Port of Seattle

ENGINEERING EVALUATION/COST ANALYSIS FOR THE EAST WATERWAY OPERABLE UNIT, HARBOR ISLAND SUPERFUND SITE

FINAL

For submittal to

The US Environmental Protection Agency
Region 10
Seattle, WA

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Maps (separate volume)

Oversize GIS maps for the main text and Appendix A are published as a separate 11 x 17″ volume.

Acronyms

ACRO	Definition
AET	apparent effects threshold
ARAR	applicable or relevant and appropriate requirement
BEHP	bis(2-ethylhexyl)phthalate
BMP	best management practice
CAD	confined aquatic disposal
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)
CSL	cleanup screening level of SMS
CSO	combined sewer overflow
cy	cubic yard
DDTs	DDT and its metabolites
EE/CA	Engineering Evaluation/Cost Analysis

ACRO	Definition
EF	exceedance factor
EPA	US Environmental Protection Agency
EWW	East Waterway
HHRA	human health risk assessment
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
ML	DMMP maximum level
MLLW	mean lower low water
NCDF	nearshore confined disposal facility
NCP	National Contingency Plan
NTCRA	non-time-critical removal action
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
Port	Port of Seattle
RAO	removal action objective
RD/RA	Remedial Design/Remedial Action
RI/FS	Remedial Investigation/Feasibility Study
RME	reasonable maximum exposure (
ROD	Record of Decision
SL	DMMP screening level
SMS	Washington State Sediment Management Standards
SQS	sediment quality standards of SMS
SVOC	semivolatile organic compound
TBT	tributyltin
TOC	total organic carbon
UCL	upper confidence limit
VOC	volatile organic compound
WDFW	Washington Department of Fish and Wildlife
Windward	Windward Environmental LLC
WSOU	Waterway Sediment Operable Unit

Executive Summary

The US Environmental Protection Agency (EPA) has ordered the Port of Seattle (Port) to address sediment contamination issues in the East Waterway (EWW) Operable Unit (OU) of the Harbor Island Superfund site per the process defined by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or Superfund. As part of this process, the Port is conducting a remedial investigation/ feasibility study (RI/FS) that will ultimately lead to an EPA Record of Decision (ROD) outlining cleanup actions to address threats to human health and the environment in the EWW. Based on a review of initial data collected, EPA has determined that a non-time-critical removal action (NTCRA) is warranted for a portion of the EWW. This NTCRA, termed in this document as the "Phase 1 Removal Action," covers approximately 20 acres in the southern portion of the EWW. Cleanup of the remainder of the EWW will be addressed in Phase 2 through either additional NTCRAs and/or a phased Remedial Design/Remedial Action (RD/RA).

SITE CHARACTERIZATION AND RISK ASSESSMENT

A total of 64 sediment samples and 35 toxicity samples have been collected from the 0-15 cm and 0-4 ft sediment depth horizons to characterize the sediments within the Phase 1 Removal boundary (referred to herein as the Phase 1 Removal area). Sediment chemistry concentrations in the Phase 1 Removal area exceeded sediment management standards for multiple chemicals, with several chemicals having Exceedance Factors greater than 10 times their respective cleanup screening level standards. The chemicals with the greatest number of exceedances are mercury, total PCBs, dieldrin and total DDTs. In addition, toxicity testing of sediments clearly showed both lethal and sublethal effects in benthic test organisms.

The synoptic sediment chemistry and toxicity test results demonstrate that sediment in the Phase 1 Removal area is toxic to the range of benthic organisms used in standard sediment toxicity testing. Based on these results, which form the basis for the risk evaluation, the Phase 1 Removal area meets the National Contingency Plan (NCP) criteria for conducting a Removal Action. Furthermore, the Phase 1 Removal Action is supported by the qualitative HHRA which identified that this action will indirectly reduce exposure to humans by removing sediment containing bioaccumulative chemicals that are found in seafood. Specifically, the Phase 1 Removal Action will take out a substantial quantity of sediment containing high concentrations of PCBs in the EWW.

SCOPE, GOALS, AND OBJECTIVES OF THE REMOVAL ACTION

This NTCRA will clean up sediments within the selected Phase 1 Removal area. The goal of this action is to reduce exposure of ecological receptors to sediment contamination, and thereby reduce or eliminate adverse effects on biological resources in the Phase 1 Removal area.

Although the potential risk to human receptors has not been estimated at this time, the action will reduce potential risks to human health by removing bioaccumulative chemicals that are found in sediment. Human health risks for the entire EWW OU will ultimately be addressed in the ROD.

Based on the existing ecological and human health risk evaluation (as summarized in Section 3.0), the following removal action objective (RAO) was developed for the Phase 1 Removal area:

> Reduce the concentrations of contaminants in sediments to below the cleanup standards (defined in Section 4.4, below) in the biologically active zone (0–10 cm)

The following applicable or relevant and appropriate requirements (ARARs) and other critical factors are of primary importance in the selection and implementation of the removal action:

- Sediment resuspension and or recontamination during the removal action will be minimized by using best management practices (BMPs).
- Consistent with State Hydraulic Code Rules and Endangered Species Act (ESA) requirements, dredging and other in-water work cannot occur during identified "fish window" closure periods. The specific dates of these closures will be identified in consultation with the natural resource trustees. It is currently anticipated that dredging will be prohibited between February 14 and August 16.
- Consistent with Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act (CWA), the selected alternative cannot prevent the use of the EWW as a working navigation channel. The Congressionally directed navigation channel depth of -51 ft mean lower low water (MLLW) must be maintained.
- The removal action will be coordinated with Tribal netfishing in the EWW.
- If possible, the removal action should begin in 2003.
- The removal action will be phased so that a contaminated sediment surface will not be left exposed between the two construction seasons in which the removal action occurs.
- To the extent practicable, the removal action will contribute to the efficient performance of the anticipated remedial action for the EWW OU.

IDENTIFICATION OF REMOVAL ACTION ALTERNATIVES

Candidate technologies for the removal action were identified and screened in order to select the preferred alternative for design and implementation. This section provides a brief description of each of the alternatives considered.

The no-action alternative provides a baseline against which the other removal action alternatives are compared. In this alternative, the sediments would be left in place, and neither dredging nor capping would be implemented in the Phase 1 Removal area.

The *in situ* capping alternative consists of placing an isolation cap composed predominantly of fine sands over the contaminated sediments within the Phase 1 Removal area. An Isolation Cap forms a surface barrier to physically isolate the contaminated sediments from the aquatic environment.

The dredging and disposal alternative consists of dredging approximately 200,000 cubic yards (cy) of contaminated sediments and approximately 59,000 cy of sediment suitable for open-water disposal according to Dredged Material Management Program (DMMP) guidelines [1]. Three potential options for disposal of the Phase 1 contaminated sediment were considered for this alternative and were compared for feasibility based on the Phase 1 Removal action schedule goal and objectives: confined aquatic disposal (CAD), nearshore confined disposal facility (NCDF), and upland landfill disposal. The upland landfill disposal option was selected as the preferred disposal option for the Phase 1 Removal action.

RECOMMENDATIONS

The Engineering Evaluation/Cost Analysis (EE/CA) identified three removal alternatives: no action, capping, and dredging and disposal. Based on the EE/CA evaluation, dredging and disposal was identified as the preferred removal action alternative for the Phase 1 Removal area. Dredging and disposal ranked high in effectiveness (reduction in risk), high in implementability (technical feasibility), and would cost the most of the three alternatives. The no-action alternative ranked low in effectiveness at achieving the objectives of the removal action and was rejected. The *in situ* capping option ranked medium in effectiveness due to long-term uncertainty about meeting all of the cleanup objectives, low in implementability due to institutional factors, and medium in cost relative to the other two alternatives.

Dredging and disposal would remove a substantial quantity of sediment that has been determined through chemical and toxicity testing to be to toxic to the range of benthic organisms used in standard sediment toxicity testing. Removal of the proposed sediment horizon will reduce risk to both ecological and human receptors, meeting the goals and objectives of the removal action.

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[1] DMMP is administered by the USACOE

1.0 Introduction

EPA has ordered the Port to address sediment contamination issues in the EWW (Map 1; GIS maps are published in a separate map folio) per the process defined by CERCLA. As part of this process, the Port is conducting an RI/FS, which will ultimately lead to an EPA ROD outlining cleanup actions to address threats to human health and the environment in the EWW. Based on a review of initial data collected, EPA has determined that a NTCRA is warranted for a portion of the EWW. This NTCRA, termed in this document as the "Phase 1 Removal Action," covers approximately 20 acres in the southern portion of the EWW. Cleanup of the remainder of the EWW will be addressed in Phase 2 through either additional NTCRAs and/or a phased RD/RA.

To fulfill section 300.415(b)(4)(i) of the NCP, an EE/CA must be completed for the Phase 1 Removal. The objectives of an EE/CA are 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 for their effectiveness, implementability, and cost

The scope of the NTCRA determines the detail of the EE/CA. NTCRAs 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 remediation 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).

As required by NCP (300.415[b][2]) the following criteria were met in determining the appropriateness of the Phase 1 Removal Action:

- Actual or potential exposure to nearby human populations, animals, or food chain from hazardous substances or pollutants or contaminants;
- Actual or potential contamination of drinking water supplies or sensitive ecosystems.

The Phase 1 Removal area is presented in Map 2. A technical memorandum presenting the analysis of EWW environmental data, which was used to identify areas suitable for a removal action, is provided in Appendix A. The evaluation reviewed sediment chemistry and toxicity results to identify contaminated areas with sufficient available data to allow for removal action alternative selection and removal action design without further sampling. The Phase 1 Removal area was selected for meeting these criteria.

This document is organized into the following sections:

- Section 2 contains site background information including a description of the site, land use, ecological habitats, and a summary of the previous sediment chemistry and biological investigations conducted within the boundary of the Phase 1 Removal action area
- Section 3 presents the results of a streamlined risk evaluation
- Section 4 presents the scope, goals, and objectives of the removal action.
- Section 5 describes the removal action alternatives
- Section 6 presents the evaluation criteria used to evaluate the proposed alternatives
- Section 7 presents an evaluation of the Phase 1 Removal alternatives
- Section 8 is a comparative analysis of the removal alternatives
- Section 9 contains a discussion of operational controls and management practices that will be employed to minimize potential environmental impacts during the removal action
- Section 10 contains a table of ARARs that will be followed to the greatest extent possible during Phase 1 Removal
- Appendix A, the Removal Boundary Identification technical memorandum, contains an analysis of existing environmental data used to identify the boundary of the Phase 1 Removal action

2.0 Site Characterization

The EWW, located in Seattle's Elliott Bay, is part of the Congressionally directed East, West, and Duwamish Waterways navigation channel. In 1996, per Section 356 of the 1996 Water Resources Development Act, the Port and the U.S. Army Corps of Engineers started working together to deepen the EWW from its current depth of between -50 and -38 ft MLLW to its Congressionally directed depth of –51 ft MLLW. Construction of Stage 1 of the EWW Deepening, which deepened a portion of the EWW to –51 ft MLLW, was completed in February 2000. The depth in the Phase 1 Removal area is approximately -38 MLLW.

The EWW OU is part of the Harbor Island Superfund Site which was listed on the NPL in 1983, due to the contaminants released from a secondary lead smelter, as well as the releases of other hazardous substances from other industrial operations on the island. The Site is being addressed as seven OUs: 1) the petroleum storage tank facilities, 2) soil/groundwater, 3) Lockheed Shipyard, 4) Lockheed Shipyard Sediments, 5) Todd Shipyard Sediments, 6) EWW, and 7) West Waterway. EPA is the lead agency for all but the petroleum storage tank facilities. The EPA site ID number for Harbor Island Superfund site is WAD 980722839.

This section contains a general description of the EWW OU, plus specific information regarding the Phase 1 Removal area, surrounding land use focusing on human health exposure pathways, ecological habitats and species usage, and a summary of previous investigations at the site.

2.1 SITE DESCRIPTION

The EWW is part of the greater Duwamish River estuary, which includes the West Waterway, on the western side of Harbor Island, and the Lower Duwamish Waterway, which extends from the southern tip of Harbor Island to Turning Basin 3 approximately 5 mi south of Harbor Island (Map 1). The bed of the EWW is owned by the State of Washington and managed by the Department of Natural Resources. The EWW is channelized, has a south-to-north orientation, and is approximately 5,800 ft long and 800 ft wide. The southern 1,500-ft section of the EWW varies in width from 225 ft to approximately 130 ft near the West Seattle Bridge (Weston 1993). The depth of the EWW ranges from 29 to 51 ft MLLW (Weston 1993). Depths diminish to 7.2 ft MLLW at the southern end, in the vicinity of the West Seattle Bridge (Weston 1993). Map 3 presents the current bathymetry in the EWW (DEA 2002).

The former Duwamish River channel and surrounding floodplains were filled and graded to form the present-day topography. Dredging in 1903-1905 created the East and West Waterways, and dredged material from the river was used to create Harbor Island (Weston 1993). The present urban and developed shoreline is primarily composed of piers, riprap bank lines, and constructed bulkheads for industrial and commercial use.

The Phase 1 Removal area is located offshore between Terminal 25 and 30. It covers 20 acres and has a depth of approximately -38 MLLW. As shown on Map 3, the Phase 1 Removal area is characterized by diminished depths as compared to the deeper berths at the surrounding terminals.

2.2 SURROUNDING LAND USE AND HUMAN EXPOSURE PATHWAYS

The banks of the EWW support heavy manufacturing and wholesale and maritime industries associated with docking services, cargo handling, fish processing, shipbuilding, and cold storage. The resulting deep-draft vessel and barge traffic on the EWW transport millions of tons of manufacturing materials and other cargo every year.

Harbor Island forms the west bank of the EWW. Used for heavy industry since its formation in the early part of the 20th century, land uses on Harbor Island have included ocean and rail transport operations, bulk petroleum shipment and storage, lead smelting, metal fabrication, food processing, solid waste transfer, wood processing, and shipbuilding. Warehouses, laboratories, and office buildings are now, and historically have been, located on the island. There are currently 35 buildings on the island, and 95% of the island's surface is covered by impervious surface.

Based on review of tax lots, the closest residential properties to the EWW are approximately 0.5 mi away. Three categories of people may have possible access to the EWW: industrial workers, trespassers, and the general public. The majority of people accessing the EWW would fit into the industrial worker category. Trespassers could also access the EWW through the terminals, but this is not expected to occur frequently. Finally, "public access" locations are defined by routes that have been constructed on public property for the express purpose of allowing access to the waterway. Public access on the EWW is limited to a small boat launch on the east shoreline at Terminal 30 and a fishing bridge at the very southern end of the waterway. Although the public boat launch is considered a direct exposure route for the general public, the fishing bridge is considered an indirect exposure pathway because contact with EWW sediment and surface water is associated indirectly through fishing activities.

Although there are no residences adjacent to the EWW, people may come in contact with contaminated sediment in the EWW directly through occupational or recreational activities, or indirectly through consumption of contaminated seafood. The principal pathways are discussed below.

2.2.1 Dermal contact with sediment and water

Individuals from the Treaty Tribes conduct annual commercial netfishing operations in the EWW. 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. People may also come in direct contact with surface water and sediment during recreational fishing. Contact with these media is likely only incidental for fishers.

2.2.2 Seafood consumption

Seafood consumed by people fishing in the EWW may have chemical residues derived via the food web or from direct exposure to contaminated sediments in the EWW.

2.3 EXISTING HABITAT CONDITIONS

The aquatic environment of the EWW is part of the ecologically important Duwamish River estuary. Dredging and development have substantially altered nearshore environments in Elliott Bay and the Duwamish River estuary. Of the pre-settlement habitat, most (98%) of the approximately 5.14 km^2 of tidal marsh and 5.9 km^2 of flats and shallows, and all of about 5 km^2 of tidal wetland, have been either filled or dredged (Blomberg et al. 1988). Currently there is no natural shoreline in the EWW.

The remaining aquatic habitats in the EWW are intertidal and subtidal sediment or water column habitats.

The Phase 1 Removal area consists of subtidal habitat. The sediment reflects riverine inputs, and is composed of organic detritus, flocculants, and river sand. The sediment within the boundary area is dark brown to black, having a total organic carbon concentration ranging from 0.6% to 5.5%, and sediment grain size ranging from 27%–97% fines. The benthic invertebrate community that inhabits the subtidal areas of EWW, including the Phase 1 Removal area, is dominated by annelids, mollusks, and arthropods. Annelids, the most prevalent benthic group in the Duwamish River estuary, are represented by 75 taxa of polychaete worms (Taylor et al. 1999). Mollusks are represented by various bivalves and to a lesser extent by gastropods. Amphipods are the most diverse group of arthropods documented.

2.4 ENDANGERED AND THREATENED SPECIES

Six species reported in the vicinity of Elliott Bay area are listed under the Federal Endangered Species Act as threatened species, endangered species, or species of concern (Table 2-1). With the exception of chinook salmon, coho salmon, bull trout, and bald eagle use of the Duwamish River estuary by these species is rare or incidental, so they are not likely to have frequent exposure to sediment-associated chemicals from the EWW. Reports of river lamprey in the Duwamish estuary are rare (Warner and Fritz 1995,; Matsuda et al. 1968). Reports of peregrine falcon presence are anecdotal (Anderson 2002). These species share life history traits with other more common species in the Duwamish River estuary such that analysis of exposure and effects due to sediment-associated chemicals for the more common species should be protective of these species of concern.

