Record of Decision

Lockheed West Seattle Superfund Site

U.S. Environmental Protection Agency, Region 10
Seattle, Washington

Docket No. CERCLA 10-2006-0321

August 2013

Contents

Acronyms and Abbreviations v

1 Declaration of the Record of Decision 1-1
1.1 Site Name and Location 1-1
1.2 Statement of Basis and Purpose 1-1
1.3 Assessment of the Site 1-1
1.4 Description of Selected Remedy 1-1
1.5 Statutory Determinations 1-3
1.6 Record of Decision Data Certification Checklist 1-3
1.7 Authorizing Signatures 1-4

2 Decision Summary 2-1
2.1 Site Name, Location, and Brief Description 2-1
2.2 Site History and Enforcement Activities 2-2
2.2.1 Site Operational History 2-2
2.2.2 Previous Investigations and Enforcement Activities 2-7
2.3 Community Participation 2-15
2.4 Scope and Role of Response Action 2-15
2.5 Site Characteristics 2-15
2.5.1 Physical Setting 2-16
2.5.2 Cultural Resources 2-21
2.5.3 Biological Resources 2-21
2.5.4 Marine Surface Water 2-22
2.5.5 Geology and Hydrogeology 2-22
2.6 Conceptual Site Model 2-23
2.6.1 Sources of Contamination 2-23
2.6.2 Background Concentrations 2-24
2.6.3 Summary of the Nature and Extent of Contamination 2-28
2.6.4 Fate and Transport of Contaminants of Concern 2-29
2.6.5 Exposure Pathways 2-30
2.7 Current and Potential Future Land and Resource Uses 2-39
2.7.1 Current Land Use 2-39
2.7.2 Anticipated Future Land Use and Water Body Use 2-39
2.7.3 Current and Potential Groundwater and Surface Water Uses 2-39
2.8 Summary of Site Risks 2-39
2.8.1 Summary of Human Health Risk Assessment 2-39
2.8.2 Summary of Ecological Risk Assessment 2-49
2.8.3 Summary of Contaminants of Concern 2-60
2.8.4 Basis for Action 2-66
2.9 Remedial Action Objectives 2-66
2.9.1 Specific Remedial Action Objectives 2-66
2.9.2 Cleanup Levels 2-67
2.9.3 Principal Threat Waste 2-72

2.10 Description of Alternatives 2-73
2.10.1 Remedial Action Levels 2-73
2.10.2 Areas of Potential Action 2-74
2.10.3 Description of Remedial Approaches 2-77
2.10.4 Key Applicable or Relevant and Appropriate Requirements 2-88
2.10.5 Long-term Reliability 2-92
2.10.6 Waste Quantities 2-92
2.10.7 Design and Construction Time Frame 2-92
2.10.8 Estimated Costs 2-92
2.10.9 Expected Outcomes of Each Alternative 2-92
2.11 Comparative Analysis of Alternatives 2-99
2.11.1 Overall Protection of Human Health and the Environment 2-99
2.11.2 Compliance with Applicable or Relevant and Appropriate Requirements 2-100
2.11.3 Long-term Effectiveness and Permanence 2-107
2.11.4 Reduction of Toxicity, Mobility, or Volume through Treatment 2-108
2.11.5 Short-term Effectiveness 2-108
2.11.6 Implementability 2-110
2.11.7 Cost 2-111
2.11.8 State/Tribal Acceptance (Modifying Criterion) 2-111
2.11.9 Community Acceptance (Modifying Criterion) 2-111
2.11.10 Summary of Comparative Analysis 2-112
2.12 Selected Remedy 2-112
2.12.1 Summary of the Rationale for the Selected Remedy 2-112
2.12.2 Detailed Description of the Selected Remedy 2-115
2.12.3 Summary of the Estimated Remedy Costs 2-119
2.12.4 Expected Outcomes of the Selected Remedy 2-119
2.13 Statutory Determinations 2-125
2.13.1 Protection of Human Health and the Environment 2-125
2.13.2 Compliance with ARARs 2-129
2.13.3 Cost Effectiveness 2-131
2.13.4 Use of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable 2-131
2.13.5 Preference for Treatment as a Principal Element 2-132
2.13.6 Five-Year Review Requirements 2-133
2.13.7 Documentation of Significant Changes 2-133

3 Responsiveness Summary 3-1
3.1 Stakeholder Comments and Lead Agency Responses 3-1
3.2 Technical and Legal Issues 3-1

4 References 4-1

Appendixes

A Department of Ecology Concurrence Letter
B Comments Received During Public Comment Period and EPA Responses

Tables

1 Lockheed West Site Record of Decision Data Certification Checklist 1-4
2 Comparison of Surface Sample Results with the Sediment Management Standard Criteria....2-11
3 Comparison of Subsurface Sample Results with the Sediment Management Standard Criteria 2-13
4 Sediment Background Concentration Information....2-27
5 Cancer Risks and Noncancer Hazard Estimates for Human Health Risk Assessment Scenarios ..2-44
6 Summary of Human Health Risk Assessment Uncertainties 2-48
7 Intertidal Sediments Benthic Invertebrate Community Risk Potential 2-53
8 Subtidal Sediment Benthic Invertebrate Community Risk Potential 2-56
9 Summary of Risks for Crabs and Fish 2-57
10 Summary of Risks for Spotted Sandpiper 2-59
11 Summary of Ecological Risk Assessment Uncertainties 2-61
12 Summary of Cleanup Levels for Contaminants of Concern in Sediment 2-68
13 Residual Risk Levels by Remedial Action Objective at Completion of Construction 2-72
14 Remedial Action Levels for the Risk-Driver Contaminants of Concern in Sediment 2-74
15 Summary of Containment-Focus Alternatives....2-81
16 Summary of Partial Removal-Focus Alternatives....2-85
17 Summary of Complete Removal-Focus Alternatives 2-91
18 Applicable or Relevant and Appropriate Requirements 2-93
19 Summary of Alternative Quantities and Costs 2-97
20 Summary of Criteria Comparisons for Remedial Action Alternatives 2-101
21 Cost Estimate Summary for the Selected Remedy – 3C Plus 2-120
22 Net Present Value Analysis for the Selected Remedy – 3C Plus 2-123
23 Summary of Compliance Zones and Cleanup Levels for COCs 2-129

Figures

1 Location and Vicinity Map 2-3
2 Current Management and Ownership....2-5
3 1980 Aerial Photograph 2-9
4 Lockheed West Site Bathymetry....2-17
5 Remedial Investigation Sediment Sampling Locations 2-19
6 Conceptual Site Model....2-25
7 Exceedances of Sediment Quality Standards in Surface Sediment Samples from 2007 2-31
8 Exceedances of Cleanup Screening Levels in Surface Sediment Samples from 2007 2-33
9 Exceedances of Sediment Quality Standards in Subsurface Sediment Samples from 2007 2-35
10 Exceedances of Cleanup Screening Levels in Subsurface Sediment Samples from 2007....2-37
11 Conceptual Site Model for Human Health Risk Assessment at the Lockheed West Site 2-41
12 Conceptual Site Model for Benthic Invertebrates, Fish, and Wildlife at the Lockheed West Site 2-51
13 Areas of Potential Action 2-75
14 Containment-Focus Alternatives 2-79
15 Removal-Focus Alternatives 2-83
16 Complete Removal Alternatives 2-89
17 Selected Remedy – Alternative 3C Plus 2-113

Acronyms and Abbreviations

µg/kg	micrograms per kilogram
µg/kg-dw	micrograms per kilogram – dry weight
µg/L	microgram(s) per liter
-	minus
+	plus
±	plus or minus
3-D	three-dimensional
95 UCL	95th percentile upper confidence level
AOPA	area of potential action
ARAR	applicable or relevant and appropriate requirement
AWQC	ambient water quality criteria
BSAF	biota-sediment accumulation factor
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	*Code of Federal Regulations*
cfs	cubic feet per second
cm	centimeter
COC	contaminant of concern
COPC	contaminant of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSF	cancer slope factor
CSL	cleanup screening level
CSM	conceptual site model
CY	cubic yard(s)
DDT	dichlorodiphenyltrichloroethane
DMMP	dredged material management program
DNR	Washington State Department of Natural Resources
DOH	Washington Department of Health
Ecology	Washington State Department of Ecology
ENR	enhanced natural recovery
EPA	U.S. Environmental Protection Agency

EPC	exposure point concentration
ERA	ecological risk assessment
ESA	Endangered Species Act
FS	Feasibility Study
GSR	green and sustainable remediation
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IC	institutional control
LDW	Lower Duwamish Waterway
LOAEL	lowest observed adverse effect level
Lockheed West Site	Lockheed West Seattle Superfund Site
LTMMP	Long-term Monitoring and Maintenance Plan
mg/kg-dw	milligrams per kilogram - dry weight
MLLW	mean lower low water
MTCA	Model Toxics Control Act
NCP	National Oil and Hazardous Substances Pollution Contingency Plan; National Contingency Plan
NOAEL	no observed adverse effect level
OMB	Office of Management and Budget
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PM_{10}	particulate matter of 10 microns in diameter
Port	Port of Seattle
ppm	parts per million
ppt	parts per trillion
PRP	potentially responsible party
PSR	Pacific Sound Resources
RA-5	Remediation Area 5
RAL	remedial action level
RAO	remedial action objective
RBTC	risk-based threshold concentration
RCRA	Resource Conservation and Recovery Act of 1976

RfD	reference dose
RI	Remedial Investigation
RME	reasonable maximum exposure
ROC	receptor of concern
ROD	Record of Decision
Site	Lockheed West Seattle Superfund Site
SMS	sediment management standards
SQS	sediment quality standards
SVOC	semivolatile organic compound
SWHC	Southwest Harbor Cleanup Project
TBT	tributyltin
TCDD	tetrachlorodibenzodioxin
TEQ	toxicity equivalent
TI	technical impracticability
TMV	toxicity, mobility, and volume
TRV	toxicity reference value
TSCA	Toxic Substances Control Act
U&A	Usual and Accustomed
UECA	Uniform Environmental Covenants Act
USACE	U.S. Army Corps of Engineers
WAC	Washington Administrative Code
WRDA	Waterway Resource Development Act

1 Declaration of the Record of Decision

1.1 Site Name and Location

Facility Name:	Lockheed West Seattle Superfund Site
Site Location:	Latitude 47°34'21.53"N, Longitude 122°21'41.16"W Seattle, Washington
U.S. Environmental Protection Agency (EPA) Identification Number:	WAN001002655

1.2 Statement of Basis and Purpose

This decision document presents the Selected Remedy for the in-waterway portions of the Lockheed West Seattle Superfund Site (Lockheed West Site or Site). The Lockheed West Site was formerly known as Lockheed Shipyard No. 2, located near the confluence of the West Waterway and Elliott Bay, west of the city of Seattle, Washington. The Selected Remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and, to the extent practicable, the "National Oil and Hazardous Substances Pollution Contingency Plan" (40 *Code of Federal Regulations* [CFR] 300) (National Contingency Plan [NCP]). This decision is based on the Administrative Record file for this Site. The State of Washington, through the Washington State Department of Ecology (Ecology), concurs with the Selected Remedy.

1.3 Assessment of the Site

The response action selected in this Record of Decision (ROD) is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants into the environment. Such a release or the threat of release may present an imminent and substantial endangerment to public health, welfare, or the environment.

1.4 Description of Selected Remedy

The Selected Remedy for the Lockheed West Site addresses unacceptable human health risks associated with seafood consumption, net fishing, clamming, and beach play, and ecological risks posed to benthic invertebrates, fish, and birds. This cleanup is a final action.

The Selected Remedy is expected to achieve substantial long-term risk reduction and allow the Site to be used for the current and reasonably anticipated future uses. This ROD documents the final remedial action for the Site.

The Selected Remedy includes the following elements:

- Dredge the former shipway area (westernmost portion of the Site) to remove sediments with contaminants of concern (COC) concentrations above the sediment quality standards (SQS), which are the lower of the two sediment comparison criteria under the Washington State sediment

management standards (SMS) [1]. A thin layer (6 to 9 inches) of clean material will then be placed to cover dredge residuals and promote enhanced natural recovery (ENR).

- Dredge the Navigation Channel in the West Waterway to remove sediments with COC concentrations that exceed the SQS, and place a thin layer of clean material to cover dredge residuals and promote ENR.
- Dredge the former Dry Docks 1 through 3 area and other localized areas throughout the Site to remove sediments with COC concentrations above the cleanup screening levels (CSLs), which are the higher of the two SMS comparison values. A thin layer of clean material will then be placed to cover dredge residuals and promote ENR.
- Place a thin layer of clean material to promote ENR over the remainder of the subtidal area.
- Dredge the shoreline bank and intertidal zone (defined as areas extending from mean high higher water at plus [+] 11.3 feet mean lower low water (MLLW) to minus [-] 10 feet MLLW) to remove sediments with COCs at levels above the SQS, as structurally practicable, and backfill with clean material to grade.
- Remove debris, riprap, failing wooden bulkheads, and pilings as necessary or directed by the EPA, and dispose of them offsite.
- Dispose of dredged sediments and other related remediation materials by truck or rail transport to an appropriate offsite upland facility permitted to accept these materials.
- Place institutional controls (ICs) in the form of a proprietary control that runs with the property and that requires coordination with the EPA and management of any residual contamination (above Cleanup Levels) that is disturbed or encountered in the event of future excavation or dredging within the boundaries of the Site. In addition, the current fish advisory for Recreational Marine Area 10 (Elliott Bay) under the Puget Sound Fish Consumption Advisory, established by the Washington State Department of Health, to reduce human exposure from ingestion of contaminated seafood will continue to be posted at the Site. The EPA can revise the fish advisory as warranted.
- Conduct post-remedial confirmation sampling of sediment and surface water.
- Conduct long-term monitoring at the Site. The monitoring interval and other criteria will be defined in the Long-term Monitoring and Maintenance Plan (LTMMP). Additional monitoring, following identified triggering weather and seismic events, also will be defined in the LTMMP. If such events occur, bathymetric monitoring will be implemented to determine whether one or more components of the Selected Remedy are affected.
- Conduct five-year reviews, which will include sediment sampling for risk-driver COCs, bathymetric surveys to ensure that the thin cover/ENR layer remains in place, file reviews, and interviews with the landowner(s) pertaining to any development that has occurred at the Site since remediation was completed. Surface water and fish tissue samples will not be collected as part of five-year reviews.

[1] The Washington State SMS (Washington Administrative Code [WAC] 173-204) provide a basis for the management and reduction of pollutant discharges and guide contaminated sediment cleanup efforts for the protection of benthic receptors. The standards include regionally developed numerical sediment criteria that protect the benthic (that is, bottom-dwelling) invertebrate community. The benthic invertebrate numerical criteria are not intended to be protective of human health with regard to consumption of bioaccumulative contaminants in seafood. There are two levels of chemical and biological SMS. The more stringent level, the SQS, is the sediment cleanup objective and corresponds to a sediment quality that has no acute or chronic adverse effects on benthic marine organisms. The less stringent level, the CSL, is the level above which minor adverse effects may occur in benthic marine organisms.

A technical impracticability (TI) waiver of the Federal ambient water quality criteria (AWQC) for arsenic is part of the Selected Remedy. As described in the TI waiver rationale memorandum (EPA, 2013), it is technically impracticable for remediation of contaminated sediments at this small, 40-acre Site to measurably improve the overall water quality for arsenic within the larger Elliott Bay, and there are no treatment technologies capable of surface water treatment for arsenic at the scale of Elliott Bay (approximately 5.42×10^{11} gallons, assuming no replenishment from Puget Sound). It is expected that arsenic concentrations in Elliott Bay would remain the same after Site cleanup. All Site-related arsenic sources are or will be controlled after sediment remediation. The TI waiver would apply only to AWQC exceedances at the Site and would not prevent the EPA or other regulatory agencies from taking actions related to AWQC exceedances.

The NCP establishes the expectation that treatment will be used to address the principal threats posed by a site whenever practicable, in accordance with Federal regulations (40 CFR 300.430[a] [1] [iii] [A]). In general, principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be contained in a reliable manner.

There is no source or other material at this Site that constitutes principal threat waste. Contaminants identified at the Site are considered low-level threats and are not highly mobile or highly toxic. For example, the maximum polychlorinated biphenyl (PCB) sediment concentration at the Site is 3 parts per million (ppm), with an average of 0.42 ppm. These values are well below the 50-ppm threshold for designation as a Toxic Substances Control Act (TSCA) waste. Similarly, the maximum dioxins/furans level expressed as the tetrachlorodibenzodioxin (TCDD) toxicity equivalent (TEQ) is 13.8 parts per trillion (ppt), as compared to the background concentration of 2 ppt. Metals concentrations also do not trigger principal threat waste issues, and no Resource Conservation and Recovery Act of 1976 (RCRA)-listed hazardous wastes will be generated during Site remediation.

1.5 Statutory Determinations

The Selected Remedy is protective of human health and the environment, cost-effective, and complies with state and Federal requirements that are legally applicable or relevant and appropriate to the remedial action, with the exception of the Federal AWQC for arsenic in surface water. The remedy uses permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable. However, treatment of the marine sediments was not found to be practicable.

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years after initiation of remedial action (and at 5-year intervals thereafter), in accordance with CERCLA Section 121(c) and NCP Section 300.430(f)(4)(ii), to ensure that the remedy provides adequate protection of human health and the environment.

1.6 Record of Decision Data Certification Checklist

The information outlined in Table 1 is included in the Decision Summary (Part II) of this ROD. Additional information can be found in the Administrative Record for the Lockheed West Site, which can be found at: http://yosemite.epa.gov/r10/cleanup.nsf/sites/LockheedWest.

TABLE 1
Lockheed West Site Record of Decision Data Certification Checklist
Lockheed West Seattle Record of Decision

Information	Location in ROD
COCs and their respective concentrations	Section 2.6.2
Baseline risk represented by the COCs	Section 2.8
Cleanup Levels established for COCs and the basis for these levels	Section 2.9.2
How source materials constituting principal threat wastes are addressed	Section 2.9.3
Current and reasonably anticipated future land use and current and potential future beneficial uses of groundwater	Section 2.7
Potential land and groundwater use that will be available at the site as a result of the selected remedy	Section 2.12.4
Estimated capital, annual operations and maintenance, and total present value costs, discount rate, and the number of years over which the remedy cost estimates are projected	Section 2.12.3
Key factors that led to selecting the remedy	Section 2.12.1

1.7 Authorizing Signatures

This signature sheet documents the EPA approval of the Lockheed West Record of Decision. The Record of Decision is selected by the EPA, with concurrence by the Washington State Department of Ecology.

_____ _____

Cami Grandinetti Date
Program Manager
Remedial Cleanup Program

2 Decision Summary

This Decision Summary provides a description of the Site-specific factors and analyses that led to selection of the remedy for the Lockheed West Seattle Superfund Site (Lockheed West Site or Site). In identifying the Selected Remedy, the U. S. Environmental Protection Agency (EPA) considered many factors, including information about the Site background, the nature and extent of contamination, the assessment of human health and environmental risks, and the identification and evaluation of remedial alternatives.

The Decision Summary also describes the involvement of the public throughout the Remedial Investigation (RI)/Feasibility Study (FS) process, and the environmental programs, regulations, and statutes that may relate to or affect the cleanup alternatives considered for this Site. The Decision Summary concludes with a description of the Selected Remedy and a discussion of how it meets the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and to the extent practicable, the National Contingency Plan (NCP).

Documents supporting this Decision Summary are included in the EPA's Administrative Record for the Lockheed West Site.

2.1 Site Name, Location, and Brief Description

This Record of Decision (ROD) addresses the in-waterway portion of the Lockheed West Site of what formerly was known as Lockheed Shipyard No. 2, located near the confluence of the West Waterway and Elliott Bay, west of the city of Seattle, Washington (Figure 1). The upland areas of the Site where shipyard support operations formerly took place and where sources to the in-waterway portion of the Site were located is referred to as Remediation Area 5 (RA-5) and was previously remediated under a Washington State Model Toxics Control Act (MTCA) cleanup order. The Lockheed West Site is adjacent to the upland areas of the Port of Seattle (Port) Terminal 5, which is not part of the Lockheed West Site.

The Site includes the in-water marine sediments where the former Lockheed Shipyard No. 2 was located (the shipway and dry docks were located in the water over the sediments). It is impacted by tides with additional influence from the Lower Duwamish Waterway (LDW) that flows into the West Waterway. The Site also includes a narrow shoreline bank and intertidal sediments along the northern and eastern shorelines, and subtidal sediments that extend from minus (-) 40 to -50 feet mean lower low water (MLLW) in historically dredged areas. Numerous pilings remain within the footprint of the former shipway and pier structures in the northwestern portion of the Site.

Several other Superfund sites resulting from separate industrial operations are located near the Site:

- Pacific Sound Resources (PSR) Superfund Site borders the Site on the west
- Harbor Island Superfund Site, including the following:
  - Todd Shipyard Sediment Operable Unit on the east side of the West Waterway and northwest side of Harbor Island
  - Lockheed Shipyard No. 1 Sediment Operable Unit on the west side of Harbor Island along the West Waterway
  - West Waterway Operable Unit
  - East Waterway Operable Unit

- LDW Superfund Site flows into the West and East Waterways of Harbor Island and into Elliott Bay

In addition to these Superfund sites, the Washington Department of Ecology (Ecology) issued state MTCA cleanup orders for the remediation of five areas located in the Terminal 5 upland area adjacent to the Lockheed West Seattle and PSR Superfund sites. The predominant cleanup action applied to these upland remediation areas was capping to keep soil contamination in place and to prevent surface water infiltration into the underlying groundwater. RA-5 is located in the upland area immediately south of the Site and was the site of former shipbuilding activities.

The 40-acre Site includes approximately 33 acres of state-owned aquatic lands and 7 acres of Port-owned aquatic tidelands, as shown by the color-shaded areas on Figure 2. The Port-owned tidelands and Port-managed harbor areas (blue-shaded area) are adjacent to the Port's Terminal 5 facility upland operations, which include container transfer and handling associated with marine terminal operations. The state-owned aquatic lands include:

- 18 acres of State Harbor Area in Elliott Bay (brown-shaded area)
- 8 acres of State Harbor Area managed by the Port under a Port Management Agreement, of which approximately 3 acres are located within the harbor area north of the Site, and 5 acres of harbor area are located east of the Site (purple-shaded areas)
- 7 acres of State Waterway in West Waterway managed by the Washington State Department of Natural Resources (DNR) (green-shaded area). The U.S. Army Corps of Engineers (USACE) has jurisdiction for maintaining the West Waterway navigation channel, currently authorized to -34 feet MLLW, which is coincident with the state-platted West Waterway.

The Site is not currently used for Port-related or other commercial activities, but the Port envisions expanding Terminal 5 pier structures to include a multi-modal container terminal along the West Waterway. Container ships use the navigational channel and offload in West Waterway at Terminal 5. In 2010 and 2011, the Port requested Waterway Resource Development Act (WRDA) authorization to dredge the navigation channel from its current elevation (-43 feet MLLW) to -50 feet MLLW. The Port described potential future development in letters to the EPA in November 2010, May 2011, and September 2011.

The Site and adjacent aquatic areas are designated as Tribal Usual and Accustomed (U&A) Fishing Areas. The public may access the bank and intertidal portions of the Site from the water. Access via land is restricted primarily because the adjacent uplands are part of Terminal 5 and are fenced-off from the intertidal portion of the Site; however public access would be possible from the west via Jack Block Park if fencing were removed.

2.2 Site History and Enforcement Activities

This section provides background information on past activities that have led to the current contamination at the Site, as well as studies that have been conducted at the Site.

2.2.1 Site Operational History

Prior to industrial development, the Site and surrounding area consisted of an intertidal delta at the mouth of the Duwamish River. Most of the original wetlands and mudflats were lost during construction of the LDW and Harbor Island and as result of the dredging of intertidal areas on the northern terminus of the current Port Terminal 5.

Legend

- Approximate Site Boundary: Site boundaries will be finalized in the Record of Decision.
- Highway
- Major Road
- Local Road
- RA5 - Former Shipyard Uplands
- Creek
- Railroad
- Greenbelt
- LSSOU — Lockheed Shipyard Sediment Operable Unit
- TSSOU — Todd Shipyard Sediment Operable Unit
- OU — Operable Unit

Figure 1 Lockheed West Site Location and Vicinity Map

0 500 1,000 Feet

TETRA TECH

ES100512034318SEA

TETRA TECH

Lockheed West Seattle Superfund Site, Seattle, WA

Figure 2
Current Management and Ownership

Z:\Pdrive\Projects_2006\Lockheed\maps\RIFS_Report\Fig10-1_current_ownership_management.mxd

At the outset of World War II, a shipyard owned and operated by the Puget Sound Bridge and Dredge Company was constructed at the Site. The company conducted ship repair, maintenance, and vessel construction at five major piers (remnants of Piers 23 and 24 and all of Pier 25 remain today), three dry docks, and a shipway. These features are depicted in a 1980 aerial photograph of the Site (Figure 3). Lockheed Shipbuilding and Construction Company purchased the Site assets in 1959, and continued shipyard operations until 1987. In 1988, the Port purchased the adjacent upland property and the harbor leases from Lockheed Martin. In 1996, the Port discontinued the harbor leases causing them to be returned to DNR management. Figure 2 indicates the current ownership areas of the Site.

Industrial activities generated considerable quantities of sandblast grit and other industrial waste that discharged to sediments and accumulated beneath the dry docks and shipways and was disseminated into the underlying sediments.

The Site was placed on the National Priorities List on March 7, 2007. Prior to this, the Site (then referred to as Lockheed Shipyard No. 2) was listed as a sediment cleanup priority project under State of Washington authority through the requirements of MTCA.

2.2.2 Previous Investigations and Enforcement Activities

Since 1984, an extensive series of studies have been independently conducted by Lockheed Martin and the Port in an effort to determine the nature and extent of sediment contamination at the Site. Much of this information was compiled by Parametrix (1994a and b) and by Enviros (1990) to support characterization of the Lockheed Shipyard No. 2 site as part of harbor development planning by the Port. Available historical sediment quality information in the vicinity of the Site includes samples collected prior to 1998 and in 2003 as part of a due diligence investigation (Hart Crowser, 2003).

2.2.2.1 Lockheed Shipyard – Upland

The former Lockheed Shipyard upland was designated as remediation area RA-5 in support of the Southwest Harbor Cleanup Project (SWHP) conducted by Ecology. Results of the prior Site investigations were used to identify contaminants of concern (COCs) and cleanup levels during the FS for the Port of Seattle's Terminal 5 expansion project. Contaminated soils in upland areas were excavated and treated in 1994. The former storm drain system was also decommissioned, and catch basin sediments were removed. An asphalt cap was placed over the entire site. Long-term monitoring of the former Lockheed Shipyard uplands is being performed by the Port under Ecology supervision as part of the SWHP. A comprehensive discussion of the SWHP, including remedial actions, ongoing long-term monitoring, and current environmental status is provided in the Source Control Information and Data Gap Reports (Tetra Tech, 2009a and 2009b).

2.2.2.2 Lockheed Shipyard – Waterway

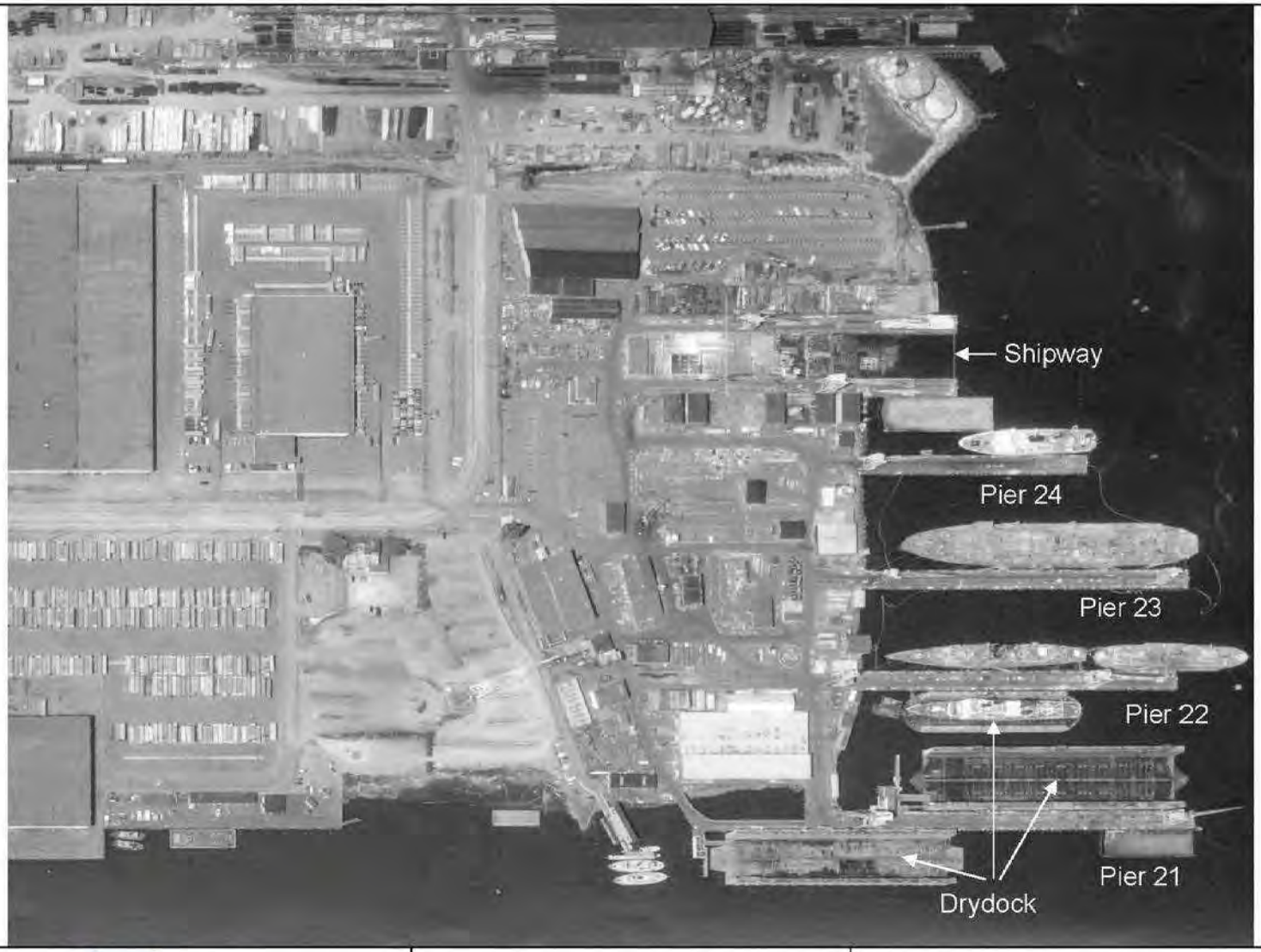
Lockheed Martin submitted the *Final Remedial Investigation/Feasibility Study for the Lockheed West Seattle Superfund Site* to EPA Region 10 in May 2012 (Tetra Tech, 2012). The Site RI fieldwork was conducted from 2006 through 2008. RI field activities and collected data include the following:

- Performance of a high-resolution multibeam bathymetry survey, shoreline conditions survey, and topographic survey
- Collection of surface sediment samples from the intertidal and subtidal areas
- Collection of subsurface sediment samples from the subtidal area
- Collection of pore water and surface water samples
- Performance of clam reconnaissance surveys and collection of clam tissue samples

Analytical data from surface and subsurface sediment samples indicate that metals, polyclorinated biphenyls (PCBs), tributyltin (TBT), and polycyclic aromatic hydrocarbons (PAHs) are the most frequently detected compounds in the study area. Typical shipyard-related metals (including arsenic, chromium, copper, lead, mercury, and zinc) in surface and subsurface sediment exceeded Washington sediment management standards (SMS) for protection of benthic invertebrates[2]. These concentrations were used to evaluate the nature and extent of contamination at the Site (see Section 2.6.3 of this ROD). It is important to note that the SMS criteria do not address risks to human health or to animals coming into contact with sediment or eating fish and shellfish that live in the waterway. However, as documented in Section 2.8 of this ROD, risk levels at the Site exceed the EPA triggers for remedial action (excess cancer risk greater than 1×10^{-4} and noncancer hazard quotient [HQ] greater than 1) (EPA, 1991). Once remedial action is triggered, more stringent state applicable or relevant and appropriate requirement (ARARs) are applied, including the MTCA 1×10^{-6} excess cancer risk standard, and the use of natural background levels when risk-based threshold concentrations (RBTC) are more stringent than background. Also note that risk levels are determined using averaged concentrations of contaminants in an exposure area, rather than by point-by-point comparisons to criteria such as the SMS.

Tables 2 and 3 summarize carbon-normalized results for total PAHs, PCBs, and several miscellaneous semivolatile organic compounds (SVOCs) and dry-weight results for metals in comparison with SMS screening criteria. PCBs were the most common contaminant detected above sediment quality standards (SQS) and cleanup screening levels (CSL) in both surface and subsurface samples. PAHs were the next most common contaminant detected with exceedances of SMS criteria. Dioxins and furans also were identified as COCs based on their assumed presence at the Site and risk levels identified for the LDW site, which were extrapolated to the Lockheed West Site. The results from the clam reconnaissance confirmed the presence of low levels of dioxins and furans in the sediments at the Site. No response actions have been implemented at this Site. Remediation activities conducted at adjacent sites include both upland and in-waterway sediment cleanups. Detailed information concerning these activities is summarized and evaluated in the *Final Existing Information and Data Gap Summary Report* (Tetra Tech, 2009a) and the *Final Source Control Evaluation Report* (Tetra Tech, 2009b). Environmental cleanups performed immediately adjacent to the Site include the Port upland remediation area to the south (RA-5), and the PSR site to the west. Upland and in-waterway cleanups also were completed on and adjacent to Harbor Island to the east of the Site.

[2] The Washington State SMS (Washington Administrative Code 173-204) provide a basis for the management and reduction of pollutant discharges and guide contaminated sediment cleanup efforts for the protection of benthic receptors. The standards include regionally developed numerical sediment criteria that protect the benthic (that is, bottom-dwelling) invertebrate community. The benthic invertebrate numerical criteria are not intended to be protective of human health with regard to consumption of bioaccumulative contaminants in seafood. There are two levels of chemical and biological SMS. The more stringent level, the SQS, is the sediment cleanup objective and corresponds to a sediment quality that has no acute or chronic adverse effects on benthic marine organisms. The less stringent level, the CSL, also known as the minimum cleanup level, is the level above which minor adverse effects may occur in benthic marine organisms.



TETRA TECH

Lockheed West Seattle
Superfund Site
Seattle, WA

Figure 3
1980 Aerial Photograph

TABLE 2

Comparison of Surface Sample Results with the Sediment Management Standard Criteria (Page 1 of 2)

Lockheed West Seattle Record of Decision

Parameter	SQS (mg/kg – OC)	CSL (mg/kg – OC)	LAET (µg/kg-dw)[a, b]	2LAET (µg/kg-dw)[a, b]	Number Samples Exceeding SQS/LAET[c]	Percent Exceeding SQS/LAET[c]	Number Samples Exceeding CSL/2LAET[c]	Percent Exceeding CSL/2LAET[c]
PAHs								
Acenaphthylene	66	66	1,300	1,300	6	8.2	2	2.7
Benzo(a)anthracene	110	270	1,300	1,600	9	12.3	1	1.4
Benzo(a)pyrene	99	210	1,600	3,000	9	12.3	1	1.4
Benzofluoranthenes (total)	230	450	3,200	3,600	5	6.8	1	1.4
Benzo(g,h,i)perylene	31	78	6,760	720	21	28.8	2	2.7
Chrysene	110	460	1,400	2,800	15	20.5	1	1.4
Dibenzo(a,h)anthracene	12	33	230	540	14	19.2	2	2.7
Fluoranthene	160	1,200	1,700	2,500	19	26	0	0
Indeno(1,2,3-cd)pyrene	34	88	600	690	15	20.5	2	2.7
Phenanthrene	100	480	1,500	5,400	11	15.1	0	0
Pyrene	1,000	1,400	2,600	3,300	0	0	0	0
Acenaphthene	16	57	500	730	6	8.2	2	2.7
Anthracene	220	1,200	960	440	0	0	0	0
Fluorene	23	79	1,700	2,500	5	6.8	0	0
Naphthalene	99	170	2,100	2,400	1	1.4	0	0
2-Methylnaphthalene	38	68	670	1,400	0	0	0	0
Total LPAH	370	780	5,200	13,000	2	2.7	1	1.4
Total HPAH	960	5,300	12,000	17,000	15	20.5	0	0
Other SVOCs								
1,2-Dichlorobenzene	2.3	2.3	35	50	0	0	0	0
1,4-Dichlorobenzene	3.1	9	110	120	0	0	0	0
1,2,4-Trichlorobenzene	0.81	1.8	31	51	0	0	0	0
2-Methylphenol	63	63	63	63	0	0	0	0
4-Methylphenol	670	670	670	670	0	0	0	0
2,4-Dimethylphenol	29	29	29	29	0	0	0	0
Benzyl alcohol	57	73	57	73	0	0	0	0
Benzoic Acid	650	650	650	650	0	0	0	0
Butyl benzyl phthalate	4.9	64	63	900	0	0	0	0
Dibenzofuran	15	58	540	700	2	2.7	0	0

TABLE 2

Comparison of Surface Sample Results with the Sediment Management Standard Criteria (Page 2 of 2)

Lockheed West Seattle Record of Decision

Parameter	SQS (mg/kg – OC)	CSL (mg/kg – OC)	LAET (µg/kg-dw)[a, b]	2LAET (µg/kg-dw)[a, b]	Number Samples Exceeding SQS/LAET[c]	Percent Exceeding SQS/LAET[c]	Number Samples Exceeding CSL/2LAET[c]	Percent Exceeding CSL/2LAET[c]
Bis(2-ethylhexyl) phthalate	47	78	1,300	1,900	8	11.0	3	4.1
Diethylphthalate	61	110	200	200	0	0	0	0
Dimethyl phthalate	53	53	71	160	0	0	0	0
Di-n-butyl phthalate	220	1,700	1,400	1,400	0	0	0	0
Di-n-octyl phthalate	58	4,500	6,200	6,200	0	0	0	0
Hexachlorobenzene	0.38	2.3	22	70	2	2.7	0	0
Hexachlorobutadiene	3.9	6.2	11	120	0	0	0	0
Pentachlorophenol	360	650	360	650	4	5.4	0	0
Phenol	420	1,200	420	1,200	0	0	0	0
PCBs								
PCBs (total)	12	65	130	1,000	59	81	11	15.1
Metals								
Arsenic	57	93	57	93	12	16.4	10	13.7
Cadmium	5.1	6.7	5.1	6.7	0	0	0	0
Chromium	260	270	260	270	3	4.1	3	4.1
Copper	390	390	390	390	16	21.9	16	21.9
Lead	450	530	450	530	3	4.1	002.7	2.7
Mercury	0.41	0.59	0.41	0.59	32	44	24	33
Silver	6.1	6.1	6.1	6.1	0	0	0	0
Zinc	410	960	410	960	17	23.3	3	4.1

[a] Metals criteria are mg/kg-dw

[b] OC-normalized criteria converted to dry weight concentration

[c] For OC-normalized SQS and CSL criteria where the percent OC in the sample is less than 0.5 percent, the sample concentrations are compared to the LAET or 2LAET for SQS and CSL, respectively.

Notes:

2LAET = Second Lowest Apparent Effects Threshold
µg/kg-dw = microgram per kilogram dry weight
CSL = Cleanup Screening Level
HPAH = heavy weight polycyclic aromatic hydrocarbon
LAET = Lowest Apparent Effects Threshold
LPAH = light weight polycyclic aromatic hydrocarbon
mg/kg-dw = milligram per kilogram dry weight
mg/kg-OC = milligram per kilogram organic carbon
OC = organic carbon
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
SQS = Sediment Quality Standard
SVOC = semivolatile organic compound

Adapted from RI/FS Report Table 4-8 (Tetra Tech, 2012)

TABLE 3

Comparison of Subsurface Sample Results with the Sediment Management Standard Criteria (Page 1 of 2)

Lockheed West Seattle Record of Decision

Parameter	SQS (mg/kg – OC)	CSL (mg/kg – OC)	LAET (µg/kg-dw)[a, b]	2LAET (µg/kg-dw)[a, b]	Number Samples Exceeding SQS/LAET[c]	Percent Exceeding SQS/LAET[c]	Number Samples Exceeding CSL/2LAET[c]	Percent Exceeding CSL/2LAET[c]
PAHs								
Acenaphthylene	66	66	1,300	1,300	9	5.6	9	5.6
Benzo(a)anthracene	110	270	1,300	1,600	45	28	29	16
Benzo(a)pyrene	99	210	1,600	3,000	38	24	24	15
Benzofluoranthenes (total)	230	450	3,200	3,600	34	21	23	14
Benzo(g,h,i)perylene	31	78	6,760	720	49	31	30	19
Chrysene	110	460	1,400	2,800	46	29	21	12
Dibenzo(a,h)anthracene	12	33	230	540	53	33	26	16
Fluoranthene	160	1,200	1,700	2,500	55	34	26	16
Indeno(1,2,3-cd)pyrene	34	88	600	690	26	16	7	4.4
Phenanthrene	100	480	1,500	5,400	52	33	32	20
Pyrene	1,000	1,400	2,600	3,300	26	16	16	10
Acenaphthene	16	57	500	730	56	35	36	23
Anthracene	220	1,200	960	440	28	18	3	1.9
Fluorene	23	79	1,700	2,500	49	31	32	20
Naphthalene	99	170	2,100	2,400	23	14	18	6.3
2-Methylnaphthalene	38	68	670	1,400	16	10	12	7.5
Total LPAH	370	780	5,200	13,000	47	29	36	23
Total HPAH	960	5,300	12,000	17,000	53	33	19	12
Other SVOCs								
1,2-Dichlorobenzene	2.3	2.3	35	50	0	0	0	0
1,4-Dichlorobenzene	3.1	9	110	120	0	0	0	0
1,2,4-Trichlorobenzene	0.81	1.8	31	51	0	0	0	0
2-Methylphenol	63	63	63	63	0	0	0	0
4-Methylphenol	670	670	670	670	0	0	0	0
2,4-Dimethylphenol	29	29	29	29	0	0	0	0
Benzyl alcohol	57	73	57	73	0	0	0	0
Benzoic Acid	650	650	650	650	0	0	0	0
Butyl benzyl phthalate	4.9	64	63	900	0	0	0	0

TABLE 3

Comparison of Subsurface Sample Results with the Sediment Management Standard Criteria (Page 2 of 2)

Lockheed West Seattle Record of Decision

Parameter	SQS (mg/kg – OC)	CSL (mg/kg – OC)	LAET (µg/kg-dw)[a, b]	2LAET (µg/kg-dw)[a, b]	Number Samples Exceeding SQS/LAET[c]	Percent Exceeding SQS/LAET[c]	Number Samples Exceeding CSL/2LAET[c]	Percent Exceeding CSL/2LAET[c]
Dibenzofuran	15	58	540	700	48	30	28	18
Bis(2-ethylhexyl) phthalate	47	78	1,300	1,900	38	24	29	16
Diethylphthalate	61	110	200	200	0	0	0	0
Dimethyl phthalate	53	53	71	160	0	0	0	0
Di-n-butyl phthalate	220	1,700	1,400	1,400	0	0	0	0
Di-n-Octyl phthalate	58	4,500	6,200	6,200	2	1.3	0	0
Pentachlorophenol	360	690	22	70	4	2.6	0	0
Phenol	420	1,200	11	120	0	0	0	0
PCBs								
PCBs (total)	12	65	130	1,000	74	46	36	23
Metals								
Arsenic	57	93	57	93	27	17	15	9.4
Cadmium	5.1	6.7	5.1	6.7	0	0	0	0
Chromium	260	270	260	270	7	4.4	7	4.4
Copper	390	390	390	390	29	18	29	18
Lead	450	530	450	530	14	8.8	11	6.9
Mercury	0.41	0.59	0.41	0.59	52	33	43	27
Silver	6.1	6.1	6.1	6.1	0	0	0	0
Zinc	410	960	410	960	33	21	17	11

[a] Metals criteria are mg/kg-dw

[b] OC- normalized criteria converted to dry weight concentration

[c] For OC normalized SQS and CSL criteria where the percent OC in the sample is less than 0.5 percent the sample concentrations are compared to the LAET or 2LAET for SQS and CSL, respectively.

Notes:

2LAET = Second Lowest Apparent Effects Threshold
CSL = Cleanup Screening Level
HPAH = heavy weight polycyclic aromatic hydrocarbon
LAET = Lowest Apparent Effects Threshold
LPAH = light weight polycyclic aromatic hydrocarbon
mg/kg-dw = milligram per kilogram dry weight
mg/kg-OC = milligram per kilogram organic carbon
µg/kg-dw = microgram per kilogram dry weight
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
SQS = Sediment Quality Standard
SVOC = semivolatile organic compound

Adapted from RI/FS Report Table 4-10 (Tetra Tech, 2012)

2.3 Community Participation

This section describes how the public participation requirements of CERCLA and the NCP were met in the remedy selection process.

The RI/FS Report (Tetra Tech, 2012) and Proposed Plan (EPA, 2012) for the Lockheed West Site were made available to the public in July 2012. They can be found in the Administrative Record file located online at: http://yosemite.epa.gov/r10/cleanup.nsf/sites/LockheedWest.

These files are also accessible at the location below:

EPA Seattle Office, Superfund Records Center
(contains the Administrative Record)
1200 6th Avenue
Seattle, Washington 98101
206-553-4494 or 800-424-4372

The following activities were conducted as part of the formal community participation process under CERCLA and the NCP § 300.430(f)(3):

- The notice of availability of the Proposed Plan was published in the *Seattle Times*, on July 2, 2012.
- A public comment period for the Proposed Plan was held from July 2, 2012, to August 3, 2012.
- A public meeting to present and solicit comments on the Proposed Plan with a broader community audience was held on July 19, 2012, at the South Seattle Community College, West Seattle Campus, 600 16th Avenue SW, Seattle, Washington, Room CEC102.
- Responses to the comments received during the Proposed Plan public comment period are included in the Responsiveness Summary, which is Part 3 of this ROD.

2.4 Scope and Role of Response Action

The remedial action selected in this ROD is intended to be the final remedy for the Site. The ROD addresses Site-related contamination in the shoreline bank, intertidal, and subtidal sediments that pose unacceptable risk to human health and the environment, and in particular, aquatic organisms. The remedy will prevent the contamination at the Site from having detrimental impacts to the water quality of Elliott Bay.

This ROD selects a final remedial action for the Lockheed West shipyard and related contamination that has come to reside in the in-waterway portion of the Site, which is expected to be designed and implemented over the next 2 to 3 years following the ROD signature by the potentially responsible party under EPA oversight. The upland site sources have already been controlled pursuant to state authority. The remedy is expected to be protective, meet all ARARs, except for arsenic in surface water, and achieve Cleanup Levels for sediments. The remediation also will eliminate the Site as a significant source to surface water. There is potential for some recontamination from areawide anthropogenic sources.

2.5 Site Characteristics

This section summarizes information obtained through the RI/FS process, including information found in the following documents:

- *Final Remedial Investigation/Feasibility Study Work Plan for the Lockheed West Seattle Superfund Site* (Tetra Tech, 2008a)

- *Remedial Investigation Data Report* (Tetra Tech, 2008b)
- *Final Ecological Risk Assessment Report for the Lockheed West Seattle Superfund Site* (Tetra Tech and Pascoe, 2009a)
- *Final Human Health Risk Assessment Report for the Lockheed West Seattle Superfund Site* (Tetra Tech and Pascoe, 2009b)
- *Final Source Control Evaluation Report, Lockheed West Seattle Superfund Site* (Tetra Tech, 2009b)
- *Final Remedial Investigation/Feasibility Study Report for the Lockheed West Seattle Superfund Site* (Tetra Tech, 2012)

2.5.1 Physical Setting

The Site consists of approximately 40 acres of in-water sediments where the former Lockheed Shipyard No. 2 was located. It is tidally affected with additional influence from the LDW that flows into the West Waterway. The Site is predominantly subtidal, with mudline elevations extending from -10 feet MLLW to -40 to –50 feet MLLW in historically dredged areas. Shallower areas are present beneath the former shipyard piers (elevations of –20 to –30 feet MLLW). The intertidal and shoreline portions of the Site extend from mean high higher water at plus (+) 11.3 feet MLLW to -10 feet MLLW. Site bathymetry is presented in Figure 4. Site features and sample locations are shown in Figure 5.

The Duwamish Estuary and Elliott Bay have experienced extensive development and urban growth during the 20th century. Tidal flats and marshes that once dominated the mouth of the river were dredged and filled to form Harbor Island and the upland areas of the Site. The shoreline is densely armored with riprap, and includes wooden and steel retaining walls or bulkheads. Since closure of the shipyard, the Port has demolished Piers 21 and 22 and removed the decking from Piers 23 and 24. Pilings for these piers and the former shipway area still exist, and the Port is required to remove them in the State Harbor Area per an agreement with DNR, the current owner of this portion of the Site. A narrow intertidal zone extends along the landward edge of the Site, wrapping around the eastern and northern shoreline between the West Waterway and the PSR Superfund site and deepens toward offshore areas (Figure 5). Numerous pilings remain within the footprints of the former shipway and pier structures in the northern portion of the Site.

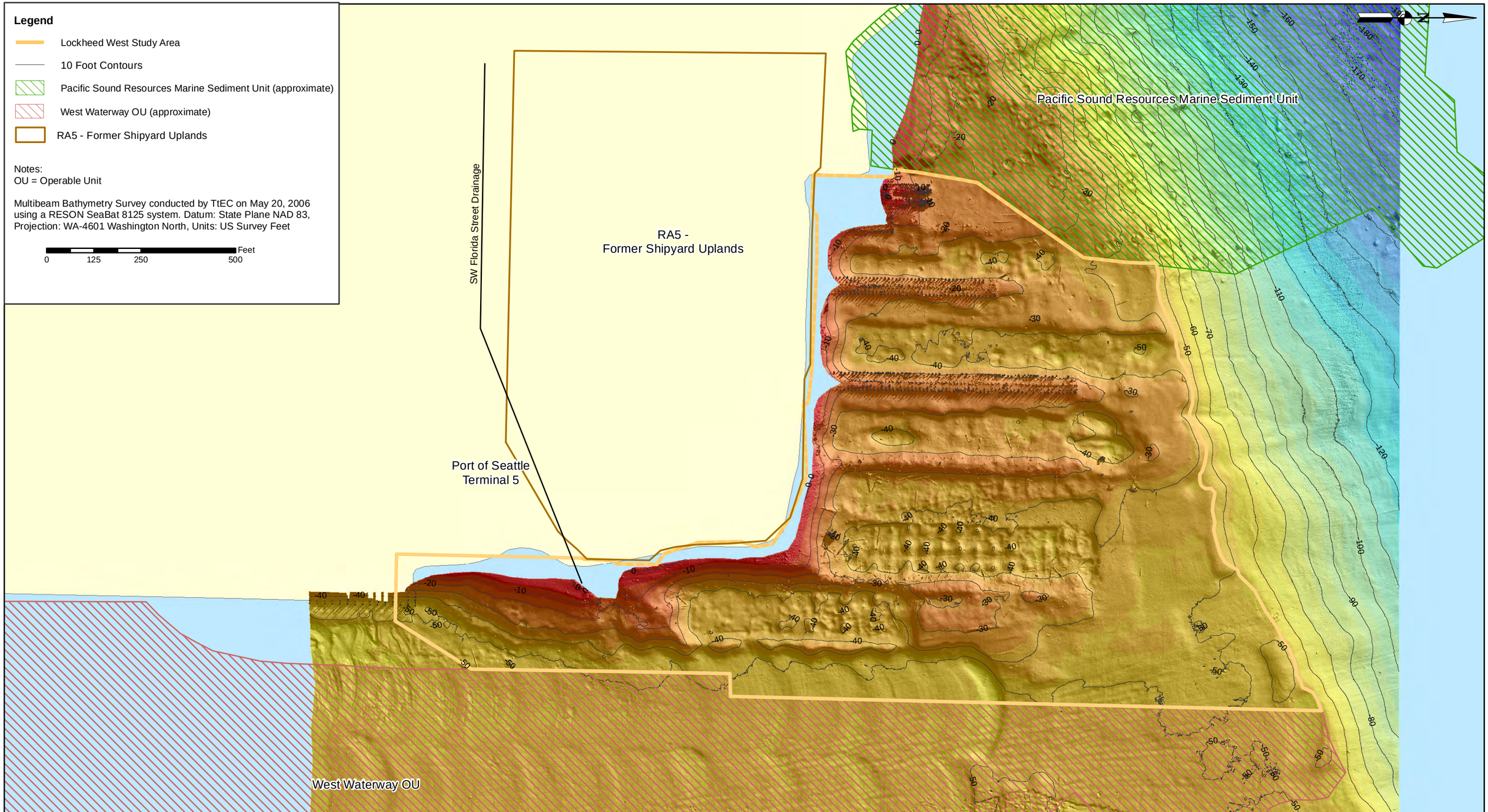
There are no known cultural resources such as Native American graves, sacred sites, historic sites or structures, or archaeological resources associated with the Site.

