EXPLANATION OF SIGNIFICANT DIFFERENCES

LOCKHEED SHIPYARD SEDIMENT OPERABLE UNIT
HARBOR ISLAND SUPERFUND SITE

FEBRUARY 2002

U.S. Environmental Protection Agency
Region 10
Office of Environmental Cleanup

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EXPLANATION OF SIGNIFICANT DIFFERENCES
TO THE LOCKHEED SHIPYARD SEDIMENT OPERABLE UNIT
SEATTLE, WASHINGTON

SELECTED REMEDIAL STRATEGY

I. Introduction

A. Purpose

The purposes of this Explanation of Significant Differences (ESD) are: (1) to further define, update and expand upon the remedial parameters for the Shipyard Sediment Operable Unit (SSOU)[1] of the Harbor Island Superfund Site described in the November 1996 Record of Decision (ROD), based on additional information gathered during pre-remedial design activities[2] associated with Lockheed Shipyard sediments; (2) to select a strategy for implementing the remedy; and (3) document those instances where the ESD-selected strategy to implement the remedy differs from the remedy selected in the ROD.

B. Lead and Support Agencies

U.S. Environmental Protection Agency (EPA) – Lead Agency for sediment remediation

State of Washington, Department of Ecology – Support Agency for sediment remediation; Lead Agency for upland remediation

C. Statutory Authorities for the Explanation of Significant Differences

Section 117(c) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. § 9617(c), and Section 300.435(c)(2) of the National Oil and Hazardous Substances Contingency Plan (NCP), authorize changes to the selected remedial action after issuance of a ROD. This ESD documents refinements to the selected remedial action for the Lockheed Shipyard Sediment Operable Unit.

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[1] Since divided into the Lockheed Shipyard Sediment Operable Unit and Todd Shipyard Sediment Operable Unit. This ESD addresses the Lockheed Shipyard Sediment Operable Unit only.

[2] Pre-remedial design activities refer to data gathering and analysis performed post-ROD to define the nature and extent of contamination. The pre-remedial design data supplements the remedial investigation and feasibility data for the Harbor Island Superfund Site.

D. Administrative Record

This ESD with Response to Public Comments, the draft ESD, the Fact Sheet announcing the public comment period for the ESD, the Record of Decision, the Remedial Design Data Investigation Report, draft Final Basis of Design Report and draft Final Basis of Design Technical Memorandum, and other reports and information related to the Lockheed Shipyard Sediment Operable Unit are part of the administrative record for the Site. The administrative record is available for public review at the following location:

Environmental Protection Agency
1200 Sixth Avenue, 7th floor
Seattle, Washington
(206) 553-4494

II. Background

A. Site Name, Location and History:

Harbor Island is located approximately one mile southwest of downtown Seattle, in King County, Washington, and lies at the mouth of the Duwamish River on the southern edge of Elliott Bay (Figure 1). The island is man-made and has been used for industrial purposes since about 1912. The island is approximately 430 acres in size and is bordered by the East Waterway and West Waterway of the Duwamish River and by Elliott Bay to the north. Major features of Harbor Island, including the locations of the Todd and Lockheed shipyards, are shown in Figure 2.

Prior to 1885, the area that is currently Harbor Island consisted of tideflats and a river mouth delta with some piling-supported structures. Initial construction of the island began between 1903 and 1905 when dredging of the East and West waterways and the main navigational channel of the Duwamish River occurred. Dredged sediment was spread across the present island area to form a fill 5 to 15 feet thick. This dredged sediment was later covered with soil and demolition debris from Seattle regrade projects.

Since its construction, the island has been used for commercial and industrial activities. Major activities have included ocean and rail transport operations, bulk petroleum storage and transfer, a secondary lead smelter, metal fabrication, and shipbuilding and repair. Warehouses, laboratories, and office buildings also have been located on the island. The Harbor Island Superfund Site was listed on the National Priorities List (NPL) in 1983, due to the release of lead from a

secondary lead smelter on the island, as well as the release of other hazardous substances from other industrial operations on the island.
The Harbor Island Superfund Site is divided into seven operable units: (1) the petroleum storage tank facilities operable unit (OU), (2) the Soil/Groundwater OU, (3) the Lockheed Shipyard OU, (4) the Lockheed Shipyard Sediment Operable Unit[3], (5) the Todd Shipyard Sediments Operable Unit, (6) the East Waterway Sediment OU, and (7) the West Waterway Sediment OU. The Todd Shipyard Sediment Operable Unit includes nearshore sediments at Todd Shipyards out to the edge of the steep slopes of Elliott Bay (to the north) and the West Waterway (to the west), which occur approximately at the minus 42 (-42) foot Mean Lower Low Water (MLLW) contour, as shown in Figure 3. The Lockheed Shipyard Sediment Operable Unit includes nearshore sediments at Lockheed Shipyard out to the edge of the steep slope of the West Waterway, which occurs at approximately the minus 36 (-36) foot MLLW contour, as shown in Figure 4. These sediments are distinct from other contaminated sediments at Harbor Island because they are predominantly contaminated with hazardous substances and shipyard wastes (primarily abrasive grit blast (AGB)) released by shipbuilding and maintenance operations at Todd and Lockheed shipyards. Hazardous substances released from these shipyards include arsenic, copper, lead, mercury, tributyltin (TBT), and zinc, which were additives to marine paints used on ships. Other hazardous substances potentially associated with shipyard activities include polychorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs).

B. Nature and Extent of Contamination

An initial investigation of marine sediments around Harbor Island was completed by EPA in 1988 as part of the Elliott Bay Action Program. The nature and extent of contamination in Harbor Island sediments was characterized in a Remedial Investigation (RI) Report issued by EPA in September 1994. A Supplementary RI Report conducted by a group of Potentially Responsible Parties (PRPs) in 1995 further characterized the extent of chemical contamination in Harbor Island sediments and reported results of biological effects tests conducted on these sediments.

Evidence for adverse effects in benthic organisms due to contaminants in the SSOU have been demonstrated by exceedances of effects-based chemical thresholds, bioassays, and a mussel bioaccumulation study. The mussel study results further indicated that copper, lead, zinc, and TBT in the SSOU sediments

[3] At the time of the ROD, Todd and Lockheed Shipyard Sediment Operable Units were part of the Shipyards Sediments Operable Unit (SSOU). EPA created the Lockheed and Todd Shipyard Sediment Operable Units from the SSOU because they have different remedial issues that are better addressed as separate OUs.

are biologically available and bioaccumulate in mussels, causing adverse effects on these organisms.

The average risk from consumption of Elliott Bay fish was found to be 3 in 10,000 (3.0E-04) and high risk was found to be 4 in 1,000 (4.0E-03). Both of these risk levels exceed the acceptable excess cancer risk of 1 in 10,000 (1.0E-04) identified in the National Contingency Plan. The primary contaminant of concern for the human fish consumption risk is PCBs.

C. Shipyard Sediment Operable Unit Record of Decision

The ROD concluded that actual or threatened releases of hazardous substances from the SSOU may present an imminent and substantial endangerment to human health and the environment. The cleanup objective for the Lockheed Shipyard Sediment Operable Unit is to reduce concentrations of hazardous substances to levels which will have no adverse effect on marine organisms. The ROD further states that "current standards for PCBs are not intended to be protective of human health from bioaccumulation of PCBs in seafood. Also, there are no standards for TBT, which is toxic to marine organisms. The ROD does not establish TBT or PCB bioaccumulation cleanup goals" for the Lockheed Shipyard Sediment Operable Unit.

EPA's November 1996 ROD for the SSOU for the Harbor Island Superfund Site selected a remedy involving five essential elements:

(1) dredging to remove shipyard waste and contaminated sediments exceeding the cleanup screening level (CSL) of the State of Washington Sediment Management Standards (SMS);
(2) capping contaminated sediments exceeding the sediment quality standards (SQS) of the SMS;
(3) identification of acceptable disposal options;
(4) specification of design criteria for acceptable habitat and to prevent future recontamination; and
(5) institution of long-term monitoring and maintenance of the remedy.

The ROD also identified eight remedial design objectives which are to:

(1) identify sediment contamination exceeding the CSL and SQS;
(2) conduct confirmatory biological effects tests (optional);
(3) characterize dredged sediments;
(4) evaluate armoring of any caps;
(5) conduct habitat inventory;
(6) evaluate potential disposal sites;
(7) evaluate physical separation technologies for shipyard waste; and
(8) determine the extent of dredging under-pier sediments.

Additionally, the ROD notes that "(t)he extent of dredging of contaminated sediments and waste under piers at .... Lockheed Shipyard will be determined during remedial design based on cost, benefit and technical feasibility."

Therefore, prior to the start of 30 percent remedial design, additional data gathering and analyses were conducted to determine the extent of contamination. This additional information was used to further refine capping and/or dredging locations based on criteria outlined in the ROD. EPA presented this data with six responsive strategies in a draft of this ESD. A 30-day public comment period yielded comments and EPA responses are attached to this ESD as Appendix D.