A biological assessment will be conducted in conjunction with the Phase 1 Remedial Design to evaluate the impacts of this removal on endangered and threatened species. Further assessment of endangered and threatened species will be addressed in Phase 2 of this project.

Table 2-1. Federally Listed Endangered or Threatened Species

COMMON NAME	SCIENTIFIC NAME	STATUS
Chinook salmon	*Oncorhynchus tshawytscha*	FT
Coho salmon	*Oncorhynchus kisutch*	FC
River lamprey	*Lampetra ayresi*	FSC
Bull trout	*Salvelinus confluentes*	FT
Bald eagle	*Haliaeetus leucocephalus*	FT[a]
Peregrine falcon	*Falco peregrinus*	FSC

FT – Federal threatened species

FC – Federal candidate species

FSC – Federal species of concern

[a] Listing currently under review for removal

2.5 SUMMARY OF ENVIRONMENTAL DATA

The EWW has been the subject of a number of sediment investigations in recent years. Studies conducted since 1990 are summarized in the Data Summary Report (Windward 2003a). A number of these studies have collected sediment for chemical analysis and toxicity testing in the Phase 1 Removal area (Table 2-2). These studies form the basis for this analysis.

2.5.1 Sediment chemistry characterization

Sixty-four sediment samples have been collected in the Phase 1 Removal area, 10 from the 0-15 cm sediment horizon and 54 from the 0-4 ft sediment horizon (Table 2-2). These samples were collected in nine separate sampling events.

Table 2-2. Number of samples collected within the Phase 1 remedial dredge boundary for each EWW sediment sampling event

Event Name	Reference Source	Sampling Dates	Sample Collection Method	Total Samples Analyzed	Surface Sediment Samples (0–15 cm)	Surface Sediment Samples (0–4 ft)a	Subsurface Sediment Samples (>4 ft)	Post-Dredging Surface Sediment Samples (>-51 ft MLLW)	Toxicity Test Samples
Harbor Island RI	Weston 1993	9/24- 10/31/91	0.1 m^2 van Veen	6	6	0	0	0	0
Harbor Island SRI (HIRI95)	EVS 1996	3/10/-3/23/95	0.1 m^2 van Veen and vibracorer	6	2 [a]	4	0	0	2
KC CSO 95	King County 1995	6/26-6/29/95	0.1 m^2 van Veen	1	1	0	0	0	0
KC CSO 96	King County 1996	9/24-9/30/96	0.1 m^2 van Veen	1	1	0	0	0	1
T-18-Phase 1	EVS 1998	3/11-31/96	vibracorer	33	0	25	8	0	25
T-18-Phase 2	EVS 1998	5/27-6/12/96	vibracorer	22	0	18	4	0	0
EWW-ChannelDeep	SAIC 1999	7/27-8/28/98	vibracorer	21	0	4	17	0	4
EWW/HI Nature and Extent-Phase 3a	Windward 2002	12/7-12/11/01	pneumatic corer	11	0	0	0	11	0
EWW/HI Nature and Extent-Phase Recency	Windward 2003b	2/11-2/12/03	vibracorer	3	0	3	0	0	3

na – Not applicable

[a] Samples were collected from the 0-10 cm sediment depth horizon

2.5.1.1 Physical characteristics

Sediment within the Phase 1 Removal area boundary ranges from silty sand to sandy silt, with the percentage of sand ranging from 3% to approximately 65% sand. The minimum, maximum, and mean grain sizes for each sediment horizon from the Phase 1 Removal area are summarized in Table 2-3.

Table 2-3. Summary of grain size results

SEDIMENT HORIZON	% GRAVEL	%SAND	% SILT	%CLAY
0-15 cm				
Mean	0.40	21.2	51.7	26.8
minimum	0	11	35.5	15
Maximum	1.2	43.9	61	37
0-4 ft				
Mean	0.762	22.9	57.7	19.25
Minimum	0	3	22.9	6.4
Maximum	5.7	65.3	77.4	35

Total organic carbon (TOC) concentrations in the Phase 1 Removal area range from 0.61% to 5.4%. The minimum, maximum, and mean TOC concentrations for each sediment horizon in the Phase 1 Removal area are summarized in Table 2-4.

Table 2-4. Summary of TOC results

SEDIMENT HORIZON	MEAN TOC (%)	MIN TOC (%)	MAX TOC (%)
0-15 cm	1.93	0.61	3.4
0-4 ft	3.06	0.98	5.4

2.5.1.2 Sediment chemistry results

Sediment chemistry results from the Phase 1 Removal area for the 0-15 cm and 0-4 ft sediment horizons are presented in Table 2-5 and 2-6 and in Maps 4 and 5 respectively.

Sediment horizon: 0-15 cm

Table 2-5 presents the results of chemical analysis of samples collected in the 0-15 cm sediment horizon. Map 4 shows the location and distribution of samples collected at the 0-15 cm sediment horizon. Of the 62 chemicals analyzed in the 0-15 cm sediment horizon, 44 were detected in at least one sample, and 18 were never detected. All detected chemicals had a detection frequency greater than 10%.

Table 2-5. Summary of 0-15 cm sediment chemistry results

Analyte	Units	Number of Samples	Detection Frequency	Min Result	Max Result
Metals					
Antimony	mg/kg dry wt	6	66.7	1.9	6.1
Arsenic	mg/kg dry wt	9	100	7.5	16
Cadmium	mg/kg dry wt	4	100	1.4	2.7
Chromium	mg/kg dry wt	9	100	40.2	56.7
Copper	mg/kg dry wt	9	100	88	123
Lead	mg/kg dry wt	9	100	53.7	180
Mercury	mg/kg dry wt	9	100	0.27	4.2
Nickel	mg/kg dry wt	9	100	24.9	36.3
Silver	mg/kg dry wt	4	100	1.2	3.1
Zinc	mg/kg dry wt	9	100	155	250
VOCs					
1,2,4-Trichlorobenzene	µg/kg dry wt	8	25	5.44	800
1,2-Dichlorobenzene	µg/kg dry wt	8	25	3.84	800
1,3-Dichlorobenzene	µg/kg dry wt	8	37.5	9.47	800
1,4-Dichlorobenzene	µg/kg dry wt	8	62.5	18	800
SVOCs					
2,4-Dimethylphenol	µg/kg dry wt	8	0	18	800
2-Methylnaphthalene	µg/kg dry wt	8	87.5	22	1,000
2-Methylphenol	µg/kg dry wt	8	0	18	800
4-Methylphenol	µg/kg dry wt	8	37.5	18	440
Benzoic acid	µg/kg dry wt	4	25	21	560
Benzyl alcohol	µg/kg dry wt	4	0	18	55
Bis(2-ethylhexyl)phthalate	µg/kg dry wt	8	87.5	850	4,400
Butyl benzyl phthalate	µg/kg dry wt	8	50	0	440
Dibenzofuran	µg/kg dry wt	8	37.5	30	800
Diethyl phthalate	µg/kg dry wt	7	0	18	800
Dimethyl phthalate	µg/kg dry wt	8	12.5	18	800
Di-n-butyl phthalate	µg/kg dry wt	8	37.5	31	800
Di-n-octyl phthalate	µg/kg dry wt	8	0	22	800
Ethylbenzene	µg/kg dry wt	1	0	23	23
Hexachlorobenzene	µg/kg dry wt	8	0	0.94	800
Hexachlorobutadiene	µg/kg dry wt	8	0	18	800
Hexachloroethane	µg/kg dry wt	6	0	51	800
N-Nitrosodiphenylamine	µg/kg dry wt	8	0	18	800
Pentachlorophenol	µg/kg dry wt	8	0	51	2,000
Phenol	µg/kg dry wt	8	75	18	1,600
Tetrachloroethene	µg/kg dry wt	1	0	23	23
Trichloroethene	µg/kg dry wt	1	0	23	23
Xylene (total)	µg/kg dry wt	1	0	23	23

Analyte	Units	Number of Samples	Detection Frequency	Min Result	Max Result
LPAHs					
Acenaphthene	µg/kg dry wt	8	87.5	24	720
Acenaphthylene	µg/kg dry wt	8	37.5	18	800
Anthracene	µg/kg dry wt	8	100	85	640
Fluorene	µg/kg dry wt	8	87.5	33	910
Naphthalene	µg/kg dry wt	8	87.5	39	2,300
Phenanthrene	µg/kg dry wt	8	100	210	3,600
Total LPAH (calc'd)	µg/kg dry wt	8	100	399	8,231
HPAHs					
Benzo(a)anthracene	µg/kg dry wt	8	100	270	1,800
Benzo(a)pyrene	µg/kg dry wt	8	100	210	2,000
Benzo(g,h,i)perylene	µg/kg dry wt	8	50	170	800
Chrysene	µg/kg dry wt	8	100	370	2,100
Dibenzo(a,h)anthracene	µg/kg dry wt	8	37.5	81	800
Fluoranthene	µg/kg dry wt	8	100	420	2,200
Indeno(1,2,3-cd)pyrene	µg/kg dry wt	8	50	229	920
Pyrene	µg/kg dry wt	8	100	580	2,400
Total HPAH (calc'd)	µg/kg dry wt	8	100	2830	15,030
Pesticides					
DDTs (total-calc'd)	µg/kg dry wt	8	37.5	0.95	110
Aldrin	µg/kg dry wt	8	25	0.47	14
alpha-Chlordane	µg/kg dry wt	8	0	0.94	68
Dieldrin	µg/kg dry wt	8	0	0.95	14
gamma-BHC	µg/kg dry wt	8	0	0.47	14
Heptachlor	µg/kg dry wt	8	0	0.47	14
PCBs (total calc'd)	µg/kg dry wt	9	100	41	4,600
TBT					
Tributyltin as ion	µg/kg dry wt	7	100	66	1,218

HPAH - high-molecular-weight polycyclic aromatic hydrocarbon

LPAH - low-molecular-weight polycyclic aromatic hydrocarbon

PCB - polychlorinated biphenyl

SVOC – semivolatile organic compound

VOC – volatile organic compound

TBT - tributyltin

Sediment horizon: 0-4 ft

Table 2-6 presents the results of chemical analysis of samples collected in the 0-4 ft sediment horizon. Map 5 shows the location and distribution of samples collected at the 0-4 ft sediment horizon. Of the 60 chemicals analyzed in the 0-4 ft sediment horizon, 45 were detected in at least one sample, and 15 chemicals were never detected. All detected chemicals had a detection frequency greater than 5%.

Table 2-6. Summary of 0-4 ft sediment chemistry results

Analyte	Units	Number of Samples	Detection Frequency	Min Result	Max Result
Metals					
Antimony	mg/kg dry wt	32	84.4	0.49	8
Arsenic	mg/kg dry wt	35	94.3	5.7	35
Cadmium	mg/kg dry wt	35	100	0.22	7.9
Chromium	mg/kg dry wt	5	100	22.9	62.7
Copper	mg/kg dry wt	35	100	33	220
Lead	mg/kg dry wt	35	100	10	660
Mercury	mg/kg dry wt	38	100	0.164	12.7
Nickel	mg/kg dry wt	35	100	14	52
Silver	mg/kg dry wt	35	91.4	0.1	12
Zinc	mg/kg dry wt	35	100	52	630
VOCs					
1,2,4-Trichlorobenzene	µg/kg dry wt	35	8.6	5.7	58
1,2-Dichlorobenzene	µg/kg dry wt	34	11.8	1.1	79
1,3-Dichlorobenzene	µg/kg dry wt	34	14.7	1.5	200
1,4-Dichlorobenzene	µg/kg dry wt	34	50	1.5	900
SVOCs					
2,4-Dimethylphenol	µg/kg dry wt	34	0	10	97
2-Methylnaphthalene	µg/kg dry wt	35	80	20	3,700
2-Methylphenol	µg/kg dry wt	35	0	10	97
4-Methylphenol	µg/kg dry wt	35	25.7	20	190
Benzoic acid	µg/kg dry wt	22	0	100	960
Benzyl alcohol	µg/kg dry wt	35	0	12	120
Bis(2-ethylhexyl)phthalate	µg/kg dry wt	35	97.1	20	9,300
Butyl benzyl phthalate	µg/kg dry wt	35	25.7	19	240
Dibenzofuran	µg/kg dry wt	35	71.4	20	480
Diethyl phthalate	µg/kg dry wt	31	0.0	19	190
Dimethyl phthalate	µg/kg dry wt	35	0.0	19	190
Di-n-butyl phthalate	µg/kg dry wt	35	25.7	19	290
Di-n-octyl phthalate	µg/kg dry wt	35	5.7	19	190
Ethylbenzene	µg/kg dry wt	29	37.9	1.1	64
Hexachlorobenzene	µg/kg dry wt	35	0	0.97	120
Hexachlorobutadiene	µg/kg dry wt	35	0	0.97	150

Analyte	Units	Number of Samples	Detection Frequency	Min Result	Max Result
Hexachloroethane	µg/kg dry wt	30	0	19	190
N-Nitrosodiphenylamine	µg/kg dry wt	35	0	12	120
Pentachlorophenol	µg/kg dry wt	35	0	51	480
Phenol	µg/kg dry wt	35	77.1	20	410
Tetrachloroethene	µg/kg dry wt	29	0	1.1	9
Trichloroethene	µg/kg dry wt	28	0	1.1	9
Xylene (total)	µg/kg dry wt	25	52.0	4	290
LPAHs					
Acenaphthene	µg/kg dry wt	35	85.7	20	700
Acenaphthylene	µg/kg dry wt	35	20	19	190
Anthracene	µg/kg dry wt	35	97.1	20	740
Fluorene	µg/kg dry wt	35	94.3	20	920
Naphthalene	µg/kg dry wt	35	88.6	20	860
Phenanthrene	µg/kg dry wt	35	100	52	3,900
Total LPAH (calc'd)	µg/kg dry wt	35	100	52	6,350
HPAHs					
Benzo(a)anthracene	µg/kg dry wt	35	100	26	1,100
Benzo(a)pyrene	µg/kg dry wt	35	100	25	910
Benzo(g,h,i)perylene	µg/kg dry wt	35	91.4	20	590
Total Benzofluoranthenes	µg/kg dry wt	35	97.1	20	2,090
Chrysene	µg/kg dry wt	35	100	33	1,500
Dibenzo(a,h)anthracene	µg/kg dry wt	35	42.9	20	190
Fluoranthene	µg/kg dry wt	35	100.0	61	3,300
Indeno(1,2,3-cd)pyrene	µg/kg dry wt	35	94.3	18	530
Pyrene	µg/kg dry wt	35	100	66	4100
Total HPAH (calc'd)	µg/kg dry wt	35	100	211	13,080
Pesticides					
DDTs (total-calc'd)	µg/kg dry wt	45	77.8	1.2	301
Aldrin	µg/kg dry wt	41	63.4	0.71	44
alpha-Chlordane	µg/kg dry wt	41	34.1	0.9	100
Dieldrin	µg/kg dry wt	45	73.3	0.81	140
gamma-BHC	µg/kg dry wt	40	0	0.61	24
Heptachlor	µg/kg dry wt	41	0	0.61	24
PCBs (total calc'd)	µg/kg dry wt	51	100	29	12,100
TBT					
Tributyltin as ion	µg/kg dry wt	26	100	6.3	300

HPAH - high-molecular-weight polycyclic aromatic hydrocarbon
LPAH - low-molecular-weight polycyclic aromatic hydrocarbon
PCB - polychlorinated biphenyl
SVOC – semivolatile organic compound
VOC – volatile organic compound
TBT - tributyltin

2.5.1.3 Porewater chemistry results

Porewater chemistry results from the Phase 1 Removal area are only from the 0-4 ft sediment horizon. Six samples were analyzed for TBT in porewater with concentrations ranging from 0.00741 to 0.62 µg/L.

2.5.1.4 Tissue chemistry results

Three separate studies have examined tissue concentrations in the EWW. Skinless fillets of English sole were analyzed for PCBs (as Aroclors), mercury, and TBT. All chemicals were detected. PCBs, mercury, and TBT were also measured in the edible tissue of red rock crab and fillets of striped perch, both with and without skin (ESG 1999). PCBs and mercury were detected in all three tissue types. TBT was detected in the perch fillets but was not detected in the red rock crab tissue. Edible tissues from mussels were analyzed for 114 different chemicals (King County 1999). Sixteen of the 114 chemicals were detected. The detected chemicals included nine metals, TBT, polycyclic aromatic hydrocarbons (PAHs), PCBs, benzoic acid, and 2-methylphenol. Mercury was not detected in the mussel tissue samples.

The available tissue data are limited to fish fillet samples collected for a human health risk assessment and transplanted mussel samples. None of the available data are suitable for an ecological risk assessment, which will require a larger quantity of whole-body fish samples and resident benthic invertebrate samples.

2.5.2 Sediment toxicity samples

Thirty-five sediment samples collected in the Phase 1 Removal area in five surveys (Table 2-2) were tested for toxicity. Only three of these samples were taken from the 0-15 cm sediment horizon. The following toxicity tests were conducted: acute 10-day amphipod test using *Eohaustorius estuarius*, *Ampelisca abdita*, or *Rhepoxynius abronius* (amphipod test); acute bivalve larval combined mortality test using the blue mussel, *Mytilus galloprovincialis*, or echinoderm embryo (larval test); and chronic 20-day juvenile polychaete biomass test using *Neanthes arenaceodentata* (*Neanthes* test). Results of the toxicity tests are presented in Section 3.2.1.2.