2.5.1.1 Shoreline Characteristics

Elliott Bay and the Duwamish Waterway are shorelines of statewide significance under the Shoreline Management Act and the Coastal Zone Management Program. They are part of Puget Sound, an estuary of national significance under the National Estuary Program.

2.5.1.2 Sediments

The sediment profile is composed of an upper layer of 3 feet of very loose sandy silt, followed by a 10- to 20-foot layer of interbedded soft sandy silt and loose silty sand, underlain by medium dense to dense silty sand to a depth of 75 to 100 feet, below which the material becomes very dense. This pattern is consistent with deltaic deposits. These delta deposits transition to glacial till at about 150-foot depth; below 300 feet the glacial till behaves as bedrock. Bedrock at the Site is at a range of 650 to 1,000 feet (Hart Crowser, 2003).

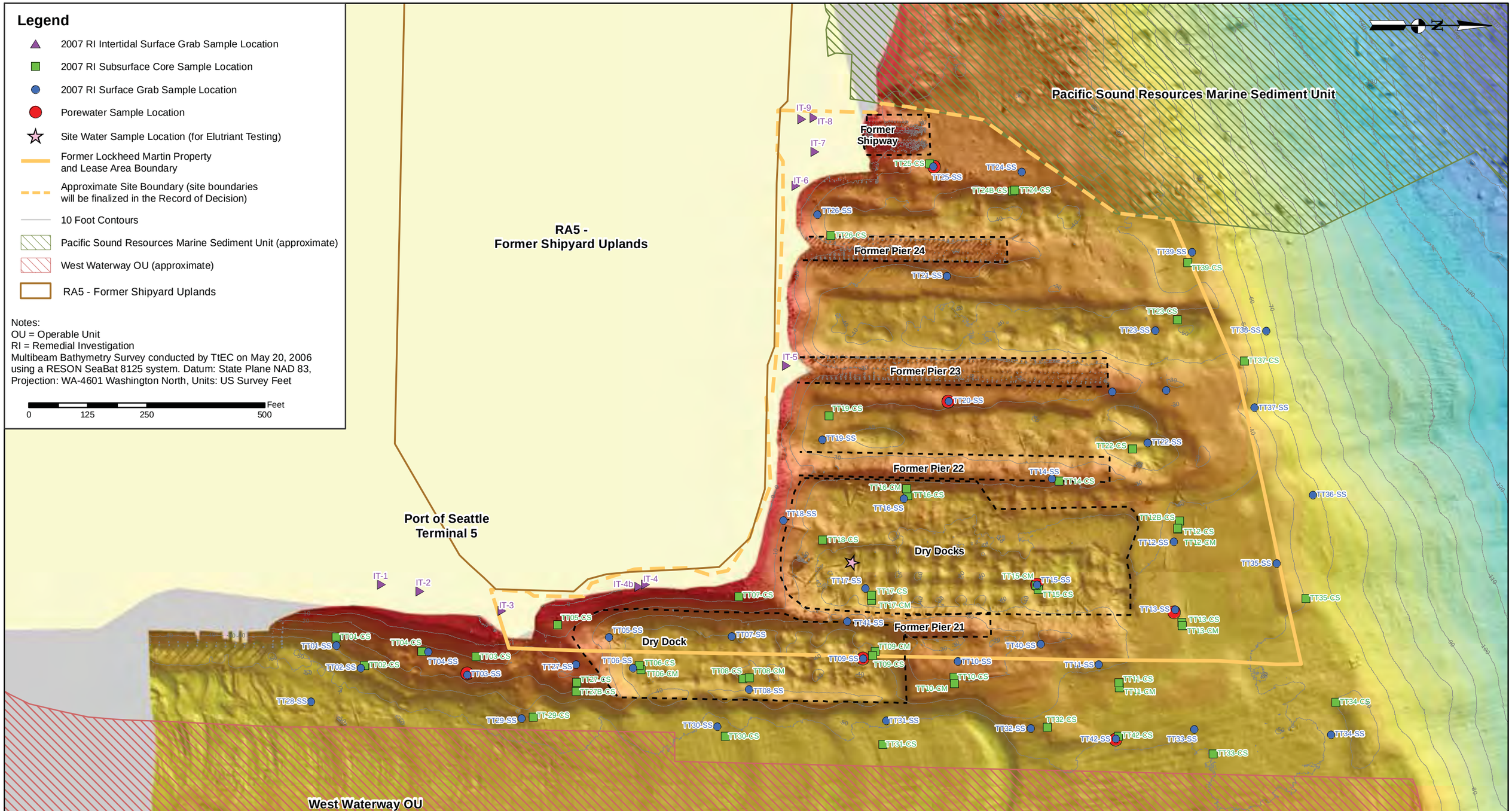


TETRA TECH

Lockheed West Seattle Superfund Site, Seattle, WA

Figure 4
Lockheed West Site Bathymetry

Y:\GIS\Pdrive\Projects_2006\Lockheed\maps\harbor_island\Fig_2-9.mxd



TETRA TECH

Lockheed West Seattle Superfund Site Seattle, WA

Figure 5 Remedial Investigation Sediment Sampling Locations

Z:\Pdrive\Projects_2006\Lockheed\maps\RIFS_Report\Fig_4-2.mxd

The shoreline area is composed of medium sand, shell hash, small- to medium-size cobbles, medium to large riprap, concrete keel blocks, cut-off and broken-off wood pilings, and debris, including trash, wire rope, concrete and ductile iron piping, and portions of deteriorated wooden bulkheads. Numerous debris piles and multiple pilings are present in the intertidal and subtidal areas of the former dry docks and shipway.

2.5.1.3 Seismic Conditions

An engineering evaluation of seismic stability and liquefaction potential that incorporated several representative remedial alternatives was completed for the Site as part of the RI/FS (Tetra Tech, 2012). The seismic evaluation assessed the outcome for nominal 100-, 500-, and 2,500-year earthquake events in terms of ground movement, sediment disturbance, and predicted impacts to Site remedial actions. This seismic evaluation confirmed that extensive liquefaction and ground failure of sediments within the Site boundary and vicinity are likely to occur during moderate to large earthquakes. These areas are also susceptible to lateral spreading, post-liquefaction settlement, and earthquake-induced displacement during seismic events.

2.5.2 Cultural Resources

The Site and adjacent aquatic areas are designated as Tribal U&A Fishing Areas, as defined by treaty and confirmed by the Boldt Decision. As such, the area has both cultural and commercial significance. Historically, the Suquamish and Muckleshoot Tribes have depended on fish and shellfish for subsistence. Salmon was the primary staple food; other species, including cod, smelt, herring, clams, oysters, and moon snails, supplemented salmon in their diet.

2.5.3 Biological Resources

The environmental media (sediments and water column) on the east portion of the Site that lies in the West Waterway are estuarine in nature. The shoreline habitat is typical of the industrial shoreline in much of the Duwamish Waterway with armoring and sheet pile bulkheads, along with broken pilings, deteriorating wooden bulkheads, and debris. A single, small intertidal beach area is present along the West Waterway between the Terminal 5 pier and the South Florida Street Outfall. Current shoreline conditions within the remainder of the Site boundary indicate a highly modified and impacted industrial shoreline with little to no natural intertidal habitat.

Flora and fauna of the in-waterway area and shoreline include bivalves, crustaceans, and worms in the fine sediments. Crustaceans and mollusks are typically found in coarser sediments. The Site environment also supports birds (such as sandpiper), crabs, resident fish (such as perch, sculpin, rockfish), as well as anadromous fish (such as salmon).

Several bottomfish (sole, sculpin, flounder) and water column fish (perch and herring) are abundant in the LDW, as are salmon. The Green/Duwamish River system supports eight species of salmonids: coho, Chinook, chum, sockeye, and pink salmon, plus cutthroat trout, both winter- and summer-run steelhead, and bull trout. Juvenile Chinook and chum have a residence time in the LDW from several days to 2 months; coho are in the LDW for only a few days; and sockeye are rare in the LDW. Salmon found in the LDW spawn mainly in the middle reaches of the Green River and its tributaries. The juvenile outmigration generally starts between March and June. Outmigration usually lasts through mid-July to early August.

Puget Sound Chinook salmon are listed as threatened under the Federal Endangered Species Act (ESA). Other relevant fish species listed as threatened under the ESA include the coastal Puget Sound bull trout and the Puget Sound steelhead. The LDW is designated as critical habitat for bull trout and Chinook

salmon. The bald eagle was delisted in 2007 under the ESA but is protected under the Bald and Golden Eagle Protection Act, as well as under the Migratory Bird Treaty Act.

Typical of most estuaries, the benthic invertebrate community is dominated by annelids (worms), mollusks (clams and snails), and crustaceans (such as shrimp and crabs). Dungeness and other crabs are present in the LDW, although their distribution is generally limited to the portions of the LDW with higher salinity.

The common shorebirds and wading birds observed in the LDW are sandpipers, killdeer, and great blue herons. Bald eagles, ospreys, and great blue herons nest on or near the LDW and use the LDW for foraging. The LDW provides habitat for mammal species including harbor seals, sea lions, and river otters.

Based on the RI findings, critical habitat does not appear to be present at the Lockheed West Site. However, EPA will consult with and obtain Biological Opinions from appropriate agencies. Chinook salmon are listed as threatened species, and Federal agencies must confer with the National Oceanic and Atmospheric Administration National Marine Fisheries Service on any action that may impact listed species.

2.5.4 Marine Surface Water

Surface water at the Site is predominantly tidal with additional influences from river flows from the West Waterway at the mouth of the Duwamish/Green River watershed. This watershed drains an area of approximately 483 square miles. USACE manages river water flows limiting discharges to 12,000 cubic feet per second (cfs) at the city of Tukwila and minimum flows to as low as 200 cfs, with an average flow of 1,500 to 1,800 cfs. The West Waterway carries most of the river flow due to shoaling at the entrance of the East Waterway. Also, contributing flow from Longfellow Creek discharges into the head of the West Waterway. Longfellow Creek and the areas surrounding it have been remediated through Ecology orders.

The Site is affected by relatively low-salinity water from the Duwamish River that forms an approximate 3- to 6-foot layer over denser saline waters. There is an apparent upwelling effect of marine waters toward the northern edge of the Site, west towards Duwamish Head. Based on a tidal reference station located approximately 1 mile from the mouth of the estuary, the mean tide stage is 6.5 feet above MLLW, and maximum and minimum estimated stages are 15.0 feet plus or minus (±) 0.5 foot above MLLW and 4.5 feet ± 0.5 foot below MLLW, respectively.

Circulation of water in the LDW is a function of river flows and movement of saltwater upstream during tidal cycles. Intrusion of saltwater into the river creates a wedge overlain by freshwater extending as far as 10 miles upstream. The general circulation pattern in the interior of Elliott Bay is counterclockwise, with Duwamish River flows discharging into the bay. This pattern can create eddies at the mouth of West Waterway during high river flows and ebb tides. The combination of tidal and river flows results in a consistent flow across the Site from west to east and does not appear to be a source of erosion. Current meters placed at depths in excess of 100 meters showed that current velocities in the bay are too low to resuspend sediments at these depths. Localized currents may disturb some shallow sediment. An analysis of the PSR Marine sediment cap indicates that fine-grained cap materials would be stable at current velocities less than 0.7 feet per second (20 centimeters [cm] per second).

2.5.5 Geology and Hydrogeology

There are four distinct geological units under and surrounding the Site:

- **Upland Fill** – A soil unit underlying the present upland configuration consisting of an approximate 20-foot-thick layer of medium dense fill material composed of varying amounts of sand, silt, and clay.
- **Recent Sediment Deposits** – An upper offshore geological unit composed of a veneer of soft, organic silt and sand deposited at the Site after completion of historical dredging activities.
- **Post-Glacial Deposits** – A post-glacial unit underlying recent sediment deposits composed of soft, organic silt ranging from approximately 3 to 7 feet in thickness. Below its surface silt layer are sands with interbedded thin silt layers. This post-glacial unit ranges from approximately 100 feet to greater than 155 feet in thickness. This unit is likely the result of estuarine deposition from the Duwamish River.
- **Glacial Deposit** – A unit of hard sandy silt was observed in the two southernmost portions of the offshore area of the Site. This unit is a glacially overridden deposit and was encountered at elevations of approximately -60 to -140 feet MLLW. This unit is assumed to slope downward into the Site toward Elliott Bay.

There are two hydrogeologic zones in the vicinity of the Site:

- **Shallow Fill Aquifer** – A zone consisting of various fill materials that range from 20 to 40 feet in thickness. This aquifer is only present beneath the adjacent RA-5 upland.
- **Deeper Estuarine Aquifer** – An aquifer with sandy silt to silty fine sand tide-flat deposits, typically 1 to 10 feet in thickness over most of the Site (with the exception of the easternmost portion nearest the West Waterway), resulting in locally confined conditions. The Estuarine Aquifer zone is underlain by a lower permeability unit that occurs at depths ranging from 30 to 50 feet below the upland ground surface.

Groundwater flow in the vicinity of the Site is tidally influenced. Groundwater flowing northward from the adjacent upland areas discharges into Elliott Bay at elevations of approximately -40 feet MLLW and above. At low tide, groundwater may discharge to surface water through intertidal seeps. Shallow groundwater flow is generally toward Elliott Bay and the West Waterway. Recently, groundwater flow west of the Site has been modified following installation of a slurry wall at the nearby PSR Facility to control flow of nonaqueous phase liquids from historical operations. There is no indication that nonaqueous phase liquids are migrating toward the Site. Ongoing monitoring is conducted at PSR via five-year reviews.

2.6 Conceptual Site Model

A conceptual site model (CSM) documents current and potential future site conditions and illustrates site conditions including contaminant source, transport mechanisms, exposure pathways, exposure routes, and potential human and ecological receptors. The physical CSM for the Site is described in the following subsections and illustrated in Figure 6.

2.6.1 Sources of Contamination

The primary source of Site sediment contamination is historical shipyard operations/activities and related discharges from historical shipyard operations. Contaminants (such as PCBs, carcinogenic PAHs [cPAHs], metals, and TBT) were released into the surface-receiving waters during Site operations and accumulated in sediments. Shipyard operations were discontinued in 1987. Currently, no industrial activities take place at the Site. However, there are upland and upstream sources of contamination in

the vicinity of the Site. These sources could include spills from nearby facilities, wastewater discharges, combined sewer overflows, stormwater discharges, upland contaminated groundwater discharges, and atmospheric deposition.

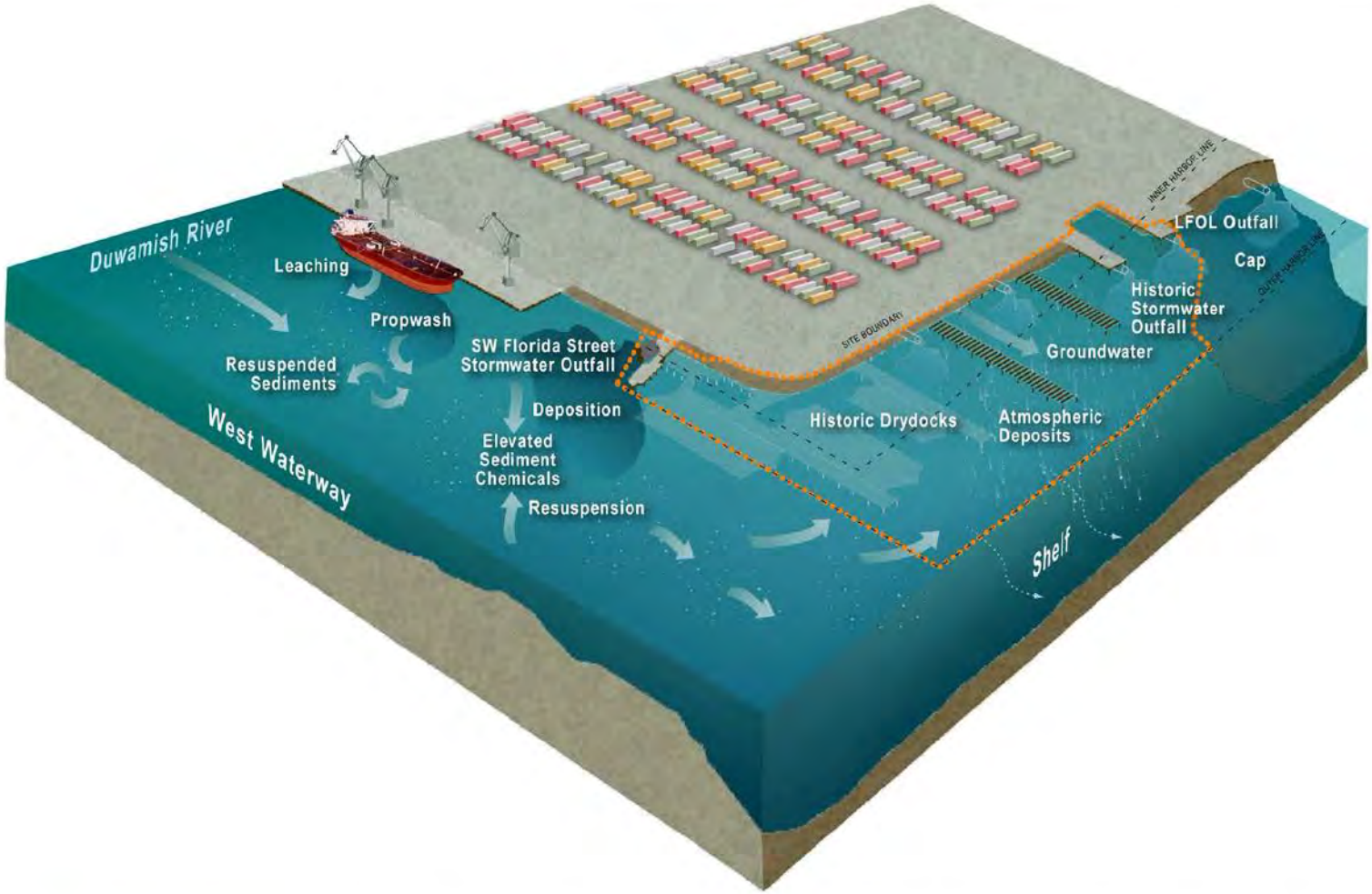
2.6.2 Background Concentrations

Under CERCLA, it is the EPA's policy in some instances to not remediate contamination below anthropogenic background concentrations (EPA, 2002a). Under MTCA, Cleanup Levels are established by determining RBTCs that are protective of human health for the contaminants identified. When RBTC concentrations are lower than natural background concentrations at a remediation site, the higher natural background concentrations are identified as the Cleanup Levels for final remedies. Under MTCA, cleanups to area or anthropogenic background are interim actions.

2.6.2.1 Comparison of Detected Contaminant Concentrations with Puget Sound Background Levels

Natural background values were determined by the EPA using data collected in the EPA "Bold Study" (EPA, 2009a). Consistent with MTCA requirements, natural background is the only type of background considered in the selection of Cleanup Levels for the Site. Sediment samples from all areas throughout the Site contain PCBs, PAHs, and several metals at concentrations that exceed natural background levels established for the Puget Sound region. See Table 4 for natural background concentrations.

The Lockheed West RI/FS project did not conduct separate sampling to establish anthropogenic background concentrations. However, non-regulatory Urban Background values were determined using data from an Urban Waters Initiative project conducted by Ecology (Ecology, 2009a). This data set included sediment samples obtained in three anthropogenic-use/geomorphological areas of Elliott Bay: deep basin, urban/mid-bay, and harbor/inner bay. The 95th percentile upper confidence level (95 UCL) values from the urban/mid-bay data set hereinafter referred to as "Urban Background" in this ROD, were only used as a means of comparison for characterizing different zones of sediment contamination at the Site as a basis for developing certain remedial alternatives and may not be considered "anthropogenic values" as determined by the EPA. These values were not considered in the selection of Cleanup Levels for the Site. See Table 4 for Urban Background concentrations.



TETRA TECH

Lockheed West Seattle Superfund Site Seattle, WA

Figure 6 Conceptual Site Model

TABLE 4
Sediment Background Concentration Information
Lockheed West Seattle Record of Decision

Parameter	Bold Study (Puget Sound Natural Background Level)	Elliott Bay Sediment - Urban Waters Initiative (Elliott Bay Background)[a]		
		Deep Basin[b]	Urban/Mid-Bay[c]	Harbor/Inner Bay
Metals				
Arsenic (mg/kg-dw)	7	9.13	8.44	73.40
Copper (mg/kg-dw)	24.9	41.1	48.9	112
Lead (mg/kg-dw)	11	26.9	47	66.9
Mercury (mg/kg-dw)	0.101	0.175	0.438	0.335
Organics				
cPAHs (µg TEQ/kg-dw)	9	125	757	1210
Total PCBs (µg/kg-dw)	2[d]	48	119	355
Tributyltin (µg/kg-dw)	n/a	n/a	n/a	n/a
Dioxins/Furans (ng TEQ/kg-dw)	2	n/a	n/a	n/a

[a] Although the background data are affected by point and nonpoint pollutant sources in Elliott Bay and are not representative of natural background (or CERCLA anthropogenic background), the data provide the general concentrations of sediments in Elliott Bay during Ecology's sampling in 2007 (Ecology, 2009a). The Urban Background concentrations are typically below the SQS concentrations but above the Cleanup Level concentrations. The use of the term "background" in this context does not connote (as "natural background" does) that these concentrations are acceptable or have any legal basis or standing, and these sediments might also require cleanup in the future.
[b] Value is the maximum detected result for the two samples in the defined region.
[c] Source of Urban Background concentrations used in remedial action level development.
[d] Total PCB result is for the sum of congeners as all Aroclor data was ND for Aroclors 1221 – 1260.

Notes:
95 UCL = 95th percentile upper confidence level
µg/kg-dw = micrograms per kilogram – dry weight
µg TEQ/kg-dw = micrograms toxicity equivalent per kilogram – dry weight
cPAH = carcinogenic polycyclic aromatic hydrocarbon
mg/kg-dw = milligrams per kilogram - dry weight
n/a = analyte not analyzed
ng TEQ/kg-dw = nanograms toxicity equivalent per kilogram – dry weight
PCB = polychlorinated biphenyl

Sources:
Bold Study (EPA, 2009a) – Dredged material management program agencies collected 70 surface sediment samples at locations throughout Puget Sound. Samples were analyzed for dioxins/furans, PCBs and dredged material management program contaminants including PAHs and trace metals. The 95 UCL was determined for the six risk-driver chemicals with reported data.

Elliott Bay Sediment (Ecology, 2007) – Under the Urban Waters Initiative, the Washington State Department of Ecology collected data on sediment contaminant concentrations in three anthropogenic-use/geomorphological areas of Elliott Bay: deep basin (2 samples), urban/mid-bay (13 samples), and harbor/inner bay (15 samples).

Adapted from RI/FS Report Table 4-15 (Tetra Tech, 2012)

2.6.2.2 Recontamination Potential

Surface water and sediment conditions at the Site are influenced by the natural counterclockwise flow of water and tidal influences in Elliott Bay. Elliott Bay is affected by nearby urbanization, and overall concentrations of certain contaminants in bay sediments are higher than concentrations identified as being protective of human consumption of seafood. Therefore, sediment with contaminant concentrations higher than background concentrations, including arsenic, could migrate to the Site as a result of offsite sediment transport from adjacent areas after completion of remediation. In 2006 and 2007, USACE coordinated surface sediment sampling and chemical testing to evaluate the performance of remedial caps placed at the PSR site in 2005 (Science Applications International Corporation, 2008). The PSR site is located immediately west of the Site (Figure 1). Post-cap sediment sampling and chemical testing were conducted as part of the site monitoring program supporting the *EPA's Five-Year Review*

Report for PSR (EPA, 2009b). The PSR sediment sample testing results provide general information regarding equilibration of sediment COCs to Elliott Bay sediment conditions following placement of the PSR capping materials.

A number of the sediment samples collected from the PSR capping areas contained concentrations of metals above natural background levels established for Puget Sound by the Bold Study. For example, 11 of the 12 sediment samples collected in 2006 had concentrations of mercury in excess of the natural background concentration of 0.101 milligrams per kilogram - dry weight (mg/kg-dw), and 9 of the samples had lead concentrations in excess of the natural background concentration of 11 mg/kg-dw. Concentrations of certain metals also exceeded the Elliott Bay Urban Background levels. For example, arsenic concentrations in five of the seven samples with natural background exceedances also exceeded the Urban Background concentration. In addition, concentrations of cPAHs and PCBs in the 2007 PSR surface sediment data set also exceeded natural background levels. For example, detected concentrations of cPAHs in the 25 samples ranged from 10.48 to 242 micrograms per kilogram – dry weight (µg/kg-dw) toxicity equivalent (TEQ), and all 25 results exceeded the natural background concentration for cPAHs at 9 µg/kg-dw TEQ. However, none of the cPAH results exceeded the Urban Background level of 757 µg/kg-dw TEQ. Detected concentrations of total PCBs ranged from 2 to 317 µg/kg-dw, compared to a natural background concentration of 2 µg/kg-dw (24 of 25 samples exceeded the value, 1 equaled it). Concentrations of total PCBs in 2 of the samples exceed the Urban Background concentration of 119 µg/kg-dw.

With regard to projected post-remediation surface sediment quality at the Lockheed West Site, the PSR results indicate that COC concentrations may equilibrate to concentrations above natural background but still below SQS concentrations in the post-construction period as a result of elevated sediment concentrations from Elliott Bay migrating to the Site. To the extent that some contaminated sediment from the Lockheed West site is migrating onto the PSR site, this pathway will be eliminated after remediation of the Site. Although some level of recontamination will occur at the Site as a result of existing contaminants in Elliott Bay, remediation of individual sites such as PSR, Lockheed West, Todd Shipyards, Lockheed Yard No. 1, and East and West Waterways will result in incremental reductions in background concentrations in the larger Elliott Bay.

2.6.3 Summary of the Nature and Extent of Contamination

This section summarizes the nature and extent of contaminants in environmental media at the Site.

2.6.3.1 Sediment

Analytical data from the surface and subsurface sediment samples show that metals, PCBs, TBT, and PAHs are the most frequently detected compounds in the study area (see Tables 2 and 3).

The Washington State SMS (Washington Administrative Code [WAC] 173-204) have been identified as ARARs for evaluating sediment contamination at the Site. The SMS provide a basis for the management and reduction of pollutant discharges and guide contaminated sediment cleanup efforts for the protection of benthic receptors. The standards include regionally developed numerical sediment criteria that protect the benthic (that is, bottom-dwelling) invertebrate community. The benthic invertebrate numerical criteria are not intended to be protective of human health with regard to consumption of bioaccumulative contaminants in seafood. There are two levels of chemical and biological SMS. The more stringent level, the SQS, is the sediment cleanup objective and corresponds to a sediment quality that has no acute or chronic adverse effects on benthic marine organisms. The less stringent level, the CSL, is the level above which minor adverse effects may occur in benthic marine organisms and is also known as the minimum cleanup level. The Washington State SQS were used for screening-level comparisons during the investigation of the Site. Potential effects on human and/or other ecological receptors (such as fish or

shorebirds) were not considered in the nature and extent evaluation because these exposures are typically evaluated on a sitewide, rather than on a point-by-point, basis. Human health and other risks to other ecological receptors are addressed separately, as described in Section 2.8 of this ROD.

Sediment quality data from the RI were evaluated to estimate the extent of Site-related contamination. This evaluation included use of three-dimensional (3-D) modeling and a 3-D visualization software program known as C-Tech MVS. The distribution of surface sediment contaminant concentrations exceeding the SQS and CSL screening values is shown in Figures 7 and 8, respectively. The RI results show that the highest contaminant concentrations, including exceedances of the higher CSL screening criteria, were primarily detected in surface sediments located in the former dry dock areas and in the area of the former shipway. Lower contaminant levels were generally found at other locations throughout the Site. Contaminant concentrations in surface sediments tend to decrease outward toward the Site boundaries.

The distribution of subsurface sediment contaminant concentrations exceeding the SQS and CSL screening values is shown in Figures 9 and 10, respectively. Higher contaminant concentrations in subsurface sediments, including CSL exceedances, are primarily associated with the former dry dock areas. For the majority of the sediment cores collected, the deepest sample interval analyzed had concentrations less than the SQS level. At those locations where the deepest interval had a concentration above the SQS, data from cores nearby indicate that the likely vertical extent of contamination is not substantially deeper.

In addition to the contaminants listed above, surface sediment quality data for dioxins and furans were collected from one intertidal and three subtidal locations. Concentrations of dioxins/furans were 0.69 parts per trillion (ppt) for the intertidal sample, and 2.0 to 13.8 ppt for the subtidal samples. These concentrations represent dioxin levels expressed as the tetrachlorodibenzodioxin (TCDD) TEQ for each sample.

2.6.3.2 Surface Water

Surface water samples were not collected at the Site for characterization purposes. King County collected surface water data for Elliott Bay in 2011 as part of the Receiving Water Characterization Study for the South and West Point Wastewater Treatment Plants, Alki, Carkeek, Elliott West, and MLK/ Henderson Storage and CSO Treatment Plants (King County, 2011). These currently unpublished data were reviewed and compared to the ambient water quality criteria (AWQC) for ecological and human health. Concentrations of arsenic in samples collected from Elliott Bay in July and December 2011 ranged from 1.12 to 1.41 micrograms per liter (µg/L), all of which exceed the AWQC for human consumption of aquatic organisms (0.14 µg/L) and human consumption of water and organisms (0.018 µg/L). The Elliott Bay data were limited to metals.

2.6.3.3 Other Media

Pore water and clam tissue also were collected for laboratory analysis as part of the RI/FS, but the results of these analyses were not used to characterize the nature and extent of contamination. The pore water samples were collected to provide data for potential use in the risk assessments and evaluation of site-specific fate and transport processes at the sediment water interface. The results of the clam reconnaissance survey and analysis were used to confirm the appropriateness of the tissue biota-sediment accumulation factors (BSAFs) adopted from the LDW and used in the human health risk assessment (HHRA).

2.6.4 Fate and Transport of Contaminants of Concern

An evaluation of the chemical properties for the contaminants detected at concentrations above the SQS in the sediments at the Site was performed to determine the most important fate and transport processes. The contaminants detected at the Site are generally hydrophobic in nature and likely to be

bound to sediment particles. The potential for contaminants to be transported in the dissolved phase is low. Transport of contaminants will be primarily driven by movement of sediments at the Site. The Site is characterized by a low rate of net deposition, as evidenced by bathymetry that is consistent with historical dredging analysis of wave-generated bottom shear stress. However, the potential does exist for post-remedy recontamination through sediment transport and deposition from other (offsite) Elliott Bay sources.

2.6.5 Exposure Pathways

Current and future reasonable maximum exposure scenarios focused only on direct pathways to contaminants in sediment (such as ingestion or dermal contact) or indirect pathways (such as consumption of fish or shellfish). After consultation with the Suquamish Tribe and Muckleshoot Tribe, the EPA chose a risk assessment approach for the Lockheed West Site that is consistent with that used for the LDW site (Windward, 2007a). The risk assessment exposure scenarios consist of child beach play, collection of clams by Tribal members, Tribal netfishing, and the consumption of seafood (including clams) by Tribal adults and children. Risks from direct exposure to surface water in West Waterway and Elliott Bay were previously evaluated quantitatively (King County, 1999) and found to be lower than risks associated with the sediment or fish consumption pathways. Thus, water is not evaluated as an exposure source.

Ecological receptors of concern (ROCs) for the Site were selected based on Site habitat characteristics and the pathways of exposure to Site-related contaminants. Representative ROCs are the benthic invertebrate community, which is used to evaluate direct exposures of lower trophic benthic organisms to contaminants in Site sediment; crabs to evaluate exposures of benthic invertebrates through bioaccumulation of sediment contaminants; and English sole and Pacific Staghorn sculpin to evaluate exposures to higher trophic fish through bioaccumulation. These ROCs were evaluated for exposures to Site contaminants in both subtidal and intertidal sediments. The spotted sandpiper was evaluated as a higher trophic ROC for exposures to Site-related contaminants from the ingestion of benthic invertebrates present in intertidal sediment. All of the exposure pathways and parameters for quantifying exposure were taken from the ecological risk assessment (ERA) performed for the LDW site (Windward, 2007b). Use of the technical approach and specific exposure and toxicity parameters used at the LDW site is appropriate because of similarities between the LDW site and this Site, such as estuarine aquatic habitat and resources, and potential future uses of the Site. Pathways for the exposure of ROCs to sediment-associated contaminants at the Lockheed West Site can be designated in one of four ways:

- Complete and significant – There is a direct link between the receptor and chemical via this pathway, and the specific pathway is considered to be potentially important.
- Complete and significance unknown – There is a direct link between the receptor and the chemical via this pathway; however, insufficient data are available to quantify the significance of the pathway in the overall assessment of exposure.
- Complete and insignificant – There is a direct link between the receptor and the chemical via this pathway; however, the significance of this pathway in terms of overall exposure is considered to be negligible. Pathways classified as complete and insignificant are not evaluated in the ERA.
- Incomplete – There is no direct pathway between the receptor and the chemical. Pathways classified as incomplete are not evaluated in the ERA.

Legend

- 2007 Intertidal Surface Grab Sample Location
- 2007 Surface Grab Sample Location
- Terminal 5 Fence Line
- 2 foot Contours
- Harbor Lines
- Pacific Sound Resources Marine Sediment Unit (approximate)
- West Waterway OU (approximate)
- RA5 - Former Shipyard Uplands

Sediment Chemistry Data Summary

Analyte Groups

Individual PAH µg/Kg

Metals mg/Kg — Total HPAH µg/Kg

PCB (total) µg/Kg — Tributyltin µg/Kg

Misc. SVOCs µg/Kg

Color indicates SQS or LAET criteria exceedance for organic carbon < 0.5 % LAET used.

No SQS or LAET exceedance in analyte group

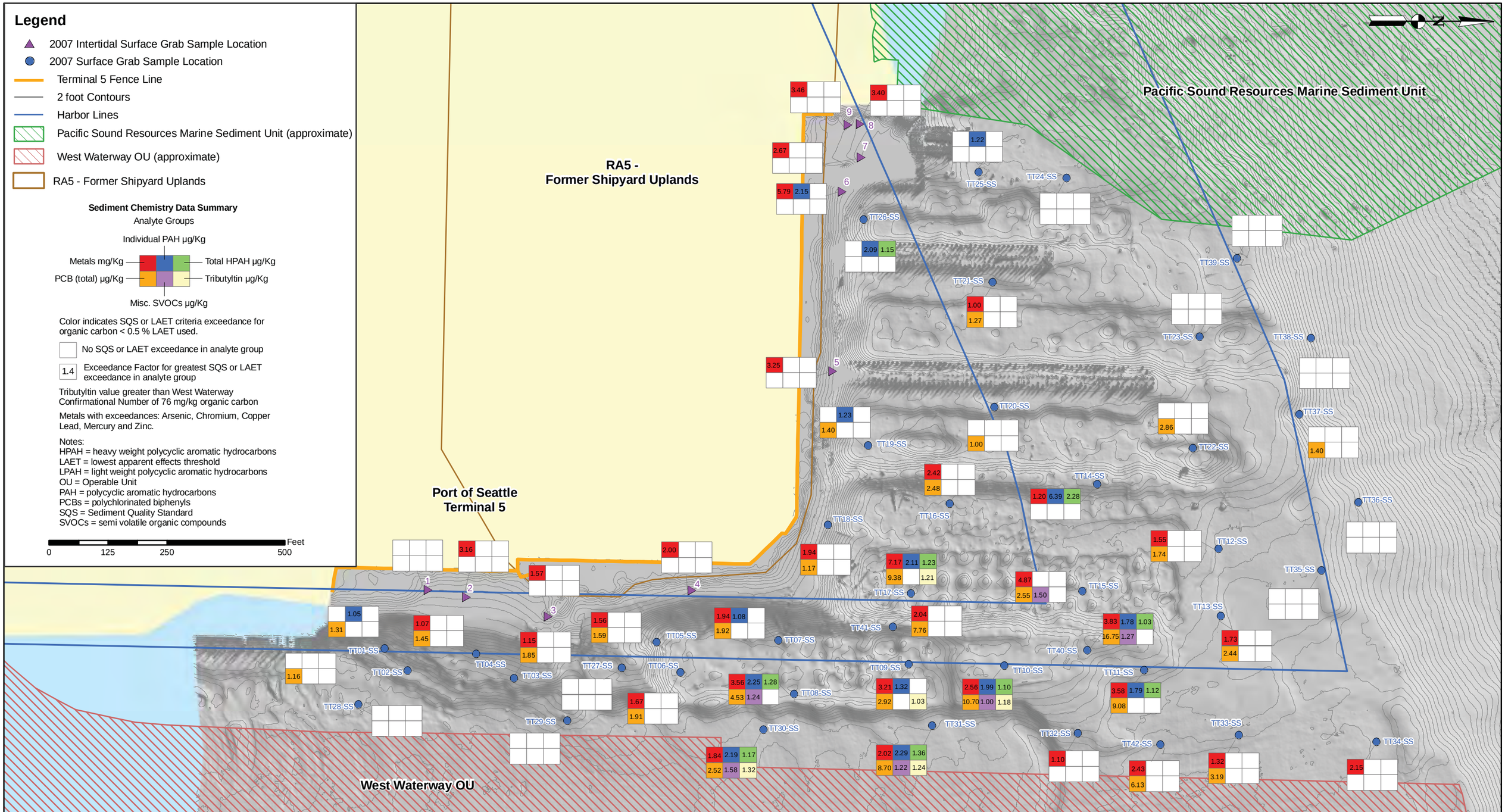
1.4 Exceedance Factor for greatest SQS or LAET exceedance in analyte group

Tributyltin value greater than West Waterway Confirmational Number of 76 mg/kg organic carbon

Metals with exceedances: Arsenic, Chromium, Copper Lead, Mercury and Zinc.

Notes:
HPAH = heavy weight polycyclic aromatic hydrocarbons
LAET = lowest apparent effects threshold
LPAH = light weight polycyclic aromatic hydrocarbons
OU = Operable Unit
PAH = polycyclic aromatic hydrocarbons
PCBs = polychlorinated biphenyls
SQS = Sediment Quality Standard
SVOCs = semi volatile organic compounds

0 125 250 500 Feet

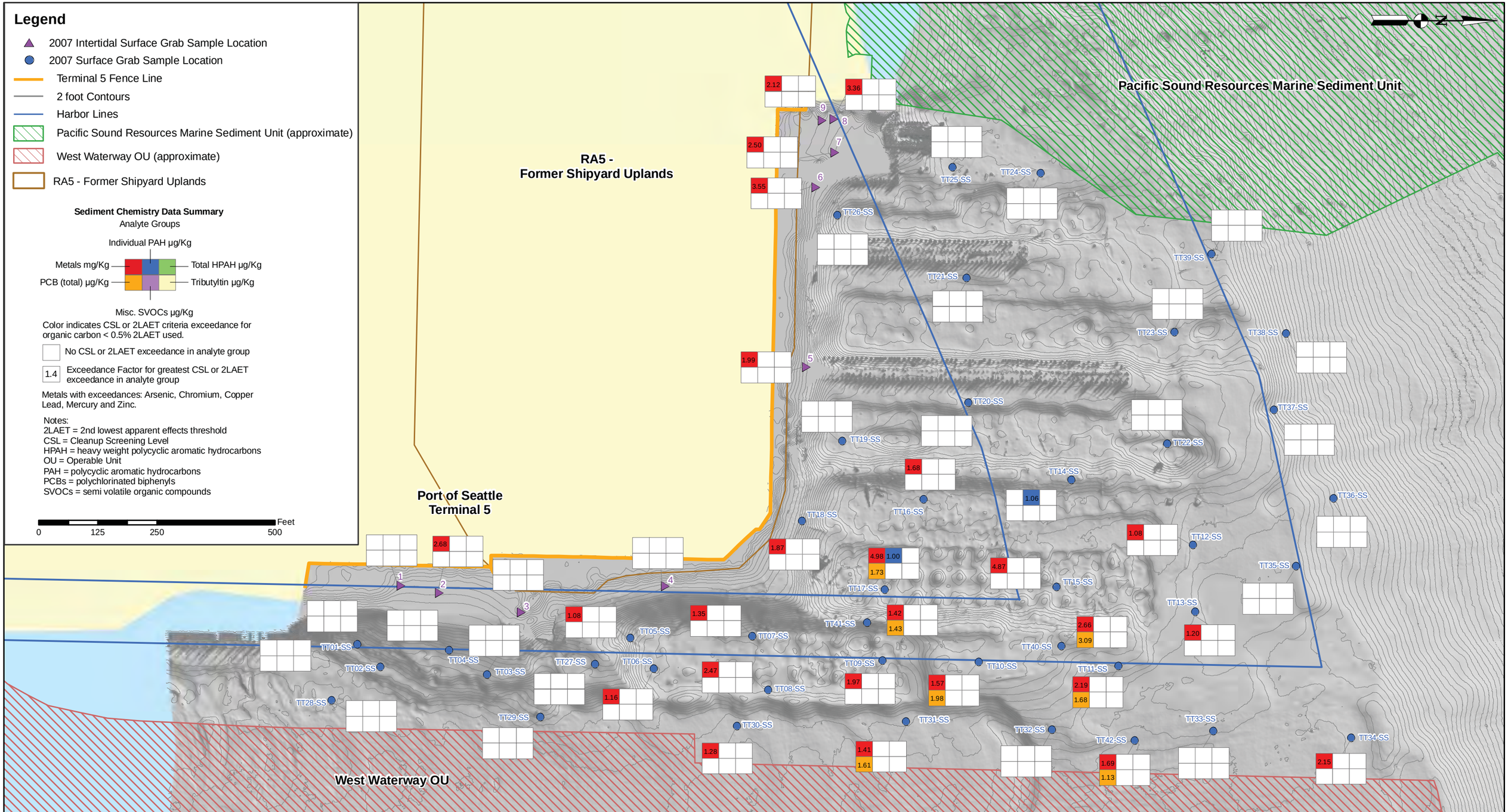


TETRA TECH

Lockheed West Seattle Superfund Site Seattle, WA

Figure 7
Exceedances of Sediment Quality Standards in Surface Sediment Samples from 2007 (Remedial Investigation Data)

Z:\Pdrive\Projects_2006\Lockheed\maps\RI_Exceedances\SQS_Surface_2007.mxd



TETRA TECH

Lockheed West Seattle Superfund Site Seattle, WA

Figure 8
Exceedances of Cleanup Screening Levels in Surface Sediment Samples from 2007 (Remedial Investigation Data)

Z:\Pdrive\Projects_2006\Lockheed\maps\RIFS_Report\Figure4-13_CSL_surface_2007.mxd

Legend

- Remedial Investigation Sampling Location with Exceedance
- Remedial Investigation Sampling Location with no SQS Exceedance
- Terminal 5 Fence Line
- 2 foot Contours
- Harbor Lines
- Pacific Sound Resources Marine Sediment Unit (approximate)
- West Waterway OU (approximate)
- RA5 - Former Shipyard Uplands

Sediment Chemistry Data Summary

Analyte Groups

Depth Interval	Metals	LPAH	HPAH	PCBs	Misc. SVOCs	Tributyltin
0 - 2 ft						

Color indicates SQS or LAET criteria exceedance for organic carbon <0.5% LAET used.

- No SQS or LAET exceedance in analyte group
- 1.4 — Exceedance Factor for greatest SQS or LAET exceedance in analyte group
- 1.1^{U} — Analytes undetected at the method detection limit. Sample dilution resulted in raised detection limits above criteria

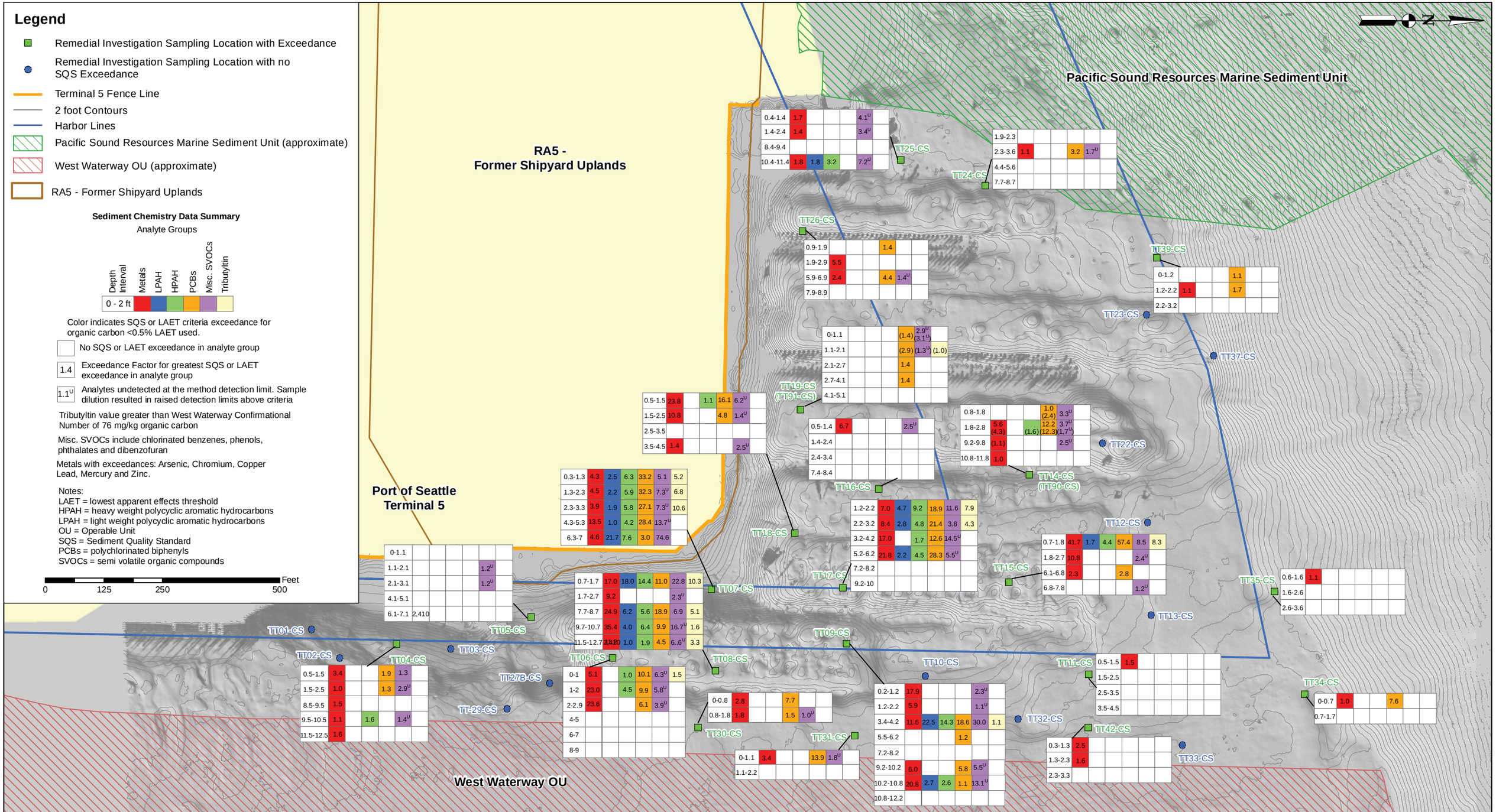
Tributyltin value greater than West Waterway Confirmational Number of 76 mg/kg organic carbon

Misc. SVOCs include chlorinated benzenes, phenols, phthalates and dibenzofuran

Metals with exceedances: Arsenic, Chromium, Copper Lead, Mercury and Zinc.

Notes:
LAET = lowest apparent effects threshold
HPAH = heavy weight polycyclic aromatic hydrocarbons
LPAH = light weight polycyclic aromatic hydrocarbons
OU = Operable Unit
SQS = Sediment Quality Standard
PCBs = polychlorinated biphenyls
SVOCs = semi volatile organic compounds

0 125 250 500 Feet



TETRA TECH

Lockheed West Seattle Superfund Site Seattle, WA

Figure 9
Exceedances of Sediment Quality Standards in Subsurface Sediment Samples from 2007 (Remedial Investigation Data)

Z:\Pdrive\Projects_2006\Lockheed\maps\RIFS_Report\Figure4-16_SQS_subsurface_2007.mxd

Legend

- Remedial Investigation Sampling Location with Exceedance
- Remedial Investigation Sampling Location with no CSL Exceedance
- Terminal 5 Fence Line
- 2 foot Contours
- Harbor Lines
- Pacific Sound Resources Marine Sediment Unit (approximate)
- West Waterway OU (approximate)
- RA5 - Former Shipyard Uplands

Sediment Chemistry Data Summary

Analyte Groups

Depth Interval	Metals	LPAH	HPAH	PCBs	Misc. SVOCs	Tributyltin
0 - 2 ft						

Color indicates CSL or 2LAET criteria exceedance for organic carbon <0.5% 2LAET used.

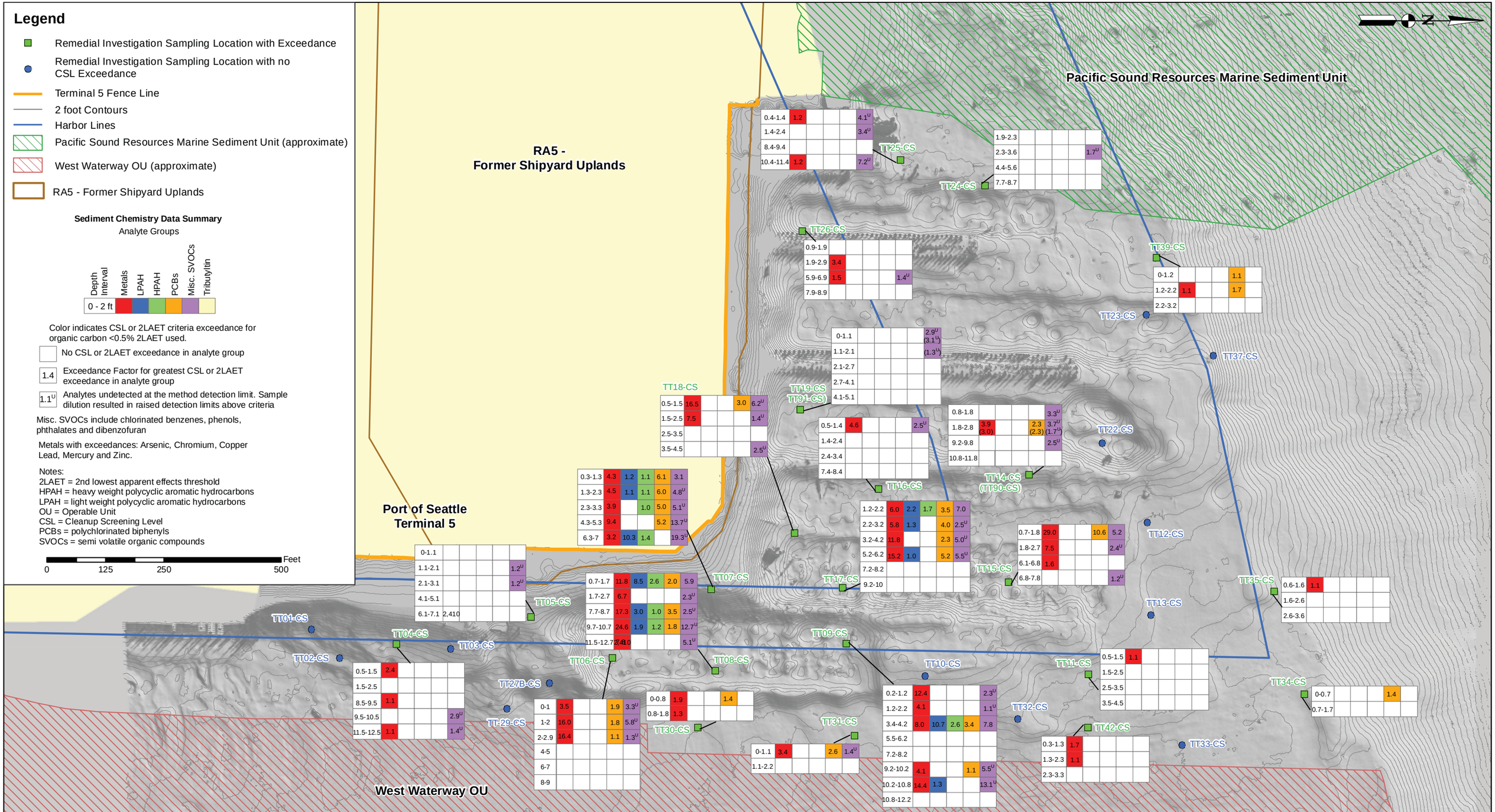
- No CSL or 2LAET exceedance in analyte group
- 1.4 — Exceedance Factor for greatest CSL or 2LAET exceedance in analyte group
- 1.1^{U} — Analytes undetected at the method detection limit. Sample dilution resulted in raised detection limits above criteria

Misc. SVOCs include chlorinated benzenes, phenols, phthalates and dibenzofuran

Metals with exceedances: Arsenic, Chromium, Copper Lead, Mercury and Zinc.

