as a chemical of potential concern for multiple scenarios, as discussed below.

- Estimated cancer risks in the LDW were found to be highest for the seafood consumption scenario. For PCBs the risk was 4 in 10,000 using a high-end seafood consumption rate[4] of approximately 68 pounds per year (11 meals per month) and assumed exposure duration of 55 years.
- Cancer risks for the netfishing scenario and the beach play scenario for the LDW site were much lower—less than 1 in 100,000. In an evaluation of noncancer risks, only the tribal seafood consumption scenario for PCBs had a hazard quotient greater than 1. These results indicate some potential for adverse effects other than cancer associated with seafood consumption.
- PCBs were identified as chemicals of concern (having a cancer risk estimate greater than 1 in 1,000,000 or a hazard quotient greater than 1) for one or more scenarios.

These findings do not constitute a definitive characterization of human health risks, nor are they specific to T-117. There are many uncertainties associated with the estimates for each exposure scenario. Many of the uncertainties may be reduced by the ongoing data collection and analysis currently underway for the Phase 2 HHRA. These uncertainties would still not change the importance of PCBs in risk estimates for T-117 and the LDW as a whole. Quantitative risk estimates will be made for both baseline and residual risk assessment for the LDW site as part of the Phase 2 LDW HHRA.

Consideration of Human Health Concerns at T-117

At T-117, the maximum surface sediment concentration of each contaminant analyzed for was compared, by EPA with available sediment screening concentrations protective of direct sediment contact for individuals engaged in net fishing or beach play activities. These screening concentrations were derived as part of the Phase I human health risk assessment for the LDW Superfund cleanup process. Evaluation of the results indicated that PCBs are the primary risk driver from a human health perspective for these two exposure pathways. Consideration of PCB exposure via bioaccumulation further suggests that PCBs are the main risk driver that should be addressed by early removal

[4] This consumption rate does not include salmon which do not accumulate appreciable amounts of PCBs from the LDW

action. Removal of PCB contaminated sediments will eliminate risk issues associated with direct sediment contact with the sediments, and will help reduce PCB exposure by bioaccumulation in the LDW.

2.5.2.4 Summary and conclusions

The streamlined ecological risk assessment compared sediment concentrations to SMS. Sediment chemical concentrations above the SQS and CSL have been measured in the removal area, primarily total PCBs in surface and subsurface sediment and bank soil.

The sediment chemistry results demonstrate that sediment in this area may potentially have adverse effects on benthic organisms. Furthermore, the removal action is supported by the qualitative HHRA, which established that this action will indirectly reduce exposure to humans by removing sediment containing bioaccumulative chemicals that are found in seafood. Specifically, the removal will remove a substantial mass of PCBs from the LDW, and will eliminate the exposure pathway to any remaining PCBs in sediments within the removal area.

2.6 UPLAND SOURCE CONTROL

The Port and City have identified and are working to control potential sources of sediment contaminants from upland areas under their control (i.e., T-117 and nearby roadway areas). As members of the SCWG, the Port and City are also encouraging the development of plans to identify and control potential sources of pollution to offshore sediment from other properties not under their direct control (i.e. Basin Oil). Investigations and source control actions will be sufficiently complete before implementing the selected early action alternative, to help prevent recontamination of LDW sediment. This approach is consistent with the source control strategy developed for the Lower Duwamish Waterway (Ecology 2004).

2.6.1 Existing and potential pathways of concern

Potential contaminant migration pathways from upland areas in the vicinity of T-117 to the nearby aquatic environment were initially discussed in the *Summary of Existing Information and Data Needs Analysis* (Windward et al. 2003b). The primary pathways of concern for the T-117 EAA are:

- Erosion of contaminated soil from the unpaved shoreline banks into the LDW
- Surface transport of contaminants from upland sources via stormwater runoff

Elevated concentrations of PCBs recently observed in the upland drainage sediment and soil highlight the need to control or remove these sources and prevent them from entering catch basins and drain lines. The T-117 site investigation results (Windward et al. 2004e) have demonstrated that groundwater discharge and seeps are not generally pathways of significant concern for release of PCBs to the LDW.

2.6.2 Activities to evaluate, control, and eliminate pathways and sources

Source control activities undertaken by the Port and City for the T-117 EAA include investigations or improvements within the T-117 upland areas, as well as the Dallas Ave S, S Donovan St, and 17th Ave S roadways. Evaluation of source control needs associated with the Basin Oil facility will be set forth in the SCWG T-117 Action Plan. Completed or anticipated source control measures associated with each of these areas are described below.

2.6.2.1 Terminal 117 upland area

Soil

PCBs are the primary soil contaminant of concern at T-117 and were detected in surface and subsurface soil during several investigations in the 1990's. A CERCLA removal emergency removal action was conducted in 1999 (Onsite 2000) under an agreement with EPA to remove the PCB contaminated soil when the Port took over the property from Malarkey. The removal area and other exposed soil areas within T-117 were capped with asphalt.

More recently completed measures designed to enhance source control at the terminal include the following:

- 2004 Utility Corridor Cleanout: TPH-contaminated soil and debris were removed from the subsurface utility corridor (Windward and Onsite 2004).
- 2004 Paving of South Building Planter: In conjunction with its source control work in the roadways adjacent to T117, the City paved the formerly exposed east planter area along the north side of the south metal building.

In general, soil upgradient of the removal area containing PCB in concentrations greater than the CSL has been removed or capped to prevent contact and erosion by stormwater runoff. Prior to the PCB soil removal and capping action in the nearshore area by the Port and the City in 1999, only portions of the upland area (including the former Malarkey plant area) were covered by pavement and concrete foundations. Following completion of the PCB soil removal action and acquisition of the Malarkey parcels, the Port applied an asphalt pavement overlay to most of the remaining exposed soil areas at the facility. Both narrow planter strips along the north side of the south building will eventually be paved, providing complete coverage for the upland T-117 area.

Stormwater

Catch basins and associated drain lines at T-117 are shown in Figure 2-14. Historically, runoff from the Basin Oil property and portions of Dallas Ave S and S Donovan St flowed onto T-117 and entered the onsite drainage system at catch basins 5 and 6. Interim source control actions completed by the City in December 2004 eliminated run-on from adjacent roadways to T-117 and isolated PCB-contaminated soil in the right-of-way with asphalt paving (see following section). Currently, only runoff from the T-117 property or treated runoff from the adjacent roadways enters on the onsite drainage system.

Catch basins 5 and 6 and the connecting drain line were recently cleaned (vactored and jetted) in December 2004 as part of the City's interim cleanup project in the Dallas Ave S, S Donovan St, and 17th Ave S rights-of-way. Catch basin 5 and the contributing drainage network will be cleaned again as part of the scheduled removal action, if necessary, and catch basin 5 will be removed and replaced with a structure better suited for retaining sediment and periodic cleaning. Prior to replacing the catch basin, all other (upgradient) catch basins on T-117 and their connecting culverts (typically 4-in. polyvinyl chloride pipe) will be thoroughly cleaned and all catch basins not having inverted outlets to trap floatable materials will be so equipped. Outfalls to the Duwamish River (from catch basins 1 and 5) will be temporarily blocked during this work to make sure no materials are discharged during cleaning. All catch basins, connecting culverts and outfalls will be cleaned again after the NTCRA is complete to make sure any material that may have entered the drainage systems during construction is removed. This will help prevent accidental reintroduction of removed bank material to sediments via stormwater.

2.6.2.2 Dallas Ave S, S Donovan St, and 17th Ave S

Approximately 1.3 ac of public right-of-way (portions of Dallas Ave S, S Donovan St, and 17th Ave S) drain to the T-117 EAA (see Figure 2-14). Street dirt and catch basin 4 and 6 soil samples collected by the Port near the south entrance to T-117 did not contain PCB concentrations in excess of the CSL (Tables 2-9 and 2-12). However, subsequent sampling conducted by the City found elevated concentrations of PCBs (Aroclor 1260) in the street dirt and underlying soil in some roadway areas. Concentrations in street dirt were as high as 9.2 mg/kg PCB dw (found in a catch basin located on 17th Ave S). Soil beneath the roadway contained as much as 66 mg/kg PCB dw. Soil collected from the public right-of-way immediately adjacent to the roadway contained up to 93 mg/kg PCB dw (City of Seattle 2004).

Soil

In November-December 2004, the City completed a source control action to limit the exposure of nearby residents to the PCBs present in the public right-of-way. The work included the following items:

- Removing contaminated soil and placing clean gravel on the roadway shoulders along Dallas Ave S and 17th Ave S
- Grading and paving S Donovan St between Dallas Ave S and 17th Ave S, 17th Ave S between S Donovan St and Dallas Ave S, and Dallas Ave S between 17th Ave S and S Donovan St

Stormwater

Source control actions implemented by the City in November-December 2004 for stormwater included installation of a temporary stormwater collection and treatment system. The system collects runoff from the public right-of-way and the Basin Oil property and routes it to a temporary treatment plant located on the south side of S Donovan St. Runoff is treated in the plant via sedimentation (clarifier and storage tanks) and sand, bag, and carbon filters prior to controlled discharge to the combined sewer on S Donovan St. The City has obtained a discharge authorization from King County Industrial Waste to allow discharge to the sewer and is currently testing all stormwater prior to discharge. PCBs were not detected (at 0.1 µg/L) in the first sample collected from the treatment system. Because of capacity problems in the local sewer system, the City has also obtained permission from the Port to discharge treated runoff to catch basin 6 located at the south entrance to T-117 under emergency conditions (i.e., if existing system capacity is exceeded).

2.6.2.3 Basin Oil facility

Information regarding the former operations at the Basin Oil facility was presented in the Task 1 report (Windward et al. 2003b). The site has recently undergone significant modification as a result of the demolition and removal of much of the facility's equipment and structures. Ecology intends to add the Basin Oil site to the confirmed and suspected hazardous site list in 2005 due to the presence of PCBs in subsurface soil and petroleum contamination found during a site hazard assessment (Cargill 2004a). Because the site is currently undergoing removal and modification, it will be necessary for the SCWG and Ecology to continue evaluating source control measures that may be required and eventually installed. The property owner is obtaining a City permit for site demolition activities.

Soil

PCBs (24 mg/kg) were found in subsurface soil (Parametrix 1991). Results from soil samples collected at 1-ft depth show low levels of PCBs in the soil, i.e., 0.11 and 1.1 mg/kg PCBs (Creative Environmental Technologies 1996). In addition, elevated TPH concentrations (72,000 and 77,000 mg/kg TPH-diesel; 3,900 and 17,000 mg/kg TPH-oil), sufficiently high to result in sheens, have been detected in samples obtained by Ecology from the plant interior (Cargill 2004b), It remains to be seen how the site will be cleaned up and possibly redeveloped.

Stormwater

The site is surrounded by City roadways (Dallas Ave S, 17th Ave S, and S Donovan St). Site runoff is currently being picked up in the temporary collection and treatment system installed by the City. Discharges from Basin Oil's oil/water separator onto the surface of Dallas Ave S (and subsequently to catch basin 5 at T-117) have been discontinued. In the short term, Ecology expects that oily or contaminated water accumulating or remaining on the site will be managed by the site owner to prevent offsite releases. While some runoff may flow onto the surrounding roadways, it is being temporarily diverted from the T-117 outfalls by the City's drainage improvements described in the previous section. In the long term it is expected that potential contaminant sources at the site will be resolved by the owner, and stormwater from the property can be released to the usual conveyances finally established by the City.

2.6.3 Measures for assuring effectiveness of source control measures

The following measures will be employed to ensure the general effectiveness of source control measures within those upland areas controlled by the Port and City:

- All T-117 pavements will be inspected to verify that they are in good condition and provide sufficient areal coverage to prevent erosion of underlying surface soil
- Any samplable solids accumulated in catch basins 1 and 5 after the final storm drain system cleaning and prior to implementation of the removal action will be sampled for PCBs. These catch basins receive drainage from upgradient catch basins at T-117 and have lines discharging directly to the river. If PCBs are detected above the SQS, additional investigations and measures will be taken as necessary to prevent recontamination.
- Any samplable solids accumulated in the first upgradient sump or catch basin in any to-be-established outfalls for stormwater from the Dallas Avenue vicinity will also be sampled. If PCBs are detected above the SQS, additional measures will be taken to prevent recontamination
- Outfalls and nearby sumps at T-117 will be re-inspected and maintained as necessary after completion of the early action to address any solids that may have accumulated
- Additional groundwater sampling from the monitoring wells to verify that this pathway is not a source of recontamination to the sediment
- EPA and Ecology will evaluate source control actions to ensure that adequate source control is in place in order to minimize the chance for recontamination after cleanup

2.6.4 Coordination with SCWG plans and objectives

The SCWG, which consists of representatives from EPA, Ecology, King County, the City, and the Port, is designing and carrying out source control efforts that focus on Superfund early action areas, including working to control current sources of pollution into the LDW. The group is currently developing a Source Control Action Plan for T-117 and has been coordinating with the T-117 EAA project team. In addition to advising participants on appropriate source control approaches, the group provides broader source control resources for upland soils, stormwater, and groundwater through the corrective action process of RCRA, the Washington Model Toxics Control Act, and other regulations. The group's Action Plan for T-117 will address additional sources as may be associated with neighboring properties and are not under the Port or City's ability to control directly. This involvement helps ensure the T-117 EAA participants that their site-specific approaches are compatible with and similar to those being applied or planned for other action areas within the Duwamish.

2.6.5 Integrating source control elements into the early action alternative

While much of the source control-related activity pertaining to the T-117 EAA will need to occur prior to implementation of the selected EAA alternative, some components will be integrated with the action. Catch basin 5 and surrounding soil are included within the proposed removal area and will be replaced as part of the early action construction work. The shoreline bank area is a significant potential source of contamination to sediment in the offshore mudflat and submerged areas. Removal of high-concentration PCB-contaminated soil from the bank area, together with other components of the recommended action, will eliminate this significant ongoing source. The SCWG and Ecology have the option of implementing additional source control actions as necessary to prevent sediment recontamination at any time prior to, during and after implementation of the early action. Monitoring for recontamination will be implemented as part of the removal action to ensure long-term effectiveness of the remedy.

2.7 PROPOSED REMOVAL BOUNDARY

The proposed boundary defining the T-117 removal area was developed using a weight-of-evidence approach, and is based on 167 PCB concentrations measured in samples collected during recent T-117 sampling, plus historical data. The boundary is configured such that the area outside of the removal area extending to the navigation channel line and up to 300 ft north and south of the boundary will have an average PCB concentration (8.4 mg/kg-OC) and 95% UCL (10.3 mg/kg-OC) below the PCB SQS criteria of 12 mg/kg-OC. Following the removal action, the PCB surface sediment concentration within the removal area will also be below the PCB SQS, because most of the new surface will consist of new material. PCB concentrations above the SQS that are left outside of the removal boundary are not considered for the early action removal based on the following:

1. PCB concentrations outside of the removal area are similar to what are found throughout the rest of the LDW (i.e. removal below concentrations in the immediate vicinity is impractical due to recontamination)
2. The purpose of this early action cleanup is to achieve maximum risk reduction by removing the highest surface sediment concentrations. These higher concentrations are identified within the T-117 cleanup boundary
3. Sediments outside of the removal area will be evaluated as part of the LDW RI/FS

The proposed removal boundary is presented in Figure 2-15 (see map folio), encompassing an area of 1.9 acres. The T-117 boundary technical memorandum

(Appendix A) discusses the rationale and justification for the delineation of the proposed removal boundary.

3.0 Identification of Removal Action Scope, Goals, and Objectives

3.1 Removal Action Scope

The following is a summary of primary project elements and site characteristics that have been considered in the development of the removal action scope.

- The T-117 site has been identified as one of seven candidate early action areas within the LDW Superfund Site. The purpose of the early action is to remove contamination that may be contributing to elevated chemistry of target compounds in the LDW. Once the early actions are completed, the remaining areas of the LDW will be evaluated and remediated under EPA's Superfund program.
- The primary chemicals of concern identified for the T-117 removal action are PCBs, which are found in site upland, bank, and shoreline soils and aquatic sediments.
- Asphalt tar, creosote-treated timbers and piles, and other debris of concern are present along the T-117 shoreline.
- The proposed removal boundary presented in Figure 3-1 (see map folio) of this EE/CA establishes the outer limit of the T-117 removal action.
- The general upland limit of the removal area boundary is shown in Figure 3-1 (map folio) and will be adjusted inland as necessary based on the results of the June 2005 supplemental upland subsurface soil sampling (Windward et al. 2005c). In the south ditch, the south shoreline area, the vicinity of catch basin 5, and the north shoreline area, soil removal will be sufficient to provide a buffer between the final cap structure and upland soils. Soil removal adjacent to the 1999 PCB soil removal area will be limited by the location of the clean 1999 quarry-spall backfill, which corresponds to the present edge of pavement. Where necessary, pavement and shallow backfill inboard of the pavement edge will be removed to facilitate a proper working slope for deeper soil removal. The Port and the City will continue consultation with EPA and Ecology, during the design phase, regarding specific localized areas for additional high PCB soil removal. This removal may include soil beneath the existing asphalt cap where appropriate and necessary.
- The final design will be adjusted so that any PCBs left in the bank will be below the TSCA(50 mg/kg dw) criteria requiring disposal in a hazardous substance landfill.