2.5.3 Data summary

A total of 64 sediment samples and 35 toxicity samples have been collected from the 0-15 cm and 0-4 ft sediment depth horizons to characterize the sediments within the Phase 1 Removal boundary. The most common groups of chemicals consistently found (e.g. highest detection frequencies) within the Phase 1 Removal area at both the 0-15 cm and 0-4 ft sediment depth horizons were: metals, PCBs, PAHs, and phthalates. These chemical groups are ubiquitous within the EWW (Windward 2003a). Because Phase 1 human health and ecological risk assessments in the West Waterway and Lower Duwamish Waterway identified PCBs as primary risk drivers, PCB concentrations in the Phase 1 Removal area were compared to concentrations across the[2] EWW. PCB concentrations were contoured in GIS[1] (Map 6). The concentration contours clearly identify the Phase 1 Removal area as being one of the primary region of PCB contamination in EWW sediments.

3.0 Streamlined Risk Evaluation

This section presents the results of a streamlined evaluation of the risk associated with no action in the Phase 1 Removal area. As described in the EE/CA guidance (EPA 1993), a streamlined risk evaluation is intermediate in scope between the limited risk evaluation conducted for emergency removal actions and the conventional baseline assessment normally conducted for remedial actions. A conservative approach was used in this streamlined risk evaluation. A baseline risk assessment will be conducted in conjunction with the RI/FS being conducted for the EWW OU, which will refine the approach used in the current evaluation.

Consistent with EE/CA guidance, this streamlined risk evaluation identifies the potential for risk if no cleanup action is taken in the Phase 1 Removal area. The streamlined risk evaluation will focus on ecological risk to benthic communities associated with elevated concentrations of chemicals in the Phase 1 Removal area. Risks from exposure to sediment contamination within the EWW OU to other ecological receptors (e.g., fish, birds, and wildlife) will be fully evaluated in a baseline risk assessment which will be part of the RI/FS for the EWW OU.

3.1 EXPOSURE PATHWAYS

The risk evaluation in this document is designed to evaluate risk from potential exposure pathways if no action occurs within the removal action boundary. An exposure pathway is considered complete if a chemical can travel from a source to an ecological or human receptor and is available to the receptor via one or more exposure routes (EPA 1997a,b). The principal human exposure pathways were characterized in Section 2.2. This section summarizes the principal exposure pathways for ecological receptors.

Because of the depth of the water and the relative isolation of sediment in the Phase 1 area, benthic invertebrates are the primary receptors of concern (ROCs). The exposure pathway for benthic invertebrates is direct and includes 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 indirect, primarily through ingestion of marine life. Bottom-feeding fish may have additional exposure resulting from contact with and ingestion of contaminated sediment. Risk associated with bioaccumulative compounds that fish, birds, and marine mammals are exposed to directly or indirectly via the food chain

[2] Contours were interpolated using an algorithm called inverse distance weighting.

will be more fully evaluated as part of the RD/RA evaluation to be conducted following the Phase 1 Removal.

3.2 RISK CHARACTERIZATION

3.2.1 Ecological risk

The State of Washington Sediment Management Standards (SMS) were promulgated to evaluate sediment chemistry and toxicity results. SMS are appropriate for addressing risks to benthic invertebrate communities as a whole, except for higher-trophic-level invertebrates, such as crabs, that may be at greater risk of exposure through bioaccumulation. Under the provisions of SMS, surface sediments with chemical concentrations equal to or less than sediment quality standards (SQS) are designated as having no adverse effects on biological resources. Sediments with chemical concentrations above the SQS are designated as having minor adverse effects (WAC173-204-301[1][a]), while sediments with chemical concentrations above the CSL are designated as having significant adverse biological effects.

The assessment of risks to the benthic community was evaluated using two approaches: 1) comparison of sediment chemical concentrations to SMS standards, and 2) comparison of toxicity response from sediment toxicity tests conducted on samples collected from within the Phase 1 Removal boundary to the toxicity response from sediment collected at reference locations.

This streamlined risk evaluation estimates risks associated with accepting the no-action alternative and not conducting the NTCRA within the Phase 1 Removal action boundary. EWW supports active container ship terminals and some of the largest deep-draft container ships call on both Terminal 18 and Terminal 30. These Terminals, which are on either side of the Phase 1 Removal area, were permitted and constructed for between -49 and -51 ft MLLW. Map 3 shows the diminished depths within the Phase 1 Removal area. Under the no-action alternative, vessels with 46-ft draft would continue to call on the Port Terminals. The reduced clearance between the vessels and the channel bottom would make the surface susceptible to movement and scour caused by conventional screw and cycloidal propellers from the ships and the larger tugs in maneuvering the 1,000-ft vessels. Occasionally ships also use their anchors when maneuvering in and out of berths, increasing the potential for disturbance of the sediment surface. Recent bathymetry of the EWW clearly shows anchor drag tracks from such maneuvers (DEA 2002). Therefore this risk assessment considers the possibility that shipping activities could erode portions of the sediment surface within the Phase 1 Removal action boundary.

Chemistry and toxicity data for sediment collected from both the 0-15 cm and 0-4 ft sediment horizons were used to estimate risks associated with the no-action alternative. Typically, sediment samples collected in the 0-15 cm sediment horizon are normally considered most appropriate for evaluating the effect of sediment exposure on benthic invertebrate organisms, however, the 0-15 cm surface sediment horizon is underrepresented within the Phase 1 Removal action boundary. Most of the sediment samples collected within this boundary span relatively broad sediment horizons, comparable to 0-4 ft horizon. Many of the larger sediment quality investigations of the EWW were intended to characterize sediment for making dredged material disposal decisions. During these investigations it became apparent that the 0-4 ft horizon within the Phase 1 Removal boundary was toxic to benthic organisms, based on sediment chemistry and toxicity test results. Given the low sedimentation rate in the EWW a conservative assumption can be made that the 0-4 ft horizon is characteristic of the surface and can be used as a surrogate for surface concentrations (EVS 1996b) . In addition it was judged appropriate to use samples from the 0-4 ft sediment horizon for risk evaluation because the effects of shipping activities (the area within the Phase 1 boundary is generally a shallower area with deeper berths constructed on either side) have been observed to disturb the upper sediment layers and expose deeper sediment to biological activity.

3.2.1.1 Risk characterization using sediment chemistry

Sediment chemistry data described in Section 2.5.1 were compared to SMS SQS and CSL standards (or to DMMP screening level [SL] and maximum level [ML] guidelines for chemicals where no SMS exist to predict risks to benthic organisms).

The numbers of SQS and CSL exceedances and the minimum and maximum exceedance factors (EFs; measured concentration divided by its respective SMS standard) for each chemical are summarized in Table 3-1 and 3-2 (0-15 cm horizon) and in Table 3-3 and 3-4 (0-4 ft horizon). For this risk characterization, non-detected concentrations were compared using the full detection limit. The result of using this approach is that for several of the chlorobenzene and phenol compounds, the number of SQS exceedances based on non-detected concentrations (but having high detection limits) greatly exceeds the number of samples with detected concentrations. In addition to addressing non-detected values, chemicals whose SMS standards are based on organic-carbon-normalized concentrations (PAHs, PCBs, and phthalates) were normalized using sample-specific TOC concentrations.

Table 3-1. Number of SQS exceedances in 0-15 cm sediment

Chemical	Number of SQS Exceedances	Min EF	Max EF
1,2,4-Trichlorobenzene	6	1.1	82
1,2-Dichlorobenzene	4	13	29
1,3-Dichlorobenzene	3	2.4	4.7
1,4-Dichlorobenzene	5	1.2	11
2,4-Dimethylphenol	6	1.8	28
2-Methylphenol	4	6.3	13
Acenaphthene	2	1.3	2.7
Acenaphthylene	1	1.0[a]	1.0[a]
Aldrin	1	1.4	1.4
alpha-Chlordane	5	4.9	6.8
Benzo(g,h,i)perylene	3	1.1	2.1

Chemical	Number of SQS Exceedances	Min EF	Max EF
Bis(2-ethylhexyl)phthalate	5	1.0	9.9
Butyl benzyl phthalate	1	7.0	7.0
DDTs (total-calc'd)	7	1.4	16
Dibenzo(a,h)anthracene	4	1.9	5.5
Dibenzofuran	3	2.2	4.4
Dieldrin	3	1.1	1.4
Diethyl phthalate	2	1.1	9.2
Dimethyl phthalate	2	1.2	6.2
Di-n-octyl phthalate	2	1.0	1.1
Ethylbenzene	1	2.3	2.3
Fluorene	2	1.2	1.8
gamma-BHC	1	1.4	1.4
Heptachlor	1	1.4	1.4
Hexachlorobenzene	4	20	170
Hexachlorobutadiene	4	8.6	40
Indeno(1,2,3-cd)pyrene	2	1.2	1.9
Mercury	5	1.1	10
N-Nitrosodiphenylamine	4	3.0	16
PCBs (total calc'd)	8	1.9	12
Pentachlorophenol	4	2.8	5.6
Phenanthrene	1	1.1	1.1
Phenol	4	1.8	3.8

[a] Value is >1.0, but is reported as 1.0 to follow significant figure rules

Table 3-2. Number of CSL exceedances in 0-15 cm sediment

Chemical	Number of SQS Exceedances	Min EF	Max EF
1,2,4-Trichlorobenzene	4	8.6	37
1,2-Dichlorobenzene	4	8.8	29
1,4-Dichlorobenzene	2	3.7	3.8
2,4-Dimethylphenol	6	1.8	28
2-Methylphenol	4	6.3	13
Acenaphthylene	1	1.0[a]	1.0[a]
Bis(2-ethylhexyl)phthalate	3	1.4	6.0
DDTs (total-calc'd)	1	1.6	1.6
Dibenzo(a,h)anthracene	3	1.0[a]	2.0
Dibenzofuran	1	1.1	1.1
Diethyl phthalate	1	6.0	6.0
Dimethyl phthalate	2	1.2	2.8
Hexachlorobenzene	4	6.3	29
Hexachlorobutadiene	4	3.7	11
Mercury	4	1.3	7.1
N-Nitrosodiphenylamine	4	3.0	11
PCBs (total calc'd)	3	1.2	2.1
Pentachlorophenol	4	1.4	2.9
Phenol	2	1.3	1.3

[a] Value is >1.0, but is reported as 1.0 to follow significant figure rules

Table 3-3. Number of SQS exceedances in 0-4 ft sediment

Chemical	Number of SQS Exceedances	Min EF	Max EF
1,2,4-Trichlorobenzene	16	1.0[a]	1.9
1,3-Dichlorobenzene	1	1.2	1.2
1,4-Dichlorobenzene	5	1.2	8.2
2,4-Dimethylphenol	14	1.2	3.3
2-Methylnaphthalene	6	1.1	2.3
2-Methylphenol	6	1.0[a]	1.5
Acenaphthene	3	1.0	1.6
Aldrin	27	1.1	4.4
alpha-Chlordane	24	1.1	10
Benzoic acid	2	1.4	1.5
Benzyl alcohol	7	1.3	2.1
Bis(2-ethylhexyl)phthalate	21	1.1	5.5
Butyl benzyl phthalate	2	1.4	1.6
Cadmium	7	1.0[a]	1.5
DDTs (total-calc'd)	43	1.4	44
Dieldrin	41	1.2	14
Ethylbenzene	5	1.2	6.4
gamma-BHC	8	2.0	2.4
Heptachlor	10	2.0	2.4
Hexachlorobenzene	33	1.2	8.0
Hexachlorobutadiene	1	1.1	1.1
Lead	2	1.1	1.5
Mercury	32	1.1	31
PCBs (total calc'd)	48	2.0	19
Pentachlorophenol	5	1.0[a]	1.3
Silver	3	1.4	2.0
Tributyltin in porewater	3	1.6	4.1
Xylene (total)	5	1.0[a]	7.3
Zinc	11	1.0[a]	1.5

[a] Value is >1.0, but is reported as 1.0 to follow significant figure rules

Table 3-4. Number of CSL exceedances in 0-4 ft sediment

Chemical	Number of SQS Exceedances	Max EF	Min EF
1,4-Dichlorobenzene	2	1.9	2.8
2,4-Dimethylphenol	14	1.2	3.3
2-Methylnaphthalene	2	1.2	1.4
2-Methylphenol	6	1.0[a]	1.5
Benzoic acid	2	1.4	1.5
Benzyl alcohol	7	1.0[a]	1.6
Bis(2-ethylhexyl)phthalate	12	1.0[a]	3.3
Cadmium	3	1.1	1.2
DDTs (total-calc'd)	21	1.0[a]	4.4
Ethylbenzene	2	1.2	1.3
Hexachlorobenzene	4	1.0[a]	1.3
Lead	1	1.2	1.3
Mercury	23	1.0[a]	22

CHEMICAL	NUMBER OF SQS EXCEEDANCES	MAX EF	MIN EF
PCBs (total calc'd)	20	1.0[a]	3.6
Silver	3	1.4	2.0
Xylene (total)	2	1.1	1.8

[a] Value is >1.0, but is reported as 1.0 to follow significant figure rules

Chemicals with detected sediment concentrations or detection limits (for concentrations reported as nondetected) that exceeded SQS standards (or DMMP SL guidelines, if the chemical did not have a SQS standard) were the only chemicals included in the risk evaluation. The following chemicals had detected concentrations or detection limits above SQS but were not included: benzoic acid, benzyl alcohol, ethyl benzene, hexachlorobutadiene, hexachloroethane, n-nitrosodiphenylamine, and total xylenes. These compounds were rarely detected in sediment samples and the calculated exceedances were largely driven by detection limits.

Sediment horizon: 0-15 cm

Table 3-1 and 3-2 present the results of screening chemical concentrations detected in the 0-15 cm sediment horizon against SQS and CSL standards (or DMMP guidelines). Maps 7-11 show the distribution of selected chemicals that exceeded SMS (or guidelines) in the 0-15 cm sediment horizon.

Detected SQS and CSL exceedances were most commonly associated with mercury, total PCB, and total DDT, 1,4-dichlorobenzene, phenol and bis(2-ethyhexyl)phthalate (BEHP) concentrations. EFs are presented for each chemical that has at least one measurement (or non-detected value with a high detection limit) that exceeds the respective SMS standard (or DMMP guideline value). Maximum SQS EFs for these chemicals range from 3.8 (for phenol) to 16 (for DDTs). Maximum CSL EFs for these same chemicals range from 1.3 (for phenol) to 6 (for BEHP). EFs for PCBs range from 1.9 to 12 for SQS and range from 1.2 to 2.1 for CSL. EFs for mercury range from 1.1 to 10 for SQS, and range from 1.3 to 7 for CSL.

Sediment horizon: 0-4 ft

Table 3-3 and 3-4 present the results of screening chemical concentrations detected in the 0-4 ft sediment horizon against SQS and CSL standards. Maps 12–19 show the distribution of selected chemicals that exceeded SMS in the 0-4 ft sediment horizon.

Detected SQS exceedances were most commonly associated with mercury, total PCBs, total DDTs, alpha-chlordane, aldrin, dieldrin, BEHP, and zinc concentrations. Detected CSL exceedances were most commonly associated with mercury, total PCBs, total DDTs, and BEHP. Maximum SQS EFs for these chemicals range from 1.5 (for zinc) to 44 (for DDTs). Maximum CSL EFs for these same chemicals range from 3.3 (for BEHP) to 22 for mercury. EFs for PCBs range from 2 to 19 for SQS and range from 1 to3.6 for CSL. EFs for mercury range from 1.1 to 31 for SQS, and range from 1 to 22 for CSL.

Overall, SMS standards were exceeded for multiple chemicals, with several chemicals having EFs greater than 10 times their respective SQS or CSL standards. Under the provisions of the SMS, exceedance of a single SQS could result in minor adverse effects, and that exceedance of a single CSL could result in significant adverse effects. Surface sediment (both the 0-15 cm and 0-4 ft horizons) within the Phase 1 Removal boundary contain multiple chemicals that exceed their respective SMS standards, indicating that these sediments may pose a risk to benthic community health. While the predictive relationship between sediment quality values and measured impacts to benthic communities is widely debated, several researchers have presented analyses that suggest that the greater a sediment quality value is exceeded the greater the likelihood that effects will occur (Hyland 1999; Swartz 1999; Fairey et al. 2001). Hyland (1999), for example, demonstrated an increased probability of adverse benthic community impacts as mean EFs increase (relative to a sediment quality value).

3.2.1.2 Risk Characterization Using Sediment Toxicity Tests

In addition to sediment chemistry, standard sediment toxicity tests have been conducted on surface sediment samples from within the Phase 1 Removal boundary to assess sediment quality. A majority of the toxicity tests have been conducted with samples collected from the 0-4 ft sediment horizon. Of the thirty-five toxicity tests conducted on sediment collected within the Phase 1 Removal boundary, only 3 tests have been conducted with sediment from the 0-15 cm horizon. The following toxicity tests were conducted: acute 10-day amphipod test using *Eohaustorius estuarius*, *Ampelisca abdita*, or *Rhepoxynius abronius* (amphipod test); acute bivalve larval combined mortality test using the blue mussel, *Mytilus galloprovincialis*, or echinoderm embryo (larval test); and chronic 20-day juvenile polychaete biomass test using *Neanthes arenaceodentata* (*Neanthes* test). All tests used are considered standard tests for determining the potential toxicity of sediment Puget Sound waters. Measurement endpoints associated with these three toxicity tests include assessment of acute (lethality in the amphipod test) and sublethal (growth in the polychaete test and abnormal development in the larval test) effects.