Notes:
2LAET = 2nd lowest apparent effects threshold
HPAH = heavy weight polycyclic aromatic hydrocarbons
LPAH = light weight polycyclic aromatic hydrocarbons
OU = Operable Unit
CSL = Cleanup Screening Level
PCBs = polychlorinated biphenyls
SVOCs = semi volatile organic compounds

0 125 250 500 Feet



TETRA TECH

Lockheed West Seattle Superfund Site Seattle, WA

Figure 10
Exceedances of Cleanup Screening Levels in Subsurface Sediment Samples from 2007 (Remedial Investigation Data)

Z:\Pdrive\Projects_2006\Lockheed\maps\RIFS_Report\Figure4-17_CSL_subsurface_2007.mxd

2.7 Current and Potential Future Land and Resource Uses

2.7.1 Current Land Use

The Site is not currently used for Port-related or other commercial activities. Container ships use the navigational channel and offload in the West Waterway at Terminal 5. The Site and adjacent in waterway areas are designated as Tribal U&A Fishing Areas. The current fish advisory for Puget Sound Marine Recreational Area 10 (Elliott Bay) includes no rock fish consumption and no more than two meals per month of flatfish (Washington Department of Health [DOH], 2006). The Site is not a major recreational resource compared with other water bodies in the area.

2.7.2 Anticipated Future Land Use and Water Body Use

The Tribes have treaty rights for unimpeded/unrestricted fishing, clamming, and access to the Site. The Port envisions expanding the Terminal 5 facility to include pier structures to create a multi-modal container terminal along the West Waterway. In 2010 and 2011, the Port requested WRDA authorization to dredge the navigation channel to -50 feet MLLW. The Port described potential future development in letters to the EPA in November 2010, May 2011, and September 2011. As the aquatic land manager, DNR is also responsible for permitting water-dependent uses at the Site.

2.7.3 Current and Potential Groundwater and Surface Water Uses

The Site consists of partially and fully submerged land in a marine environment. There are no current groundwater uses at the Site, and groundwater is not used as a drinking water source. The groundwater beneath the former Lockheed Martin uplands area, known as RA-5 by Ecology, is not potable due to marine tidal intrusion per salinity criteria in WAC 173-340-720(2).

Surface water uses are as described in Section 2.7.1. There are no other surface water uses at the Site. Surface water is not used as a drinking water source in the area because of the saline and brackish water quality.

2.8 Summary of Site Risks

The HHRA and ERA for the Site use a combination of site-specific exposure parameters (such as surface sediment data collected from the Site and identification of intertidal habitat at the Site), parameters from nearby sites, and EPA guidance on literature values. In particular, technical information from the HHRA and ERA performed at the LDW Superfund site (Windward, 2007a and 2007b), which is upstream on the West Waterway portion of the Site, was used in the evaluation. Using the technical approach and specific exposure and toxicity parameters used at the LDW site is appropriate because of similarities between the habitats, resources, and anticipated future uses at both sites.

2.8.1 Summary of Human Health Risk Assessment

The objective of the HHRA is to evaluate risks under current land use conditions, assuming no remedial action was taken, and under unrestricted land use conditions. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. The CSM for human health risk is presented in Figure 11 and discussed in Section 2.6.5.

2.8.1.1 Identification of Contaminants of Concern

To focus the risk assessment on those contaminants significant to human health, the chemical results were initially screened to identify contaminants of potential concern (COPCs). For the HHRA, COCs are identified as those COPCs with risk estimates exceeding the risk threshold levels identified by the EPA

and NCP: for carcinogenic chemicals, the risk threshold is an excess cancer risk estimate of 1 in 10,000 (1×10^{-4}); for noncarcinogenic chemicals, the threshold is an HQ of 1. Table 5 provides a summary of the calculated carcinogenic and noncarcinogenic risk levels for each COPC by human health exposure scenario. This document summarizes risk levels. Complete information on risk levels is presented in Appendix C of the RI/FS Report (Tetra Tech, 2012).

Human health COCs identified at the Site include the following:

- Arsenic
- Cadmium
- Chromium
- Copper
- Lead
- Mercury
- Zinc
- TBT
- cPAHs
- Total PCBs
- Pentachlorophenol
- Dioxins/furans

In addition, total chlordane and total dichlorodiphenyltrichloroethane (DDT) were tentatively identified contaminants retained as COCs.

2.8.1.2 Exposure Point Concentrations

Exposure point concentration (EPC) is either the maximum concentration or the 95 UCL on the mean concentration of a COPC in sediment or tissue, and is intended to represent a long-term exposure concentration. For beach play and clamming exposures, sediment EPCs were derived for intertidal sediment; for netfishing exposures, EPCs were derived for subtidal plus intertidal sediment.

Seafood tissue concentrations of COPCs were estimated from the sediment concentrations; tissue data were not collected from the Site for use in estimating tissue EPCs. Modeling was performed using BSAFs and regression equations that relate tissue concentrations of contaminants to the concentrations in sediment.

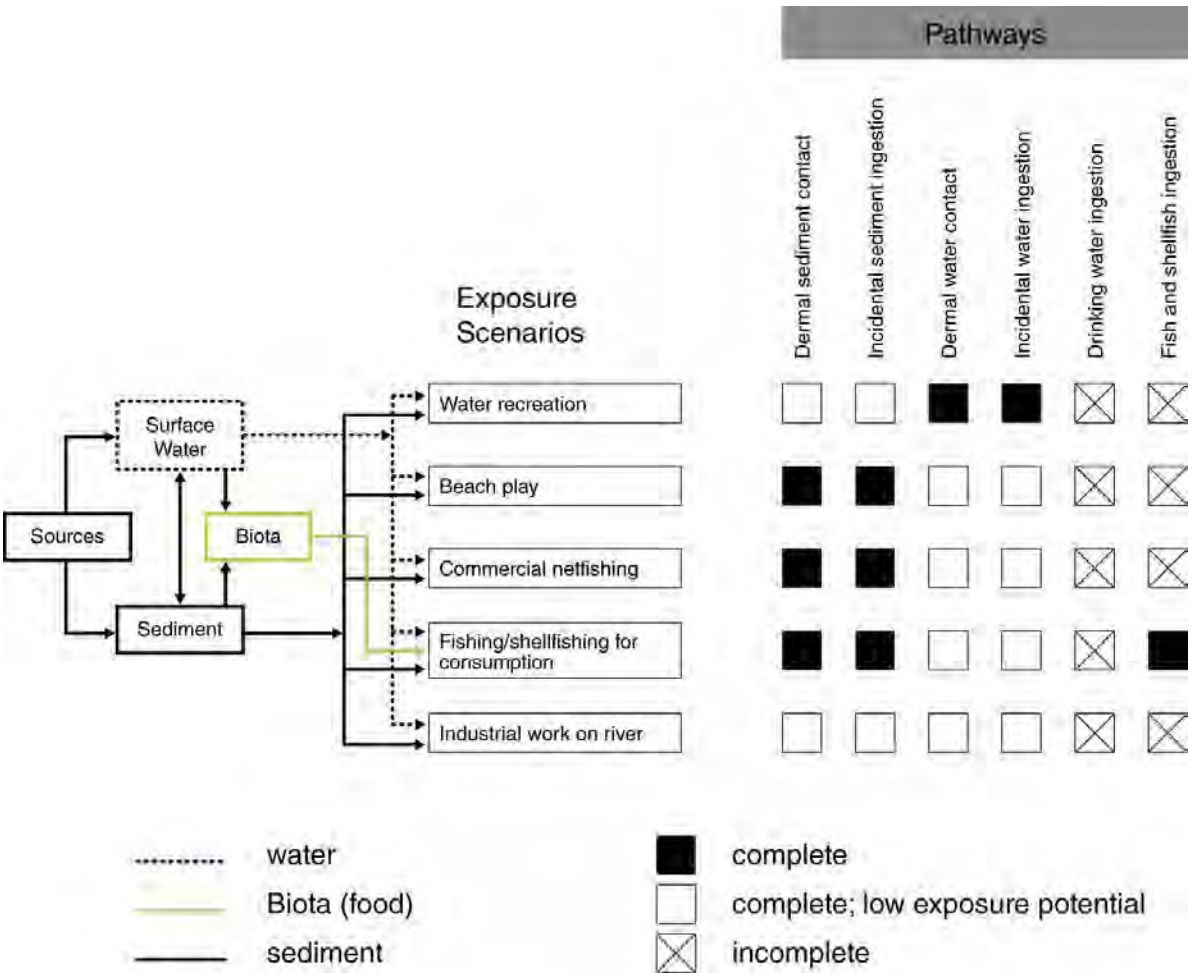


Figure 11 Conceptual Site Model for Human Health Risk Assessment at the Lockheed West Site

TABLE 5
Cancer Risks and Noncancer Hazard Estimates for Human Health Risk Assessment Scenarios (Page 1 of 2)
Lockheed West Seattle Record of Decision

RME Scenario	Medium	COPC	Cancer Risk	Hazard Quotient	COC?
Adult Tribal Seafood Consumption – Tulalip Survey	Subtidal and Intertidal Sediment	**Arsenic[a]**	**3×10^{-3}**	**5.8**	**YES**
		Cadmium	Not COPC	0.89	No
		Chromium	**Not COPC**	**1.1**	**YES**
		Copper	**Not COPC**	**1.2**	**YES**
		Mercury	Not COPC	0.40	No
		Zinc	**Not COPC**	**1.2**	**YES**
		Fluoranthene	Not COPC	0.06	No
		Pyrene	Not COPC	0.05	No
		TBT (as ion)	**Not COPC**	**89**	**YES**
		Pentachlorophenol	**3×10^{-6}**	**0.001**	**YES**
		cPAHs[b]	**3×10^{-3}**	**Not COPC**	**YES**
		Total PCBs	**3×10^{-3}**	**72**	**YES**
		Total chlordane[c]	**2×10^{-5}**	**0.1**	**YES**
		Total DDTs[c]	**3×10^{-4}**	**1.5**	**YES**
		Dioxins/Furans	**Not quantified[f]**		**YES**
		Total Excess Cancer Risk and Noncancer Hazard Index[d]	9×10^{-3}	173	
Child Tribal Seafood Consumption – Tulalip Survey	Subtidal and Intertidal Sediment	**Arsenic[a]**	**5×10^{-4}**	**12**	**YES**
		Cadmium	**Not COPC**	**1.9**	**YES**
		Chromium	**Not COPC**	**2.4**	**YES**
		Copper	**Not COPC**	**2.6**	**YES**
		Lead[e]	**NA**	**NA**	**YES**
		Mercury	**Not COPC**	**2.2**	**YES**
		Zinc	**Not COPC**	**2.6**	**YES**
		Fluoranthene	Not COPC	0.12	No
		Pyrene	Not COPC	0.11	No
		TBT (as ion)	**Not COPC**	**193**	**YES**
		Pentachlorophenol	6×10^{-7}	0.002	No
		cPAHs[b]	**3×10^{-3}**	**Not COPC**	**YES**
		Total PCBs	**5×10^{-4}**	**154**	**YES**
		Total chlordane[c]	**3×10^{-6}**	**0.22**	**YES**
		Total DDTs[c]	**5×10^{-5}**	**3.2**	**YES**
		Dioxins/furans	**Not quantified[f]**		**YES**
		Total Excess Cancer Risk and Noncancer Hazard Index[d]	4×10^{-3}	372	

TABLE 5
Cancer Risks and Noncancer Hazard Estimates for Human Health Risk Assessment Scenarios (Page 2 of 2)
Lockheed West Seattle Record of Decision

RME Scenario	Medium	COPC	Cancer Risk	Hazard Quotient	COC?
Netfishing	Subtidal and Intertidal Sediment	Antimony	Not COPC	0.02	No
		Arsenic[a]	**3×10^{-5}**	**0.1**	**YES**
		Chromium	Not COPC	0.006	No
		cPAHs[b]	**3×10^{-6}**	**Not COPC**	**YES**
		Total PCBs	4×10^{-7}	0.02	No
		Dioxins/Furans	**Not quantified[f]**		**YES**
		Total Excess Cancer Risk and Noncancer Hazard Index[d]	3×10^{-5}	0.1	
Beach Play	Intertidal Sediment	Antimony	Not COPC	0.5	No
		Arsenic[a]	**7×10^{-5}**	**1.8**	**YES**
		Chromium	Not COPC	0.2	No
		Copper	Not COPC	0.1	No
		Vanadium	Not COPC	0.03	No
		cPAHs[b]	**2×10^{-6}**	**Not COPC**	**YES**
		Dioxins/Furans	**Not quantified[f]**		**YES**
		Total Excess Cancer Risk and Noncancer Hazard Index[d]	7×10^{-5}	2.6	
Clamming – 120 day/year	Intertidal Sediment	Antimony	Not COPC	0.08	No
		Arsenic[a]	**1×10^{-4}**	**0.35**	**YES**
		Chromium	Not COPC	0.03	No
		Copper	Not COPC	0.01	No
		Vanadium	Not COPC	0.004	No
		cPAHs[b]	1×10^{-6}	Not COPC	No
		Dioxins/Furans	**Not quantified[f]**		**YES**
		Total Excess Cancer Risk and Noncancer Hazard Index[d]	1×10^{-4}	0.5	

[a] Arsenic exposure point concentrations and risk estimates are based on inorganic arsenic.
[b] cPAHs are presented as benzo(a)pyrene equivalents.
[c] Tentatively identified chemical (JN-qualified).
[d] Total across all chemicals. This total is not directly interpretable for risk assessment, but a value greater than 1 suggests that an HQ may exceed 1 for individual endpoints.
[e] Health risks from exposure to lead at the Site are estimated using the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) (EPA, 1994) and the Adult Lead Model (ALM) (EPA, 2003).
[f] Dioxin and furan data were not available at the time the risk assessment was conducted. Data obtained later confirmed the presence of dioxins and furans in clam tissue.

Notes:
Yellow highlighting indicates risk level in excess of acceptable CERCLA excess cancer risk level of 1×10^{-4} or HQ of 1.

COC = contaminant of concern, based on excess cancer risks > 1×10^{-6} or HQ > 1.
cPAH = carcinogenic polycyclic aromatic hydrocarbon
DDT = dichlorodiphenyltrichloroethane
EPC = exposure point concentration
HQ = hazard quotient
NA = analyte not analyzed
Not COPC = not a contaminant of potential concern for that scenario, or the toxicity endpoint is not relevant, and hence cancer risk or hazard quotient not calculated.
RME = reasonable maximum exposure
PCB = polychlorinated biphenyl
TBT = tributyltin

Adapted from RI/FS Report Table ES-3 (Tetra Tech, 2012)

2.8.1.3 Exposure Assessment

Exposure to COPCs at the Site were calculated using concentrations in sediment and seafood, risk equations, and exposure parameters from the LDW HHRA (Windward, 2007a) such as time spent at the intertidal sediment area during beach play, time spent in netfishing, and the amount of seafood ingested, including clams, crabs, and fish.

The Tulalip seafood consumption survey data were used to characterize the adult Tribal reasonable maximum exposure (RME) and child Tribal seafood consumption scenarios. In addition to the RME scenario, the Suquamish Tribe specifically requested inclusion of a Tribal scenario specifically tailored to Suquamish Tribal members. The analysis of adult Suquamish seafood consumption was included as a high-end exposure scenario that depicts upper-bound risks for Tribal seafood consumers.

The total consumption rate of non-anadromous seafood (that is, seafood exclusive of fish such as salmon that live in salt water and migrate upstream into freshwater to spawn) for the adult Tribal RME scenario was 97.5 grams of seafood per day (three meals per week, assuming a meal weighs 227 grams, which is about 8 ounces. The total consumption rate of non-anadromous seafood for the Suquamish scenario was 583.5 grams of seafood per day (2.6 meals per day, assuming a meal weighs 227 grams). Contaminant exposures associated with consumption of anadromous species (such as salmon) were not included in the HHRA, because it was assumed that the body burden of chemicals associated with the Site is not significant compared with the body burden acquired during open ocean migration.

2.8.1.4 Toxicity Assessment

The Toxicity Assessment identified appropriate toxicity values for all COPCs, which consisted of the cancer slope factor (CSFs) for evaluating carcinogenic risks and reference doses (RfDs) for evaluating effects other than cancer. Toxicity values were taken from EPA sources listed in the 2009 HHRA (Tetra Tech and Pascoe, 2009b). The CSFs provide a health-protective means to evaluate risks because they represent upper bound estimates of carcinogenic potency. Non-carcinogenic RfDs are typically based on the most sensitive endpoint and population for which adequate data are available, and include uncertainty and modifying factors to account for sensitive subpopulations or other limitations of the toxicity data. The toxicity values are used with the EPCs identified in the Exposure Assessment to quantify the risk estimates.

2.8.1.5 Risk Characterization

For the Risk Characterization, carcinogenic risks and noncarcinogenic hazards were evaluated separately. Carcinogenic risk estimates were calculated by multiplying the estimated chemical intake into the body by the CSF. Cancer risk estimates were compared with the CERCLA-acceptable risk range of 10^{-6} to 10^{-4} established in the NCP for Superfund sites (40 *Code of Federal Regulations* [CFR] 300). Contaminants with noncarcinogenic health effects are generally not toxic below a certain threshold, which is represented by the RfD. The potential for noncarcinogenic health effects is quantified as the ratio of the estimated contaminant intake to the RfD, expressed as an HQ. Exposures resulting in an HQ less than or equal to 1 are unlikely to result in adverse health effects. Note: For CERCLA, unacceptable excess cancer risks are those greater than 1 in 10,000 (10^{-4}) for individual or multiple contaminants. MTCA risk levels are more stringent than CERCLA. Under MTCA, unacceptable excess cancer risks are those greater than 1 in 1,000,000 (10^{-6}) for individual contaminants and greater than 1 in 100,000 (10^{-5}) for multiple contaminants, and the limit for noncancer HQ is greater than 1.

Estimated excess cancer risks were higher for the seafood consumption scenarios than the direct sediment exposure scenarios. Estimated cancer and noncancer risks for each COPC are presented in Table 5 and summarized as follows:

- **Tribal adult seafood consumption** – Arsenic, cPAHs, total PCBs, dioxins/furans, and TBT (total cancer risk = 9×10^{-3} and total noncancer hazard index [HI] = 173)
- **Tribal child seafood consumption** – Arsenic, lead, cPAHs, total PCBs, dioxins/furans, and TBT (total cancer risk = 4×10^{-3} and total noncancer HI = 372)
- **Clamming** – Arsenic, dioxins/furans (total cancer risk = 1×10^{-4} and total noncancer HI = 0.5)
- **Beach play** – Arsenic, cPAHs, dioxins/furans (total cancer risk= 7×10^{-5} and total noncancer HI = 2.6)
- **Netfishing** – Arsenic, cPAHs, dioxins/furans (total cancer risk = 3×10^{-5} and total noncancer HI = 0.1)

2.8.1.6 Human Health Risk Assessment Uncertainties

Two of the major sources of uncertainty in the risk assessment are (1) the use of exposure assumptions from the upstream LDW site without modification to conditions specific to the Lockheed West Site, and (2) the use of modeling to determine tissue concentrations of COPCs for evaluating exposures via seafood consumption. Table 6 provides a summary of the HHRA uncertainties.

2.8.1.7 Surface Water

The 2009 HHRA for the Site (Tetra Tech and Pascoe, 2009b) summarized direct contact exposure risks to surface water based on a previous quantitative evaluation by King County for Elliott Bay and the LDW.

The *King County Water Quality Assessment* (King County, 1999) evaluated direct contact risks to aquatic users using contaminant exposure point concentrations estimated from a water and sediment quality model. The King County model was further modified and calibrated as part of the HHRA completed for the LDW site (Windward, 2007a). Modeling results were applied to the Site to support the RI/FS. For noncarcinogenic risks, no risk HQs exceeding 1 were predicted by the King County model for direct-contact exposure scenarios for adults or children at any exposure levels at locations in the Duwamish River (Duwamish Park) and Elliott Bay (Duwamish Head). Negligible noncarcinogenic health effects to swimmers, scuba divers, or windsurfers were indicated from direct exposure. Estimated cancer risks were less than 1×10^{-6} for individual COPCs and for total incremental carcinogenic risks across all COPCs. Excess cancer risks for swimmers exceeding 1×10^{-6} were estimated by the King County model only at relatively high exposure levels (that is, 24 days per year at 2.6 hours per day). The latter estimate also accounted for exposure to sediments while swimming.

TABLE 6
Summary of Human Health Risk Assessment Uncertainties (Page 1 of 2)
Lockheed West Seattle Record of Decision

Exposure Scenario	Uncertainty	Under-estimates Risk	Over-estimates Risk	Unknown
Seafood Consumption	Because of the proximity of the LDW site, it was anticipated that potentially exposed human populations may be similar and that the use of exposure scenarios and parameters from the LDW site would support the development of risk management decisions for the Lockheed West Site. However, the difference in size of the two sites was not taken into account. The LDW at 5 river miles in length is much larger than the 40-acre Site. The related uncertainties are listed below:			
	English sole and crabs are food sources with larger foraging areas.	X		
	The fractional intake was set to 1.0 and assumes that 100 percent of the contaminated seafood consumed in the seafood ingestion scenarios over the duration of exposure comes from the Site.			
	Uncertainty about whether the 97.5 g/day for 70 years of seafood (Tribal adult RME) could be sustained by fishing/crabbing at this Site alone.			
	Sediment COPCs for seafood consumption were identified through a screening process using RBACGs that were based on LDW conditions using the Tribal RME scenario. Since the Suquamish consumption survey seafood ingestion rates are higher than the Tulalip survey rates that determined the Tribal RME, additional chemicals might have been identified as possibly contributing to risk estimates under a Suquamish seafood consumption scenario.			
	Additional uncertainties related to sources of the BSAFs, assumptions about modeling inorganic arsenic in clam tissue, use of regression equations from the LDW site and use of metals data from the LDW site to develop BSAFs for metals, as listed below:			
	Where BSAFs were unavailable for a given organism, the use of 90th and 75th percentile was used as a health protective approach to BSAF modeling and likely biases the tissue concentrations high.	X		
	A BSAF to model TBT concentrations in fish was not available, so an apparent BSAF was developed from field data collected for the LDW ERA.			X
	The use of BSAFs to model nonpolar organic chemicals in tissue rather than collecting tissue data from the Site.		X	
	The HHRA compared the modeled clam tissue concentrations with the Site clam data to verify that the literature BSAFs were suitable for use at the Site. Chromium was 10-fold higher in the measured concentrations, PCBs was 76 percent higher, and TBT was 60 higher. Therefore, it appears that modeling may underestimate actual metals bioaccumulation.	X		
	The assumption of proportional inorganic arsenic concentrations based on *M. arenaria* may overestimate inorganic arsenic in tissues of clams that have been found or would likely be found at the Site.			
	The assumption of proportional inorganic arsenic concentrations based on *M. arenaria* may overestimate inorganic arsenic in tissues of clams that have been found or likely would be found on the Site.			
	There may be more unknowns regarding the data used to derive the literature BSAFs than there are with the LDW food web model, which was calibrated using the LDW site data. The actual lead concentrations in all seafood tissues that are related to the Site sediment concentrations of lead in the full intertidal or subtidal data sets are not known.	X X		X
	The risk estimates for organchlorine pesticides for the Site are likely to be biased high.		X	

TABLE 6
Summary of Human Health Risk Assessment Uncertainties (Page 2 of 2)
Lockheed West Seattle Record of Decision

Exposure Scenario	Uncertainty	Under-estimates Risk	Over-estimates Risk	Unknown
Seafood Consumption (continued)	It is unknown whether PCB congener enrichment in biota at the Site may differ from the enrichment found with biota at the LDW site. Although the aquatic organisms may be present at both sites, the sources of PCBs may differ and the weathering and enrichment of dioxin-like PCB congeners may differ between sites.			X
Direct Contact	The uncertainty associated with metals that lack absorption factors is low for the child beach play direct sediment contact scenario.			X
General	Chemicals detected in sediment at a frequency less than 5 percent were screened out from further evaluation in the risk assessment. The detection limits for N-nitrosodimethylamine and gamma-BHC exceed the lowest RBCs for both chemicals, which are for the consumption of seafood. The potential risks associated with these chemicals are uncertain. Undetected chemicals with detection limits that exceed RBCs could occur at concentrations below the detection limit yet greater than a concentration that might present a risk to humans who are exposed to site sediment. The exceedance factors for five of eight contaminants are below 10, whereas the exceedance factors for two organochlorine pesticides are between 10-30, and dieldrin has an exceedance factor of 847.	X		

Notes:

BSAF = biota-sediment accumulation factor
COPC = contaminant of potential concern
ERA = ecological risk assessment
g/day = grams per day
HHRA = human health risk assessment
LDW = Lower Duwamish Waterway Superfund site
PCB = polychlorinated biphenyl
RBACG = risk-based analytical concentration goals
RBC = risk-based concentrations
RME = reasonable maximum exposure
TBT = tributyltin

2.8.2 Summary of Ecological Risk Assessment

The objective of the Site ERA was to identify contaminants, receptors, and exposure pathways that may result in unacceptable risks to the environment in the absence of remediation. The CSM for ecological risk is presented in Figure 12.

2.8.2.1 Receptors of Concern

ROCs for the baseline ERA included:

- Benthic invertebrates (including clams)
- Crabs – Selected to represent higher-trophic-level, as well as more mobile, benthic invertebrate species present at the Site.
- Benthivorous fish – Represented by English sole *(Parophrys vetulus)*, and including rock sole (*Lepidopsetta bilineata*) and starry flounder (*Platichthys stellatus*). This category is also considered to be protective of fish that prey on pelagic and encrusting organisms, such as Pacific herring and pile perch.
- Upper-trophic-level fish – Represented by Pacific staghorn sculpin *(Leptocottus armatus)*, and including bull trout and sand sole. Pacific staghorn sculpin is used to represent piscivorous and omnivorous species that prey on other fish.
- Avian receptors – Represented by the spotted sandpiper (*Actitis macularia)* that had associated COPCs exceeding risk-based contaminant concentrations in sediment.

Threatened or endangered species potentially occurring withing the local area include Chinook salmon (*Onchorhynchus tshawytscha*), Puget Sound steelhead (*Onchorhynchus mykiss*), Bull trout (*Salvelinus confluentus*), Yelloweye rockfish (*Sebastes ruberrimus*), canary rockfish (*S. pinniger*), Southern resident killer whale (*Orcinus orca*) and the marbeled murrelet (*Brachyramphus marmoratus*). Elliott Bay is designated critical habitat for Chinook salmon and Bull trout. Designated habitat for steelhead, yelloweye, and canary rockfish and for orca is currently under development.

Other potential receptors—such as mammals like river otters and harbor seals, or piscivorous birds like bald eagles, ospreys, or great blue herons—were not selected as ROCs. This was because of their limited exposure to contaminants at the Site, as well as the relatively low risks calculated for these receptors at the LDW site when compared with shorebirds.

2.8.2.2 Identification of Contaminants of Potential Concern

Ecological COPCs were identified based on the potential exposure of ROCs to contaminants present at the Site. For the benthic community, COPCs were identified by comparing sediment contaminant concentrations with sediment quality criteria listed in the Washington SMS. COPCs for fish and crab receptors were identified as contaminants exceeding risk-based bioaccumulation criteria. COPCs for avian receptors were identifed as contaminants exceeding risk-based contaminant concentrations in sediment.

2.8.2.3 Exposure Assessment

The Lockheed West ERA used the same exposure parameter values to quantify exposure as those used in the LDW ERA (Windward, 2007b), regardless of any differences in size of the exposure area at the Lockheed West Site or availability of ecological habitat under present conditions. Use of the LDW exposure scenarios and all inherent assumptions and exposure parameters is conservative because the Lockheed West Site is much smaller than the LDW site.

2.8.2.4 Effects Assessment

The Effects Assessment identified the potential adverse effects to ecological receptors from exposures to the COPCs in Site sediment. For the benthic invertebrate community, potential adverse effects for most COPCs were quantified using contaminant criteria in the SMS: the SQS, which corresponds to a sediment quality that will result in no adverse effects to biological resources, and the CSL, which corresponds to a sediment quality that will result in minor adverse effects (WAC 173-204). Toxicity information from the literature was used for COPCs without Washington State SMS. The evaluation of TBT risks to benthic invertebrates used effects data related to tissue concentrations.

For crabs and fish, effects data were identified as COPC concentrations in their tissue or tissue of prey items; for sandpiper, effects data were identified as doses. All effects data were selected for the most sensitive endpoint of survival, growth, or reproduction (EPA, 1997). Both no observed adverse effect level (NOAEL) and lowest observed adverse effect level (LOAEL) values were identified as toxicity reference values (TRVs), which were used with exposure data to characterize risks to crabs, fish, and sandpipers.

2.8.2.5 Ecological Risk Characterization

To characterize risk, exposure and effects analyses were integrated to evaluate whether sediment-associated COPCs at the Site had the potential to produce adverse ecological effects. Resulting estimates showed that selected COPCs pose ecological risks above regulatory thresholds for the benthic invertebrate community, as well as crabs, fish, and sandpipers, as shown in Tables 7 through 10 and described in the text that follows the tables.

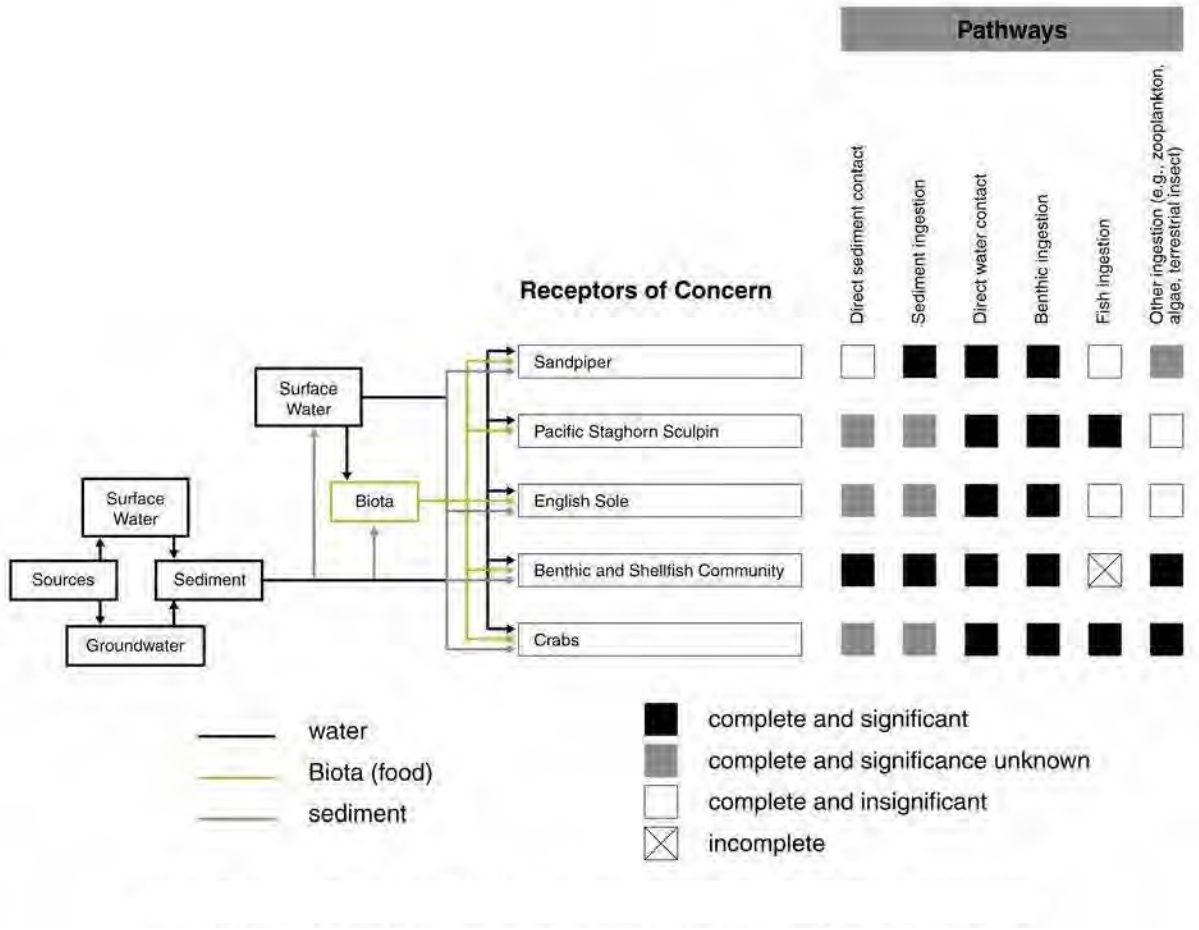


Figure 12 Conceptual Site Model for Benthic Invertebrates, Fish, and Wildlife at the Lockheed West Site

TABLE 7
Intertidal Sediments Benthic Invertebrate Community Risk Potential (Page 1 of 2)
Lockheed West Seattle Record of Decision

COPC	Detection Frequency (Percent) (n=9)	Percent of Stations > Low Criteria[a]		Percent of Stations > High Criteria[b]		COC?
		No. of Stations	Percent	No. of Stations	Percent	
Metals						
Antimony	100	0	0	0	0	No
Arsenic	**100**	**5**	**56**	**5**	**56**	**YES**
Chromium	100	1	11	1	11	No
Cobalt	100	5	56	0	0	No
Copper	**100**	**4**	**44**	**4**	**44**	**YES**
Lead	100	1	11	1	11	No
Mercury	100	1	11	0	0	No
Nickel	100	2	22	0	0	No
Selenium	100	0	0	0	0	No
Vanadium	100	2	22	0	0	No
Zinc	100	7	78	2	22	No
PAHs						
Acenaphthene	67	1	11	0	0	No
Benzo(a)anthracene	100	0	0	0	0	No
Benzo(a)pyrene	100	0	0	0	0	No
Benzo(b)fluoranthene	100	0	0	0	0	No
Benzo(g,h,i)perylene	100	0	0	0	0	No
Chrysene	100	0	0	0	0	No
Dibenzo(a,h)anthracene	78	0	0	0	0	No
Fluoranthene	100	0	0	0	0	No
Indeno(1,2,3-cd)pyrene	100	0	0	0	0	No
Phenanthrene	89	0	0	0	0	No
Total HPAH	100	0	0	0	0	No
PCBs						
PCBs (total)	100	0	0	0	0	No

TABLE 7

Intertidal Sediments Benthic Invertebrate Community Risk Potential (Page 2 of 2)

Lockheed West Seattle Record of Decision

COPC	Detection Frequency (Percent) (n=9)	Percent of Stations > Low Criteria[a]		Percent of Stations > High Criteria [b]		COC?
		No. of Stations	Percent	No. of Stations	Percent	
Other SVOCs						
bis(2-ethylhexyl)phthalate	33	0	0	0	0	No
Pentachlorophenol	0	0	0	0	0	No

[a]Low criteria = SQS, SL, NOAEL, or LAET – See Table 2.

[b]High criteria = CSL, ML, LOAEL, or 2LAET – See Table 2.

Notes:

> = greater than

COC = contaminant of concern (multiple stations exceed both criteria)

COPC = contaminant of potential concern

CSL = cleanup screening level (SMS)

DMMP = dredged material management program

HPAH = high-molecular-weight polycyclic aromatic hydrocarbon

LAET = lowest apparent effects threshold

2LAET = second lowest apparent effects threshold

LOAEL = lowest observed adverse effect level

ML = maximum level (DMMP)

NOAEL = no observed apparent effects level

PAH = polycyclic aromatic hydrocarbon

PCB = polychlorinated biphenyl

SL = screening level (DMMP)

SMS = sediment management standards

SQS = sediment quality standards

SVOC = semivolatile organic compound

Adapted from RI/FS Report Table 7-2 (Tetra Tech, 2012)

TABLE 8
Subtidal Sediment Benthic Invertebrate Community Risk Potential (Page 1 of 2)
Lockheed West Seattle Record of Decision

COPC	Detection Frequency (Percent) (n=42)	Percent of Stations > Low Criteria[a]		Percent of Stations > High Criteria[b]		COC?
		No. of Stations	Percent	No. of Stations	Percent	
Metals						
Antimony	100	1	2.4	0	0	No
Arsenic	100	6	14	4	9.5	No
Chromium	100	1	2.4	1	2.4	No
Cobalt	100	6	14	0	0	No
Copper	**100**	**8**	**19**	**8**	**19**	**YES**
Lead	100	1	2.4	0	0	No
Mercury	**100**	**21**	**50**	**17**	**41**	**YES**
Nickel	100	0	0	0	0	No
Selenium	38	8	19	0	0	No
Vanadium	100	10	24	0	0	No
Zinc	100	6	14	1	2.4	No
PAHs						
Acenaphthene	100	2	4.8	0	0	No
Benzo(a)anthracene	100	3	7.1	0	0	No
Benzo(a)pyrene	100	4	9.5	0	0	No
Benzo(b)fluoranthene	100	7	17	2	4.8	No
Benzo(g,h,i)perylene	100	9	21	0	0	No
Chrysene	100	8	19	0	0	No
Dibenzo(a,h)anthracene	100	6	14	0	0	No
Fluoranthene	100	10	24	0	0	No
Indeno(1,2,3-cd)pyrene	100	10	24	0	0	No
Phenanthrene	100	6	14	0	0	No
Total HPAH	100	9	21	0	0	No
PCBs						
PCBs (total)	**100**	**27**	**64**	**7**	**17**	**YES**

TABLE 8

Subtidal Sediment Benthic Invertebrate Community Risk Potential (Page 2 of 2)

Lockheed West Seattle Record of Decision

COPC	Detection Frequency (Percent) (n=42)	Percent of Stations > Low Criteria [a]		Percent of Stations > High Criteria [b]		COC?
		No. of Stations	Percent	No. of Stations	Percent	
Other SVOCs						
bis(2-ethylhexyl)phthalate	95	3	7.1	0	0	No
Pentachlorophenol	48	3	7.1	0	0	No

[a]Low criteria = SQS, SL, NOAEL, or LAET – see Table 2.
[b]High criteria = CSL, ML, LOAEL, or 2LAET – See Table 2

Notes:

> = greater than
COC = contaminant of concern (multiple stations exceed both criteria)
COPC = contaminant of potential concern
CSL = cleanup screening level (SMS)
DMMP = dredged material management program
HPAH = high-molecular-weight polycyclic aromatic hydrocarbon
LAET = lowest apparent effects threshold
2LAET = second lowest apparent effects threshold
LOAEL = lowest observed adverse effect level
ML = maximum level (DMMP)
NOAEL = no observed apparent effects level
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
SL = screening level (DMMP)
SMS = sediment management standards
SQS = sediment quality standards
SVOC = semivolatile organic compound

Adapted from RI/FS Report Table 7-3 (Tetra Tech, 2012)

TABLE 9
Summary of Risks for Crabs and Fish (Page 1 of 2)
Lockheed West Seattle Record of Decision

COPC	Crab		Fish – Tissue Residue		Fish – Dietary		COC?
	HQ NOAEL	HQ LOAEL	HQ NOAEL	HQ LOAEL	HQ NOAEL	HQ LOAEL	
Metals							
Chromium	0.1	0.02	--	--	0.1 – 0.3	--	No
Copper	0.3	--	--	--	**28 – 36**	**14 – 18**	**YES**
Lead	--	--	--	--	0.02 – 0.07	--	No
Mercury	0.01	0.01	0.3	0.2	--	--	No
Selenium	--	--	--	--	--	--	--
PAHs							
Acenaphthene	--	--	--	--	--	--	--
Acenaphthylene	--	--	--	--	--	--	--
Anthracene	--	--	--	--	--	--	--
Benzo(a)anthracene	--	--	--	--	--	--	--
Benzo(a)pyrene	--	--	--	--	0.009 – 0.01	0.007 – 0.009	No
Benzo(b)fluoranthene	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	--	--	--	--	--	--	--
Benzo(k)fluoranthene	--	--	--	--	--	--	--
Benzofluoranthenes (total)	--	--	--	--	--	--	--
Chrysene	--	--	--	--	--	--	--
Dibenzo(a,h)anthracene	--	--	--	--	--	--	--
Fluoranthene	--	--	--	--	--	--	--
Fluorene	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	--	--	--	--	--	--	--
Phenanthrene	--	--	--	--	--	--	--
Pyrene	--	--	--	--	--	--	--
Total PAHs	--	--	--	--	0.09 – 0.5	0.03 – 0.2	No
Organometals							
TBT	**202**	--	**158**	**18**	--	--	**YES**
Other SVOCs							
Pentachlorophenol	--	--	0.005	0.003	--	--	No
PCBs							
Aroclor 1254	--	--	--	--	--	--	--
Aroclor 1260	--	--	--	--	--	--	--
Aroclor 1268	--	--	--	--	--	--	--
Total PCBs	**9**	**0.9**	**6 – 31**	**1 – 6**	--	--	**YES**

TABLE 9

Summary of Risks for Crabs and Fish (Page 2 of 2)

Lockheed West Seattle Record of Decision

COPC	Crab		Fish – Tissue Residue		Fish – Dietary		COC?
	HQ NOAEL	HQ LOAEL	HQ NOAEL	HQ LOAEL	HQ NOAEL	HQ LOAEL	
Organochlorine Pesticides							
Total DDT	**10**	**7**	**1**	**1**	--	--	**YES**
Methoxychlor	3	0.33	2	0.4	--	--	No
Mirex	--	--	0.01	0.002	--	--	No
Chlordane (total, gamma)	0.05	0.02	0.2	0.11	--	--	No

Notes:

-- = Not a COPC for that receptor or pathway, or lack of toxicity data or modeling parameter for tissue concentration.

> = greater than

COC = contaminant of concern (NOAEL > 200 or LOAEL HQ > 1 for one or more receptors)

COPC = contaminant of potential concern

DDT = dichlorodiphenyltrichloroethane

HQ = hazard quotient

LOAEL = lowest observed adverse effect level

NOAEL = no observed adverse effect level

PAHs = polycyclic aromatic hydrocarbon

PCB = polychlorinated biphenyl

SVOC = semivolatile organic compound

TBT = tributyltin

Adapted from RI/FS Report Table 7-4 (Tetra Tech, 2012)

TABLE 10
Summary of Risks for Spotted Sandpiper
Lockheed West Seattle Record of Decision

COPC	NOAEL HQ	LOAEL HQ	COC?
Chromium	6	1	No
Copper	**4**	**3**	**YES**
Lead	**48**	**14**	**YES**
Vanadium	**1**	0.6	No
Total PCBs	0.1	0.05	No

Notes:

COC = contaminant of concern (LOAEL HQ > 1)
COPC = contaminant of potential concern
HQ = hazard quotient
LOAEL = lowest observed adverse effect level
NOAEL = no observed adverse effect level
PCB = polychlorinated biphenyl

Adapted from RI/FS Report Table 7-5 (Tetra Tech, 2012)

- Sediment –
  - Benthic Invertebrate Community (includes clams) – Comparison of sediment chemical concentrations to the SQS indicated that approximately 11 percent of the intertidal sediment area would show no adverse effects to benthic invertebrates. Comparison of sediment concentrations with higher sediment guidelines (CSLs) indicated the possibility of adverse effects at 67 percent of the intertidal sediment stations, primarily due to concentrations of arsenic and copper. The remaining intertidal sediment stations have less certain risks. Very low risks were predicted for exposure to PAHs, PCBs, and other organic chemicals in intertidal sediments due to low concentrations.

    About 24 percent of the subtidal sediment stations showed no adverse effects to benthic invertebrates relative to SQS. Exceedances of higher sediment guidelines (CSLs) indicated a potential for adverse effects at about 48 percent of the subtidal sediment stations, primarily due to mercury and, to a lesser extent, copper. Risks to gastropods from TBT exposure in subtidal sediment were low (less than 1.0) using NOAEL-based tissue HQs, but higher based on TBT concentrations in sediment pore water.
  - Crabs – Risk to crabs from exposure to TBT in site sediments were estimated to be high (NOAEL-based HQ greater than 200) but the reality of actual effects is uncertain because of the lack of a LOAEL. Overall, risks from exposure to TBT are highly uncertain owing to modeling with limited BSAF values and a lack of site-specificity in model parameters. Risks from total PCBs were estimated as low based on a LOAEL-based HQ.
  - Fish – Modeled concentrations in fish tissue (English sole and Pacific staghorn sculpin) were found to present high risks for TBT (LOAEL-based HQ of 18) but low risks for PCBs (LOAEL-based HQs ranging from 1 to 6). Risks of copper to fish (English sole and Pacific staghorn sculpin) were high (LOAEL-based HQs of 18 and 14, respectively) due to modeled dietary exposures.
  - Birds – Risks to spotted sandpiper due to dietary exposure were high for lead (LOAEL-based HQ of 14), but low for chromium and copper (LOAEL-based HQs of 1 and 3, respectively). Risks from dietary exposure to TBT and organic compounds were very low.

- Surface Water and Groundwater – The ERA considered surface water exposure for birds through ingestion and direct-contact with surface water. Surface water exposure for benthic invertebrates was assumed to be through direct exposure to groundwater/pore water discharging to surface water from adjacent upland areas.
  - Sandpipers – Results of the LDW ERA were applied to the Lockheed West Site to evaluate the sandpiper exposure scenarios. The LDW ERA determined that surface water ingestion posed an insignificant risk to sandpipers (Windward, 2007b). Direct contact also was assumed to be insignificant because of the presence of feathers that limit exposure over much of the body area. Risk to sandpiper from surface water was likewise determined to be insignificant for the Lockheed West Site because the Site is much smaller than the LDW site.
  - Benthic Invertebrates – The 2009 ERA evaluated exposure of benthic infaunal organisms to surface water based on available historical groundwater data from the adjacent uplands (Tetra Tech and Pascoe, 2009a). Although the representativeness of historical groundwater data is uncertain, results suggest that this exposure pathway does not present significant risks to benthic infaunal organisms relative to AWQC. Other mobile aquatic ROCs such as English sole and crabs have large foraging ranges, and their exposure to potential contaminants in surface water would extend far beyond the Site. For the latter species, there is no indication that the Site is contributing a disproportionate portion of potential contaminant exposure from surface water.

2.8.2.6 Ecological Risk Assessment Uncertainties

Table 11 provides a summary of the ERA uncertainties.

2.8.3 Summary of Contaminants of Concern

The final step in the characterization of risk in both the HHRA and ERA was to identify contaminants that are the main drivers of risks (risk drivers) at the Site. The purpose of identifying risk drivers was to provide focus for the development and evaluation of remedial alternatives in the FS. Risk drivers were identified based on the absolute magnitude of risk and on the relative contribution to total risk for a given human health exposure scenario or ecological receptor. Eight contaminants were identified as risk-drivers. The risk-drivers and the associated receptor and human health and ecological exposure scenarios that drive the risk are summarized as follows:

- Arsenic – Tribal adult and child seafood ingestion, net fishing, beach play, clamming; benthic invertebrates.
- Copper – Benthic invertebrates, fish, sandpiper.
- Lead – Tribal child seafood ingestion; sandpiper.
- Mercury – Benthic invertebrates.
- TBT – Tribal adult and child seafood ingestion; crabs, fish.
- cPAHs – Tribal adult and child seafood ingestion, netfishing, beach play.
- Total PCBs – Tribal adult and child seafood ingestion; benthic invertebrates, fish.
- Dioxins/furans – Tribal adult and child seafood ingestion, netfishing, beach play, clamming.