Also, the cost estimated in the ROD to implement the remedy is low. The cost estimate only included the cost of remediating the open water sediment management unit (SMU) and did not include costs for remediation of the majority of the Lockheed Shipyard Sediment Operable Unit. EPA concluded in the ROD that remediation parameters for the remainder of the Lockheed Shipyard Sediment Operable Unit would be determined during remedial design based on information gathered post-ROD. Consequently, the vast majority of the costs of remediation were not known at the time of the ROD.

III. Pre-Remedial Design Data Collection, Interpretation and Evaluation

The purpose of this section is to summarize data that was gathered and analyzed after the ROD was issued. In the ROD, EPA concluded that additional information is required to more fully define the dredge and cap remedies. For example, a more detailed understanding of the locations of CSL exceedances was needed before a dredging plan could be developed. Also, as stated in the ROD, the extent of under-pier remediation was not determined and was left to later in remedial design work based on consideration of cost, benefits, and technical feasibility.

Some of the remedial design objectives (1, 2, and 8 above) also describe some of the types of pre-remedial design information to be collected and evaluated before remedial design could begin. Specifically, more detailed information concerning surface and subsurface contamination, the locations of CSL and SQS exceedances, the definition of shipyard waste including AGB, the future use of the former Lockheed Shipyard, the technical feasibility of deep dredging and pier and piling removal, and benefits and costs associated with technically feasible remedial strategies for implementing the dredge and cap remedy. This information was gathered, evaluated and presented in several documents: Data Investigation Report (Hart Crowser, February 1999), Basis of Design Report (BDR; Hart Crowser, January 2000) and the Basis of Design Technical Memorandum (BDR TM; Hart Crowser, April 2000). This information is summarized in the following sections.

A. Delineation of Sediment Management Units and Location and Depth of Chemical and Biological Exceedances

The purpose of this subsection is to provide data that characterizes the nature and extent of contamination at the Lockheed Shipyard Sediment Operable Unit. This data provides more information about the contaminants, depth of contamination, and the location of contamination. The area identified as contaminated and subject to remediation is often broken up into Sediment Management Units (SMUs) for remedial design and action purposes. An SMU is an area that has similar remedial characteristics or problems. The Lockheed Shipyard Sediment Operable Unit was delineated into seven SMUs. The various SMUs at the Lockheed Shipyard Sediment Operable Unit are illustrated in Figure 5.

The open water SMU, identified as SMU 1, is the area running the length of the piers, outward from the pier face to the edge of the steep slope of the West Waterway at approximately -36 feet (MLLW). SMU 1 consists of unobstructed open water. The enclosed water SMU, SMU 2, is behind Pier 9. This is also an unobstructed area of open water that is bounded by the bank or bulkhead on one side and pier structures on two sides. SMUs 3, 5 and 7 designate sediment areas under the pier structure. Sediments under the shipways are designated as SMUs 4 and 6. Shipways are ramps that are used to move ships out of the water. These ramps contain decking like the pier structures and are held up by a highly dense concentration of pilings.

Site-specific data delineating areas of the Lockheed Shipyard Sediment Operable Unit exceeding the CSL and SQS is summarized in Tables 1 through 8. Figure 5 shows sampling locations. These data are summarized below for the various SMUs.

1. Subsurface Data

The concentrations of chemical constituents exceeding the CSL and SQS are generally distributed homogeneously throughout the under-pier, shipways, enclosed water and open water areas. For example, generally all contaminants are found throughout a SMU or the OU in general without any one contaminant being associated with any particular area.

The locations of the CSL exceedances in the open water SMU are not as deep as the CSL exceedances in the under-pier or shipway SMUs. CSL exceedances in the open water SMU generally extend to 5 feet below the mudline for 3 of 5 core samples (Table 1). The fourth core sample shows an exceedance of the CSL at 2.5 feet. The fifth core sample exceeds the

CSL to at least 7.5 feet[4]. Also, in the open water SMU, 4 of the 5 core samples have CSL exceedances at depths that coincide generally with the depth of SQS exceedances.
Some of the CSL exceedances in the under-pier areas (SMUs 3, 5 and 7) extend to greater than 12.5 feet below the mudline (Table 2). Sediments under the two northernmost sections of Pier 11 have contamination to at least 7.5 feet for both CSL and SQS exceedances. Sediments under the shipways (SMUs 4 and 6) exceed the CSL to at least 10 feet below the mudline (Table 3).

Data was not provided to characterize the depth of contamination in the enclosed water SMU. EPA will assume that the nature and extent of contamination in the subsurface enclosed water SMU is the same as the nature and extent of contamination in the subsurface under-pier SMU 3 surrounding the enclosed water SMU which was sampled at 12.5 feet and 10.0 feet below mudline (i.e., stations RD-C-17 and RD-C-19).

Appendix A provides a detailed summary of contaminant concentrations relative to depth of sample interval at each sampling station. The data also include the CSL Exceedance Ratio, which illustrates the magnitude of CSL exceedances.

2. Surface Data

Surface sediment chemistry data for the open water SMU indicates that the CSL is exceeded at 1 of 8 sample locations and the SQS at 6 of 8 sample locations (see Table 4). Biological tests were performed using surface samples from the 8 sample sediment locations. Of the 8 biological tests, 3 failed the CSL and 7 failed the SQS (see Table 5). One station in the open water SMU, RD-S-04, passed both the chemical and biological SQS and CSL.

The biological CSL failures were for sediments located in the northern half of the open water SMU 1. Sample locations for SQS biological test failures were in the southern third of the open water SMU 1.

All surface sediment samples in the enclosed water SMU 2 and shipway SMUs 4 and 6 exceed the CSL as did 4 of the 5 surface sediment samples for the under-pier SMUs 3, 5 and 7. One station in the under-pier SMU, RD-S-12, passed both the chemical SQS and CSL; however,

[4] The depth of contamination is known for all cores in the open water SMU except sampling station RD-C-04. Analysis of the deepest core sample for C-04 showed an exceedance of the CSL for mercury.

this station was sampled only for mercury. Tables 6, 7 and 8 summarize the surface sediment chemistry data for these SMUs.

3. Bioaccumulation Data

The West Waterway Operable Unit sediment data gathering for assessing human and marine ecological effects associated with exposure to bioaccumulative chemicals (i.e., TBT, PCBs, and mercury) included sample locations in the open water SMU at the Lockheed Shipyard Sediment Operable Unit. The TBT field and laboratory study evaluated ecological impacts associated with exposure to TBT in sediments. Sediments at 30 stations in West Waterway, including some stations within the Lockheed Shipyard Sediment Operable Unit, were collected and analyzed for bulk sediment and porewater concentrations of TBT. Next, sediments from 20 were submitted for bioaccumulative tests. Laboratory bioaccumulation tests were performed using clams and worms exposed to selected West Waterway and Lockheed Shipyard Sediment Operable Units' sediments. The resulting concentrations of TBT in the tissues of both test organisms were measured. None of the measured concentrations of TBT in tissue exceeded the EPA Superfund site-specific tissue trigger value of 0.6 ug/g wet weight (3.0 ug/g dry weight) (EVS, 1999). Certain investigators had concerns regarding the TBT results. These concerns are discussed in USEPA, 1999.

As a second component of the assessment of bioaccumulative potential, a literature review of tissue residue effects data for PCBs and mercury was completed to determine whether tissue concentrations determined to be protective of human health from seafood consumed would also be protective of aquatic invertebrates and fish. The human health-based criteria values were compared to measured tissue residue effects concentrations for mercury and PCBs and it was found that human health-based criteria values were lower than tissue concentrations associated with ecological endpoints (EVS, 1998).

In 1999, a human health risk assessment was completed to evaluate risks associated with three bioaccumulative compounds – PCBs, TBT and mercury – that may potentially bioaccumulate from sediments to fish and shellfish. For this assessment, seafood was collected from the West Waterway, and the concentrations of PCBs, TBT and mercury in the animals' tissue were measured. Based on these assessments, the cumulative risk to an individual based on reasonable maximum exposure for both current and future risk is 1 x 10-4. This level of risk is within EPA's acceptable risk range. The non-cancer health effects estimated for PCBs was a Hazard Quotient of 6.5, which is within the range of uncertainty of the PCB toxicity criterion, and thus, adverse health effects are unlikely to result from exposure to PCBs at this site. Hazard Quotient estimates for mercury and TBT are below 1, so non-cancer effects are not expected from exposures to mercury and TBT at this site (Environmental Solutions Group, 1999).

4. Summary

All surface sediment sample stations in the under-pier, shipway, enclosed water and open water SMUs fail either the CSL or SQS, except one open water station, RD-S-04. Based on the bioaccumulation results developed by analysis of data gathered from the West Waterway Operable Unit sediments and Lockheed Shipyard Sediment Operable Unit open-water SMU sediments, TBT, mercury and PCBs do not appear to pose an unreasonable risk to human health or aquatic invertebrates and fish at the tested concentrations. Concentrations of TBT, mercury and PCBs in sediments at RD-S-04 are within the range of concentrations included in the West Waterway Operable Unit assessment of bioaccumulative chemicals. The range of sediment concentrations selected for the West Waterway Operable Unit risk evaluation and the concentrations of mercury, PCBs and TBT at the Lockheed Shipyard Sediment Operable Unit station RD-S-04 are listed in Table 9. Section IV, particularly IV.C. and IV.G., of this ESD describe the remedy and how the remedy addresses physical, chemical and biological site data.