Results of toxicity tests from five studies are presented in Table 3-5 and on Maps 20-23. Toxicity results are presented as either a "pass" or "fail" based on toxicity test response analysis rules provided in the SMS. Failure of SQS rule means that the failed test sediment is designated as having minor adverse biological effects, while failure of the CSL rule means that the failed test sediment is designated as having significant adverse biological effects. Sediment from both the 0-15 cm and 0-4 ft horizons were found to be toxic to at least one of the three toxicity tests. All three 0-15 cm samples were found to be toxic to the amphipod based on the SQS data interpretation rules. Sediment collected from the 0 -4 ft horizon was found to be toxic to all three toxicity tests, and in many individual samples were toxic to all three of the tests (Maps 22 and 23). A majority of the tests conducted with all three toxicity tests failed the SQS, with 60%, 57%, and 74% failures for the amphipod, polychaete, and larval tests, respectively. Failures based on the CSL ranged from 46% of the sediment tested using the polychaete to 57% failures using the larval test.

Table 3-5. Toxicity test results compared to SMS

Survey	Sample ID	Amphipod: Absolute Mortality	Amphipod: Mortality % Difference From REF	Amphipod: SQS	Amphipod: CSL	*Neanthes*: Percent of REF GR %	*Neanthes*: SQS	*Neanthes*: CSL	Larval: NCMA % Difference from REF	Larval: SQS	Larval: CSL	Overall: SQS	Overall: CSL
0-15 cm													
HIRI 1995	HI-EW-04	41	6.3	**Fail**	Pass	104.1	Pass	Pass	14.9	Pass	Pass	**Fail**	Pass
HIRI 1995	HI-EW-05	34	-7.6	**Fail**	Pass	99.2	Pass	Pass	15.2	**Fail**	Pass	**Fail**	**Fail**
KC CSO 96	L9553-6	37	16	**Fail**	Pass	79.5	Pass	Pass	13.8	Pass	Pass	**Fail**	Pass
0-4 ft													
EW Channel Deep	S23	11	0	Pass	Pass	107.9	Pass	Pass	29.5	**Fail**	Pass	**Fail**	Pass
EW Channel Deep	S25	10	4	Pass	Pass	36.5	**Fail**	**Fail**	21.8	**Fail**	**Fail**	**Fail**	**Fail**
EW Channel Deep	S36	14	8	Pass	Pass	16	**Fail**	**Fail**	74.4	**Fail**	**Fail**	**Fail**	**Fail**
EW Channel Deep	S38	12	3	Pass	Pass	32.5	**Fail**	**Fail**	47.2	**Fail**	**Fail**	**Fail**	**Fail**
T-18 Phase 1	1C27	57	48	**Fail**	**Fail**	11	**Fail**	**Fail**	54	**Fail**	**Fail**	**Fail**	**Fail**
T-18 Phase 1	1C31	45	38	**Fail**	**Fail**	68	**Fail**	Pass	39	**Fail**	**Fail**	**Fail**	**Fail**
T-18 Phase 1	1C32	69	68	**Fail**	**Fail**	12	**Fail**	**Fail**	21	**Fail**	Pass	**Fail**	**Fail**
T-18 Phase 1	1C33	61	60	**Fail**	**Fail**	20	**Fail**	**Fail**	70	**Fail**	**Fail**	**Fail**	**Fail**
T-18 Phase 1	1C36	44	36	**Fail**	**Fail**	84	Pass	Pass	40	**Fail**	**Fail**	**Fail**	**Fail**
T-18 Phase 1	1C37	46	35	**Fail**	**Fail**	42	**Fail**	**Fail**	96	**Fail**	**Fail**	**Fail**	**Fail**
T-18 Phase 1	1C38	54	53	**Fail**	**Fail**	26	**Fail**	**Fail**	18	**Fail**	Pass	**Fail**	**Fail**
T-18 Phase 1	1C39	61	60	**Fail**	**Fail**	11	**Fail**	**Fail**	78	**Fail**	**Fail**	**Fail**	**Fail**
T-18 Phase 1	1C43	33	22	Pass	Pass	102	Pass	Pass	54	**Fail**	**Fail**	**Fail**	**Fail**
T-18 Phase 1	1C44	32	25	Pass	Pass	89	Pass	Pass	10	Pass	Pass	Pass	Pass
T-18 Phase 1	1C45	35	28	**Fail**	Pass	17	**Fail**	**Fail**	90	**Fail**	**Fail**	**Fail**	**Fail**
T-18 Phase 1	1C49	30	8	Pass	Pass	87	Pass	Pass	32	**Fail**	**Fail**	**Fail**	**Fail**
T-18 Phase 1	1C50	27	20	Pass	Pass	76	Pass	Pass	1	Pass	Pass	Pass	Pass
T-18 Phase 1	1C51	32	31	**Fail**	**Fail**	56	**Fail**	Pass	4	Pass	Pass	**Fail**	**Fail**
T-18 Phase 1	2C10	39	31	**Fail**	**Fail**	50	**Fail**	Pass	27	**Fail**	Pass	**Fail**	**Fail**
T-18 Phase 1	2C11	55	46	**Fail**	**Fail**	4	**Fail**	**Fail**	98	**Fail**	**Fail**	**Fail**	**Fail**

Survey	Sample ID	Amphipod				*Neanthes*			Larval			Overall	
		Absolute Mortality	Mortality % Difference From REF	SQS	CSL	Percent of REF GR %	SQS	CSL	NCMA % Difference from REF	SQS	CSL	SQS	CSL
T-18 Phase 1	2C12	33	24	Pass	Pass	63	**Fail**	Pass	40	**Fail**	**Fail**	**Fail**	**Fail**
T-18 Phase 1	2C13	7	-9	Pass	Pass	94	Pass	Pass	3	Pass	Pass	Pass	Pass
T-18 Phase 1	2C14	70	62	**Fail**	**Fail**	0	**Fail**	**Fail**	88	**Fail**	**Fail**	**Fail**	**Fail**
T-18 Phase 1	2C15	62	54	**Fail**	**Fail**	0	**Fail**	**Fail**	89	**Fail**	**Fail**	**Fail**	**Fail**
T-18 Phase 1	2C16	74	66	**Fail**	**Fail**	0	**Fail**	**Fail**	89	**Fail**	**Fail**	**Fail**	**Fail**
T-18 Phase 1	2C17	69	68	**Fail**	**Fail**	0	**Fail**	**Fail**	96	**Fail**	**Fail**	**Fail**	**Fail**
T-18 Phase 1	2C18	49	38	**Fail**	**Fail**	0	**Fail**	**Fail**	94	**Fail**	**Fail**	**Fail**	**Fail**
T-18 Phase 1	2C19	27	10	Pass	Pass	122	Pass	Pass	9	Pass	Pass	Pass	Pass
T-18 Phase 1	2C20	32	21	Pass	Pass	88	Pass	Pass	41	**Fail**	**Fail**	**Fail**	**Fail**
Recency	EW-S2-COMP-9	77	58	**Fail**	**Fail**	92	Pass	Pass	14.7	Pass	Pass	**Fail**	**Fail**
Recency	EW-S2-COMP-10	52	33	**Fail**	**Fail**	102	Pass	Pass	9.3	Pass	Pass	**Fail**	**Fail**
Recency	EW-S2-COMP-11	80	61	**Fail**	**Fail**	85	Pass	Pass	38.7	**Fail**	Pass	**Fail**	**Fail**

GR - individual growth rate (mg/day/worm)

NCMA - normalized combined percent mortality and abnormality

REF – reference sample

The overall results indicate that sediment collected from both the 0-15 cm and 0-4 ft horizons are toxic to standard marine test organisms. Sediment collected from 0-15 cm was found to be acutely toxic, and, in at least one sample, showed sublethal toxicity in a larval test. Sediment from 0-4 ft was clearly toxic, demonstrating both lethal and sublethal effects. Toxicity tests have been shown to be predictive of benthic community impairment. For example, Scott (1998) reported that reduced amphipod survival was found predict benthic community degradation approximately 75% of the time. Others report similar relationships between toxicity responses and benthic community impacts (McGee et al., in review; Burton et al. 2001), while others have found that sublethal effects may also be important in identifying potential benthic community impacts (Swartz et al. 1986; DeWitt et al. 1997).

3.2.2 Human health risk

This section briefly describes the risks associated with seafood consumption, as previously summarized in the human health risk assessment (HHRA) for the Waterway Sediment Operable Unit (WSOU; ESG 1999). Risk estimates for direct exposure pathways were not made previously and will be completed during the RI for this project.

One of the objectives of the WSOU HHRA was to compare risk estimates for the West Waterway with risk estimates from contiguous waterbodies, including the EWW (ESG 1999). Accordingly, perch, English sole, and crab samples were collected from the EWW and analyzed for three chemicals of concern: total PCBs, TBT, and mercury. Risk estimates were made for these chemicals using a “market-basket” approach to characterize exposure. The market-basket approach links species- or species-group-specific consumption rates with concentrations for those species or species groups, thereby providing a realistic assessment of the diet of a “typical” seafood consumer.

A health-protective reasonable maximum exposure (RME) scenario, derived to represent tribal fishers, was based on a fish consumption rate of 105 g/day and a shellfish consumption rate of 61 g/day. Excess cancer risk estimates were 3E-4 (3 in 10,000) for total PCBs. Hazard quotient[3] estimates were 17 for total PCBs, 2.1 for mercury, and less than 1.0 for TBT. Risk and hazard estimates for total PCBs were high enough to suggest that remedial action could be warranted in the EWW. The results presented in ESG (1999) provide additional justification for the Phase 1 Removal described in this EE/CA. The Phase 1 Removal will also reduce human health risks by removing substantial quantities of chemicals of concern associated with the exposure pathways described in Section 2.2.

[3] A hazard quotient is a ratio of a predicted exposure to the reference dose. Hazard quotients greater than 1 predict a higher likelihood for adverse effects.

3.2.3. Summary and conclusions

The streamlined ecological risk evaluation compared sediment concentrations to SMS and DMMP guidelines. Sediment chemical concentrations above the SQS have been measured throughout the Phase 1 Removal area for metals, PAHs, phthalates, total PCBs, pesticides, chlorobenzenes, and phenols in both the 0-15 cm and 0-4 ft sediment horizon. Metals, PAHs, phthalates, total PCBs, pesticides, and chlorobenzenes have also been measured throughout the Phase 1 Removal area at concentrations above the CSL. The chemicals with the greatest number of exceedances are mercury, total PCBs, dieldrin and total DDTs.

The synoptic sediment chemistry and toxicity test results demonstrate that sediment in this area is toxic to the range of benthic organisms used in standard sediment toxicity testing. Based on these results, which form the basis for the risk evaluation, the Phase 1 Removal area meets the NCP criteria for a Removal Action (see Section 1.0). Furthermore, the Phase 1 Removal action is supported by the qualitative HHRA which identified that this action will indirectly reduce exposure to humans by removing sediment containing bioaccumulative chemicals that are found in seafood. Specifically, the Phase 1 Removal will takeout a substantial quantity of PCBs in the EWW (see Section 2.5.3 and Map 6).

Two sources of uncertainty in this assessment are the use of the 0-4 ft sediment chemistry and toxicity data, and the evaluation of risk associated with chlorobenzenes and phenols. Section 3.2.1 discusses the use of 0-4 ft samples as surrogates for the 0-15 cm samples which are typically used in benthic risk evaluations. The SQS exceedances for the chlorobenzenes and phenols were largely driven by detection limits above the SQS for samples with non-detected concentrations. The use of the full detection limit in the sediment chemistry evaluation provided a conservative estimate of the risk associated with exposure to these compounds. Further evaluation of these data will be necessary.

4.0 Identification of Removal Action Scope, Goals, and Objectives

4.1 Scope of Removal Action

This NTCRA will clean up sediments within the Phase 1 Removal area. The final remedy for the entire EWW OU will be selected after additional characterization of the nature and extent of contamination and geotechnical evaluations. Cleanup of the remainder of the EWW OU will occur through additional NTCRAs and/or a phased RD/RA following remedy selection.

4.2 Removal Action Goal

The goal of this action is to reduce exposure of ecological receptors to sediment contamination, and thereby reduce or eliminate adverse effects on biological resources in the Phase 1 Removal area.

Although the potential risk to human receptors has not been estimated at this time, the action will reduce potential risks to human health by removing bioaccumulative chemicals that are found in sediment. Human health risks for the entire EWW OU will ultimately be addressed in the ROD.

4.3 REMOVAL ACTION OBJECTIVES

Based on the existing ecological and human health risk evaluation (as summarized in Section 3.0), the following removal action objective (RAO) was developed for the Phase 1 Removal area:

> Reduce the concentrations of contaminants in sediments to below the cleanup standards (defined in Section 4.4, below) in the biologically active zone (0–10 cm)

As discussed in Section 5.0, this RAO can be attained through removal and/or containment actions.

4.4 REMOVAL ACTION CLEANUP STANDARDS

This subsection presents the post construction cleanup standards for the Phase 1 Removal action. Final cleanup standards for the waterway will be developed in the ROD and take into account human health risk from bioaccumulative compounds, and TBT uptake. A study is currently ongoing to assist in selection of an appropriate test species to use for TBT bioaccumulation characterization.

The post-construction cleanup standards are based on SMS (WAC 173-204). These site-specific cleanup standards have been developed consistent with the requirements of WAC 173-204-570. Attaining these cleanup standards in surface sediments (0-10 cm) represents compliance with the RAO and will result in a new sediment surface that will be cleaner than the surface that currently exists and therefore it meets the Washington State anti-degradation requirement.

The chemical concentrations in the newly exposed surface sediments will be less than the SQS for the following chemicals: total DDTs, total PCBs, and mercury. These chemicals were consistently determined to exceed standards and guidelines in all regions and sediment horizons of the Phase 1 Removal area, and are identified as bioaccumulative compounds of concern based on DMMP guidelines. The chemical concentrations in the newly exposed surface sediments will also be less than the SQS (as measured by chemical or biological toxicity testing) for all other chemicals. Corrective actions will be implemented to ensure that the Phase 1 Removal area meets these cleanup standards.

4.5 OTHER FACTORS CRITICAL TO THE SELECTED ALTERNATIVE

ARARs and TBCs are listed in Section 10. The following ARARs and other critical factors are of primary importance in the selection and implementation of the remedy:

- Sediment resuspension and or recontamination during the removal action will be minimized by using best management practices (BMPs).
- Consistent with State Hydraulic Code Rules and ESA requirements, dredging and other in-water work cannot occur during identified "fish window" closure periods. The specific dates of these closures will be identified in consultation with the natural resource trustees. It is currently anticipated that dredging will be prohibited between February 14 and August 16.
- Consistent with Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act (CWA), the selected alternative cannot prevent the use of the EWW as a working navigation channel. The Congressionally directed navigation channel depth of -51 ft mean lower low water (MLLW) must be maintained.
- The removal action will be coordinated with Tribal netfishing in the EWW.
- If possible, the removal action should begin in 2003.
- The removal action will be phased so that a contaminated sediment surface will not be left exposed between the two construction seasons in which the removal action occurs.
- To the extent practicable, the removal action will contribute to the efficient performance of the anticipated remedial action for the EWW OU.

5.0 Identification of Phase 1 Removal Action Alternatives

Candidate technologies for the removal action were identified and screened to select the preferred alternative for remedial design and implementation. This section provides a brief description of each of the removal alternatives considered.

5.1 Alternative A — No Action

The no-action alternative provides a baseline against which the other removal action alternatives are compared. In this alternative, the sediments would be left in place, and neither dredging nor capping would be implemented in the Phase 1 area. Furthermore, no institutional controls would be implemented; the site would be left in its current condition.

5.2 Alternative B – *In situ* Capping

In this removal alternative, an isolation cap composed predominantly of fine sands would be placed over the contaminated sediments in the Phase 1 Removal area. Capping forms a surface barrier to physically isolate the contaminated sediments from the aquatic environment. The cap would be designed to prevent contaminant mobility through the cap and to take into account potential bioturbation and cap erosion. A typical cap thickness of 3 ft has been used successfully at other CERCLA sites and would result in a final surface elevation of –35 to -47 ft MLLW. For this evaluation, it is assumed that imported sand will be required for the capping material, and that a 1-ft-thick armoring layer would be included at the top of the cap to prevent erosion from propeller scour. Capping material could potentially be obtained from a sand source, such as the Duwamish River Turning Basin, which requires maintenance dredging every several years. The volume of material required to cap the Phase 1 Removal area is estimated to be approximately 117,000 cy. It is anticipated that construction would be completed in approximately four months.

The isolation cap would likely be placed using one of four different placement methods, or a combination of these methods:

1. Directly placing the cap material at the mudline using a dredge rehandling bucket; the rehandling bucket would grab cap material from a haul barge, and lower the material through the water column before opening slightly above the mudline
2. Hydraulically spraying the cap material off of the deck of a flat deck barge over the Phase 1 Removal area
3. Cracking open a split-hull barge full of cap material while slowly moving it across the Phase 1 Removal area

4. Placing the cap material by rehandling cap material from a haul barge into a tremie tube that would extend through the water column to deposit the cap material slightly above the mudline

In each case, the construction method would minimize disturbance of the *in situ* sediments, because the methods described all entail low-energy placement. In all cases, the armoring layer would be placed using a rehandling bucket to deposit the armor material by opening the bucket at or near the surface of the newly placed cap.