TABLE 11
Summary of Ecological Risk Assessment Uncertainties (Page 1 of 5)
Lockheed West Seattle Record of Decision

Receptor Group	Uncertainty	Under-estimates Risk	Over-estimates Risk	Un-known
Benthic Invertebrates	Whole benthic community selected as ROC. Some uncertainty that risk assessment is protective of all benthic invertebrate species.	X		
	Apparent Effects Thresholds (AETs) that are the basis for the SMS criteria and some DMMP guidelines do not exist for 15 contaminants that were detected at a frequency greater than 5%. However, 51 contaminants do have AETs and DMMP guidelines, and Site locations with the highest potential for adverse effects were identified.	X		
	Depth of biologically active zone (10 cm). Clams may burrow deeper than 10 cm and if sediment concentrations between 10 to 40 cm are appreciably different or the chemical sensitivity of an animal living deeper than 10 cm could be higher.	X		
	Chemical criteria to predict in situ effects is uncertain. Contaminant concentrations less than SQS may result in adverse effects, and contaminant concentrations greater than CSL may not result in adverse effects. Chemical-specific criteria do not assess the cumulative risks to benthic invertebrates from site-specific exposure to multiple chemicals with potentially synergistic or antagonistic effects.	X		
	Reporting limits (RL): – Three contaminants had reporting limits in at least one sample above their SQS or SL values; the RL for each of these is less than two-fold higher than the screening value. – Forty-nine contaminants that were not detected or were below the frequency criterion do not have screening criteria for benthic effects. – Elevated RL values for organochlorine pesticides were qualified as JN because of analytical interference resulting from the presence of PCB congeners.			X
	Chemical criteria, guidelines, and TRVs used to predict biological effects were based on test species that represent a small portion of the diverse benthic invertebrate community. The test species included crustaceans, which are considered to represent one of the taxonomic groups most sensitive to contaminant exposure; however, some benthic species at the Site may not be addressed by these criteria and guidelines.			
	SMS criteria were developed for application to Puget Sound sediments. There may be some spatial and temporal variation in the salinity between Elliott Bay and the West Waterway sides of the Site.	X		
	SMS chemical criteria were developed for specific chemicals based on AETs empirically derived from a dataset of field-collected sediment samples that contained diverse chemical mixtures and that were analyzed for both chemistry and toxicity.			
	In the absence of site-specific toxicity testing, the prediction of adverse effects at locations with contaminant concentrations greater than SQS or CSL chemical criteria and other guidelines is uncertain.	X		X

TABLE 11
Summary of Ecological Risk Assessment Uncertainties (Page 2 of 5)
Lockheed West Seattle Record of Decision

Receptor Group	Uncertainty	Under-estimates Risk	Over-estimates Risk	Un-known
Benthic Invertebrates (continued)	Risks from transition zone water (groundwater interface with surficial sediment at the point of groundwater discharge) was based on data collected prior to upland remediation area cleanups: – Water samples were reported with total metals and unfiltered samples, whereas water quality criteria are intended to be compared with dissolved fraction for metals. – Cyanide water quality criteria is for free cyanide whereas the measured cyanide is total cyanide. – Data used for evaluation is 17 years old and collected before the upland soils were cleaned up, hot spots removed, and stormwater catch basins were cleaned out. – Previous risk assessment for upland area of former Yard 2, demonstrated through modeling that groundwater contamination did not pose risks to aquatic receptors in nearby surface waters.		X	
	Critical tissue-residue approach for TBT used a modeled concentration that is less than the NOAEL TRV and the TRV from the LDW ERA was based on a single species, the polychaete *Armandia brevis* that would not be expected to be present in substantial numbers in the subtidal Lockheed West sediments; and the although the 95 UCL concentration of TBT fell just above the range of values used in the regression equation, the upper end of the concentrations were wells above the range. This species bioaccumulates TBT but has little ability to metabolize TBT. The finding that the modeled tissue concentration of TBT is less than the tissue-based TRV, although not based on the same species as the TRV, suggests a low risk from TBT to sensitive benthic invertebrates at Lockheed West.			
	The sources of uncertainty in the assessment of TBT risks to sensitive gastropods are both the modeled tissue residue concentration and the critical residue LOEC. The test species that the TRV is based on do not occur in the West Waterway. The finding that the modeled tissue concentration of TBT is less than the tissue-based TRV, although not based on the same species as the TRV, suggests a low risk from TBT to sensitive benthic invertebrates at Lockheed West. Most of the concentrations of TBT in the Lockheed West Site sediments (0.81 µg/kg-dw to 4,500 µg/kg-dw with a 95 UCL of 2,829 µg/kg-dw) exceeded the upper end of the range of concentrations in the LDW sediments (34 to 358 µg/kg-dw) where gastropods were studied; and the results and conclusions cannot be extrapolated to the Lockheed West Site.	X		

X

TABLE 11
Summary of Ecological Risk Assessment Uncertainties (Page 3 of 5)
Lockheed West Seattle Record of Decision

Receptor Group	Uncertainty	Under-estimates Risk	Over-estimates Risk	Un-known
Crabs	The low number of BSAFs and the BSAF values are listed for marine or estuarine crustaceans without species or location identification.			
	Crabs' home range is larger than Lockheed West Site.		X	
	There are a limited number of tissue-based TRVs in available literature, and they are for survival or growth endpoints. The LDW ERA reported effects data for decapods for only 8 of the 34 COPCs identified for crab tissue at Lockheed West.	X		
	Toxicities for individual Aroclors and DDT isomers are captured in the TRV for total PCBs and total DDTs.		X	
	JN qualified data sediment data for organochlorine pesticides from which tissue data were modeled.		X	
Fish	Uncertainties associated with the COPC screen for English sole are largely related to the lack of site-specific tissue data. Because of the high number of COPCs selected for tissues, there is low uncertainty that COPCs may have been omitted. In addition, due to lack of site-specific tissue data, modeling was based on reasonably conservative BSAFs (75th and 90th percentile values).	X		
	The ERA assumed area use for English sole to be the Lockheed West Site; whereas, findings from the LDW ERA concluded that English sole likely forage over a 6-mile area, which is larger than is covered by the LDW site.	X		
	Fish tissue COPCs that are missing TRVs are from the chemical groups PAHs, PCBs, and DDT. The potential risks from these contaminants on fish that may be exposed to them at the Site is unknown.	X		
	Numerous uncertainties in the PCB TRV study were identified including effects of elevated fish holding and exposure temperatures and in the exposure-response relationship for fecundity.	X		X
	Critical TRVs for PCBs were converted in the LDW ERA from concentrations in eggs to concentrations in whole-body tissues, which results in uncertainty associated with the use of the conversion factors.			X
	BSAFs are not available for Pacific staghorn sculpin; therefore the risks to this species based on whole body concentrations are not evaluated, but instead are referred to the risk estimates developed for English sole. Therefore, uncertainties associated with English sole apply to this species as well.			X

TABLE 11
Summary of Ecological Risk Assessment Uncertainties (Page 4 of 5)
Lockheed West Seattle Record of Decision

Receptor Group	Uncertainty	Under-estimates Risk	Over-estimates Risk	Un-known
Birds	Uncertainties related to how well the spotted sandpiper represent other benthivorous birds at the Lockheed West Site based on different diets, lower sediment, and FIRs or less frequent site use.			X
	Effects data for birds were not available for 15 individual PAHs; risks to birds from exposures to PAHs in sediment and prey were evaluated using TRVs for total PAHs and benzo(a)pyrene.			X
	Prey tissue concentrations of COPCs were based on modeling from intertidal sediment concentrations instead of site-specific tissue concentrations.			X
	PCBs used a significant linear relationship between sediment and benthic invertebrate tissue concentrations at the LDW site. For the remaining COPCs, there is high uncertainty with the use of BSAFs for the modeling of these tissue concentrations.			X
	Sediment ingestion as an exposure pathway despite low risk from this pathway (30% of FIR increases the HQs by an average of less than 0.1 at the LDW site.			
	The exposure estimate for chromium has uncertainty in that it does not account for any limited bioavailability of chromium from ingested sediments, resulting in a potential overestimation of risk. The limited BSAF data available for chromium and the low BSAF that was identified for invertebrates may result in underestimation of risk from chromium. The remaining COPCs for which risks are primarily related to ingestion of prey; the assumption of 100 percent bioavailabilty form prey tissue may overestimate exposures and risks.	X	X	
	The Site provides little habitat for spotted sandpiper, but the availability or quality of habitat was not considered in the exposure assessment.		X	
	The risk for copper could be under- or overestimated because the endpoint was based on subchronic growth effects and no reproductive endpoint was available.			X
	Total organochlorine pesticides were selected as COPCs for the spotted sandpiper based on the exceedance of a NOAEL even though none of those maximum concentrations exceeded the LOAEL-based screening values.			

X

TABLE 11

Summary of Ecological Risk Assessment Uncertainties (Page 5 of 5)

Lockheed West Seattle Record of Decision

Receptor Group	Uncertainty	Under-estimates Risk	Over-estimates Risk	Un-known

Notes:

µg/kg-dw = micrograms per kilogram – dry weight
95 UCL = 95th percentile upper confidence limit
AET = apparent effects threshold
BSAF = biota-sediment accumulation factor
cm = centimeter(s)
COPC = contaminants of potential concern
CSL = cleanup screening level
DDT = dichlorodiphenyltrichloroethane
DMMP = Dredged Material Management Program
ERA = Ecological Risk Assessment
FIR = food ingestion rate
HQ = hazard quotient
LDW = Lower Duwamish Waterway Superfund site
LOEC = lowest observed effect concentration
NOAEL = no observed adverse effect level
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
RL = reporting limit
SL = screening level
ROC = receptor of concern
SMS = sediment management standards
SQS = sediment quality standards
TBT = tributyltin
TRV = toxicity reference value

2.8.4 Basis for Action

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants into the environment. Such a release or the threat of release may present an imminent and substantial endangerment to public health, welfare, or the environment. A response action is necessary for the Lockheed West Site because of the following conditions:

- Human Health
  - Cumulative excess carcinogenic risks from inorganic arsenic, cPAHs, and total PCBs to an individual exceed the acceptable 10^{-4} risk levels for one or more reasonable maximum exposure scenarios.
  - HQs for metals (arsenic, cadmium, chromium, copper, lead, mercury, and zinc), TBT, and total PCBs exceed the acceptable noncarcinogenic risk threshold of 1 for one or more reasonable maximum exposure scenarios.
  - Dioxins/furans are present in tissue and sediments at concentrations above risk thresholds for seafood consumption and direct contact exposure scenarios.
- Ecological
  - Benthic invertebrates:
    - Metal (arsenic, copper, and mercury) concentrations in subtidal and/or intertidal sediment exceeded CSLs for evaluation of potential risks to benthic invertebrate community in at least 48 percent of sampling stations.
    - Total PCB concentrations in sediment exceeded the CSL for benthic invertebrates in 17 percent of subtidal sampling stations.
  - Fish – LOAEL-based HQs for dietary copper, fish tissue TBT, and total PCBs exceeded 1.
  - Birds – LOAEL-based HQs for chromium, copper, and lead exceeded 1.
  - Crabs – NOAEL-based HQ for TBT greater than 200.

2.9 Remedial Action Objectives

This section presents the remedial action objectives (RAOs) for the Lockheed West Site. The RAOs are descriptions of what the remedial action is expected to accomplish. The associated Cleanup Levels for COCs are provided in Table 12.

2.9.1 Specific Remedial Action Objectives

The RAOs for the Lockheed West Site are intended to address the risks posed to human health and the environment described in Section 2.8. The RAOs are as follows:

- Human Health Risks:
  - **RAO 1 –** Reduce human health risks associated with the consumption of resident seafood by adults and children with the highest potential exposure.
  - **RAO 2 –** Prevent human health risks from direct exposure (skin contact and incidental ingestion) to contaminated sediments during netfishing, clamming, and beach play.

- Ecological Risks:
  - **RAO 3** – Prevent risks to benthic invertebrates from exposure to contaminated sediments.
  - **RAO 4** – Prevent risks to crabs, fish, and birds from exposure to contaminated sediments.

2.9.2 Cleanup Levels

This section describes the numeric Cleanup Levels for the remedial alternatives developed for the Site.

2.9.2.1 Integration of Cleanup Levels with Remedial Action Objectives

The Cleanup Levels represent Site-specific concentration limits that are protective of human health and the environment and provide the basis for meeting the specific RAOs listed above. In documents leading up to the ROD, these values were identified as preliminary remediation goals. The Cleanup Levels and methods for demonstrating compliance are listed in Table 12.

The Cleanup Levels meet the RAOs in the following ways:

- Human Health Risks:
  - **RAO 1** is met when Sitewide average concentrations of COCs in the upper 45 cm of intertidal sediment and in the upper 10 cm of subtidal sediment do not exceed Cleanup Levels that are based on human consumption of seafood caught or gathered at the Site.
  - **RAO 2** is met when Sitewide average concentrations of COCs in the upper 45 cm of intertidal sediment and in the upper 10 cm of subtidal sediment do not exceed the Cleanup Levels that are based on direct contact with sediment during netfishing, Tribal clamming, or beach play.
- Ecological Risks:
  - **RAO 3** is met when point-by-point concentrations of COCs in the upper 10 cm of intertidal and subtidal sediments do not exceed Cleanup Levels that are based on protection of benthic invertebrates (SQS values).
  - **RAO 4** is met when Sitewide average concentrations of COCs in the upper 10 cm of intertidal and subtidal sediments do not exceed Cleanup Levels that are based on protection of crabs, fish, and birds.

TABLE 12
Summary of Cleanup Levels for Contaminants of Concern in Sediment (Page 1 of 4)
Lockheed West Seattle Record of Decision

COC	Risk Driver?	Units	Spatial Scale of Exposure[a]	RAO 1 Human Seafood Consumption[b] (0 to 10 cm)	RAO 2 Human Direct Contact[b] (0 to 45 cm)	RAO 3 Benthic Organisms[c] (0 to 10 cm)	RAO 4 Ecological[d] (0 to 10 cm)
Total PCBs	Yes	µg/kg-dw	Subtidal	2 (Nat Bkgd)	n/a	n/a	100 (RBTC – fish)
			Intertidal	2 (Nat Bkgd)	n/a	n/a	n/a
			Point	n/a	n/a	12 (OC)/ 180 (dw) (SQS)	n/a
cPAHs	Yes	µg TEQ/kg-dw	Subtidal	9 (Nat Bkgd)	550 (RBTC)[f]	n/a	n/a
			Intertidal	9 (Nat Bkgd)	15 (RBTC)[g]	n/a	n/a
			Point	n/a	n/a	n/a	n/a
Arsenic	Yes	mg/kg-dw	Subtidal	7 (Nat Bkgd)	7 (Nat Bkgd)	n/a	n/a
			Intertidal	7 (Nat Bkgd)	7 (Nat Bkgd)	n/a	n/a
			Point	n/a	n/a	57 (SQS)	n/a
Lead	Yes	mg/kg-dw	Subtidal	11 (Nat Bkgd)	n/a	n/a	n/a
			Intertidal	11 (Nat Bkgd)	n/a	n/a	50 (RBTC – sandiper)
			Point	n/a	n/a	n/a	n/a
Tributyltin	Yes	µg/kg-dw	Subtidal	430 (RBTC – child)	n/a	n/a	150 (RBTC – fish)
			Intertidal	2,000 (RBTC – child)[h]	n/a	n/a	n/a
			Point	n/a	n/a	n/a	n/a
Copper	Yes	mg/kg-dw	Subtidal	400 (RBTC – child)	n/a	n/a	114 (RBTC – fish)
			Intertidal	400 (RBTC – child)[h]	n/a	n/a	420 (RBTC – sandiper)
			Point	n/a	n/a	390	n/a
Mercury	Yes	mg/kg-dw	Subtidal	0.41 (RBTC – child)	n/a	n/a	n/a
			Intertidal	0.17 (RBTC – child)	n/a	n/a	n/a
			Point	n/a	n/a	0.41 (SQS)	n/a
Dioxins/ Furans	Yes	ng TEQ/kg-dw	Subtidal	2 (Nat Bkgd)	37 (RBTC [h])	n/a	n/a
			Intertidal	2 (Nat Bkgd)	13 (RBTC [h])	n/a	n/a
			Point	n/a	n/a	n/a	n/a
Antimony	No	mg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	150 (SQS)	n/a

TABLE 12
Summary of Cleanup Levels for Contaminants of Concern in Sediment (Page 2 of 4)
Lockheed West Seattle Record of Decision

COC	Risk Driver?	Units	Spatial Scale of Exposure[a]	RAO 1 Human Seafood Consumption[b] (0 to 10 cm)	RAO 2 Human Direct Contact[b] (0 to 45 cm)	RAO 3 Benthic Organisms[c] (0 to 10 cm)	RAO 4 Ecological[d] (0 to 10 cm)
Cadmium	No	mg/kg-dw	Subtidal	0.398 (RBTC)	n/a	n/a	n/a
			Intertidal	0.398 (RBTC)	n/a	n/a	n/a
			Point	n/a	n/a	n/a	n/a
Chromium	No	mg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	260 (SQS)	n/a
Cobalt	No	mg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	10 (SQS)	n/a
Nickel	No	mg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	140 (SQS)	n/a
Selenium	No	mg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	1 (SQS)	n/a
Vanadium	No	mg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	57 (SQS)	n/a
Zinc	No	mg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	410 (SQS)	n/a
Pentachloro-phenol	No	µg/kg-dw	Subtidal	58 (RBTC)	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	360 (SQS)	n/a
Bis(2-ethylhexyl)-phthalate	No	µg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	47 (OC)/ 710 (dw) (SQS)	n/a
Acenaphthene	No	µg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	16 (OC)/ 240 (dw) (SQS)	n/a

TABLE 12
Summary of Cleanup Levels for Contaminants of Concern in Sediment (Page 3 of 4)
Lockheed West Seattle Record of Decision

COC	Risk Driver?	Units	Spatial Scale of Exposure[a]	RAO 1 Human Seafood Consumption[b] (0 to 10 cm)	RAO 2 Human Direct Contact[b] (0 to 45 cm)	RAO 3 Benthic Organisms[c] (0 to 10 cm)	RAO 4 Ecological[d] (0 to 10 cm)
Benzo(a)-anthracene	No	µg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	110 (OC)/ 1,700 (dw) (SQS)	n/a
Benzo(a)pyrene	No	µg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	99 (OC)/ 1,500 (dw) (SQS)	n/a
Benzo(g,h,i)-perylene	No	µg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	31 (OC)/ 470 (dw) (SQS)	n/a
Total Benzofluor-anthenes	No	µg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	1,800 (SQS)	n/a
Chrysene	No	µg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	110 (OC)/ 1,700 (dw) (SQS)	n/a
Dibenz(a,h)-anthracene	No	µg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	12 (OC)/ 180 (dw) (SQS)	n/a
Fluoranthene	No	µg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	160 (OC)/ 2,400 (dw) (SQS)	n/a
Indeno(1,2,3-cd)pyrene	No	µg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	34 (OC)/ 510 (dw) (SQS)	n/a
Phenanthrene	No	µg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	100 (OC)/ 1,500 (dw) (SQS)	n/a

TABLE 12
Summary of Cleanup Levels for Contaminants of Concern in Sediment (Page 4 of 4)
Lockheed West Seattle Record of Decision

COC	Risk Driver?	Units	Spatial Scale of Exposure[a]	RAO 1 Human Seafood Consumption[b] (0 to 10 cm)	RAO 2 Human Direct Contact[b] (0 to 45 cm)	RAO 3 Benthic Organism[c] (0 to 10 cm)	RAO 4 Ecological[d] (0 to 10 cm)
Total HPAH	No	µg/kg-dw	Subtidal	n/a	n/a	n/a	n/a
			Intertidal	n/a	n/a	n/a	n/a
			Point	n/a	n/a	960 (OC)/ 14,400 (dw) (SQS)	n/a

[a] The spatial scale of exposure is measured as sitewide (i.e., all subtidal and intertidal sediments), intertidal sediments only, and point measurements at single locations throughout the site (i.e., all subtidal and intertidal sediment locations) or at single locations in intertidal sediment only. The spatial scale is RAO-specific, with sitewide exposures applicable to human seafood consumption, human direct contact, and exposures of fish and crab. Intertidal-only exposures are applicable to human consumption of clams from intertidal areas and exposures of sandpiper. Point exposures are applicable to benthic organisms, which are evaluated at single station locations. The statistical metric for sitewide and intertidal evaluation of alternatives and compliance monitoring is the upper confidence limit on the mean, whereas point exposures are evaluated with concentration data at single locations.

[b] Cleanup levels are based on 10^{-6} cancer risk for carcinogens (e.g., PCBs, cPAHs, arsenic) or on a child exposure hazard quotient of 1 for noncarcinogens (lead, tributyltin, copper). Where Cleanup Levels are based on carcinogenic risks are below background, the background concentration is selected; where no background values are available (chlordanes and DDT), the method detection limit (MDL) is selected.

[c] Applicable on a point exposure only. Values for PCBs and PAHs (except total benzofluoranthenes) are the organic carbon-normalized SQS and the dry weight equivalent based on an average sediment TOC content of 1.5%; for all other compounds values are dry weight. Under the SMS, sediment cleanup standards are established on a site-specific basis within an allowable range. The SQS and CSL define this range. For chemicals without SMS, LAET and 2LAET values or the SL and ML of the DMMP define this range.

[d] Cleanup levels for sitewide exposure are the lowest for either fish or crab; Cleanup levels for intertidal exposure are for sandpiper

[e] The cleanup level is the MDL.

[f] The cleanup level for sitewide direct contact is based on netfishing.

[g] The cleanup level for intertidal direct contact is based on the lowest for either Tribal clamming or child beach play exposures.

[h] The cleanup for intertidal seafood consumption is based on consumption of clams from the intertidal sediment.

Notes:

µg/kg-dw = micrograms per kilogram dry weight
µg TEQ/kg-dw = micrograms Toxicity Equivalents per kilogram dry weight
COC = contaminant of concern
cm = centimeter(s)
cPAH = carcinogenic polycyclic aromatic hydrocarbon
dw = dry weight
HPAH = heavy weight polycyclic aromatic hydrocarbon
mg/kg-dw = milligrams per kilogram dry weight
n/a = compounds do not present a risk for the RAO scenario
Nat Bkgd = natural background
ng TEQ/kg-dw = nanograms toxicity equivalents per kilogram dry weight
OC = organic carbon (1.5%)
PCB = polychlorinated biphenyl
RAO = remedial action objective
RBTC = risk-based threshold concentrations
SQS = sediment quality standards

Adapted from RI/FS Report Table 9-5 (Tetra Tech, 2012)

By achieving these Cleanup Levels, risks to receptors will be reduced to the levels shown in Table 13. The risk thresholds for RAO 1 are elevated because the Cleanup Level for total PCBs is based on natural background, which is higher than the RBTC of less than 1 micrograms per kilogram (µg/kg). A fish advisory is necessary to achieve acceptable levels of risk.

TABLE 13
Residual Risk Levels by Remedial Action Objective at Completion of Construction
Lockheed West Seattle Record of Decision

RAO	Risk Level Achieved
RAO 1 – Human Seafood Consumption	Cumulative cancer risk less than 9×10^{-5}, HQ 5[a]
RAO 2 – Human Direct Contact	Cumulative cancer risk less than or equal to 1×10^{-5}, HQ less than 1
RAO 3 – Benthic Receptor	SQS (NOAEL)
RAO 4 – Ecological	HQ less than 1

Notes:
NOAEL = no observed adverse effect level
SQS = sediment quality standards

Once remediation has been completed, post-construction sediment verification sampling will be conducted to confirm that the RAOs have been met. Post-construction surface water samples also will be collected and analyzed, however, fish tissue will not be sampled.

As noted in Section 2.6.2.2, surface water and sediment conditions at the Site are influenced by the natural counterclockwise flow of water and tidal influences in Elliott Bay. Elliott Bay is affected by nearby urbanization, and overall concentrations of certain COCs in bay sediments are not at the natural background concentrations identified as being protective of human consumption of seafood. Therefore, it is likely that concentrations of these COCs will increase in Site sediments after remediation as a result of the movement of sediment and surface water from Elliott Bay. If this occurs, sediment concentrations at the Site may no longer meet Cleanup Levels that are based on natural background concentrations. This would not constitute a failure of the Selected Remedy. This is because the RAOs for this remedial action will be met through active remediation and institutional controls (ICs) despite any post-remedial action recontamination from other non-Site sources. The intent of this remedial action is to address the contamination attributable to shipyard operations at the Site. Reducing contaminant loads incrementally through individual site remediation improves the overall health of the larger Elliott Bay.

2.9.3 Principal Threat Waste

The NCP establishes the expectation that treatment will be used to address the principal threats posed by a site whenever practicable, in accordance with Federal regulations (40 CFR 300.430[a] [1] [iii] [A]). In general, principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be contained in a reliable manner. There is no source or other material at this Site that constitutes principal threat waste. Contaminants identified at the Site are considered low-level threats and are not highly mobile or highly toxic. For example, the maximum PCB sediment concentration at the Site is 3 parts per million (ppm), with an average of 0.42 ppm. These values are well below the 50-ppm threshold for designation as a Toxic Substances Control Act (TSCA) waste. Similarly, the maximum dioxins/furans concentration is 13.8 ppt TEQ as compared to the natural background concentration of 2 ppt. Metals concentrations also do not trigger principal threat waste issues, and no Resource Conservation Recovery Act (RCRA)-listed hazardous wastes will be generated during Site remediation.

2.10 Description of Alternatives

This section describes the remedial alternatives identified and evaluated for the Site. Remedial alternatives were developed to meet the requirements of the NCP (40 CFR 300.430). The NCP requires a range of remedial alternatives be considered in which treatment that reduces the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants is a principal element. As appropriate, this range shall include an alternative that removes or destroys hazardous substances, pollutants, or contaminants to the maximum extent feasible, eliminating or reducing to the degree possible, the need for long-term management. Remedial alternatives must provide protection of human health and the environment primarily by preventing or controlling exposure to hazardous substances, pollutants, or contaminants. The development, screening, and analysis of remedial alternatives form the basis for the Selected Remedy.

2.10.1 Remedial Action Levels

Remedial action levels (RALs) are contaminant-specific sediment concentrations that identify the levels that must be achieved in areas of active remediation, such as dredging, capping, or thin layer placement of cover material. The RALs were developed for the Site to define areas of sediments for active remediation based on different assumptions to develop remedial alternatives. RALs are used to define where active remediation may occur for a given cleanup alternative. In addition, the RALs will be used to verify that active remediation for an alternative is complete or successful before construction equipment is demobilized.

RALs and Cleanup Levels can be different concentrations. While RAL concentrations delineate the area where active remediation may occur, Cleanup Levels must still be achieved at the Site for the remedy to achieve protectiveness and meet ARARs. To achieve protectiveness, ICs are incorporated into any remedy that leaves behind contaminant concentrations in excess of the Cleanup Levels and into any remedy where a Cleanup Level is based on natural background, because the RBTC is lower than natural background.

Four RAL groups were used in developing alternatives to address specific areas of potential action (AOPAs) at the Site.

- Cleanup Levels (lowest of the RBTCs or natural background, if natural background is higher than the lowest RBTC)
- Elliott Bay Urban Background[3] concentrations
- SQS criteria for protection of benthic invertebrates
- CSL criteria for protection of benthic invertebrates

[3] Although the Urban Background data are affected by point and nonpoint pollutant sources in Elliott Bay and are not representative of natural background (or CERCLA anthropogenic background), the data provide the general concentrations of sediments in Elliott Bay during Ecology's sampling in 2007 (Ecology, 2009a). The Urban Background concentrations are typically below the SQS concentrations but above the Cleanup Level concentrations. The use of the term "background" in this context does not connote (as "natural background" does) that these concentrations are acceptable or have any legal basis or standing, and these sediments might also require cleanup in the future.

Concentrations of risk driver COCs for each RAL group, which reflect a range in the magnitude of risk reduction achieved and degree of active remediation, are listed in Table 14.

TABLE 14
Remedial Action Levels for the Risk-Driver Contaminants of Concern in Sediment
Lockheed West Seattle Record of Decision

Risk Driver	Basis	Remedial Action Level Group			
		Cleanup Levels (RBTC/ Nat Bkgd)[a]	Urban Background	SQS	CSL
Total PCBs	µg/kg-dw	2 (Nat Bkgd)	119	180[b]	1,000[b]
	mg/kg-OC	n/a	n/a	12	65
cPAHs	µg/kg-dw	9 (Nat Bkgd)	757	1,100[b]	3,000[b]
Arsenic	mg/kg-dw	7 (Nat Bkgd)	8.44	57	93
Lead	mg/kg-dw	11 (Nat Bkgd)	47	450	530
Copper	mg/kg-dw	114 (RBTC – fish)	49	390	390
Mercury	mg/kg-dw	0.41 (RBTC -seafood consumption)	0.44	0.41	0.59
TBT	µg/kg-dw	150 (RBTC – fish)	n/a	1,335[b, c]	1,335[b, c]
	mg/kg-OC	n/a	n/a	78[c]	78[c]

[a] Lowest of the human and ecological RBTCs or natural background if higher than the lowest RBTC (source listed after value)
[b] Assumes 1.5% total organic carbon as measured at Site
[c] West Waterway confirmation value

Notes:

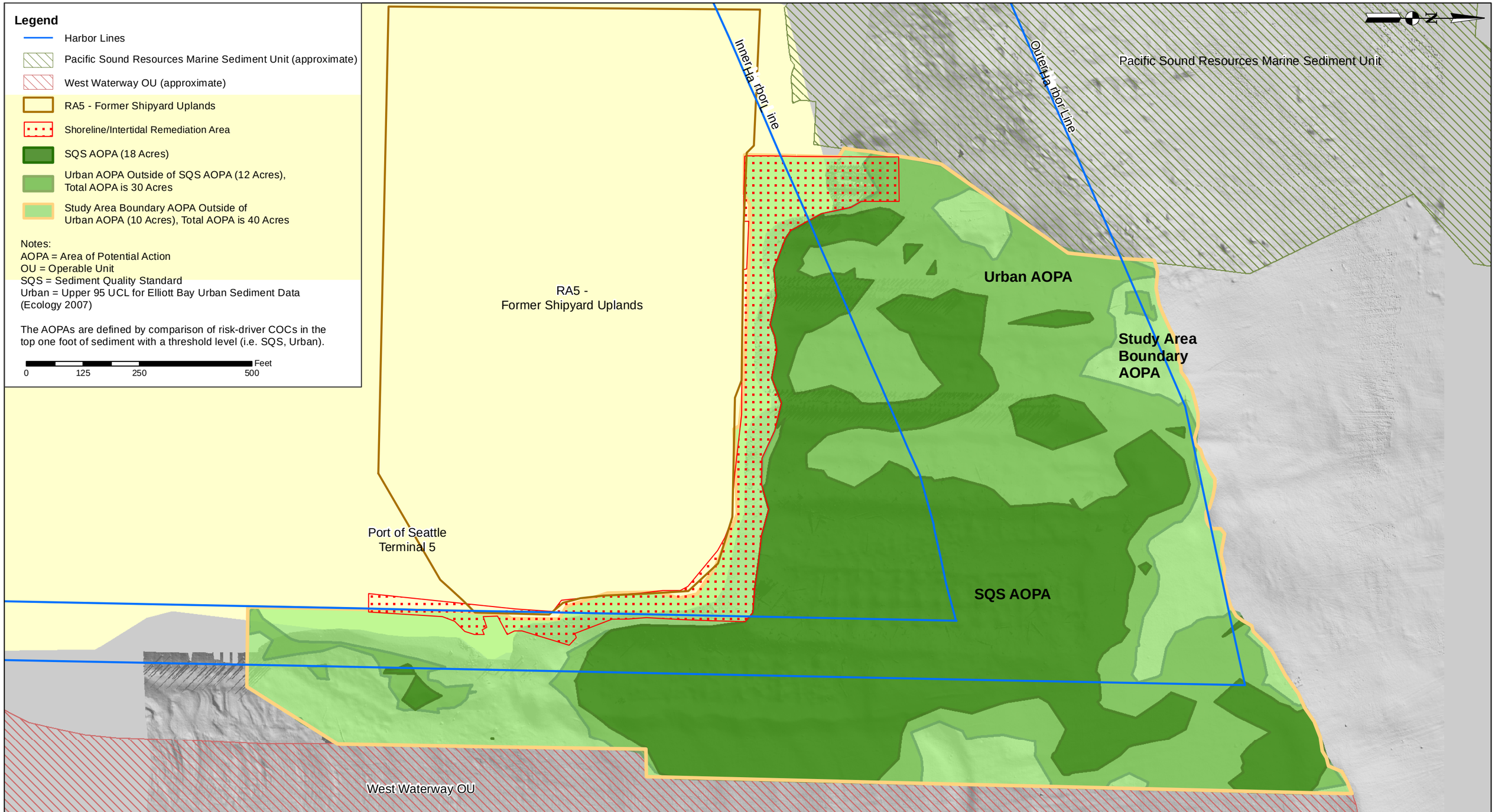
µg/kg-dw = microgram per kilogram dry weight
cPAH = carcinogenic polycyclic aromatic hydrocarbon
CSL = cleanup screening level
mg/kg-OC = milligram per kilogram organic carbon
mg/kg-dw = milligram per kilogram dry weight
n/a = not applicable; background value was not calculated
Nat Bkgd = natural background
PCB = polychlorinated biphenyl
RBTC = risk-based threshold concentration
SQS = sediment quality standards
TBT = tributyltin

Adapted from RI/FS Table 11-1 (Tetra Tech, 2012)

2.10.2 Areas of Potential Action

In developing remedial alternatives, four AOPAs were defined by comparing concentrations of risk-driver COCs in the upper 1 foot of sediment with the RALs described in Section 2.10.1, with modifications to account for physical constraints and boundaries. The AOPAs, which are depicted in Figure 13, include the following:

- **SQS AOPA** — The SQS footprint is the extent of surface sediment in the subtidal area where the concentrations of COCs are above the SQS RALs. The SQS AOPA is approximately 18 acres.
- **CSL AOPA** — The CSL footprint is a subarea of the SQS AOPA where concentrations of COCs are also above the CSL RALs. The CSL AOPA is approximately 11.6 acres.



TETRA TECH

Lockheed West Seattle Superfund Site, Seattle, WA

Figure 13
Areas of Potential Action

Z:\Rdrive\Projects_2006\Lockheed\maps\RIFS_Report\Figure_11-1.mxd

- **Urban Background AOPA** — The Urban Background AOPA is the extent of surface sediment in the subtidal area where the concentrations of COCs are above the Urban Background levels listed in Table 4. The Urban Background AOPA is approximately 30 acres.
- **Study Area AOPA** — The Study Area AOPA is defined by the administrative boundaries that exist for the Site, the West Waterway Operable Unit to the east of the Site, and the PSR marine sediment unit to the west of the Site, as well as to the north shoreline, where sediment concentrations are above RBTCs, or natural background concentrations if higher than RBTCs (essentially, the RAO 1 Cleanup Levels). The Study Area AOPA is approximately 40 acres.

2.10.3 Description of Remedial Approaches

The EPA developed four general remedial approaches—no action, containment, partial removal, and complete removal—which were used to develop remedial action alternatives for the Site. The technologies used in the development of alternatives were capping, dredging, and thin layer placement of clean material that promotes enhanced natural recovery (ENR). ICs also were included in all active remedial alternatives. A total of 19 alternatives were developed using different combinations of remedial technologies and AOPAs. These alternatives are described generally below.

2.10.3.1 No Action Alternative

As required under CERCLA, a no action alternative (Alternative 1) was evaluated to compare cleanup alternatives with baseline site conditions.

2.10.3.2 Containment-Focus Alternatives

The Containment-Focus alternatives combine conventional capping (approximately 3 feet) of more-contaminated areas and placement of a thin layer cover (6 to 9 inches) in less-contaminated areas to promote ENR. The Containment-Focus alternatives include:

- 2A1 – Conventional capping over the CSL footprint and thin cover/ENR layer over the remaining SQS footprint.
- 2A2a – Conventional capping over the CSL footprint and thin cover/ENR layer over the remaining Urban Background footprint.
- 2A2a Plus – Variant of Alternative 2A2a, adds dredging sediment above the SQS in the navigational channel in the West Waterway, and application of thin cover/ENR layer to the Study Area boundary.
- 2A2b – Conventional capping over the SQS footprints and thin cover/ENR layer over the remaining Urban Background footprint.
- 2A3 – Conventional capping over the CSL footprint and thin cover/ENR layer over the remaining Study Area footprint.
- 2A4a – Conventional capping over the SQS footprint.
- 2A4b – Conventional capping over the Urban Background footprint.
- 2A4c – Conventional capping over the Study Area footprint.
- 2B – Capping surface sediments over the CSL footprint and removal of sediments within the capping footprint to maintain bathymetry and thin cover/ENR layer over the remaining Study Area footprint.

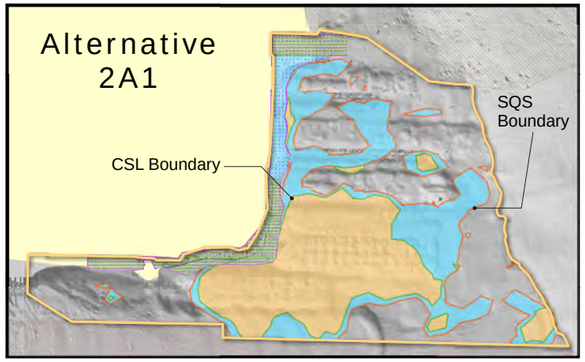
Figure 14 provides a general schematic of each of the nine Containment-Focus alternatives. A summary listing the elements (capping, thin cover/ENR layer, and other components) for each of the Containment-Focus alternatives is presented in Table 15.

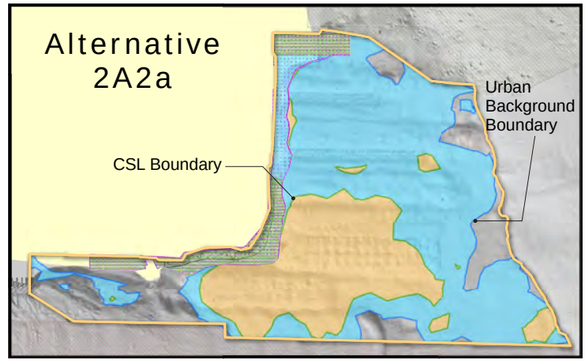
2.10.3.3 Partial Removal-Focus Alternatives

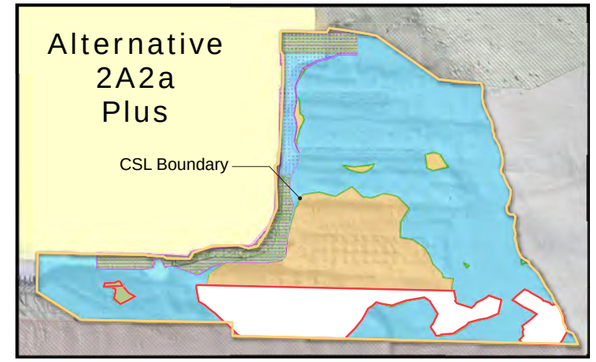
The Partial Removal-Focus alternatives use a combination of contaminated sediment removal by dredging and dredge residual management and placement of a thin cover/ENR layer (6 to 9 inches) in less contaminated areas. The Partial Removal-Focus alternatives include:

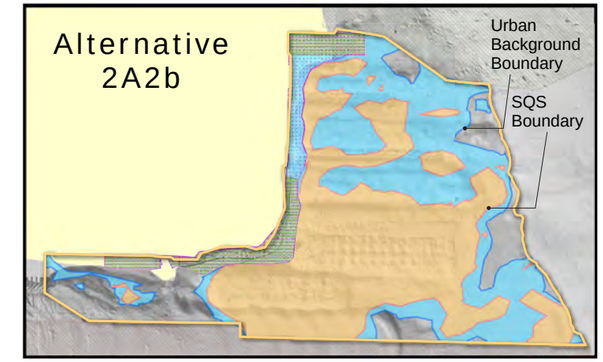
- 3A1 − Remove up to 3 feet of sediment over the CSL footprint, conventional cap where exposed residual concentrations are between the SQS and CSL, and thin cover/ENR layer over the remaining Urban Background footprint.
- 3A2 − Remove up to 3 feet of sediment over the SQS footprint, conventional cap where exposed residual concentrations are between the SQS and CSL, and thin cover/ENR layer over remaining Urban Background footprint.
- 3A2 Plus − Variant of 3A2; includes all of the 3A2 elements, plus dredging all sediment above the SQS in the navigational channel in West Waterway, and extending thin cover/ENR layer to the Study Area boundary.
- 3B − Remove sediments over CSL within the former Dry Dock 1 (entire depth), conventional capping over the remaining CSL footprint, and thin cover/ENR layer over the remaining Urban Background footprint.
- 3C − Remove sediments over CSL within all of the former dry dock areas (entire depth), conventional capping over the remaining CSL footprint, and thin cover/ENR layer to the Urban Background footprint.
- 3C Plus − Variant of 3C; remove sediments over CSL within all of the former dry dock areas (entire depth), dredge remaining CSL footprint, dredge sediment above the SQS in the navigational channel in West Waterway and the former shipway area, remove pilings from former shipway area, and extend thin cover/ENR layer to the Study Area boundary.

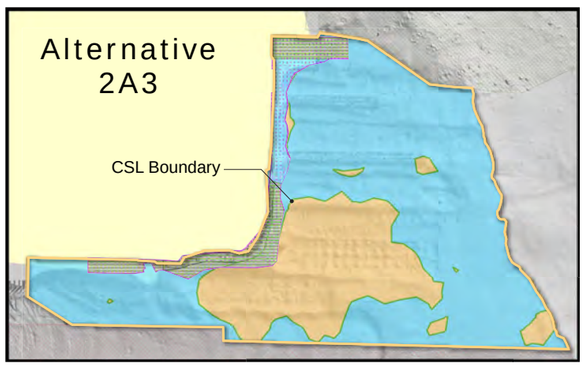
Figure 15 provides schematics of the six Partial Removal-Focus alternatives. A summary listing the components for each of the Partial Removal alternatives is presented in Table 16.

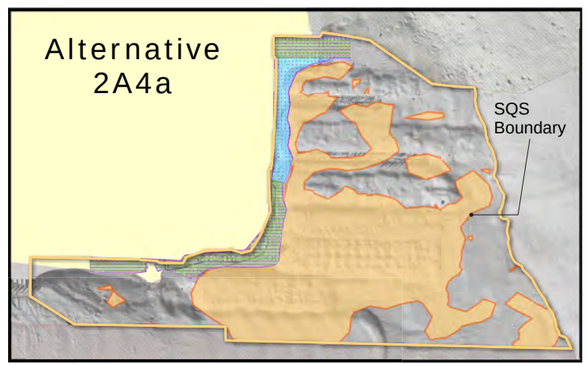


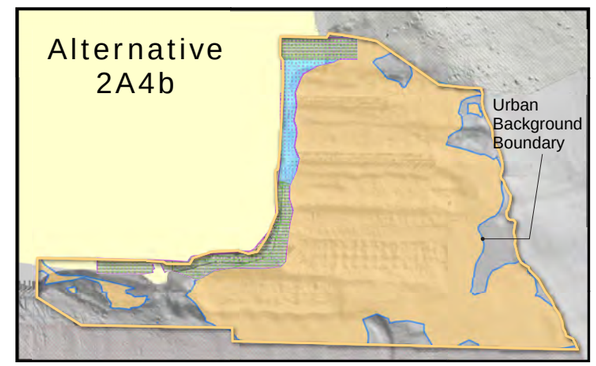


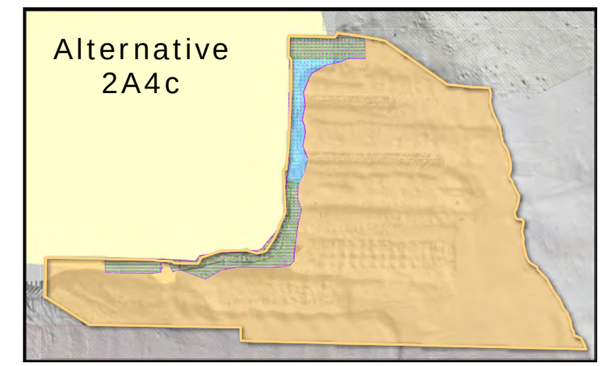


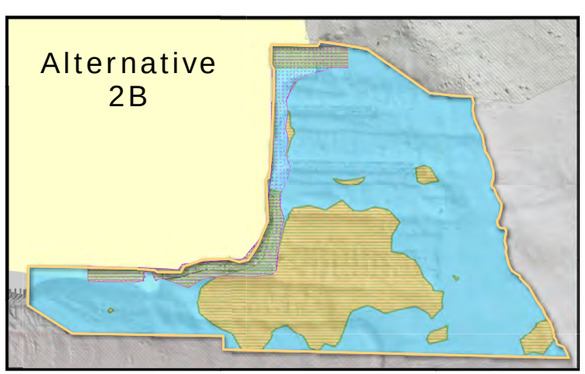












LEGEND

- CONVENTIONAL CAP
- DREDGE TO FIT CAP TO CSL FOOTPRINT
- DREDGE TO FULL SQS IN WEST WATERWAY NAVIGATION CHANNEL
- ENR
- SHORELINE/SHIPWAY REMEDIATION AREA
- LOCKHEED WEST STUDY AREA BOUNDARY

Feet
0 125 250 500

Source: Adapted from Tetra Tech, May 2012, Final RI/FS.

Figure 14
Containment-Focus Alternatives
Lockheed West Superfund Site
Seattle, WA

ES100512034318SEA

TABLE 15
Summary of Containment-Focus Alternatives
Lockheed West Seattle Record of Decision

#	Alternative Description	Capping Extent				Thin Cover/ENR Extent			Additional Components			Common Elements
		SQS	CSL	Urban Bkgd[a]	Study Area	SQS	Urban Bkgd	Study Area	Dredging to SQS	Dredging to CSL	Cap Replacement	
2A1	Conventional capping over the CSL footprint and thin cover/ENR over the remaining SQS footprint.		X			X					X	X
2A2a	Conventional capping over the CSL footprint and thin cover/ENR over the remaining Urban Background footprint.		X				X				X	X
2A2a Plus	Variant of Alternative 2A2a, adds dredging sediment above the SQS in the navigational channel in the West Waterway, and application of thin cover/ENR to the Study Area boundary.		X					X	X		X	X
2A2b	Conventional capping over the SQS footprints and thin cover/ENR over the remaining Urban Background footprint.	X					X				X	X
2A3	Conventional capping over the CSL footprint and thin cover/ENR over the remaining Study Area footprint.		X					X			X	X
2A4a	Conventional capping over the SQS footprint.	X									X	X
2A4b	Conventional capping over the Urban Background footprint.			X							X	
2A4c	Conventional capping over the Study Area footprint.				X						X	X
2B	Capping surface sediments over the CSL footprint and removal of sediments within the capping footprint to maintain bathymetry. Thin cover/ENR over the remaining Study Area footprint.		X					X		X	X	X

Common Elements:

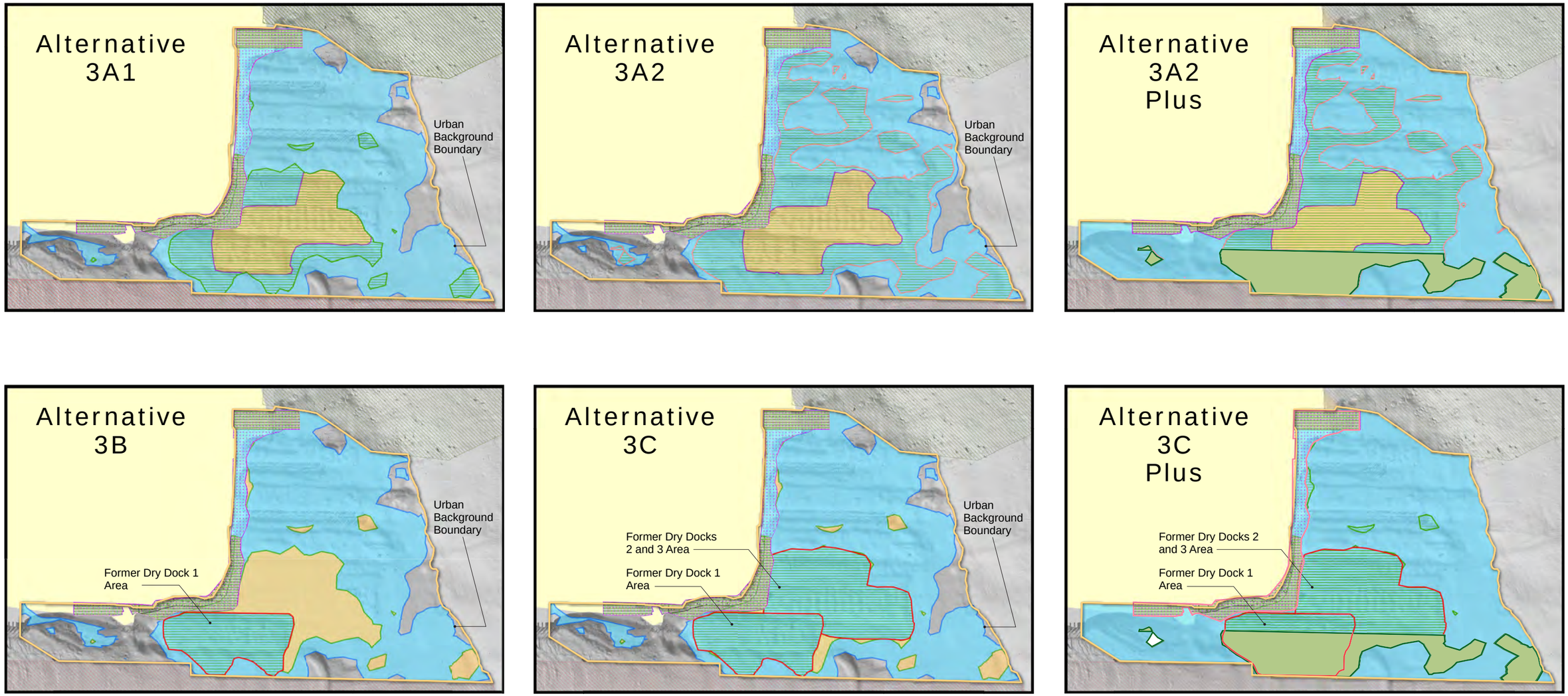
- **Former Shipway Area Remediation** – Remove sandblast grit and contaminated sediments to the extent possible, place 3-foot cap with habitat mix, blend cap with PSR beach next to former shipway.
- **Shoreline/Intertidal Remediation and Habitat Improvements** – Remove existing shoreline structures (such as debris piles, remaining derelict bulkhead, and some pilings), dredge and backfill shoreline slopes from edge of existing intertidal habitat to landward edge of cleanup boundary with the goal of no net loss of intertidal habitat.
- **Disposal:**
  - Transport sediment via truck or rail for disposal at permitted upland landfill facility.
  - Dispose of debris and pilings at an appropriate permitted facility.
- **Institutional Controls**:
  - Proprietary Controls (for alternatives that leave sediment concentrations greater than Cleanup Levels), including deed restrictions and restrictive covenants.
  - Informational Devices – Elliott Bay fish consumption advisories posted at the Site.
- **Surface Water** – Surface water will be monitored during the remediation activities to ensure that short-term water impacts are not caused by cleanup actions addressing contaminated sediments (dredging, dredge water treatment and return). The EPA would waive the surface water ARAR, the Federal ambient water quality criteria for arsenic through a technical impracticability waiver based on engineering feasibility.

- **Long-term Monitoring –** Identification of activities to cover post-construction monitoring and maintenance activities that are required to ensure the long-term performance of the remedy and outline performance expectations and potential courses of action that should be taken based on construction confirmation sampling results, passage of time, influence of marine activities, or occurrence of natural phenomenon such as earthquakes or significant weather events.

[a] Although the Urban Background data are affected by point and nonpoint pollutant sources in Elliott Bay and are not representative of natural background (or CERCLA anthropogenic background), the data provide the general concentrations of sediments in Elliott Bay during Ecology's sampling in 2007 (Ecology, 2009a). The Urban Background concentrations are typically below the SQS concentrations but above the Cleanup Level concentrations. The use of the term "background" in this context does not connote (as "natural background" does) that these concentrations are acceptable or have any legal basis or standing and these sediments might also require cleanup in the future.

Notes:

ARAR = applicble or relevant and appropriate requirement
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CSL = cleanup screening level
ENR = enhanced natural recovery
PSR = Pacific Sound Resources
SQS = sediment quality standards
Urban Bkgd = Urban Background



LEGEND

- DREDGE TO 3-FOOT DEPTH IN CSL FOOTPRINT
- DREDGE TO 3-FOOT DEPTH IN SQS FOOTPRINT
- PLACE 3-FOOT CAP IN POST-DREDGE AREAS WITH RESIDUAL CONTAMINANT CONCENTRATIONS BETWEEN THE SQS AND CSL (RISK-DRIVER COCs) AND NO GREATER THAN 2 TIMES THE SOS (REMAINING COCs)
- CAP REMAINING CSL FOOTPRINT
- DREDGE TO SQS IN WEST WATERWAY NAVIGATION CHANNEL
- ENR
- SHORELINE/SHIPWAY REMEDIATION AREA
- LOCKHEED WEST STUDY AREA BOUNDARY

Feet
0 125 250 500

Source: Adapted from Tetra Tech, May 2012, Final RI/FS.

Figure 15
Removal-Focus Alternatives
Lockheed West Superfund Site
Seattle, WA

ES100512034318SEA

TABLE 16
Summary of Partial Removal-Focus Alternatives
Lockheed West Seattle Record of Decision

#	Alternative Description	Dredging Extent		Conventional Cap Extent		Thin Cover/ENR Extent			Remove Pilings in Former Shipway	Common Elements
		SQS	CSL	CSL	>SQS and <CSL	Dredged Areas	Urban Bkgd[a]	Study Area		
3A1	Remove up to 3 feet of sediment over the CSL footprint, conventional cap where exposed residual concentrations are between the SQS and CSL, and thin cover/ENR over the remaining Urban Background footprint.		X		X		X			X
3A2	Remove up to 3 feet of sediment over the SQS footprint, conventional cap where exposed residual concentrations are between the SQS and CSL, and thin cover/ENR over remaining Urban Background footprint.	X			X		X			X
3A2 Plus	Variant of 3A2 includes all of the 3A2 elements, plus dredging all sediment above the SQS in the navigational channel in West Waterway, and extending thin cover/ENR to the Study Area boundary.	X			X			X		X
3B	Remove sediments over CSL within the former Dry Dock 1 (entire depth), conventional capping over the remaining CSL footprint, and thin cover/ENR over the remaining Urban Background footprint.		X	X			X			X
3C	Remove sediments over CSL within all of the former dry dock areas (entire depth), conventional capping over the remaining CSL footprint, and thin cover/ENR to the Urban Background footprint.		X	X		X	X			X
3C Plus	Variant of 3C; remove sediments over CSL within all of the former dry dock areas (entire depth), dredge remaining CSL footprint, dredge sediment above the SQS in the navigational channel in West Waterway and the former shipway area, remove pilings from former shipway area, and extend thin cover/ENR to the Study Area boundary.	X	X			X	X	X	X	X*

Common Elements:

- **Former Shipway Area Remediation** – Remove sandblast grit and contaminated sediments to the extent possible, place 3-foot cap with habitat mix, blend cap with PSR beach next to former shipway. [*Note: Alternative 3C Plus removes all sediments with concentrations above SQS.]
- **Shoreline/Intertidal Remediation and Habitat Improvements** – Remove existing shoreline structures (such as debris piles, remaining derelict bulkhead, and some pilings), dredge and backfill shoreline slopes from edge of existing intertidal habitat to landward edge of cleanup boundary with the goal of no net loss of intertidal habitat.
- **Disposal:**
  - Transport sediment via truck or rail for disposal at permitted upland landfill facility.
  - Dispose of debris and pilings at an appropriate permitted facility.
- **Institutional Controls**:
  - Proprietary Controls (for alternatives that leave sediment concentrations greater than Cleanup Levels), including deed restrictions and restrictive covenants.
  - Informational Devices – Elliott Bay fish consumption advisories posted at the Site.

- **Surface Water** – Surface water will be monitored during the remediation activities to ensure that short-term water impacts are not caused by cleanup actions addressing contaminated sediments – dredging, dredge water treatment and return. The EPA would waive the surface water ARAR, the Federal ambient water quality criteria for arsenic through a technical impracticability waiver based on the fact that cleaning up contaminated sediments at this small 40-acre Site would not likely improve the water quality to a measurable extent with Elliott Bay even though the source of contaminated sediments at this Site would be removed or covered.
- **Long-term Monitoring** – Identification of activities to cover post-construction monitoring and maintenance activities that are required to ensure the long-term performance of the remedy and outline performance expectations and potential courses of action that should be taken based on construction confirmation sampling results, passage of time, influence of marine activities, or occurrence of natural phenomenon such as earthquakes or significant weather events.