- The historical and recent sediment sampling data show a spatial trend of PCB concentrations that decrease from the bank out toward the navigation channel. Sediment samples with PCB concentrations above the PCB CSL (65 mg/kg-OC) are found within 100 ft of the top of the bank.
- The highest observed concentrations of PCBs within the removal area are found adjacent to the shoreline within the upper 1-5 ft of surface soils in the central and northern end of the property. PCB concentrations in upland/bank soils are as high as 10,000 mg/kg-OC, with a median of approximately 1,200 mg/kg-OC.
- The PCBs in the upland and bank soils within the removal area, if left unaddressed, have the potential to erode into the LDW and adversely impact waterway sediments.
- Intermediate concentrations of PCBs, as high as 2,500 mg/kg-OC with a median of approximately 130 mg/kg-OC, are found in deeper soils along the shoreline and in shallow intertidal surface sediments (above elevation 0 ft MLLW).
- Lower concentrations of PCBs, as high as 250 mg/kg-OC with a median of approximately 30 mg/kg-OC, are found deeper than the 0 ft MLLW contour, with concentrations tending to decrease moving away from the shoreline.
- Within the removal area, the layer of PCB-containing sediment is generally 1-3 ft thick with the exception of the area deeper than the 0 ft MLLW contour in the central portion of the site (Transects 1 & 2), where the impacted sediment extends 4 ft below mudline.
- Site studies (Windward et al. 2005a) have shown that the groundwater at the T-117 EAA does not contain measurable concentrations of PCBs. Groundwater from T-117 is not considered a significant pathway for the release of PCBs to the LDW.
- Independent of the T-117 early action, the South Park Marina has proposed maintenance dredging to an elevation of -8.0 ft MLLW, with a 1 ft overdredge (creating a 5 ft dredge cut) to limit the grounding of vessels at the facility. The marina proposes to dredge approximately 15,500 cubic yards (cy) from the mooring area. As part of the EE/CA, the South Park Marina maintenance dredging sediment adjacent to the T-117 EEA was tested and the removal boundary was adjusted to include maintenance material not suitable for open-water disposal. The T-117 EAA dredging will completed before the marina dredging project, while at the same time coordinating the removal action with the Marina to limit the disruption to the degree reasonably possible. With such coordination it is possible that the maintenance dredging may closely follow the T-117 removal action.
- Six species reported in the LDW are listed under the federal ESA as candidate species, threatened species, or species of concern (Table 2-1). Of these, chinook salmon, coho salmon, bull trout, and bald eagle, may use the LDW on more than

an incidental basis. The T-117 early action will be implemented according to the constraints set forth by the ESA process, with a goal of no net loss of habitat acreage.

The removal area is defined by the proposed removal boundary line shown on Figure 3-1 (see map folio). It includes the upland unpaved area adjacent the shoreline, the bank extending down to the waterway and intertidal to shallow subtidal sediment areas.

3.2 REMOVAL ACTION GOALS AND OBJECTIVES

The goal of the NTCRA at T-117 is to significantly reduce exposure of ecological and human receptors to sediment contamination and thereby reduce or eliminate adverse effects on biological resources in the removal area. The removal action will reduce potential risks to human health by removing or isolating bioaccumulative chemicals that are found in sediment or are sources to the sediment. Human health risks for the entire LDW will ultimately be addressed in the Record of Decision, which will establish human health-based cleanup levels.

More specifically, the following remedial action objectives (RAOs) were developed for the T-117 removal area as a means of meeting the stated goal:

- Reduce the concentrations of contaminants in surface sediment (biological active zone, 0-10 cm) within the removal area boundary to below the SQS for PCBs (12 mg/kg OC).
- Ensure that any remaining bank contamination at T-117 will not be released into the waterway and result in exposure to human and ecological receptors above protective levels by removal and capping of PCB contaminated soils.

The National Contingency Plan (40 CFR 300.415C) states that removal actions shall, to the extent practicable, contribute to the efficient performance of any anticipated long-term remedial action with respect to the release concerned. Therefore the removal action will:

- Contribute to the efficient performance of any long-term remedial action on the LDW
- Be protective of human health and the environment in the long-term

As discussed in Section 5, these RAOs can be attained through removal and/or containment actions.

3.3 REMOVAL AREA PHYSICAL SETTING

The removal area is defined by the removal boundary shown on Figure 3-1 (see map folio). It includes the upland unpaved area adjacent the shoreline, the bank extending down to the waterway, and intertidal to shallow subtidal sediment areas. The area within the boundary has been subdivided into four zones characterized by similar physical characteristics, as described below and shown on Figure 3-1. These zones have been established based on the removal action approach that emphasizes using land-based earthwork equipment whenever reasonably possible.

- **Upland—**This is the portion of the site above elevation +14 ft MLLW that is located between the existing paving and the toe of the slope that extends down to the waterway. Elevation +14 ft MLLW is used as the base of the upland zone because it is within 1 ft above the expected highest tide at the site. The upland is generally level ground with existing grade elevations varying between +17 ft and +20 ft MLLW. Removal action in the upland would be completed by land-based excavation and trucking equipment.
- **Bank—**The bank is adjacent to the upland. It starts at elevation +14 ft MLLW near the top of the slope and extends down to the waterway to the start of the intertidal mudflat at about elevation +5 ft MLLW. The bank is mainly covered with blackberry vegetation, and is composed of a mixture of soil, debris, and creosote-treated timber bulkheads. Removal action along the bank would be completed by land-based excavation and trucking equipment when tidal waters are not present.
- **Mudflat—**The mudflat zone is adjacent to and offshore of the bank. As defined in this EE/CA, the mudflat zone starts at the toe of the bank slope at the edge of the intertidal mudflat near elevation +5 ft MLLW and extends out to the existing mudline at 0 ft MLLW. Removal action in the mudflat zone would be completed by land-based equipment working when tidal waters are generally not present.
- **Submerged—**The submerged zone is adjacent to and offshore of the mudflat zone. As defined in this EE/CA, the submerged zone starts at elevation 0 ft MLLW at the existing mudline and extends to the eastern removal boundary, typically near elevation -5 ft to -8 ft MLLW. Except during periods of very low tide the sediment in the submerged zone is under water. Removal actions in the submerged zone would be completed with floating equipment working when the tides are high enough to provide the draft required for the floating equipment.

4.0 Identification of Removal Action Technologies

Removal action alternatives in the T-117 EAA are considered within two distinct sets of areas according to whether they will be applied from the upland side of the site (land-based removal action) or as in-water (waterway-based removal action). Generally, land-based removal technologies will be applied to the upland, bank, and mudflat zones to control suspended sediment transport. Waterway-based actions will address submerged zone sediment. The removal action technologies considered for the T-117 removal area are discussed in Section 4.1 and 4.2. Treatment and disposal technologies are discussed in Section 4.3.

4.1 LAND-BASED REMOVAL ACTION

The two land-based removal actions and technologies under consideration for this EE/CA are excavation and capping. Both would be completed with upland earthmoving equipment, and both would be completed generally in the dry when the tides are out. The general aspects of land-based removal actions are discussed first, followed by specifics for excavation and capping.

The site characterization studies completed to date indicate that PCBs are the primary chemicals of concern for the removal action. The highest concentrations of PCBs are found in the upland surface soils (0-5 ft below ground surface), with intermediate concentrations of PCBs found behind the bank and in the mudflat surface sediments.

Removal actions in the upland zone are not tide-dependent because this zone is located above the highest tide level expected in the waterway. In consultation with the NMFS and US Fish and Wildlife Services (USFWS), work below ordinary high water may be allowed outside the established in-water construction window if the work is completed basically in the dry when tides are out. Bank and mudflat actions occur within a zone of the shoreline that is periodically submerged and then exposed due to the changing tide levels. Land-based removal actions are planned out to the existing mudline elevation of 0 ft MLLW.

To work down to the existing 0 ft MLLW contour when tides are out requires scheduling the removal actions during periods of negative low tides so there is sufficient time to work at the 0 ft MLLW contour. A low-tide elevation of at least -2.0 ft MLLW is used for planning purposes in this EE/CA. It is desirable to work during daytime low tides, as apposed to nighttime low tides, for worker safety. As shown on the predicted tide charts for the Duwamish Waterway for 2006 (Table 4-1 and Appendix C), the primary periods of daytime very low tides (-2 ft MLLW or lower) generally occur in the months of April through August each year, with the most events of negative daytime low tide occurring in June and July. The nighttime very low tides typically occur in October through January with the lowest tides occurring in December. The predicted 2006 tides below -2 ft MLLW at Duwamish Waterway, 8th Ave S are presented in Table 4-1.

Table 4-1. 2006 predicted tides below -2 ft MLLW

MONTH AND DAYS	NEG. LOW TIDE ft MLLW	DAYTIME	NIGHTTIME
January 2-3	-2.2 ft to -2.9 ft	none	2 days
January 27-30	-2.1 ft to -2.7 ft	none	4 days
February	none	none	none
March	none	none	none
April 28-30	-2.1 ft to -2.4 ft	3 days	none
May 14-17	-2.0 ft to -2.2 ft	4 days	none
May 26-29	-2.4 ft to -2.8 ft	4 days	none

Month and Days	Neg. Low Tide ft MLLW	Daytime	Nighttime
June 11-15	-2.2 ft to -3.0 ft	5 days	none
June 23–27	-2.1 ft to -2.6 ft	5 days	none
July 9–13	-2.1 ft to -3.0 ft	5 days	none
July 23	-2.0 ft	1 day	none
August 8-10	-2.0 ft to -2.4 ft	3 days	none
September	none	none	none
October 10	-2.0 ft	none	1 day
November 5-9	-2.2 ft to -2.8 ft	none	4 days
December 3-8	-2.0 ft to -3.0 ft	none	5 days
December 20-22	-2.1 ft to -2.3 ft	none	3 days
TOTAL		**30 days**	**19 days**

As shown in the table, there are no daytime very low tides before April or after August during 2006.

Based on the above, it would be preferable to schedule the removal action to start in early May, with completion of the upland work during May and initiation of the bank and mudflat work on May 26, 2006. The bank and mudflat work could then be completed during the period that includes the 20 days of very low tides between May 26 and July 23, with three days of very low tides in August held in reserve for contingency actions.

The land-based removal actions presented in this EE/CA provide planning level descriptions of proposed excavation and capping that may be modified based on the findings from the additional shoreline and south ditch soil sampling (Windward et al. 2005c). For example, the design will be modified to ensure that any concentrations of PCBs left in the bank face following excavation are below TSCA hazardous substance disposal level (50 mg/kg dw). EPA will approve the excavation and cap design when the final design documents are approved.

4.1.1 Land-based excavation

Soil data collected from borings along the shoreline indicated that the soil behind the bank is composed primarily of loose-to-medium-dense silty gravelly sand, with deposits of sand and of silt. Generally, cut slopes of 2 horizontal to 1 vertical (2H:1V) are used for establishing the configuration of land-based excavations. The slope will be further discussed with EPA as part of the design process and the final slope will be approved by EPA the final design documents Steeper finished slopes would likely require shoring or armoring to remain stable.

Land-based excavations are to be completed within the removal area in a manner that does not undermine the terminal work areas outside the removal boundary and other facilities on the adjacent upland. The extent of upland and bank excavations considered in this EE/CA originates at the upland project boundary and slopes down and out. The cross-sections presented in Section 5 show a 2H:1V reference line starting at the upland boundary and extending down towards the waterway. Additional upland soil removal will be included in the final design as necessary to address findings from the additional shoreline and south ditch soil sampling (Windward et al. 2005c). Excavation will include removal of the catch basin 5 and surrounding soil, as well as soil removal from the south drainage ditch.

Excavation of the upland, bank, south drainage ditch, and mudflat sediments will be completed with upland-based earthmoving equipment (excavators, front-end loaders, and dump trucks). Impacted material will be excavated, then placed in properly lined trucks, and transported over city streets to selected disposal facilities. The upland-based excavation will be designed to remove PCB containing soils, asphalt tar, creosote-treated timbers and piles, drums, and other debris of concern from along the T-117 shoreline, as well as manage the groundwater seeps along the shoreline. A contingency plan will be developed during removal design to respond to unanticipated conditions encountered during excavation, such as excessive groundwater seeps or pockets of oil-saturated soil.

Work in the bank and mudflat zones will be completed when the tides are out to maintain construction activities above the tidal waters except as specifically noted below. The land-based excavation will remove material to the design grades, and then immediately covered(i.e., prior to the incoming tide) with filter fabric initially secured by sand bags or other suitable anchoring. The placement of permanent quarry spalls and surface layer over the filter fabric will follow as allowed by the tides. The work will be sequenced such that the bank will be excavated and covered with filter fabric in sections so as to avoid submerging uncovered excavated soils at high tide.

Land-based excavation is the preferred method for the upland, bank, and mudflat portions of the T-117 site, as opposed to water-borne action. With the land-based action occurring when tides are out, the action is completed in the dry. Completing excavations in the dry provides several advantages as compared to working in the water when the tides are in and the land is submerged. These advantages include:

- Allows operators to see the work area and accurately place the bucket to ensure complete removal of the impacted material
- Allows the operators and oversight staff to see the excavated face and adjust the depth of excavation based on observed conditions
- Maintains the material to be removed in an intact state, and avoids the potential for creating a soupy mix of sediment and water that can be difficult to capture in the excavator bucket
- Generally eliminates the potential to entrain impacted material in the water column for off-site transport

As detailed above, the majority of the mudflat excavation will be completed in the dry while the tides are out. However, excavating 2 ft of material at the existing 0 ft MLLW contour, down to elevation -2 ft MLLW, will result in the most outboard portion of the excavation (10-15 ft) occurring partially in 1-2 ft of water.

4.1.2 Land-based capping

PCBs are the target compound for capping in the T-117 removal area. PCBs are generally not water soluble and tend to stay tightly bound to sediment particles. Groundwater monitoring at the site indicates that there are no measurable PCBs in site groundwater (which will be verified during the project with additional monitoring). Site capping is designed to provide physical containment of contaminated soil particles in order to prevent migration of contaminants from beneath the cap as well as manage the groundwater seeps along the shoreline. The cap design presented in this EE/CA is a planning-level description of proposed capping. A detailed cap design evaluation will be conducted as part of the post-EE/CA design efforts for this project. This evaluation will comply with EPA guidance (Palermo et al. 1998), including measures taken to prevent contaminant transport through the cap. The design evaluation will specifically address the long-term durability of the filter fabric and cap system. Note that the cap design presented in this EE/CA may be modified pending the results of further subsurface soil and groundwater sampling conducted in June 2005 (Windward et al. 2005c). Additionally, since the highest PCB concentrations will be removed, the cap will not contain soils that exceed TSCA hazardous substance disposal level (50 mg/kg dw). EPA will approve the cap design when the final design documents are approved.

Capping of upland, bank, and mudflat soil and sediment is planned to be completed with upland-based earthmoving equipment (excavators, front-end loaders, and dump trucks). Clean capping material would be imported to the site in dump trucks or on barges, and then placed as engineered fill over the impacted soil and sediment. The cap would be designed to resist disturbance and re-exposure of the capped materials.

The capping design for T-117 upland, bank, and mudflat areas consists of placing a heavy geotextile or filter fabric over the exposed impacted soil and sediment to provide a physical containment barrier of soil and sediment particles. This is covered by a layer of quarry spalls to provide resistance to erosion and traffic, which is followed by a surface layer of natural sand and gravel that is also resistant to erosion. The long term stability of the filter fabric and its ability to withstand the process of compressing the quarry spalls will be discussed further in the design documents. Work in the bank and mudflat zones would be completed when the tides are out to generally maintain construction activities above the tidal waters.