B. Shipyard Waste, Abrasive Grit Blast and Shipyard Debris Definitions

This subsection describes the information and rationale used to propose a definition for shipyard waste. The ROD required that shipyard waste be dredged because shipyard waste may adversely affect habitat value, dredging operations, or the implementation or efficacy of a cap. The ROD also refers to removal of sandblast grit and debris. None of these terms were defined in the ROD. Definitions for these terms are proposed in Section IV.B. of this ESD. Shipyard waste, abrasive grit blast (AGB) and debris definitions were based on information concerning work performed at the shipyards over time, the chemicals and materials used, side-scan sonar, and field surveys. The following discussion in this subsection provides background information and rationale supporting the proposed definitions.

Based on information received from the shipyards regarding the potential sources and physical characteristics of AGB (e.g., Asarco slag), EPA concluded that AGB probably consists of a coarse-grained material with high metals concentrations. Next, additional specific AGB characteristics, based on an examination of surface sediment data from both shipyards, were identified for use in developing an AGB definition. Chemical (metals, TBT, total organic carbon) and physical characteristics (grain size) of samples from the shipyards were compiled. This information was paired with observations by field personnel during pre-remedial design investigations regarding the presence of grit or coarse-grained black material. Graphical plots were examined to identify potential AGB characteristics. The spatial distribution of the exceedances of the

Sediment Management Standards Cleanup Screening Levels (CSLs) was also reviewed. After examining site data, EPA considered the following as characteristic of AGB:

- sediment containing more than 60 percent sand (60 percent sand was used to ensure that material was primarily coarse-grained)
- copper concentrations greater than the CSL, 390 mg/kg
- arsenic concentrations greater than the CSL, 937 mg/kg
- zinc concentrations greater than the CSL, 960 mg/kg
- tributyltin concentrations greater than 200 mg/kg (normalized to organic carbon)

TBT co-occurred frequently with characteristic AGB chemicals. However, unused AGB does not contain TBT and environmental transport and fate processes distributed TBT over a broader area where other AGB characteristics were not prevalent. Therefore, EPA decided that the presence of TBT was not reliable as an AGB characteristic[5].

Based on these criteria and using the definitions in Section IV.B. of this ESD, significant deposits of AGB and shipyard waste were identified as primarily located along the bulkhead and nearshore portions of the under-pier, shipways and enclosed water areas, specifically SMUs 2, 3, 4, 5, 6 and limited areas of SMU 7. Nearshore AGB and shipyard waste deposits are typically surficial ranging to:

- 2 feet in depth in the enclosed water area (SMU 2)
- 2 to 5 feet in depth under Pier 9 (SMU 3)
- 2 feet in depth under Pier 10 (SMU 5)
- 2 to 5 feet in depth under the shipways (SMUs 4 and 6), and
- 4 to 6 feet in depth under the northern portion of Pier 11 (SMU 7)

C. Dredge and Cap Strategies Considered for Cost, Benefit and Technical Feasibility Evaluation

The ROD specified a generic dredge and cap remedy for the Lockheed Shipyard Sediment Operable Unit as described in Section II.C. above. EPA concluded in the ROD that the open water area should be dredged to the CSL and sediments exceeding the SQS should be capped but that the extent that the remedy could be implemented in the under-pier, shipway and enclosed water areas would be based on consideration of cost, benefit and technical feasibility factors. To this

[5] EPA decided that TBT would be addressed within the context of other remedial action decisions for individual sediment management units within each shipyard.

end, Lockheed identified and evaluated 16 dredge and/or cap strategies by which the remedy would be implemented. These strategies are presented and evaluated by Lockheed in the BDR. Lockheed recommended adoption of Strategy 16 for implementation at the Lockheed Shipyard Sediment Operable Unit, which is a cap-only remedy.

EPA reviewed and commented on the 16 strategies developed by Lockheed. EPA rejected Lockheed's recommended Strategy 16 because it would not fulfill the requirements of the ROD. EPA requested that Lockheed "evaluate a strategy that evaluates dredging in the under-pier, shipway and open water areas coupled with capping such that existing grade is restored..." and that the evaluation include an analysis of cost, benefit, and technical feasibility. Lockheed, in the BD TM, developed and evaluated this additional strategy, referred to as Strategy 17.

Lockheed's Strategy 17 did not consider the cost, benefit and technical feasibility of piling removal as a way to increase the effectiveness of dredging in the under-pier areas. For this ESD, EPA has modified Lockheed's Strategy 17 into four similar substrategies, referred to as Strategies 18A, 18B, 18C and 18 D. Table 10 summarizes and compares the components of Strategies 1, 16, 18A, 18B, 18C and 18D. (Note: Strategies 2 through 15 are not presented in this ESD for further consideration. Descriptions of those strategies are available in the BDR.)

In place of Strategy 17, EPA considered piling removal; a minimal dredge for the under-pier, shipway and enclosed water SMUs; and four substrategies (18A through 18D) for a dredge and/or cap remedy for the open water area. Each of the four sub-strategies is based on the same remedial concept for the under-pier, shipway, and enclosed water SMUs – pier decking and piling removal, dredge 3.5 feet, and cap to restore original bathymetry. The only difference among the substrategies is the treatment of the open water SMU. These strategies and substrategies have been analyzed further by EPA on a cost, benefit and technical feasibility basis.

For comparison purposes, EPA has also included Lockheed's Strategies 1 and 16 in this ESD. Strategy 1 is a dredge and cap strategy where the dredge depth is determined by technical feasibility. Strategy 16, Lockheed's recommended remedy, is a capping remedy that does not include any dredging. Note that EPA slightly modified Strategies 1 and 16 so that all strategies could be evaluated based on similar assumptions, i.e., reconstruction of the pier and/or removal of piling as well as pier and shipway decking.

In this ESD, EPA assumed, based on best professional judgement, the cap would be 3.5 feet thick for cost analysis purposes. In most strategies, dredging is also assumed to be 3.5 feet deep. Dredging to 3.5 feet is required to accommodate a cap of 3.5 feet while maintaining the original bathymetry and water column. The depth of this dredging activity may be modified during remedial design based on benefits, costs and technical site constraints and practicality (e.g., primarily geotechnical considerations regarding slope and bulkhead stability). Also, actual design parameters for the cap will be determined during remedial design. The cap must be physically and chemically confining. Dredging depth will be adjusted during remedial design to take into account cap design specifications. Table 10 summarizes the components of Strategies 1, 16, 18A, 18B, 18C and 18D.

1. Technical Feasibility

All strategies evaluated in this ESD were considered to be technically feasible. However, none would result in the removal of all sediment contaminated above the CSL. Strategy 1 assumed that dredging would only be conducted to a depth that would not compromise the bulkhead or slope stability. All other strategies assumed a more shallow dredge depth or no dredge at all.

EPA concluded in the ROD that a technical feasibility, cost and benefit evaluation would be conducted to determine the extent of a cap and dredge remedy in the under-pier, shipway and enclosed water SMUs. Implicit in this is the idea that a dredge of all sediments contaminated above the CSL may not be possible, as it was assumed to be in the open water SMU. Therefore, dredge depths will be limited by technical feasibility, cost and benefits. Data indicates that sediment contamination exceeding the CSL in the under-pier and shipway SMU is at least 10 feet below the mudline. Lockheed assumed that to maintain bulkhead and slope stability, a maximum 2H:1V slope perpendicular to the bulkhead would be necessary. Consequently, Lockheed concluded that a maximum feasible dredge, Strategy 1, would not remove all sediments exceeding the CSL.

All strategies assumed that the Lockheed Shipyard Sediment Operable Unit pier and shipway decking and piling would be removed. A demonstration project at the Olympic View Superfund Site confirmed that aged pilings could be removed by current technology. For details, see Appendix B.

Some piles may be left in place to ensure bulkhead or slope stability, as necessary. However, these piles must be cut or broken off below the mudline to accommodate dredging. The number and location of piles to be left in place will be determined during remedial design.

2. Costs

For cost evaluation purposes, all strategies assumed complete pier and shipway decking and piling removal and included no pier replacement costs. Pier removal is a viable strategy for the Lockheed Shipyard Sediment Operable Unit because LSSOU is not presently a working shipyard and the pier structure is in a degraded condition. The remedial cost for each strategy is summarized in Table 11. Costs were developed almost entirely using the assumptions, quantities and unit pricing provided by Lockheed in the BDR and BDR TM. EPA adopted Lockheed's assumptions, quantities and unit prices because they seemed reasonable and allow for comparison among candidate strategies (as well as those in the BDR and BDR TM) to be made on equivalent terms. For further details, see Appendix C.

3. Benefits

All strategies in this ESD were analyzed for benefits derived if that strategy were implemented and compared by listing the benefits. The range of anticipated benefits is summarized below:

- largest percent of contamination removed from the aquatic environment
- lowest implementation cost
- lowest O&M cost
- maintenance of existing bathymetry preserves benthic habitat
- maintenance of water column depth/habitat
- effectiveness/protectiveness of the remedy
- meets ROD criteria
- does not restrict future use options
- maintains options for marine commerce
- increases existing water column/depth in the open water area with inherent positive effect on navigational issues
- overall habitat improvement

Some strategies present more or higher-priority benefits than other strategies. Higher priority benefits include protectiveness of remedy, satisfaction of the most ROD criteria, maintenance of water column for habitat and navigation, and lower remedial costs.