[a] Although the Urban Background data are affected by point and nonpoint pollutant sources in Elliott Bay and are not representative of natural background (or CERCLA anthropogenic background), the data provide the general concentrations of sediments in Elliott Bay during Ecology's sampling in 2007 (Ecology, 2009a). The Urban Background concentrations are typically below the SQS concentrations but above the Cleanup Level concentrations. The use of the term "background" in this context does not connote (as "natural background" does) that these concentrations are acceptable or have any legal basis or standing and these sediments might also require cleanup in the future.

Notes:

> = greater than
< = less than
ARAR = applicble or relevant and appropriate requirement
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CSL = cleanup screening level
ENR = enhanced natural recovery
PSR = Pacific Sound Resources
SQS = sediment quality standards
Urban Bkgd = Urban Background

2.10.3.4 Complete Removal-Focus Alternatives

The emphasis of the Complete Removal-Focus alternatives is removal through dredging followed by dredge residual management to address SQS, Urban Background, and Cleanup Level exceedances, respectively. The Complete Removal-Focus Alternatives include:

- 4A – Complete removal to SQS exceedance boundary.
- 4B – Complete removal to Urban Background exceedance boundary.
- 4C – Complete removal to Cleanup Level exceedance boundary (Study Area).

Figure 16 provides a schematic of the Complete Removal-Focus alternatives. A summary listing the components of the three Complete Removal alternatives is presented in Table 17.

2.10.3.5 Common Elements of Cleanup Alternatives

The elements common to all the alternatives evaluated, except for Alternative 1 (no action) are as follows:

- **Former Shipway Area Remediation** – Remove sandblast grit and CSL-contaminated sediments to the extent possible, place 3-foot cap of habitat mix, blend cap with PSR beach next to former shipway. Note: Under Alternative 3C Plus, the former shipway is dredged to the SQS instead of being capped.
- **Shoreline/Intertidal Remediation and Habitat Improvements** – Remove existing shoreline structures (such as debris piles, remaining derelict bulkhead, and some pilings), dredge and backfill shoreline slopes from edge of existing intertidal habitat (-10 MLLW) to landward edge of cleanup boundary at the top of mean high higher water (+11.3 feet MLLW) with the goal of no net loss of intertidal habitat.
- **ICs**:
  - Proprietary Controls (for alternatives that leave bank areas or sediment concentrations greater than Cleanup Levels), including environmental covenants pursuant to the Washington Uniform Environmental Convenants Act (UECA) to ensure the integrity of the remedy and guide management of any residual contamination that is disturbed or encountered in the event of future dredging or construction at the Site.
  - Informational Devices – Fish consumption advisories to reduce human exposure from consumption of contaminated seafood. There are no additional restrictions on fishing at the Site above and beyond what is already advised by the Elliott Bay advisory posted at the Site.
- **Sediment Disposal** – Transport dredged sediment via truck or rail for disposal at permitted upland landfill facility. Dispose of debris and pilings at an appropriate permitted facility.
- **Surface Water** – Surface water will be monitored during the remediation activities to ensure that short-term water impacts are not caused by cleanup actions addressing contaminated sediments (dredging, dredge water treatment and return). The remedy is not expected to meet the Federal AWQC for arsenic in surface water. Therefore, the EPA is issuing a technical impracticability (TI) waiver based on engineering feasibility because cleaning up contaminated sediments at this small, 40-acre Site would not likely improve the overall water quality for arsenic with the larger Elliott Bay, even though the source of contaminated sediments at this Site would be removed or covered. It is expected that arsenic concentrations in Elliot Bay, which range from 1.12 to 1.41 µg/L, would remain the same after implementation of any of the alternatives. All Site-related arsenic sources are or will be controlled after sediment remediation. Removal of additional arsenic in the water column would

require pumping and treating the water of Elliott Bay, which is not practicable. The TI waiver would apply only to AWQC exceedances at the Site and would not prevent the EPA or other regulatory agencies from taking source control or sediment cleanup actions related to AWQC exceedances.

- **Long-term Monitoring and Maintenance** – Post-construction monitoring and maintenance activities are required to ensure the long-term performance of the remedy and are specific to each alternative group. For the Containment-Focus alternatives, long-term monitoring and maintenance include periodic sampling, as well as provisions for cap replacement in the event of seismic or weather-related damages.

2.10.3.6 Thin Layer Cover/Enhanced Natural Recovery

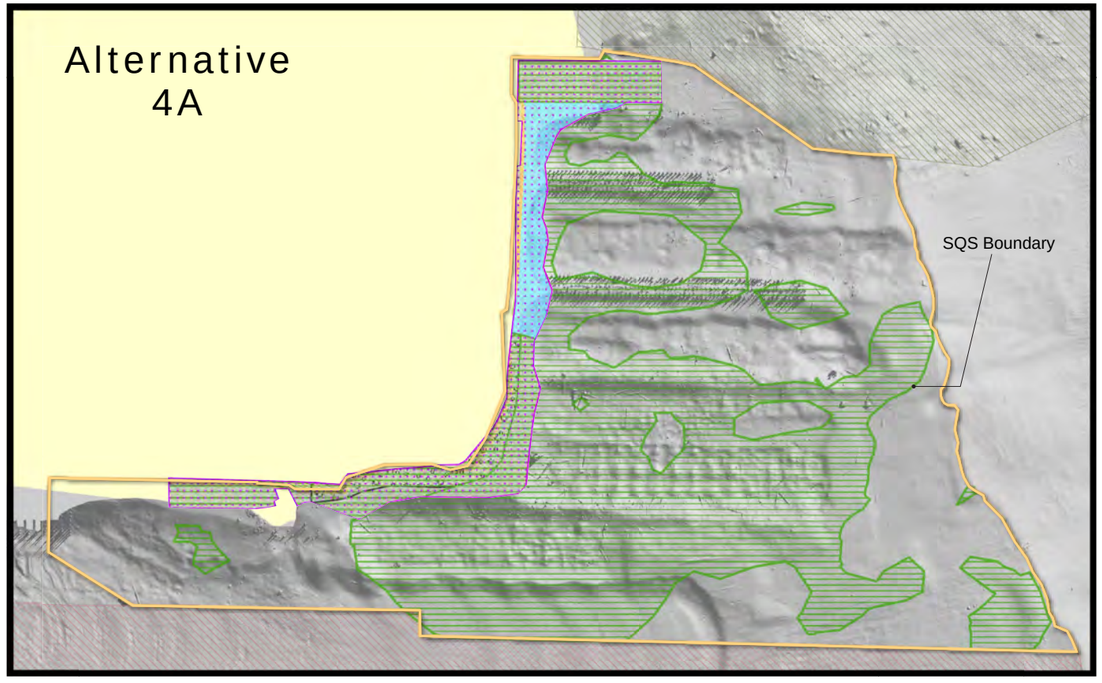
Many of the Containment-Focus and Partial Removal-Focus alternatives include placement of a 6- to 9-inch layer of clean imported backfill material to help settle and cover particulate residuals from dredging, support subtidal benthic organisms, and promote ENR. Application of the thin cover/ENR layer will result in a clean sediment surface that meets Site Cleanup Levels for all RAOs.

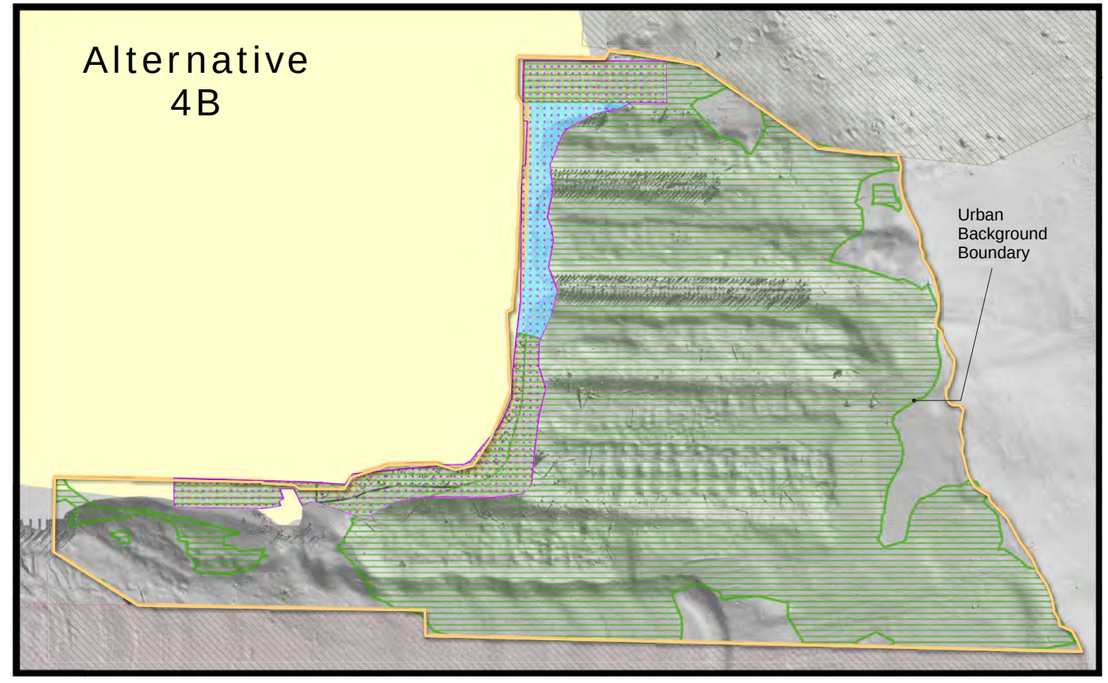
2.10.4 Key Applicable or Relevant and Appropriate Requirements

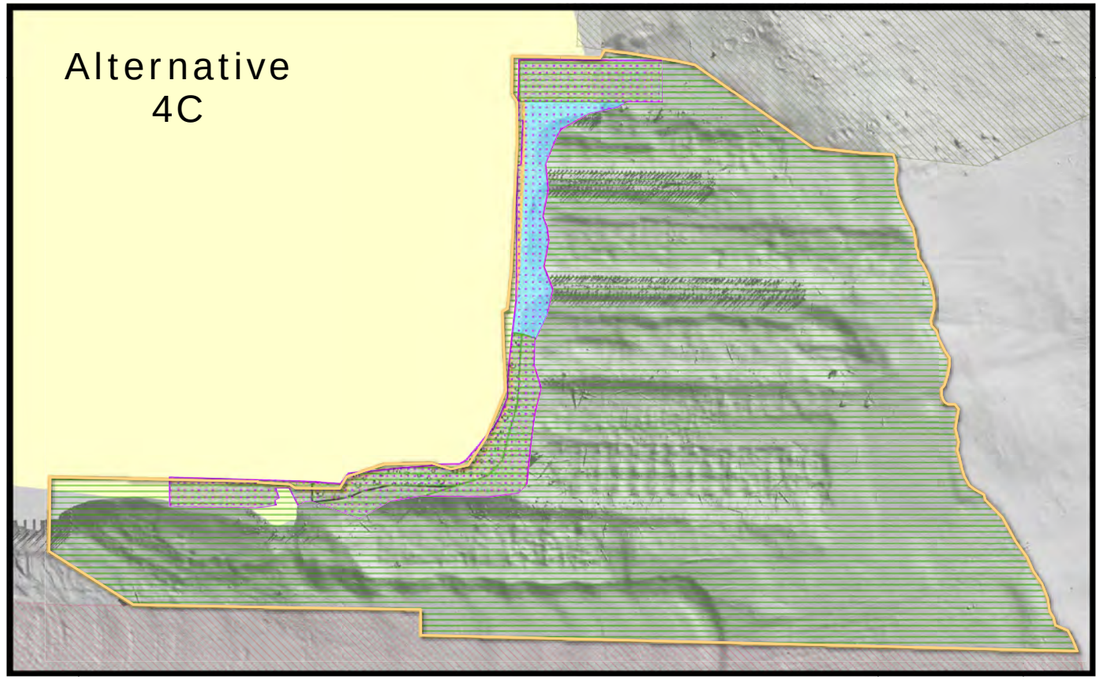
In addition to ensuring that human and ecological receptors are protected, actions to remediate a site must result in conditions that meet or waive ARARs, which are derived from promulgated Federal, or more stringent promulgated state standards. The identification of ARARs is an iterative process, which is complete with the preparation of the ROD. Table 18 provides a complete list of ARARs for the Site.

The key ARARs are the same for all alternatives, except Alternative 1 (no action). These ARARs include the MTCA excess cancer and noncarcinogenic risk standards and its default to natural background when RBTCs are more stringent than background, the SMS for sediment, Federal AQWC for surface water, and the ESA. To protect threatened species under the ESA, including Puget Sound Chinook salmon, environmental windows (or “fish windows”) have been established for Elliott Bay. These are designated periods (generally from October through February) when effects of in-water construction on spawning, rearing, and habitat are minimized, largely because juvenile salmon are not migrating through the area. The EPA will consult with the National Marine Fisheries Service to ensure protection of threatened salmon species.

All alternatives require a TI waiver of the Federal AWQC for arsenic based on engineering feasibility. As described in the TI waiver rationale memorandum (EPA, 2013), it is technically impracticable for remediation of contaminated sediments at this small, 40-acre Site to measurably improve the overall water quality for arsenic within the larger Elliott Bay, and there are no treatment technologies capable of surface water treatment for arsenic at the scale of Elliott Bay (approximately 5.42×10^{11} gallons, assuming no replenishment from Puget Sound). It is expected that arsenic concentrations in Elliott Bay would remain the same after Site cleanup. All Site-related arsenic sources are or will be controlled after sediment remediation. The TI waiver would apply only to AWQC exceedances at the Site and would not prevent the EPA or other regulatory agencies from taking actions related to AWQC exceedances.







LEGEND

- DREDGING/REMOVAL AREA
- ENR
- SHORELINE/SHIPWAY REMEDIATION AREA
- LOCKHEED WEST STUDY AREA BOUNDARY

N

0 125 250 500 Feet

Source: Adapted from Tetra Tech, May 2012, Final RI/FS.

Figure 16
Complete Removal Alternatives
Lockheed West Superfund Site
Seattle, WA

TABLE 17
Summary of Complete Removal-Focus Alternatives
Lockheed West Seattle Record of Decision

#	Alternative Description	Dredging and Thin Cover Extent			Common Elements
		Cleanup Levels	SQS	Urban Bkgd[a]	
4A	Complete removal to SQS boundary.		X		X
4B	Complete removal to Urban Background boundary.			X	X
4C	Complete removal to Cleanup Levels to Study Area boundary.	X			X*

*Proprietary Controls excluded for Alternative 4C

Common Elements:

- **Former Shipway Area Remediation** – Remove sandblast grit and contaminated sediments to the extent possible, place 3-foot cap with habitat mix, blend cap with PSR beach next to former shipway.
- **Shoreline/Intertidal Remediation and Habitat Improvements** – Remove existing shoreline structures (such as debris piles, remaining derelict bulkhead, and some pilings), dredge and backfill shoreline slopes from edge of existing intertidal habitat to landward edge of cleanup boundary with the goal of no net loss of intertidal habitat.
- **Disposal:**
  - Transport sediment via truck or rail for disposal at permitted upland landfill facility.
  - Dispose of debris and pilings at an appropriate permitted facility
- **Institutional Controls:**
  - Proprietary Controls (for alternatives that leave sediment concentrations greater than Cleanup Levels), including deed restrictions and restrictive covenants.
  - Informational Devices – Elliott Bay fish consumption advisories posted at the Site.
- **Surface Water** – Surface water will be monitored during the remediation activities to ensure that short-term water impacts are not caused by cleanup actions addressing contaminated sediments – dredging, dredge water treatment and return. The EPA would waive the surface water ARAR, the Federal ambient water quality criteria for arsenic through a technical impracticability waiver based on the fact that cleaning up contaminated sediments at this small 40-acre Site would not likely improve the water quality to a measurable extent with Elliott Bay even though the source of contaminated sediments at this Site would be removed or covered.
- **Long-term Monitoring** – Identification of activities to cover post-construction monitoring and maintenance activities that are required to ensure the long-term performance of the remedy and outline performance expectations and potential courses of action that should be taken based on construction confirmation sampling results, passage of time, influence of marine activities, or occurrence of natural phenomenon such as earthquakes or significant weather events.

[a] Although the Urban Background data are affected by point and nonpoint pollutant sources in Elliott Bay and are not representative of natural background (or CERCLA anthropogenic background), the data provide the general concentrations of sediments in Elliott Bay during Ecology's sampling in 2007 (Ecology, 2009a). The Urban Background concentrations are typically below the SQS concentrations but above the Cleanup Level concentrations. The use of the term "background" in this context does not connote (as "natural background" does) that these concentrations are acceptable or have any legal basis or standing and these sediments might also require cleanup in the future.

Notes:

ARAR = applicble or relevant and appropriate requirement
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
PSR = Pacific Sound Resources
SQS = sediment quality standards
Urban Bkgd = Urban Background

2.10.5 Long-term Reliability

The long-term reliability of all alternatives except Alternative 1 (no action) is high. Most of the alternatives have very low to low potential for re-exposure of underlying contaminated sediments. However, alternatives that rely primarily on containment have greater potential for re-exposure due to anchor drag and scour if ICs are not maintained. In addition, natural processes that lead to large-scale disturbances (for example, seismic events) could expose underlying contaminated sediments. Containment alternatives include provisions for cap replacement if either man-made or natural disturbance events take place and underlying contaminated sediment is exposed.

2.10.6 Waste Quantities

Table 18 provides a summary of alternative components including quantities and costs.

2.10.7 Design and Construction Time Frame

Most of the cleanup alternatives are expected to take 1 year to complete. Alternatives with more dredging are expected to take longer. Alternatives 3C and 3C Plus may take 1 to 2 years, Alternative 4A may take 3 years, Alternative 4B may take 6 years, and Alternative 4C may take 9 years to remove all the contaminated sediments. All in-water work will take place during the “fish window” established for Elliott Bay.

2.10.8 Estimated Costs

Table 19 provides a summary of alternative components including quantities and costs.

2.10.9 Expected Outcomes of Each Alternative

The expected outcome analysis is based on compatibility with future land use and other benefits or impacts associated with the different alternative remediation approaches. For the most part, future land use would be most strongly affected by implementation of all of the containment–focused alternatives and most of the partial removal-focused alternatives (Alternative 3C Plus is the exception), as these alternatives include installation of a conventional cap over some portion of the Site and require ICs to maintain the integrity of the cap. These ICs could include: posted no anchor areas, minimizing marine speeds and wakes, and modifying Coast Guard charts to indicate these restrictions. In addition, caps potentially obstruct future water-dependent uses (such as in a navigational channel), require the developer to coordinate its activities in the area of a cap with the EPA, require long-term maintenance and monitoring, and may need to be replaced in the event of a significant weather or seismic event. Also, the potentially responsible party would be required to compensate the Port and the DNR monetarily, because caps are not a beneficial water-dependent use and may impede or obstruct future water-dependent land use. In addition, capping results in contamination remaining in a Tribal U&A area, and the Tribes prefer that contamination be removed from the environment, with cap use eliminated or minimized.

The alternatives that rely on dredging and placement of a thin cover to manage dredge residuals and promote ENR have fewer impacts on future land use and Tribal preferences. However, all of the alternatives, except Alternative 4C (complete removal), require a UECA covenant to manage future Site disturbances, because some level of contamination relative to RAO-specific Cleanup Levels is left onsite. In addition, the DOH fish advisory for Elliott Bay, or a revised advisory as determined necessary by the EPA, is necessary for all the alternatives because the Cleanup Levels for PCBs, cPAHs, arsenic, lead, and dioxins/furans are based on natural background rather than RBTCs (which would allow unlimited human consumption of seafood).

TABLE 18
Applicable or Relevant and Appropriate Requirements (Page 1 of 2)
Lockheed West Seattle Record of Decision

Topic	Standard or Requirement	Regulatory Citation: Federal	Regulatory Citation: State or Local	Project-Specific Comments
Hazardous Waste Cleanup	Washington State cleanup standards		Washington State Model Toxics Control Act (RCW 70.105D; WAC 173-340)	MTCA is applicable or relevant and appropriate where the substantive requirements are more stringent than CERCLA and the NCP. The more stringent requirements of MTCA include, but are not limited to, acceptable excess cancer risk standards and the default to natural background for final remedies where risk-based threshold concentrations are below background.
Sediment Quality	Sediment quality standards, cleanup screening levels		Sediment Management Standards (WAC 173-204)	The SMS are a statutory requirement under MTCA and applicable or relevant and appropriate under CERCLA. Numerical standards for the protection of benthic marine invertebrates. Final remedy will meet requirements of the SMS. SQS of the SMS are the standard for protection of benthic invertebrates.
Surface Water Quality Standards	Surface water quality standards	Ambient Water Quality Criteria established under Sections 304(a) of the Clean Water Act (33 U.S.C. 1251et seq; , 40 CFR 131) http:// water,epa,gov/scitech/swguidance/ standards/criteria/current/index.cfm	Washington Water Pollution Control Act - State Water Quality Standards for Surface Water (RCW 90.48; WAC 173-201A)	State surface water quality standards are applicable where the state has adopted, and EPA has approved, Water Quality Standards (Aquatic Life Criteria), as are the National Toxics Rule standards. Federal-recommended Water Quality Criteria established under Section 304(a) of the Clean Water Act that are more stringent than state criteria and that are relevant and appropriate also apply. Both marine chronic and acute standards are used as appropriate.
Waste Treatment, Storage, and Disposal	Hazardous Waste Management	Resource Conservation and Recovery Act (42 U.S.C. 6901-6992K, 40 CFR 260-279, 265)	Washington State Dangerous Waste Regulations (RCW 70.105; WAC 173-303)	No known listed or chracteristic hazardous wastes are present at the Site. However, if such wastes are encountered during Site cleanup, portions of RCRA and Washington State Dangerous Waste Regulations related to hazardous waste determination and analytical testing, and onsite storage, treatment, and disposal may be ARARs to this project. State criteria for dangerous waste are applicable; Federal criteria may be relevant and appropriate.
Land Disposal of Waste	Management and disposal of materials containing PCBs	Toxic Substances Control Act (15 U.S.C. 2605; 40 CFR 761.61)	Washington State Dangerous Waste Regulations (RCW 70.105; WAC 173-303, 140, 141)	No known TSCA wastes are present at the Site. However, if such wastes are encountered during Site cleanup, disposal of PCBs may be applicable.
	Hazardous waste	Resource Conservation and Recovery Act Land Disposal Restrictions (42 U.S.C. 6901-6992K; 40 CFR 268)		No known listed or chracteristic hazardous wastes are present at the Site. However, if such wastes are encountered during Site cleanup, portions of RCRA and Washington State Dangerous Waste Regulations related to hazardous disposal would be applicable to this project. State dangerous waste is defined more broadly than Federal hzardous waste.
Solid Waste Disposal	Requirements for solid waste handling management and disposal	Solid Waste Disposal Act (42 U.S.C. 6901-6992K; 40 CFR 257-258)	Solid Waste Handling Standards (RCW 70.95; WAC 173-350)	Covers nonhazardous waste generated during remedial activities unless wastes meet recycling exemptions.
Dredge/Fill and Other In-water Construction Work	Discharge of dredged/fill material into navigable waters or wetlands	Clean Water Act (33 U.S.C. 1341, 1344, 40 CFR 121.2, 230, 231; 33 CFR 320, 322, 323) Rivers and Harbor Appropriations Act (33 U.S.C. 403)	Hydraulic Code Rules (RCW 77.65; WAC 220-110)	Requirements for in-water dredging, filling, or other in-water construction.
	Open-water disposal of dredged sediments	Marine Protection, Research and Sanctuaries Act (33 U.S.C. 1401-1445)	Dredged Materials Management Program (RCW 79.105.500; WAC 332-30-166 (3))	Regulates dumping of dredged material in open water.

TABLE 18
Applicable or Relevant and Appropriate Requirements (Page 2 of 2)
Lockheed West Seattle Record of Decision

Topic	Standard or Requirement	Regulatory Citation		Project-Specific Comments
		Federal	State or Local	
Discharge to Surface Water	Point source standards for new discharges to surface water	National Pollutant Discharge Elimination System 33 U.S.C. 1342 (40 CFR 122, 125)	Discharge Permit Program (RCW 90.48; WAC 173-216, 220, 226)	Remediation discharges must comply with substantive requirements of NPDES rules. If upland handling of sediment is planned, construction stormwater requirements will be addressed including development of a stormwater pollution prevention plan and implementation of best management practices. NPDES program requirements will be reviewed as part of project final design.
Shoreline	Construction and development	Coastal Zone Management Act (16 U.S.C. 1451 *et seq*.)	Shoreline Management Act (WAC 173-16)	These regulations are applicable to construction activities within 200 feet of the shoreline.
Habitat for Fish, Plants, or Birds	Conserve endangered or threatened species, consult with species listing agencies, evaluate and mitigate habitat impacts	Clean Water Act Section 404 (b)(1)) Endangered Species Act of 1973 (16 USC 1531 *et seq*.; 50 CFR 17, 222-224, 226.212 to 402 402); Magnuson-Stevens Fishery Conservation and Management Act (16 USC 1801-1884) Migratory Bird Treaty Act (16 U.S.C. 703-712) and 50 CFR 10, 17 Eagle Protection Act 16 U.S.C. 668, 50 CFR 22	City of Seattle Master Plan Seattle Municipal Code 23.60	Habitat mitigation will be assessed and addressed in the remedial design if necessary. Mitigation requirements will be defined in remedial design and vary with the type of work conducted if necessary. Consult and obtain Biological Opinions.

Notes:
ARAR = applicable or relevant and appropriate requirement
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CFR = Code of Federal Regulations
MTCA =Model Toxics Control Act
NCP = National Contingency Plan
NPDES = National Pollutant Discharge Elimination System
PCB = polychlorinated biphenyl
RCRA = Resource Conservation and Recovery Act
RCW = Revised Code of Washington
SMS = sediment management standards
SQS = sediment quality standards
TSCA = Toxic Substances Control Act
U.S.C. = United States Code
WAC = Washington Administrative Code

TABLE 19

Summary of Alternative Quantities and Costs (Page 1 of 2)

Lockheed West Seattle Record of Decision

#	Alternative Description*	Cap Area (acres)	Thin Cover/ ENR Area (acres)	Dredging Area (acres)	Estimated Cost		
					Capital (MM)	ICs and LTM (MM)	NPV Total Cost (MM)
1	No action	0	0	0	$0	$0	$0
2A1	Conventional capping over the CSL footprint and thin cover/ENR over the remaining SQS footprint.	10.3	7.7	0	$11.0	$6.0	$17.0
2A2a	Conventional capping over the CSL footprint and thin cover/ENR over the remaining Urban Background footprint.	10.3	19.7	0	$12.7	$6.1	$18.7
2A2a Plus	Variant of Alternative 2A2a; adds dredging sediment above the SQS in the navigational channel in the West Waterway, and application of thin cover/ENR to the Study Area boundary.	7	27.6	5.4	$31.1	$4.7	$35.8
2A2b	Conventional capping over the SQS footprints and thin cover/ENR over the remaining Urban Background footprint.	18	12	0	$15.8	$9.2	$25.0
2A3	Conventional capping over the CSL footprint and thin cover/ENR over the remaining Study Area footprint.	10.3	29.7	0	$14.1	$6.1	$20.2
2A4a	Conventional capping over the SQS footprint.	18	0	0	$14.0	$8.4	$22.4
2A4b	Conventional capping over the Urban Background footprint.	30	0	0	$20.3	$13.7	$34.1
2A4c	Conventional capping over the Study Area footprint.	40	0	0	$25.7	$18.1	$43.8
2B	Capping surface sediments over the CSL footprint and removal of sediments within the capping footprint to maintain bathymetry. Thin cover/ENR over the remaining Study Area footprint.	10.3	29.7	10.3	$27.4	$5.8	$33.3
3A1	Remove up to 3 feet of sediment over the CSL footprint, conventional cap where exposed residual concentrations are between the SQS and CSL, and thin cover/ENR over the remaining Urban Background footprint.	5.4	19.7	10.3	$24.8	$4.1	$28.9
3A2	Remove up to 3 feet of sediment over the SQS footprint, conventional cap where exposed residual concentrations are between the SQS and CSL, and thin cover/ENR over remaining Urban Background footprint.	5.4	12	18	$43.4	$4.0	$47.5
3A2 Plus	Variant of 3A2; includes all of the 3A2 elements, plus dredging all sediment above the SQS in the navigational channel in West Waterway, and extending thin cover/ENR to the Study Area boundary.	4.4	17.6	18	$52.7	$3.1	$55.8
3B	Remove sediments over CSL within the former Dry Dock 1 (entire depth), conventional capping over the remaining CSL footprint, and thin cover/ENR over the remaining Urban Background footprint.	6.3	19.7	4 (Dry Dock 1)	$33.0	$4.4	$37.5
3C	Remove sediments over CSL within all of the former dry dock areas (entire depth), conventional capping over the remaining CSL footprint, and thin cover/ENR to the Urban Background footprint.	1.3	18.4	10.3 (Dry Docks 1, 2, 3)	$44.5	$2.4	$47

TABLE 19
Summary of Alternative Quantities and Costs (Page 2 of 2)
Lockheed West Seattle Record of Decision

#	Alternative Description*	Cap Area (acres)	Thin Cover/ ENR Area (acres)	Dredging Area (acres)	Estimated Cost		
					Capital (MM)	ICs and LTM (MM)	NPV Total Cost (MM)
3C Plus*	Variant of 3C; removes sediments over CSL within all of the former dry dock areas (entire depth), dredge remaining CSL footprint, dredge sediment above the SQS in the navigational channel in West Waterway and the former shipway area, remove pilings from former shipway area, and extend thin cover/ENR to the Study Area boundary.	0	28.4	11.6	$47.7	$0.5	$48.1
4A	Complete removal to SQS boundary.	0	0	18	$92.0	$0.3	$92.3
4B	Complete removal to Urban Background boundary.	0	0	30	$203.8	$0.3	$204.0
4C	Complete removal to Cleanup Levels to Study Area boundary.	0	0	40	$302.8	$0	$302.8

***Alternatives 2A1 through 4C include the following common elements (exceptions noted):**

- **Former Shipway Area Remediation** – Remove sandblast grit and CSL-contaminated sediments (approximately 700 CY) to the extent possible, place 3-foot cap with habitat mix, blend cap with PSR beach next to former shipway. Note: Alternative 3C Plus removes all sediments with concentrations above SQS.
- **Shoreline/Intertidal Remediation and Habitat Improvements** – Remove existing shoreline structures (such as debris piles, remaining derelict bulkhead, and some pilings), dredge (approximately 9,300 CY) and backfill shoreline slopes from edge of existing intertidal habitat to landward edge of cleanup boundary with the goal of no net loss of intertidal habitat.
- **Disposal:**
  - Transport sediment via truck or rail for disposal at permitted upland landfill facility.
  - Dispose of debris and pilings at an appropriate permitted facility.
- **Institutional Controls (excluded for Alternative 4C)**:
  - Proprietary Controls, including deed restrictions and restrictive covenants.
  - Informational Devices – Elliott Bay fish consumption advisories posted at the Site.
- **Surface Water** – Surface water will be monitored during the remediation activities to ensure that short-term water impacts are not caused by cleanup actions addressing contaminated sediments (dredging, dredge water treatment and return). The EPA would waive the surface water ARAR, the Federal ambient water quality criteria for arsenic through a technical impracticability waiver based on the fact that cleaning up contaminated sediments at this small 40-acre Site would not likely improve the water quality to a measurable extent with Elliott Bay even though the source of contaminated sediments at this Site would be removed or covered.
- **Long-term Operations and Maintenance** – Identification of activities to cover post-construction monitoring and maintenance activities that are required to ensure the long-term performance of the remedy and outline performance expectations and potential courses of action that should be taken based on sampling results, passage of time, influence of marine activities or occurrence of natural phenomenon such as earthquakes or significant weather events.

Notes:

ARAR = applicable or relevant and appropriate requirement
CSL = cleanup screening level
CY = cubic yard(s)
IC = institutional control
MM = million
NPV = net present value (3% discount rate applied)
LTM = long-term monitoring
PSR = Pacific Sound Resources
SQS = sediment quality standards

2.11 Comparative Analysis of Alternatives

This section of the ROD summarizes the comparative analysis of alternatives presented in the Lockheed West RI/FS (Tetra Tech, 2012). The major objective of the analysis was to evaluate the relative performance of the alternatives with respect to the nine evaluation criteria described in Section 121(b) of CERCLA and NCP 40 CFR 300.430(f)(5)(i), so that the advantages and disadvantages of each alternative are clearly understood. The nine CERCLA evaluation criteria are as follows:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and performance
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

The first two criteria, overall protection and compliance with ARARs, are defined under CERCLA as "threshold criteria." Threshold criteria must be met for an alternative to be eligible for selection. The next five criteria are defined as "primary balancing criteria" and are used to weigh major trade-offs among alternatives. The last two criteria, state acceptance and community acceptance, are defined as "modifying criteria." In the final comparison of alternatives to select a remedy, both balancing criteria and modifying criteria are considered. Table 20 summarizes the comparative analysis.

2.11.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or ICs.

All of the alternatives except Alternative 1 (no action) would provide protection of human health and the environment by eliminating, minimizing, or controlling risk through engineering controls and/or ICs. All of the alternatives would require ICs.

Alternatives that include active remediation to the Site boundary and ICs would meet the Cleanup Levels for RAO 1 at the surface (0 to 45 cm in intertidal sediments and 0 to 10 cm in subtidal sediment) at the completion of remediation. A fish advisory IC to limit the number of fish meals eaten per week would still be required because the natural backround-based Cleanup Level for PCBs is higher than the modelled RBTC for sediment that allows for unrestricted consumption of fish and shellfish (Windward, 2010). RAO 2 is met by removing contaminated sediments in the intertidal area and placing clean backfill to eliminate direct contact and incidental ingestion of impacted sediments. Ecological RAOs (RAOs 3 and 4) are met by all alternatives that use Cleanup Level or SQS as the basis for removal, capping, or covering surficial sediments. RAO 4 also is met by eliminating or reducing crab, fish, and sandpiper exposure to Site contaminants in the top 10 cm of sediment throughout the Site. The risk levels associated with acheivement of each RAO are listed on Table 13.

Partial Removal and Complete Removal alternatives result in less subsurface contamination after remediation. These alternatives achieve greater long-term effectiveness and permanence because a reduction in the quantity of subsurface contamination naturally reduces the risk of disruption and

redistribution of residual sediment. Containment alternatives leave higher concentrations of subsurface contamination in place, which could result in recontamination of the surface sediments. All of the alternatives requiring capping include long-term maintenance and monitoring and ICs to ensure the cap stays in place, as well as provisions to replace the cap in the event it is damaged during the long-term monitoring period.

Most of the Containment and Partial Removal alternatives include placing a thin layer (6 to 9 inches) of clean backfill over contaminated sediments to promote ENR. This cover represents an active remedy, addressing areas with relatively low concentrations of contaminants (areas with concentrations exceeding Cleanup Levels but generally below the SQS RAL). Placing this thin cover/ENR layer in such areas and extending it to the Site boundary is a more protective remedial approach because it eliminates direct exposure in areas with low levels of contamination. Alternatives that extend the thin cover/ENR layer to the Urban Background boundary are less protective because contaminant concentrations between the Cleanup Level and Urban Background RAL concentrations are still exposed.

2.11.2 Compliance with Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA and NCP Section 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations upon completion of remedial action, unless such ARARs are waived under CERCLA Section 121(d)(4).

The ARAR for human seafood consumption (RAO 1) is MTCA. This ARAR would be met by seven alternatives (2A2a Plus, 2A3, 2A4c, 2B, 3A2 Plus, 3C Plus, and 4C) , in which contaminated sediments are completely removed, sequestered by a conventional sediment cap, and/or covered by thin cover/ENR layer combinations that extend to the Site boundary, thereby resulting in surface sediment concentrations that would not contribute to seafood contaminantion above RBTCs or natural background.

The ARAR for human contact with sediment (RAO 2) is also MTCA. This ARAR would be met by all alternatives that achieve RAO 1 Cleanup Levels and by all alternatives that meet RBTCs for beach play, net fishing, and clamming. Alternative 2A4a (capping to the SQS) is the only alternative that would not meet the Cleanup Levels for RAO 2.

The ARAR for protection of benthos (RAO 3) is the SMS. Accordingly, the RAO 3 Cleanup Levels should be as close as practicable to the SQS, but in no case should exceed the minimum cleanup level, which is the CSL. All of the alternatives which result in sediment concentrations that meet the SQS and the CSL on a point by point basis would acheive this ARAR.

Protection for other ecological receptors, such as crabs, birds, and fish (RAO 4), is a requirement of the NCP. Section 300.430(e)(2)(i) states that remediation goals (or Cleanup Levels) are to be established to acceptable exposure levels that are protective of human health and the environment. Section 300.430(e)(2)(i)(G) states that environmental evaluations shall be performed to assess threats to the environment, especially sensitive habitats and critical species protected by the EPA. The development of RBTCs for ecological receptors, other than benthic invertebrates, is based on guidance issued by the EPA under CERCLA and the NCP. Alternatives that reduce the HQs for crabs, fish, and birds to protective levels based on an HQ less than 1 would meet RAO 4. Accordingly, all of the alternatives except Alternatives 1 and 2A1 meet the Cleanup Levels for RAO 4.

TABLE 20
Summary of Criteria Comparisons for Remedial Action Alternatives (Page 1 of 3)
Lockheed West Seattle Record of Decision

Alternative	Description	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Costs (Total MM$)
1	No action	— Does not provide adequate protection to human health and the environment.	— Does not comply with ARARs.	— Largest amount of surface and subsurface contamination and greatest potential for exposure, no monitoring /maintenance, no ICs.	— No treatment	+ No short-term impacts, but contamination remains above protective levels.	+ No construction period, no potential for technical/administrative difficulties and schedule delays.	**$0**
2A1	Conventional capping over the area defined by the CSL footprint and thin layer cover/ENR over the remaining area to the SQS footprint.	✔ Adequate overall protection to human health and the environment, partially achieves some Cleanup Levels, ICs required.	— Does not comply with Cleanup Level ARARs for RAO 1 and RAO 4. TI waiver required for AWQC.	✔ Low to moderate potential for re-exposure, monitoring and maintenance of cap required, moderate ICs.	— No treatment	+ Low short-term impacts during construction.	+ Short construction period. Low potential for technical/administrative difficulties and schedule delays.	**$17**
2A2a	Conventional capping over the areas defined by the CSL footprint and thin layer cover/ENR over the remaining area to the Urban Background footprint.	+ Adequate overall protection to human health and the environment, fully achieves Cleanup Levels, ICs required.	— Does not comply with Cleanup Level ARAR for RAO 1. TI waiver required for AWQC.	✔ Low to moderate potential for re-exposure, monitoring and maintenance of cap required, moderate ICs.	— No treatment	+ Low short-term impacts during construction.	+ Short construction period. Low potential for technical/administrative difficulties and schedule delays.	**$18.7**
2A2a Plus	Variant of Alternative 2A2a; adds dredging sediment with concentrations above the SQS in the navigational channel in the West Waterway, and application of thin layer cover/ENR to the Study Area boundary.	+ Adequate overall protection to human health and the environment, fully achieves Cleanup Levels, ICs required.	+ Complies with ARARs. TI waiver required for AWQC.	✔ Low to moderate potential for re-exposure, monitoring and maintenance of cap required, moderate ICs.	— No treatment	+ Low short-term impacts during construction.	+ Short construction period. Low potential for technical/administrative difficulties and schedule delays.	**$35.8**
2A2b	Conventional capping over the areas defined by the risk-drivers to the SQS footprint and thin layer cover/ENR over the remaining area to the Urban Background footprint.	+ Adequate overall protection to human health and the environment, fully achieves Cleanup Levels, ICs required.	— Does not comply with Cleanup Level ARARs for RAO 1. TI waiver required for AWQC.	✔ Low potential for re-exposure, monitoring and maintenance of cap required, moderate ICs.	— No treatment	+ Low short-term impacts during construction.	+ Short construction period. Low potential for technical/administrative difficulties and schedule delays.	**$25**
2A3	Conventional capping over the area defined by the CSL footprint and thin layer cover/ENR over the remaining area to the Study Area boundary.	+ Adequate overall protection to human health and the environments, fully achieves Cleanup Levels, ICs required.	+ Complies with ARARs. TI waiver required for AWQC.	✔ Low to moderate potential for re-exposure, monitoring and maintenance of cap required, moderate ICs.	— No treatment	+ Low short-term impacts during construction.	+ Short construction period. Low potential for technical/administrative difficulties and schedule delays.	**20.2**
2A4a	Conventional capping to the SQS footprint.	✔ Adequate overall protection to human health and the environment, partially achieves some Cleanup Levels, ICs required.	— Does not comply with Cleanup Level ARARs for RAO 1 or RAO 4. TI waiver required for AWQC.	✔ Low potential for re-exposure, monitoring and maintenance of cap required, moderate ICs.	— No treatment	+ Low short-term impacts during construction.	+ Short construction period. Low potential for technical/administrative difficulties and schedule delays.	**$22.4**
2A4b	Conventional capping to the Urban Background footprint.	+ Adequate overall protection to human health and the environment, fully achieves Cleanup Levels, ICs required.	— Does not comply with Cleanup Level ARARs for RAO 1. TI waiver required for AWQC.	✔ Low potential for re-exposure, monitoring and maintenance of cap required, moderate ICs.	— No treatment	✔ Moderate short-term impacts during construction.	+ Short construction period. Low potential for technical/administrative difficulties and schedule delays.	**$34.1**

TABLE 20
Summary of Criteria Comparisons for Remedial Action Alternatives (Page 2 of 3)
Lockheed West Seattle Record of Decision

Alternative	Description	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Costs (Total MM$)
2A4c	Conventional capping to the Study Area boundary footprint.	+ Adequate overall protection to human health and the environment, fully achieves Cleanup Levels, ICs required.	+ Complies with ARARs. TI waiver required for AWQC.	✔ Very low potential for re-exposure, monitoring and maintenance of cap required, moderate ICs.	— No treatment	✔ Moderate short-term impacts during construction.	+ Short construction period. Low potential for technical/administrative difficulties and schedule delays.	**$43.8**
2B	Capping surface sediments in areas above the CSL footprint and removal of sediments within the capping footprint to maintain bathymetry. Thin layer cover/ENR applied in remaining areas to the Study Area boundary.	+ Adequate overall protection to human health and the environment, fully achieves Cleanup Levels, ICs required.	+ Complies with ARARs. TI waiver required for AWQC.	✔ Low to moderate potential for re-exposure, monitoring and maintenance of cap required, moderate ICs	— No treatment	✔ Moderate short-term impacts during construction.	✔ Short construction period. Moderate potential for technical/ administrative difficulties and schedule delays.	**$33.3**
3A1	Remove 3 feet of sediment over the CSL footprint, conventional cap where exposed residual concentrations are between the SQS and CSL, and thin layer cover/ENR to Urban Background footprint.	+ Adequate overall protection to human health and the environment, fully achieves Cleanup Levels, ICs required.	— Does not comply with Cleanup Level ARARs for RAO 1. TI waiver required for AWQC.	✔ Low to moderate potential for re-exposure, monitoring and maintenance of cap required, moderate ICs.	— No treatment	✔ Moderate short-term impacts during construction.	✔ Short construction period. Moderate potential for technical/ administrative difficulties and schedule delays.	**$28.9**
3A2	Remove 3 feet of sediment over the SQS footprint, conventional cap where exposed residual surface concentrations are between the SQS and CSL, and thin layer cover/ENR to Urban Background footprint.	+ Adequate overall protection to human health and the environment, fully achieves Cleanup Levels, ICs required.	— Does not comply with Cleanup Level ARARs for RAO 1. TI waiver required for AWQC.	✔ Low potential for re-exposure, monitoring and maintenance of cap required, moderate ICs.	— No treatment	✔ Moderate short-term impacts during construction.	✔ Short construction period. Moderate potential for technical/ administrative difficulties and schedule delays.	**$47.5**
3A2 Plus	Variant of 3A2; includes all of the 3A2 elements, plus dredging all sediment with concentrations above the SQS in the navigational channel in West Waterway, and extending thin layer cover/ENR area to the Study Area boundary.	+ Adequate overall protection to human health and the environment, fully achieves Cleanup Levels, ICs required.	+ Complies with ARARs. TI waiver required for AWQC.	✔ Low potential for re-exposure, monitoring and maintenance of cap required, moderate ICs.	— No treatment	✔ Moderate short-term impacts during construction.	✔ Short construction period. Moderate potential for technical/ administrative difficulties and schedule delays.	**$55.8**
3B	Remove sediments over CSL within the former Dry Dock 1 (entire depth), conventional capping over the remaining CSL footprint, and thin layer cover/ENR to the Urban Background footprint.	+ Adequate overall protection to human health and the environment, fully achieves Cleanup Levels, ICs required.	— Does not comply with Cleanup Level ARARs for RAO 1. TI waiver required for AWQC.	✔ Low to moderate potential for re-exposure, monitoring and maintenance of cap required, moderate ICs.	— No treatment	✔ Moderate short-term impacts during construction.	✔ Short construction period. Moderate potential for technical/ administrative difficulties and schedule delays.	**$37.5**

TABLE 20
Summary of Criteria Comparisons for Remedial Action Alternatives (Page 3 of 3)
Lockheed West Seattle Record of Decision

Alternative	Description	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Costs (Total MM$)
3C	Remove sediments over CSL within all of the former Dry Dock areas (entire depth), conventional capping over the remaining CSL footprint, and thin layer cover/ENR to the Urban Background footprint.	+ Adequate overall protection to human health and the environment, fully achieves Cleanup Levels, ICs required.	— Does not comply with Cleanup Level ARARs for RAO 1. TI waiver required for AWQC.	✔ Low to moderate potential for re-exposure, monitoring and maintenance of small cap required, minimal ICs.	— No treatment	✔ Moderate short-term impacts during construction.	✔ Moderate construction period. Moderate potential for technical/ administrative difficulties and schedule delays.	**$47**
3C Plus	Variant of 3C; includes all of the 3C elements, plus dredging all sediment with concentrations above the SQS in the navigational channel in West Waterway and the former shipway area, removing pilings from former shipway area, and extending thin layer cover/ENR area to the Study Area boundary.	+ Adequate overall protection to human health and the environment, fully achieves Cleanup Levels, ICs required.	+ Complies with ARARs. TI waiver required for AWQC.	+ Low potential for re-exposure, no monitoring/maintenance of cap, minimal ICs.	— No treatment	✔ Moderate short-term impacts during construction.	✔ Moderate construction period. Moderate potential for technical/ administrative difficulties and schedule delays.	**$48.1**
4A	Complete removal to SQS surface sediment footprint.	+ Adequate overall protection to human health and the environment, fully achieves Cleanup Levels, ICs required.	— Does not comply with Cleanup Level ARARs for RAO 1. TI waiver required for AWQC.	+ Very low potential for re-exposure, no monitoring/maintenance of cap, minimal ICs.	— No treatment	— High short-term impacts during construction and longer time to achieve RAOs.	✔ Moderate construction period. Moderate potential for technical/ administrative difficulties and schedule delays.	**$92.3**
4B	Complete removal to Urban Background surface sediment footprint.	+ Adequate overall protection to human health and the environment, fully achieves Cleanup Levels, ICs required.	— Does not comply with Cleanup Level ARARs for RAO 1. TI waiver required for AWQC.	+ Very low potential for re-exposure, no monitoring/maintenance of cap, minimal ICs.	— No treatment	— High short-term impacts during construction and longer time to achieve RAOs.	— Long construction period. High potential for technical/ administrative difficulties and schedule delays.	**$204**
4C	Complete removal to Cleanup Levels to Study Area boundary.	+ Adequate overall protection to human health and the environment, fully achieves Cleanup Levels, ICs required.	+ Complies with ARARs. TI waiver required for AWQC.	+ No potential for re-exposure, no monitoring/maintenance of cap, minimal ICs.	— No treatment	— High short-term impacts during construction and longer time to achieve RAOs.	— Long construction period. High potential for technical/ administrative difficulties and schedule delays.	**$302.8**

Notes:

Adapted from RI/FS Report Tables 13-1 and 13-2 (Tetra Tech, 2012)

Selected Remedy

Rating Key: — = Low ✔ = Moderate + = High

ARAR = applicable or relevant and appropriate requirement
AWQC = ambient water quality criteria
CSL = cleanup screening level
ENR = enhanced natural recovery
IC = institutional control
RAO = remedial action objective
SQS = sediment quality standards
TI = technical impracticability

All alternatives require a TI waiver of the Federal AWQC for arsenic based on engineering feasibility. As described in the TI waiver rationale memorandum (EPA, 2013), it is technically impracticable for remediation of contaminated sediments at this small, 40-acre Site to measurably improve the overall water quality for arsenic within the larger Elliott Bay; and there are no treatment technologies capable of surface water treatment for arsenic at the scale of Elliott Bay (approximately 5.42×10^{11} gallons, assuming no replenishment from Puget Sound). It is expected that arsenic concentrations in Elliott Bay would remain the same after Site cleanup. All Site-related arsenic sources are or will be controlled after sediment remediation. The TI waiver would apply only to AWQC exceedances at the Site and would not prevent the EPA or other regulatory agencies from taking actions related to AWQC exceedances.

The remaining location- and action-specific ARARs listed in Table 18 are similar for all alternatives, except for Alternative 1 (no action).

2.11.3 Long-term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met. The criterion includes the consideration of residual risk that will remain onsite following remediation and adequacy and reliability of controls.

Partial Removal and Complete Removal alternatives are more effective and permanent than alternatives that rely only on containment alone, because sediment contamination is physically removed from the Site. Remedies that rely on dredging, capping, and thin cover/ENR layer placement to the Study Area boundary are the most effective in the long term. These remedies are Alternatives 2A2a Plus, 2A3, 2A4c, 2B, 3A2 Plus, 3C Plus, and 4C. Remedies that include more dredging are more permanent cleanup alternatives because the sediment contamination in the dredged areas is removed permanently.

Of the Partial Removal and Complete Removal alternatives, Alternative 4C achieves the most long-term effectiveness and permanence, because all of the sediment contamination greater than the Cleanup Levels would be removed from the Site (entire Study Area AOPA). Alternative 3B, which removes contaminated sediment to the CSL RAL only in Dry Dock 1, and includes conventional capping, and thin cover/ENR layer placement through the rest of the Study Area AOPA, is the least protective. Alternatives 3A2, 3A2 Plus, 3C Plus, 4A, and 4B remove contamination to the SQS RAL in all or portions of the Site, and would result in a more permanent remedy than Containment and combination Removal and Containment alternatives. Any alternative that leaves sediment concentrations in excess of the Cleanup Levels requires (1) proprietary ICs that run with the property, and (2) coordination with the EPA for any future disturbance (for example, excavation or dredging) in the cleanup area.

The next most effective and permanent alternatives include combinations of dredging and containment with at least 3 feet of cap material to contain remaining contaminated sediments (Alternatives 2A2a Plus, 2B, 3A1, 3A2, 3A2 Plus, 3B, and 3C). Containment is proven to be effective and permanent accompanied by ICs that prohibit activities that may damage or compromise the cap (for example, anchor drag or scour). In addition, all alternatives with caps include provisions for cap replacement following seismic or other erosive events that disturb the cap. Of the combination alternatives, Alternative 3A2 has the largest area/volume of dredging (3 feet of dredging in all areas exceeding the SQS RAL) and capping of the remaining areas with concentrations between the SQS and CSL RALs. Alternative 3B has the smallest volume/area of dredging (3 feet of dredging in Dry Dock 1 only) and capping of the remainder of the CSL AOPA.

Cleanup alternatives that rely on containment alone can also be effective and permanent in the long term when combined with long-term monitoring and ICs. The most effective and permanent alternative

that relies solely on containment is 2A4c, which caps the entire Study Area AOPA. Alternative 2A4b is the next most protective Containment alternative. It requires capping to the Urban Background boundary. Containment alternatives that isolate only the CSL AOPA are less effective because sediment concentrations between the SQS and CSL are not sequestered. Consequently, sediment concentrations in excess of the SQS are left onsite, and these concentrations are known to have potential adverse effects to benthic invertebrates (including clams).