Land-based capping is the preferred method for the upland, bank, and mudflat portions of the T-117 site, as compared to water-borne capping. Working in the dry provides several advantages as compared to working in the water when the tides are in and the land is submerged. These advantages include:

- Allows workers to easily and efficiently place the geotextile material on the exposed surface, and to verify that the required overlap has been achieved between strips of fabric

- Allows equipment operators to see where the capping material is being placed to ensure that the required coverage and material thickness is achieved

4.2 Waterway-Based Removal Action

The PCB concentrations in the submerged zone (defined in this EE/CA as deeper than the existing mudline of 0 ft MLLW) are considerably lower than those found in the upland, bank, and mudflat zones. Land-based operations are preferred for removal actions in upland, bank, and mudflat areas; waterway-based operations are recommended only for removal actions in the submerged zone. This approach captures the most impacted sediment while working from the upland, without significant exposure to the water column. As planned, only the less-impacted sediments in the submerged zone would be addressed by waterway-based equipment. Allowable in-water construction windows will be determined by EPA in consultation with the NMFS and USFWS.

The submerged zone of the site extends from 0 ft MLLW down to about -5 to -8 ft MLLW. Because the submerged zone is in relatively shallow water, the waterway-based removal actions would likely have to be limited to periods of moderate to high tides in order to provide required flotation for the equipment (5-15 ft draft depending on specific equipment).

Most of the submerged area is open to access by conventional floating equipment. However, there is a relatively thin strip of the submerged zone within the South Park Marina with very limited access due to the presence of existing floats and boats. This area will likely not be accessible to conventional marine equipment unless the adjacent floats and boats are first removed. It is possible that the removal action in this area will have to be coordinated with the planned navigation dredging at the marina. It is anticipated that the temporary relocation of boats and floats for the navigation dredging will be sufficient to allow access of floating equipment for the removal action in the submerged area at the marina.

The final design for the dredging will establish best management practices (BMPs) to be used during dredging to limit the adverse environmental impacts of dredging.

4.2.1 Waterway-based dredging

Both mechanical and hydraulic dredging methods were considered for the project. The equipment required for both methods is discussed below, along with factors that influence the selection of one method or the other for a sediment remediation project.

Mechanical dredging involves lowering a bucket or clamshell to the bottom, excavating the target material, and then lifting it to the surface. The dredged material is placed into a barge for transport to a placement or offloading site. The two primary types of mechanical dredges are cable dredges, in which a clamshell bucket lifted by the cable of a crane located on a barge, and excavator dredges, in which a digging bucket or clamshell bucket on an excavator boom-stick configuration. Mechanical dredging is adaptable to various site conditions by changing bucket type and size to match the material being removed. Because mechanical dredging uses conventional marine and upland construction equipment (barges, cranes, excavators) there are multiple sources of the equipment in the Puget Sound region.

The hydraulic dredging process involves loosening the target material from the bed with some form of agitation equipment, mixing the loosened material with water to form a slurry, and then transporting the slurry to a placement or process site via either a pipeline (pipeline dredge) or via a storage hopper in the hull of the dredge (hopper dredge). Two of the more common types of pipeline dredge are classified by the method of agitation, cutterhead and auger dredges. Cutterhead dredges are commonly used for navigation dredging and are capable of moving very large volumes (1,000 cy/hr +) of dredged material. Auger dredges, used most commonly for dredging waste ponds, are generally smaller than typical cutterhead dredges, with production rates on the order of a few hundred cubic yards per hour. A small hydraulic dredge (8-10–in. discharge pipe diameter) would be used for a small project like T-117. However there are few small hydraulic dredges located in the Seattle area or the Northwest because of the specialized nature and limited demand for the equipment.

Debris can be a significant factor in selecting a dredge. Debris can pose operational problems for hydraulic dredging, especially smaller hydraulic dredges Debris often associated with industrial areas (boulders, steel plate, construction rubble, cables, chains) can plug the pipeline and result in considerable down time. In contrast, mechanical dredges, can handle a wide range of the debris that is commonly associated with industrial sites. It is only limited by what can be captured in the bucket.

Water management is another factor in selecting a dredge. Considerable resources can be required to process the water generated by dredging, especially hydraulic dredging. Hydraulic dredging can generate a slurry volume that is on the order of ten to twenty times the volume of the in-place target material, because of the significant water added during the dredging process. For example, the removal of 5,500 cy of sediment could generate a pipeline volume of over 55,000 cy (~11 million gallons) to over 100,000 cy of slurry. A dredging production rate of 1,000 cy per day would could generate at least 10,000 cy of water per day (at 10:1 ratio). A pond roughly 300 ft by 300 ft (90,000 ft^2), by 3 ft deep would be required to contain 10,000 cy of slurry. Two to three such cells would be required to handle the current day's production and the processing volume (180,000 to 270,000 ft^2). Cutting the dredge production rate in half to only 500 cy per day would still require two to three ponds each roughly 200 ft by 200 ft (40,000 sf each, 80,000 to 120,000 ft^2 total) by 3 ft deep at the low end of the slurry to sediment range (10:1). The cost and logistics of setting up such a water management facility for hydraulic dredging would not be insignificant, and would be spread out over only several days of dredging. On the other hand the requirements for water management for mechanical dredging would be relatively straight forward, far less expensive, and could likely be accomplished on a barge. Water management ponds to support hydraulic dredging could not be constructed at the T-117 site because the size of the available open land (approximately 47,000 ft^2 of yard space) is just a fraction of that required for storage ponds.

Disposal cost is also a factor in selecting a dredge. The costs of transportation and disposal of dredged material to a landfill are directly related to the weight of material to be handled. The process of hydraulic dredging adds considerable water to the dredged material, and even with dewatering can significantly increase the weight of dredged material and the cost of disposal. Consequently, mechanical dredging is normally used when dredged material is to be disposed at a landfill.

Mechanical dredging was selected for the T-117 project for the following reasons:

- **Disposal—** mechanical dredging is best suited to landfill disposal because it avoids the addition of large volumes of water associated with hydraulic dredging
- **Debris:—**a mechanical dredge is more capable of handling the variety of debris that can be associated with an industrial site dredging project, especially true when compared to a small (8- to 10-in pipeline) hydraulic dredge that might be used for a project the size of T-117
- **Water Management—**mechanical dredging generates much less water than hydraulic dredging; the size of the upland facility and infrastructure required to manage the water associated with even a small hydraulic dredge would be considerable
- **Equipment Availability —** mechanical dredging is completed with normal marine/upland construction equipment, while hydraulic dredging requires dedicated equipment. There are more equipment options associated with mechanical dredging, especially considering the small size of the dredging project.

The thickness of impacted sediment in the submerged zone ranges from 1-4+ ft. A mechanical dredge (excavator or derrick) would use a bucket to remove material from the bed and place it into a haul barge. The dredge material would be transported in the haul barge to a waterfront location for offloading and then transport to selected disposal facility.

Conventional dredging methods advance each dredge cut at a constant dredge elevation within a discrete area. Dredging of sloped areas is normally completed with a series of stair-step cuts. The removal of a sloping layer is thus achieved by completing a series of horizontal step cuts into the slope. Based on the relatively flat mudflat and submerged zone slopes, step cuts on the order of 20 ft wide are used for planning purposes in this EE/CA. The stair-step cuts result in the dredging of some clean sediment along with the impacted sediment in order to achieve the desired removal. The actual dredging pattern for the slopes will be established by the selected removal action contractor to match the capabilities of the dredging equipment.

As part of the design process, BMPs will be defined to manage the environmental components of the project, such as sediment resuspension and water quality. The selected contractor will be required to include BMPs in their remedial action work plan submitted to EPA for review and approval, and shared with the public.

4.2.2 Waterway-based capping

Capping of submerged-zone sediment could be completed with floating equipment similar to that used for mechanical dredging. The dredge would use a bucket to collect capping material from a haul barge and place the material on the bed of the waterway. The analysis for this EE/CA assumes a subtidal cap consisting of three layers: a sandy material to provide primary physical and chemical containment of the impacted sediment, an armor layer to protect against erosion, and a surface layer of natural sand and gravel. Configuration of the cap will be established in the removal design.

The cap design presented in this EE/CA is a planning-level description of proposed capping. A detailed cap design evaluation will be conducted as part of the post-EE/CA design efforts for this project. This evaluation will comply with EPA guidance (Palermo et al. 1998), including measures taken to prevent contaminant transport through the cap. EPA will approve the cap design when the final design documents are approved.

4.3 Material Disposal and Treatment

Identification and development of disposal and treatment technologies for the T-117 removal action took into account the broader range of technologies identified by the LDWG in the draft Candidate Technologies memorandum (Retec 2005) and other programs such as MUDS (USACE 2003). These sources identify several disposal and treatment technologies that are considered potentially applicable, with particular emphasis on their applicability to remedial actions for the LDW as a whole. These technologies are discussed below and evaluated for their applicability to the T-117 removal action. This EE/CA focuses on demonstrated technologies appropriate for the size, timeframe, and site-specific conditions of the T-117 NTCRA.

4.3.1 Off-site disposal

Disposal of excavated and dredged material in permitted TSCA or RCRA Subtitle D landfills meets the state and federal minimum requirements for properly disposing of PCB-contaminated solids off-site and uses reliable and demonstrated technologies. It is readily implemented and minimizes the amount of upland area and time required for material handling and loading. Landfilling is routinely approved by EPA and the State for disposal of PCB-contaminated solids. Disposal sites must be evaluated and approved by EPA before they are selected to receive materials originating from CERCLA sites. Agency site review includes the site's compliance with TSCA and/or RCRA permits and governing regulations. Landfill disposal will also be consistent under the Off-Site Rule (40 CFR 200.440) which is intended to avoid having CERCLA waste contribute to present or future environmental problems by directing these waste to sites determined to be environmentally sound.

Hauling of material from the removal area to the disposal site would result in increased truck traffic on neighborhood streets for the duration of the removal phase. Transportation and safety plans addressing hours of operations; estimated numbers of trucks and barges required for soil and sediment hauling; anticipated transport routes; material spill prevention, containment and response plans; and other protective and mitigating elements will be prepared by the selected contractor as part of the removal action work plan documents.

4.3.1.1 Regional solid waste landfills

Dredged material that satisfies the solid waste regulations could be disposed in Subtitle D RCRA commercial landfills. Two upland regional landfills have established services to receive dredged sediments and low-concentration contaminated soil (PCB concentration <50 mg/kg dw): Roosevelt Regional Landfill near Goldendale, Washington, and Columbia Ridge Landfill near Arlington, Oregon. These sites are licensed as Subtitle D (RCRA) commercial landfills in the states in which they operate, and both have the ability to receive wet dredged sediments delivered to the landfill by rail.

The Regional Disposal Company (RDC) operates the Roosevelt Regional Landfill. During 2004 RDC handled dredged material at a barge-to-rail loading facility at the Port of Seattle. RDC is currently looking for a new property to provide barge-to-rail trans-loading in the future. Dredged material would be delivered to RDC's sediment offloading facility via barge, while upland excavated material would be transported by truck to a RDC transfer facility.

Waste Management operates the Columbia Ridge Landfill. In 2004 Waste Management completed significant upgrades at the landfill to allow offloading of rail cars loaded with soil and dredged material. During 2004, Waste Management loaded railcars with dredged material at the Lockheed site on Harbor Island, with delivery to and disposal in the Columbia Ridge landfill. Waste Management does not currently operate a barge-to-rail transfer facility in the area.

4.3.1.2 TSCA landfills

As discussed in Section 2.4, PCB concentrations in some upland soil are equal to or exceed 50 mg/kg dw and, if landfilled, must be placed in a hazardous waste landfill specially designed and permitted under TSCA to receive such materials. Landfills meeting these requirements and effectively providing disposal services for TSCA-regulated solids containing PCBs suitable for landfilling and originating in the Northwest include:

- **Chemical Waste Management of the Northwest—**Chemical Waste Management's facility located at Arlington, Oregon. This "Subtitle C" secure landfill facility provides land disposal of soil and debris contaminated with PCBs at concentrations exceeding levels allowed in regional solid waste landfills. The Arlington site is accessible from Seattle by rail.

- **US Ecology—**A subsidiary of the American Ecology Corporation, US Ecology operates chemical waste landfills permitted under TSCA for accepting PCB-contaminated materials at Grand View, Idaho, and Beatty, Nevada. The Beatty facility is located 100 miles northwest of Las Vegas. The site at Grand View is accessible by rail.

TSCA regulated solids containing PCBs at concentrations equal to or exceeding 500 mg/kg dw are prohibited from land disposal under TSCA and are typically incinerated. However, data from the site indicate these concentrations should not be encountered.

4.3.2 On-site disposal

On-site disposal involves consolidating the removed material in a containment cell constructed within the project boundaries. Upland on-site disposal involves placing removed material into a lined and capped embankment constructed away from the shoreline. In-water on-site disposal involves placing dredged material into a cell constructed in the aquatic environment. One example of in-water disposal involves placing dredged material into a submerged pit, which is then covered by a cap, referred to as confined aquatic disposal. Another example of in-water disposal involves placing dredged material into a diked cell extending from the shoreline that is then capped to create new uplands. This is referred to as nearshore confined disposal.

Implementation of on-site disposal technologies normally requires extensive site evaluations and design studies. Issues to be addressed include contamination transport and containment, long-term stability, land-use regulations, comparison to alternate technologies, and public acceptance.

On-site disposal was not considered viable for the T-117 NTCRA based on the following preliminary evaluations:

- **Schedule—**The time required to fully investigate, design, and implement an on-site disposal technology can be well over a year, which is too long and not appropriate for an NTCRA.
- **Land Availability—**There is no land available within the removal boundary to construct an upland containment cell. Open areas of T-117, including the PCB soil removal area (Onsite 2000) are stabilized by former building foundations and an asphalt cap. These structures would need to be partially or entirely removed, resulting in significant destabilization of the upland area that could result in potential runoff recontamination. Relocation of dredged material into the upland would also cause unacceptable changes to the terminal topography that would significantly limit the future productive use of the T-117 facility.

- **Alternate Technologies—**Section 404 of the Clean Water Act (CWA) limits the construction of in-water disposal sites to situations where there is no other practicable alternative. Since off-site disposal is a currently available practical alternative for the T-117 early action, in-water filling is not being considered for the project.
- **Cost—**The development of an on-site disposal facility would require significant expenditures for evaluations, design, permitting, and construction. To be cost-effective, these high development costs need to be spread over large volumes (100,000 cy plus) of disposed material, or constructing the facility needs to result in other benefits such as the creation of new industrial uplands or new habitat. Because of the relatively low volume of material generated by the T-117 removal action (10,000 cy or less), the creation of on-site containment is not considered to be cost-effective as compared to off-site disposal.

4.3.3 Treatment technologies

The draft Candidate Technologies Memorandum identified several treatment technologies deemed to have potential applicability for site-wide cleanup in the LDW (Retec 2005). These include incineration and alternate treatment methods including soil washing and high-temperature thermal desorption. These technologies are discussed below and evaluated for their applicability to the T-117 removal action. Table 4-2 summarizes some of the general pros and cons of applying these treatment technologies for this early action. The following subsections provide specific discussions of these technologies.

Table 4-2. Pros and cons of using treatment technologies for T-117 cleanup

EE/CA Evaluation Criterion	Treatment Pros	Treatment Cons
Effectiveness	May destroy some or most of the organic contaminants such as PCBs May reduce amount of PCBs being landfilled May allow for beneficial use of the treated material Incineration and high-temperature thermal desorption have proven effectiveness for PCBs.	Effectiveness of advanced soil washing is unproven for these site conditions Each of the technologies produces waste streams (e.g., off gasses, wastewater) that may contain contaminants and may increase short-term risks. Waste streams from advanced soil washing require landfilling or discharge to water Treated material may still have residual contamination. Beneficial use may create higher exposures and risks compared to landfilling without treatment. Beneficial use requires careful evaluation.
Implementability	Offsite incineration at established facilities is readily implementable	Advanced soil washing would require treatability testing, delaying cleanup. Administratively difficult to assess and implement re-use options in short timeframe. On-site treatment facility requires significant land and infrastructure Administratively difficult to site a new PCB treatment facility
Cost	No cost advantages	Substantially higher costs than direct landfill disposal of untreated materials. Advanced soil washing costs are difficult to predict, and there is substantial potential for cost overruns. Costs may further increase if beneficial use cannot be implemented. Costs of each treatment technology is substantial and disproportionate to any benefits gained. Landfill disposal is a proven, lower-cost alternative.

4.3.3.1 Incineration

Incineration uses high temperatures, (870-1,200°C or 1,600-2,200°F) to volatilize and combust (in the presence of oxygen) organics in hazardous wastes. Auxiliary fuels are often employed to initiate and sustain combustion.