All strategies are protective to some degree. Strategy 1, removal of the largest amount of sediment exceeding the CSL, is the most protective strategy because it leaves the least amount of contamination in the environment. Costs among strategies are similar (Strategy 16 is the least costly), with the exception of Strategy 1, which is 2 to 4 times more costly than other remedies. Strategies 1, 18C and 18D satisfy the ROD criteria of dredging to the CSL in the open water SMU, maintaining the water column depth/habitat in all SMUs, and being consistent with current and future site uses. Table 12 summarizes the benefits identified for each strategy.

IV. Description of and Basis for the Significant Differences

A. Introduction

The general cleanup approach specified in the ROD requires, in accordance with the Washington Sediment Management Standards (SMS): (1) all sediment exceeding the CSL of the SMS and shipyard waste be dredged and disposed of in an appropriate in-water or upland disposal facility, (2) all sediments exceeding the chemical and/or biological SQS of the SMS be capped with a minimum of 2 feet of clean sediment, and (3) long-term monitoring to be conducted for any capped areas. In addition, the ROD concluded that the “extent of dredging of contaminated sediments and waste under piers at the Todd and Lockheed shipyards will be determined during remedial design based on cost, benefit, and technical feasibility.” (See ROD, Section K, The Selected Remedy in U.S. EPA 1996).

Subsequent to the ROD, pre-remedial design studies for the Lockheed Shipyard Sediment Operable Unit have better defined the nature and extent of contamination. This sediment characterization has been further used by EPA to determine the most technically feasible, cost-effective approach for implementing the dredge and cap remedy. During this pre-remedial design phase EPA has also developed definitions for “shipyard waste,” including definitions for AGB and shipyard debris. The Port of Seattle, the current owner of the Lockheed Shipyard Sediment Operable Unit, has identified future uses for the Lockheed operable unit (See Section E).

This ESD documents the following changes for the Lockheed Shipyard Sediment Operable Unit:

(1) the definition of shipyard waste, including AGB;
(2) the dredge depths and cap locations by SMU;
(3) the size of the contaminated area requiring remediation, the approximate volume of sediment to be dredged and the cost of the remedial action;
(4) future site uses and remedial action time frames; and
(5) potential for recontamination from upland groundwater.

B. Definition for Shipyard Waste, Abrasive Grit Blast and Shipyard Debris.

Definitions for shipyard waste, AGB and shipyard debris are defined (see below) based on the rationale and information summarized in Section III.B. The definition for AGB consists of a physical and a chemical component which when combined are a "signature" for AGB. Based on activities associated with shipyards, field observations, seabed characterization work (including bathymetry and sidescan sonar) and other site investigation data, EPA has determined that shipyard waste shall be defined as consisting of 1 or 2:

1. Abrasive Grit Blast (AGB)

Identification of AGB may be made by one of two means: visible evidence, or chemical and physical evidence. Visual identification alone is sufficient to identify AGB (see a. below). The second means (see b. below) of identification is a combination of chemical and physical evidence. The criteria for determining AGB are:

a. Visual identification: EPA and Lockheed agree that the material is predominantly AGB.

OR

b. Chemical and physical evidence: Data indicating that the grain size of the material is greater than (or equal to) 60 percent total sand;

AND AT LEAST TWO OF THE FOLLOWING:

i. Copper concentration greater than the CSL of 390 mg/kg;
ii. Zinc concentration greater than the CSL of 960 mg/kg;
iii. Arsenic concentration greater than the CSL of 93 mg/kg.

2. Shipyard Debris and Other Shipyard Waste

Wood, concrete, sheet steel, steel cables, tires, welding rods, and various other debris or shipyard waste that will impede dredging activities or compromise the integrity of the cap.

The above AGB definition is a generic definition developed solely for the Todd and Lockheed Shipyard Sediment Operable Units at the Harbor Island Superfund Site. However, the definition may be refined further based on additional site-specific data. For example, additional data was provided to EPA by Todd Shipyards to refine the grain size criterion cited in 1.b above. Specifically, Todd Shipyards conducted a grain size analysis on samples of spent AGB from the Todd Shipyards facility, and grain size fractions characteristic of AGB were identified. Based on the grain size characteristics of the spent AGB, EPA modified the AGB definition for the Todd Shipyard Sediment Operable Unit by replacing 1.b of the generic AGB definition with:

> "Greater than (or equal to) 50 percent coarse material typically associated with spent grit blast (i.e., 0.15 to 2.0 mm in size)."

Some of the AGB used at the Lockheed Shipyard Sediment Operable Unit was from a different source and may, therefore, have a different grain size profile than the AGB used at the Todd Shipyard Sediment Operable Unit. If Lockheed wishes to refine the generic AGB definition further to be specific for the Lockheed Shipyard Sediment Operable Unit AGB, Lockheed should provide a rationale and supporting data to substantiate a modification.

C. EPA Remedial Strategy: Dredge Depths and Cap Locations by SMU

In accordance with the ROD requirement that additional information be obtained to further define the cleanup of under-pier areas, Lockheed collected, analyzed and reported information in the Remedial Design Data Investigation Report, the draft Final BDR, and the draft Final BDR TM. In the BDR and the BDR TM, Lockheed proposed 17 strategies for implementing the remedy. The strategies considered by EPA are slight modifications of strategies evaluated by Lockheed in the BDR and BDR TM. Based on this analysis, EPA selects Strategy 18C to further refine the dredge and cap remedy selected in the ROD. This strategy is described as follows:

1. **In the under-pier, shipway and enclosed areas**:
   (a) remove the shipway pier and decking; remove or modify pilings to the maximum extent practicable so as not to compromise the stability of the existing bulkhead or existing slope but to permit dredging and capping as defined below;
   (b) remove any shipyard debris that will impede dredging activities or compromise the integrity of the cap to be placed in these areas;
   (c) dredge AGB to a sufficient depth to accommodate the cap without any loss of the present water column[6];
   (d) dredge all sediments exceeding CSL to a depth sufficient depth
   to accommodate the cap without any loss of the present water

[6] For purposes of the cost analysis, EPA assumed the cap would be 3.5 feet thick. In most strategies, dredging is also assumed to be 3.5 feet deep. Dredging to 3.5 feet is required to accommodate a cap of 3.5 feet while maintaining the original bathymetry and water column.

column [7] ;
(e) cover all sediments exceeding SQS with a cap that shall physically and chemically contain and confine contaminants of concern; and
(f) dispose of contaminated dredged material at an appropriate upland landfill.

2. In the open water areas:

(a) remove any shipyard debris that will impede dredging activities or compromise the integrity of the cap to be placed in these areas;
(b) dredge all sediments exceeding SQS; and
(c) dispose of contaminated dredged material at an appropriate upland landfill.

D. Remedial Costs

The ROD concluded that in areas with shipyard waste and exceedances of the CSL and SQS, the volume of contaminated sediment to be dredged and the associated costs would be refined during remedial design. Since the ROD was issued, additional investigations and studies have been undertaken by Lockheed at the Lockheed Shipyard Sediment Operable Unit. Pre-remedial design studies at the Lockheed Shipyard Sediment Operable Unit identified a higher volume of sediment requiring dredging and disposal than was estimated in the ROD. The investigative studies demonstrate that sediment contamination extends to greater depths than was believed when the 1996 ROD was issued. The ROD provided quantities and cost estimates for dredging and disposal for only the open water SMU because there was not sufficient information to estimate these quantities for the under-pier, shipway and enclosed water SMUs. A comparison of assumed depths and volume estimates in the 1996 ROD with the refined volume estimates for the strategy proposed by EPA is provided in Table 13.

EPA has selected Strategy 18C for implementing the ROD. Estimates cited for this ESD in Table 13 are based on the dredge volumes of contaminated sediments exceeding the SQS in open water SMU and the CSL in under-pier, shipway and enclosed water SMUs; and the volume of capping material required to cover contaminated sediments exceeding the SQS in under-pier, shipway and enclosed water SMUs.

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[7] For purposes of the cost analysis, EPA assumed the cap would be 3.5 feet thick. In most strategies, dredging is also assumed to be 3.5 feet deep. Dredging to 3.5 feet is required to accommodate a cap of 3.5 feet while maintaining the original bathymetry and water column. The depth of this dredging activity may be modified during remedial design based on technical site constraints and practicality (e.g., primarily geotechnical considerations regarding slope and bulkhead stability).

The ROD provided estimated costs for a remedy at the Lockheed Shipyard Sediment Operable Unit that included dredging and/or capping contaminated sediment and upland disposal of dredged material. Table 14 provides a comparison of the cost estimates in the ROD to the estimates for this ESD. The cost estimated to implement the ROD remedy is low because the 1996 cost estimate included only the cost of remediating the open water SMU and did not include costs for remediation of the majority of the Lockheed Shipyard Sediment Operable Unit. EPA concluded in the ROD that remediation parameters for the remainder of the Lockheed Shipyard Sediment Operable Unit would be determined during remedial design. Consequently, the vast majority of the costs of remediation were not known at the time of the ROD. Detailed cost estimates are provided in the BDR, BDR TM and in Appendix C of this ESD.