Any alternative that leaves sediment concentrations greater than Cleanup Levels at depth (only Alternative 4C does not) allows for the possibility of redistribution of subsurface contaminants into surface sediment. However, such redistribution is only possible through uncontrolled human disturbance or significant seismic or weather events.

Contaminants left in place beneath a thin cover/ENR layer have a greater potential for re-exposure (versus a capped area) because this remedial measure is not engineered to ensure isolation and containment of buried contaminated sediments. Instead, this approach anticipates that clean material will stay largely in place or will mix naturally with underlying sediments through bioturbation, natural movement of sediments, or human activities such as anchorings. The potential for contaminated sediment to be exposed by scour or future uncontrolled human disturbance is greater in thin cover/ENR areas than in capped areas because the cover layer is thinner. For this reason, thin cover/ENR layer placement is used only in portions of the Site with lower surface sediment concentrations.

All of the cleanup remedies considered for the Site can be monitored. All the alternatives include posting of the Elliott Bay fish advisory signs along the shore of the Site. There are no additional restrictrions for fish consumption at the Site beyond those in the Elliott Bay advisory.

2.11.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume (TMV) through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

Reduction of TMV through treatment will not occur with any of the alternatives because treatment would not be utilized. None of the alternatives evaluated rely on treatment due to the complexities of treating multiple types of contamination (metals, PCBs, dioxin/furans, TBT, and cPAHs) at relatively low concentrations. A multi-step treatment train would be necessary and also would result in residuals that would require offsite upland disposal in an appropriate facility. Consequently, treatment was eliminated as a possible component of remedial action alternatives in the technology screening portion of the RI/FS (Tetra Tech, 2012). Reduction of TMV comes soley from dredging contaminated sediments, disposing them in an upland landfill facility, and covering the remaining Site with clean sediments.

2.11.5 Short-term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy until cleanup levels are achieved.

Short-term impacts associated with the cleanup alternatives may include traffic, noise, air emissions, habitat disturbance, sediment recontamination from dredge residuals, and elevated fish tissue concentrations during implementation of the cleanup. Local transportation impacts (traffic, noise, air pollution) from implementation of these alternatives are proportional to the amount of dredged or capping fill and cover materials that have to be transported primarily by road and rail, and to a lesser extent by barge. Among the technologies evaluated, dredging has the highest potential for short-term impacts because it takes longer to implement than other technologies, requires transportation of

sediments to a landfill, and creates more disturbance of contaminated subsurface sediments and dredge residuals. Short-term impacts identified in the RI/FS will be evaluated further during remedial design, and efforts will be made to mitigate them and otherwise enhance the environmental benefits of the remedy consistent with CERCLA, the NCP, and EPA Region 10's green and sustainable remediation (GSR) policy. For example, impacts due to construction will be reduced to the extent possible using best management practices and performing in-water work when threatened juvenile salmon are not migrating. Dredging often leaves residual contamination behind. This will be managed by selecting appropriate dredging techniques and placing a thin cover/ENR layer after dredging.

Alternatives that include removal of contaminated sediment (Alternatives 2A2a Plus, 3A1, 3A2, 3A2 Plus, 3B, 3C, 3C Plus, 4A, 4B, and 4C) require longer construction times and create larger amounts of contaminated materials that need to be handled and disposed. As a result, these remedies pose proportionately larger risks to workers, the community, and the environment. Dredging also may redistribute contaminated dredge material to nearby sediments and to the water column in the form of dredge residuals. The longer construction periods for these alternatives also increase impacts from equipment and vehicle emissions and congestion, noise, and resource disruption and consumption, even when implementing GSR policies. The duration of each alternative assumes that in-water work will only be conducted during the "fish-window" (generally October though February).

Containment-only alternatives (Alternatives 2A1, 2A2, 2A2b, 2A3, 2A4a, 2A4b, and 2A4c) have low to moderate short-term risks and cause fewer greenhouse gas emissions and particulate matter of 10 microns in diameter (PM_{10}), use less fuel, do not use any landfill capacity, and pose fewer risks to workers because the cleanup time is shorter. However, they do use more capping material than the dredging-only alternatives and require more material to be delivered, handled, and placed onsite. Typically this material is transported by barge. Combination Removal and Containment alternatives (Alternatives 2A2a Plus, 2B, 3A1, 3A2, 3A2 Plus, 3B, and 3C) have moderate short-term risks based on the amount of fuel needed forremedial activities, local transportaton issues, carbon footprint and PM_{10} emissions, and landfill space.

Larger active remediation areas (measured in acres capped or dredged or depth of sediments dredged) increase the short-term disturbance of the existing benthic community and other resident aquatic life and can potentially cause releases of bioavailable contaminants over a longer period of time. Alternatives 4A, 4B, and 4C dredge the most contaminated sediments and would result in the highest short-term risks to workers and benthos and greater potential for dredge residuals. These alternatives also create the most greenhouse gas emissions and PM_{10}, consume the most fuel, and need the most landfill capacity, even when implementing GSR policies. These alternatives would take 3 to 9 years to implement.

Containment alternatives have fewer short-term impacts to the community than Partial Removal and Complete Removal alternatives because capping material likely would be delivered by barge. Alternatives with dredging and disposal have more short-term risks because there is increased truck/rail hauling unless the material is taken to a disposal location by barge. Most of the disposal locations are in eastern Washington or Oregon, so truck/rail hauling would be necessary for some of the transportation. Potential short-term risks to workers would be from dredging, capping, or disposal operations.

Initially, containment and dredging have the same negative environmental impacts to the aquatic life at the Site. However, over the long-term, capping could have more negative impacts if all or portions of the cap need to be replaced. Thin cover/ENR material can be placed in shallow lifts of material, allowing for some of the aquatic life to migrate to the sediment surface before placement of the next lift of material.

Water quality monitoring programs will ensure that surface water is not impacted during implementation of either capping or dredging remedies.

2.11.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

All of the alternatives evaluated are implementable. There is sufficient availability of resources, workers, and companies to perform the activities associated with each alternative. In general, the potential for technical problems and schedule delays increases in direct proportion to duration and complexity of the cleanup alternative.

Containment-only alternatives (Alternatives 2A1, 2A2, 2A2a, 2A2b, 2A3, 2A4a, 2A4b, 2A4c, and 2B) have a low potential for technical and administrative difficulties and schedule delays. From the operational reliability perspective, the alternatives with dredging components (Alternatives 2A2a, 3A1, 3A2, 3A2 Plus, 3B, 3C, 3C Plus, 4A, 4B, and 4C) are more challenging than the Containment-only alternatives. This is mainly due to residuals management, which poses a concern for reliability insofar as additional passes or expansion of the limits of dredge footprints may be required.

Alternatives with dredging components (Alternatives 2A2a, 3A1, 3A2, 3A2 Plus, 3B, 3C, 3C Plus, 4A, 4B, and 4C) have more complex technical and administrative implementability issues (such as coordination with agencies, and availability of dredge equipment) due to the complexity of dredging and ancillary technologies (water management, transporting, transloading, truck or rail transport, disposal, dredge monitoring, and residuals management). Alternatives with larger remediation areas that are designed to remove large volumes of material and require longer construction periods have a comparatively higher potential for problems and delays than the alternatives with smaller active footprints, smaller volumes of material, or shorter construction times.

Containment-only alternatives (Alternatives 2A1, 2A2, 2A2a, 2A2b, 2A3, 2A4a, 2A4b, 2A4c, and 2B) are easier to implement technically and administratively than the Partial Removal and Complete Removal alternatives (Alternatives 2A2a, 3A1, 3A2, 3A2 Plus, 3B, 3C, 3C Plus, 4A, 4B, and 4C). Truck or rail haul routes for capping materials would have to be coordinated with the Port's container deliveries, worker traffic in/out of Harbor Island and West Seattle, and businesses/events in South Seattle. However, if capping material is delivered by barge, these impacts to the immediate upland area would be diminished. Although CERCLA cleanups do not require permits, capping alternatives would require more coordination and agreements with the landowner, aquatic land manager, and the Tribes. For any alternatives with a conventional cap (Alternatives 2A1, 2A2, 2A2a Plus, 2A2b, 2A3, 2A4a, 2A4b, 2A4c, 2B, 3A1, 3A2, 3A2 Plus, 3B, and 3C) measures will be taken to monitor, and if necessary, maintain the cap. Activities such as anchoring that create scour or other disturbances to the cap would be restricted.

For dredging alternatives, there is sufficient offsite disposal capacity at several upland landfills. Truck or rail haul routes for the removed sediment would have to be coordinated with the Port's container deliveries, worker traffic in/out of Harbor Island and West Seattle, and businesses/events in South Seattle. Complete removal alternatives (Alternatives 4A, 4B, and 4C) are harder to implement due to the scope and duration of the remedies.

In any areas with contaminants left in place at concentrations higher than Cleanup Levels, a propriety control that runs with the property that requires coordination with the EPA for any activity, excavation, or dredging in the cleanup area, will be necessary. The control is expected to be implemented in accordance with the state UECA. Also, for all of the alternatives, a fish advisory is necessary to modulate

how many resident fish meals are consumed each week. Although the advisory signs can be written in several languages and placed in clearly visible locations, these restrictions present challenges in enforcement to ensure that they are followed.

2.11.7 Cost

Includes estimated capital and operation and maintenance costs. Costs are expected to be accurate within a range of +50 to -30 percent.

The costs summarized in Table 19 range between $17 million and $303 million. Alternative 2A1 (conventional capping to the CSL RAL and thin cover/ENR layer to the SQS RAL) is the least expensive active remedy. The most expensive remedy, Alternative 4C, calls for dredging sediment to the Cleanup Levels, which would remove all of the contaminated sediments from the Site. In general, the Containment alternatives are less costly than the Partial Removal alternatives, and the Complete Removal alternatives are the most expensive and would take the most amount of time to implement.

2.11.8 State/Tribal Acceptance (Modifying Criterion)

Considers whether the State supports EPA's analyses and recommendations of the RI/FS and the Proposed Plan.

Ecology reviewed the RI/FS and was briefed on the Proposed Plan in March 2012. Ecology concurs with the preferred remedy selected by the EPA. Ecology's concurrence letter is provided in Appendix A.

The Site is located within a U&A Fishing Area for the Suquamish and Muckleshoot Indian Tribes, who have treaty rights in this area. None of the alternatives, even Alternative 4C (dredging to the Cleanup Levels), will result in conditions that will allow unrestricted fishing in the area because the natural background concentration of PCBs (2 µg/kg-dw) exceeds the RBTC of less than 1 µg/kg-dw for Tribal seafood consumption that was derived from the regression equation from the LDW food-web model and alternative single value BSAFs presented to the EPA on November 13, 2008. Given a natural background level of 2 µg/kg-dw total PCBs, the lowest achievable cancer risk is 9×10^{-5} for Tribal adult seafood consumption; and the lowest noncancer HQ is 5 for Tribal child seafood consumption. In addition, although a cap does not interfere with treaty rights, including fishing or clamming, Tribes prefer contaminant removal (dredging) and are not supportive of caps because contaminated sediments are allowed to remain at the Site.

The Muckleshoot and Suquamish Indian Tribes were offered government-to-government consultation for the Lockheed West RI/FS in June 2006 and for the Proposed Plan in April 2012. In addition, Tribal representatives from both Tribes participated in the development of the RI/FS and were briefed on the development of the Proposed Plan several times in the spring of 2012. The Suquamish Tribe provided comments on the Proposed Plan. The Tribe's comments focused on the larger-scale issues common to most alternatives, including the need for a consistent, comprehensive (watershed) approach to Duwamish River and Elliott Bay sediment remediation sites, RAO content and terminology, opposition to a TI waiver for surface water, and the need for long-term monitoring of sediment and surface water concentrations. Responses to the Tribe's comments were discussed with the Tribal representatives in December 2012 and are provided in Part 3 of this ROD, the Responsiveness Summary.

2.11.9 Community Acceptance (Modifying Criterion)

Considers whether the local community agrees with EPA's analysis and recommendations of the RI/FS and the Proposed Plan.

None of the alternatives are expected to significantly modify current land use within Elliott Bay. However, alternatives that include installation and maintenance of conventional caps (all of the Containment-focus alternatives and all of the Removal-focus alternatives, except Alternative 3C Plus) may complicate future development of the Port. The DNR aquatic land manager does not consider placement and maintenance of caps a beneficial water-dependent use.

Overall, based on the public comment period, the community accepts the remedy selected by the EPA. Comments identifying inconsistencies in terminology or requesting clarification have been addressed in this ROD. Responses to specific comments are presented in the Part 3 of this ROD, the Responsiveness Summary. In general, the project stakeholders support the selection of Alternative 3C Plus. The Sediment Management Working Group, a national workgroup comprising private companies, municipalities, and ports, recommended capping be a more significant component of the remedy.

2.11.10 Summary of Comparative Analysis

Table 20 provides a summary of the comparative analysis.

2.12 Selected Remedy

The EPA is selecting Alternative 3C Plus as the remedy, as presented on Figure 17 and described in detail below. This decision is based on information contained in the Administrative Record, including the final RI/FS and comments received during the Proposed Plan public comment period as summarized in the following section.

2.12.1 Summary of the Rationale for the Selected Remedy

Alternative 3C Plus was selected based on the following:

- Protection of human health and the environment
- The ability of the remedy to meet ARARs, with the exception of the AWQC
- Long-term effectiveness and permanence, which includes limiting seismic impacts and minimizing the extent of ICs because no engineered caps are selected
- Community and Tribal acceptance, including considerations regarding reasonably anticipated future land use
- Cost

The Selected Remedy maintains and upholds the treaty rights in this area. The Selected Remedy does not impede or obstruct future water-dependent land use by the DNR or the Port. It does, however, require coordination with the EPA when sediments may be disturbed, because sediment concentrations above Cleanup Levels will remain onsite at depth. By removing the most highly contaminated sediments from the navigation channel, if WRDA authorization is granted, the Port and USACE can dredge the area without concerns about elevated sediment concentrations from past shipyard operations.

LEGEND

- LOCKHEED WEST STUDY AREA
- REMOVAL TO CSL
- REMOVAL TO SQS (WEST WATERWAY NAVIGATION CHANNEL)
- REMOVAL TO SQS IN SHORELINE/INTERTIDAL, AND FORMER SHIPWAY AREAS
- ENR TO STUDY AREA BOUNDARY
- FORMER DRY DOCK AREAS
- HABITAT SOFTENING/ENHANCEMENT IN EXISTING RIPRAP AREAS
- HABITAT MIX PLACEMENT
- RIPRAP ARMOR STABILIZATION
- BACKFILL TO EXISTING ELEVATIONS
- REMNANT PILING AREAS (OTHER SMALLER AREAS OF REMNANT PILINGS ARE EXCLUDED)

Notes:
AC = Acre
SQS = Sediment Quality Standard
CSL = Cleanup Screening Level
CY = Cubic Yard
ENR = Enhanced Natural Recovery

Removal-Focus Alternative 3C Plus

Alternative Description: Removal of sediment with concentrations above the CSL within the former Dry Dock areas and remaining CSL footprint, and ENR to the Study Area Boundary. Removal to SQS in portions of the West Waterway navigation channel, shoreline/intertidal, area, and former shipway area.

Remediation Below -10 ft MLLW

	Area (AC)	Volume (CY)
Removal	11.6	151,650
ENR	28.4	45,900

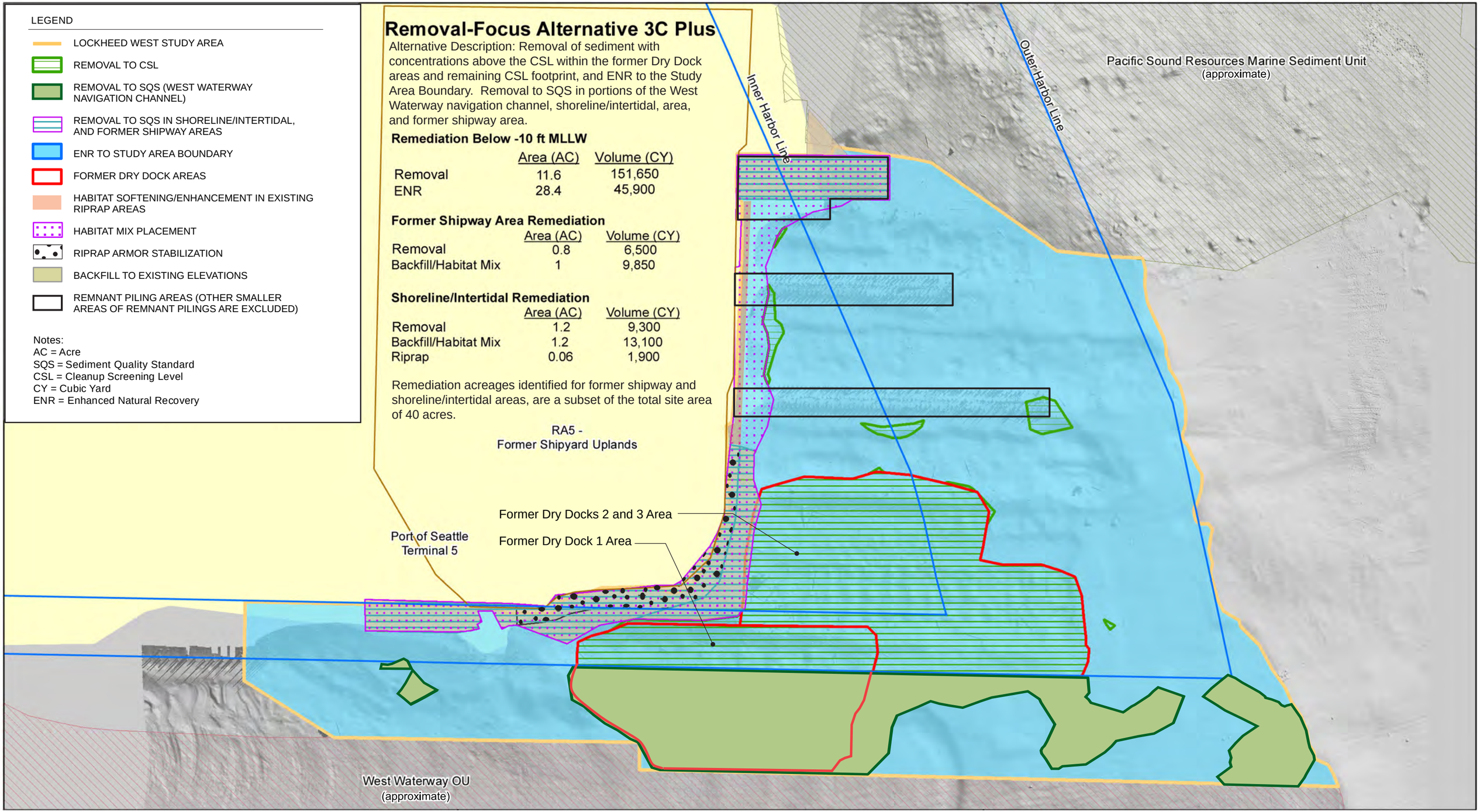
Former Shipway Area Remediation

	Area (AC)	Volume (CY)
Removal	0.8	6,500
Backfill/Habitat Mix	1	9,850

Shoreline/Intertidal Remediation

	Area (AC)	Volume (CY)
Removal	1.2	9,300
Backfill/Habitat Mix	1.2	13,100
Riprap	0.06	1,900

Remediation acreages identified for former shipway and shoreline/intertidal areas, are a subset of the total site area of 40 acres.



0 125 250 500 Feet

Source: Adapted from Tetra Tech, May 2012, Final RI/FS.

Figure 17
Selected Remedy – Alternative 3C Plus
Lockheed West Superfund Site
Seattle, WA

2.12.2 Detailed Description of the Selected Remedy

The Selected Remedy includes the following elements:

- Dredge the former shipway area (westernmost portion of the Site) to remove sediments with COC concentrations above the SQS and place a thin layer (6 to 9 inches) of clean material to cover dredge residuals and promote ENR.
- Dredge the Navigation Channel in the West Waterway to remove sediments with COC concentrations that exceed the SQS and place a thin layer of clean material to cover dredge residuals and promote ENR.
- Dredge the former Dry Docks 1 through 3 area and other localized areas throughout the Site to remove sediments with COC concentrations above the CSL RAL, and place a thin layer of clean material to cover dredge residuals and promote ENR.
- Place a thin layer of clean material to promote ENR over the remainder of the subtidal area.
- Dredge the shoreline bank and intertidal zone (defined as areas extending from mean high higher water at +11.3 feet MLLW to -10 feet MLLW) to remove sediments with COCs at levels above the SQS, as structurally practicable, and backfill with clean material to grade.
- Remove debris, riprap, failing wooden bulkheads, and pilings as necessary or directed by the EPA, and dispose of them offsite.
- Dispose of dredged sediments and other related remediation materials by truck or rail transport to an appropriate offsite upland facility permitted to accept these materials.
- Place ICs in the form of a proprietary control that runs with the property and that requires coordination with the EPA and management of any residual contamination (above Cleanup Levels) that is disturbed or encountered in the event of future excavation or dredging within the boundaries of the Site. In addition, the current fish advisory for Recreational Marine Area 10 (Elliott Bay) under the Puget Sound Fish Consumption Advisory, established by the Washington State Department of Health, to reduce human exposure from ingestion of contaminated seafood will continue to be posted at the Site. EPA can revise the fish advisory as warranted.
- Conduct post-remedial confirmation sampling of sediment and surface water.
- Conduct long-term monitoring at the Site. The monitoring interval and other criteria will be defined in the Long-term Monitoring and Maintenance Plan (LTMMP). Additional monitoring, following identified triggering weather and seismic events, also will be defined in the LTMMP. If such events occur, bathymetric monitoring will be implemented to determine whether one or more components of the Selected Remedy are affected.
- Conduct five-year reviews, which will include sediment sampling for risk driver COCs, bathymetric surveys to ensure that the thin cover/ENR layer remains in place, file reviews, and interviews with the landowner(s) pertaining to any development that has occurred at the Site since remediation was completed. Surface water and fish tissue samples will not be collected as part of five-year reviews.

A TI waiver of the Federal AWQC for arsenic is part of the Selected Remedy. As described in the TI waiver rationale memorandum (EPA, 2013), it is technically impracticable for remediation of contaminated sediments at this small, 40-acre Site to measurably improve the overall water quality for arsenic within the larger Elliott Bay; and there are no treatment technologies capable of surface water treatment for arsenic at the scale of Elliott Bay (approximately 5.42×10^{11} gallons, assuming no replenishment from Puget Sound). It is expected that arsenic concentrations in Elliott Bay would remain

the same after Site cleanup. All Site-related arsenic sources are or will be controlled after sediment remediation. The TI waiver would apply only to AWQC exceedances at the Site and would not prevent the EPA or other regulatory agencies from taking actions related to AWQC exceedances.

The Selected Remedy is depicted in Figure 17. Key components of the remedy are detailed in the following subsections. The remedy may be refined as a result of future remedial design and construction implementation. Any significant changes to the remedy made during remedial design will be documented through technical memoranda in the Administrative Record, Explanation of Significant Differences, or ROD Amendment, in accordance with CERCLA requirements.

2.12.2.1 Removal of Contaminated Sediments

Contaminated sediments will be removed from the following locations:

- Shoreline and intertidal area to remove sediments with COC concentrations in excess of the SQS RAL, as structurally practicable (large riprap currently serving as shoreline protection in the middle of the north face of Terminal 5 will remain in place).
- Former shipway (westernmost portion of the Site) to remove sediments with COC concentrations in excess of the SQS RAL.
- Navigation channel in the West Waterway to remove sediments with COC concentrations that exceed the SQS RAL.
- Former Dry Docks 1 through 3 to remove sediments with COC concentrations in excess of the CSL RAL.
- Remove sediments in isolated locations where COC concentrations exceed the CSL RAL.

A total of 13.6 acres (167,450 cubic yards [CY]) of contaminated sediment will be removed. Sediment removal will be accomplished with mechanical dredging using a conventional barge-mounted clamshell dredge and/or environmental bucket to meet action-specific water quality ARARs. Conventional excavation technologies, such as backhoes, loaders, or barge-mounted precision excavators, may be used in shallow water areas including shoreline and exposed intertidal areas, and during debris removal activities, as necessary.

All in-water construction will be conducted during the designated “fish window” (generally October through February), although this official work window may be limited based on location-specific factors. The final work window will be defined and coordinated in consultation with the Tribes and other resource agencies before implementation.

2.12.2.2 Thin Cover/Enhanced Natural Recovery Layer Placement

Dredging typically causes a degree of resuspension of contaminated sediment that settles back onto the dredged surface. Operational in-water controls will be developed during remedial design to manage residuals. Removal of sediment below -10 feet MLLW will be followed by placement of 9 inches of clean backfill to achieve 6 inches of coverage over the dredge footprint. Placement of backfill is intended to manage dredge residuals, provide a thin cover, and promote ENR.

During design, the thin cover/ENR material will be evaluated to ensure that the layer is appropriate to support benthos in the area and that the cover thickness will be sufficient to ensure that surface sediment (0 to 10 cm) concentrations meet the Cleanup Levels.

2.12.2.3 Removal of Debris and Pilings

Site preparation is generally limited to clearing the remediation and associated operational areas of debris and other obstructions as needed on a location-specific basis. The nature and extent of debris that will be removed will be determined during remedial design. Large debris, such as logs, concrete, and other materials will be removed before commencing sediment removal. Debris removal will be conducted using a derrick barge and clamshell dredge. The debris will then be barged and offloaded at a transfer facility for subsequent shipment to an upland landfill or for potential recycling and beneficial reuse.

The Selected Remedy includes removal of pilings in the former shipway. Piling and pier removal elsewhere is not considered part of the general Site preparation. The Port and DNR will determine the final disposition of these pilings and piers subject to the terms of the lease termination agreement between the Port and DNR (DNR, 2007) in the Harbor Area; although the EPA expects that the pilings will be removed by the time a remedy is implemented.

2.12.2.4 Shoreline/Intertidal Area Backfill

Approximately 1.2 acres of dredged surfaces between mean higher high water (approximately +11.3 feet MLLW) and -10 feet MLLW (habitat areas) will be backfilled to approximate pre-dredge grades. Riprap may be needed to stabilize slopes and prevent erosion and sloughing. Such areas would be identified during remedial design. Treatment of shoreline areas will be coordinated during remedial design with the EPA, the stakeholders, and the Tribes. Habitat/fish mix may be placed in the interstices of riprap to provide a more favorable environment for aquatic species. The details of shoreline remediation (that is, limits of removal, backfill thickness, and design of riprap armoring) will be determined during remedial design.

2.12.2.5 Waste Disposal and Management

Wastes generated as a result of dredging include dredged sediment and water. The dredged sediment will be dewatered on the dredge scows, and the water will be allowed to discharge back within the active dredge area. Appropriate best management practices (for example, hay bales, filter fabric, and geo bags) will be installed to filter the discharges in order to maintain compliance with water quality criteria established for the dredging operations. The dredged material placed onto the barge will be transported to a transloading facility where the material will be transferred to railcars for disposal at either the Roosevelt Regional Landfill near Roosevelt, Washington, or Columbia Ridge Landfill in Arlington, Oregon. Both landfills are permitted to receive wet sediment. The logistics for waste management, transloading, and disposal will be determined during remedial design.

2.12.2.6 Monitoring During and After Remedial Action

Monitoring during construction will be used to ensure achievement of RAOs and compliance with ARARs during construction. Water quality monitoring will be conducted during in-water work.

2.12.2.7 ARAR Waiver – Technical Impracticability

A TI waiver of the Federal AWQC for arsenic is part of the Selected Remedy. As described in the TI waiver rationale memorandum (EPA, 2013), it is technically impracticable for remediation of contaminated sediments at this small, 40-acre Site to measurably improve the overall water quality for arsenic within the larger Elliott Bay; and there are no treatment technologies capable of surface water treatment for arsenic at the scale of Elliott Bay (approximately 5.42×10^{11} gallons, assuming no replenishment from Puget Sound). It is expected that arsenic concentrations in Elliott Bay would remain the same after Site cleanup. All Site-related arsenic sources are or will be controlled after sediment

remediation. The TI waiver would apply only to AWQC exceedances at the Site and would not prevent the EPA or other regulatory agencies from taking actions related to AWQC exceedances.

2.12.2.8 Institutional Controls

The ICs associated with the Selected Remedy include the existing Elliott Bay fish advisory proprietary controls, which run with the land and require coordination with the EPA, and management of any residual contamination that is disturbed or encountered in the event of future excavation or dredging within the boundaries of the Site.

The existing fish advisory for Recreational Marine Area 10 (Elliott Bay) under the Puget Sound Fish Consumption Advisory, established by the DOH to reduce human exposure from ingestion of contaminated seafood, will continue to be posted at the Site and are the only fishing restrictions that will be imposed at the Site The current fish advisory for Elliott Bay includes no rock fish consumption and no more than 2 meals per month flatfish consumption.

It is the EPA's expectation that the state UECA will be used as the proprietary control. This IC will not affect or restrict Tribal fishing rights in this area nor will it restrict pile installation, anchoring, or water-based commerce.

2.12.2.9 Long-term Monitoring and Maintenance

Long-term monitoring is expected to include sediment sampling, sitewide bathymetry, and other assessment techniques to ensure that the thin cover/ENR layer and other components of the Selected Remedy are undisturbed. The details of long-term monitoring including performance standards, sampling intervals, benchmarks, and associated contingency actions will be outlined in a LTMMP to be developed prior to construction. The LTMMP also will outline performance expectations and potential courses of action to be taken based on the influence of marine activities including any marine construction, passage of time, or the occurrence of natural phenomena such as earthquakes or significant weather events. Sampling of surface water or tissue for chemical analysis is not anticipated.

The results of the long-term monitoring program will be documented during five-year reviews, which also will include file reviews and interviews with the landowner(s) pertaining to any development that has occurred at the Site since remediation was completed.

2.12.2.10 Quantities and Volumes

The overall size of the Site is approximately 40 acres. Implementation of the Selected Remedy will encompass the entire Site and will involve removal and/or addition of the following approximate quantities of materials:

- Dredging − 13.6 acres total (167,450 CY) derived from the following areas:
  - Shoreline/intertidal area – 1.2 acres (9,300 CY)
  - Former shipway area – 0.8 acre (6,500 CY)
  - Dry docks, navigation channel, and selected areas below -10 feet MLLW – 11.6 acres (151,650 CY)
- Backfill shoreline and /intertidal areas – 2.2 acres total (24,850 CY) in the following areas:
  - Shoreline/intertidal area – 1.2 acres (13,100 CY of habitat mix, 1,900 CY of riprap)
  - Former shipway area – 1 acre (9,850 CY of habitat mix)

- Place thin cover/ENR layer in following areas:
  - Dredged areas areas below -10 feet MLLW – 11.6 acres (14,000 CY)
  - Undredged areas below -10 feet MLLW to the limits of the Site boundary – 28.4 acres (45,900 CY)

2.12.3 Summary of the Estimated Remedy Costs

This section presents a breakdown of estimated costs associated with implementing Alternative 3C Plus as the Selected Remedy. Summarized costs are presented in Table 21. Net present value (NPV) costs are presented in Table 22. Additional costing detail, unit cost assumptions, and other assumptions were presented in Appendixes F and I of the RI/FS.

The total capital cost to construct the preferred alternatives is estimated to be $47.7 million. Assuming a 3 percent discount rate for 30 years, long-term operations and maintenance costs add $453,000 for a total of $48.1 million NPV. The 3 percent discount rate was used based on the 2012 Office of Management and Budget Circular (OMB, 2012). The total cost of the Selected Remedy does not change appreciably if the EPA-recommended 7 percent discount rate (EPA, 2000) is used because of the low cost of the ICs and monitoring associated with the Selected Remedy ($48 million versus $48.1 million).

The estimated costs are presented for Alternative 3C Plus as the Selected Remedy at a nominal order-of-magnitude engineering range of +50 to -30 percent. The cost estimate does not constitute a bid to complete the work. The cost estimate information presented is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the Selected Remedy. Major changes may be documented in the form of memoranda in the Administrative Record file, an Explanation of Significant Differences, or ROD amendment, as appropriate.

2.12.4 Expected Outcomes of the Selected Remedy

The expected outcome of the Selected Remedy is removal of the most highly contaminated sediment at the Site with concentrations of total PCBs, arsenic, copper, lead, mercury, cPAHs, and TBT that exceed the Cleanup Levels for RAO 1 through 4. Residual risks from these and other COCs would be mitigated through placement of 6- to 9-inch layer of layer of clean imported sediment and ICs. Following implementation of the remedy, the Site would be suitable for its current and anticipated future use, which includes a navigation channel. However, due to the ongoing presence of other contaminant sources in the area, the Site will not be suitable for unrestricted consumption of fish. The remedy is expected to take 1 to 2 years to implement.

TABLE 21
Cost Estimate Summary for the Selected Remedy – 3C Plus (Page 1 of 3)
Lockheed West Seattle Record of Decision

Task	Quantity	Unit	Unit Cost	Total Cost
PRECONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$ 150,000	$ 150,000
Mobilization/Demobilization	1	LS	$ 500,000	$ 500,000
Site Preparation, Environmental Controls	1	LS	$ 150,000	$ 150,000
Subtotal:				**$ 800,000**
PIER DEMOLITION (NOT INCLUDED IN TOTAL COSTS - PIERS MAY BE REMOVED AT DIRECTION OF THE EPA)				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood		Tons	$ 110	
Debris and Pilings, Metal Waste		Tons	$ 110	
Transport and Disposal		Tons	$ 68	
Demolition QA/QC, Waste Characterization, Monitoring		LS	$ 456,000	
Subtotal:				
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	151,646	CY	$ 20	$ 3,032,920
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	227,469	Tons	$ 12	$ 2,729,628
Transloading Area Setup	1	LS	$ 1,000,000	$ 1,000,000
Water Management	186	Daily rate	$ 8,000	$ 1,486,725
Handling, Transport and Subtitle D Landfill Disposal	227,469	Tons	$ 60	$ 13,648,140
Backfill Material Procurement, Delivery, Placement	14,036	CY	$ 20	$ 280,720
Subtotal:				**$ 22,178,100**
SEDIMENT CAPPING AND ENR				
Cap Material Procurement, Delivery, Placement	0	CY	$ 30	$
ENR Material Procurement, Delivery, Placement	45,900	CY	$ 30	$ 1,514,700
Material Barge and Assist Tug for Capping	0	Tons	$ 10	$ -
Material Barge and Assist Tug for ENR	68,850	Tons	$ 10	$ 757,350
Subtotal:				**$ 2,272,000**
SHIPWAY REMEDIATION				
Pilings Removal and Disposal	1	LS	$ 450,000	$ 450,000
Sediment Removal and Disposal	6,481	CY	$ 80	$ 518,519
Backfill/Habitat Material Procurement and Placement	9,853	CY	$ 30	$ 295,578
Subtotal:				**$ 1,264,000**

TABLE 21
Cost Estimate Summary for the Selected Remedy – 3C Plus (Page 2 of 3)
Lockheed West Seattle Record of Decision

Task	Quantity	Unit	Unit Cost	Total Cost
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$ 100	$ 930,000
Backfill Placement	11,160	CY	$ 20	$ 223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	Tons	$ 50	$ 175,817
Habitat Material (Sand and Fish Mix) Procurement and Placement	1,852	CY	$ 30	$ 55,556
Habitat Enhancement and Riparian Planting	2	Acres	$ 50,000	$ 100,000
Subtotal:				**$ 1,485,000**
CONSTRUCTION QA/QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	186	Daily rate	$ 7,000	$ 1,300,885
Verification Sediment Sampling (Dredging)	1	LS	$ 164,388	$ 164,388
Verification Sediment Sampling (Capping)	1	LS	$ 8,190	$ 8,190
Verification Sediment Sampling (ENR)	1	LS	$ 115,920	$ 115,920
Remedial Action Completion Reporting	1	LS	$ 80,000	$ 80,000
Subtotal:				**$ 1,669,000**
			BASE CAPITAL COST	**$ 29,670,000**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$ 10,384,500
Project Management	5%			$ 1,483,500
Remedial Design and Data Collection	8%			$ 2,373,600
Construction Management/QA Support	6%			$ 1,780,200
Agency Oversight (25% of Construction Management/QA Support)	1.50%			$ 445,050
Washington State Sales Tax	9.50%			$ 1,522,000
Subtotal:				**$ 17,989,000**
			TOTAL CAPITAL COST	**$ 47,659,000**

TABLE 21
Cost Estimate Summary for the Selected Remedy – 3C Plus (Page 3 of 3)
Lockheed West Seattle Record of Decision

Task	Quantity	Unit	Unit Cost	Total Cost
Annual Operation and Monitoring Costs				
ICs Planning and Implementation	30	Years	See NPV (page 2)	$ 108,000
Monitoring and Reporting	6	Events	See NPV (page 2)	$ 185,000
ENR Repair	1	Event	See NPV (page 2)	$ 160,650
Subtotal:				**$ 450,000**
			TOTAL PRESENT WORTH COST	**$ 48,110,000**

Notes:
Adapted from information in RI/FS Appendixes F and I (Tetra Tech, 2012)
CY = cubic yard(s)
ENR = enhanced natural recovery
IC = institutional control
LS = lump sum
NPV = net present value
QA/QC = quality assurance/quality control

TABLE 22

Net Present Value Analysis for the Selected Remedy – 3C Plus (Page 1 of 2)

Lockheed West Seattle Record of Decision

Year	Discount Factor (3%)	Capital Costs	IC Costs	IC Costs (NPV)	O&M Costs	O&M Costs (NPV)	ENR Repair	ENR Repair (NPV)	Comment
0	1.0000	$ 47,659,000	$10,000	$ 10,000					
1	0.9709		$ 5,000	$ 4,855					
2	1.0000		$ 5,000	$ 5,000					
3	0.9151		$ 5,000	$ 4,576					
4	0.8885		$ 5,000	$ 4,443					
5	0.8626		$ 5,000	$ 4,313	$ 50,000	$ 43,130			Bathymetric survey and five-year review
6	0.8375		$ 5,000	$ 4,188					
7	0.8131		$ 5,000	$ 4,066					
8	0.7894		$ 5,000	$ 3,947					
9	0.7664		$ 5,000	$ 3,832					
10	0.7441		$ 5,000	$ 3,721	$ 50,000	$ 37,205			Bathymetric survey and five-year review
11	0.7224		$ 5,000	$ 3,612					
12	0.7014		$ 5,000	$ 3,507					
13	0.6810		$ 5,000	$ 3,405					
14	0.6611		$ 5,000	$ 3,306					
15	0.6419		$ 5,000	$ 3,210	$ 50,000	$ 32,095	$ -	$ -	Bathymetric survey and five-year review
16	0.6232		$ 5,000	$ 3,116	$ -	$ -	$ 257,780	$ 160,650	ENR repair
17	0.6050		$ 5,000	$ 3,025	$ -				
18	0.5874		$ 5,000	$ 2,937	$ -				
19	0.5703		$ 5,000	$ 2,852	$ -				
20	0.5537		$ 5,000	$ 2,769	$ 50,000	$ 27,685			Bathymetric survey and five-year review
21	0.5375		$ 5,000	$ 2,688	$ -				
22	0.5219		$ 5,000	$ 2,610	$ -				

TABLE 22

Net Present Value Analysis for the Selected Remedy – 3C Plus (Page 2 of 2)

Lockheed West Seattle Record of Decision

Year	Discount Factor (3%)	Capital Costs	IC Costs	IC Costs (NPV)	O&M Costs	O&M Costs (NPV)	ENR Repair	ENR Repair (NPV)	Comment
23	0.5067		$ 5,000	$ 2,534	$ -				
24	0.4919		$ 5,000	$ 2,460	$ -				
25	0.4776		$ 5,000	$ 2,388	$ 50,000	$ 23,880			Bathymetric survey and five-year review
26	0.4637		$ 5,000	$ 2,319	$ -				
27	0.4502		$ 5,000	$ 2,251	$ -				
28	0.4371		$ 5,000	$ 2,186	$ -				
29	0.4243		$ 5,000	$ 2,122	$ -				
30	0.4120		$ 5,000	$ 2,060	$ 50,000	$ 20,600			Bathymetric survey and five-year review
Total Present Worth Cost		**$ 47,659,000**		**$ 108,000**		**$ 185,000**		**$ 160,650**	

Notes:

Adapted from information in RI/FS Report Appendixes F and I (Tetra Tech, 2012)

ENR = enhanced natural recovery
IC = institutional control
NPV = net present value
O&M = operations and maintenance

2.13 Statutory Determinations

CERCLA Section 121 and the NCP Section 300.430(f)(5)(ii) require selection of a remedy or remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost-effective, and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous substances, pollutants, or contaminants as a principal element, and a bias against offsite disposal of untreated wastes.

The selected remedy meets these statutory requirements. The subsections below summarize the basis for determining the Selected Remedy for the site meets the statutory requirements.

2.13.1 Protection of Human Health and the Environment

The Selected Remedy for remediation of the Lockheed West Site will protect human health and the environment by removal of contaminated sediment in the intertidal and subtidal zones, management of dredge residuals and low-level sediment contamination through placement of a 6- to 9-inch thin cover/ENR layer, implementation of ICs to ensure residual contamination is not released, and reliance on Elliott Bay Fish Advisories so long as that is necessary. Table 23 provides a summary of the Cleanup Levels and compliance zones for COCs.

2.13.1.1 RAO 1 – Human Seafood Consumption

The primary human health risks associated with the Site are consumption of seafood that contains elevated concentrations of COCs. The estimated lifetime excess cancer risk from this pathway, assuming a subsistence-level consumption rate, is 9×10^{-3} for adults and 4×10^{-3} for children. HQs for noncancer risks are 173 (adults) and 372 (children). After implementation of the remedy, the following risk levels will be achieved (elevated risks are related to the Cleanup Level for total PCBs, which is based on the natural background concentration rather than the lower RBTC):

- Excess Cancer Risks:
  - Adult Tribal – 9×10^{-5}
  - Child Tribal – 2×10^{-5}
- Noncancer HQ:
  - Adult Tribal – 2
  - Child Tribal – 5

The sediment cleanup actions (dredging and thin cover) will reduce the concentrations of COCs in surface sediments. This reduction is not likely to directly affect the currently estimated risks from seafood consumption because this Site is not a primary contributor to overall contaminant concentrations in Elliott Bay. It is expected that the Selected Remedy, in combination with remediation of other sites in the area, will eventually result in overall reductions in contaminant concentrations in marine tissue in Elliott Bay, with a corresponding reduction in human health risk. Until that time, the existing DOH fish advisory concerning consumption limits for fish caught in Elliott Bay will remain in effect. If warranted, EPA can revise this advisory.

TABLE 23
Summary of Compliance Zones and Cleanup Levels for Contaminants of Concern (Page 1 of 4)
Lockheed West Seattle Record of Decision

COC	Risk Driver?	Compliance Basis	Compliance Zone	Lowest Applicable Cleanup Level for Compliance Zone	Units	Source of Lowest Applicable Cleanup Level
Total PCBs	Yes	Subtidal	0 to 10 cm	2	µg/kg-dw	Nat Bkgd
		Intertidal	0 to 45 cm	2	µg/kg-dw	Nat Bkgd
		Point	0 to 10 cm	12 180	µg/kg-OC µg/kg-dw	SQS
cPAHs	Yes	Subtidal	0 to 10 cm	9	µg TEQ/kg-dw	Nat Bkgd
		Intertidal	0 to 45 cm	9	µg TEQ/kg-dw	Nat Bkgd
		Point	0 to 10 cm	-		
Arsenic	Yes	Subtidal	0 to 10 cm	7	mg/kg-dw	Nat Bkgd
		Intertidal	0 to 45 cm	7	mg/kg-dw	Nat Bkgd
		Point	0 to 10 cm	57	mg/kg-dw	SQS
Lead	Yes	Subtidal	0 to 10 cm	11	mg/kg-dw	Nat Bkgd
		Intertidal	0 to 45 cm	11	mg/kg-dw	Nat Bkgd
		Point	0 to 10 cm	-		
Tributyltin	Yes	Subtidal	0 to 10 cm	150	mg/kg-dw	RBTC – fish
		Intertidal	0 to 45 cm	2,000	mg/kg-dw	RBTC – child
		Point	0 to 10 cm	-		
Copper	Yes	Subtidal	0 to 10 cm	400	mg/kg-dw	RBTC – child
		Intertidal	0 to 45 cm	400	mg/kg-dw	RBTC – child
		Point	0 to 10 cm	390	mg/kg-dw	SQS and CSL
Mercury	Yes	Subtidal	0 to 10 cm	0.41	mg/kg-dw	RBTC – child
		Intertidal	0 to 45 cm	0.17	mg/kg-dw	RBTC – child
		Point	0 to 10 cm	0.41	mg/kg-dw	SQS
Dioxins/Furans	Yes	Subtidal	0 to 10 cm	2	ng TEQ/kg-dw	Nat Bkgd
		Intertidal	0 to 45 cm	2	ng TEQ/kg-dw	Nat Bkgd
		Point	0 to 10 cm	-		
Antimony	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	150	mg/kg-dw	SQS
Cadmium	No	Subtidal	0 to 10 cm	0.398	mg/kg-dw	RBTC
		Intertidal	0 to 45 cm	0.398	mg/kg-dw	RBTC
		Point	0 to 10 cm	-		

TABLE 23
Summary of Compliance Zones and Cleanup Levels for Contaminants of Concern (Page 2 of 4)
Lockheed West Seattle Record of Decision

COC	Risk Driver?	Compliance Basis	Compliance Zone	Lowest Applicable Cleanup Level for Compliance Zone	Units	Source of Lowest Applicable Cleanup Level
Chromium	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	260	mg/kg-dw	SQS
Cobalt	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	10	mg/kg-dw	SQS
Nickel	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	140	mg/kg-dw	SQS
Selenium	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	1	mg/kg-dw	SQS
Vanadium	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	57	mg/kg-dw	SQS
Zinc	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	410	mg/kg-dw	SQS
Pentachlorophenol	No	Subtidal	0 to 10 cm	58	mg/kg-dw	RBTC
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	360		SQS
Bis(2-ethylhexyl)-phthalate	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	47 710	µg/kg-OC µg/kg-dw	SQS
Acenaphthene	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	16 240	µg/kg-OC µg/kg-dw	SQS
Benzo(a)-anthracene	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	110 1,700	µg/kg-OC µg/kg-dw	SQS

TABLE 23
Summary of Compliance Zones and Cleanup Levels for Contaminants of Concern (Page 3 of 4)
Lockheed West Seattle Record of Decision

COC	Risk Driver?	Compliance Basis	Compliance Zone	Lowest Applicable Cleanup Level for Compliance Zone	Units	Source of Lowest Applicable Cleanup Level
Benzo(a)pyrene	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	99 1,500	µg/kg-OC µg/kg-dw	SQS
Benzo(g,h,i)-perylene	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	31 470	µg/kg-OC µg/kg-dw	SQS
Total Benzofluoranthenes	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	1,800 SQS	µg/kg-dw	SQS
Chrysene	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	110 1,700	µg/kg-OC µg/kg-dw	SQS
Dibenz(a,h)-anthracene	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	12 180	µg/kg-OC µg/kg-dw	SQS
Fluoranthene	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	160 2,400	µg/kg-OC µg/kg-dw	SQS
Indeno(1,2,3-cd)pyrene	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	34 510	µg/kg-OC µg/kg-dw	SQS
Phenanthrene	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	100 1,500	µg/kg-OC µg/kg-dw	SQS

TABLE 23
Summary of Compliance Zones and Cleanup Levels for Contaminants of Concern (Page 4 of 4)
Lockheed West Seattle Record of Decision

COC	Risk Driver?	Compliance Basis	Compliance Zone	Lowest Applicable Cleanup Level for Compliance Zone	Units	Source of Lowest Applicable Cleanup Level
Total HPAH	No	Subtidal	0 to 10 cm	-		
		Intertidal	0 to 45 cm	-		
		Point	0 to 10 cm	960 14,400	µg/kg-OC µg/kg-dw	SQS

Notes:

µg/kg-dw = micrograms per kilogram – dry weight
µg TEQ/kg-dw = micrograms Toxicity Equivalents per kilogram – dry weight
cm = centimeter(s)
COC = contaminant of concern
cPAH = carcinogenic polycyclic aromatic hydrocarbons
CSL = cleanup screening level
mg/kg-dw = milligrams per kilogram – dry weight
ng TEQ/kg-dw = nanograms toxicity equivalents per kilogram – dry weight
OC = Organic Carbon (1.5%)
PCB = polychlorinated biphenl
Nat Bkgd = Natural Background
RBTC = risk-based threshold concentrations
SQS = sediment quality standards

2.13.1.2 RAO 2 – Human Direct Contact

Human health risks associated with direct contact with contaminated sediment are estimated at 7 X 10^{-5} and 2.6 for beach play, 1 x 10^{-4} and 0.5 for clamming, and 3 x 10^{5} and 0.1 for netfishing, respectively. The Selected Remedy is expected to reduce contaminant concentrations in Site sediments to the cumulative direct contact goals of less than 1 x 10^{-5} and 1. The RAO 2 goals will be achieved immediately after implementation of the remedy.

2.13.1.3 RAO 3 – Benthic Invertebrates

The Selected Remedy will reduce risks posed to benthic invertebrates (including clams) through exposure to contaminated surface sediment to the SQS, which are protective of benthic organisms. The RAO 3 goals will be achieved immediately after implementation of the remedy.

2.13.1.4 RAO 4 – Crabs, Fish, and Birds

Current HQs for crab and fish exposure to COCs in sediment range from less than 1 (multiple COCs) to 202 (TBT), and current HQs for birds range from less than 1 (multiple COCs) to 48 (lead). Note: HQ is the only measure of risk to ecological receptors; cancer risks are not considered. The HQs for crabs, fish, and birds will be reduced to protective levels (HQ less than 1) through implementation of the remedy. The RAO 4 goals also will be met immediately after implementation of the remedy.

2.13.2 Compliance with ARARs

All Federal and state ARARs will be met upon completion of the Selected Remedy, with the exception of Federal AWQC for arsenic in surface water.

The ARARs are the substantive provisions of any promulgated Federal environmental or more stringent state environmental or facility siting standards, requirements, criteria, or limitations that are determined

to be legally applicable or relevant and appropriate for a CERCLA site or action. Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site (40 CFR § 300.5). Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or state environmental or facility siting laws that, while not legally "applicable" to circumstances at a particular CERCLA site, address problems or situations sufficiently similar to those encountered at the site that their use is well-suited (40 CFR § 300.5).

The ARARs and associated citations identified for this remedy are listed in Table 19 and further described below:

- Hazardous Waste Cleanup Requirements – Washington State MTCA. The overall cancer risk and HI requirements and provisions requiring cleanup levels not to exceed natural background for final remedies are ARARs when establishing cleanup levels in sediments for protection of human health. The selected remedy will comply with the requirements of these regulations by achieving the Cleanup Levels for human health documented in this ROD.
- Sediment Quality – Washington State SMS. These regulations are applicable to the selection of sediment cleanup levels and selection of cleanup actions. The SMS have a narrative statement requiring sediment cleanup standards to be protective of human health, but MTCA provides the standards that define protection of excess cancer and noncarcinogenic risks. The Selected Remedy will comply with the requirements of these regulations by achieving Cleanup Levels for benthos documented in this ROD.
- Surface Water Quality – These regulations set forth surface water quality criteria for the protection of aquatic organisms and human health (through ingestion of water and aquatic organisms and through ingestion of aquatic organisms only). In accordance with Sections 121(d)(2)(A)(ii) and (B)(i) of CERCLA and WAC 173-340-730(3)(c), surface water quality shall be at best as stringent as: (1) Aquatic Life Criteria for WAC 173-201A-240; (2) the National Toxics Rule of 40 CFR 131.36(b)(1) as applied to Washington 40 CFR 131.36(d)(14); and (3) Federal criteria pursuant to Section 304(a) of the Clean Water Act. The Aquatic Life Criteria and National Toxics Rule criteria for protection of aquatic organisms and protection of human health are applicable to surface waters of Elliott Bay. The Federal AWQC are relevant and appropriate; the AWQC for arsenic is waived because it is technically impracticable for remediation of contaminated sediments at this small 40-acre Site to measurably improve the overall water quality for arsenic within the larger Elliott Bay; and there are no treatment technologies capable of surface water treatment for arsenic at the scale of Elliott Bay (approximately 5.42×10^{11} gallons, assuming no replenishment from Puget Sound). It is expected that arsenic concentrations in Elliott Bay would remain the same after Site cleanup. All Site-related arsenic sources are or will be controlled after sediment remediation. The TI waiver would apply only to AWQC exceedances at the Site and would not prevent the EPA or other regulatory agencies from taking actions related to AWQC exceedances.
- Dredge/Fill and Other In-water Construction Work – Clean Water Act , Rivers and Harbor Appropriations Act, Hydraulic Code Rules. These regulations identify the requirements for in-water dredging, filling, or other in-water construction work.
- Shoreline Work – Coastal Zone Management Act, Shoreline Management Act. These regulations identify the requirements for construction within 200 feet of the shoreline.