Effectiveness: The destruction and removal efficiency for properly operated incinerators exceeds the 99.99% requirement for hazardous waste and can be operated to meet the 99.9999% requirement for PCBs. Incineration is generally not effective for inorganic contaminants. Off-gases and combustion residuals generally require treatment. Short-term risks to local communities associated with incineration are managed through the requirements of the incinerator's operating permits. The processed soil, can constitute a significant percentage of the original feedstock (by volume) and must still be disposed of, most likely in a solid waste landfill. This type of processing does little to reduce the impact on landfill capacity, would require additional waste transport and handling steps (added short-term risk). In summary, incineration can effectively treat PCBs but may not effectively treat inorganics or substantially reduce disposal requirements.

Implementability: Siting and permitting of a mobile incinerator in the LDW vicinity would present substantial administrative feasibility concerns. The technology is not available in the region and requires material to be shipped over significant distances. Therefore, incineration would require transporting waste over significant distances to commercially permitted facilities located in Utah, Arkansas, or Texas. TSCA requires that PCB-contaminated soil with concentrations equal to or greater than 500 mg/kg dw be treated using a TSCA-approved incinerator. However, existing data for the site indicate that these concentrations should not be encountered. Materials containing PCBs less than 500 mg/kg dw can be cost-effectively disposed by landfilling.

Cost: Incineration technology has the specific shortcomings of long haul distances and high cost, and is typically applied only to those materials for which it is mandated under TSCA, where alternate disposal or treatment methods for materials containing lower concentrations of PCBs are not allowed. The technology is not cost-effective compared to direct land disposal.

Based on these considerations, incineration of higher-concentration PCB-contaminated materials is not retained for further consideration as a treatment alternative for waste material derived from the T-117 removal action.

4.3.3.2 Alternate treatment methods

The feasibility and cost-effectiveness of sediment treatment for the project depend on a number of factors, including the quantity of material to be treated over time, contaminant types and concentrations, the target post-treatment contaminant concentrations, and the potential end uses and marketability of the treated material. Based on the demonstrations in the New York/New Jersey harbor region that were supported by large experimental technology grants, sediment treatment has the potential to become a viable alternative for sediments in the future. However, the total cost and overall feasibility of treatment must first approach the cost and feasibility of the disposal alternatives (USACE 2003). In general, for treatment to potentially approach the cost-effectiveness of other disposal alternatives, the treated material would require beneficial use to reduce disposal costs. A recent document that summarized the technical and policy considerations related to the use of Biogenesis process for the treatment of contaminated sediments that are dredged from the LDW concluded that this process is not viable for the early action sites because its effectiveness is unproven, it would be difficult to implement and would delay cleanup, and is not cost effective (Retec and Integral 2005).

The local market for beneficial reuse of treated sediment originating from Superfund cleanup sites is anticipated to be very limited, and placement of treated materials back onto the T-117 removal area is not considered to be a practical option due to construction specifications. Even if beneficial use can be arranged, the cost of treatment (depending on the technology and specific project conditions) may be substantially greater than the cost of landfill disposal of untreated material.

Alternate treatment technologies specifically targeting PCB and other organic contaminants in excavated/dredged materials were initially identified in the Candidate Technologies memorandum (Retec 2005). These included:

- advanced soil washing
- high-temperature thermal desorption

As discussed below, none of these technology-intensive processes were retained for the T-117 removal action due to the following project- and site-specific limitations:

Effectiveness: Advanced soil washing and high-temperature thermal desorption have limitations on their effectiveness for particular soil types. For example, soil washing and thermal desorption are less effective at removing contaminants from fine soil particles (silts and clays). The T-117 soils are expected to contain a significant percentage of fines (20-98%). It is unlikely that this fines fraction could be sufficiently cleaned to overcome the strict institutional barriers to disposal of treated materials within the aquatic environment, particularly for higher-concentration soils originating from the upland. Advanced soil washing has never been implemented full-scale and limited pilot-scale data are available. The pilot-scale tests have limited comparability to the T-117 soil conditions. For example, the maximum reported PCB concentration in untreated sediments tested by Biogenesis is 0.3 mg/kg for a pilot scale project completed in NJ. Concentrations of PCBs at T-117 are estimated to average approximately 10 to 12 mg/kg. At the NJ pilot test, treated sediment had grain size of 52% silt and 42% clay. This grain size is significantly finer than the T117 sediments. Although the vendor claims that a 95% reduction of PCB concentrations is feasible, the results of the treatment as published on the website for this fine grained sediment resulted in 45 percent reduction of PCB concentrations. This percent reduction would not result in T117 sediments being below SMS criteria. Finally, the vendor has not been able to provide mass balance information from the previous testing, and it is not known how much of the PCBs would simply be transferred to other waste streams such as sludges and wastewater. Overall, the uncertainties associated with effectiveness for the T117 site would require evaluation in a pilot study that would delay the cleanup, and still not resolve all the concerns with implementability or cost effectiveness.

While thermal desorption systems may be able to receive low-level contaminated soil (i.e., containing concentrations lower than 50 mg/kg), most of them are geared to processing other types of solid waste (i.e., refuse) or soil contaminants (i.e., TPH). Lower-temperature thermal treatment of PCBs (lower than temperatures in TSCA-approved incinerators) can be problematic, resulting in only partial destruction and the generation of partially oxidized, highly toxic byproducts such as dioxins. Incinerators specially permitted to accept PCBs have very strict monitoring requirements for their process and emissions, beyond those normally practiced at other facilities. Without such safeguards, one cannot guarantee that the PCBs are being effectively treated (destroyed) or that potential health impacts to the surrounding community are adequately addressed.

Implementability: There are significant potential liability issues with off-site re-use soils containing residual levels of PCBs and other contaminants. On-site re-use is not considered administratively implementable due to logistics and concerns over re-introducing contaminants to a sensitive aquatic habitat. Compared with landfill disposal, most potential reuse options (either on-site or off-site) would have the potential for greater long-term human and/or environmental exposures to residual concentrations of contaminants. In the case of soil washing, residual levels of treatment chemicals may also create toxicity. Therefore any reuse option would require careful evaluation (and potentially permitting) by regulatory agencies and other stakeholders. Such evaluations could require considerable time and effort. These concerns coupled with the short timeframe for the T-117 early action, make it likely that most or all of the treated soil would still require disposal at a permitted RCRA landfill. The other waste streams (such as sludges and wastewater containing PCBs from soil washing; or gasses from thermal desorption) also require treatment or disposal. Additional elements impacting implementability include:

- **Testing and Design Requirements:** Treatability testing would be required for evaluating the effectiveness of these technologies for the T-117 soils and optimizing the process for these soils. This process, including sampling, analysis, treatability testing, and reporting, would require at least 6 months of additional planning time (see section on treatability testing below). Should the process show promise for these specific soils, the subsequent design, contracting, and mobilization of this technology would also add several months to the project schedule. The goal of this NTCRA is to provide early risk reduction in an accelerated cleanup process. Therefore, in the context of the timeframe of this removal action, these technologies are not readily implementable.

- **Need for Pre- and Post-Treatment:** Treatment processes require that large debris first be screened out, with only the uniform soil particles being processed. Upland and bank zone soils contain greater concentrations of PCBs, and also likely contain greater debris and asphalt then found in the mudflat and submerged zone sediment. Pre-screening would necessarily be more intensive for the upland and bank zone soils as compared to other, more typical soils.

- **Lack of Established Facilities:** There are no treatment facilities set up near the T-117 site that routinely process PCB-contaminated materials. Consequently, a significant piece of upland property would be required to erect and operate a mobile plant to accommodate material pretreatment and handling processes.

Area at T-117 is extremely limited (~ 47,000 ft^2 of yard space). Much of this space will be required for soil/sediment removal and staging operations:

- work zone along the tope of the shoreline bank for excavators and trucks (at least 30 ft wide zone inboard of the removal area ~ 24,000 ft^2).
- excavated soil staging areas (~ 3,000–5,000 ft^2)
- truck entrance/exit paths, loading and wash areas (~ 10,000 ft^2)
- project support area for project trailer, vehicles, and equipment storage and lay-down (~ 7,000 ft^2)

Taken together, these operations require a majority of the available space at the T-117 site (up to 46,000 ft^2), leaving little area for a processing plant and contingency areas as may be needed during construction. An alternate processing site would need to be established and would require additional waste handling and hauling, increasing the risk of short term re-contamination and exposure. The processing site may also require permitting, which may not be feasible in the timeframe of this NTCRA. While treatment systems may exist in other cities or states, waste would need to be hauled over long distances to be processed and residuals re-loaded and hauled to a final disposal site (i.e., landfill).

- **Treatability testing timing**: The degree of required testing is dependant on the degree to which the technology has been implemented in full-scale applications with materials and contaminants similar to the site conditions. The testing can be bench-, pilot-, or full-scale. Bench-scale tests are small-quantity, batch simulations of what is really a continuous large-scale process. Pilot-scale tests are typically on-site and treat on the order of 1 to 10 tons of material. In general, a successful bench-scale test yields qualitative data and needs to be followed by a pilot- or full-scale test to yield quantitative, real-world cost and performance data. This is particularly important for sediments, which are a complex and heterogeneous matrix: sediments often contain high silt and/or clay content, significant organic content, salinity, debris, high water content, sulfides, and multiple organic and inorganic contaminants. Considerable time is required to plan, execute, and evaluate the testing results. General steps in the process include:
  - Bench-Scale testing (6-18 months):
    - Identify and contract with vendors and laboratories. Public agencies may need to contract with multiple vendors to satisfy contracting laws
    - Design the study: plan sample collection for representative/worst case matrix conditions, identify treatment goals, design the study to evaluate the effects of multiple parameters (e.g., analysis of variance design), identify QA requirements

- Develop study work plans and obtain agency approvals
- Collect the field samples
- Conduct the testing by the vendor, analyses by labs, and obtain raw data
- Evaluate and report the data

- Pilot-Scale Testing (12-24+ months). Includes all of the Bench-scale considerations, plus:
  - Arrange logistics of siting a treatment system (land, utilities, permits)
  - Contract with a construction contractor for removal of tons of material from the water
  - Develop construction work plans, time the removal for fish windows, obtain all agency approvals and certification for in-water work, potentially including ESA considerations
  - Mobilize construction and treatment contractors
  - Operate the treatment system, vary process parameters to evaluate/optimize performance
  - Evaluate and report the data

Successful completion of these steps allows planning to begin for the full-scale design. At T-117, it is expected that the cleanup would be delayed by 1-3 years if treatability testing were pursued.

Cost: Experience has shown that mobilization and setup of a project-specific treatment facility entails a significant initial cost. The treatment plant must process a significant volume of material to recover the fixed mobilization and setup costs. This may not be possible for the T-117 site, where only 9,000-13,000 cy of material will be removed from the upland, bank, mudflat, and submerged zones. If the early actions at both T-117 and Slip 4 were delayed by up to three years, it might be possible to combine the volumes of sediment from both sites. However, this would not fundamentally alter the overall poor cost-effectiveness of treatment. LDWG has analyzed potential costs for a hypothetical combined T-117 / Slip 4 advanced soil washing treatment project. While the treatment cost estimates have significant uncertainties, the incremental costs of treatment (compared to direct landfill disposal) may be on the order of $11-13 million, depending on reuse options. These costs are considered substantial and disproportionate to any benefits gained by treatment. Taken together with high implementation and pilot testing costs, treatment technologies are not cost-effective for this particular site-specific application and are not retained as part of the removal action alternatives.

5.0 Removal Action Alternatives

The identification of removal action alternatives for the T-117 removal area is based on an evaluation of multiple options for the upland, bank, mudflat, and submerged zones.

The options considered in the EE/CA are presented below, with a description of the option along with benefits, site constraints, and a finding on the viability of the option. The more promising options are then combined into two removal action alternatives for further consideration.

A no-action alternative was not considered for the T-117 removal area. Such an alternative would not satisfy the removal action objective of removing or controlling PCB-containing sediment at the T-117 EAA that has the potential to be released to the waterway and result in adverse PCB sediment concentrations in the LDW.

5.1 Removal Action Options

Removal action options are generally identified for each of the different zones of the site. As detailed below, the upland and bank zones are considered together, while the mudflat and submerged zones are considered separately. As discussed in Section 4.3, landfilling has been selected for the disposal of excavated and dredged material.

The list of options is presented below, followed by a more detailed description of each.

Upland/bank zone removal options

- Option UB1—Excavation of soil to achieve RAOs
- Option UB2— Capping of soil to achieve RAOs
- Option UB3 —Combined excavation and capping of soil to achieve RAOs

Mudflat zone removal options

- Option M1 —Excavation of sediment to achieve RAOs
- Option M2—Capping of sediment to achieve RAOs
- Option M3—Combined excavation and capping of sediment to achieve RAOs

Submerged zone removal options

- Option S1—Excavation of sediment to achieve RAOs
- Option S2 —Capping of sediment to achieve RAOs
- Option S3—Combined excavation and capping of sediment to achieve RAOs
- Option S4—Combined excavation of sediment to achieve RAOs followed by backfilling to original grades

5.1.1 Upland/bank zone removal options

5.1.1.1 Option UB1 - Excavation of soil to achieve RAOs

The contaminated soils within the removal area would be excavated and transported off site to an approved disposal facility. The upland and bank work would be completed as land-based removal actions.

Benefits

Excavation of impacted soil in the upland/bank zones would substantially reduce the potential for ongoing release of PCB-containing soil from the upland and bank zones of the site to the LDW. The bank excavations would also remove creosote-treated timbers and pilings, asphalt, and other debris located along the shoreline.

Site Limitations

Land-based excavations are generally to be completed in a manner that does not undermine the terminal work areas and structures. The general upland limit of the removal area boundary is shown in Figure 3-1 (map folio) and will be adjusted inland as necessary based on the results of supplemental upland subsurface soil sampling (Windward et al. 2005c).

In the south ditch, the south shoreline area, the vicinity of catch basin 5, and the north shoreline area, soil removal will be sufficient to provide a buffer between the final cap structure and upland soils. Soil removal adjacent to the 1999 PCB soil removal area will be limited by the location of the clean 1999 quarry-spall backfill, which corresponds to the present edge of pavement. In some areas (i.e., the south ditch and south shoreline), soil removal will be constrained by the presence of the nearby building, surrounding foundations, and the sloped embankment extending up to the Boeing property bordering the site on the south side.

Where necessary, pavement and shallow backfill inboard of the pavement edge will be removed to facilitate a proper working slope for deeper soil removal. The Port and the City will continue consultation with EPA and Ecology, during the design phase, regarding specific localized areas for additional high PCB soil removal. This removal may include soil beneath the existing asphalt cap where appropriate and necessary.

Finding

Option UB1 is not carried forward because of site limitations such as existing building foundations, terminal operations, and upland embankments that make it impractical to remove all PCBs.

5.1.1.2 Option UB2 – Capping of soil to achieve RAOs

The entire upland and bank area would be capped to provide long-term isolation of the underlying PCB-containing soils.

Benefits

Isolation capping of impacted soil in the upland/bank zones would substantially reduce the potential for ongoing release of PCB-containing soil from the upland and bank zones of the site to the LDW.

Site Limitations

Placing a cap of nominal 3 ft thickness up to the upland edge of the project boundary would require the construction of a short retaining wall along the boundary, as well as the reconfiguration of the surface water drainage of the existing uplands. Because the existing bank slope is considerably steeper than 2H:1V along much of its length, construction of a conventional soil cap over the existing bank would first require the placement of fill in order to establish a stable slope, followed by the construction of the cap. This filling would move the shoreline out towards the waterway and result in the net loss of intertidal habitat. Loss of habitat is viewed as contrary to the overall objectives of the ESA and is not considered a suitable outcome for the T-117 early action. The CWA also prohibits filling of the waters of the US unless there is no other practicable alternative.

Finding

UB2 is not carried forward because it would result in the net loss of aquatic habitat while there are other practical alternatives that would not result in such loss.

5.1.1.3 Option UB3 - Combined excavation and capping of soil to achieve RAOs

The upland and bank area would be excavated within the limits of the site constraints, which is currently proposed as a 2H:1V slope cut starting at the inboard project boundary down to the mudflat zone. The exposed surface of the upland/bank zone would then be capped to isolate any remaining soil with elevated PCBs. The upland and bank work would be completed as land-based removal actions.

Benefits

The combination of excavation and capping would substantially reduce the potential for ongoing release of PCB-containing soil from the upland and bank zones of the site to the LDW. The bank excavations would also remove creosote-treated timbers and pilings, asphalt, and other debris located along the shoreline.

Site Limitations

By combining excavation and capping, the removal action could be designed to produce no net loss of aquatic habitat while avoiding long-term exposure of low-level contaminated soil and any undermining of the adjacent terminal work areas and structures.

Finding

Option UB3 is carried forward in the development of alternatives for the T-117 removal area.