5.3 ALTERNATIVE C – EXCAVATION AND DISPOSAL

In this alternative, approximately 200,000 cy of contaminated sediments (i.e., sediment determined to be unsuitable for DMMP open-water unconfined disposal) and approximately 59,000 cy of interdispersed sediment suitable for DMMP open-water disposal, would be dredged from the EWW Phase 1 Removal area. Sediments would be dredged to -51 ft MLLW to meet navigational requirements plus any additional dredging to meet cleanup requirements. Monitoring during construction would ensure that cleanup objectives were being met. If monitoring indicated that cleanup objectives were not being met, additional dredging or potential thin-layer capping, and/or modifying contractor operations could be implemented. The total volume anticipates including a toe-of-slope setback along the existing sediment mound at Slip 27 to avoid potential slope stability impacts during Phase 1 Removal. The actual slope setback would be evaluated during design.

It is anticipated that the construction would be completed in approximately six months. The sediment suitable for open-water disposal would be dredged and loaded onto bottom dump barges for transport and disposal at the Elliott Bay DMMP open-water unconfined disposal site.

For contaminated sediments, landfill disposal is the preferred disposal alternative, as discussed in Section 7.3. Previous dredging experience within the EWW suggests that the contaminated sediment dredged from the EWW will require dewatering prior to transport to the landfill. Sediments would be placed onto barges, and hauled to a temporary offloading/dewatering site located within the Harbor Island Superfund site. A land-based crane would be used at the staging area for offloading sediments from the barges onto the backland. After processing (which may include dewatering and/or amendment and re-handling), sediments would be loaded by front-end loaders into either trucks or rail cars for transport to an approved upland landfill. Alternatively, the sediments could be loaded directly from the barge into trucks or rail cars without additional on-site processing if their moisture content on the barge is compatible with the requirements of the landfill facility.

Approximately 2 to 5 ac would be required for the offloading and dewatering site. Special preparation, including placement of a filter fabric, a drainage system, and treatment of free water would likely be required for this area. A surface water runoff system would be installed to ensure that water quality standards were being met at the compliance boundary before discharging back into the EWW.

It is possible that no dewatering system would be required. The need for and details of the dewatering system would be determined during the preliminary and final design.

5.4 IDENTIFICATION OF DISPOSAL OPTIONS

Three options for disposal of the Phase 1 contaminated sediment were identified for use in the dredging and disposal alternative, and were evaluated for feasibility based on the Phase 1 Removal action schedule and objectives. The disposal options include confined aquatic disposal (CAD), use of a NCDF, and upland landfill disposal. Based on the evaluation below, upland landfill disposal was selected as the preferred disposal option for Phase 1 Removal action.

5.4.1 Disposal option D1 – Confined aquatic disposal

CAD is a method of underwater containment and isolation that includes some form of lateral confinement (e.g., placement in natural or excavated bottom depressions or behind constructed berms) to minimize spread of the materials on the bottom. A cap of clean material isolates the contaminated sediment from the aquatic environment and prevents potential contaminant migration. The cap needs to be thick enough to account for erosion and bioturbation effects.

To develop a CAD cell within the EWW big enough to accommodate the volume of contaminated sediment from the Phase 1 area, a deep pit would need to be excavated outside the Phase 1 area to accommodate approximately 200,000 cy of contaminated sediment from the Phase 1 area, plus the associated cap volume. A deep pit could not be excavated within the Phase 1 area because it would not be logistically feasible to stockpile the contaminated sediment within the Phase 1 area during the dredging of the pit. The surface elevation of the cap that contains the cell would need to be at or below –51 ft MLLW to accommodate the Congressionally directed navigation depth within the EWW. The overburden material from the cell would need to be dredged and disposed of prior to filling operations. Portions of the overburden sediment might be contaminated and would require upland landfill disposal, while suitable overburden sediment could be disposed of at the Elliott Bay DMMP site.

Engineering for development of a CAD cell would require significant additional sediment characterization and geotechnical data collection within the EWW. The time needed to collect the required data, as well as to design the CAD cell, precludes this disposal option under the Phase 1 Removal action, so the CAD disposal option was eliminated from further consideration.

5.4.2 Disposal option D2 – Nearshore confined disposal (NCDF)

The NCDF disposal option would consist of placing contaminated sediment behind a containment berm (closure dike) located in the nearshore region within the EWW, capping the contaminated sediment with a clean cap, and raising the final surface elevation above the water surface. NCDFs have been successfully designed and constructed at other CERCLA sites. Within the EWW, the potential NCDF locations would be either Slip 27 or Pier 36. Because of the potential limited storage capacity of an NCDF, excess contaminated sediments would be disposed at an upland landfill.

The configuration of an NCDF in the EWW would be based on the following additional criteria:

- Maximizing NCDF capacity
- Need for limiting elevation of placed contaminated sediment to +9 ft MLLW to keep the contaminants below the existing groundwater level and thus minimize potential mobilization of metals
- Not interfering with operations at adjacent Port facilities
- Possible need for berm foundation treatment for stability
- Need for berm armor layer to protect from vessel wake and propeller wash
- Berm dimensions: top elevation of +16.0 ft MLLW, top width of 10.0 ft, and 2H:1V sideslopes[4]

Mitigation would be needed under section 404 of the CWA in addition a significant amount of time would be required for approval by the trustees and public.

As with the CAD disposal option, engineering for development of an NCDF and its containment berm would require substantial additional geotechnical data collection, contaminant mobility testing, and design evaluation. The time needed to collect the required data and design the NCDF precludes this disposal option under the Phase 1 Removal action, so the NCDF disposal option was eliminated from further consideration.

5.4.3 Disposal option D3 – Upland landfill disposal

The upland landfill disposal option assumes placement of all 200,000 cy of Phase 1 contaminated sediments within an existing solid waste landfill that would be proposed by the Port and EPA. If sediments are not eligible for open-water disposal and they pass the toxicity characteristic leaching procedure test, they can be disposed of in a RCRA Subtitle D landfill.

Because of the water content in dredged material, the sediments typically need to be dewatered prior to transport to a landfill. The Paint Filter Test is the standard test required by landfill facilities to determine the suitability of dewatered sediment for transport. Dewatering requires rehandling of the contaminated sediments into an onshore facility. Potential locations for offloading sediment include Terminal 25, Terminal 30 or other Port facilities within the Harbor Island Superfund Site. The

[4] Based on best engineering judgment

dewatering facility is commonly a bermed containment area, although storage tanks have also been used. Dewatering methods may include active dewatering (e.g., adding stabilizers or applying surcharge to the sediment) and/or passive dewatering (e.g., settling and desiccation). Facility requirements will be determined during remedial design.

The current standard transportation practice is to rehandle dewatered sediments into 20-ft or 40-ft containers for transport by truck or rail. These containers often have extra liners to prevent leakage. Once sediments are unloaded at the landfill, they can be placed in an active cell for disposal or, if appropriate, used as daily cover material to cover other waste materials.

No additional data collection is necessary to implement upland landfill disposal. Therefore, for the Phase 1 Removal action, upland landfill disposal is considered the preferred disposal option.

6.0 Evaluation Criteria

This section compares the criteria set out in EE/CA guidance with the various removal alternatives, and defines the evaluation criteria that were used to assess each removal alternative.

6.1 EFFECTIVENESS

Effectiveness is the degree to which a given alternative reduces toxicity, mobility, or potential exposure hazard of chemical constituents over the long term. Effectiveness also relates to the protectiveness of the alternative, including consistency with environmental, land use, and aquatic use regulations. Options with high effectiveness have a high probability of success to minimize both short-term impacts and residual risks, afford long-term protection, and comply with cleanup objectives. The specific cleanup objectives by which effectiveness will be evaluated for the Phase 1 Removal action are presented in Section 4.

6.2 IMPLEMENTABILITY (TECHNICAL FEASIBILITY)

Technical feasibility considers the constructability and logistical challenges for each alternative. A low score for technical feasibility indicates that a nonstandard or unproven technology is involved, that the option is relatively complex or difficult to construct, or that the alternative requires extensive maintenance. The following technical feasibility issues apply to the removal action alternatives:

- availability of technology, facilities, equipment, and trained workforce
- equipment staging and site access
- water quality management
- type of existing site sediment and geotechnical considerations

- depth of water and gradient or slope of the bed
- in-water construction constraints
- constructability

6.3 IMPLEMENTABILITY (INSTITUTIONAL FACTORS)

The following institutional factors apply to the evaluation of implementability for each of the removal action alternatives:

- existing and planned site use and adjacent property use
- potential conflicts with future uses
- compliance with Congressionally directed channel depth requirements
- compliance with Native American treaty rights, including fishing activities

6.4 COST

The relative costs to implement each alternative (i.e., capital costs) were considered at a preliminary screening level. Long-term monitoring costs were not included because of the wide range of potential long-term monitoring costs that may be required. The screening-level cost comparison is intended only as a preliminary guide to convey a sense of the relative costs associated with each option. The general range of costs is based on experience with similar processes, as applied to project-specific cost components. The screening-level cost estimates include dredging costs, disposal costs, and capping costs. Cost components included the following:

- mobilization/demobilization
- construction
- material purchase
- disposal fees

7.0 Evaluation of Phase 1 Removal Action Alternatives

The anticipated effectiveness, technical and institutional feasibility, and cost for each option were evaluated at a qualitative level based on available information and experience at sites with conditions similar to the EWW. These factors were assigned relative ratings of low, medium, or high based on the expected implementability for the site conditions and sediment characteristics, the effectiveness at achieving the objectives of the removal action, and the relative cost of the alternative.

7.1 ALTERNATIVE A – NO ACTION

7.1.1 Effectiveness

The no-action alternative does not achieve the objectives of the removal action, which include affording long-term protection, achieving removal objectives, and minimizing residual risks. Specifically, the no-action alternative does not remove sediments with chemicals exceeding CSLs

7.1.2 Implementability

Because the no-action alternative does not involve any construction, there are no implementation issues and this alternative ranks high for implementability.

7.1.3 Cost

There are no costs associated with the no-action alternative.

7.2 ALTERNATIVE B – *IN SITU* CAPPING

7.2.1 Effectiveness

The *in situ* capping alternative is considered effective in achieving the objectives of a removal action in the Phase 1 area based on the success of other *in situ* caps placed at similar CERCLA sites. In the short term, an engineered *in situ* cap would successfully isolate contaminated sediments from the aquatic environment, prevent bioturbation, and allow for sediment consolidation. Long-term effectiveness requires designing and maintaining the cap against potential erosion from vessel propeller wash. The cap would be designed to be erosion resistant by incorporating a granular armor layer. because the EWW experiences significant vessel traffic, erosion prevention would be a critical component to a successful *in situ* cap.

During implementation, the capping operations would not be expected to have significant environmental or human health impacts. During capping, potential water quality impacts (e.g., turbidity) would be controlled by using low-energy cap placement methods as previously described. Furthermore, the only materials being handled by the construction equipment would be clean cap and armoring materials. The potential for short-term health impacts to the general public is judged to be negligible. The effectiveness for this alternative is considered to be medium, due to the uncertainty of its long-term effectiveness and the need for continued monitoring and maintenance.

7.2.2 Implementability

In situ capping would use standard construction techniques, equipment, and materials that are readily available in the local area. *In situ* capping has been demonstrated to be constructible and stable in the long term for similar projects in the Puget Sound region. An adequate staging area is readily available in several locations at or near the site. One technical challenge for implementation of capping would be compatibility with the remainder of the remediation of the EWW. If a future remedy includes dredging and disposal adjacent to the Phase 1 area, some portion of the cap could potentially be impacted by the adjacent dredging. On the whole, however, as a removal action, the capping alternative is technically feasible.

There is a significant institutional factor that renders the capping alternative not implementable. The Phase 1 Removal area is within the EWW federal channel, with an Congressionally directed depth of -51 ft MLLW. The current mudline elevation in the Phase 1 area ranges from -38 to -50 ft MLLW, and the Port requires full navigation depth within the EWW to provide access to its terminals. With the addition of a 3-ft-thick cap, the water depth would be even shallower, with the mudline at -37 to -47 ft MLLW. Therefore, because the thickness of the cap prevents achieving the required water depth, the *in situ* capping alternative is considered to have low implementability due to institutional factors.

7.2.3 Cost

The estimated construction cost for the capping alternative, as described herein, is approximately $5,000,000. Costs are broken out in Table 7-1.

7.3 ALTERNATIVE C – EXCAVATION AND DISPOSAL

7.3.1 Effectiveness

Excavation and disposal is considered effective in achieving the objectives of the removal action because this alternative will remove a substantial quantity of the contaminated sediments from the aquatic environment. Short-term risks would be minimized during construction using a variety of BMPs, operational controls, and construction monitoring. Long-term protection would be afforded by meeting cleanup objectives in the Phase 1 area, which would be verified through a post-dredge monitoring program. The dredging and disposal alternative is anticipated to require two construction seasons due to the large dredge volume and anticipated start-date at the end of 2003. This schedule would allow some mid-construction verification to be performed to further ensure the effectiveness of this alternative by allowing a change in construction procedures or BMPs, or by modifying the dredging plan in the second year of construction if necessary to achieve cleanup objectives.

Table 7-1. Preliminary cost estimate for capping

CATEGORY	QUANTITY	UNIT COST ($)	COST ($)	TOTAL COST
Capping				
Mobilization/Demobilization	1	$150,000	$150,000	
Capping Phase 1 Area 1:				
Purchase, transport and place 2-ft thick sand layer	88,000 cy	$30/cy	$2,640,000	
Purchase, transport and place 1-ft-thick armor layer	29,000 cy	$35/cy	$1,020,000	
Subtotal Capping				$3,810,000
Monitoring				
Water quality monitoring during construction	1	$350,000	$350,000	
Construction oversight/management	1	$150,000	$150,000	
Subtotal monitoring				$500,000
Engineering and Project Management				
Engineering and permitting	1			
Internal Port staff	1			
Subtotal Engineering and PM				$0
Contingency on Capping	15%			$572,000
Total Cost				**$5,000,000**

Note: Assumes all cap placement using rehandling clamshell bucket

Monitoring during construction and after dredging would take place to ensure that the removal action meets the project objectives. If project objectives have not been met, the Contractor will be directed to perform additional dredging and/or thin layer capping. Effectiveness is considered high for this alternative.

7.3.2 Implementability

The dredging and disposal alternative would use standard construction techniques, equipment, and materials that are readily available in the local area. The dredging would be performed with mechanical dredging equipment, which has been successfully used during prior dredge projects on the EWW and in other Puget Sound locations. The depth of dredging is well within the capability of standard dredge equipment, and there are no adjacent structures or slopes that would be impacted by dredging in the Phase 1 area. The Port would determine the location for barge offloading/staging during remedial design and ensure that the area is available during the project timeframe. Terminal 25 has been provisionally identified as a likely location. The volume of contaminated sediments that would be shipped offsite for upland landfill disposal is not anticipated to impact the capacity of the receiving facilities. The activity is also not anticipated to pose undue burden on the rail transport system. The dredging and disposal alternative is a technically feasible removal action.

The dredging and disposal alternative is also judged to be implementable based on a review of institutional factors. The proposed depth of dredging would be -51 ft MLLW or more to meet cleanup objectives and also to be compatible with the Congressionally directed channel depth. The adjacent temporary staging area would be designed and protected in a manner that is consistent with land use regulations. The Phase 1 dredge material has been recharacterized to meet recency guidelines under DMMP and a suitability determination will be obtained from the Dredged Materials Management Office. The dredging and disposal alternative is considered to have a high ranking for implementability based on a review of both technical feasibility and institutional factors.

7.3.2.1 Recontamination evaluation

The Phase 1 Removal action will be conducted during two in-water construction seasons. Based on a review of potential sources and source control measures that have been implemented, the potential for recontamination of the Phase 1 Removal action area between the two construction seasons is not considered to be significant (EVS 1996b). There is potential for recontamination after the Phase 1 Removal action is complete, with a primary source being the King County Metro combined sewer overflows (CSOs), although this is not considered to be significant (EVS 1996b). Source control measures for the King County Metro CSOs are ongoing under activities that are independent of the EWW remediation.

A full evaluation of recontamination potential will be completed during Phase 2 of the EWW investigation. Potential sources of contamination include adjacent upland sources, outfalls, the Duwamish River, and in-water construction activities. These sources of potential recontamination, as well as proposed mitigation measures, will be discussed in detail in the Remedial Design report for the Phase 1 Removal action.

7.3.2.2 Predicted quality of new sediment surface

Sediment samples have been collected at a depth representative of the new sediment surface (–51 ft to –52 ft MLLW), as well as sediment strata up to 3 ft below the future sediment surface, to characterize the new surface horizon (Windward 2002). Five of these sampling locations are in the Phase 1 Removal area.

Table 7-2 and Map 24 summarize the detected chemical concentrations with SMS exceedances from these five new sediment surface sampling locations. In two locations, SQS exceedances were found in all three sediment horizons (–51 ft to –52 ft, –52 ft to –53 ft and –53 ft to –54 ft MLLW). The predominant SQS exceedances in the five samples were for mercury, DDT, and PCBs. Exceedances of the CSL for mercury were found in the second sediment horizon (-52 ft to – 53 ft) at two locations. A comparison of the analytical results presented in Table 7-2 with the data presented in Tables 3-1, 3-2, 3-3, and 3-4 for the existing 0-15 cm and 0-4 ft chemistry data shows that the new sediment surface is expected to be of significantly better quality than the existing surface. Both the number of chemicals exceeding their respective SQS and

CSL standards is less, and the relative EF for the chemicals that do exceed the SQS or CSL is lower. For example, the maximum SQS EF for total PCBs in the existing surface horizon (0-15 cm data only) is 11.5, while the maximum SQS EF for total PCBs in the new surface horizon is 1.8. In any case, the new sediment surface must meet the cleanup standards as defined in Section 4.4.