- Habitat Protection – Clean Water Act, ESA of 1973, Magnuson-Stevens Fishery Conservation and Management Act, U.S. Fish and Wildlife Mitigation Policy, U.S. Fish and Wildlife Coordination Act, Migratory Bird Treaty Act, Endangered, threatened, and sensitive wildlife species classification. These regulations identify endangered or threatened species, require consultation with species listing agencies, and require evaluation and mitigation of habitat impacts. Habitat mitigation needs will be assessed and addressed in the remedial design if necessary. Mitigation requirements will be defined in project permitting and vary with the type of work conducted if necessary. To protect threatened species under the ESA, including Puget Sound Chinook salmon, environmental windows (or "fish windows") have been established for Elliott Bay. These are designated periods (generally from October through February), when effects of in-water construction on spawning, rearing, and habitat are minimized, largely because juvenile salmon are not migrating through the area. The EPA will consult with the National Marine Fisheries Service to ensure protection of threatened salmon species.

2.13.3 Cost Effectiveness

The costs for the active cleanup alternatives range from $17 million to $303 million. However, the most cost-effective remedy is not necessarily the least-costly alternative that is protective of human health and the environment, but rather the alternative that provides the best balance of tradeoffs with respect to the remedy selection criteria.

Permanent removal of the most highly contaminated sediment and elimination of capping and related capping ICs better ensures long-term effectiveness, minimizes long-term ICs, and reduces long-term sediment sampling requirements. In addition, the stakeholders' preference was to not include caps as part of the remedy or to rely on capping to the minimal extent practicable because of ownership, Tribal treaties, and land management concerns. Dredging the most contaminated areas of the Site, avoiding permanent reliance on capping, and IC monitoring result in the Selected Remedy being more cost-effective than Alternatives 3C, 2A2a Plus, and other Containment-focus alternatives. The difference in costs between the Selected Remedy and Alternative 3C ($1.1 million) is due to the difference in area covered by the thin cover/ENR layer; Alternative 3C applies the thin cover/ENR layer only to the Urban Background boundary, while the Selected Remedy applies the thin cover/ENR layer to the Study Area boundary. The additional 10 acres of thin cover/ENR ensures the Selected Remedy meets ARARs and maximizes the reduction of risk to human and ecological receptors.

The projected cost of the Selected Remedy is $12.3 million more than the next "best" alternative—Alternative 2A2a Plus. Alternative 2A2a Plus includes a cap, cap-related ICs, long-term monitoring and maintenance, cap replacement costs in the event of seismic damage, and payment to Port and DNR for capping on their property. The additional cost of the Selected Remedy is offset by the benefits of not having long-term cap ICs and by Tribal, state, and community acceptance regarding the core elements of the remedy (significant removal of sediment contaminated above the SQS, permanent remedy, limited to no seismic impacts at the Site should a significant earthquake occur, best addresses reasonably anticipated future land uses). These considerations make the Selected Remedy the alternative that provides the best balance of tradeoffs with respect to the remedy selection criteria.

2.13.4 Use of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

This Selected Remedy represents the maximum extent to which permanent solutions (dredging) are practicable at this Site based on the "best balance of tradeoffs" as compared to other options. The factors that weigh more heavily in favor of selection of Alternative 3C Plus are long-term effectiveness and protectiveness, and tribal, state, and community acceptance.

Only the complete dredge alternatives (Alternatives 4A, 4B, and 4C), would remove more total sediment contamination from the Site at considerable cost ($92 to $303 million). However, even Alternatives 4A (dredge to SQS) and 4B (dredge to Urban Background) would leave exposed surface sediments with contaminant concentrations higher than risk-based or natural background concentrations, because a thin cover/ENR layer is not placed to the Study Area boundary as part of these cleanup alternatives. The Selected Remedy, Alternative 3C Plus, does not leave exposed surface sediment with low levels of contaminated sediment concentrations at the Site. The remaining Removal and Containment-focused alternatives rely on combinations of dredging and capping, or capping alone, to isolate contaminated surface sediments. Remedies that rely on caps are less permanent, require long-term monitoring and maintenance, and do not reduce toxicity or volume of contaminated sediment left beneath the cap. Short-term effectiveness is differentiated primarily between the cleanup alternatives that take 1 to 2 years for implementation (most of them) and the remedies that take 3 to 9 years to implement (Alternatives 4A, 4B, and 4C). Therefore, most of the alternatives considered are on par with each other with respect to short-term risks to site cleanup personnel, ecological impacts, and disruption to the local community while remediation is underway. Any cleanup alternative selected will need to comply with water quality criteria (that is, water quality certification) and BMPs during implementation. Alternative 3C Plus would take 1 to 2 years to implement and has short-term risks commensurate with most of the other alternatives.

The type of remedial activities associated with the Selected Remedy (dredging, disposal, intertidal area backfill, and thin cover/ENR layer placement) can be performed by a number of companies who routinely conduct this type of work. The alternatives that rely in part, or wholly, on caps, have more ICs to manage, as well as long-term monitoring and maintenance requirements.

2.13.5 Preference for Treatment as a Principal Element

Contaminants identified at the Site are considered low-level threats and are not highly mobile or highly toxic. For example, the maximum PCB sediment concentration at the Site is 3 ppm, with an average of 0.42 ppm. These values are well below the 50-ppm threshold for designation as a TSCA waste. Similarly, the maximum dioxin/furan concentration is 13.8 ppt TEQ as compared to the natural background concentration of 2 ppt. Metals concentrations also do not trigger principal threat waste issues, and no RCRA-listed hazardous wastes will be generated during Site remediation.

The Selected Remedy does not satisfy the statutory preference for treatment as a principal element of the remedy, because there is no cost-effective means of treating the large quantity of low-level contamination in Site sediments. The remedy will not reduce the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants through treatment, but will provide for the offsite disposal of more highly contaminated sediment at a facility that will minimize the potential for those hazardous substances to migrate or otherwise pose a threat.

The NCP Section 300.430(f)(1)(ii)(E) calls for balancing “long-term effectiveness” and “reduction of toxicity, mobility or volume through treatment,” a preference for treatment, and bias against offsite disposal. None of the remedial alternatives considered for the Site evaluated treatment because the anticipated effectiveness of in situ and ex situ treatment technologies for sediments is low for the following reasons:

- Contaminant concentrations at the Site, although higher than the EPA risk-range and hazard quotient thresholds, do not constitute principal threat wastes (see Section 2.9.3).
- None of the available treatment technologies is capable of treating the mixture of organic and inorganic contaminants in sediments (metals, PCBs, PAHs) at this Site by itself. A combination of technologies would be needed to address all Site contaminants. For example, thermal treatment

and biological treatment could be considered for the organic contaminants. However, metals contamination would not be addressed through these treatments. Consequently, the sediment would need to be further treated using soil washing, extraction, or solidification technologies.

- Treatment technologies are expected to provide little incremental benefit in the form of toxicity reduction or contaminant destruction/immobilization relative to the incremental benefits of removing contaminants from the system and offsite landfill disposal. The dredging component of the Selected Remedy directly reduces the toxicity, mobility, and volume of contaminated sediments, without treatment. Offsite disposal of treated sediments would still be necessary if there were a treatment technology that could be applied.
- Sediment treatment options have been shown to be impracticable with disproportionately higher costs than alternative sediment management strategies that have been implemented or contemplated in the Puget Sound region (RETEC Group, Inc., 2005).

2.13.6 Five-Year Review Requirements

Because the Selected Remedy will result in hazardous substances, pollutants, or contaminants remaining onsite at levels that do not allow unrestricted use and unrestricted exposure, the Site will be reviewed every 5 years after the remedial action is completed to ensure the remedy is protective of human health and the environment.

The five-year review will include sediment sampling, bathymetric surveys to ensure that the thin cover/ ENR layer remains in place, file reviews, and interviews with the landowner pertaining to any development that has occurred at the Site since remediation was completed.

2.13.7 Documentation of Significant Changes

CERCLA Section 117(b) requires an explanation of significant changes from the Selected Remedy presented in the Proposed Plan that was published for public comment. The Selected Remedy was not modified based on comments received during the public comment period. Comments received during the public comment period are discussed in Part 3, Responsiveness Summary.

The following substantive changes were made to information presented in the Proposed Plan:

- The RAOs were modified to more clearly explain the expected outcomes of the remedial action.
- Risk assessment tables were updated to include missing COC information and updated risk levels.
- The scope of the ARAR waiver was limited to arsenic, based on Elliott Bay data.
- The detailed description of the Selected Remedy was modified to more clearly explain the objectives of remedial action in each subarea.
- The quantity and cost table was updated to include missing volumes and updated costs.
- Sediment sampling was added to the long-term monitoring program.

3 Responsiveness Summary

3.1 Stakeholder Comments and Lead Agency Responses

Based on the results of the public comment period, no changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate. Participants in the public meeting held July 19, 2012, included community members and representatives of the U.S. Environmental Protection Agency (EPA) and Lockheed Martin. One community group provided oral comments during the public comment period. The community group indicated their support for the Proposed Remedy. Written comments on the Proposed Plan were received from the Port, Suquamish Tribe, Washington State Department of Natural Resources (DNR), Lockheed Martin, the Sediment Management Working Group, and the National Oceanic and Atmospheric Agency. Lockheed Martin, in consultation with the EPA, will prepare a remedial design, remedial action work plan, and Long-term Maintenance and Monitoring Plan (LTMMP) that will address comments made on the implementability of the Selected Remedy. Comments received during the public comment period and the EPA responses to these comments are provided in Appendix B.

3.2 Technical and Legal Issues

No technical or legal issues associated with the Lockheed West Record of Decision (ROD) were identified.

4 References

Enviros, Inc. 1990. *Lockheed Shipyard #2: Sediment Characterization and Geotechnical Study.* Report prepared for the Port of Seattle, by Enviros, Inc., Kirkland, Washington.

Hart Crowser. 2003. *Environmental Status Report Lockheed Yard 2 Aquatic Area, Seattle, Washington.* Prepared for Lockheed Martin Corporation. April.

King County. 1999*. Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay.* February.

King County, Washington. 2011 (unpublished). Elliott Bay surface water data collected in 2011 as part of the Receiving Water Characterization Study for the South and West Point Wastewater Treatment Plants, Alki, Carkeek, Elliott West, and MLK/Henderson Storage and CSO Treatment Plants.

Office of Management and Budget (OMB). 2012. *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs.* OMB Circular No. A-94. Appendix C (Revised December 2011).

Parametrix. 1994a. *Southwest Harbor Cleanup and Redevelopment Project, Joint Federal/State Final Environmental Impact Statement.* Prepared for U.S. Army Corps of Engineers (Seattle District), the Washington State Department of Ecology, and the Port of Seattle.

Parametrix. 1994b. *Southwest Harbor Cleanup and Redevelopment Project Final Environmental Impact Statement.* Technical Appendix A-4 Risk Assessment. November.

RETEC. 2005. *Identification of Candidate Cleanup Technologies for the Lower Duwamish Superfund Site.* Prepared for Lower Duwamish Group. December.

Science Applications International Corporation. 2008. *2007 Long-Term Monitoring Pacific Sound Resources Superfund Site, Seattle, WA Monitoring Report*. Revised Draft. Prepared for U.S. Army Corps of Engineers, Seattle District. February.

Tetra Tech and Pascoe Environmental Consulting (Pascoe). 2009a. *Ecological Risk Assessment for Lockheed West Seattle Superfund Site.* Prepared for Lockheed Martin Corporation. June.

Tetra Tech and Pascoe Environmental Consulting (Pascoe). 2009b. *Human Health Risk Assessment for Lockheed West Seattle Superfund Site.* Prepared for Lockheed Martin Corporation. June.

Tetra Tech. 2006. *High-Resolution Multibeam Sonar Bathymetric Survey conducted for Lockheed Martin Corporation.* Prepared by Tetra Tech, Inc., Bothell, WA.

Tetra Tech. 2008a. Final Remedial Investigation/Feasibility Study Work Plan for the Lockheed West Seattle Superfund Site. Prepared for the Lockheed Martin Corporation. Revision 3. June.

Tetra Tech. 2008b. *Remedial Investigation Data Report.* Prepared for Lockheed Martin Corporation. Revision 1. January.

Tetra Tech. 2009a. *Final Existing Information and Data Gap Summary Report, Lockheed West Seattle Superfund Site, Potential Sources of Remedy Recontamination.* Prepared by Tetra Tech Inc. for Lockheed Martin Corporation. March.

Tetra Tech. 2009b. *Final Source Control Evaluation Report, Lockheed West Seattle Superfund Site, Potential Sources of Remedy Recontamination.* Prepared for Lockheed Martin Corporation. December.

Tetra Tech. 2010c. *Draft Screening of Remedial Technologies and Assembly of Preliminary Alternatives.* Prepared for Lockheed Martin Corporation. July.

Tetra Tech. 2012. *Final RI/FS for the Lockheed West Seattle Superfund Site.* May.

U.S. Army Corps of Engineers (USACE). 2008. *Dredged Material Evaluation and Disposal Procedures User's Manual.* July.

U.S. Environmental Protection Agency (EPA). 1991. Memorandum. *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions.* OSWER Directive 9355.0-30.

U.S. Environmental Protection Agency (EPA). 1994. *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children.* EPA 540-R-93-081. Technical Review Workgroup for Lead, U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency (EPA). 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments.* EPA/540/R-97/006. Interim final. Environmental Response Team, U.S. Environmental Protection Agency, Edison, NJ.

U.S. Environmental Protection Agency (EPA). 1999a. *EPA Superfund Record of Decision: Pacific Sound Resources*, EPA ID: WAD009248287, OU 02, Seattle, WA. EPA/ROD/R10-99/083. September 30.

U.S. Environmental Protection Agency (EPA). 2000. *A Guide to Developing and Documenting Cost Estimates during the Feasibility Study.* EPA 540-R-00-02, OSWER 9355.0-75. July.

U.S. Environmental Protection Agency (EPA). 2002a. Transmittal of Policy Statement: "Role of Background in the CERCLA Cleanup Program." OSWER 9285.6-07P. From Michael B. Cook, Director Office of Emergency and Remedial Response. May 1.

U.S. Environmental Protection Agency (EPA). 2002b. *National Recommended Water Quality Criteria: 2002.* Office of Water, Office of Science and Technology. EPA-822-R-02-047. November.

U.S. Environmental Protection Agency (EPA). 2002c. *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites.* EPA 540-R-01-003. U.S. Environmental Protection Agency, Washington, DC. September.

U.S. Environmental Protection Agency (EPA). 2002d. *Arsenic Treatment Technologies for Soil, Waste, and Water.* EPA Office of Solid Waste and Emergency Response. EPA 542-R-004. September.

U.S. Environmental Protection Agency (EPA). 2003. *Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil.* EPA-540-R-03-001. Technical Review Workgroup for Lead, U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency (EPA). 2004. *Five-Year Review Report, First Five-Year Review Report, Pacific Sound Resources Superfund Site, Seattle, Washington.* Prepared by the RETEC Group, Inc. under contract to Port of Seattle for EPA Region 10. September 28.

U.S. Environmental Protection Agency (EPA). 2007. *Revised Discussion Draft: Developing Anthropogenic Background (ABG) for the Lower Duwamish Waterway (LDW) Superfund Site.* August 23.

U.S. Environmental Protection Agency (EPA). 2009a. *OSV Bold Summer 2008 Survey. Data Report. The Dredged Material Management Program (DMMP)*; U.S. Army Corps of Engineers, Seattle District, EPA Region 10, Washington State Department of Natural Resources, Washington State Department of Ecology. June 25.

U.S. Environmental Protection Agency (EPA). 2009b. *Five-Year Review Report, Pacific Sound Resources Superfund Site, Seattle, King County, Washington, First Five-Year Review for the Marine Sediments Unit, Second Five-Year Review for the Upland Unit.* EPA Region 10. September 28.

U.S. Environmental Protection Agency (EPA). 2012. *Proposed Plan, Lockheed West Seattle Superfund Site.* July.

U.S. Environmental Protection Agency (EPA). 2013. *Technical Impracticability of Surface Water Restoration Lockheed West Seattle Superfund Site Seattle, Washington.* August.

Washington State Department of Ecology (Ecology). 2001. *Model Toxics Control Act Cleanup Regulations*, Chapter 173-340 WAC. Publication No. 94-06. Toxics Cleanup Program, Washington State Department of Ecology, Olympia, WA.

Washington State Department of Ecology (Ecology). 2009a. *Urban Waters Initiative, 2007: Sediment Quality in Elliott Bay.* Publication No. 09-03-014. September.

Washington State Department of Ecology (Ecology). 2009b. *Sediment Management Standards Rule Revisions.* November.

Washington State Department of Health (DOH). 2006. *Puget Sound Fish Consumption Advice.* October.

Washington State Department of Natural Resources (DNR). 2007. *Notice and Agreement to Terminate Lease 22-090031, 22-090032, 22-090033, 22-001982, 22-002564, and 22-002119.*

Washington State Department of Toxicology. 1995. *Guidance on Sampling and Data Analysis Methods.* Publication 94-49. January.

Weston, R.F., Inc. 1993. *Remedial Investigation, Harbor Island, Part 2 – Sediment.* Prepared for EPA.

Windward. 2007a. *Lower Duwamish Waterway Remedial Investigation Baseline Human Health Risk Assessment.* Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. November.

Windward. 2007b. *Lower Duwamish Waterway Remedial Investigation Baseline Ecological Risk Assessment.* Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. July.

Windward. 2010. *Lower Duwamish Waterway Remedial Investigation Report.* Final. Prepared for Lower Duwamish Waterway Group. July.

Appendix A
Department of Ecology Concurrence Letter

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
PO Box 47600 • Olympia, WA 98504-7600 • 360-407-6000
711 for Washington Relay Service • Persons with a speech disability can call 877-833-6341

August 28, 2013

Mr. Dennis McLerran, Regional Administrator
U.S. Environmental Protection Agency Region 10
1200 Sixth Avenue
Seattle, WA 98101

RE: Lockheed West EPA Superfund Site Record of Decision

Dear Mr. McLerran:

The Lockheed West Record of Decision (ROD) has identified 3C Plus as the selected remedy for cleaning up marine sediments at the Lockheed West Seattle Site (Site). The Site, formerly known as Lockheed Shipyard No.2, is adjacent to Remediation Area 5, an upland site being addressed by the Port of Seattle. Remediation Area 5 is within Terminal 5 near the confluence of the West Waterway and Elliott Bay.

The ROD addresses marine sediment contamination associated with historical operations of the Lockheed Martin shipyard facility. The ROD concluded that ongoing sources from Remediation Area 5 to the off-shore environment have been controlled by early cleanup actions conducted by the Washington State Department of Ecology (Ecology).

The selected alternative presented in the ROD selects an overall cleanup strategy which includes dredging followed by a residuals management layer, and a thin layer cover supporting an enhanced natural recovery layer. The areas identified for these actions are dependent upon the concentrations of the contaminants of concern (COCs) in the area being addressed. Because the selected remedy will result in hazardous substances remaining on site at depth, long term post remediation monitoring and a 5-year review will occur.

Ecology has evaluated criteria and approaches the EPA utilized to determine if the selected remedy is protective of human health and the environment. The evaluation is based on whether the selected remedy is applicable, appropriate and cost-effective under the federal and state requirements. Ecology realizes that the cleanup strategy will not reduce bioaccumulative COCs to risk based threshold concentrations (RBTCs) which are established at $1X10^{-6}$, but rather will default to natural background as is acceptable under the Model Toxics Control Act rule (MTCA) and the amended Sediment Management Standards (SMS). This will result in the cleanup levels being in compliance with MTCA and the amended SMS rule.

EPA consulted with Ecology during development of the selected remedy for the Site. In addition, the selected remedy was finalized after EPA reviewed and considered all information and comments provided by interested parties during a 30-day public comment period (July 2012) on the Remedial Investigation and Feasibility Study Report. The ROD documented appropriate solutions and changes to address public comments and concerns.

Ecology concurs with the selected remedy due to the factors explained in the ROD. Having participated in Ecology's SMS rule revision process, EPA is aware of promulgation of the new regulation in February 2013. The amended SMS rule will become effective September 1, 2013. Ecology expects the EPA to consider the amended SMS rule during the 5-year review process.

Ecology's concurrence with the selected remedy is based on site specific factors and should not necessarily be considered precedent for other Superfund or MTCA cleanup sites in the state of Washington.

Ecology expects to be involved during the cleanup design and construction phase and to be consulted about any proposed changes related to the cleanup that may arise. We look forward to working with EPA on this Site.

Sincerely,

James J. Pendowski, Program Manager
Toxic Cleanup Program

cc: Elizabeth McKenna, EPA
Piper Peterson, EPA
Bob Warren, Ecology
Peter Adolphson, Ecology
Grant Yang, Ecology

Appendix B
Comments Received During Public Comment Period and EPA Responses

Compiled Comments and Responses
Lockheed West Seattle Site Proposed Plan (August 28, 2013)

Topic	Comment	EPA Response
Design – Pilings	**DNR1** **General Comments** DNR agrees that while all piling within the harbor area must be removed not only for the remedial action, but in compliance with an agreement with the Port of Seattle, it also supports the removal of all piling within the site boundaries, including those that are located on Port-owned property. In reviewing the proposed plan elements, it would seem that the implementation of preferred remedial action will be impeded if the pilings remain in place. If they do remain, additional institutional controls should be required to ensure that any future removal will not result in recontamination. It should also be noted that it is DNR's policy to support removal of all creosoted pilings within the aquatic environment.	**DNR1 – Response** **General Comments** The EPA agrees that, all things considered, it is best to remove old, creosote-treated and/or damaged wooden pilings in a remediation area. However, sometimes there are reasons that pilings need to remain. Where pilings are left, the EPA and PRPs are able to remediate around the pilings. It is always EPA preference to remove creosote-treated pilings where found, and when necessary, replace them with concrete or steel pilings. Not only are the new pilings made of "inert" materials, but often fewer new pilings are required depending on the future use. The UECA covenant, which will be prepared and filed at the end of the remediation, will address new and existing piles on the Site.
Design – Habitat Improvement	**DNR2** **General Comments** DNR supports any habitat improvements within Elliott Bay, including those that are proposed at Lockheed West Seattle. However, these improvements appear to be located on Port of Seattle property and would seem to require an agreement with the Port.	**DNR2 – Response** **General Comments** It is correct that the Lockheed Martin Corporation will have to coordinate and/or have an agreement with the Port of Seattle about how the intertidal area is left after cleanup. The structural integrity of the bank will be evaluated during the design. The Selected Remedy improves the quality of the intertidal and subtidal sediments in this area by removing contaminated sediments. The purpose of backfill in the intertidal area is to return the intertidal sediments to the existing grade. The materials used for backfill should be "fish and aquatic habitat-friendly," rather than riprap, cobble, or gravel, which are not conducive substrates for supporting benthic infauna and aquatic species. Use of habitat-friendly materials is a common practice at sediment remediation sites and is not intended as Superfund habitat "mitigation" or "restoration" as would be required by CERCLA and the NRDA respectively.
ICs – Covenant	**DNR3** **General Comments** DNR is willing to file an environmental covenant for State-Owned Aquatic Lands located within the site. DNR understands that this environmental covenant will not restrict public access, but will only require notification to EPA of any future development on the Lockheed West Seattle site, similar to the one filed by DNR for the Milwaukee Habitat Area in Commencement Bay. Such a covenant will cover all State-Owned Aquatic Lands, including those managed by the Port of Seattle under a PMA. DNR requests that it be reimbursed for the administrative fees associated with the preparation and filing of this covenant. The Port of Seattle will have to create a separate, environmental covenant to cover Port owned property.	**DNR3 – Response** **General Comments** The EPA appreciates DNR's willingness to file an environmental covenant for State-Owned Aquatic Lands. Any reimbursement for this covenant will need to be discussed directly with the Lockheed Martin Corporation.

Compiled Comments and Responses
Lockheed West Seattle Site Proposed Plan (August 28, 2013)

Topic	Comment	EPA Response
Site Description	**DNR4** **Section 3.1** **Page 3-1, First Paragraph** First Paragraph: this paragraph is quite confusing, and the following language is suggested: the 40 acre site includes approximately 7 acres of Port of Seattle-owned aquatic tidelands, and 33 acres of State-Owned Aquatic Lands. These 33 acres include approximately 8 acres of State Harbor Area managed by the Port of Seattle under a Port Management Agreement, of which approximately 3 acres are located within the harbor area north of the site and 5 acres of harbor area located east of the site. The Port-owned tidelands and Port-managed harbor areas are adjacent to the Port's terminal 5 facility upland operations, which includes container transfer and handling associated with marine terminal operations. These 33 acres also include approximately 18 acres of State Harbor Area in Elliott Bay, and approximately 7 acres of State Waterway in West Waterway managed by DNR. The U.S. Army Corps of Engineers has jurisdiction for maintaining the West Waterway navigation channel currently authorized to -34 ft mllw which is coincident with the state-platted West Waterway. These DNR-managed areas are available to the Port for future inclusion into its PMA upon application to the State.	**DNR4 – Response** **Section 3.1** **Page 3-1, First Paragraph** The EPA has made this modification in the ROD.
Site Description – Access	**DNR5** **Section 3.1** **Page 3-1** Third Paragraph: Please identify the homeland security regulation that restricts public recreation to State-Owned Aquatic Lands within the Lockheed West Seattle CERCLA site. To the best of DNR's knowledge, only the uplands adjoining these aquatic lands have been fenced off	**DNR5 – Response** **Section 3.1** **Page 3-1** The Proposed Plan mistakenly stated that public access to the area outside of the Port's fence line on Terminal 5 is limited due to Homeland Security issues. The Port of Seattle has recently stated this is not the case, and public access to the bank and intertidal areas of the Site is permissible. The EPA will work with the Port of Seattle during cleanup to determine if additional access east of Jack Block Park could be made available to the public. However, if this occurs, it is not part of the Selected Remedy.
Recontamination	**DNR6** **Section 4** **Page 4-1** "Contaminant concentrations higher than background could be brought onto the site" by sediment transport mechanisms and Elliott Bay water quality exceedances?	**DNR6 – Response** **Section 4** **Page 4-1** This statement is accurate as confirmed by data obtained in the Five-Year Reviews for PSR, Lockheed Yard 1, and Todd Shipyards. Data supporting this statement are found in the Administrative Record. This sentence will be revised to "Sediment with contaminant concentrations higher than background concentrations could migrate to the Site as a result of offsite sediment transport from adjacent areas."

Compiled Comments and Responses
Lockheed West Seattle Site Proposed Plan (August 28, 2013)

Topic	Comment	EPA Response
Site Description – Land Management	**DNR7** **Section 8** **Page 8-46** DNR is not a landowner. Sentence should read DNR and the Port of Seattle as managers of State-Owned Aquatic Lands, and the Port as owner of private tideland within the site, "also have concerns about the use of conventionally capped areas."	**DNR7 – Response** **Section 8** **Page 8-46** The EPA has made this modification in the ROD.
ICs – Covenant	**DNR 8** **Page 10-1** It should also be noted that ICs for the remedial action will not limit public access, including recreational fishing. DNR will file an environmental covenant for State-Owned Aquatic Lands within the site, but request that it be compensated for any administrative fees.	**DNR 8 – Response** **Page 10-1** This is correct. One of the ICs selected as part of this remedy, the UECA covenant, will not limit public access, including tribal or recreational fishing. However, the fish advisory for Elliott Bay under the Puget Sound Fish Consumption Advisory Recreational Marine Area 10 (Elliott Bay) will still exist and apply to this Site. The EPA appreciates that DNR will file an environmental covenant for the State-Owned Aquatic Lands within the Site, and DNR will need to discuss compensation for this with the Lockheed Martin Corporation.
PRGs and RALs	**POS1** **General Comment** First, we appreciate that EPA has taken into consideration the Port's land use needs in developing the Proposed Plan's selected alternative, Alternative 3C Plus. In particular, we appreciate the addition of dredging in the navigation channel and dry dock areas. EPA's selection of dredging for these areas of higher contamination results in a remedy that is more environmentally protective in the short-and long-term, given the current waterway use as a container terminal. Our main concern is the lack of justification behind changing cleanup levels for different areas of the site (SQS for navigation channel, CSL for other dredge areas). We ask that EPA provide justification behind using different cleanup levels, as general site use and conditions are similar between the two areas.	**POS1 – Response** **General Comment** The RI/FS evaluated residual risks associated with dredging, capping, and ENR for the alternatives evaluated. Dredging portions of the former dry dock areas east of the navigation channel for Alternative 3C Plus achieves the CSL at all points, and is also predicted to achieve the SQS over most of this area. This is demonstrated in RI/FS Appendix I, Table 1-6A , where only mercury at two sample locations and PCBs at two sample locations are predicted to remain above the SQS (and below the CSL) following dredging for Alternative 3C Plus. ENR material (thin layer cover) placed post-dredging would further reduce any COC concentrations remaining above the Cleanup Levels that may be the result of dredge residuals. The EPA determined that this Selected Remedy provides suitable short- and long-term risk protection as a permanent remedy.
Design – General	**POS2** **General Comment** In addition, as an affected property owner, we have some concerns with some aspects of the proposed plan that require additional discussion. To date, we have not had any discussions with Lockheed Martin Corporation (Lockheed) on what this remedy would entail on Port property and anticipate coordination on many details during design. We anticipate further discussions with EPA and with Lockheed to work towards resolution of the following issues, as discussed below.	**POS2 – Response** **General Comment** The EPA agrees that the Lockheed Martin Corporation and the EPA will need to discuss many design issues as they relate to actions that will be performed on the Port's property and in areas managed by DNR. These discussions can begin as soon as the ROD is final in order to inform Consent Decree negotiations and the remedial design process.

Topic	Comment	EPA Response
ICs – Covenant	**POS3** **General Comment** **Restrictive Covenants on Port Land** As currently drafted, Alternative 3C Plus requires institutional controls (ICs) on Port aquatic lands, using the format provided for under the Uniform Environmental Covenant Act (UECA). The Proposed Plan requires that Lockheed work with the Port to secure appropriate restrictive covenants on our land. We understand that it is EPA's intent that these ICs will not restrict pile installation, anchoring, or similar activities necessary for water-based commerce. We understand that instead the ICs will be limited to requiring notification of such activities, to allow for EPA coordination of future activities in this area. Maintaining the ability to develop its property is critical to the Port's Century Agenda goals of economic growth. The Elliott Bay shoreline to the north of Terminal 5 is likely the only remaining place in Elliott Bay where terminal development could be accommodated in the future. We respectfully request that the language of the Proposed Plan be amended to explicitly state that the ICs should contain only a notification requirement and will not limit future development.	**POS3 – Response** **General Comment** **Restrictive Covenants on Port Land** The EPA appreciates this comment and understands the Port's concern about any limitations to this area for future Port (or any future landowner) development. The IC identified in the ROD will require the EPA to be notified about any future actions in this area because contamination above the Cleanup Levels will be left in place in the subsurface sediments. Because specific development plans for this area have not yet been identified, the EPA will not restrict this IC to "notification only." Depending on what future development may be, some BMPs may be required by the EPA to ensure that concentrations of contaminants above the Cleanup Levels are not released during future development activities. The EPA does not believe that BMPs will "limit future development," but the Agency cannot give the Port that assurance without having specific development plans to consider.
Design – Habitat Improvement	**POS4** **General Comment** **Habitat Softening on Port Shoreline** The Proposed Plan includes dredging, backfilling, and habitat softening in most of the Port owned intertidal areas of Terminal 5. Some of this activity is clearly associated with contaminant removal in these areas. However, some of the intertidal work on the north face of Terminal 5 consists of placement of habitat mix on existing surfaces for the sole purpose of providing "a more habitat friendly environment." The Proposed Plan should not blur the lines between what actions are necessary to achieve remedial action goals under CERCLA, and which actions are being done simply for the benefit of the environment generally. In all intertidal areas, we understand that EPA's proposal for habitat softening is not considered to be an environmental restoration or mitigation requirement under CERCLA. We understand the requirement for dredging and backfilling in contaminated areas, but it is not clear what the habitat softening involves or what its specific purpose is. As currently described, the Port does not support the habitat softening. We reserve our rights as property owner to perform any necessary modifications in these areas in the future. Such future modifications could range from development to alternative habitat restoration projects. In addition, we will need to ensure that any habitat softening does not result in a loss of upland property. We ask that EPA explicitly exclude any habitat softening that is not necessary for compliance with CERCLA.	**POS4 – Response** **General Comment** **Habitat Softening on Port Shoreline** The Selected Remedy, Alternative 3C Plus, includes placement of habitat mix material in shoreline locations adjacent to areas identified for active remediation. Placement of habitat-friendly material provides a substrate that is suitable for benthic infauna and aquatic species and is a typical "finishing layer" when completing CERCLA sediment actions. Placing habitat mix in the intertidal areas benefits aquatic and transitional areas with minimal disturbance to the shoreline and Port of Seattle facilities. The placement of habitat mix is not intended as habitat "mitigation" or "restoration" for NRDA; it is an element of remediation and is a one-time-only application. These habitat remediation efforts are consistent with general practices at other sediment remediation projects, and are in accordance with requirements of Section 404 permits under the Clean Water Act, which allow for sediment to be returned or for the sediment condition to be improved as part of the dredging operation. Additionally, under the Endangered Species Act, a Biological Assessment or Biological Opinion is generally needed as a BMP or conservation measure. Habitat-friendly material placed on top of backfill or capping material (sediments) does not preclude future land use modifications.

Topic	Comment	EPA Response
Design – Pilings	**POS5** **General Comment** **Debris and Pile Removal** We understand that the Proposed Plan also requires removal of debris, riprap, falling wooden bulkheads, and pilings as necessary or as required by EPA. It is critical that upland slope stability not be affected by any of this structural removal on the banks. We anticipate working with EPA and Lockheed during design on the amount and purpose of any structural removals on Port uses site property to ensure our upland are not impacted. In addition, the Port expects coordination regarding the locations of pilings identified for removal in aquatic areas to minimize impacts to Port use. We respectfully request that EPA provide more detail in the Proposed Plan on the locations and rational behind the requirement of pile removal on Port property.	**POS5 – Response** **General Comment** **Debris and Pile Removal** The EPA will coordinate with the Port during remedial design on a variety of issues, including stability of the upland areas and removal of debris, riprap, falling wooden bulkheads, and pilings as necessary. During sediment remediation, it is always easier and more efficient to place a cap or dredge sediments in areas that are not obstructed with pilings. However, there are situations where pilings cannot be moved (for example, holding up a structure that cannot be removed such as a building or a functional pier), yet capping and dredging can still occur. Most of the pilings in the Port-owned property are in disrepair, are not structurally sound, and cannot be used for future development; the EPA will have discussions with the Port, Lockheed Martin Corporation, and the U.S. Army Corps of Engineers regarding the pilings. The EPA will make the final decision about maintaining or removing pilings during remedial design.
RAOs	**LM1** **Topical Comments** **Section 7** **Page 7-1** **REMEDIAL ACTION OBJECTIVES** All of the RAOs in Section 7.0 of the Proposed Plan have been revised from what was included in the EPA-approved Final RI/FS. In RAOs 1 and 4, the surface water component has been removed and the need for a technical impracticability waiver for surface water is described in section 7.2 of the proposed plan. RAO 1 now includes a reference to levels that are protective of "subsistence fishing." The risk assessments performed for the Site were based on enhanced Tribal seafood consumption rates. While it is appropriate to reference "Tribal fishing" in the RAO (i.e., the basis for the risk assessment), it is inappropriate to reference subsistence fishing. RAOs 2 and 3 now include "Prevent" exposure rather than "Reduce" exposure, as was presented in the EPA-approved Final RI/FS. It is not clear how complete prevention of exposure can be achieved, especially at PRG levels. The RAOs as written do not make grammatical sense, and as such we recommend replacing "prevent" with "Reduce" in RAOs 2 and 3.	**LM1 – Response** **Topical Comments** **Section 7** **Page 7-1** In accordance with comments received from multiple stakeholders, the RAOs in the Proposed Plan have been modified and amended as follows: • Human Health Risks: – **RAO 1 –** Reduce human health risks associated with the consumption of resident seafood by adults and children with the highest potential exposure. – **RAO 2 –** Prevent human health risks from direct exposure (skin contact and incidental ingestion) to contaminated sediments during net fishing, clamming, and beach play. • Ecological Risks: – **RAO 3 –** Prevent risks to benthic invertebrates from exposure to contaminated sediments. – **RAO 4 –** Prevent risks to crabs, fish, and birds from exposure to contaminated sediments.
ICs – Covenant	**LM2** **Topical Comments** **Sections 1.1 and 10.1** **Bullet 9** **INSTITUTIONAL CONTROLS**	**LM2 – Response** **Topical Comments** **Sections 1.1 and 10.1** **Bullet 9** The statement that Alternative 3C Plus "negates the need for more

Topic	Comment	EPA Response
	EPA states the requirement for proprietary controls and restrictive covenants in the form of a state Uniform Environmental Covenant Act (UECA). However, in Section 10.2 the Alternative 3C Plus is noted for "negating the need for more restrictive ICs and long-term monitoring." The stated requirement with the proprietary controls for restrictive covenants (i.e., UECA) with sediment above PRGs is inconsistent with the previous statement. In addition, it is Lockheed Martin's understanding based on previous discussions with EPA Region 10 representatives that implementation of a dredging-focus alternative such as 3C Plus would not result in the need for restrictive covenant, including need for a state UECA agreement. We recommend that Bullet No 9 in Sections 1.1 and 10.1 be revised to omit the requirement for a covenant.	restrictive ICs and long-term monitoring as that required by alternatives 2A2a or 2A2a Plus" is accurate, because the ICs for a capping remedy typically include: posted speed limits for marine vessels to minimize scour, anchor restrictions, Coast Guard notification, and regular long-term monitoring activities to ensure that caps, which sequester contaminated sediments, stay in place. Such ICs are NOT required for the Selected Remedy because a cap is not part of the remedy. A UECA covenant is required for any remediation alternative that leaves sediment concentrations above risk-based threshold criteria or natural background concentrations (that is, the Cleanup Levels). All remediation alternatives with capping would include a UECA covenant and additional ICs to ensure the cap stays in place, is not damaged, and in the event of modified future land use, that notifications to the EPA are provided. Changes to the text were not made.
Remedy Selection	**LM3a** **Topical Comments** **Sections 3.5 and 10.2** **Pages 3-2 and 10-3** **JUSTIFICATION FOR REMEDY SELECTION** The summary of seismic conditions and distinguishing features of the remedy, as presented in the Proposed Plan as justification for selection of Alternative 3C Plus, do not appropriately represent the findings of the RI/FS as described below: **Seismic Conditions**. The summary of the seismic conditions for the site in the Proposed Plan do not fully represent the findings of the seismic evaluation completed as part of the RI/FS. The proposed plan states that the site is subject to "extensive liquefaction and ground failure" for "moderate to large earthquakes." The proposed plan notes that the area is "susceptible to lateral spreading, post-liquefaction settlement, and earthquake-induced displacement during seismic events" but does not include the relative scale of these occurrences or that damage to caps placed at the site could be repaired if such events happened. The conclusions of the seismic report in the Final RI/FS indicate that capping is protective and that there is no significant risk of complete cap failure and recontamination under all events other than the most catastrophic (i.e., 2500-yr) event. Note that the seismic design criteria for the EPA-implemented and approved cap at PSR was for a 100-yr event. Since that cap was installed, there has been an event greater than the cap design criteria (i.e., the Nisqually earthquake; ~150-yr event) and no liquefaction or displacement was noted for the PSR cap. Thus the results of the seismic evaluation alone, do not justify EPA's decision for the removal action under Alternative 3C Plus.	**LM3a – Response** **Topical Comments** **Sections 3.5 and 10.2** **Pages 3-2 and 10-3** The relative scale of seismic event occurrences documented in the seismic evaluation report will be added to the ROD.

Compiled Comments and Responses
Lockheed West Seattle Site Proposed Plan (August 28, 2013)

Topic	Comment	EPA Response
Remedy Selection	**LM3b** **Topical Comments** **Sections 3.5 and 10.2** **Pages 3-2 and 10-3** **JUSTIFICATION FOR REMEDY SELECTION** **Distinguishing Features of the Remedy.** This section includes the statement that "Alternatives that do not include capping will allow for unrestricted fishing, clamming and boat anchorage, which meets the Tribal treaty requirements for the Suquamish and Muckleshoot Tribes." Alternatives that include capping, for example alternative 2A2APlus, can meet these requirements just as well as removal options. It is noted in the Proposed Plan that fish advisories will remain in place regardless of the remedy at this site and so the note on unrestricted fishing here appears misleading.	**LM3b – Response** **Topical Comments** **Sections 3.5 and 10.2** **Pages 3-2 and 10-3** Lockheed Martin is correct that the Proposed Plan language was not accurate. Fishing activities would not be curtailed with capping alternatives. The EPA will modify the language in the ROD to reflect that there are no restrictions to fishing and no additional restrictions to eating the fish at the Lockheed West site above and beyond the recommendations in the current Puget Sound fish advisory for Elliott Bay. The EPA agrees that with any capping alternative that includes a thicker cap (that is, 5 feet, like that placed at PSR), boat anchoring could be unrestricted. Any cap that decreases the navigation depth would have to be identified on Coast Guard charts.
Design – Long-term Monitoring	**LM4** **Sections 1.1 and 10.1** **Pages 10-1 and 10-2 - Bullet 11** **LONG-TERM MONITORING REQUIREMENTS** A major storm event is defined as an event "with high winds from the north at 30 miles per hour or greater, that persist for more than 4 hours." It may be more appropriate to define major storm events based on data collected and available in the public sector (for example, use a specified recurrence interval). Lockheed recommends deleting the specific storm event criteria in the Proposed Plan in Bullet No. 11. The details of what defines a triggering event should be developed during design and as part of the Operation, Monitoring, and Maintenance Plan (OMMP).	**LM4 – Response** **Sections 1.1 and 10.1** **Pages 10-1 and 10-2 - Bullet 11** Details concerning triggering events will be removed from the ROD as they are more appropriately defined in the Long-term Monitoring and Maintenance Plan (LTMMP).
Editorial	**LM5** **Editorial Comments** **Acronym list** Acronym list-WRDA should be "Waterway Resources Development Act" not "Waterway Resources District Act"	**LM5 – Response** **Editorial Comments** **Acronym list** Acronym changed in ROD.
Editorial	**LM6** **Editorial Comments** **Section 1 – Third Sentence** Section 1.0, third sentence: Replace "in Elliott Bay" with "at the Site." Should be more specific to the sediments at the Site not Elliott Bay in general. There are a lot of sources of contaminants to Elliott Bay.	**LM6 – Response** **Editorial Comments** **Section 1 – Third Sentence** Text will be modified in ROD.
Editorial	**LM7** **Editorial Comments** **Figure 1-2** Figure 1-2 -legend mixes "removal" and "dredge" to indicate the same thing. Suggest using "Removal" for all legend occurrences.	**LM7 – Response** **Editorial Comments** **Figure 1-2** Figure will be modified as suggested for ROD.

Compiled Comments and Responses
Lockheed West Seattle Site Proposed Plan (August 28, 2013)

Topic	Comment	EPA Response
Editorial	**LM8** **Editorial Comments** **Section 1.1, Page 1-2** Sentence beginning "The overall size of... "; Add "approximate" after "following" and before "quantities."	**LM8 – Response** **Editorial Comments** **Section 1.1, Page 1-2** Text will be modified in ROD.
Editorial	**LM9** **Editorial Comments** **Sections 1.1 and 10.1** **Second bullet listing specific quantities** Replace "Backfill/capping" with "Backfill/dredge residual management layer." There is no "capping" being performed as part of Alternative 3C Plus.	**LM9 – Response** **Editorial Comments** **Sections 1.1 and 10.1** **Second bullet listing specific quantities** Text will be modified in ROD.
Editorial	**LM10** **Editorial Comments** **Section 2.1, Fourth sentence** Revise the parenthetical statement to"... remnants of Piers 23 and 24 and all of Pier 25 remain today."	**LM10 – Response** **Editorial Comments** **Section 2.1, Fourth sentence** Text will be modified in ROD.
Editorial	**LM11** **Editorial Comments** **Section 3.1, Second paragraph** Replace "Waterway Resources District Act" with "Waterways Resources Development Act."	**LM11 – Response** **Section 3.1, Second paragraph** Text will be modified in ROD
Editorial	**LM12** **Editorial Comments** **Section 4, page 4-1, last sentence** The sentence incorrectly states the basis for inclusion of dioxins and furans as COCs for the Site. Dioxins and furans were identified as COCs based on their assumed presence at the site and the risk determined for the LDW. The results from the clam reconnaissance confirmed the presence of low levels of dioxins and furans in the sediments at the site.	**LM12 – Response** **Editorial Comments** **Section 4, page 4-1, last sentence** Text will be modified in ROD.
Editorial	**LM13** **Editorial Comments** **Section 4.2, last sentence** Background levels were determined by EPA using the data collected in the EPA "Bold Study." The "Bold Study" did not determine "background concentrations."	**LM13 – Response** **Editorial Comments** **Section 4.2, last sentence** Text will be modified in ROD.
Editorial	**LM14** **Editorial Comments** **Section 4.3** Add reference to Table 4-2 after "Elliott Bay urban background levels"	**LM14 – Response** **Editorial Comments** **Section 4.3** Reference will be added in ROD.

Topic	Comment	EPA Response
Editorial	**LM15** **Editorial Comments** **Table 7-2** Units confusion in Table 7-2 on dry weight and OC-normalized values -need to identify units for OC-normalized values.	**LM15 – Response** **Editorial Comments** **Table 7-2** Units will be added to table in ROD
Editorial	**LM16** **Editorial Comments** **Table 7-2** Used non-site specific dry weight value for PCB of 130 ppb; should be 180 ppb using site-specific % organic carbon values in Table 7-2.	**LM16 – Response** **Editorial Comments** **Table 7-2** Table will be corrected in ROD.
Editorial	**LM17** **Editorial Comments** **Section 8.4** Section 8.4 notes the alternatives that achieve PRGs throughout the site. The list of alternatives that meet this level does not included alternatives 2A2a Plus and 3A2 Plus, though both do and should be included.	**LM17 – Response** **Editorial Comments** **Section 8.4** Text will be modified in ROD.
Editorial	**LM18** **Editorial Comments** **Section 8.6** DNR is not a landowner; they manage state-owned lands.	**LM18 – Response** **Editorial Comments** **Section 8.6** Text will be modified in ROD.
Editorial	**LM19** **Editorial Comments** **Section 9.1.1, last sentence** All alternatives with caps included provisions for full cap replacement, not just Alternatives 2A2a Plus and 3A2 Plus. This comment applies throughout Section 9, as this statement is repeated several times.	**LM19 – Response** **Editorial Comments** **Section 9.1.1, last sentence** Text will be modified in ROD.
Editorial	**LM20** **Editorial Comments** **Section 10, introductory paragraph** Section 10-Introductory paragraph identifies EPA's preferred Alternative as "Alternative 3C" rather than 3C Plus.	**LM20 – Response** **Editorial Comments** **Section 10, introductory paragraph** Text will be modified in ROD.
RAOs	**ST1** **General Comments – RAO Language** The RAO 1 language has been changed. Current language states: Reduce human exposure from ingestion of onsite seafood contaminated with COCs from Site sediments to levels that are protective of recreational or subsistence fishing. The new language emphasizes reducing the potential for exposure rather than reducing risks. This allows greater reliance on ICs, such as fish advisories, and minimizes the need for long-term monitoring to evaluate the	**ST1 – Response** **General Comments – RAO Language** RAO 1 was modified to better reflect project Cleanup Levels. It currently states—**"**Reduce human health risks associated with the consumption of resident seafood by adults and children with the highest potential exposure." The modification to RAO 1 is intended as a specific measure of remediation achievement at the Site. Comparison of this RAO with LDW objectives is not appropriate because there are many factors, including site-specific conditions, that support a different analysis at the two sites. The EPA

Topic	Comment	EPA Response
	effectiveness of the remedy components in achieving the RAOs. The new language is not consistent with the LDW (see general comment below regarding consistency) and was not agreed to by the Tribe or discussed with the stakeholder group. The Tribe requests that the current language be replaced with the following (taken from the Final RI/FS). Reduce human health risks associated with the consumption of resident Lockheed West Site seafood by reducing sediment and surface water concentrations of contaminants of concern to protective levels.	concluded that the modified RAO 1 is the most suitable approach for the Site.
TI Waiver	**ST2** **General comments - TI Waiver** The Suquamish Tribe does not support the use of TI waivers. The Tribe does not intend to compromise treaty-reserved rights or give up on resources, and will continue to work diligently to restore resources and habitat throughout the U&A. We understand that it may not be technically possible to meet cleanup levels in the required timeline but we would prefer flexibility in the clean-up timeline (interim ROD) over a TI waiver. Not only does a TI waiver set unacceptable precedent regarding sediment remedies but a TI waiver does not protect Tribal treaty rights for future generations and precludes future use of new, innovative technologies. No discussion/dialogue with the stakeholders has occurred regarding the use of waivers. Any consideration and/or discussion of ARAR waivers based on technical impracticability must include stakeholders	**ST2 – Response** **General comments – TI Waiver** The EPA also would prefer to meet all of the ARARs at the Site, but in this case realizes that a comprehensive remediation of this Site, as identified in the Selected Remedy, will still not result in Elliott Bay meeting the AWQC for arsenic at the end of Site remediation. There are no additional Superfund remediation actions that could be taken at the Site that would result in achievement of this water quality standard. It is the EPA's belief that spending more time trying to achieve this standard with an interim ROD will not meet the standard. Implementing a TI waiver at this Site does not limit the EPA, Ecology, or other regulatory agencies from identifying remediation for Elliott Bay surface water or sediments in order to meet the arsenic standard in the future. Language was added to the ROD that states, "The TI waiver would apply only to AWQC exceedances at the Site and would not prevent the EPA or other regulatory agencies from taking source control or sediment cleanup actions related to AWQC exceedances elsewhere in Elliott Bay." On several occasions, including conference calls in March and May 2012, the EPA told the Tribe and other project stakeholders that a surface water TI was likely. For several years before the proposed remedy was selected, the possibility of a TI waiver was also discussed at monthly stakeholder meetings.
Remedy Selection	**ST3** **General Comments – Background** There are numerous contradictory statements concerning the long-term potential recontamination of the site. The following support the argument that site conditions are relatively stable and that the proposed alternative can be successful in obtaining cleanup levels: • There are no known or suspected adjacent sources affecting the site. • The site is net depositional, with a low sedimentation rate (so low that bathymetry at the site has not noticeably changed in decades). • Pore water and surface water dynamics have little impact on	**ST3 – Response** **General Comments – Background** The ROD text regarding the Selected Remedy, Alternative 3C Plus, clarifies that Cleanup Levels are achieved after implementation of the remedy; the remedy does not rely on Urban Background concentrations to achieve Cleanup Levels. Urban Background concentration comparisons were used to define areas of sediment contamination where specific elements of a remedial action alternative could be applied (for example, placement of ENR to the Urban Background boundary [Alternative 2A2a], conventional capping to the Urban Background boundary [Alternative 2A4b], or removal of sediment to the Urban Background boundary [Alternative 4B]). The Urban

Topic	Comment	EPA Response
	contaminant fate and transport at the site. Without supporting data, the use of the Elliott Bay Urban values as "background" is not justified simply based on the potential for recontamination. The 2009 report cited as a reference for this information does not contain specific information and merely concludes with a series of assumptions. Considering the current available information shows there is low potential for recontamination the Tribe does not agree that the use of the Elliott Bay urban background data set (implying some given level of contamination) is the most appropriate measure for comparison.	Background values used are based on best available data (Ecology, 2009), and the intent of using them was only to show intermediary remediation alternatives (such as cost, scope, volumes, implementation duration) between remediating Site sediments to the Cleanup Levels and the SQS RAL. The use of the term "background" in this context does not connote (as "natural background" does) that these concentrations are acceptable or have any legal basis or standing and these sediments might also require cleanup in the future.
Design – Long-term Monitoring	**ST4** **General Comments – Monitoring** Monitoring of the remedy is necessary to ensure that the remediation goals are being met and that the remedy is protective of human health and the environment over the long term. Bathymetric surveys following storm events, as proposed, will not do this. Chemistry sampling of sediment and tissue is needed for proper evaluation of remedy success at the 5-year review. Lockheed has stated that it may be difficult to distinguish between recontamination from off-site sources vs. remedy failure, since low-level contamination from Elliott Bay or the Lower Duwamish River may be transported to the Lockheed West site. To address this issue sediment traps can be installed to measure deposition. Long-term monitoring is also used to verify assumptions made during the RI/FS process and remedial design, including the relationship between sediment and seafood concentrations, sedimentation rates, and the potential for on- or off-site contaminant migration.	**ST4 – Response** **General Comments – Monitoring** The ROD was revised to include sediment sampling to support the Five-Year Review. However, surface water and fish tissue will not be collected or analyzed.
Design – ENR	**ST5** **General Comments – Cap and/or ENR Material** Cap material is not discussed and has been deferred to the design phase and ENR material is described as a "sand and gravel mix." It is preferable to place material with physical characteristics similar to existing sediments. Use of rip rap is not supported by the Tribe. It should not be assumed that covering riprap armor with habitat mix will create a "habitat layer" and be acceptable. Please note that any "habitat layers" or "habitat mix" will need provisions for monitoring and maintenance as a remedy component.	**ST5 – Response** **General Comments – Cap and/or ENR Material** Riprap will be used only where it is structurally necessary to ensure the stability of the bank. The Port of Seattle, landowner, Tribes, and other stakeholders will be included in the remedial design process as the EPA and Lockheed collect the necessary geotechnical data to make determinations regarding the type of backfill and ENR material that will stay in place and provide the most benefit to benthic invertebrates and aquatic organisms at the Site.
ICs – Fish Advisory	**ST6** **General Comments – Institutional Controls** Institutional controls (ICs) should be not described as remedy components or be used in lieu of cleanup actions rather they limit land or resource use and/or by providing information that helps modify or guide human behavior at the site by minimizing exposure and/or protecting engineered remedies (sic). ICs do not protect human health pursuant to achieving Remedial Action	**ST6 – Response** **General Comments – Institutional Controls** The NCP provides the EPA's expectations for developing appropriate remedial alternatives, including ICs under CERCLA, as further discussed in OSWER 9355.0-74FS-P, September 2000 (*ICs: A Site Manager's Guide to Identifying, Evaluating and Selecting ICs at Superfund and RCRA Corrective Action Cleanups*). The NCP emphasizes the use of ICs to supplement

Topic	Comment	EPA Response
	Objective - 1 (RAO 1). RAO 1 requires achievement of human health protective levels through the reduction of COC concentrations in sediment and surface water. Therefore, ICs can be used to meet the intent of RAO 1 by limiting exposure, but cannot be said to achieve specific numeric clean up levels such as PRGs or RALs.	engineering controls during all phases of remediation and as a component of the completed remedy. At the Site, dredging will be used to remove the most contaminated sediments, and backfill and ENR (a thin layer cover) will be placed throughout the Site to manage dredge residuals and to cover and mix with low levels of surface contamination across the remainder of the remediation area. After remediation is finished and the Cleanup Levels and ARARs are met, concentrations of PCBs in sediment are still expected to be higher than the risk-based threshold concentrations at a 10^{-6} risk level, even after the most technically practicable remediation action is completed. This is because the Cleanup Level for PCBs is set at the natural background concentration in sediment (2 µg/kg-dw), which is above the RBTC for PCBs in sediment (less than 1 µg/kg-dw) for tribal seafood consumption. For this reason, a fish advisory IC is necessary. Rather than being used "in lieu of" active remediation, this IC is being used because the final Cleanup Level for PCBs (that is, natural background as allowed by MTCA) is not sufficiently protective of human health without using the Puget Sound fish advisory for Elliott Bay.
Consistency with LDW	**ST7** **General Comments – Consistency** As previously stated by the Tribe, and others**,** a consistent, comprehensive (watershed) approach to Duwamish River and Elliott Bay sediment remediation sites is essential. This includes but is not limited to assessment of human health and ecological risks, incorporation of congruent background levels and cleanup standards, and the appropriate coordination and phasing of cleanup activities. The inclusion of the Elliott Bay urban data set clearly deviates from the approach adopted for the LDW site, which was the basis for acceptance of a "streamlined" RI/FS process for the Lockheed West site.	**ST7 – Response** **General Comments – Consistency** The EPA agrees that a comprehensive approach is applicable to all of the remediation sites within Elliot Bay and the LDW. For this reason, the project managers and technical support staff working on these projects do a significant amount of collaboration (such as discuss remediation approach, cleanup numbers, etc.) to remediate these sites in a similar and protective manner. In some instances, differences are also identified through this collaboration, such as the use of the Elliot Bay Urban Background Data Set (Ecology, 2009) that is specific to Elliott Bay, but would not be applicable to the LDW. Ecology's Urban Background data set (Ecology, 2009) is not used for any regulatory purpose; rather it is only used as reference point for the FS evaluation. Generally the Urban Background concentrations are higher than the Cleanup Levels, but lower than the SMS SQS values, therefore the SQS concentrations were used as RALs to evaluate several potential alternatives for Site remediation. The Selected Remedy, Alternative 3C Plus, does not include Urban Background concentrations for any aspect of site remediation.