E. Future Site Use

EPA regulations and policy specify that EPA should take into consideration probable future uses of a cleanup area when defining and selecting a remedy. Since 1959, the Lockheed Shipyard Sediment Operable Unit has been used as a shipyard for construction and maintenance of Naval ships. Shipyard activities ceased in 1986, and the property was purchased by the Port of Seattle[8] in 1996. Presently, the Lockheed Shipyard Sediment Operable Unit consists of four piers and three shipways in declining condition built upon Washington State marine sediments leased to Lockheed from the Washington Department of Natural Resources. The overwater structures are supported by about 6,000 piles. Piers 9 and 9a (or 9.5) comprise the largest pier and are approximately 61,000 square feet (sq. ft.) and are supported by about 1,100 piles. Piers 9 and 9a occur on the southern end of the property and are the oldest in-water structures. Piers 10 and 11 are to the north of Pier 9 and are 24,000 sq. ft and 36,000 sq. ft. respectively.
About 1,300 piles support these piers. The remainder of the piling supports the decking in the three shipways.

EPA conducted a cost, benefit and technical feasibility analysis on various strategies for implementing the ROD. From that analysis, EPA determined that removal of the pier and piling significantly improved the remediation of the Lockheed Shipyard Sediment Operable Unit without a significant increase in cost. Removal of the piling will enable Lockheed to dredge and cap the under-pier area without loss of the water column habitat. Removal of the piers, including most of the 6000 piles, will allow for the implementation of a more cost-effective, protective and permanent remedy than attempting to dredge and cap

[8] The sediments at the Lockheed Shipyard Sediment Operable Unit are owned by the State of Washington and managed by the Washington Department of Natural Resources.

around existing piles, many of which are past or nearly past their service life. Additionally, many piles are so close together that remedial action would be nearly impossible if they were left in place. Therefore, the old Lockheed pier will be taken down to accommodate the timing of a speedy and improved remediation of the Lockheed Shipyard Sediment Operable Unit.

It is EPA's understanding that the Port of Seattle acquired the Lockheed uplands and docks from Lockheed in 1997. Following acquisition, the Port has allowed a tenant's contractor to use the northern docks in conjunction with bringing over 500,000 tons of aggregate to Harbor Island for use in the redevelopment and expansion of Terminal 18. The uplands area of the former Lockheed property has been used as a staging and storage area for this project, which is now nearing completion. Absent demolition of the docks for cleanup for the Lockheed Shipyard Sediment Operable Unit, the Port reasonably anticipates continued use of the upland property and the dock areas for maritime commerce subject to necessary repair, replacement and/or upgrade of the docks and pier structure. By removing the docks and pier structure for sediment remedial action, EPA does not intend to impair the value of the Port's property or the Port's ability to use its property for maritime commerce. EPA will consider the Port's plans for future use of the site and how these plans may be implemented in conjunction with the remedial design and remedial action for the site and will ensure that these plans are consistent with the remedy and schedule for the Lockheed Shipyard Sediment Operable Unit. Remedial work for the Lockheed Shipyard Sediment Operable Unit is in the early design phases and EPA expects that remedial action will start as early as mid-year 2003 and be completed in early 2004.

F. Upland Groundwater Assessment of Source Control

During remedial design, EPA will evaluate the groundwater flowing from the Lockheed uplands. If this groundwater is contaminated, and EPA determines the groundwater may recontaminate a clean dredged/capped area, EPA will require source control efforts to address the contaminants of concern. If this groundwater is not contaminated at levels of concern but EPA determines that the groundwater may mobilize sediment contamination that is left in place at depth, EPA may require sediments in these areas to be dredged deeper than the point of contact with the groundwater. This issue should be resolved as part of 30 percent design.

G. Summary and Basis of Remedial Strategy, 18C, Selection

The data indicates that contaminated sediments exceeding the CSL at LSSOU are deeper in all areas – the under-pier area, shipways, enclosed water and open water areas – than presumed in the ROD. Generally, the contamination in the open water area is about 5 feet deep for both CSL and SQS exceedances. The actual depth of CSL and SQS exceedances in the under-pier, shipways and enclosed water areas has not been determined because at least one chemical, in each core, exceeded the CSL at the furthest extent of the core samples. The core depths vary from 7.5 feet to 12.5 feet in depth. However, based on the data, the extent and depth of sediments with CSL exceedances is similar to the extent and depth of sediments with SQS exceedances across the Lockheed Shipyard Sediment Operable Unit. CSL and SQS exceedances consist primarily of metals, specifically arsenic, copper, lead, mercury and zinc.

Surface sediment chemistry data for the open water SMU indicates that the CSL is exceeded at 1 of 8 sample locations and the SQS at 6 of 8 sample locations. Biological toxicity tests were performed using open water surface samples from the 8 sample sediment locations. Of the 8 biological tests, 3 failed the CSL and 7 failed the SQS. Given these results, 7 of the 8 open water stations failed SMS and one station, S-04, passed SMS. Surface sample data results from the under-pier, shipway and enclosed water SMUs all exceed the CSL.

Field observations indicate that the Lockheed Shipyard Sediment Operable Unit has AGB contamination in the under-pier, shipway and enclosed water SMUs at depths that vary between 2 and 6 feet; however, AGB has not been observed in the open water SMU. Determination as to the presence of shipyard debris will be made at the time of remedial action; any debris will be removed at that point.

The only station EPA assessed for bioaccumulation for the purposes of this ESD is RD-S-04 because it is the only station that passed SMS and AGB criteria for remediation. Bioaccumulation data indicate that the concentrations of TBT, mercury and PCBs present in the area represented by RD-S-04 do not pose an unreasonable risk to human health or aquatic invertebrates and fish.

After analysis of numerous alternatives by Lockheed which were presented in the BDR and BDR TM, EPA further evaluated six remedial strategies for implementing the dredge and cap remedy based on cost, benefit and technical feasibility as specified in the ROD. All strategies were considered to be technically feasible. Strategy 1, where the largest amount of sediment exceeding the CSL would be removed, is the most environmentally protective strategy. However, the cost is significantly larger than all the other strategies, and would still result in some sediment contaminated above the CSL remaining in place. This is because dredging depth would be limited by concerns for bulkhead and slope stability. Sediment contamination exceeding the CSL in the under-pier, shipway and enclosed water SMUs is at least 10 feet deep. To maintain bulkhead and slope stability, Lockheed assumed (without extensive geotechnical data) that a maximum 2H:1V slope perpendicular to the bulkhead would be used to determine the maximum feasible dredging depths . Working with this assumption, Lockheed determined that a maximum feasible dredging depth, Strategy 1, would not remove all sediments exceeding the CSL. The other remedial strategies also reflect this limitation on dredging depth by minimizing the dredge depth and as such acknowledge that there are no cost-effective remedial strategies that would result in the certain removal of all contaminated sediments exceeding the CSL.

Strategy 16, Lockheed's recommended cap-only strategy, is the least costly strategy but results in substantial loss of intertidal and subtidal water column habitat and is not consistent with the requirements of the ROD that CSL exceedances be removed and that "to the extent practicable the marine habitat...must also be restored to its most productive condition...". Further, the cost of intertidal and subtidal habitat mitigation was not determined and included in the cost estimate, so the cost of implementing Strategy 16 is artificially low. Finally, Strategy 16 is also not consistent with current or future site uses since raising the elevation of the intertidal and subtidal zones will interfere with navigation while endangering the integrity of the cap and require more extensive long-term monitoring and maintenance than the other strategies.

Strategies 18A through 18D were all developed using the same assumptions of limited dredging sufficient to accommodate a cap without loss of water column (assumes a 3.5-foot dredge) in the under-pier, shipway and enclosed water SMUs. This was because, as discussed above, removal of all CSL exceedances was not considered to be technically feasible. Consequently, the differences between Strategies 18A through 18D are the remedial strategies for the open water SMU.

In Strategy 18A, sediments in the open water SMU would be dredged 3.5 feet and capped to restore original bathymetry and thus prevent water column loss. Strategy 18A would not satisfy the ROD requirement for the open water SMU because 1.5 feet of sediment exceeding the CSL would remain undredged in a large portion of the open water SMU. The cost for Strategy 18A is estimated to be $13.2 million.

In Strategy 18B, sediments in the open water SMU would not be dredged but a 3.5-foot cap would be placed across the open water SMU. Strategy 18B does not satisfy the ROD requirements because no sediments exceeding the CSL would be removed from the open water SMU and placement of the cap would result in a loss of the water column depth/habitat. While this loss of water column may not significantly impact marine habitat, a more shallow water column would adversely affect the use of the area for commercial marine traffic in a consistently high-traffic volume environment. Further, given that the open water SMU is adjacent to a primary navigation channel, the potential for impacts to the cap due to prop wash and scouring will be high, thus leading to higher operation and maintenance (O&M) costs than areas that are relatively protected or where there is no cap. The remedial cost for Strategy 18B is estimated to be $11.0 million.