Table 7-2. Detected chemical concentrations with SMS exceedances of new sediment surface sampling locations

Location ID	Sample ID[a]	Parameter	Value	Unit (dw)	SQS EF	CSL EF
EW-145	EW-145-01	PCBs (total calc'd)	13.3	mg/kg-oc	1.1	
EW-145	EW-145-01	Mercury	0.5	mg/kg	1.2	
EW-145	EW-145-01	DDTs (total-calc'd)	15	µg/kg	2.8	
EW-145	EW-145-02	PCBs (total calc'd)	16.5	mg/kg-oc	1.4	
EW-145	EW-145-02	DDTs (total-calc'd)	9.3	µg/kg	1.4	
EW-145	EW-145-02	Mercury	0.6	mg/kg	1.5	1.0
EW-145	EW-145-03	PCBs (total calc'd)	16.6	mg/kg-oc	1.4	
EW-145	EW-145-03	Mercury	0.5	mg/kg	1.2	
EW-145	EW-145-03	DDTs (total-calc'd)	8.2	µg/kg	1.2	
EW-146	EW-146-01	1,4-Dichlorobenzene	3.9	mg/kg-oc	1.3	
EW-146	EW-146-01	PCBs (total calc'd)	16	mg/kg-oc	1.3	
EW-146	EW-146-01	Mercury	0.5	mg/kg	1.1	
EW-146	EW-146-01	DDTs (total-calc'd)	21.8	µg/kg	3.2	
EW-146	EW-146-02	PCBs (total calc'd)	21.9	mg/kg-oc	1.8	
EW-146	EW-146-02	DDTs (total-calc'd)	9.2	µg/kg	1.3	
EW-146	EW-146-02	Mercury	0.6	mg/kg	1.5	1.0
EW-146	EW-146-03	1,2,4-Trichlorobenzene	1.5	mg/kg-oc	1.8	
EW-146	EW-146-03	1,4-Dichlorobenzene	7.1	mg/kg-oc	2.3	
EW-146	EW-146-03	PCBs (total calc'd)	60	mg/kg-oc	5.0	
EW-146	EW-146-03	DDTs (total-calc'd)	20.8	µg/kg	3.0	

dw - dry weight

EF - exceedance factor

[a] The last two numbers on the sample ID represent the depth interval: 01 = –51 ft to –52 ft, 02 = –52 ft to –53 ft, and 03 = 53 ft to –54 ft MLLW

7.3.3 Cost

The estimated construction cost of the dredging and disposal alternative described herein is approximately $17,000,000. Costs are broken out in Table 7-3.

Table 7-3. Preliminary cost estimate for dredging and disposal

CATEGORY	QUANTITY	UNIT COST ($)	COST ($)	TOTAL COST
Dredging				
Mobilization/Demobilization	1	$250,000	$250,000	
Site Preparation				
Construct dewatering/staging facility	1	$150,000	$150,000	
Dredging unsuitable sediments and upland disposal:				
Dredge, rehandle, dewater, transport and dispose at upland facility	200,000 cy	$68	$13,600,000	
Dredging suitable sediments and disposal at PSDDA site:				
Dredge and dispose clean sediments	59,000 cy	$6/cy	$354,000	
DNR disposal site use fee	59,000 cy	$0.45/cy	$27,000	
Subtotal Dredging				$14,380,000
Monitoring				
Water quality monitoring during construction	1	$350,000	$350,000	
Construction oversight/management	1	$150,000	$150,000	
Subtotal Monitoring				$500,000
Engineering and Project Management				
Engineering and permitting	1		$0	
Internal Port staff	1		$0	
Subtotal Engineering and PM				$0
Contingency on Dredging	15%			$2,160,000
Total Cost				**$17,000,000**

Note: Total PSDDA unsuitable volume 200,000
Total PSDDA suitable volume 59,000
Total volume 259,000

Total volume of suitable vs. unsuitable is based on previously calculated DMMUs, and adjusted to account for additional unsuitable volume that would be dredged based on a developed dredge plan.

8.0 Comparative Analysis of Phase 1 Removal Action Alternatives

This section presents a brief comparative analysis of each of the three removal alternatives against the evaluation criteria. Based on the comparative analysis (Table 8-1), the dredging and disposal alternative was considered to be the Port's preferred removal action alternative for the Phase 1 Removal action. Dredging and disposal ranked high in effectiveness, high in implementability and low in cost (i.e., cost effectiveness) relative to the other two alternatives. While this is the preferred removal action for the Port, EPA has the final authority to select the actual alternative that will be implemented during Phase 1.

8.1 EFFECTIVENESS

The no-action alternative is not effective at achieving the objectives of the removal action, and was thus discarded from further consideration. Both the *in situ* capping and the dredging and disposal alternatives were judged to be effective at meeting the removal action objectives. *In situ* capping ranked medium due to uncertainty about its long-term effectiveness and need for continued maintenance, while dredging and disposal ranked high. A comparison of effectiveness, strengths, and weaknesses is provided in Table 8-1.

8.2 IMPLEMENTABILITY

No action and the dredging and disposal alternatives were judged to be implementable for the Phase 1 Removal action. The *in situ* capping alternative was judged to have low implementability due to institutional factors. A comparison of implementability strengths and weaknesses is provided on Table 8-1.

8.3 COST

To evaluate the alternatives, screening-level construction, operation, and maintenance costs have been estimated for each case. These costs include capping, dredging, transportation, and disposal. Table 8-1 provides the estimated cost for the three alternatives. No action is the least costly, followed by capping, and finally dredging and disposal.

Table 8-1. Evaluation of Phase 1 Removal alternatives

ALTERNATIVE	EFFECTIVENESS		IMPLEMENTABILITY		APPROXIMATE CONSTRUCTION COST
	STRENGTHS	WEAKNESSES	STRENGTHS	WEAKNESSES	
No action	▪ None	▪ Not effective at achieving removal action objectives	▪ No implementation issues because no work is performed	▪ No implementation issues because no work is performed	$0
In situ capping	▪ Isolates contaminated sediments from aquatic environment ▪ Achieves short-term and long-term protection of the environment	▪ Potential re-exposure of contamination if dredging is ever required in the area of the cap ▪ Long-term stability is uncertain ▪ Long-term maintenance requirements	▪ Contractors experienced in capping ▪ Standard equipment ▪ Readily available materials (cap sediments) ▪ Process appropriate for any type sediment ▪ Adequate staging areas available	▪ Capping design would need to be compatible with future remediation of areas adjacent to Phase 1 ▪ Federal Channel does not achieve the required depth of -51 ft MLLW	$5,000,000
Excavation and disposal	▪ Substantial removal of contamination from the Phase 1 area ▪ Achieves short-term and long-term protection of the environment	▪ Potential for sediment release during dredging, which must be controlled using BMPs, operational controls, and construction monitoring	▪ Contractors experienced in dredging ▪ Significant amount of past experience with this method in the EWW ▪ Standard equipment ▪ Adequate staging areas available ▪ Process appropriate for any type of sediment	▪ Potential impacts associated with dredging and transport ▪ Need to locate upland offload/ rehandling location ▪ Need to manage effluent	$17,000,000

9.0 Anticipated Measures to Minimize Potential Environmental Impacts During Construction

This section provides a brief description of potential environmental impacts during construction and also gives a general description of BMPs that could be implemented during construction to minimize the potential for environmental impacts. Mitigating potential impacts will entail limiting sediment resuspension and loss, and verifying that the cleanup objectives are met (e.g., ensuring that all contaminated sediment is removed to the RAO, as translated in the design specifications) through construction and post-construction monitoring. The Port will provide a water quality monitoring plan for agency comment as part of the Remedial Design documents submittal. The CWA §401 water quality certification will include the water quality monitoring requirements.

9.1 Design Considerations

Based on the estimated dredging production rate, the duration of the Phase 1 dredging activities is expected to range from 4 to 6 months. The dredging activities are anticipated to take place over two construction seasons because of the limited window in which in-water activities are permitted to occur. Between seasons, the Phase 1 dredge area will have portions of the Removal area that may be left above the required dredge elevation of -51 ft MLLW. In order to avoid leaving a contaminated surface that has potentially higher levels of contamination than the existing surface, the contractor will be required to dredge the contaminated sediment to the depth where either:

- The required elevation of -51 ft MLLW is reached; or
- The underlying suitable DMMU[5] is reached.

The construction sequencing will minimize the potential for environmental impacts between the two construction seasons.

9.2 Water Quality Monitoring

Previously, dredging within the EWW has resulted in some turbidity criterion exceedances at a typical dilution mixing zone boundary of 300 ft, though the majority of monitoring indicated that the contractor was able to meet the turbidity standard at the mixing zone boundary. The geometry and site conditions within the EWW increase the likelihood of short-term water quality impacts during dredging. The

[5] DMMU suitability is determined based on DMMP disposal guidelines for chemistry and biological testing. Suitable DMMUs in the Phase 1 Removal area met the disposal guidelines for Tier 3 biological testing.

EWW is channelized, which helps direct the resuspended sediment unidirectionally due to unidirectional current flow. Also, the EWW experiences low current velocities that reduce the lateral dispersion and diffusion, increasing maximum downstream total suspended sediment concentrations.

Previous dredging projects have used specialized equipment (i.e., closed bucket) to minimize water quality impacts. However, due to the density of the sediment, this method did not effectively remove all the required dredged material. The Port has had success with minimizing potential water quality impacts by implementing a higher frequency sampling and reporting scheme during monitoring, to provide more timely information to the construction manager when the contractor exceeded water quality criteria. Using greater sampling frequency allowed the construction manager to direct the contractor to modify operations to stay within compliance.

9.3 OPERATIONAL CONTROLS

For dredging projects, operational controls are defined as modifications in the standard operation of the dredging equipment intended to minimize resuspension of materials. Operational controls can be employed with mechanical dredges, hydraulic dredges, hopper dredges, or barges. Example operational control methods for mechanical dredges are described in the following sections.

9.3.1 Increasing cycle time

Longer cycle time generally means reducing the velocity of the ascending loaded bucket through the water column, which reduces potential to wash sediment from the bucket. However, limiting the velocity of the descending bucket may reduce the volume of sediment that is picked up by the bucket, thus requiring more total bites to remove the project material, and increasing the overall project duration. Sediment resuspension also occurs when the bucket impacts the bottom surface. Sediment resuspension can also be reduced by pausing the bucket at the sediment surface before digging and pausing the bucket at water line during the ascent, both of which increase cycle time.

9.3.2 Eliminating multiple bites

When the clamshell bucket hits the bottom, an impact wave of suspended sediment travels along the bottom away from the dredge bucket. When the clamshell bucket takes multiple bites, the bucket loses sediment as it is reopened for subsequent bites. Sediment is also released higher in the water column, as the bucket is raised, opened, and lowered.

9.3.3 Eliminating dredging during peak tidal exchange periods

Dredging during peak tidal exchange periods (i.e., an ebb tide and high river currents) may increase downstream turbidity.

9.3.4 Eliminating bottom stockpiling

Bottom stockpiling of the dredged sediment in silty sediment has an effect similar to multiple bite dredging: an increased volume of sediment is released into the water column from the operation.

9.3.5 Eliminating barge overflow

Overflow of sediment from the barge can lead to increases in turbidity in the upper water column.

9.3.6 Filtering material placement at barge scuppers

Placement of filter material over the barge scuppers decreases the suspended sediment loading from barge drainage.

9.4 SPECIALIZED EQUIPMENT, SILT CURTAINS, AND GUNDERBOOMS®

As with the compliance/operational controls described above, these specialty equipment options have the potential to reduce sediment resuspension, but also may increase costs. This category includes specialized dredging equipment, as well as silt curtains and Gunderboom® technology.

9.4.1 Closed or environmental bucket

This technology consists of specially constructed dredging buckets designed to reduce or eliminate increased turbidity of suspended solids from entering a waterway. As mentioned above, the closed-bucket approach was not effective when used during a prior EWW project due to the relatively dense sediments in the waterway.

9.4.2 Precision dredging equipment

This technology utilizes special tools and techniques to restrict the material dredged to that specifically identified. This technology may necessitate dredging thin layers, either surficial or imbedded, or limiting dredging to tightly controlled boundaries.

9.4.3 Silt curtains and Gunderbooms®

The objective when using silt curtains is to create a physical barrier around the dredge equipment to allow the suspended sediments to settle out of the water column in a controlled area. Silt curtains are typically constructed of flexible, reinforced, thermoplastic material with flotation material in the upper hem and ballast material in the lower hem. The curtain is placed in the water surrounding the dredge or disposal area, allowed to unfurl, and then anchored in place using anchor buoys. Silt curtains are most effective on projects where they are not opened and closed to allow equipment access to the dredging or disposal area. Because they are impermeable, silt curtains are easily affected by tides and currents and generally should not be used in areas with greater than 1-2 knot currents (Hartman 2001). Silt curtains can be deployed so that they extend to within 2 ft of the bottom, but this is seldom practical due to water currents. As such, most projects only use curtains that extend a maximum of 10 to 12 ft below the surface. A key advantage of silt curtains is that if they are deployed correctly, they can protect the adjacent resources by controlling surface turbidity. The main disadvantages of silt curtains are that they are not effective in high-energy environments, they have no effect on bottom turbidity, and they limit navigation in the dredging vicinity.

A Gunderboom® works in a similar way, except that the curtain is made of a permeable geotextile fabric that allows the water to pass through, but filters out the particulates. While silt curtains are typically deployed so that they extend downward through part of the water column, Gunderbooms® are designed to be installed from the water surface to the project bottom. The advantages of Gunderbooms® are that they allow unlimited curtain depth and permit unrestricted water flow; the disadvantages are that they are more expensive than silt curtains and can become clogged with silt.

9.5 POST-CONSTRUCTION MONITORING

Post construction monitoring will be conducted to measure sediment chemical concentrations associated with the new sediment surface to document that sediment quality objectives are met. Details will be developed in the Remedial Design.

9.6 PHASE 1 REMOVAL SCHEDULE

Based on an estimated production rate of 1,500 to 2,500 cy per day for contaminated sediments and 2,000 to 3,000 cy per day for DMMP open water disposal - suitable sediments, the project duration is expected to range from 4 to 6 months to complete the Phase 1 Removal Action dredging activities.

The dredging activities are anticipated to take place over two construction seasons due to the limited window in which in-water activities are permitted to occur. Assuming the approval of the design documents in July 2003, the dredging for the first construction season is anticipated to start in late 2003 and finish by February 15, 2004. No in-water construction activities will occur between February 15, 2004, and mid-August 2004, during the fish closure window. The second season of dredging would typically start in mid-August 2004 and extend through February 14, 2005.

10.0 Applicable or Relevant and Appropriate Requirements

Table 10-1 is a comprehensive list of ARARs applicable to the EWW Phase 1 Removal. The Phase 1 Removal will meet substantive requirements of ARARs to the greatest extent practicable.

Table 10-1. ARARs

Source		Requirement
1.	State Model Toxics Control Act WAC 173-340-440	These regulations are applicable to establishing institutional controls for capping.
2.	Federal Water Pollution Control Act/ Clean Water Act 33 USC 1251-1376 40 CFR 100-149	Acute Marine Criteria are anticipated to be relevant and appropriate requirements for discharge to marine surface water during sediment dredging.
3.	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. The standards for marine waters will be applicable to discharges to surface water during sediment dredging.
4.	Washington Sediment Management Standards WAC 173-204	Chemical concentration and biological effects standards are established for Puget Sound sediments and are applicable to the Phase 1 EWW removal action. Sediment cleanup standards are established on a site-specific basis from a range of concentrations.
5.	State Water Pollution Control Act/Water Resources Act RCW 90.48 RCW 90.54	Requirements for all known, available, and reasonable technologies for treating wastewater prior to discharge to state waters are applicable to any dewatering of marine sediment prior to upland disposal. Section 401 requires certification for activities conducted under Section 404 authorities. The substantive requirements of a certification determination are applicable.
6.	Construction in State Waters, Hydraulic Code Rules RCW 75.20 WAC 220-110	Hydraulic Project Approval (HPA) and associated requirements for construction projects in state waters have been established for the protection of fish and shellfish.
7.	State Discharge Permit Program/NPDES Program WAC 173-216 WAC 173-220	The Washington State NPDES program provides conditions for authorizing direct discharges to surface waters and specifies point source standards for such discharges. These standards are applicable to discharges to surface waters resulting from sediment dewatering operations during dredging and disposal work.
8.	Federal Clean Water Act Dredge and Fill Requirements, Sections 401 and 404 33 USC 401 et. seq 33 USC 1251-1316 33 USC 1413 40 CFR 230-231 33 CFR 320-330	These regulations provide requirements for the discharge of dredged or fill material to waters of the United States, and are applicable to any in-water work.

Source		Requirement
9.	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 Remedial Design Documents in consultation with NOAA Fisheries and USFWS.
10.	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.
11.	Resource Conservation and Recovery Act 40 CFR 261.4(g)	This regulation is an exemption determining that dredged contaminated sediments that are subject to the requirements of Section 404 of the Clean Water Act are not RCRA hazardous waste.
12.	State Aquatic Lands Management Laws RCW 79.90-79.96 WAC 332-30	The final remedy must be consistent with state laws that promote environmental protection, public access, water dependent uses, and uses of renewable resources, and that generate revenue to the State in a manner consistent with these management goals.