5.1.2 Mudflat zone removal options

5.1.2.1 Option M1—Excavate sediment to achieve RAOs

The contaminated mudflat sediment would be excavated and transported off site to approved disposal facility. The mudflat work would be completed as land-based removal actions.

Benefits

Excavation of the impacted mudflat sediment would substantially reduce the potential for ongoing release of PCB-containing sediment from the mudflat zone of the site to the LDW.

Site Limitations

Excavation of 1-3 ft of intertidal sediment will result in the corresponding drop in elevation of the mudline. This will increase the extent of deeper intertidal areas and reduce the extent of shallower intertidal areas at the site, but without a net loss of overall intertidal habitat at the site.

Finding

Option M1 is carried forward in the development of alternatives for the T-117 removal area.

5.1.2.2 Option M2—Capping of sediment to achieve RAOs

The contaminated sediment in the mudflat zone would be capped to provide long-term isolation of the underlying PCB-containing soils.

Benefits

Isolation capping of impacted sediment in the mudflat zone would substantially reduce the potential for ongoing release of PCB-containing sediment from the mudflat zone of the site to the LDW.

Site Limitations

Placement of 3 ft of cap material will result in the corresponding rise in elevation of the mudline. This will increase the extent of shallower intertidal habitat areas at the site, but without a net loss of overall intertidal habitat at the site.

Flood Routing

Placement of a cap on existing grades would decrease the cross-sectional area of the waterway. A river hydraulics analysis may be needed to establish the impact of the capping on flood routing in the LDW.

Finding

Option M2 is carried forward in the development of alternatives for the T-117 removal area.

5.1.2.3 Option M3—Combined excavation and capping of sediment to achieve RAOs

The mudflat zone would be partially excavated and then capped to isolate any remaining sediment with elevated PCBs. The mudflat work would be completed as land-based removal actions.

Benefits

The combination of excavation and capping would substantially reduce the potential for ongoing release of PCB-containing sediment from the mudflat zone of the site to the LDW.

Site Limitations

The mudflat excavation would be limited to the depths above elevation 0 ft MLLW so that all of the mudflat excavation could be completed in the dry when the tides are out. The combined excavation and capping action could result in some change in the relative areas of shallow and deeper intertidal habitat areas at the site, but without a net loss of overall intertidal habitat acreage.

Finding

Option M3 is carried forward in the development of alternatives for the T-117 EAA.

5.1.3 Submerged zone removal options

5.1.3.1 Option S1—Dredging of sediment to achieve RAOs

The submerged zone contaminated sediment would be dredged and transported off site to approved disposal facility. The submerged zone work would be completed with floating equipment.

Benefits

Dredging impacted submerged zone sediment would substantially reduce the potential for ongoing release of PCB-containing sediment from the submerged zone of the site to the LDW.

Site Limitations

Dredging of 1-3 ft of sediment from a sloping surface will require a series of stair-step cuts, which will result in the removal of clean sediment from the waterway. This will result in a corresponding drop in elevation of the mudline and in portions of the bed that are currently between elevation 0 ft MLLW and -4 ft MLLW being deepened to below elevation -4 ft MLLW. This will decrease the extent of intertidal areas at the site and increase the portion of subtidal areas at the site, with a net loss of overall intertidal habitat at the site.

Finding

Option S1 is not carried forward because it would result in the net loss of intertidal habitat while there are other practical alternatives that would not result in such loss.

5.1.3.2 Option S2 – Capping of sediment to achieve RAOs

The submerged zone contaminated sediment would be capped to provide long-term isolation of the underlying PCB-containing soils.

Benefits

Isolation capping of impacted sediment in the submerged zone would substantially reduce the potential for ongoing release of PCB-containing sediment from the submerged zone of the site to the LDW.

Site Limitations

Placement of 3 ft of cap material will result in the corresponding rise in elevation of the mudline. This will increase the extent of shallower intertidal areas at the site, without a net loss of overall intertidal habitat at the site.

Flood Routing

Placement of a cap on existing grades would decrease the cross-sectional area of the waterway. A river hydraulics analysis may be needed to establish the impact of the capping on flood routing in the LDW.

Finding

Option S2 is carried forward in the development of alternatives for the T-117 EAA.

5.1.3.3 Option S3 - Combined dredging and capping of sediment to achieve RAOs

The submerged zone contaminated sediment would be partially excavated and then capped to isolate any remaining soil with elevated PCBs. The submerged zone work would be completed with floating equipment.

Benefits

The combination of excavation and capping would substantially reduce the potential for ongoing release of PCB-containing sediment from the submerged zone of the site to the LDW.

Site Limitations

This option could involve dredging 3 ft of material in areas of thicker deposits of impacted sediment and then covering the dredged area with a 3-ft-thick cap back to original grades, or dredging some portions of the submerged zone to expose clean sediments while capping other portions without dredging. The combined excavation and capping action could potentially result in some change in the shallow and deeper intertidal habitat but without net loss of overall intertidal habitat acreage.

Flood Routing

Placement of a cap on existing grades would decrease the cross-sectional area of the waterway. A river hydraulics analysis may be needed to establish the impact of the capping on flood routing in the LDW.

Finding

Option S3 is carried forward in the development of alternatives for the T-117 EAA.

5.1.3.4 Option S4—Combined dredging of sediment to achieve RAOs and backfilling with clean material

The submerged zone contaminated sediment would be dredged and transported off site to approved disposal facility. The dredged area would then be backfilled with clean imported sediment to re-establish existing grades. The submerged zone work would be completed with floating equipment.

Benefits

Dredging the impacted submerged zone sediment would substantially reduce the potential for ongoing release of PCB containing sediment from the submerged zone of the site to the LDW. Backfilling the dredged areas would maintain the habitat elevations to the approximate conditions that existed before dredging.

Site Limitations

With backfilling after dredging, there is no net loss of intertidal habitat acreage from the action.

Finding

Option S4 is carried forward in the development of alternatives for the T-117 EAA.

5.1.4 Summary of removal action options

The findings from the evaluation of options are summarized in Table 5-1.

Table 5-1. Summary of option screening for T-117 removal area

OPTION	FINDING	REASON
Upland/bank		
UB-1 Excavation	not carried forward	undermine existing cap
UB-2 Capping	not carried forward	loss of habitat
UB-3 Excavation and Capping	carried forward	practical
Mudflat		
M1 Excavation	carried forward	practical
M2 Capping	carried forward	practical
M3 Excavation and Capping	carried forward	practical
Submerged		
S1 Dredging	not carried forward	loss of habitat
S2 Capping	carried forward	practical
S3 Dredging and Capping	carried forward	practical
S4 Dredging and Backfilling	carried forward	practical

5.2 IDENTIFICATION OF REMOVAL ACTION ALTERNATIVES

Two alternatives have been developed for the T-117 removal area based on options that were carried forward from the initial screening of technologies for the different site zones.

The first alternative maximizes removal of PCB-impacted material from the options carried forward. This alternative combines options UB3 (cap and excavate) with M1 (excavate) and S4 (dredge and backfill). This alternative does involve capping because there are no excavation-only options carried forward for the upland and bank zone.

A second alternative was developed from the options carried forward to remove the highly PCB-impacted material to the maximum extent practical, and cap the lesser PCB-impacted material. This alternative combines options UB3 (excavate and cap) with M3 (excavate and cap) and S2 (cap). A complete capping alternative was not developed as there were no capping only options carried forward for the upland and bank zones.

Option M2 (mudflat capping) was not incorporated into either alternative because the other options (M1-excavation and M3-excavation and capping) integrated better with the Upland/Bank excavation and capping approach.

Option S3 (submerged dredging and capping) was not incorporated into either alternative because clean substrate is encountered within a relatively short depth of dredging beneath the existing mudline, which made the other two options more practical (dredge to clean or cap without dredging).

For both alternatives, most of the contaminated material will be removed and disposed prior to any placement of clean material. The two alternatives are summarized below:

- **Alternative 1** combines the options that focus on the removal of PCBs from the site, with only limited capping along the upland/bank zone and backfilling of the mudflat and submerged zones after dredging to re-establish the original bottom contours. Excavated and dredged material would be disposed at approved TSCA and Subtitle D landfills.

- **Alternative 2** combines the options that maximize removal of sediment with higher concentrations of PCBs from the upland/bank and near-bank mudflat zones, with capping of sediment with lower concentrations of PCBs in the mudflat and submerged zones. Excavated and dredged material would be disposed at approved TSCA and Subtitle D landfills.

Based on the streamlined risk assessment (see Section 2.5), the no-action alternative was not further evaluated for the T-117 removal area. Such an alternative would not satisfy the RAO of removing or controlling PCB-containing sediment at the T-117 EAA that has the potential to be released to the waterway and result in adverse PCB sediment concentrations in the LDW.

In the following sections, each alternative will be defined and then evaluated with regard to effectiveness, implementability, and cost.

5.2.1 Alternative 1

Alternative 1 is a combination of the options that focus on the removal of impacted soil and sediment from the T-117 removal area, while at the same time avoiding the net loss of intertidal habitat. The configuration of Alternative 1 is presented as a site plan on Figure 5-1, and as cross-sections on Figures 5-2 through 5-12 (see map folio). Alternative 1 combines the following options:

- Upland/bank option UB3—Excavation and Capping
- Mudflat option M1—Excavation
- Submerged zone option S4—Dredging and Backfilling
- Piling removal

The details of each component of Alternative 1 are described below.

5.2.1.1 Alternative 1 – Upland/bank excavation and capping (UB3) component

Upland Excavation

The upland areas of T-117 (defined as existing grade down to elevation +14 ft MLLW) contain the highest concentrations of PCBs at the site (up to 200 mg/kg dw). As envisioned in this EE/CA, Alternative 1 includes upland excavation starting at the upland removal area boundary, extending sufficiently deep to remove highly contaminated subsurface soil, then generally extending down at a 2H:1V slope to elevation +14 ft MLLW, and then extending horizontally to the shoreline. Remaining material on the slope exposed by the excavation would be covered by a permanent cap consisting of filter fabric, quarry spalls, and a surface layer of sand and gravel. As discussed in Section 2.6.2.1, catch basin 5 will be removed as part of the action and replaced with a structure better suited for retaining sediment and periodic cleaning.

The actual configuration of the excavation and capping would be established during design. Results of additional explorations and studies being conducted along the upland bank and south ditch area (Windward et al. 2005c) will be incorporated into the final design to refine the depth and extent of removal, as well as the nature and extent of backfill and capping (if required), which may change the configuration from that shown on Figures 5-2 through 5-6. Caps would be designed in general accordance with applicable EPA capping guidance. The design would also establish contingency actions to address unanticipated materials and conditions.

The upland zone at the northern end of the site (from transect 2 north) contains an estimated 1,300 to 1,500 cy of soil with an average concentration of 70-75 mg/kg dw PCBs. The southern end of the upland zone contains an estimated 800-1,000 cy of soil with an average concentration of around 15-20 mg/kg dw PCBs. As discussed in Section 4.3, excavated material containing more than 50 mg/kg dw PCBs must be handled according to the TSCA-mandated requirements set forth under 40CFR761. Under Alternative 1, the northern end of the upland zone would thus be set up as a separate removal management zone with the excavated material disposed in a TSCA landfill.

Bank Excavation and Capping

The configuration of the bank is such that full removal of the impacted material is not practical (see discussion of option UB1 in Section 5.1.1). Consequently, the bank work is a combination of excavation and capping. As envisioned in this EE/CA, the bank would be excavated to a 2H:1V slope, removing impacted soil, creosote-treated timbers and piles, asphalt, debris, and other material. Following excavation, the exposed surface of the slope would be capped with filter fabric, quarry spalls, and a surface layer of sand and gravel.

The actual configuration of the excavation and capping would be established during design. As shown on the drawings, the concept cap covers the full extent of the excavated slope down to the toe of the slope at post-removal elevation 0′MLLW, and then extends horizontally about ten feet into the cleaned mudflat zone. While no contamination is expected in the mudflat zone beyond the toe of the slope at post-removal elevation 0′ MLLW, the cap is extended into the zone to provide for long-term integrity of the cap structure at the toe of the bank. Caps would be designed in general accordance with applicable EPA capping guidance. The design would also establish contingency actions to address unanticipated materials and conditions.

Bank Alignment

The alignment of the bank excavation and capping would be such as to avoid undermining the paving cap adjacent to the removal boundary, and to avoid any net loss of intertidal habitat acreage. For the purposes of the EE/CA, the +10 ft MLLW elevation contour of the existing grade is generally used as the control line for maintaining intertidal habitat acreage, as shown on the cross-sections for Alternative 1 along transect M1 (Figure 5-2), transects 1, 2, and 3 (Figures 5-5, 5-6, and 5-7, respectively), and transect 5 (Figure 5-9). At these transects the +10 ft MLLW contour of the cap matches the location of the +10 ft MLLW contour of the existing grades.

At transect 4 (Figure 5-8) and transect 6 (Figure 5-10), the +10 ft MLLW contour of the cap is located outboard of the +10 ft MLLW contour of the existing grade to avoid undermining of the existing paving cap and the concrete slab at the south end of the site. Additional studies would be completed during removal design to evaluate refinements that might reduce the extent of filling in these areas and thereby reduce the impacts to habitat acreage.

South Park Marina Bank Alignment

Within the South Park Marina, the final grade of the cap is pulled into the shoreline so as to maintain the navigation channel in the marina at the planned -8 ft MLLW (transects M-2 and M-3, Figures 5-3 and 5-4). For the purpose of the EE/CA, the 0 ft MLLW contour of the cap was generally set to match the 0 ft MLLW contour of the existing grade in the marina. The final bank alignment in South Park Marina would be refined during design.

Along a portion of the South Park Marina shoreline, the upland area may extend slightly (0-10 ft) into the interior of the paved area of T-117, where a short sheet pile retaining wall may be installed to avoid encroachment of the cap into the marina navigation channel (see Figures 5-3 and 5-4). The application of the sheet pile wall will be determined by EPA during the design process. The base of the sheet pile wall would be located above elevation +12 to +14 ft MLLW. Final configuration of the South Park Marina would be established during design.

South Drainage Ditch

Surface soils with elevated PCBs would be excavated in the bank and upland portion of the south drainage ditch. The extent of the excavation is limited by the presence of building foundations to the north and a steep bank with large trees leading to the Boeing property to the south. Additional explorations and studies are planned during final design to refine the depth and extent of the south ditch removal, as well as the nature and extent of backfill and capping (if required), which may change the excavation from that shown on Figure 5-11.

5.2.1.2 Alternative 1 – Mudflat excavation (M1) component

The mudflat zone contains moderately elevated PCB concentrations, less than those found in the upland bank zone. Alternative 1 removes mudflat material with elevated PCBs, exposing native sediment that meets the cleanup standard. The mudflat excavation would start at the toe of the bank cut and progress out to the limit of the mudflat zone at the existing 0 ft MLLW contour, as shown on Figures 5-6 through 5-10. Most of the excavation would be completed in the dry while the tides are out. Excavating 2 ft of material at the existing 0 ft MLLW contour, down to elevation -2 ft MLLW would result in the most outboard portion of the excavation (a strip 10-15 ft wide) occurring partially in 1-2 ft of water.

South Park Marina

As shown on Figures 5-2, 5-3, and 5-4, the cut slope extends down to elevation -10 ft MLLW without a bench cut at elevation 0 ft MLLW in order to maintain navigation depths in the marina.

The volume of sediment to be removed from the mudflat zone for Alternative 1 is estimated at 1,700-2,000 cy, with an average concentration of 5-10 mg/kg dw PCBs.

5.2.1.3 Alternative 1 – Submerged zone dredging and backfilling (S4) component

Dredging

The submerged zone typically contains the lower levels of PCB sediment concentrations found within the project boundary. Alternative 1 removes submerged zone sediment with elevated PCBs, exposing native sediment that meets cleanup standard. The submerged zone dredging would start at the existing 0 ft MLLW contour and normally consist of two step cuts out to the boundary line. At the southern end of the site, the first step cut would be at elevation -4 ft MLLW and the second at -7 ft MLLW (Transects 3, 4, and 5 on Figures 5-7, 5-8, and 5-9, respectively). In the central portion of the site, the first step cut would be at elevation -5 ft MLLW and the second at -10 ft MLLW (Transects 1 and 2, Figures 5-5 and 5-6). At the South Park Marina there would be only one cut elevation, at -10 ft MLLW, due to the navigation issues at the marina (transects M-1, M-2, and M-3, on Figures 5-2, 5-3, and 5-4, respectively). Dredge cuts will be finalized in the removal design. The dredging would be completed with floating equipment, working at higher tides as needed to provide the needed draft for the barges.

The volume of sediment to be removed from the submerged zone for Alternative 1 is estimated at 5,000-5,500 cy, with an average concentration of 1-2 mg/kg dw PCBs.