Strategy 18C would involve dredging contaminated sediments to the SQS in the open water thus making a cap unnecessary. The remedial cost for Strategy 18C is estimated to be $12.1 million. Strategy 18D would involve dredging to the CSL and capping SQS exceedances in the open water SMU. The remedial cost for Strategy 18D is estimated to be $12.4 million. Both Strategies 18 C and D would satisfy the requirements of the ROD.

EPA selected Strategy 18C over Strategy 18D because the open water SMU will be dredged to the SQS instead of the CSL which is clearly beneficial and is less costly than 18D. While the ROD requires dredging only to the CSL, dredging to the SQS instead of the CSL will remove substantially more contamination. While
the dredging will deepen the mudline by approximately 5 feet (and since capping is not required, the mudline will not be brought back to the original bathymetry), the change in the water column will occur at depths from -20 ft MLLW to -36 ft MLLW. This change should not have a significant adverse impact on the marine habitat in that area. Other significant benefits are:

(1) a permanent remedy for the open water SMU;
(2) no long-term monitoring and maintenance for a cap;
(3) increased confidence in the integrity and efficacy of the remedy; e.g., no additional releases of contamination from cap breach, failure or demise;
(4) consistency with current and future site uses; and
(5) increased volume of contaminated sediment removal.

The remedial strategy proposed in this ESD requires dredging to the SQS of all sediments in the open water SMU even thought the surface sediments represented by RD-S-04 do not exceed cleanup criteria. EPA has decided to include sediments represented by surface sediment station, RD-S-04, for the following reasons:

(1) the concentration of mercury in RD-S-04 does not exceed the SQS of 0.41 mg/kg but is borderline at 0.41 mg.kg;
(2) sediments in the core composite sample closest to RD-S-04, RD-C-02, exceed the SQS and CSL in the 0.0 to 2.5-foot interval[9];
(3) the nearsurface exceedances and the surface mercury concentration, if not removed, may serve as a source of future recontamination of remediated areas;
(4) satisfaction of the ROD requirement for a flat, smooth surface will be difficult to obtain if the sediments represented by RD-S-04 remain as is;
(5) additional sampling would be required to define the area to be

[9] The open water SMU surface chemical and biological samples were not co-located with core samples and in 7 of 8 cases, the core and surface sample locations were far apart relative to the area they represent. Chemistry data from the core samples was obtained, as composites, at 2.5-foot intervals starting with the interval 0 to 2.5 feet below the mudline. Of the 5 open water core sample locations, 5 exceeded the CSL at the 0 to 2.5-foot interval.

represented by RD-S-04; and

(6) overall, the benefits of dredging all contaminated sediment in the open water SMU to the SQS overweigh additional costs associated with dredging to the SQS instead of the CSL[10].

This ESD is consistent with the requirements and considerations for remediation established in the ROD. It requires removal of pier and shipway decking and piling: dredging to accommodate a cap in the under-pier, shipway, and enclosed water SMU; and dredging to the SQS in the open water SMU without subsequent capping. Dredging to the SQS without capping in the open water SMU is consistent with the ROD's direction to consider the cost-benefit of implementing the alternative of dredging to the SQS instead of the CSL. Dredging and capping of the Lockheed Shipyard Sediment Operable Unit shall be conducted in such a way that the cap restores the existing bathymetry in the under-pier, shipway and enclosed water SMUs, thus resulting in a natural bathymetric surface (i.e., smooth without holes).

V. Affirmation of Statutory Determinations

Strategy C for implementation of the selected remedy at the LSSOU will be protective of human health and the environment, complies with federal and state requirements that were identified in the ROD as applicable or relevant and appropriate to this remedial action, and is cost-effective. The remedy continues to utilize permanent solutions and alternative treatment technologies to the maximum extent possible.

VI. Public Participation Activities

EPA provided a 30-day public comment period for this ESD. Copies of the Fact Sheet were distributed to the Harbor Island mailing list of approximately 250 individuals. EPA received 9 comment letters from Natural Resource Trustees, several federal and state resource and regulatory agencies, the Muckleshoot Indian Tribe, Lockheed Martin and several other interested parties. EPA responses to public comments are in Appendix D.

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Michael F. Gearheard Date

[10] The cost associated with Strategy 18C, which requires dredging to the SQS, is less costly than Strategy 18D, which requires dredging to the CSL.

(6) overall, the benefits of dredging all contaminated sediment in the open water SMU to the SQS overweigh additional costs associated with dredging to the SQS instead of the CSL[10].

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Michael F. Gearheard — Feb 22, 2002

Michael F. Gearheard
Director, Office of Environmental Cleanup

Date

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[10] The cost associated with Strategy 18C, which requires dredging to the SQS, is less costly than Strategy 18D, which requires dredging to the CSL.

Director, Office of Environmental Cleanup

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FIGURES

TABLES

Table 1. SMU 1 Subsurface Chemical Exceedances by Depth and Contaminant

Open Water Subsurface Sediments – SMU 1		
Sample No. and Interval in Feet of Depth Below the Mudline	Contaminant Exceeding Chemical SQS	Contaminant Exceeding Chemical CSL and SQS
RD-C-01		
0.0 - 2.5	As, Cu, Hg, Zn, tPCBs	Cu, Hg
2.5 - 5.0	Cu, Hg, Zn, tPCBs	Cu, Hg
5.0 - 7.5		
RD-C-02		
0.0 - 2.5	Hg, Zn, tPCBs, LPAHs	Hg
2.5 - 5.0		
5.0 - 7.5	Hg, tPCBs	
7.5 - 10.0		
RD-C-03		
0.0 - 2.5	As, Cu, Pb, Hg, Zn, tPCBs	Cu, Pb, Hg, Zn
2.5 - 5.0	As, Cu, Pb, Hg, Zn, LPAHs	
5.0 - 7.5		As, Cu, Pb, Hg, Zn
RD-C-04		
0.0 - 2.5	Cu, Hg, Pb, Zn, tPCBs	Cu, Pb
2.5 - 5.0	As, Cu, Pb, Hg, Zn, tPCBs	As, Cu, Pb, Hg, Zn
5.0 - 7.5	As, Hg, Zn	Hg
RD-C-05		
0.0 - 2.5	Pb, Hg, Zn, tPCBs	Pb, Hg
2.5 - 5.0	Hg	Hg
7.5 - 10.0		

As - arsenic
Cu - copper
Hg - mercury
Pb - lead
Zn - zinc
tPCBs - total polychlorinated biphenyls
LPAHs - light polycyclic aromatic hydrocarbons
HPAHs - heavy polycyclic aromatic hydrocarbons

Blank line indicates that no exceedance was detected.

Table 2. SMUs 3, 5 and 7 Subsurface Chemical Exceedances by Depth and Contaminant

Under-Pier Subsurface Sediments – SMUs 3, 5 and 7		
Sample No. and Interval in Feet of Depth Below the Mudline	Contaminant Exceeding Chemical SQS	Contaminant Exceeding Chemical CSL and SQS
RD-C-06		
0.0 - 2.5	Cu, Pb, Hg, Zn, tPCBs, HPAHs	Cu, Pb, Hg, Zn
2.5 - 5.0	As, Cu, Pb, Hg, Zn, tPCBs, HPAHs	As, Cu, Pb, Hg, Zn
5.0 - 7.5	Cu, Pb, Hg, Zn	Cu, Pb, Hg, Zn
RD-C-08		
0.0 - 2.5	As, Hg, Pb, Zn, tPCBs	As, Hg, Pb, Zn
2.5 - 5.0	As, Hg, Pb, Zn, tPCBs	Hg, Pb
5.0 - 7.5	As, Hg, Pb, Zn, tPCBs	As
RD-C-11		
0.0 - 2.5	As, Pb, Zn, tPCBs, HPAHs	Pb
2.5 - 5.0	As, Cu, Zn, tPCBs, LPAHs, HPAHs	As, Cu, Zn, LPAHs
5.0 - 7.5	As, Hg, tPCBs, HPAHS	Hg
RD-C-14		
0.0 - 2.5	As, Cu, Zn, LPAHs, HPAHs	As, Cu, Zn, LPAHs, HPAHs
2.5 - 5.0	As, Cu, Pb, Zn, tPCBs, LPAHs, HPAHs	As, Cu, Pb, Zn, LPAHs, HPAHs
5.0 - 7.5	As, Cu. PB, Zn, tPCBs, SVOCs	As, Cu. PB, Zn, SVOCs
RD-C-17		
0.0 - 2.5	As, Cu, Zn, HPAHs	As, Cu
2.5 - 5.0	As, Cu, Zn, LPAHS, HPAHS, tPCBs	As, Cu, Zn, LPAHS, HPAHS, tPCBs
5.0 - 7.5	As, Cu, Pb, Hg, Zn, tPCBs, LPAHs, HPAHs	Cu, Zn, LPAHS, HPAHS, tPCBs
10.0-12.5	Cu, Zn, tPCBs, LPAHs, HPAHs	Cu, Zn, tPCBs, LPAHs, HPAHs
RD-C-19		
7.5 - 10.0	As, Zn	As, Zn
10.0-12.5	As, Pb, Zn, tPCBs tPCBs	As, Pb, Zn