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APPENDIX A:

REMOVAL BOUNDARIES TECHNICAL MEMORANDUM FOR THE EAST WATERWAY OPERABLE UNIT, HARBOR ISLAND SUPERFUND SITE

A.1.0 Introduction

The EPA has ordered the Port to address sediment contamination issues in the EWW per the process defined by CERCLA. A ROD has not been completed for the EWW. However, EPA has determined that a NTCRA is warranted for a portion of the EWW. Cleanup of the remainder of the EWW will be addressed in Phase 2 either through additional NTCRAs or a phased RD/RA to complete the cleanup of the EWW.

This memo provides a review of the existing sediment chemistry and toxicity data to identify areas that would be suitable for the Phase 1 Removal. The following factors were used in identifying and prioritizing areas of concern:

- sample locations were identified in which sediment chemistry values exceeded the corresponding CSLs/MLs; groups or clusters of locations with CSL exceedances were identified as areas of concern
- sediment chemistry and toxicity exceedances of CSLs/MLs were used to prioritize areas

The areas of concern were further evaluated to identify areas suitable for dredging in the Phase 1 Removal. First, the sufficiency of the available data for each area of concern was evaluated. Only areas with sufficient data available to delineate areal extent and depth of sediment contamination were retained for further evaluation. Then, the technical feasibility of dredging each area as part of the Phase 1 Removal was evaluated.

The Phase 1 Removal area identified using this process is located in the southern portion of the EWW; the area includes much of the center of the waterway between the Lander and Hanford CSO outfalls. This area met the following criteria:

- sediment chemistry and toxicity test results indicated numerous CSL exceedances and failures of toxicity tests
- the area is sufficiently well-characterized to proceed without additional sampling prior to dredging
- dredging in the area is feasible without slope stability issues that would require additional engineering and design work

The memo is organized into the following sections, Section 2 provides the guidelines used in the evaluation of the available sediment chemistry data, Section 3 includes a review of the existing sediment chemistry and toxicity data that were used to identify and prioritize twelve areas of concern, as well as an assessment of the sufficiency of the existing data at each area. Section 4 presents a feasibility evaluation for the remaining areas of concern and finally, the proposed Phase 1 dredge boundary is presented in Section 5.

This memo is intended as a companion document to the East Waterway Data Summary Report (Windward 2003). The Data Summary Report provides a detailed discussion of the sediment chemistry and toxicity data that is summarized here for the purposes of identifying a removal boundary area for the Phase 1 Removal action.

A.2.0 Sediment Chemistry Evaluation

Sediment and porewater chemistry results were compared to the Washington State sediment management standards (SMS) sediment quality standards (SQS) and cleanup screening levels (CSLs). These values are presented in Table 2-1. When these standards were not available, dredged material management program (DMMP) guidelines, screening level (SL) and maximum level (ML) values were used. For those chemicals whose standards are based on organic-carbon normalized concentrations (i.e. PAHs, PCBs, and phthalates), samples with organic carbon contents below 0.2 % and greater than 8% were not organic carbon normalized due to the uncertainty associated with normalization using these extremely low and high TOC values. The concentrations associated with these samples were compared to the two lowest available apparent effects threshold (AET) values on a dry weight basis. The samples that were compared to AET values are presented in Attachment A. In addition, the following chemicals do not have CSL values: 1,3-dichlorobenzene, aldrin, alpha-chlordane, dieldrin, heptachlor, and tributyltin. Exceedances of CSL values were used to identify the areas of concern, therefore the concentrations of chemicals without CSL values did not influence the selection of areas of concern.

Table A-2-1. Regulatory standards and guidelines for chemicals of interest

ANALYTE	SQS[a]	CSL[a]
Antimony	150 mg/kg [b]	200 mg/kg [c]
Arsenic	57 mg/kg	93 mg/kg
Cadmium	5.1 mg/kg	6.7 mg/kg
Chromium	260 mg/kg	270 mg/kg
Copper	390 mg/kg	390 mg/kg
Lead	450 mg/kg	530 mg/kg
Mercury	0.41 mg/kg	0.59 mg/kg
Nickel	140 mg/kg [b]	370 mg/kg [c]
Silver	6.1 mg/kg	6.1 mg/kg
Zinc	410 mg/kg	960 mg/kg
LPAH	370 mg/kg OC	170 mg/kg OC
HPAH	960 mg/kg OC	5,300 mg/kg OC
Naphthalene	99 mg/kg OC	170 mg/kg OC
2-Methylnaphthalene	38 mg/kg OC	64 mg/kg OC
Acenaphthylene	66 mg/kg OC	66 mg/kg OC
Acenaphthene	16 mg/kg OC	57 mg/kg OC

ANALYTE	SQS[a]	CSL[a]
Fluorene	23 mg/kg OC	79 mg/kg OC
Phenanthrene	100 mg/kg OC	480 mg/kg OC
Anthracene	220 mg/kg OC	1,200 mg/kg OC
Fluoranthene	160 mg/kg OC	1,200 mg/kg OC
Pyrene	1,000 mg/kg OC	1,400 mg/kg OC
Benz(a)anthracene	110 mg/kg OC	270 mg/kg OC
Chrysene	110 mg/kg OC	460 mg/kg OC
Benzo(b+k)fluoranthene	230 mg/kg OC	450 mg/kg OC
Benzo(a)pyrene	99 mg/kg OC	210 mg/kg OC
Indeno(1,2,3-cd)pyrene	34 mg/kg OC	88 mg/kg OC
Dibenz(a,h)anthracene	12 mg/kg OC	33 mg/kg OC
Benzo(g,h,i)perylene	31 mg/kg OC	78 mg/kg OC
1,2-dichlorobenzene	2.3 mg/kg OC	2.3 mg/kg OC
1,3-dichlorobenzene	170 µg/kg [b]	na
1,4-dichlorobenzene	3.1 mg/kg OC	9 mg/kg OC
1,2,4-Trichlorobenzene	0.81 mg/kg OC	1.8 mg/kg OC
Hexachlorobenzene	0.38 mg/kg OC	2.3 mg/kg OC
Dimethyl phthalate	53 mg/kg OC	53 mg/kg OC
Diethyl phthalate	61 mg/kg OC	110 mg/kg OC
Di-*n*-butyl phthalate	220 mg/kg OC	1,700 mg/kg OC
Butyl benzyl phthalate	4.9 mg/kg OC	64 mg/kg OC
Bis(2-ethylhexyl) phthalate	47 mg/kg OC	78 mg/kg OC
Di-*n*-octyl phthalate	58 mg/kg OC	4,500 mg/kg OC
Dibenzofuran	15 mg/kg OC	58 mg/kg OC
Benzyl alcohol	57 µg/kg	73 µg/kg
Benzoic acid	650 µg/kg	650 µg/kg
Hexachlorobutadiene	3.9 mg/kg OC	6.2 mg/kg OC
Hexachloroethane	1,400 µg/kg [b]	14,000 µg/kg [c]
N-nitrosodiphenylamine	11 mg/kg OC	11 mg/kg OC
Trichloroethene	160 µg/kg [b]	1,600 µg/kg [c]
Trichloroethene	57 µg/kg [b]	210 µg/kg [c]
Total DDTs	6.9 µg/kg [b]	69 µg/kg [c]
Aldrin	10 µg/kg [b]	na
Alpha-chlordane	10 µg/kg [b]	na
Dieldrin	10 µg/kg [b]	na
Heptachlor	10 µg/kg [b]	na
Total PCBs	12 mg/kg OC	65 mg/kg OC
Phenol	420 µg/kg	1,200 µg/kg
2-Methylphenol	63 µg/kg	63 µg/kg
4-Methylphenol	670 µg/kg	670 µg/kg
2,4-Dimethylphenol	29 µg/kg	29 µg/kg

ANALYTE	SQS[a]	CSL[a]
Pentachlorophenol	360 µg/kg	690 µg/kg
TBT (as ion in porewater)	0.15 µg/L[b]	na

na - not available

OC - organic carbon-normalized

[a] SMS guidance criteria (SQS=Sediment Quality Standards, CSL=Cleanup Screening Level)

[b] DMMP guideline, SL=Screening Level

[c] DMMP guideline, ML=Maximum Level

A.3.0 Area of Concern Identification

Within East Waterway, areas of concern were identified as areas with sediment chemical concentrations that exceeded the corresponding CSL values. The sediment chemistry results are presented in Section 3.1 and the results of sediment toxicity testing conducted with sediments collected in the areas of concern are presented in Section 3.2. The sediment chemistry and toxicity test results presented here are also presented in greater detail in Windward 2003. The extent to which each area is sufficiently well characterized to proceed with a removal design without additional sampling prior to dredging was assessed in Section 3.3. Then the areas with sufficient data to characterize the lateral and vertical extent of the contamination within the area were identified and prioritized in terms of sediment chemistry and toxicity data. The areas with the highest levels of sediment contamination and toxicity were retained for a feasibility evaluation in Section 4.

A.3.1 CHEMISTRY DATA

Areas of concern were identified as areas in which at least one location contains a sediment chemical concentration greater than the corresponding CSL standards. Groups or clusters of stations with CSL exceedances were treated as one area of concern. All available data regarding the system geography and known sources of contamination were considered to ensure that distinctions were made between areas of concern that are physically separated or influenced by different sources.

The number of chemicals that exceeded CSL standards for each location in EWW are illustrated for each sediment horizon in Maps 1-3. In addition the maximum CSL exceedance factor (EF; measured concentration divided by the CSL standard) calculated for each location is presented in Maps 4-6 (GIS maps are located at the end of this document). Twelve areas of concern have been identified based on the observed CSL exceedances. These areas are presented in Maps 1-6 and Table 3-1.

Table A-3-1. Proposed areas of concern

AREA OF CONCERN	SEDIMENT HORIZON	CONTAMINANTS EXCEEDING CSL
Area 1: Slip 36	0-15 cm	copper, mercury, LPAH, HPAH, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzo(ghi)perylene, benzofluoranthenes, dibenz(ah)anthracene, chrysene, dibenzofuran, fluoranthene, fluorene, indenopyrene, phenanthrene, pyrene
	0-4 ft	total DDT, arsenic copper, mercury, lead, silver, LPAH, acenaphthene, benzo(a)anthracene, benzofluoranthenes, chrysene, fluoranthene, phenanthrene, 2,4-dimethylphenol, pyrene
	>4 ft	total DDT, LPAH, acenaphthene, 2-methylnaphthalene, naphthalene, dibenzofuran, fluorene, phenanthrene, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, hexachlorobenzene, 2-methylphenol, 2,4-dimethylphenol, benzoic acid, benzyl alcohol
Area 2: Rabanco/GATX	0-15 cm	total DDT, arsenic
	0-4 ft	total DDT, total PCBs, mercury, 2-methylnaphthalene, 2-methylphenol, 4-methylphenol,dibenzofuran, 2,4-dimethylphenol
	>4 ft	no data
Area 3: Northern pierface of Terminal 18	0-15 cm	total DDT, total PCBs, acenaphthene
	0-4 ft	total PCBs
	>4 ft	no data
Area 4: Mid-channel in northern portion of waterway	0-15 cm	total DDT, total PCBs, BEHP
	0-4 ft	mercury
	>4 ft	no exceedances
Area 5: Cable Crossing	0-15 cm	total PCBs
	0-4 ft	mercury
	>4 ft	no exceedances
Area 6: Mid-channel in center of waterway	0-15 cm	mercury
	0-4 ft	total PCBs, mercury, BEHP
	>4 ft	No data
Area 7: Lander CSO	0-15 cm	no exceedances
	0-4 ft	total PCBs, BEHP
	>4 ft	no exceedances
Area 8: mid-channel between Lander and Hanford CSOs	0-15 cm	total PCBs, total DDT, mercury, 1,4-dichlorobenzene, phenol, BEHP
	0-4 ft	total PCBs, total DDT, cadmium, lead, mercury, silver, zinc, 1,4-dichlorobenzene, 2-methylnaphthalene, 2,4-dimethylphenol, BEHP, ethylbenzene, xylene
	>4 ft	total PCBs, total DDT, copper, mercury, silver, 1,4-dichlorobenzene, 2-methylnaphthalene, BEHP
Area 9: Slip 27	0-15 cm	total PCBs, mercury, zinc, benzofluoranthenes, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, BEHP
	0-4 ft	total PCBs, total DDT, cadmium, mercury,
	>4 ft	total PCBs, acenaphthene

Area of Concern	Sediment Horizon	Contaminants Exceeding CSL
Area 10: Hanford CSO	0-15 cm	total PCBs, mercury, BEHP, benzoic acid, phenol
	0-4 ft	mercury, silver, BEHP, 1,2-dichlorobenzene, 1,4-dichlorobenzene
	>4 ft	no data
Area 11:Southern T-18 to T-25	0-15 cm	1,2,4-trichlorobenzene
	0-4 ft	total PCBs, mercury, BEHP
	>4 ft	no exceedances
Area 12: Southern end of waterway	0-15 cm	total PCBs, BEHP, phenol
	0-4 ft	total PCBs, mercury, BEHP
	>4 ft	no data

A.3.1.1 Area 1: Slip 36

Thirty locations have been sampled for all three sediment horizons. The majority of the CSL exceedances in the 0-15 cm horizon were due to sediment PAH concentrations (Table 3-2). In the 0-4 ft sediment horizon CSL exceedances were reported for PAH compounds as well as total DDT and mercury concentrations. Most of the CSL exceedances in the >4 ft sediment horizon were reported for total DDT concentrations. The maximum CSL EF for the 0-15 cm sediment horizon was 5.26 reported for the PAH compound acenaphthene. The maximum EF for the 0-4 ft horizon was 5.10 for total DDTs. Finally, the maximum CSL EF for the >4 ft sediment horizon was 65.2 for a hexachlorobenzene concentration measured under Pier 36.

Table A-3-2. Area 1: Locations with CSL exceedances

	0-15 cm	0-4 ft	>4 ft
Locations with CSL exceedances	6	6	5
Maximum CSL EF	5.3	5.1	65
Mean CSL EF[a]	2.2	1.9	6.7
Total Locations	8	13	9

[a] mean CSL EF calculated using only EFs greater than 1.0

A.3.1.2 Area 2: Rabanco/GATX

Twelve locations have been sampled for two surface sediment horizons (0-15 cm and 0-4 ft). CSL exceedances in the 0-15 cm sediment horizon were due to arsenic and total DDT concentrations (Table 3-3). In the 0-4 ft sediment horizon CSL exceedances were seen for individual PAH concentrations as well as total DDT, total PCB, mercury, methyl phenol, dibenzofuran, and dimethylphenol. The maximum CSL EF in the 0-15 cm sediment horizon was 2.59 for arsenic. The maximum CSL EF in the 0-4 ft sediment horizon was 48.3 for 2,4-dimethyl phenol. No samples were collected from the >4 ft sediment horizon.

Table A-3-3. Area 2: Locations with CSL exceedances

	0-15 CM	0-4 FT	>4 FT
Locations with CSL exceedances	2	4	nd
Maximum CSL EF	2.6	48	nd
Mean CSL EF[a]	1.8	6.6	nd
Total locations	8	4	nd

[a] mean CSL EF calculated using only EFs greater than 1.0

nd - no data available

A.3.1.3 Area 3: Northern pierface of Terminal 18

A total of five locations have been sampled in this area. The CSL exceedances in the 0-15 cm sediment horizon are due to sediment total PCB, and total DDT concentrations and one exceedance for an individual PAH compound (acenaphthene) (Table 3-4). The maximum CSL EF was 12.2, reported for total DDTs. One sample collected in a 0-4 ft core had an extremely high sediment TBT concentration (21,000 µg TBT/kg dw). One CSL exceedance was reported for the 0-4 ft horizon for total PCBs with a CSL EF of 1.39. No data were available for the >4 ft sediment horizon.

Table A-3-4. Area 3: Locations with CSL exceedances

	0-15 CM	0-4 FT	>4 FT
Locations with CSL exceedances	3	1	nd
Maximum CSL EF	12	1.4	nd
Mean CSL EF[a]	4.1	1.4	nd
Total locations	4	2	nd

[a] mean CSL EF calculated using only EFs greater than 1.0

nd - no data available

A.3.1.4 Area 4: Mid-channel in northern portion of waterway

Twelve locations were sampled in Area 4 representing all three sediment horizons. The CSL exceedances observed in samples collected in Area 4 are primarily due to sediment total PCB and total DDT concentrations.. The maximum CSL EF for the 0-15 cm horizon was 13.0 reported for total PCBs (Table 3-5). One sample from the 0-4 ft sediment horizon had a sediment mercury concentration greater than the corresponding CSL value with a CSL EF of 1.04.

Table A-3-5. Area 4: Locations with CSL exceedances

	0-15 CM	0-4 FT	>4 FT
Locations with CSL exceedances	4	1	0
Maximum CSL EF	13	1.0	ne
Mean CSL EF[a]	4.0	1.0	ne
Total locations	7	4	1

[a] mean CSL EF calculated using only EFs greater than 1.0

ne - no exceedances

A.3.1.5 Area 5: Cable crossing

A total of eight locations have been sampled in Area 5. The CSL exceedances in the 0-15 cm horizon are due to total PCBs (Table 3-6). The maximum CSL EF was 4.06 for total PCBs. Three CSL exceedances in the 0-4 ft sediment horizon are due to mercury concentrations greater than the corresponding CSL values. The maximum CSL EF in this sediment horizon was 1.86 for mercury.