Backfilling

Once dredging is complete, the submerged and mudflat zones outside the South Park Marina would be backfilled to the pre-existing elevations to maintain a similar acreage and elevation of habitat, as shown on Figures 5-5 through 5-11. The backfill material would be imported, contaminant-free natural (not crushed) sand and gravel. The backfill would be placed with floating equipment, working at higher tides as needed to provide the needed draft for the barges.

5.2.1.4 Alternative 1—Volumes

The estimated volumes of excavation, dredging, capping, and backfilling associated with Alternative 1 are summarized in Table 5-2. Capping is planned for the upland and bank areas of the site, as well as the submerged zone adjacent the marina at the north end of the site (see Figures 5-2 through 5-5 for submerged zone capping). Backfilling is planned over clean excavated/dredged surfaces of the mudflat zone (except for toe of bank cap), as well as over the majority of the submerged zone, except at area of capping adjacent the marina.

Table 5-2. Alternative 1 volumes

ZONE	PCBS REMOVED (lbs)	AVERAGE PCB CONCENTRATION (mg/kg dw)	VOLUME REMOVED (cy)	CAP MATERIAL VOLUME (cy)	BACKFILL VOLUME (cy)
Upland north	~280	70-75	1,500	1,000	0
Upland south	~40	15-20	1,000	500	0
Bank	~60	5-10	3,000	3,000	0
Mudflat	~30	5-10	2,000	1,000	1,000
Submerged	~20	1-2	5,500	1,000	3,000
Total	~430	-	13,000	6,500	4,000

5.2.1.5 Alternative 1—Piling removal and replacement

The numerous out-of-service creosote-treated timber piles within the removal area would be pulled or cut off below mud line and disposed. In addition, the creosote-treated timber piles currently in service as a debris barrier at the upstream end of South Park marina would be pulled and replaced with not treated piles (steel or concrete – to be established during final design).

5.2.1.6 Evaluation of Alternative 1

An initial evaluation of Alternative 1 is provided below, followed by a more detailed comparative analysis of Alternatives 1 and 2 in Section 6.

Effectiveness

Alternative 1 would be effective in removing and controlling PCB contamination from the T-117 EAA. Both removal and capping are proven technologies that have been used successfully in similar shoreline cleanup actions at EPA Region 10 Superfund sites. Alternative 1 satisfies the RAOs for the T-117 removal area by creating a post-construction surface that meets the cleanup standards, and providing effective long-term containment of remaining material. By meeting the cleanup standards, Alternative 1 will also be protective of human health and the environment by removing or isolating PCB-containing soil and sediment.

Based on the proven success of similar EPA Region 10 removal/capping projects, Alternative 1 is expected to comply with applicable or relevant and appropriate requirements (ARARs).

Alternative 1 would remove a total of approximately 430 pounds of PCBs from the aquatic environment. Remaining impacted material would be reliably contained by capping, which would require long-term management. Alternative 1 does not include treatment to reduce the toxicity, mobility, or volume of contaminants.

Implementability

The Alternative 1 removal and capping in the upland, bank, and mudflat zones can be completed using commonly available upland construction equipment and materials. Excavated materials can readily be trucked off site and imported material brought on site with conventional trucking equipment. The work for Alternative 1 would be completed when the tides are out and it is possible to readily see and control the work being completed. The work would best be scheduled during May through August to maximize the days of very low tides available for completion of the work.

The submerged-zone removal for Alternative 1 can be completed using commonly available materials and floating construction equipment. Dredged materials can readily be moved off site and imported material brought on site with conventional barges. Dredged sediment can be offloaded from barges to either rail cars or trucks at existing re-handling facilities within the Port of Seattle. The submerged-zone work for Alternative 1 would be completed during periods of the day when the tides are high to provide the needed draft for the floating equipment.

Most of the work for Alternative 1 would be completed on land owned or controlled by the Port, including the South Park Marina. Coordination is ongoing between the Port and the South Park Marina to integrate the cleanup action with the Marina's proposed navigation dredging. No special arrangements regarding easements or rights-of-way are anticipated for the work. There are no apparent impediments to imposing deed restrictions to provide long-term protection of the capped area because all of the affected area is controlled by the Port.

Cost

The estimated removal action cost for Alternative 1 is detailed on Table 5-3.

Table 5-3. Alternative 1 cost estimate

Task	Cost
Mobilization	$200,000
Upland/bank excavation and demolition	$200,000
Mudflat excavation	$50,000
Submerged dredging and marine demolition/construction	$250,000
Capping from upland	$200,000
Capping from waterway	$150,000
Washington State sales tax estimate	$100,000
Disposal	$1,150,000
Contingency (~25%)	$500,000
Removal action oversight (~15%)	$400,000
Long-term monitoring and maintenance, present value[a]	$150,000
Total estimated cost	$3,350,000

[a] Long-term monitoring costs based on six events at $15,000 each over ten years. Maintenance costs assumed to have a present value of 1/3 the construction cost of the cap, or about $65,000.

5.2.2 Alternative 2

Alternative 2 combines options that remove the soil and sediment with higher concentrations of PCBs from the upland/bank and near-bank mudflat zones and cap the sediment with lower concentrations of PCBs in the mudflat and submerged zones. Alternative 2 also has the potential to expand the intertidal habitat within the project boundary. The configuration of Alternative 2 is presented as a site plan on Figure 5-13, and as cross-sections on Figures 5-14 through 5-20 (see map folio). Alternative 2 is the combination of the following options:

- Upland/bank option UB3 – Excavation and capping (same as for Alternative 1)
- Mudflat option M3 – Excavation and capping
- Submerged option S2 – Capping
- Piling removal

The details of Alternative 2 components are described below.

5.2.2.1 Alternative 2—Upland/bank excavation and capping (UB3) component

The upland bank component of Alternative 2 is the same as for Alternative 1 (UB3 Excavate and Cap). See Section 5.2.1 for a detailed description of this component. In summary, Option UB3 removes upland material (upland defined as existing grade down to elevation +14 ft MLLW) except as limited for the protection of the existing upland structures. The bank would be excavated down to a slope, removing impacted soil, creosote-treated timbers and piles, asphalt, debris, and other material. Then the exposed upland/bank surface would be capped with filter fabric, quarry spalls, and a surface layer of sand and gravel.

The volume of sediment to be removed from the upland/bank zone for Alternative 2 is the same as for Alternative 1.

5.2.2.2 Alternative 2—Combined mudflat excavation and capping (M3) component

The mudflat zone contains moderately elevated PCB concentrations, less than those found in the upland bank zone. The highest concentrations of PCBs in the mudflat zone are found closest to the bank, with lower concentrations found further offshore. Alternative 2 removes the mudflat material with higher PCB concentrations closer to the bank, and caps the material with lesser PCB concentrations further offshore. The mudflat excavation would start at the toe of the bank cut at elevation 0 ft MLLW and progress horizontally out to the limit of the mudflat zone at the existing 0 ft MLLW contour, as shown on Figures 5-14 through 5-19. Unlike Alternative 1, which dredges to clean material a couple of feet below the existing 0 ft MLLW contour, Alternative 2 dredges no deeper then 0 ft MLLW (horizontal cut at 0 ft MLLW) out to the 0 ft MLLW contour. By setting the deepest extent of the mudflat excavation to 0 ft MLLW (horizontal cut down to elevation 0 ft MLLW), all of the excavation would be completed in the dry while the tides are out beyond the 0 ft MLLW contour. Once the excavation is complete the exposed mudflat surface would be capped in the same manner as the upland/bank, with filter fabric, quarry spalls, and a surface layer of sand and gravel.

The volume of sediment to be removed from the mudflat zone for Alternative 2 is estimated at 1,200-1,500 cy, with an average concentration of 5-10 mg/kg dw PCBs.

5.2.2.3 Alternative 2—Submerged zone capping (S2) component and limited dredging

The submerged zone typically contains the lowest concentrations of PCBs in sediments found within the project boundary. Except for South Park Marina, Alternative 2 leaves the submerged zone sediments in place, covered with a minimum of 3 ft of capping material, as shown on transects 1 through 6 (Figures 5-14 through 5-19, respectively). Within South Park Marina, the submerged zone impacted sediment is removed as described in Alternative 1 to maintain navigation depths in the marina. The capping material would be placed with floating equipment, working at higher tides as needed to provide the required draft for the barges.

The volume of sediment to be removed from the submerged zone for Alternative 2 is estimated at 1,800-2,000 cy, with an average concentration of <1-mg/kg dw PCBs.

5.2.2.4 Alternative 2—Volumes

The estimated volumes of excavation, dredging, and capping associated with Alternative 2 are summarized in Table 5-3.

Table 5-4. Alternative 2 volumes

Zone	PCBs Removed (lbs)	Average PCB concentration (mg/kg dw)	Volume Removed (cy)	Capped Material Volume (cy)	Backfill Volume (cy)
Upland north	~280	70-75	1,500	1,000	0
Upland south	~40	15-20	1,000	500	0
Bank	~60	5-10	3,000	3,000	0
Mudflat	~20	5-10	1,500	2,000	0
Submerged	~2	<1	2,000	3,500	0
Total	~400		9,000	10,000	0

5.2.2.5 Alternative 2—Piling removal and replacement

The numerous out-of-service creosote-treated timber piles within the removal area would be pulled or cut off below mud line and disposed. In addition, the creosote-treated timber piles currently in service as a debris barrier at the upstream end of South Park marina would be pulled and replaced with not treated piles (steel or concrete – to be established during final design).

5.2.2.6 Evaluation of Alternative 2

An initial evaluation of Alternative 2 is provided below, followed by a more detailed comparative analysis of Alternatives 1 and 2 in Section 6.

Effectiveness

Alternative 2 would be effective in removing and controlling PCB contamination from the T-117 EAA. Both removal and capping are proven technologies that have been used successfully in similar shoreline cleanup actions at EPA Region 10 Superfund sites. Alternative 2 satisfies the RAOs for the T-117 removal area by creating a post-construction surface that meets the cleanup standards, and providing effective long-term containment of remaining material. By meeting the cleanup standards, Alternative 2 would also be protective of human health and the environment by removing or isolating PCB-containing soil and sediment.

Based on the proven success of similar EPA Region 10 removal/capping projects, Alternative 2 is expected to comply with ARARs.

Implementability

The Alternative 2 removal and capping in the upland, bank, and mudflat zones has the same implementability and scheduling considerations as Alternative 1.

The submerged-zone removal and capping for Alternative 2 can be completed using commonly available materials and floating construction equipment. Dredged materials can readily be moved off site and imported material brought on site with conventional barges. Dredged sediment can be offloaded from barges to either rail cars or trucks at existing re-handling facilities within the Port of Seattle. The submerged-zone work for Alternative 2 would be completed during periods of the day when the tides are high to provide the needed draft for the floating equipment.

The work for Alternative 2 would be completed on land owned or controlled by the Port, including the South Park Marina. Coordination is ongoing between the Port and the South Park Marina to integrate the cleanup action with the Marina's proposed navigation dredging. No special arrangements regarding easements or rights-of-way are anticipated for the work. There are no apparent impediments to imposing deed restrictions to provide long-term protection of the capped area because all of the affected land is controlled by the Port.

Cost

The estimated removal action cost for Alternative 2 is detailed on Table 5-5.

Table 5-5. Alternative 2 cost estimate

Task	Cost
Mobilization	$200,000
Upland/bank excavation and demolition	$200,000
Mudflat excavation	$50,000
Submerged dredging and marine demolition/ construction	$150,000
Capping from upland	$250,000
Capping from waterway	$100,000
Washington State sales tax estimate	$100,000
Disposal	$850,000
Contingency (~25%)	$500,000
Removal action oversight (~15%)	$300,000

TASK	COST
Long-term monitoring and maintenance, present value[a]	$400,000
Total estimated cost	$3,100,000

[a] - Long-term monitoring costs based on six events at $50,000 each over ten years. Maintenance costs assumed to have a present value of 1/3 the construction cost of the cap, or about $100,000.

6.0 Comparative Analysis of Removal Action Alternatives

This comparative analysis follows EPA's *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (EPA/540-R-93-057), which is based on a comparison of effectiveness, implementability, and cost as follows:

- Effectiveness
  - overall protection of human health and the environment
  - achievement of RAOs
  - compliance with ARARs
  - reduction of toxicity, mobility, or volume through treatment
  - short-term effectiveness
  - long-term effectiveness and permanence
- Implementability
  - technical feasibility
  - availability
  - administrative feasibility
- Cost

The comparative analysis of the two alternatives based on these criteria is presented below.

6.1 EFFECTIVENESS

6.1.1 Overall protection of human health and the environment

Alternatives 1 and 2 are identical for the upland/bank zones of the removal area, and include removal to the maximum extent practicable and capping. Alternative 1 removes all of the impacted sediment within the mudflat and subtidal zones, while Alternative 2 includes capping in these zones. Both alternatives would reduce risks to human health and the environment over the long term by removing PCB-containing soil and sediment, and containing any remaining PCB-containing soil and sediment with an engineered cap. Both alternatives would achieve the RAOs and comply with all ARARs. Both alternative rely on removal and capping technologies which are proven technologies that have been used successfully in similar shoreline cleanup actions at EPA Superfund sites

6.1.2 Achievement of RAOs

Both Alternatives 1 and 2 satisfy the RAOs for the T-117 removal area in the upland, bank, mudflat, and submerged zones by creating a post-construction surface that meets the cleanup standards, and providing effective long-term containment of remaining material with engineered caps.

6.1.3 Compliance with ARARs

Potential ARARs were identified for the LDW in the Phase 1 RI (Windward 2003a). Many of these ARARs are also relevant to both removal alternatives. The T-117 removal action will meet the substantive requirements of ARARs to the greatest extent practicable. Additional discussion on ARAR compliance is provided below for selected ARARs, including SMS, ESA, and TSCA.

The SMS include numeric chemical standards for total PCBs in sediment. Within the removal boundary, total PCB concentrations in sediment will be well below the SQS for both alternatives because of the use of clean capping material.

Compliance with the ESA will be addressed in the biological assessment to be completed as part of the removal design process. The removal action is expected to be beneficial to threatened chinook salmon by greatly reducing their potential exposure to PCBs. In addition, bank remediation is expected to result in a net increase in intertidal acreage, thereby providing additional habitat for this species.

As discussed in Section 3.1, one of the ESA-related goals of the project is that the early action result in no net loss of aquatic habitat acreage. Habitat considerations will be discussed with the National Oceanic and Atmospheric Administration (NOAA), USFWS, and WDFW during design. Table 6-1 summarizes the surface area within different elevation ranges for the existing condition and Alternatives 1 and 2, and documents the achievement of this goal.

Table 6-1. Habitat acres by elevation range

Habitat Elev. Range (ft MLLW)	Existing Acres	Alternative 1 Acres	Alternative 2 Acres
Upland (Above +12)	0.40	0.37	0.37
Aquatic (Below +12)			
+12 to +4	0.34	0.34	0.34
+4 to -4	1.00	0.93	1.02
-4 to -10	0.14	0.24	0.15
Deeper than -10	0.00	0.00	0.00
Subtotal - Aquatic	1.48	1.51	1.51
Total	1.88	1.88	1.88

As shown in Table 6-1, there is slight decrease of upland habitat and a corresponding increase in aquatic habitat for both Alternatives 1 and 2 (0.03-ac change). There is also a slight redistribution of aquatic habitat by elevation ranges from the existing condition to that for Alternative 1 or 2. Alternative 1 shows a 0.07-ac decrease of habitat area in the +4 to -4 ft MLLW elevation range, and a 0.10-ac increase of habitat area in the -4 to -10 ft MLLW elevation range. Alternative 2 shows a 0.02-ac increase of habitat area in the +4 to -4 ft MLLW elevation range, and a 0.01-ac increase of habitat area in the -4 to -10 ft MLLW range.

Both alternatives will comply with TSCA because all soils and sediments with total PCB concentrations greater than 50 mg/kg dw will be designated for disposal at a TSCA landfill, as described in Section 4.3.1.2.

Table 6-2 is a comprehensive list of ARARs that were identified as a potential ARARs in the LDW in the Phase 1 RI (Windward 2003a) and are applicable to the T-117 removal action.