As - arsenic
Cu - copper
Hg - mercury
Pb - lead
Zn - zinc
tPCBs - total polychlorinated biphenyls
LPAHs - light polycyclic aromatic hydrocarbons
HPAHs - heavy polycyclic aromatic hydrocarbons

Table 3. SMUs 4 and 6 Subsurface Chemical Exceedances by Depth and Contaminant

Shipway Subsurface Sediments – SMU 4 and 6		
Sample No. and Interval in Feet of Depth Below the Mudline	Contaminant Exceeding Chemical SQS	Contaminant Exceeding Chemical CSL and SQS
RD-C-09		
0.0 - 2.5	As, Cu, Zn, SVOCs	As, Cu, SVOCs
2.5 - 5.0	Cu, tPCBs, LPAHs, HPAHs	LPAHs, HPAHs, Cu
5.0 - 7.5	Pb, SVOCs	Pb, SVOCs
7.5 - 10.0	As, Cu, Zn, SVOCs	Cu, SVOCs
RD-C-12		
0.0 - 2.5	As, Cu, Zn	As, Cu, Zn
2.5 - 5.0	As, Cu, Pb, Zn	As, Cu, Zn
5.5 - 8.0	As, Cu, Hg, Pb, Zn, tPCBs, LPAHs, HPAHs	As, Cu, Zn, LPAHs, HPAHs
8.5 - 11.0	As, Cu, Hg, Pb, Zn, tPCBs, SVOCs	As, Cu, Pb, Zn, SVOCs
RD-C-13		
0.0 - 2.5	As, Cu, Pb, Zn, LPAHs, HPAHs	LPAHs, HPAHs
2.5 - 5.0	As, Cu, Hg, Pb, Zn	As, Cu, Hg, Pb, Zn
5.0 - 7.5	As, Cu, Pb, Zn, tPCBs, LPAHs, HPAHs	As, Cu, Pb, Zn
8.5 - 11.0	Hg, LPAHs, HPAHs	SVOCs
RD-C-15		
5.0 - 7.5	LPAHs, HPAHs	
7.5 - 10.0	SVOCs	SVOCs

As - arsenic
Cu - copper
Hg - mercury
Pb - lead
Zn - zinc
tPCBs - total polychlorinated biphenyls
LPAHs - light polycyclic aromatic hydrocarbons
HPAHs - heavy polycyclic aromatic hydrocarbons

Table 4. SMU 1 Surface Chemical Exceedances by Contaminant

Open Water – SMU 1		
Sample	Contaminant Exceeding Chemical SQS	Contaminant Exceeding Chemical CSL and SQS
RD-S-01	tPCBs	
RD-S-02	Hg, tPCBs	
RD-S-03	tPCBs	
RD-S-04		
RD-S-05		
RD-S-06	tPCBs	
RD-S-07	Hg, tPCBs	
RD-S-08	Hg, Zn	Hg

Hg - mercury
tPCBs - total polychlorinated biphenyls

Blank line indicates that no exceedance was detected.

Table 5. SMU 1 Surface Biological Exceedances

Open Water - SMU 1	
Sample ID	**Bioassay Evaluation**
RD-S-01	Fails SQS
RD-S-02	Fails SQS
RD-S-03	Fails SQS
RD-S-04	Pass
RD-S-05	Fails SQS and CSL
RD-S-06	Fails SQS and CSL
RD-S-07	Fails SQS and CSL
RD-S-08	Fails SQS

Table 6. SMU 2 Surface Chemical Exceedances by Contaminant

Enclosed Water – SMU 2		
Sample	Contaminant Exceeding Chemical SQS	Contaminant Exceeding Chemical CSL and SQS
RD-A-04	As, Cu, Pb, Zn, tPCBs	As, Cu, Pb, Zn
RD-B-01	As, Cu, ZN, tPCBs	As, Cu
RD-B-02	As, Cu, Pb, Zn	As, Cu, Pb, Zn
RD-S-17	As, Cu, Pb, Zn, tPCBs, LPAHs	As, Cu, Pb, Zn

As - arsenic
Cu - copper
Hg - mercury
Pb - lead
Zn - zinc
tPCBs - total polychlorinated biphenyls
LPAHs - light polycyclic aromatic hydrocarbons
HPAHs - heavy polycyclic aromatic hydrocarbons

Table 7. SMUs 3, 5 and 7 Surface Chemical Exceedances by Contaminant

Under-Pier Surface Sediments – SMU 3		
Sample	Contaminant Exceeding Chemical SQS	Contaminant Exceeding Chemical CSL and SQS
RD-B-03	As, Pb, Zn	Pb, Zn
Under-Pier Surface Sediments – SMU 5		
Sample	Contaminant Exceeding Chemical SQS	Contaminant Exceeding Chemical CSL and SQS
RD-B-05	As, Cu, Zn	As, Cu
Under-Pier Surface Sediments – SMU 7		
Sample	Contaminant Exceeding Chemical SQS	Contaminant Exceeding Chemical CSL and SQS
RD-B-05	no exceedances	no exceedances
RD-S-9	As, Cu. Hg, Pb, Zn, tPCBs	As, Cu. Hg, Pb, Zn, tPCBs
RD-S-10 (only sampled for Hg)	Hg	Hg
RD-S-11 (only sampled for Hg)	Hg	Hg
RD-S-12 (only sampled for Hg)		
RD-S-13 (only sampled for Hg)	Hg	Hg

Blank line indicates that no exceedance was detected.

Table 8. SMUs 4 and 6 Surface Chemical Exceedances by Contaminant

Shipway Surface Sediments – SMUs 4 and 6		
Sample	Contaminant Exceeding Chemical SQS	Contaminant Exceeding Chemical CSL and SQS
RD-S-14	Cu, Zn	Cu
RD-S-15	As, Cu, Zn, SVOCs	As, Cu, Zn, SVOCs
RD-S-16	As, Cu, Zn, HPAHs	As, Cu, Zn
RD-A-01	As, Zn, SVOCs, tPCBs	SVOCs
RD-A-02	As, Cu, Zn, LPAHs, HPAHs	As, Cu, Zn, LPAHs, HPAHs
RD-A-03	As, Zn	As, Zn

As - arsenic
Cu - copper
Hg - mercury
Pb - lead
Zn - zinc
tPCBs - total polychlorinated biphenyls
LPAHs - light polycyclic aromatic hydrocarbons
HPAHs - heavy polycyclic aromatic hydrocarbons

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Table 9. Comparison of Bioaccumulation Test Concentrations and Concentration of Analytes at RD-S-04

Open Water Surface Sediment – SMU 1 – Station RD-S-04		
Analyte	**Range of Bioaccumulation Test Concentrations**	**Concentration of Analytes at RD-S-04**
mercury	1.42 to 2.30 mg/kg DW[11]	0.41 mg.kg DW
tPCBs	0.10 to 87.90 mg/kg OC[12]	10.5 mg/kg OC
TBT (cation)	17.33 to 218.75 mg/kg OC[13]	112.9 mg/kg OC

[11] Applicable only to range of concentrations for the West Waterway Sediment Operable Unit.

[12] Same as footnote 11.

[13] Range of concentrations tested for bulk sediment in the West Waterway Sediment Operable Unit and the open water SMU at the Lockheed Shipyard Sediment Operable Unit and selected for bioaccumulation testing.

Table 10. Strategies Considered by EPA for Cost, Benefit, Technical Feasibility Evaluation

Strategy	Under-Pier (SMUs 3, 5 and 7)	Shipways (SMUs 4 and 6)	Enclosed Water (SMU2)	Open Water (SMU 1)
1	dredge to CSL/max. feasible depth[14] and cap surface areas > SQS	dredge to CSL/max. feasible depth[15] and cap surface areas > SQS	dredge to CSL/max. feasible depth[16] and cap surface areas > SQS	dredge to CSL/max. feasible depth[17] and cap surface areas > SQS
16	cap across SMUs	cap across SMUs	cap across SMU	cap across SMU
18A	dredge 3.5 ft and cap across SMUs[18]	dredge 3.5 ft and cap across SMUs[19]	dredge 3.5 ft and cap across SMU[20]	dredge 3.5 ft and cap across SMU
18B	" "	" "	" "	3.5 ft cap across SMUs
18C	" "	" "	" "	dredge to SQS; no cap required
18D	" "	" "	" "	dredge to CSL, cap surface areas > SQS

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[14] The "maximum feasible depth" assumes that sediments can be dredged to a maximum 2H:1V slope perpendicular to the bulkhead, beginning at an elevation of 10 feet at the bulkhead. For SMUs 2-7, some sediments exceeding the CSL probably would remain in place because the depth of contamination > CSL is deeper than the maximum feasible dredge depth.

[15] Same as 14

[16] Same as 14

[17] The dredge depth obtainable in the open water (SMU 1) adjacent to the pier face may be limited by the remedial option applied to the under-pier area. EPA assumes that all sediments > CSL will be dredged in the open water SMU.

[18] Explorations indicate that surficial waste and AGB are generally limited to the upper 3 feet and upper 5 feet, respectively, in the nearshore areas of the enclosed water and the under-pier/shipway SMUs. Therefore, a 3.5-foot dredge cut in these SMUs should remove most surficial waste and AGB.