Topic	Comment	EPA Response
PRGs and RALs	**ST8** **Section 4** Terms and concepts discussed need better explanations, including but not limited to the differences between SQS and CSL, and the use of the Elliott Bay urban background levels. For SQS and CSL, it is unclear why CSL should be used for comparisons (and later for establishing AOPCs) instead of the more conservative SQS. Regarding the use of the Elliott Bay urban background levels, Section 4.2 defines natural background as characterized by the Bold data and then just drops the Elliott Bay data set into Section 4.3 without any explanation of where it came from or why anything besides natural background would be considered. A distinction should also be made in Table 4-2 as to what component of the Elliott Bay data set (urban) is being used. The last sentence on Page 4.3 states: "….COC concentrations may equilibrate to concentrations above background over time." Please clarify what "over time" means. Does background refer to the Bold data or Elliot Bay?	**ST8 – Response** **Section 4** These terms have been clarified in the ROD. The revised Table 4 in the ROD presents Urban Background in conjunction with Puget Sound natural background and cites sources of the information. Revised text in the ROD indicates that Urban Background and other Table 4 background levels are presented for comparative purposes, and that these levels were used in FS as basis for developing some alternatives. The use of the term "background" (as in Elliott Bay Background,) does not connote that these concentrations are acceptable or have any legal basis or standing and these sediments might also require cleanup in the future. Revised text in the ROD indicates that "over time" refers to the post-construction period where data collected from PSR, Todd Shipyards, and Lockheed Yard 1 long-term monitoring programs and Five-Year Reviews will be used as a temporal reference in conjunction with the data to be collected specific to the Lockheed West Site Post-construction Monitoring program.
TI Waiver	**ST9** **Section 7.2** Please provide the Tribe with the Elliot Bay water quality data that is being used and add citations to the document. If there is no data available and assumptions are being made the document needs to clearly state this. Unless there is actual data demonstrating that ambient conditions in Elliott Bay exceed AWQC, there is no basis for TI waiver at this time.	**ST9 – Response** **Section 7.2** Text in ROD has been revised to indicate sources forming the basis for the statements regarding water quality and risk presented in Section 6.3 of the Proposed Plan. In August 2012, the EPA sent the Tribes and King County surface water data, as requested.
PRGs and RALs	**ST10** **Section 7.3, last paragraph** The last paragraph contains a statement that natural background concentrations are identified as being protective of human consumption of seafood. This statement is erroneous and misleading. Background does not always equate with acceptable risk levels and is not based on seafood consumption. Please clarify this is a policy decision by EPA and Ecology that it is not practicable to require clean up levels below background concentrations.	**ST10 – Response** **Section 7.3, last paragraph** This statement has been revised in the ROD as stated in the response to comment ST6. For example, the natural background concentration for PCBs of 2 µg/kg-dw exceeds the RBTC level of less than 1 µg/kg-dw which is protective for consumption of seafood. The state's MTCA regulation allows parties to not remediate to the RBTC if there are higher concentrations than the RBTCs in the environment that is not within an area identified as contaminated. In addition to active remediation (dredging and a thin layer cover), a fish consumption advisory (known as an IC) will be required. The Tribe's statement is correct, and the ROD was modified to clarify that unlimited seafood consumption is not protective, but that eating the quantity of fish as per the Department of Health Puget Sound fish advisory is protective of human health.
Recontamination	**ST11** **Section 7.5** See the general comment above on conflicting statements regarding the potential for re-contamination.	**ST11 – Response** **Section 7.5** See response to Comment ST3.

Topic	Comment	EPA Response
Design – Pilings	**ST12** **Section 8.2.6** The Tribe concurs with DNR regarding the piling removal. While we support piling removal in the harbor area we prefer removal of all pilings within the site boundaries. We understand that the remaining pilings are being left to ease future permitting processes. However, this is not likely going to be the result as removal at a later date will potentially complicate the Selected Remedy implementation as well as raise significant concerns regarding contamination releases with future redevelopment activities.	**ST12 – Response** **Section 8.2.6** At this time, the number of pilings that will be removed throughout the Site will be determined at the EPA's discretion. The Tribes will have the opportunity to participate in this decision-making process during development of the remedial design plans. The landowner, Port of Seattle, has expressed an interest that the pilings on its property not be removed (see Comment POS5). Although it is easier to remediate a site after all the pilings have been removed, it is possible the BMPs could be used at this Site to allow protective remediation without full removal of all pilings. If some or all of the pilings remain on the Port's property, and future development warrants removal of some or all of these pilings, then the EPA will oversee this activity and the landowner will be required to follow specific guidelines and BMPs to reduce the chance that contaminated sediments will be released to the surface sediments. Monitoring may be part of these BMPs. Leaving pilings on the Port's property may not necessarily "ease future permitting processes." Any future landowner development will have to go through the permitting process, which allows for public comment.
ICs	**ST13** **Section 8.4** See general comment regarding Institutional Controls above.	**ST13 – Response** **Section 8.4** See response to Comment ST6.
Design – Long-term Monitoring	**ST14** **Section 9.11, first bullet** All alternatives (including the preferred alternative) need to include provisions for long-term monitoring (see monitoring general comment above). This is especially crucial for any alternative that leaves sediment concentrations greater than PRGs (at depth) which creates the potential for re-contamination via re-exposure of contaminated material, and ENR areas which have a greater potential for re-exposure because ENR is not engineered to ensure isolation and containment.	**ST14 – Response** **Section 9.11, first bullet** See response to Comment ST4 regarding provisions for long-term monitoring. Long-term sediment monitoring will be conducted at the Site.
Alternatives – Cap Repair	**ST15** **Section 9.11, second bullet** All alternatives (including the preferred alternative) should include repair/replacement provisions should damage occur.	**ST15 – Response** **Section 9.11, second bullet** Text has been modified in ROD.

Topic	Comment	EPA Response
Remedy Selection – General	**SMWG1 – General** **General Comment** **The Proposed Plan Deviates From U.S. EPA's National Contaminated Sediment Policy** In December 2005, U.S. EPA issued the *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites.* This Guidance embodies national policy on contaminated sediment and should be followed at all contaminated sediment sites (Guidance, p. 7-1). Its focus is on selecting remedies that will control sources and achieve long-term protection while minimizing short-term impacts and being cost-effective (Guidance, p. 7-17). The Guidance further emphasizes the importance of focusing on risk reduction, not simply assuming that mass removal equates to risk reduction. The Guidance provides a risk management decision-making framework to assist with selecting remedies that reduce human health and ecological risks effectively (Guidance, p. 7-1). Contrary to U.S. EPA's national contaminated sediment policy, which is focused on reducing risks associated with contaminated sediment sites, the Proposed Plan appears to be focused on mass removal over risk reduction. The Proposed Plan is a combination remedy with dredging as a significant component (Alternative 3C Plus) whereas the preferred alternative in the Feasibility Study is a combination remedy with capping as a significant component (Alternative 2A2a). U.S. EPA listed four reasons for selecting Alternative 3C Plus over Alternative 2A2a. Each will be addressed in turn:	**SMWG1 - General – Response** **General Comment** The *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (Guidance), is guidance and policy and contrary to the SMWG's statement "does not have to be followed at all contaminated sediments sties," but rather is used for guidance and overall direction. Remedy selection ultimately needs to be consistent with CERCLA and the NCP, including the Nine Criteria, and site-specific circumstances may warrant deviation from the Guidance to achieve consistency with the NCP and CERCLA. It is unclear from the SMWG's comments why the SMWG believes that mass removal would not reduce site risks. Based on the remedy selected, the Site-wide risk reduction and ultimate concentrations remaining in the sediment are identified in Table 13 of the ROD, and the State's SMS are based on risk. Risks at the Site will be reduced from greater than 10^{-3} and an HQ >1 to a cumulative risk of 10^{-5} and an HQ <1. The highest levels of contamination (sediments with concentrations greater than CSL) and a significant amount of sediments with concentrations greater than SQS will be removed to achieve this significant risk reduction.
Remedy Selection – ENR	**SMWG1A** **General Comment** **A. Reason Number One for Selecting Alternative 3C Plus - Expansion of the Remediation Footprint** The first reason for selecting Alternative 3C Plus over Alternative 2A2a given is: > "The actively remediated site surface area is greater for Alternative 3C Plus because it extends to the Study Area boundary rather than the Urban Background boundary." Approximately 10 additional acres are included in the remediation footprint by extending it from the Urban Background boundary to the Study Area boundary. This increase of 10 acres of remediation (from 30 acres to 40 acres) will not, however, result in additional risk reduction because it is fully expected that the Site's post-construction surfaces "may unavoidably re-equilibrate to levels above natural background over the longer term" due to "urban pollutant influences" in Elliott Bay (R10's Response to NRRB's Recommendations). The anticipated "re-equilibration" is based on monitoring data from the adjacent Pacific Sound Resources Superfund Site, which showed that only	**SMWG1A – Response** **General Comment** The EPA focuses on Site remediation and does not manage areas significantly beyond the Site remediation boundaries. Although the EPA recognizes that there are contaminant concentrations that may move back onto the Site from Elliott Bay, the Superfund remediation addresses Site risk and Site-related contamination. At the conclusion of the remediation, the Cleanup Levels for each RAO will be met. At this time, neither the EPA nor Ecology has identified Elliott Bay as a remediation area. In addition, cleaning up this urban embayment goes far beyond "source control activities" that would be reasonably associated with the Site remediation. If there is recontamination at this Site from offsite sources, then these other sources need to be evaluated for remediation versus reducing the extent of the remedy at the Lockheed West Site. The Tribes are on the record as not supporting remediation to the Urban Background concentrations. If remediation of Elliott Bay is determined to be necessary in the future, then the regulatory agency responsible for ordering this action will also need to re-evaluate if additional work may be necessary at sites already cleaned up in Elliott Bay and around Harbor Island. The reason the ENR area is extended to the study area boundary in the

Topic	Comment	EPA Response
	two years after construction completion, the cap's surface had concentrations of COCs exceeding natural background. In fact, some of the concentrations of COCs approached urban background. For example, in 24 of 25 samples, PCB concentrations exceeded the natural background concentration of 2 ug/kg dw and two of the samples exceeded the urban background concentration of 119 ug/kg dw (PCB concentrations ranged from 2 to 317 ug/kg dw). For cPAHs, all 25 samples exceed the natural background concentration of 9 ug/kg dw. The concentrations of cPAHs ranged from 10.48 to 242 ug/kg dw. In addition to the samples exceeding natural background for PCBs and P AHs that were taken two years after construction completion, samples taken one year after construction completion exceeded natural background for mercury (11 of 12 samples), lead (9 of 12 samples), and arsenic (5 of 7 even exceeded urban background). This recontamination one to two years following construction completion was not due to cap failure, but rather to the urban influences in Elliott Bay (i.e., urban background). Therefore, due to the anticipated "re-equilibration", remediating the additional 10 acres between the Urban Background boundary and the Study Area boundary does not provide additional risk reduction. Because there is no risk reduction purpose, using the additional remediation acreage as a rationale for selecting Alternative 3C Plus contravenes the Guidance's focus on risk reduction.	Alternative 3C Plus remedy is to ensure that the human health Cleanup Levels (which are determined by site-wide average concentrations) will be met. If ENR was not extended to the additional 10 acres on the Site and only encompassed the area delineated by Urban Background concentrations, then the RAO 1 Cleanup Levels would not be met; this is because in these 10 remaining acres, some contaminant concentrations are higher than these Cleanup Levels. If these higher sediment concentrations were averaged into the clean ENR and post-dredging surface sediment concentrations, the Site-wide average would be higher than the Cleanup Levels and this remediation would neither be protective of human health, nor would it meet the Site ARARs. Urban Background concentrations are used only for discussion/evaluation purposes to provide a relative scale for contaminant concentrations found on the Site. Remediation under CERCLA is authorized to meet anthropogenic background concentrations (however, the Urban Background concentrations have not been identified by the EPA as such), but under the state's MTCA (which is an ARAR at this site), the lower natural background concentrations have to be met. Alternative 3C Plus accomplishes this objective.
Remedy Selection – Future Use Assumptions	**SMWG1B1** **General Comment** **B. Reasons Number Two and Three for Selecting Alternative 3C Plus – No Capping** The second reason for selecting Alternative 3C Plus over Alternative 2A2a given is: "Alternative 3C Plus does not involve capping, negating the need for more restrictive ICs [institutional controls] and long-term monitoring." The third reason for selecting Alternative 3C Plus over Alternative 2A2a given is: "Future site use restrictions required by capping that could affect Port development plans, and that are inconsistent with the DNR mandate for "water dependent uses" of state-owned lands would be eliminated by Alternative 3C Plus. Alternative 2A2a encumbers the Site with a cap and additional ICs, but does not preclude reasonably anticipated future land uses envisioned by the Port and DNR." These two reasons are related to concerns over potential restrictions on future site use. The administrative record confirms that capping does not preclude	**SMWG1B1 – Response** **General Comment** There are five parties that have specific and significant interests in the Site. The Suquamish and Muckleshoot Indian Tribes have tribal treaty rights at the Site. The Port and DNR have ownership and/or land-management responsibility. The EPA has tribal trust responsibility and environmental regulatory authority at the Site. The Port, DNR, and the two Tribes specifically requested that capping alternatives not be selected (see comment letters in the administrative record). And, in the case of the Port, there are two WRDA requests for deepening the navigation channel in the West Waterway, which is part of the Site. The Port also has a Shoreline Management Plan that identifies potential future development on the northern shore of the Site. The use of the Site in the future by the Port, or any future landowner, would not be precluded by capping, as the SMWG correctly points out. However, a cap would require additional ICs to ensure long-term protectiveness and/or require additional financial expenditures during future development activities such as disposal of cap material, disposal of underlying contaminated material, and sampling during development activities, etc. Furthermore, Lockheed would have been required to have significant

Topic	Comment	EPA Response
	reasonably anticipated future site uses. The RI/FS Report notes that "potential future use restrictions related to cap areas can be minimized during design by increasing the thickness of the cap to allow anchoring and grounding of small vessels and by coordinating with the Muckleshoot and Suquamish Tribes, Port of Seattle, and DNR." Moreover, as U.S. EPA acknowledges, Alternative 2A2a "does not preclude reasonably anticipated future land uses envisioned by the Port and DNR," so it is difficult to understand why the potential future development plans of the Port are used as a reason to reject a primarily capping alternative based on acknowledged site-specific conditions. Such a concern could be addressed by dredging in the small number of acres, if any, which might encroach a deeper navigational channel. Finally, the Site has limited public access due to its Homeland Security designation, which is not likely to change, especially if the Port expands the terminal. Thus, potential future site uses do not appear to preclude capping.	financial assurance obligations for maintenance and possible future replacement of a cap. Additional ICs related to a cap: Even a cap with additional material added to it to allow for anchoring would require ICs to ensure that the cap stays in place and sequesters the underlying contaminated sediments. Additionally, the Coast Guard would have to indicate the modified bathymetry on Coast Guard charts and maps. Additional costs related to a cap: In the event a future owner needed to remove sediments in a capped area, the EPA agrees that this would be allowable with EPA oversight. However, the landowner would have additional disposal costs for disposing both the clean cap material (potentially up to 5 feet if additional material was used to allow for small boat anchors as was done at the adjacent PSR site) and any contaminated material beneath the cap to the depth of their intended use. Disposal of contaminated sediments is appreciably more expensive than disposing clean material (which may be accepted at the local DMMP site in Elliott Bay). In addition, development dredging activities pose the same short-term risk of dredge residuals, which would need to be managed post-dredge with placement of clean material. Costs were not available during the time of alternative development regarding what the Port and DNR would charge Lockheed Martin if a cap were placed in this area (DNR does not deem a cap a “water dependent use”) and if future development activities required that it be removed. These costs would be based on negotiations between those parties, and these negotiations were not conducted before remedy selection. The Proposed Plan mistakenly stated that the area outside of the Port’s fence line on Terminal 5 limits public access due to Homeland Security issues. The Port of Seattle has recently stated that this is not the case, and public access to the bank and intertidal areas of the Site is permissible.

Topic	Comment	EPA Response
Remedy Selection – Dredging	**SMWG1B2** **General Comment** **B. Reasons Number Two and Three for Selecting Alternative 3C Plus – No Capping** An additional "site use factor" that favors capping over dredging is the duration of construction, which is very disruptive to use of the water body. Capping can achieve the cleanup goals faster and, more importantly, with fewer short-term impacts than dredging. With the shorter construction duration of capping, use of the water body will be impacted less than it would be in a primarily dredging remedy.	**SMWG1B2 – Response** **General Comment** In its evaluation of the Nine Criteria, the EPA acknowledged that there may be fewer short-term risks with capping. However when evaluating the Nine Criteria collectively, the EPA determined that the need for long-term effectiveness and permanence outweighed short-term effectiveness and short-term impacts to the Site; and based on the current water quality monitoring and turbidity readings at the Boeing Plant 2 dredge project, the EPA is confident that any short-term risks can be minimized. Additionally, the Port has stated that this is one of the last significant areas that can be developed in the future. Therefore, it is not a matter of if, but a matter of when dredging will occur in this area and for reasons stated previously, the EPA has selected Alternative 3C Plus as the Selected Remedy. Dredging provides more long-term effectiveness and permanence, has significantly less long-term costs, and meets concerns of landowners, managers, and those with treaty rights. All of these considerations, plus the seismically active nature of the area (see response to Comment SMWG1C), demonstrate that the benefits of dredging outweigh capping at this Site. Alternative 3C Plus is anticipated to take 1 to 2 years to complete. However, once design is started, minimizing the dredge work to 1 year will be evaluated. Therefore, the duration of implementing capping or this dredging remedy is not likely to be significantly different.
ICs – Covenant	**SMWG1B3** **General Comment** **B. Reasons Number Two and Three for Selecting Alternative 3C Plus – No Capping** Neither Alternative 3C Plus nor Alternative 2A2a eliminate the need for institutional controls. Both require a restrictive covenant ''that runs with land and requires coordination with U.S. EPA and management of any residual contamination that is disturbed or encountered in the event of future excavation or dredging within the boundaries of the Site." Additionally, both require fish consumption advisories because the risk-based cleanup levels are below natural background. Institutional controls are, therefore, necessary under either alternative.	**SMWG1B3 – Response** **General Comment** It was not the EPA's intent to state or infer that there were not any ICs with Alternative 3C Plus. The UECA covenant required with Alternative 3C Plus is a much less onerous IC than any of the other ICs that would be necessary for a capping alternative because of the high concentrations of contamination that would be left on the Site in perpetuity under a cap. With the capping alternatives, future development activities would have significantly more material (both clean and contaminated) to remove and dispose, significantly increasing future redevelopment costs. The fish consumption advisory is not unique to this remediation. It is in effect throughout Elliott Bay, which includes this Site, and elsewhere in Puget Sound. The advisory was identified in the Proposed Plan to ensure that the PRP and the public did not think that remediation at this Site was sufficient to eliminate the fish advisory. In addition to ICs to ensure the contamination is "permanently" sequestered, the PRP would be required to provide for full cap replacement costs in the event of an earthquake and would have to provide Financial Assurance for the 100+ years that this remedy would remain effective.

Topic	Comment	EPA Response
		Alternative 2A2a requires more ICs than Alternative 3C Plus as described in the Proposed Plan and the EPA's response to Comment SMWG1B1.
Design – Long-term Monitoring	**SMWG1B4** **General Comment** Similarly, neither Alternative 3C Plus nor Alternative 2A2a eliminate the need for monitoring (Proposed Plan). Long-term monitoring is part of most sediment remedies (Guidance, p. 8-1), including Alternatives 3C Plus and 2A2a. Moreover, long-term monitoring of caps is not, in of itself, an acceptable basis to exclude capping from consideration. Thus, the long-term monitoring requirements of the proposed cap should not preclude selection of a primarily capping remedy at this Site. Based on anticipated future site uses, the ability to account for these in designing a cap, the shorter duration of a capping construction project, and the need for some institutional controls regardless of the remedy, future site uses should not preclude capping.	**SMWG1B4** **General Comment** Long-term monitoring requirements for capping remedies did not preclude selecting capping as the remedy for this Site. (See the EPA responses to previous SMWG comments.) The EPA agrees that at most sites sediment remedies are monitored after remediation actions are complete—and the extent of monitoring is determined based on the extent and type of remedial activities implemented except in instances where all or most of the contamination is removed. This is the case with the Selected Remedy for this Site. Since releasing the Proposed Plan, the EPA has determined that sediment monitoring will be a remedy component. However, the extent of monitoring will be different than if a cap was selected. The EPA's evaluation and weighting of the Nine Criteria is different than that of the SMWG.
Remedy Selection – Seismic Concerns	**SMWG1C** **General Comment** **C. Reason Number Four for Selecting Alternative 3C Plus - Seismic Concerns** The fourth reason for selecting Alternative 3C Plus over Alternative 2A2a given is: "Potential for re-exposure of subsurface contaminated sediments and seismic damage is less for Alternative 3C Plus because the areas of highest-contaminant concentrations are being removed via dredging and the remaining contaminant concentrations on the Site are low (generally less than SQS [Sediment Quality Standards])." This rationale is not well-supported by the evidence nor is it a reasonable risk-based reason. The Guidance cautions that there should not be "a presumption that removal of contaminated sediments from a water body will be necessarily more effective or permanent than capping or MNR" (Guidance, p. 3-16). Rather, an evaluation of a proposed cap's long-term effectiveness and permanence should be conducted based on site-specific conditions. To address the potential impact of seismic events on the long-term permanence and effectiveness of the remedial alternatives, a seismic evaluation of the potential for liquefaction, slope stability and flow was conducted. As discussed below, this evaluation showed that capping would be an effective, permanent remedy at the Site. The results of a seismic evaluation show that "for nominal I00-year and 500-year events," the analyses "do not suggest a large-scale failure" related to liquefaction, slope stability or flow slides (RI0's Response to NRRB	**SMWG1C – Response** **General Comment** The EPA fully evaluated Alternative 3C Plus and the site-specific potential for seismic events and determined that the Selected Remedy is protective of human health and the environment. The EPA stands by its conclusion that in the event of a seismic event, "the potential for re-exposure of subsurface contaminated sediments and seismic damage is less for Alternative 3C Plus…" As stated in the Lockheed West seismic evaluation and supporting documentation (USGS, 2007), the Duwamish Delta sits in a unique geologic environment in relationship to most regions of the United States. Specifically, the Site, situated on the southern boundary of Elliot Bay, is near the northern edge of the Seattle Fault Zone and is underlain by interbedded silts and sands that are highly susceptible to liquefaction. Historical evidence supports earthquakes associated with this fault in excess of magnitude 7.0 and possible accelerations of 0.6g within the last 1,100 years. This earthquake resulted in nearly 7 meters of vertical displacement on Bainbridge Island, 5 miles due west of Seattle. This displacement can also be observed on Kellogg Island, roughly 1 mile south of the Site. Besides ground shaking and displacements from a seismic event on the Seattle fault, the area is also vulnerable to strong ground shaking from a seismic event on the Cascadia subduction zone. The portion of the subduction zone located off the west coast of Washington (often referred to as the Cascadia Megathrust source) was the cause of an estimated 9.0+ magnitude earthquake approximately 300 years ago, which caused liquefaction throughout the area

Topic	Comment	EPA Response
	Recommendations). More specifically, while the sediment may be susceptible to liquefaction during a seismic event, "the risk of potential upwelling, exposure and spreading of contaminated sediment beneath the capped areas" is "expected to be localized" (RI0's Response to NRRB Recommendations) and may only occur during the 2,500-year event, but is not expected during a I00-year or 500-year event (RI/FS Appendix H - Liquefaction Potential and Seismic Stability Evaluation of Remedial Alternatives). Moreover, "[s]uch an event may cause short-term disruption of the benthic community in the affected zone but could be repaired by placement of additional cap material" (RIO's Response to NRRB Recommendations). Similarly, for either a capping or dredging remedy, the slope stability analysis demonstrates that if "slope stability failure of those capped berms or former dredge cuts occur", the "failure would be localized and easily repaired by placing additional cap material" (RIO's Response to NRRB Recommendations). Additionally, "the current analysis does not suggest occurrence of a large-scale flow slide that may affect the stability of contaminated sediments" (RI0's Response to NRRB Recommendations). Finally, the results of monitoring within the vicinity of the Site during a 2001 earthquake (Nisqually earthquake), which had characteristics similar to the IOO-year and 500-year events analyzed, "do not indicate any recognizable effect of liquefaction, slope failure, or flow slides" (RIO's Response to NRRB Comments). Thus, as acknowledged by U.S. EPA in its Response to NRRB Comments, the seismic analyses and real world monitoring data from a seismic event suggest that seismic-related issues can be addressed as part of the operations and maintenance plan for a cap at the Site. The seismic analysis of a I00-year event is in line with the Guidance, which recommends evaluating extreme events, such as floods, hurricanes and earthquakes, based on a probability of occurrence of 0.01 in a year (Guidance, p. 2-29). Similarly, the Guidance recommends designing caps "to withstand forces with a probability of 0.01 per year" (i.e., I00-year event) (Guidance, p. 5-9). The seismic analyses show no anticipated exposure of contaminated sediment as a result of a I00-year or a 500-event. For a 2,500-year event, which is far outside the recommended evaluation and design event of a IOO-year event, any impact is anticipated to be localized and can be addressed with the operations and maintenance plan for a cap (RIO's Response to NRRB Recommendations; RIIFS Appendix H). There is, therefore, no reasonable risk-based reason for selecting dredging over capping due to seismic concerns.	from several minutes of strong ground shaking. The recent 6.8 Nisqually earthquake (February 2001) also was located on the Cascadia subduction zone as it dives from the Pacific coastline below Seattle. The epicenter for the Nisqually earthquake was nearly 50 miles from the Duwamish. Considerable variation in ground motion occurred in the Puget Sound Region, with observed liquefaction in many areas including Port of Seattle facilities. Liquefaction caused damage to pavements and buried utilities in the vicinity of the Lockheed West Site and along the Duwamish corridor, including Terminal 5 immediately south of the Lockheed West Site. Based on seismic analyses conducted for Lockheed West and other sediment remediation projects described in Appendix H of the RI/FS, higher ground motions than the 0.22g assigned to the Nisqually earthquake are appropriate to consider for cap design. Also relevant to the analysis, is the similarity of the Duwamish area to areas that liquefied during both the 1989 Loma Prieta, California, and 1995 Kobe, Japan, earthquakes. As outlined in the USGS professional paper (USGS, 2007), the geologic conditions and proximity to significant faults are similar in all three regions. In Kobe, harbor piers supported on engineered fills, similar in construction to containment caps, displayed 13 feet of vertical displacement as a result of liquefaction generated by the 6.9 magnitude Kobe earthquake. Though sufficiently engineered and constructed per the standard of the day, the piers failed as a result of the liquefaction of the underlying sediments and not from the failure of the pier itself. Considerable variation in ground motion occurred within the Puget Sound area during the Nisqually earthquake, and the assumption that the sediments experience a 0.22g earthquake is subject to debate. There is no debate, however, that the Nisqually earthquake caused considerable liquefaction within the Port of Seattle, despite the distance to the epicenter. Based on information presented in Appendix H of the RI/FS, higher ground motions than the 0.22g assigned to the Nisqually earthquake must be considered for cap design, consistent with most other recent projects in the areas (Table H-1 in RI/FS). Seismic evaluations conducted at Lockheed West during the RI/FS indicated that sediments within about 50 feet of existing grade are susceptible to liquefaction that would likely be initiated during 100-, 500-, and 2,500-year events. These events range in magnitude from 6.5 to 6.7 on the Richter scale and have peak ground accelerations of 0.18g to 0.75g. When using these earthquakes, predicted liquefaction of shallow sediments during these events could result in failure of a cap either from sliding of the cap on sloping ground or from general ground disruption. Sediment layers where liquefaction is likely to be initiated represent approximately 13 to 36 percent of the subsurface characterized by site borings extending to depths of 75 to 125 feet. In particular, the approximate top 10 feet of silty sediments within

Topic	Comment	EPA Response
		the dry dock area could form a fairly homogenous liquefiable layer. In addition to liquefaction, seismic evaluations of slope stability and potential large-scale flow were conducted. Both localized slope failures and larger lateral flow slides were identified as being possible, with some movement related to lateral spreading predicted even during the 100-year event. Although disruption of capped areas may be localized during the lesser events, this scenario represents an important consideration for remedy performance. The EPA *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (EPA, 2005) document indicates that events with a probability of occurrence similar to the 100-year recurrence interval should be considered where such events could disrupt the remedy. The guidance further indicates that it may be appropriate to analyze effects of events with lower ***and higher*** probabilities to understand the cost-effectiveness of various design decisions. In particular, the guidance indicates that capping alternatives should consider events such as seismic disturbances with a similar probability of occurrence as the 100-year event, ***at a minimum***. Given the uncertainty in soil/sediment response to seismic loading, a 100-year design basis is too short for the Lockheed West Site. The risk to the environment serves as a reasonable basis for evaluating longer-term recurrence intervals, consistent with construction design practices in the Puget Sound area. The predicted failure scenarios combined with the observed damage in Kobe and Loma Prieta earthquakes of similar magnitude influenced Lockheed's recommendation for a removal alternative and EPA concurrence. Another consideration was long-term cost, primarily financial assurance obligations and cap replacement costs. When determining the appropriate option, long-term considerations of the permanence of the cap were considered. Though the EPA typically only requires 30 years of financial assurance (for cost purposes in the FS), a cap would need to be maintained in perpetuity. In addition, the seismic models predicted the "average" reoccurrence time for these seismic events, and that the potential for a larger earthquake, such as a magnitude 7.5 earthquake on the Seattle Fault, could result in need for full replacement of a cap.

Topic	Comment	EPA Response
PRGs and RALs	**SMWG2A** **General Comment** **U.S. EPA Should Waive The Natural Background ARAR Because Sediment Will Likely "Re-Equilibrate" To Levels Above Natural Background.** The Proposed Plan identifies the State of Washington's Model Toxics Control Act ("MTCA") as an ARAR. Where risk-based cleanup levels are below natural background, "the cleanup level shall be established at a concentration equal to the practical quantitation limit or natural background concentration, whichever is higher." WAC 1 73-340-700(6)(d). As described in Section I above, U.S. EPA anticipates that within a few years of construction completion, the sediment will "re-equilibrate" to concentrations above natural background due to the Site's location in an urban/industrial waterway. It is disingenuous to state that the Proposed Plan will meet the MTCA natural background ARAR while acknowledging that the Site will likely "re-equilibrate" to concentrations above natural background before the Five-Year Review based on monitoring data from one and two years following construction completion at the adjacent Pacific Sound Resources Superfund Site. Maintaining (long-term effectiveness) natural background at this Site is technically impracticable, and thus, this ARAR should be waived pursuant to 40 CFR §300.430(f)(l)(ii)(C)(3).	**SMWG2 – Response** **General Comment** The EPA's remediation will meet MTCA, thus, a waiver of the ARAR is not appropriate. As previously stated, the fact that the Site sits within the greater Elliott Bay and may be affected by elevated contaminant levels in Elliott Bay is an issue that the EPA and Ecology may need to address through regulation in the future. The EPA has determined that, within the larger Elliott Bay, it is appropriate to clean up discrete areas and specific sources of contamination regardless of the larger Elliot Bay background contamination load. This is a legitimate approach to address contamination in increments, with each incremental remediation reducing the contaminant loading to Elliott Bay. If data collected at the Site indicate that recontamination of the Site has occurred, but that the source of materials is from offsite (contaminants would be in the upper 10 cm), the remedy would still be considered successful and protective, given the objectives of the remedial action. In the event MTCA were waived, the Selected Remedy still must address the contamination on the Site to the maximum extent technically practicable, which is Alternative 3C Plus.
TI Waiver	**SMWG2B** **General Comment** There is precedent at this Site for proposing a technical impracticability ARAR waiver due to the on-going urban/industrial influences in Elliott Bay. With respect to the Ambient Water Quality Criteria ("AWQC") ARAR, U.S. EPA has already proposed a technical impracticability waiver because the Site's surface water "will continue to be impacted by the flow of surface water in Elliott Bay and the Lower Duwamish Waterway," which are urban/industrial waterways (RIO's Response to NRRB Recommendations). Due to the continued urban/industrial influence, the Proposed Plan will not result in meeting the AWQC. Thus, the limitations of what can be achieved at the Site due to its location in an urban/industrial waterway have been recognized and, appropriately, a technical impracticability waiver has been proposed for the AWQC ARAR. U.S. EPA should extend its acknowledgement of the practical limitations of what can be achieved and maintained at the Site with respect to the sediment cleanup numbers and seek a technical impracticability waiver for the MTCA natural background ARAR.	**SMWG2B – Response** **General Comment** As demonstrated by recent evaluation of Elliott Bay surface water data collected by King County, concentrations of arsenic in excess of the AWQC for human consumption of aquatic organisms are present in surface waters. As such, it is possible that the surface water will not meet AWQC for arsenic at the completion of the remediation, at which time a TI waiver will not be needed for sediments because sediments will be compliant with MTCA (that is, natural background levels) following construction. See the EPA's response to Comment SMWG 2.

Topic	Comment	EPA Response
Remedy Selection – Risk Reduction	**SMWG3A** **General Comment** **The Proposed Plan Is Not Consistent With The NCP.** The NCP requires that the selected remedial action be cost-effective by having a proportionality between the effectiveness of each remedial alternative in relation to their respective costs: "Each remedial action selected shall be cost-effective" (40 CFR §300.430(f)(l)(ii)(D)). Cost-effectiveness is defined as "costs are proportional to its overall effectiveness." (40 CFR §300.430(f)(l)(ii)(D)). The Proposed Plan violates the NCP's cost effectiveness because its costs ($48.1 million) are not proportionate to its anticipated effectiveness. First, the Proposed Plan is not expected to result in any measurable reduction in PCB concentrations in fish tissue, and therefore, is not expected to reduce human health risks associated with fish consumption. U.S. EPA acknowledges this expectation in Region 10's response to the NRRB's Recommendations: "[I]t is not certain that fish tissue concentrations will dramatically improve after this action given that the fish move throughout Elliott Bay. By the same token, it is hard to quantify the reduction, if any, in human health risks." This lack of measurable risk reduction in the human health fish consumption pathway is the case for both Alternative 3C Plus (cost - $48.1 million and Alternative 2A2a (cost - $18.6 million), but Alternative 3C Plus costs 2.5 times as much to not reduce risks to human health associated with fish consumption.	**SMWG3A – Response** **General Comment** At the time of the NRRB review, the EPA was still developing its preferred alternative. Among the alternatives being considered by the EPA were 2A2a, 3A2, and 3C. After the NRRB review, as the RI/FS was being finalized, Lockheed Martin participated in a series of meetings with several Stakeholders – the Port of Seattle, DNR, and the Suquamish Tribe. Part of the information they gathered was the interest in having the navigation channel dredged to SQS. As a result of these discussions and additional discussions with the EPA, Alternative 2A2a Plus was developed. After evaluating the modifications to this alternative, the EPA also requested that several other alternatives be similarly modified (these modified alternatives are discussed in Appendix I of the RI/FS). As the Proposed Plan states, the comparison of the Selected Remedy is not to 2A2a, but rather to 2A2a Plus ($35.8 million). The additional $12.3 million cost of Alternative 3C Plus ($48.1 million) over Alternative 2A2a Plus ($35.8 million) includes removal of the highest levels of contamination from the Site, obviates the need for extensive ICs associated with capping remedies that are left in place in perpetuity (such as significant long-term sediment monitoring), and eliminates payments to the Port and DNR for capping on their property. Alternative 3C Plus also eliminates potential dredged material disposal costs for future landowners in the event redevelopment occurs in this area and eliminates concern for exposing high levels of contamination in the event of a significant seismic event, as the Site is on the Seattle Fault line. The placement of ENR over additional 10 acres extends the remediation area to the Study Area boundary and ensures that compliance with MTCA is attained. The EPA identified 3C Plus as the Preferred Alternative based on these benefits, which makes this alternative cost-effective. Superfund guidance entitled *A Guide to Preparing Superfund Proposed Plans, RODs and Other Remedy Selection Decision Documents* (EPA, 1999), states on page 6-51 that “It is important to note that more than one cleanup alternative can be cost-effective and the Superfund program does not mandate the selection of the most cost-effective cleanup alternative. In addition, the most cost-effective remedy is not necessarily the remedy that provides the best balance of tradeoffs with respect to the remedy selection criteria nor is it necessarily the least-costly alternative that is both protective of human health and the environment and ARAR-compliant. Rather, cost-effectiveness is concerned with the reasonableness of the relationship between the effectiveness afforded by each alternative and its costs compared to other available options.”

Topic	Comment	EPA Response
Remedy Selection – PRGs and RALs	**SMWG3B** **General Comment** **The Proposed Plan Is Not Consistent With The NCP.** Second, proposing to remediate additional acreage (approximately an extra 10 acres) beyond the "Urban Background footprint" to natural background cannot, by definition, be cost effective. It is not cost-effective to remediate sediment with COCs below urban background concentrations knowing that it is likely to recontaminate to urban background concentrations within a few years of construction completion. Remediating sediment to achieve concentrations below urban background, while fully anticipating recontamination of the remediated sediment to urban background concentrations within a few years of remediation, is the antithesis of long-term remedial effectiveness, ignores the reality of the Site and is a waste of resources.	**SMWG3B – Response** **General Comment** Adding 10 additional acres of ENR to the Study Area boundary costs about $0.8 million and results in meeting the natural background concentrations for COCs on a site-wide basis. This provides greater long-term protection cost benefits over ENR placement to the Urban Background footprint. At the end of construction, the remedy will be protective and will meet ARARs, with the exception of the surface water AWQC for arsenic. As stated in earlier responses, it is anticipated that through discrete actions around Elliot Bay, the overall sediment concentrations in Elliott Bay will decrease, and therefore the current Urban Background level, which does not have any legal basis or standing, is not an appropriate long-term remedial goal for this site.
Remedy Selection – General	**SMWG3C** **General Comment** **The Proposed Plan Is Not Consistent With The NCP.** Third, the Feasibility Study presented a preferred option that met the NCP Criteria, but cost only $18.6 million (Alternative 2A2a). Per the U.S. EPA's 1999 guidance, *A Guide to Preparing Proposed Plans, Records of Decision, and Other Remedy Selection Documents,* "cost-effectiveness is concerned with the reasonableness of the relationship between the effectiveness afforded by each alternative and its costs compared to other available options." Moreover, "if the difference in effectiveness is small but the difference in cost is very large, a proportional relationship between the alternatives does not exist" (Preamble to NCP). These proportionality requirements were reiterated by U.S. EPA in the Guidance. Spending 2.5 times more money (almost an additional $30 million) to achieve likely no measurable reduction in human health risks associated with fish consumption, remediate sediment that is below urban background that will likely "re-equilibrate" to urban background within a couple of years, that has more short-term impacts due to the risks associated with dredging, and that requires a longer construction duration is not reasonable nor is it cost-effective. Thus, the Proposed Plan is inconsistent with the NCP and with U.S. EPA guidance.	**SMWG3C– Response** **General Comment** See response to Comment SMWG3A. As noted in the response to Comment SMWG3A, the EPA identified Alternative 3C Plus as the Preferred Alternative based on the benefits of contaminant removal that are commensurate with the estimated implementation cost. The sediment removal elements of 3C Plus obviate the need for extensive ICs, long-term sediment cap monitoring, and payments to the Port and DNR for cap placement. Alternative 3C Plus also eliminates potential dredged material disposal costs for future landowners and decreases risks associated with seismic concerns. The additional 10 acres of ENR (thin layer cover) ensure that compliance with MTCA is attained and the Selected Remedy has community and Tribal acceptance. Appendix I of the FS, which identifies the “Plus” alternatives and was developed after the FS was substantially complete, reflects the results of discussions between Lockheed Martin, the Tribes, DNR, and the Port concerning dredging the navigation channel as part of the remedy. Dredging the navigation channel (Alternative 2A2a Plus, $35.8 million) was developed in response to concerns expressed at these meetings.
Remedy Selection – General	**SMWG4** **Conclusions** The Guidance provides a scientifically sound, risk-based approach to addressing contaminated sediment sites. Sediment sites present challenging problems, but following the policy and procedures in the Guidance is necessary to assure that the Selected Remedy will reduce risk and be cost-effective. The Proposed Plan for the Lockheed West Seattle Superfund Site	**SMWG4 – Response** **Conclusions** Overall, the SMWG appears to prefer capping alternatives to dredging alternatives based on its comments. Based on site-specific circumstances outlined in the Proposed Plan, the ROD, and this Responsiveness Summary, the EPA has selected a dredging remedy at this Site. The SMWG has not presented any new information that has not already been considered by the

Topic	Comment	EPA Response
	deviates from the NCP and the Guidance in several critical ways, including not following the Guidance's risk management framework for selecting a risk-reduction focused remedy and failing to comply with the NCP's requirement that remedies be cost-effective. As a consequence, the Proposed Plan selects an alternative that is not focused on risk reduction, is not cost-effective, and costs 2.5 times more than an alternative that would provide similar long-term protection and effectiveness as the selected alternative. Moreover, significant recontamination of the surface sediment with concentrations of COCs greater than the remediation goals is a virtual certainty, as admitted in the Proposed Plan and in Region 10's response to the National Remedy Review Board's "Recommendations for the Lockheed West Seattle Superfund Site." Accordingly, the Proposed Plan should be withdrawn and a new remedy should be selected.	agency, or discussed with the PRP and stakeholders for the last 5+ years while developing the RI/FS. The EPA appreciates the comments and perspective of the SMWG, but respectfully disagrees and will not modify the Selected Remedy based on these comments. The Selected Remedy is consistent with CERCLA and the NCP..
Design – Long-term Monitoring	**N1** **General Comment** Monitoring is needed for this remedy, albeit less monitoring than would have been necessary if a less comprehensive remedy had been selected. We need to ensure that remaining contamination is not migrating upwards through the ENR layer and that the ENR layer is not being washed away. The proposed alternative (3C+) removes all contamination above the CSL and much but not all of the contamination above the SQS. Whenever contamination is left onsite, the 5-year reviews must assess whether the remedy remains protective. A bathymetric survey alone, as proposed in the Proposed Plan, will not be able to adequately assess this, as it won't be able to observe subsurface mixing or migration that would bring buried contamination back up to the surface. Analytical chemistry sampling is needed in time for evaluation at the 5-year review, but should allow some time after remediation to ensure that longer-term processes are represented, thus I suggest sampling during year 3. Lockheed has stated that it may be difficult to distinguish between recontamination from off-site sources vs. remedy failure, since low-level contamination from Elliott Bay or the Lower Duwamish River may be transported to the Lockheed West site. Some suggested methods to address this difficulty are listed below. Since the ENR layer should be readily visually distinguishable from the in situ sediments, 1-2 foot core samples could be taken in clear plastic coring devices to visually inspect the ENR layer. The thickness of the ENR layer should be evaluated to determine whether it is being eroded away. (Since core samples often compress upon collection, it is understood that this method can only measure relatively large amounts of erosion.) Samples for chemistry could then be taken from the top of the core (to represent new sedimentation on top of the ENR layer) and from the ENR layer itself (to	**N1 – Response** **General Comment** The EPA has added sediment sampling to the Selected Remedy, and it will be performed as part of the LTMMP.

Topic	Comment	EPA Response
	assess whether migration through this layer is occurring). Samples from below the ENR layer could also be taken to determine whether SQS-level material is still present onsite (to determine the need for future monitoring beyond the 5-year review). Additionally, since all material above SQS is to be removed from shorelines and intertidal areas and from the shipway and navigation channel, another possibility would be to perform chemical monitoring at these locations and to compare the results to chemical monitoring from the dry dock areas of the site (where contamination above SQS will remain under the ENR layer). If the dry dock areas are observed to recontaminate while the other areas do not, that could indicate remedy failure. In contrast, if all areas of the site experience the same low-level recontamination, that may indicate the source of the recontamination is off-site (i.e. Elliott Bay or Lower Duwamish River).	
Remedy Selection – General	**PM1** **People for Puget Sound** We just want to be on record that People for Puget Sound does prefer a full removal of contaminated sediment in all sites in Puget Sound. We understand at this site, that has not been preferred alternative. We do feel it's been a good process over the past few years with stakeholders and that a lot of our concerns have been addressed and those were, for example, seismic activity in Elliott Bay, the Seattle fault, groundwater contamination that's still kind of in progress, and concerns about future uses in terms of the depth -- for depth of ports use.	**PM1 – Response** **People for Puget Sound** Comment noted.
General	**PM2** **People for Puget Sound** We, generally, would like, and we're kind of disappointed, that we still don't have this packet to go forward with the regional treatment facility because we have so many sites in Puget Sound, not just in Seattle, but in Bellingham locations where -- that we think and the Duwamish River Cleanup Coalition also thinks could be a viable and strong idea and create green jobs opportunity for Puget Sound.	**PM2 – Response** **People for Puget Sound** Comment noted.
General	**PM3** **People for Puget Sound** Finally, I'd like to appreciate Lockheed and their attitude throughout this process of doing a good job.	**PM3 – Response** **People for Puget Sound** Comment noted.

Topic	Comment	EPA Response

Sources:

U.S. Environmental Protection Agency (EPA). 1999. A Guide to Preparing Superfund Proposed Plans, RODs and Other Remedy Selection Decision.

U.S. Environmental Protection Agency (EPA). 2005. Contaminated Sediment Remediation Guidance for Hazardous Waste Sites. Office of Solid Waste and Emergency Response.

U.S. Geological Survey (USGS). 2007. Seismic Stability of the Duwamish River Delta, Seattle, Washington. USGS Professional Paper 1661-E. Authored by Robert E. Kayen and Walter A. Barnhardt.

Washington State Department of Ecology (Ecology). 2009. Sediment Management Standards Rule Revisions. November.

Washington State Department of Ecology (Ecology). 2009. Urban Waters Initiative, 2007. Sediment Quality in Elliott Bay. Publication No. 09-03-014. September.

Notes:

>	=	greater than
<	=	less than
µg/kg-dw	=	micrograms per kilogram – dry weight
ARAR	=	applicable or relevant and appropriate requirement
AWQC	=	ambient water quality criteria
BMP	=	best management practice
CERCLA	=	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
cm	=	centimeter
COC	=	contaminant of concern
CSL	=	cleanup screening level
DMMP	=	dredged material management program
DNR	=	Washington State Department of Natural Resources
Ecology	=	Washington State Department of Ecology
ENR	=	enhanced natural recovery
EPA	=	U.S. Environmental Protection Agency
FS	=	Feasibility Study
g	=	acceleration
HQ	=	hazard quotient
IC	=	institutional control
LDW	=	Lower Duwamish Waterway
LTMMP	=	Long-term Monitoring and Maintenance Plan
MTCA	=	Model Toxics Control Act
NCP	=	National Contingency Plan
NRDA	=	Natural Resources Defense Act
NRRB	=	National remedy review board
OSWER	=	Office of Solid Waste and Emergency Response
PCB	=	polychlorinated biphenyl
POS	=	Port of Seattle
ppm	=	parts per million
PRG	=	preliminary remediation goal
PRP	=	potentially responsible party
PSR	=	Pacific Sound Resources
RAL	=	remedial action level
RAO	=	remedial action objective
RBTC	=	risk-based threshold concentration
RI	=	Remedial Investigation
ROD	=	Record of Decision
SMS	=	sediment management standards
SMWG	=	Sediment management work group
SQS	=	sediment quality standard
TI	=	technical impracticability
UECA	=	Uniform Environmental Covenants Act
U.S. EPA	=	U.S. Environmental Protection Agency
USGS	=	U.S. Geological Survey