Table 6-2. ARARs

SOURCE	REQUIREMENT
Washington State Model Toxics Control Act WAC 173-340-440	These regulations are applicable to establishing institutional controls for capping and for selecting cleanup actions. The removal would comply with these requirements by implementing appropriate institutional controls in capped areas administered by the Port.
Federal Water Pollution Control Act/ Clean Water Act (CWA) 33 USC 1251-1376 40 CFR 100-149	Established the basic structure for regulating discharges of pollutants into the waters of the United States. Section 404 regulates the discharge of dredged material or fill into navigable waters. Section 401 requires water quality certification for such activities. The removal action will comply with these regulations through the implementation of best management practices and a water quality monitoring program.
Washington State Water Quality Standards for Surface Waters WAC 173-201A	Standards for the protection of surface water quality have been established in Washington State. Acute marine criteria are anticipated to be relevant and appropriate requirements for discharge to marine surface water during sediment dredging. The removal action will comply with these regulations through the implementation of best management practices and a water quality monitoring program.
Washington State Sediment Management Standards WAC 173-204	Chemical concentration and biological effects standards are established for Puget Sound sediments and are applicable to both alternatives. Within the removal boundary, total PCB concentrations in sediment will be well below the SQS for both alternatives because of the use of clean capping material.
Construction in State Waters, Hydraulic Code Rules RCW 75.20 WAC 220-110	Hydraulic project approval and associated requirements for construction projects in state waters have been established for the protection of fish and shellfish. The removal action will comply with the substantive requirements of these regulations by implementing best management practices for the protection of fish and shellfish, as recommended by the Washington Department of Fish and Wildlife.
Toxic Substances Control Act (TSCA) 40 CFR 761	This regulation pertains to upland remediation PCB waste. The removal action will comply with TSCA because all soils and sediments with total PCB concentrations greater than 50 mg/kg dw will be designated for disposal at a TSCA landfill.

SOURCE	REQUIREMENT
Federal Endangered Species Act of 1973 16 USC 1531 et seq. 50 CFR 200 50 CFR 402	This regulation is applicable to any actions performed at this site as this area is potential habitat for threatened and/or endangered species. A biological assessment will be conducted in conjunction with the removal design documents in consultation with NOAA Fisheries (NMFS) and USFWS. The removal action will comply with the substantive requirements of the Act by implementing best management practices for the protection of fish and shellfish, as recommended by NMFS and USFWS.
Essential Fish Habitat (EFH) provisions of the Magnuson-Stevens Fishery Conservation and Management Act 50 CFR 600	Identifies and protects important habitats of federally managed marine and anadromous fish species in consultation with NMFS regarding the potential effects of the action on EFH. The removal action will comply with the requirements of the Act by implementing best management practices for the protection of EFH, as recommended by NMFS, and respond in writing to NMFS's recommendations.
US Fish and Wildlife Coordination Act. 16 USC 661-667(e)	Prohibits water pollution with any substance deleterious to fish, plant life, or bird life. The US Fish and Wildlife Service and appropriate state agencies will be consulted to ascertain the means and measures necessary to prevent, mitigate, or compensate for project-related damages or losses to fish and wildlife resources.
Migratory Bird Treaty Act 16 USC 703-712	Governs the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts and nests. Action will be taken to protect habitat for migratory birds.
Rivers and Harbors Appropriations Act 33 USC 403 33 CFR 322	Section 10 of this act establishes permit requirements for activities that may obstruct or alter a navigable waterway. Activities that could impede navigation and commerce are prohibited. These substantive permit requirements are anticipated to be applicable to actions such as dredging, which may affect the navigable portions of the waterway.
Solid Waste Handling Standards WAC 173-350	Applicable to the disposal of non-hazardous waste generated during removal activities. These standards set minimum functional performance standards for the proper handling and disposal of solid waste, identifies functions necessary to assure effective solid waste handling programs at both the state and local level, and follows priorities for the management of solid waste as set by the legislature in chapter 70.95 RCW, Solid waste management -- reduction and recycling.
Washington Dangerous Waste Regulations WAC 173-303	The state RCRA program regulations which operate in lieu of the federal RCRA program in Washington, and contain a series of rules that are applicable to the generation, handling, storage and disposal of dangerous waste.
Native American Graves Protection and Repatriation Act 25 USC 3001 et seq; 43 CFR Part 10	Excavation must cease if Native American burials or cultural items are inadvertently discovered.
American Indian Religious Freedom Act 42 USC 1996 et seq.	Work must stop if sacred religious sites are discovered.
National Historic Preservation Act 16 USC 470(f); 36 CFR Parts 60, 63, and 800	The removal action must be evaluated to avoid, minimize, or mitigate the impact on historic sites or structures if discovered.
Archaeological Resources Protection Act 16 USC 470 et seq; 43 CFR Part 7	Removal of archaeological resources is prohibited without a permit.
Shorelines Management KCC Title 25	Regulates all building, excavation, dredging, and filling within 200 feet of regulated shorelines. Any illegal fill placed after 1972 must be removed.

Source	Requirement
Critical Areas KCC Title 21A.24	State law (the Growth Management Act) requires local governments to develop regulations to protect critical areas, but the content of these regulations is left to local government discretion, and these ordinances are nor subject to state approval. These will be addressed as To Be Considered for CERCLA purposes.

6.1.4 Long-term effectiveness and permanence

6.1.4.1 Upland/bank

Both Alternatives 1 and 2 involve partial excavation of PCB-contaminated material, followed by capping of the remaining PCB-containing material. Removal provides the greatest long-term reliability because the PCB material is removed from the shoreline area and will not be available for release to the LDW sediment in the future. The cap proposed for Alternatives 1 and 2 is designed to remain stable and provide long-term containment of the remaining impacted soil. Both the bank and upland zones are outside of areas of activity that could damage the cap, such as vehicle or ship traffic or prop wash. Long-term reliability of the upland/bank cap can be maintained with deed restrictions that limit disturbing activities, and through an operations and maintenance plan that requires periodic monitoring and repair of the cap. The design life of the upland/bank cap will be evaluated in a Design Analysis Report, which will include the cap's length of performance as designed, assuming it is not disturbed. The cap's performance will be monitored to assure it continues to provide long-term containment and the associated protection of human health and the environment. EPA will assess the performance of the cap no less frequently than every five years, for as long as hazardous substances remain on site at concentrations of concern.

6.1.4.2 Mudflat

Alternative 1 removes all of the PCB-containing material in the mudflat zone, while Alternative 2 involves partial excavation and then capping of remaining PCB-containing sediment. Removal provides the greatest long-term reliability because the PCB material is removed from the shoreline area and will not be available for release to the LDW sediment in the future. The mudflat zone cap proposed for Alternative 2 is designed to remain stable and provide long-term containment of the remaining impacted soil. The mudflat zone is outside of areas of activity that could damage the cap, such as large-ship traffic or prop wash. Long-term reliability of the mudflat zone cap can be maintained with deed restrictions that limit disturbing activities, and through an operations and maintenance plan that requires periodic monitoring and repair of the cap.

6.1.4.3 Submerged zone

Alternative 1 removes all of the PCB-containing sediment from the submerged zone, while Alternative 2 leaves the PCB-containing sediment in place and covers it with a cap. Removal provides the greatest long-term reliability because the PCB material is removed from the shoreline area and will not be available for release to the LDW sediment in the future. The submerged-zone cap proposed for Alternative 2 is designed to remain stable and provide long-term containment of the remaining PCB-containing sediment. The submerged zone is outside of the navigation channel where shipping activity could damage the cap. Long-term reliability of the submerged-zone cap can be maintained with deed restrictions that limit disturbing activities, and through an operations and maintenance plan that requires periodic monitoring and repair of the cap.

6.1.5 Reduction of toxicity, mobility, or volume through treatment

Neither Alternative 1 nor Alternative 2 involves treatment. The reduction of toxicity, mobility, or volume through treatment is not considered practicable for the T-117 EAA because of the limited volume associated with the work, as well as the extended schedule required to implement a treatment alternative (see Section 4.3).

6.1.6 Short-term effectiveness and implementation risk

6.1.6.1 Upland/bank

Disturbance of the soil cover and removal of impacted soil from the upland/bank zone would result in some short-term release of PCB-containing material to the LDW. However, the highest concentrations of PCBs are found in the soils upland zone, which will not be exposed to the tides. Soils with intermediate concentrations of PCBs are found in the bank zone soils. Engineering controls (completing the excavation when the tides are out, and covering the excavated face soon after it is exposed) could greatly limit the release potential from the upland and bank zones. By generally completing the upland/bank excavation from the top down, material released during excavation from the upper reaches of the cut can be captured when the lower reaches of the cut, including the mudflat zone, are completed.

6.1.6.2 Mudflat

Disturbance of impacted sediment from the mudflat zone would result in some short-term release of PCB-containing material to the LDW. However, lower concentrations of PCBs are found in the mudflat zone than in the upland and bank zones. Engineering controls (completing the excavation when the tides are out, and covering the excavated face soon after it is exposed) could greatly limit the release potential from the mudflat zone. Scheduling the upland/bank work between May and August would allow for the greatest number of very low tide days, when the risk of release due to exposure of the cut face to the rising tide is lowest. Alternative 2 involves only a partial removal, all above elevation 0 ft MLLW, while Alternative 1 involves complete removal in the mudflat zone to a cut elevation as low as -2 ft MLLW. Consequently, Alternative 1 has a slightly higher risk of release because of the portion of the excavation that will likely be completed in 1-2 ft of water near the edge of the mudflat excavation.

6.1.6.3 Submerged zone

Disturbance of PCB-containing sediment from the submerged zone will result in some short-term release of PCB-containing material to the LDW. While lower concentrations of PCBs are found in the submerged zone than in the upland, bank, and mudflat zones, the removal from the submerged zone will be with dredging equipment rather than upland-based equipment. Engineering controls (dredging and barge filling practices to limit turbidity) will limit the release potential from the submerged zone.

Alternative 2 calls for capping and does not involve dredging in the submerged zone, while Alternative 1 involves complete removal in the submerged zone. Alternative 1 thus has a slightly higher risk of release during implementation because of disturbance of the submerged sediment by dredging.

6.2 IMPLEMENTABILITY

6.2.1 Sequencing

The implementation of both Alternatives 1 and 2 is based on the sequencing of removal that goes from the upland/bank to the mudflat to the submerged zone. The intent of the sequencing is to remove the most highly impacted material first in order to limit the potential for recontamination. The implementation is also based on upland-based excavation of the upland, bank, and mudflat zone when the tides are out to limit the potential for water-borne sediment transport and recontamination. Sequencing will be further addressed during design, including development of provisions to protect and monitor sediment quality in completed areas of the site from the impacts of subsequent work in adjacent areas.

6.2.2 Technical feasibility and availability

6.2.2.1 Upland/bank

The upland/bank removal and capping for Alternatives 1 and 2 would be completed using commonly available upland construction equipment and materials. The work is located above the highest tide of the LDW and could therefore be completed at any time because it is not impacted by tidal fluctuations in the river. Excavated materials could readily be trucked off site with conventional trucking equipment. This work would be completed when the tides are out and it is easy to see and control the work being completed.

6.2.2.2 Mudflat

The mudflat zone removal for Alternative 1 and partial removal and capping for Alternative 2 would be completed using commonly available upland construction equipment and materials. Excavated materials could readily be trucked off site and imported material brought on site with conventional trucking equipment. The work for both 1 and 2 would be completed when the tides are out and it is possible to see and control the work being completed. The work would best be scheduled between May and August to maximize the days of very low tides for completion of the work. Alternative 2 involves about 500 cy less material handling than Alternative 1, and would consequently require fewer low-tide days to complete. Alternative 2 would result in a small reduction in the cross-sectional area of LDW, and a river hydraulics analysis may be needed to establish the impact (if any) of the capping on flood routing in the LDW.

6.2.2.3 Submerged

The submerged zone removal for Alternative 1 and the capping for Alternative 2 would be completed using commonly available materials and floating construction equipment. Dredged materials can readily be moved off site and imported material brought on site with conventional barges. Offloading of dredged sediment from barges to truck or rail for landfill delivery could be completed at existing facilities. The work for both 1 and 2 would be completed when the tides are high to provide the needed draft for the floating equipment. Alternative 2 would result in a reduction in the cross-sectional area of LDW, and a river hydraulics analysis may be needed to establish the impact (if any) of the capping on flood routing in the LDW.

6.2.3 Administrative feasibility

The work for Alternatives 1 and 2 would be completed on land owned or controlled by the Port, including the South Park Marina. Coordination is ongoing between the Port and the South Park Marina to integrate the cleanup action with the Marina's proposed navigation dredging. No special arrangements regarding easements or rights-of-way are anticipated for the work. There are no apparent impediments to imposing deed restrictions to provide long-term protection of the capped area because all of the affected land is controlled by the Port. Institution controls (ICs) will be developed as part of the design process that will limit site disturbance of capped areas.

6.2.4 Public Involvement

The Port, City, and EPA will coordinate with the public on issues such as schedule, transportation safety plans, and BMPs. The Port and the City will coordinate with EPA to hold meetings or otherwise provide information and get input from stakeholders during the design and cleanup work. These activities would focus on issues of concern (i.e. truck traffic and control of the cleanup site and protection of natural resources).

6.3 COST

The estimated costs for removal Alternatives 1 and 2 are $3,350,000 and $3,100,000, respectively based on present value[5], including long-term monitoring and maintenance costs[6] for the capping components of the cleanup. When long-term monitoring and

[5] Present net worth analysis based on 2006 year 0, and 5% net discount rate.

[6] Long-term monitoring costs based on six events over ten years. Maintenance costs assumed to have a present value of 1/3 the construction cost of the cap.

maintenance costs are considered, the cost difference between Alternatives 1 and 2 is on the order of only $250,000 (~8%), which at a planning level is indicative of the same basic cost for both alternatives.

6.4 SUMMARY OF COMPARATIVE ANALYSIS

Table 6-3 presents a comparison of the removal alternatives.

Table 6-3. Summary of comparative analysis

COMPONENT	ALTERNATIVE 1	ALTERNATIVE 2
General (Tables 5-2 and 5-4)		
Volume removed	1,500 cy upland north 1,000 cy upland south 3,000 cy bank 2,000 cy mudflat 5,500 cy submerged **13,000 cy total**	1,500 cy upland north 1,000 cy upland south 3,000 cy bank 1,500 cy mudflat 2,000 cy submerged **9,000 cy total**
Volume capping/backfill	10,500 cy	10,000 cy
PCB concentration of removed material	70-75 mg/kg dw upland north 15-20 mg/kg dw upland south 5-10 mg/kg dw bank 5-10 mg/kg dw mudflat 1-2 mg/kg dw submerged	70-75 mg/kg dw upland north 15-20 mg/kg dw upland south 5-10 mg/kg dw bank 5-10 mg/kg dw mudflat <1 mg/kg dw submerged
PCBs removed, lbs[a]	~380 upland/bank ~30 mudflat ~20 submerged **~430 total**	~380 upland/bank ~20 mudflat ~2 submerged **~400 total**
Protection of human health and environment	protective	protective
Achievement of RAOs	achieved	achieved
ARARs	Complies with ARARs. Surface sediment PCB concentrations will be below the SQS following the removal action. No net loss of aquatic habitat, with no significant change of the mudflat/submerged contours. Limited in-water work for dredging and for upland-based excavation at and near elevation 0 ft MLLW. Landfill disposal complies with federal and state regulations.	Complies with ARARs Surface sediment PCB concentrations will be below the SQS following the removal action. No net loss of aquatic habitat, with the cap raising the bed of the mudflat and submerged zone about 3 ft. This will result in upward shifts in the bed between approximately elevation 0 and -5 ft MLLW. Limited in-water work for dredging. Landfill disposal complies with federal and state regulations.