[19] Same as 18.

[20] Same as 18

Table 11. Estimated Remedial Cost by Strategy Compared with Dredge and Cap Volumes

Strategy	Dredge Volume (cy)	Cap Volume (tons)	Remedial Cost ($ million in (1999 Dollars)
1	209,800	85,120	$23.7
16	n/a	85,120	$7.0
18A	47,388	85,119	$13.0
18B	26,288	85,119	$10.9
18C	46,625	53,429	$12.0
18D	40,329	85,212	$12.3

Table 12. Comparison of Benefits by Strategy

Benefit	Strategy					
	1	16	18A	18B	18C	18D
Largest % of contamination and waste are removed	X					
Significant amounts of contaminated sediments and waste are removed from the marine environment	X		X	X	X	X
All contaminated sediments and waste are removed in the open water area					X	
All CSL exceedances are removed in the open water area					X	X
Least costly strategy		X				
Lowest long-term monitoring costs (due to off-site confinement of all contaminated sediment and waste)	X					
Lowest long-term monitoring costs in open water area					X	
Least short-term impact due to no dredging		X				
Shortest time for implementation due to no dredging requirement		X				
Increases existing water column/depth in the open water area with inherent positive effect on navigational issues					X	
Maintains existing water column depth in the enclosed water, shipway, and under-pier areas			X	X also in open water	X	X
Maintains existing bathymetry in the enclosed water, shipway, and under-pier areas			X	X also in open water	X	X
Maintains options for marine commerce	X		X	X	X	X

Table 13. Comparison of Estimated Depth of Contamination and Estimated Volume to Dredge and Cap in the 1996 ROD and the 2001 ESD

Lockheed Shipyard Sediment Operable Unit (LSSOU)	1996 ROD estimated depth of contamination	2001 ESD estimated depth of contamination	1996 ROD estimated volume to dredge/cap	2001 ESD estimated volume to dredge/cap
	3-5 feet below the mudline	2.5 - 12.5 + feet below the mudline	18,000 cubic yards to dredge; 11,000 cubic yards of capping material (Note: The ROD only provides quantities and cost estimates for the open water area.)	46,625 cubic yards to dredge; 11,100 cubic yards of surficial debris removal; 53,429 cubic yards of capping material

Table 14. Comparison of Estimated Remedial Cost in the 1996 ROD and the 2001 ESD

Lockheed Shipyard Sediment Operable Unit (LSSOU)	1996 ROD estimated design and construction cost (1996 $ million)	2001 ESD estimated design and construction cost (1999 $ million)
	$ 1.5 (incomplete estimate)	$12.0

CSL EXCEEDANCE RATIO

Appendix A

TECHNICAL FEASIBILITY

Appendix B

Feasibility of Pulling Piling at the LSSOU

Sediment Management Units (SMUs) 3 through 7 are located under existing piers and/or shipways. Together these structures encompass over 4.4 acres, or approximately 57 percent of the LSSOU area. The piers and shipways are made up of decking and support structures (i.e., piles, stringers, and pile caps). The decking portion restricts access to contaminated sediments and shipyard waste from above. The support structures hinder access to the sediments from above and from the side.

Lockheed presented various sitewide remedial strategies in the Basis of Design Report (BDR) and the BDR Technical Memorandum. These documents included unit costs for removal of component parts of the pier structures (e.g., removal of individual piles). As implied above, the advantages of removing parts or all of the existing structures include providing better access to the contaminated sediments and shipyard waste, which would facilitate contamination removal (i.e., dredging) and placement and maintenance of the engineered cap.

Access to the sediments is limited because of the location and number of piles supporting the pier structure. The pile spacing varies at different locations within the LSSOU, but the piling is generally quite closely spaced. Pile densities are greater where higher vertical loading was anticipated (e.g., in the shipways) or in areas where greater lateral forces would be encountered (e.g., at the pier face). Additionally, as piles deteriorated and their load-bearing capacity was reduced, they were replaced by driving additional piles adjacent to them rather than by removing the old pile and driving the new pile in its place.

Dredging of contaminated sediment and placement and maintenance of the cap is most difficult when the entire structure (piling and decking) is left in place. Without removing the pier structure, excavation of contaminated sediments would have to be accomplished through the face of the piers and would not be feasible in the shipways. Removing the decking but leaving the piling in place will still interfere with dredging and capping operations by requiring more time to maneuver equipment around the structures and/or requiring smaller equipment that can fit between the support structure elements.

Furthermore, EPA believes that the remedial effectiveness of dredging and capping operations will be compromised to a significant degree with the piling left in place. First, if portions of the pier and shipway structures are not removed (e.g., the piling or both piles and pile caps are left), it will be difficult to remove all of the contaminated sediment. A clamshell would not be able to remove all of the contaminated material because it simply would not fit between the piles in some locations. Additionally, even when the clamshell could be used in between piles, it cannot be used in such a way to effectively remove contaminated sediment, identified for removal, located next to a pile. On the other end of the spectrum, small diver-controlled suction dredges could probably be fit in between the piles but would face several significant operational problems–stiffer material could not be removed, production rates would be very low, and lower percent solids in the dredged material and even smaller debris could cause significant problems, etc.

The second significant impact of leaving the piling in place would the reduced effectiveness of placing the capping materials. While the difficulties of cap placement are perhaps less challenging than dredging around numerous piles, achieving the desired chemical isolation is far less likely with the piling in place. The presence of about 6,000 "interruptions" to the continuity of the cap would intuitively make it less likely that the desired isolation could be accomplished as effectively as without the piling present. The presence of the piling would also increase the difficulty of placing armor stone that protects the other components of the cap from various erosion forces. EPA believes that the improved access would provide for a considerably more effective dredging and capping remedy.

One concern with piling removal is that the removal of all pile stubs below the mudline could destabilize the slope in the SMUs located under the piers and shipways. Lockheed will be conducting further studies of the effect of piling removal on slope stability. If these studies indicate that slope stability may be jeopardized, some portion of the piles may be broken off at the dredge cut line, leaving some pile stubs in place to reinforce the slope.

The piling has undergone normal deterioration over the years, with some marine borer infestation noted. The piling under locations where building structures used to exist is in much worse condition than piling in other areas. Even without updated condition survey information, historical records would indicate that a significant portion of the piling is near or has exceeded its normal design or service life.

Because of the increased efficacy of the remedy that would be realized and because of the overall condition of the piling, EPA prefers a remedial strategy for SMUs 3 through 7 that includes the removal of the piles to the degree possible without jeopardizing slope stability in the area. However, both the condition of the piling and the pile spacing raise questions about the feasibility of effective piling removal at the LSSOU.

To obtain firsthand information for use in addressing these feasibility questions, EPA observed a demonstration pile pull at the Olympic View Resource Area on July 30. The primary objective of the demonstration was to test alternative means and methods of removing various pile structures using full-size removal equipment. Equipment included a boom crane with clamshell bucket and vibratory extractor. Testing focused on removal methods that have the potential to achieve full pile extraction. Methods included vibratory extraction and direct pulling through the use of a choke collar.

Hart Crowser developed the scope of work for the demonstration pile pull and provided technical oversight of the construction contractor that conducted the test program. Based on observations of the demonstration and the test results, EPA believes that pulling timber piling at the LSSOU is technically feasible. For further information, refer to General Construction Company, 2001.

COST TABLES BY STRATEGY

Appendix C

Validation of PRP's Remedial Cost Estimates

Lockheed presented cost estimates developed by its contractor, Hart Crowser, for various sitewide remedial strategies in the Basis of Design Report (BDR) and the BDR Technical Memorandum. Lockheed had two separate contractors independently review and confirm these cost estimates. EPA also reviewed the cost estimates in the process of reviewing the BDR and BDR TM. EPA offered some minor review comments for refinement of the estimates, while validating the cost estimates as acceptable within "standard of practice" accuracy ranges.

As an additional step of independent verification of unit prices, EPA contacted RABANCO on August 21, 200, to establish current disposal prices for contaminated sediments (like those at the LSSOU) at Roosevelt landfill. EPA verified anecdotal information that there had recently been significant price reductions at Roosevelt. However, prices had increased quite significantly since Hart Crowser did its cost estimates for the BDR (in 1999 dollars), and the net result was that the unit price in the BDR of $42.00 per cubic yard was verified as just about right. RABANCO was quoting approximately $25 per ton for disposal for quantities like Lockheed's in August. Converting that to a price per cubic yard and adding "a couple dollars" for transportation equals approximately $40 per cubic yard, within reasonable accuracy for such estimates at this stage of the project.

RESPONSIVENESS SUMMARY

Appendix D

VI. Public Participation Activities

EPA provided a 30-day public comment period for this ESD. Copies of the Fact Sheet were distributed to the Harbor Island mailing list of approximately 250 individuals. EPA received 9 comment letters from Natural Resource Trustees, several federal and state resource and regulatory agencies, the Muckleshoot Indian Tribe, Lockheed Martin and several other interested parties. EPA responses to public comments are in Appendix D.

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Michael F. Gearheard Date
Director, Office of Environmental Cleanup

Initial					
Name	Priddy	Ordine	Cohen	Kowalski	
Date					