Table A-3-6. Area 5: Locations with CSL exceedances

	0-15 CM	0-4 FT	>4 FT
Locations with CSL exceedances	2	4	0
Maximum CSL EF	4.1	1.9	ne
Mean CSL EF[a]	2.7	1.6	ne
Total locations	2	4	2

[a] mean CSL EF calculated using only EFs greater than 1.0

ne - no exceedances

A.3.1.6 Area 6: Mid-channel in center of waterway

Twelve locations were sampled in Area 6, representing the 0-15 cm and 0-4 ft sediment horizons. In the 0-15 cm sediment horizon CSL exceedances were due to sediment mercury concentrations at three locations. The maximum CSL EF was 1.54 for mercury. In the 0-4 ft sediment horizon CSL exceedances were due to total PCB, mercury and BEHP concentrations. The maximum CSL EF was 2.29 for total PCBs. No data was available for the >4 ft sediment horizon.

Table A-3-7. Area 6: Locations with CSL exceedances

	0-15 CM	0-4 FT	>4 FT
Locations with CSL exceedances	3	4	nd
Maximum CSL EF	1.5	2.4	nd
Mean CSL EF[a]	1.3	1.5	nd
Total locations	6	6	nd

[a] mean CSL EF calculated using only EFs greater than 1.0

nd - no data available

A.3.1.7 Area 7: Lander CSO

A total of 6 locations have been sampled in Area 7 representing all three sediment horizons. CSL exceedances were reported for three locations in the 0-4 ft sediment horizon due to total PCBs and BEHP concentrations (Table 3-8). The maximum CSL EF was 1.50 for total PCBs.

Table A-3-8. Area 7: Locations with CSL exceedances

	0-15 CM	0-4 FT	>4 FT
Locations with CSL exceedances	0	3	0
Maximum CSL EF	ne	1.5	ne
Mean CSL EF[a]	ne	1.4	ne
Total locations	1	3	2

[a] mean CSL EF calculated using only EFs greater than 1.0

ne - no exceedances

A.3.1.8 Area 8: Mid-channel between Lander and Hanford CSOs

Area 8 contains more sampling locations than any of the other areas with a total of 86 sampling locations. The majority of the sample locations represent the 0-4 ft and >4 ft sediment horizons. The majority of the CSL exceedances in all three sediment horizons are due to total PCB, total DDT, mercury, dichlorobenzene and BEHP concentrations. In addition, CSL exceedances in the 0-15 cm sediment horizon were reported for phenol. The maximum CSL EF reported for the 0-15 cm sediment horizon was 5.99 for BEHP. The maximum CSL EF was 21.7 for the 0-4 ft sediment horizon for 2,4-dimethylphenol and the maximum CSL EF reported for the >4 ft sediment horizon was 10.3 for 1,4-dichlorobenzene.

Table 3-9. Area 8: Locations with CSL exceedances

	0-15 CM	0-4 FT	>4 FT
Locations with CSL exceedances	5	33	7
Maximum CSL EF	6.0	22	10
Mean CSL EF[a]	2.7	2.1	2.3
Total locations	7	49	30

[a] mean CSL EF calculated using only EFs greater than 1.0

A.3.1.9 Area 9: Slip 27

The majority of the CSL exceedances in the 0-15 cm sediment horizon in Area 9 were due to sediment concentrations of total PCBs, mercury, individual PAH (dibenzo(a,h) anthracene and indeno(1,2,3-cd)pyrene), total HPAHs, and zinc(Table 3-10). The maximum CSL EF was 1.84 for mercury.

In the 0-4 ft layer the majority of the exceedances were due to detected sediment total PCB and mercury concentrations. The maximum CSL EF for this sediment horizon was 2.00 for total PCBs. In the >4 ft sediment horizon, one sample exceeded the CSL for total PCBs and one sample exceeded the CSL for acenaphthene with an CSL EF of 1.65.

Table 3-10. Area 9: Locations with CSL exceedances

	0-15 CM	0-4 FT	>4 FT
Locations with CSL exceedances	10	6	1
Maximum CSL EF	1.8	2.0	1.7
Mean CSL EF[a]	1.2	1.4	1.5
Total locations	13	10	11

[a] mean CSL EF calculated using only EFs greater than 1.0

A.3.1.10 Area 10: Hanford CSO

Ten locations were sampled in Area 10 representing two sediment horizons, 0-15 cm and 0-4 ft. The majority of CSL exceedances were due to sediment concentrations of BEHP, total PCBs, and mercury. The maximum CSL EF in the 0-15 cm sediment horizon was 8.42 for total PCBs (Table 3-11). The maximum CSL EF in the 0-4 ft horizon was 26.7 for 1,4-dichlorobenzene.

Table 3-11. Area 10: Locations with CSL exceedances

	0-15 CM	0-4 FT	>4 FT
Locations with CSL exceedances	7	1	nd
Maximum CSL EF	8.4	27	nd
Mean CSL EF[a]	2.4	7.0	nd
Total locations	9	1	nd

[a] mean CSL EF calculated using only EFs greater than 1.0

nd - no data available

A.3.1.11 Area 11: Southern T-18 to T-25

The majority of the CSL exceedances in Area 11 are associated with total PCB, mercury, and BEHP concentrations in the 0-4 ft sediment horizon (Table 3-12). The maximum CSL EF in the 0-4 ft sediment horizon was for total PCBs. The single CSL exceedance in the 0-15 cm horizon was due to a trichlorobenzene concentration with a CSL EF of 1.40.

Table 3-12. Area 11: Locations with CSL exceedances

	0-15 CM	0-4 FT	>4 FT
Locations with CSL exceedances	1	10	0
Maximum CSL EF	1.4	2.4	ne
Mean CSL EF[a]	1.4	1.3	ne
Total locations	4	25	9

[a] mean CSL EF calculated using only EFs greater than 1.0

ne - no exceedances

A.3.1.12 Area 12: Southern end of the waterway

Twelve locations were sampled in Area 12 representing the 0-15 cm and 0-4 ft sediment horizons (Table 3-13). In the 0-15 cm sediment horizon, CSL exceedances were seen for total PCB, phenol, and BEHP concentrations. The maximum CSL EF was 7.94 for BEHP. In the 0-4 ft sediment horizon the majority of the exceedances were due to sediment total PCB, total DDT, and mercury concentrations. The maximum CSL EF was 1.80 for mercury.

Table 3-13. Area 12: Locations with CSL exceedances

	0-15 CM	0-4 FT	>4 FT
Locations with CSL exceedances	3	2	nd
Maximum CSL EF	7.9	1.8	nd
Mean CSL EF[a]	4.1	1.4	nd
Total locations	10	2	nd

[a] mean CSL EF calculated using only EFs greater than 1.0

nd – no data available

A.3.2 TOXICITY DATA

This section summarizes the results of toxicity testing conducted with EWW sediment samples. Results from toxicity tests conducted with sediments that were subsequently removed during the Phase 1 or T-30 dredging events are not included. Toxicity test results were used only if the tests were conducted in accordance with SMS protocols. The following toxicity tests were included: acute 10-day amphipod test using *Eohaustorius estuarius*, *Ampelisca abdita*, or *Rhepoxynius abronius* (amphipod test); acute bivalve larval combined mortality test using the blue mussel, *Mytilus galloprovincialis*, or echinoderm embryo (larval test); and the chronic 20-day juvenile polychaete biomass test using *Neanthes arenaceodentata* (*Neanthes* test). Results of toxicity tests for two sediment horizons, 0-15 cm and 0-4 ft are summarized below.

A.3.2.1 Sediment horizon: 0-15 cm

Forty-six sediment samples from the 0-15 cm sediment horizon were submitted for toxicity testing. The greatest number of failures was seen for the larval toxicity in all regions. The lowest number of failures was seen for the *Neanthes* test. The CSL failures for each test are summarized by region in Table 3-14 and Map 7.

The only station that failed all three tests was located in area 3 (location 2139). Two stations failed the larval and amphipod tests, one station in Area 3 (location 14) and one station in Area 6 (location 6).

Table A-3-14. 0-15 cm toxicity CSL failures by area

0-15 cm Area	Number of Samples	Toxicity CSL Failures		
		Amphipod	*Neanthes*	Larval
1	2	0	0	1
2	8	0	0	5
3	4	2	1	4
4	6	0	0	0
5	1	0	0	0
6	5	2	0	1
7	1	0	0	1
8	3	0	0	0
9	1	0	0	1
10	6	1	0	1
11	0	0	0	0
12	9	0	0	3
Total	**46**	**5**	**1**	**17**

A.3.2.2 Sediment horizon: 0-4 ft

A total of 79 sediment samples were submitted for toxicity testing in this sediment horizon. The majority of the samples were collected in Areas 8 and 11 as part of sediment characterization for proposed dredging in these areas. The greatest number of CSL failures was seen for the larval toxicity. The CSL failures for each test are presented by Area in Table 3-15 and Map 8. Area 8 had the greatest number of samples tested. Ten samples within Area 8 failed all three toxicity tests and nine samples failed two of the three tests. None of the samples collected in the other areas failed more than one of the toxicity tests.

Table A-3-15. 0-4 ft toxicity CSL failures

0-4 ft Area	Number of Samples	Toxicity CSL Failures		
		Amphipod	*Neanthes*	Larval
1	9	0	0	4
2	1	0	0	0
3	0	0	0	0
4	1	0	0	0
5	0	0	0	0
6	3	1	0	0
7	3	0	0	0
8	31	14	18	24
9	6	1	1	0
10	1	0	0	1
11	24	0	0	1
12	0	0	0	0
Total	**79**	**16**	**19**	**30**

A.3.3 Data Summary

The sediment chemistry and toxicity results for all twelve areas are summarized in Table 3-16. The surface area of each area is also presented. Area 8 has the largest surface area (20 acres) as well as the largest number of locations sampled for both sediment chemistry and toxicity testing. Other areas with greater than 30 locations for sediment chemistry and more than 5 locations for toxicity include areas 1,9, and 11. Each of these areas encompasses approximately 10 acres of surface area. The areas with the greatest number of sampling locations tend to have the highest number of locations with CSL exceedances for sediment chemistry. Area 8 contains the highest number of locations with exceedances followed by Areas 9,1, and 11.

For the toxicity results, the relationship between the number of sampling locations and the number of locations with CSL failures is not as strong. Area 8 has the greatest number of toxicity locations as well as the greatest number of locations with CSL failures of the toxicity tests. However, Area 11 also has a large number of toxicity locations with only one location with a CSL failure. It is also important to note that many locations within Area 8 failed the CSL standards for multiple toxicity tests so the number of toxicity failures is much higher than the number of locations with toxicity failures.

Table A-3-16. Sediment chemistry and toxicity results

Sediment Chemistry Results						Toxicity Results		
Area	Surface area (acres)	Number of locations	Locations with CSL exceedance	Max CSL EF	Mean CSL EF[a]	Area	Number of locations	Locations with CSL failure
Area 1	10	30	17	65.2	3.21	Area 1	11	5
Area 2	7.3	12	6	48.3	5.78	Area 2	9	5
Area 3	3.3	6	4	12.2	3.58	Area 3	4	4
Area 4	7.6	12	5	13.0	3.55	Area 4	7	0
Area 5	1.5	8	6	4.06	1.96	Area 5	1	0
Area 6	9.0	12	7	2.29	1.45	Area 6	8	5
Area 7	1.8	6	3	1.50	1.36	Area 7	4	1
Area 8	20	86	45	21.7	2.19	Area 8	34	24
Area 9	9.0	34	17	2.00	1.29	Area 9	7	3
Area 10	1.5	10	8	26.7	3.73	Area 10	7	3
Area 11	11	38	11	2.44	1.35	Area 11	24	1
Area 12	14	12	5	7.94	2.73	Area 12	9	3

[a] Mean CSL EF calculated using only EF values greater than 1

A.3.4 Data Assessment

A qualitative assessment of the extent to which each area of concern has been characterized was performed. The horizontal and vertical characterization of the sediment chemistry and toxicity was examined in order to identify areas that are sufficiently well characterized to proceed with the Phase 1 dredging without additional sampling to determine the dredge boundaries. The results of this assessment are summarized in Table 3-17. Four of the Areas of Concern (Areas 1, 7, 8,and 11) were determined to have sufficient data to proceed with Phase 1 dredging without requiring additional sampling to establish dredge boundaries. These areas will be retained for further assessment in the following sections. The areas that were determined to have insufficient data for Phase 1 will be further evaluated in Phase 2.

Table A-3-17. Qualitative assessment of data sufficiency for each area of concern

Area of Concern	Sufficient/ Insufficient	Comment
Area 1	**sufficient**	Limited data >4 ft
Area 2	insufficient	Most data is surface (0-15 cm)
Area 3	insufficient	No data for 0-4 and >4 ft horizons
Area 4	Insufficient	No toxicity test and limited chemistry data in 0-4 and >4 ft horizons
Area 5	insufficient	No toxicity data
Area 6	insufficient	Limited chemistry and toxicity data in 0-4 and >4 ft horizons
Area 7	**sufficient**	No surface (0-15 cm) chemistry data

Area of Concern	Sufficient/ Insufficient	Comment
Area 8	**sufficient**	Limited 0-15 cm chemistry and toxicity data
Area 9	insufficient	Limited toxicity data
Area 10	insufficient	No data for the >4 ft horizon and little data for the 0-4 ft horizon
Area 11	**sufficient**	Limited surface (0-15 cm) chemistry and toxicity data
Area 12	insufficient	No toxicity test and limited chemistry data for the 0-4 ft and >4 ft horizons

The site characterization process identified Area 1 and Area 8 as the two areas with sufficient chemistry and toxicity data that contained the greatest number of locations with chemistry and toxicity CSL exceedances. Areas 7 and 11 also were determined to have sufficient chemistry and toxicity data. However, these areas had fewer exceedances of both the sediment chemistry and toxicity standards. Therefore, Areas 1 and 8 were identified as high priority areas based on sediment chemistry and toxicity results as well as the fact that these areas have been sufficiently characterized to proceed with the Phase 1 Removal action without requiring further testing. In the following section, the technical feasibility of dredging these areas is evaluated.

A.4.0 Feasibility Evaluation

The feasibility evaluation focused on whether there is sufficient existing information to proceed with dredge design within an area. Critical information that may impact the feasibility to design and implement removal during Phase 1 includes slope stability, structural impacts, and administrative factors (such as the existing use and future development and cleanup of the Coast Guard facilities at Slip 36). An area was ranked as feasible where administrative factors are not of concern, adjacent structures would not be impacted, and where slope stability was either not a factor, or where stability had been fully evaluated so that the design could proceed without the need for additional sediment physical characterization. An area was ranked as infeasible if any of the three aforementioned factors were applicable to that area.

A.4.1 Area 1: Slip 36

Area 1 is comprised of the Coast Guard property at Slip 36. The Coast Guard is currently preparing to dredge the western portion of the slip. Dredging within the slip will require remedial measures to ensure slope stability beneath the piers. Therefore, dredging in Area 1 is not feasible as part of the Phase 1 dredging.

A.4.2 Area 8: Midchannel between Lander and Hanford CSOs

Dredging Area 8 is technically feasible under Phase 1 Removal activities. Along the eastern edge of Area 8, near the Hanford CSO, an existing mound of sediment will be avoided based on steep side slopes and geotechnical instability. Although sampling indicates that there is contaminated sediment present on this mound, the dredge plan will be formulated to minimize impacts on side slopes and to minimize the potential for leaving a significantly contaminated side slope exposed following Phase 1. In order to prevent impacts on this mound, the dredge prism will be offset from the toe of the mound sufficient to allow the 11-ft to 12-ft deep dredge cuts to be made, while preventing the undermining of the mound by the dredge cut side slopes.

A.5.0 Summary and Proposed Boundary Determination

Three criteria were proposed for the identification of the Phase 1 Removal boundary:

- sediment chemistry and toxicity test results indicated numerous CSL exceedances and failure of multiple toxicity tests
- the area is sufficiently well-characterized to proceed without additional sampling prior to dredging
- dredging in the area is feasible without slope stability issues that would require additional engineering and design work

The application of the first criterion resulted in the identification of twelve areas of concern using available sediment chemistry data. Of these twelve areas, four were determined to have been sufficiently characterized to proceed with the Phase 1 dredging without further testing (Areas 1, 7, 8, and 11). The sediment chemistry and toxicity test results indicated that the highest priority areas of the four areas with sufficient data were Areas 1 and 8. Finally, the technical feasibility evaluation determined that dredging Area 8 is technically feasible for the Phase 1 Removal action.

The proposed removal boundary is presented in Map 9. This area represents a large area of highly contaminated sediment within the EWW (Maps 1-6) that has been thoroughly characterized and determined to contain sediment concentrations greater than established clean up standards. In addition, sediment in this area has been determined to be toxic to the range of benthic organisms used in standard sediment bioassay testing (Maps 7 and 8). The presence of these sediments in the EWW clearly poses a potential risk to benthic community. Finally, several of the contaminants that exceeded CSL standards in this area are classified as bioaccumulative compounds of concern (i.e. PCBs, DDT, and BEHP). These compounds may be accumulated in the tissues of benthic organisms and fish resulting in potential risk to human and ecological receptors who consume these species within the waterway.

A.6.0 References

Windward. 2003. Data summary report, East Waterway, Harbor Island Superfund site: Nature and extent of contamination. Prepared for the Port of Seattle. Windward Environmental LLC, Seattle, WA.