COMPONENT	ALTERNATIVE 1	ALTERNATIVE 2
Long-term effectiveness and permanence	Effective and permanent. Removes 430 lbs of PCBs. Upland/bank cap requires long-term monitoring and maintenance.	Effective and permanent. Removes 400 lbs of PCBs. Upland/bank/mudflat/submerged cap requires long-term monitoring and maintenance. Capping area of Alternative 2 is approximately 30% larger than for Alternative 1.
Short-term effectiveness	Highest concentrations of PCBs, found in the upland, are excavated totally in the dry above high water, greatly reducing the short-term potential for PCB release to the LDW. Upland/bank/mudflat excavations are completed from upland to reduce potential risk of PCB release to LDW. Alternative 1 involves some upland-based excavation in the water close to the existing 0 ft MLLW contour. Alternative 1 involves 5,500 cy of submerged zone dredging. Short-term impacts to water quality would be managed through engineering controls and BMPs.	Highest concentrations of PCBs, found in the Upland, are excavated totally in the dry above high water, greatly reducing the short-term potential for PCB release to the LDW. Upland/bank/mudflat excavations completed from upland to reduce potential risk of PCB release to LDW. Alternative 2 does not involve upland-based excavation in the water since upland excavation will not go deeper than 0 ft MLLW contour. Alternative 2 involves 2,000 cy of submerged zone dredging, about 35% of the Alternative 1 dredging. Short-term impacts to water quality would be of slightly shorter duration as compared to Alternative 1.
Implementability	Upland/bank/mudflat work is best completed in May through August when very low tides occur. Alternative 1 involves some upland-based excavation in the water at the existing 0 ft MLLW contour (2 ft deep to elevation -2 ft MLLW) which is more difficult to implement than Alternative 2. Work is completed with conventional upland and waterway-based equipment. The work will be completed on land owned or controlled by the Port. No easements or rights-of-way are anticipated for the work. There are no apparent impediments to imposing deed restrictions to provide long-term protection of the capped area because all of the affected land is controlled by the Port. Institutional controls are required to protect the cap, including deed restrictions if the property is sold	Upland/bank/mudflat work is best completed in May through August when very low tides occur. Alternative 2 does not involve any upland-based removal below elevation 0 ft MLLW, which is easier to implement than Alternative 1. Work is completed with conventional upland and waterway-based equipment. Since Alternative 2 involves Mudflat and submerged zone capping that will result in a slight decrease of the cross-sectional area of the LDW. The work will be completed on land owned or controlled by the Port. No easements or rights-of-way are anticipated for the work. There are no apparent impediments to imposing deed restrictions to provide long-term protection of the capped area because all of the affected land is controlled by the Port. Institutional controls are required to protect the cap, including deed restrictions if the property is sold
Cost	**$3,350,000**	**$3,100,000**

[a] volume of PCBs removed are estimates

In summary, Alternatives 1 and 2 are similar in their effectiveness, implementability, and cost. Alternative 1 offers the advantage of increased removal of PCBs and lesser extent of capping, but comes with a slightly greater short-term water quality impacts during excavation and dredging and at a higher initial cost than Alternative 2. Alternative 2 offers the advantage of lower potential for short-term releases due to a lower volume of in-water removal as well as a lower initial cost, but comes with a higher risk for long-term release from the larger capped area and higher long term costs.

7.0 Recommended Removal Action Alternative

Alternatives 1 and 2 are similar and are both considered valid and viable for the T-117 removal action. The Port and City are recommending Alternative 1 because it removes a greater volume of PCBs from the environment with a lesser risk of potential future release of PCBs to the LDW.

8.0 Schedule

Table 8-1 presents major milestones for the T-117 EE/CA and Removal Design/Removal Action (RD/RA). Figure 8-1 is a Gantt chart of the relationship between milestones and activities.

Table 8-1. Schedule for T-117 EE/CA and RD/RA

MILESTONE	DATE
EE/CA report	
First draft	January 5, 2005
EPA review and comment	10 days from draft submittal
Stakeholder review and comment	15 days following EPA review
Stakeholder briefing [a]	February 14, 2005
Second draft	15 days from close of stakeholder review and comment period
Public comment period	30 days from receipt of second draft
Public meeting [a]	March 15, 2005
Revise second draft	20 days from receipt of public comments period
EE/CA approval [a]	July 2005
EPA Action Memorandum [a]	July 2005
ESA and CWA	
Draft CWA 404 memorandum [a]	November 2005
Draft biological assessment [a]	November 2005
Design	
Prefinal (60%) design [a]	October2005
Final (100%) design [a]	December 2005
RA work plan	
Draft removal action work plan [a]	March 2006
Final removal action work plan [a]	April 2006
Removal action	
Contractor selection [a]	April 2006
Removal action activities – approximate start date [a]	May 2006
Removal action activities – approximate end date [a]	February 2007
Draft RA completion report [a]	March 2007
Final RA completion report [a]	May 2007

[a] Estimates shown for information purposes only

9.0 References

Anderson B. 2002. Personal communication (telephone conversation with Berit Bergquist, Windward Environmental LLC, regarding raptors in the LDW). Falcon Research Group, Bow, WA. March 22.

Beach RA, Geiger C, Jeffries SJ, Treacy SD, Troutman BL. 1985. Marine mammals and their interactions with fisheries of the Columbia River and adjacent waters, 1980-1982. Third annual report. Wildlife Management Division, Washington Department of Wildlife, Olympia, WA.

Canning DJ, Herman SG, Shea GB. 1979. Terminal 107 environmental studies, wildlife study. Prepared for Port of Seattle. Oceanographic Institute of Washington and Northwest Environmental Consultants, Inc., Seattle, WA.

Cargill D. 2004a. Personal communication (discussion with B. Schmoyer, Seattle Public Utilities). December 30, 2004. Washington State Department of Ecology, Bellevue, WA. December 30, 2004.

Cargill D. 2004b. Personal communication (e-mail dated December 2, 2004 to Warren Hansen, FW: 0411-151 PCBs). Toxics Cleanup Program, Washington State Department of Ecology, Bellevue, WA.

City of Seattle. 2004. Personal communication (Unpublished data provided by B. Schmoyer). Seattle Public Utilities, Seattle, WA.

Cohen L. 2003. Personal communication (letter dated May 2 to Nancy Glaser, Wayne Grotheer, Steve Tochko, and Don Theiler regarding Malarkey Early Action Area). Manager, Cleanup Unit No. 3, Office of Environmental Cleanup, US Environmental Protection Agency Region 10, Seattle, WA.

Cordell JR, Tear LM, Simenstad CA, Hood WG. 1996. Duwamish river coastal America restoration and reference sites: Results from 1995 monitoring studies. Fish Research Institute, University of Washington, Seattle, WA.

Cordell JR, Tear LM, Jensen K, Luiting V. 1997. Duwamish river coastal America restoration and reference sites: Results from 1996 monitoring studies. Fisheries Research Institute, University of Washington, Seattle, WA.

Cordell JR, Tear LM, Jensen K, Higgins HH. 1999. Duwamish River coastal America restoration and reference sites: Results from 1997 monitoring studies. FRI-UW-9903. Fisheries Research Institute, University of Washington, Seattle, WA.

Cordell JR, Tear LM, Jensen K. 2001. Biological monitoring at Duwamish River coastal America restoration and reference sites: A seven-year retrospective. SAFS-UW-0108. Wetlands Ecosystem Team, School of Aquatic and Fisheries Sciences, University of Washington, Seattle, WA.

Creative Environmental Technologies. 1996. Level 1 environmental site assessment report, southwest Seattle property located at 8661 Dallas Avenue South. Prepared for Basin Oil Company, Inc. Creative Environmental Technologies, Inc., Tacoma, WA.

Dexter RN, Anderson DE, Quinlan EA, Goldstein LS, Stickland RM, Pavlou SP, Clayton JR, Kocan RM, Landolt M. 1981. A summary of knowledge of Puget Sound related to chemical contaminants. NOAA technical memorandum OMPA-13. Office of Marine Pollution Assessment, National Oceanic and Atmospheric Administration, Boulder, CO.

Ecology. 2004. Lower Duwamish Waterway source control strategy. No. 04-09-043. Washington Department of Ecology, Northwest Regional Office, Toxics Cleanup Program, Bellevue, WA.

Ecology. 2005. Lower Duwamish Waterway source control action plan for the Terminal 117/Malarkey Asphalt early action cleanup. Draft. Washington Department of Ecology, Northwest Regional Office, Bellevue, WA.

EPA. 1993. Guidance on conducting non-time-critical removal actions under CERCLA. EPA/540-R-93-057. Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington, DC.

EPA. 1997a. Ecological risk assessment guidance for Superfund: Process for designing and conducting ecological risk assessments. EPA/540/R-97/006. Interim final. Environmental Response Team, US Environmental Protection Agency, Edison, NJ.

EPA. 1997b. EPA Region 10 supplemental ecological risk assessment guidance for Superfund. EPA/910/R-97/005. Region 10 Office of Environmental Assessment Risk Evaluation Unit, US Environmental Protection Agency, Seattle, WA.

ESG. 1999. Waterway sediment operable unit, Harbor Island Superfund site. Assessing human health risks from the consumption of seafood: human health risk assessment report. Prepared for Port of Seattle, Todd Shipyards, and Lockheed-Martin for submittal to US Environmental Protection Agency, Region 10, Seattle, WA. Environmental Solutions Group, Inc., Seattle, WA.

King County. 1999. King County combined sewer overflow water quality assessment for the Duwamish River and Elliott Bay. Vol 1, Appendix B2, B3, & B4: human health, wildlife, and aquatic life risk assessments. King County Department of Natural Resources, Seattle, WA.

Leon H. 1980. Final Report: Terminal 107 environmental studies. Benthic community impact study for terminal 107 (Kellogg Island) and vicinity. Prepared for Port of Seattle Planning and Research Department. Pacific Rim Planners, Inc., Seattle, WA.

Malins DC, McCain BB, Brown DW, Sparks AK, Hodgins HO. 1980. Chemical contaminants and biological abnormalities in central and southern Puget Sound. NOAA Technical Memorandum OMPA-2. Environmental Conservation Division, National Marine Fisheries Service, Seattle, WA.

Matsuda RI, Isaac GW, Dalseg RD. 1968. Fishes of the Green-Duwamish River. Water Quality Series No. 4. Municipality of Metropolitan Seattle, Seattle, WA.

Meyer JH, Pearce TA, Patlan SB. 1981. Distribution and food habits of juvenile salmonids in the Duwamish Estuary. Prepared for Seattle District, US Army Corps of Engineers. US Fish and Wildlife Service, Olympia, WA.

Miller BS, Wingert RC, Borton SF. 1975. Ecological survey of demersal fishes in the Duwamish River and at West Point 1974. Prepared for Municipality of Metropolitan Seattle. Report no. FRI-UW-7509. Fisheries Research Institute, University of Washington, Seattle, WA.

Miller BS, Simenstad CA, Moulton LL, Fresh KL, Funk FC, Karp WA, Borton SF. 1977. Puget Sound baseline program nearshore fish survey. Final report, July 1974-June 1977. Prepared for Washington Department of Ecology. Fisheries Research Institute, University of Washington, Seattle, WA.

Mowbray EE, Pursley D, Chapman JA. 1979. The status, population characteristics, and harvest of river otters in Maryland. Maryland Wildlife Administration. Waverly Press, Bethesda, MD.

Norman D. 2002. Personal communication (email on 4/5/02 to Berit Bergquist, Windward Environmental LLC, regarding great blue herons in the LDW). Norman Wildlife Consulting, Shoreline, WA. April 5.

Onsite. 2000. PCB removal/containment action, South Park Site. Prepared for Port of Seattle. Onsite Enterprises, Inc., Redmond, WA.

Onsite. 2003. Groundwater sampling results for Port of Seattle's Terminal 117. Letter report submitted to T. Newlon, Stoel Rives, LLP. Onsite Enterprises, Inc., Redmond, WA.

Onsite. 2004. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. T-117 south entrance/access roadway soil sampling. Final work plan and field forms. Prepared for Port of Seattle. Onsite Enterprises, Inc., Redmond, WA.

Palermo M, Maynord S, Miller J, Reible D. 1998. Guidance for In-situ subaqueous capping of contaminated sediments. EPA 905-B96-004. Great Lakes National Program Office, US Environmental Protection Agency, Chicago, IL.

Parametrix. 1991. Site hazard assessment summary report for Malarkey Asphalt Company, Seattle, Washington. Prepared for Washington State Department of Ecology. Parametrix, Inc., Bellevue, WA.

Retec. 2005. Identification of candidate technologies for the Lower Duwamish Waterway. Prepared for the Lower Duwamish Waterway Group. Draft January 2005. Retec Inc., Seattle, WA.

Retec, Integral. 2005. Lower Duwamish Waterway remedial investigation/feasibility study: Technical and policy issues associated with the use of the biogenesis process for the treatment of LDW sediment. Draft. Retec, Seattle, WA and Integral Consulting, Inc., Mercer Island, WA, Integral.

Stewart BS, Leatherwood SL, Yochem PK. 1989. Harbor seal tracking and telemetry by satellite. Mar Mam Sci 5:361-375.

Tabor JE, Wight HM. 1977. Population status of river otter in western Oregon. J Wildl Manage 41:692-699.

Tanner CD. 1991. Potential intertidal habitat restoration sites in the Duwamish River Estuary. EPA 910/9-91-050. US Environmental Protection Agency, Region 10, Seattle, WA.

Taylor WJ, Shreffler DK, Cordell JR. 1999. Duwamish East Waterway channel deepening project: alternative dredge disposal sites juvenile salmonid and epibenthic prey assessment. Technical report. Preliminary draft. Prepared for Port of Seattle. Taylor Associates, Seattle, WA.

URS. 1994. Site inspection report for the Malarkey Asphalt Company, Seattle, Washington. Prepared for the US Environmental Protection Agency, Region 10. URS Consultants, Seattle, WA.

USACE. 2003. Puget Sound confined disposal site study, Washington. U.S. Army Corps of Engineers, Seattle District, Seattle, WA.

Walker B. 1999. Monitoring of 1998-99 California sea lion predation in the Lake Washington estuary and the lower Duwamish River. Washington Department of Fish and Wildlife, Lacey, WA.

Warner EJ, Fritz RL. 1995. The distribution and growth of Green River chinook salmon (*Oncorhynchus tshawytscha*) and chum salmon (*Oncorhynchus keta*) outmigrants in the Duwamish estuary as a function of water quality and substrate. Water Resources Division, Muckleshoot Indian Tribe, Auburn, WA.

WDFW. 2003. Species of concern in Washington State [online]. Washington Department of Fish and Wildlife, Olympia, WA. Updated May 2003. Available from: <http://www.wa.gov/wdfw/wlm/diversty/soc/soc.htm.

Weitkamp DE, Campbell RF. 1980. Port of Seattle Terminal 107 fisheries study. Parametrix, Inc., Bellevue, WA.

West JE, O'Neill SM, Lippert G, Quinnell S. 2001. Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington. Results of the Puget Sound ambient monitoring program fish component 1989-1999. Washington Department of Fish and Wildlife, Olympia, WA.

Weston. 1999. Site inspection report, Lower Duwamish River (RK 2.5-11.5), Seattle, Washington. Vol 1-Report and appendices. Prepared for US Environmental Protection Agency, Region 10. Roy F. Weston, Inc., Seattle, WA.

Williams MS. 1990. Port of Seattle Terminal 107 (Kellogg Island), biological assessment - 1989. Parametrix, Inc, Bellevue, WA.

Windward. 2003a. Lower Duwamish Waterway remedial investigation. Phase 1 remedial investigation report. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2003b. Lower Duwamish Waterway remedial investigation. Task 5: Identification of candidate sites for early action, technical memorandum: Data analysis and candidate site identification. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2004a. Lower Duwamish Waterway remedial investigation. Crab and shrimp pilot study and first quarterly survey data report. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2004b. Lower Duwamish Waterway remedial investigation. Crab and shrimp pilot study and quarterly surveys data report. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2004c. Lower Duwamish Waterway remedial investigation. Crab and shrimp survey second quarterly report. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2004d. Lower Duwamish Waterway remedial investigation. Crab and shrimp survey third quarterly report. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2004e. Lower Duwamish Waterway remedial investigation. Intertidal clam survey data report. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2005a. Lower Duwamish Waterway remedial investigation. Data report: Chemical analyses of benthic invertebrate and clam tissue samples and co-located sediment samples. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2005b. Lower Duwamish Waterway remedial investigation. Data report: Fish and crab tissue collection and chemical analyses. Draft. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2005c. Lower Duwamish Waterway remedial investigation. Technical memorandum: Results from survey of potential human access locations on the

Lower Duwamish Waterway. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward, Onsite. 2004. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. T-117 abandoned utility corridor—excavation, removal and replacement of structurally unsuitable and contaminated fill materials. Prepared for the Port of Seattle. Windward Environmental LLC and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, Onsite. 2003a. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. Quality assurance project plan. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmstead & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, Onsite. 2003b. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. Task 1: Summary of existing information and data needs analysis. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmstead & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, Onsite. 2004a. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. Quality assurance project plan addendum. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmstead & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, Onsite. 2004b. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. T-117 preliminary boundary technical memorandum. Draft. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmstead & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, Onsite. 2004c. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. T-117 quality assurance project plan addendum - South Park Marina sediment sampling. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmstead & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, Onsite. 2004d. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. T-117 quality assurance project plan addendum - surface sediment and analysis of archived sediment samples. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmstead & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, Onsite. 2004e. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. T-117 upland sources data report. Draft. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmstead & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, Onsite. 2005a. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. Sediment, soil, and water field sampling, cruise and data report. Final. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmstead & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, Onsite. 2005b. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. T-117 - South Park Marina sediment sampling data report. Draft. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmstead & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, Onsite. 2005c. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. T-117 quality assurance project plan addendum - additional upland subsurface soils and monitoring wells. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmstead & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.