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KING COUNTY DEPARTMENT OF
NATURAL RESOURCES AND PARKS

# DENNY WAY/LAKE UNION CSO CONTROL PROJECT

## SEDIMENT REMEDIATION PLAN

King County

MAY 1999

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# DENNY WAY/LAKE UNION CSO CONTROL PROJECT
# SEDIMENT REMEDIATION PLAN

**May 1999**

**Submitted to:**

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# EXECUTIVE SUMMARY

Under contract to Black & Veatch, Striplin Environmental Associates (SEA) evaluated alternatives for addressing the contaminated sediment offshore from the existing Denny Way Regulator and Discharge Structure. Sediments within the pipeline will be excavated during the installation of the new Denny Way/Lake Union CSO Marine Outfalls. Under a separate task order, SEA characterized the sediment around the 1990 Denny Way sediment cap in the Sediment Characterization Report, completed in June 1998. The characterization of the sediment from the cap focused only on sediments that may be excavated during installation of the new outfalls. King County had previously evaluated the cap and the underlying sediments, most recently in 1996.

SEA chemically characterized the surface sediment from 37 locations and subsurface sediment from a subset of 13 surface sediment stations. The results of the laboratory analyses for most samples were compared to the Sediment Management Standards (SMS) and Puget Sound Dredged Disposal Analysis (PSDDA) programs screening criteria. The SMS evaluation addressed whether the sediments were candidates for remediation, and the PSDDA characterization addressed whether sediments excavated from the outfall extension corridor would be suitable for open-water disposal.

Based on a comparison of chemical concentrations present at the Denny Way CSO site to PSDDA criteria, it was determined that little sediment within the outfall extension corridor was suitable for open-water disposal.

Based on a comparison of chemical concentrations present at the Denny Way CSO site to SMS criteria, surface and subsurface sediment that potentially require remediation were identified. Stations were identified as candidates for remediation if they had surface sediments with chemical concentrations in excess of either of the two SMS criteria, the Sediment Quality Standards (SQS) or the Cleanup Screening Level (CSL). The chemical concentrations that most frequently exceeded SMS standards were for mercury, PCBs, bis(2-ethyhexyl)phthalate, and butyl benzyl phthalate. Stations where surface sediment values exceeded SMS criteria were mapped and used to define Remediation Areas. Five Remediation Areas were identified and labeled as Areas A - E.

Remediation areas are defined as rectangles enclosing sampling locations with contaminant levels exceeding SQS or CSL criteria, and are aligned parallel to the seafloor contours. The areal extent of the remediation areas depends on the proximity of sampling locations without SQS exceedances and physical structures such as the shoreline and the existing sediment cap. The boundaries of the Remediation Areas extend half the distance to the closest sampling location without an exceedance, whenever possible.

Applicable laws and regulations pertaining to sediment remediation were reviewed. The review includes laws that define the need for potential remediation, laws that establish cleanup criteria, laws that govern disposal of material removed during remediation, and laws that may apply during remediation.

The Remediation Plan identifies and broadly evaluates six categories of remediation options including no action, natural recovery, excavation, treatment, containment, and disposal. The four criteria used to evaluate these options were technical effectiveness, implementability, cost effectiveness, and adverse impacts. The preliminary screening identified the following five potentially applicable remediation alternatives: 1) No Action, 2) Natural Recovery, 3) Excavation by Mechanical Dredging with Disposal at a RCRA Subtitle D Landfill, 4) Excavation with Mechanical Dredging with Thermal Treatment at a Cement Plant, and 5) Containment by Thin-Layer Capping.

These alternatives were then evaluated in detail for each Remediation Area against the eight criteria defined in the SMS: 1) protection of human health and environment, 2) compliance with cleanup standards, 3) short-term effectiveness, 4) long-term effectiveness, 5) implementability, 6) cost, 7) community concerns, and 8) waste minimization and recycling. To estimate costs, assumptions were made for depth of excavation required, side slopes of excavation, and availability of staging areas for off-loading excavated materials. Costs were also estimated for backfill materials for each remediation area. Alternatives were ranked on the basis of these criteria, and a preferred alternative was selected for each remediation area.

By evaluating each Remediation Area independently, the remediation of each area can be phased separately. At a minimum, the sediment within the pipeline corridor will be excavated during outfall construction. The remaining sediments may be remediated at any time although there may be cost and logistical benefits by either phasing remediation or conducting a portion of the remediation in tandem with outfall construction.

The preferred and backup alternatives for the outfall construction corridor and each of the five remediation areas are summarized in Table ES-1. The costs for each alternative are summarized in Table ES-2.

Based on the preferred alternatives for each of the remediation areas, remediation of the areas offshore and away from the existing cap would clearly benefit from decoupling remediation activities from outfall construction. By delaying remediation of these three offshore areas (Remediation Areas C, D and E) until construction activities are completed and the new outfall is in operation, the risk of recontaminating these areas is greatly reduced. The presence of the newly constructed outfall would not hinder remediation activities for the offshore areas. Therefore, it is recommended that the remediation schedule for Remediation Areas C, D and E be developed in conjunction with the sediment management program currently under development by King County.

For the two remediation areas adjacent to the shore and the existing outfall (Remediation Areas A and B), there could be some cost and logistical benefits to combining remediation with excavation of the corridor for the outfall construction and minimization of risk to the new outfalls. However, there would be a risk for recontamination of areas A and B until the project construction is completed and the facilities are on line. Therefore, it is recommended that cleanup of Remediation Areas A and B be implemented immediately after the outfall project is completed and facilities are functioning.

**Table ES-1.** Preferred and back-up alternatives for sediment groups, and remediation areas.

| *Sediment Group*<br>*Remediation Area* | 1<br>**Preferred Alternative** | 2<br>**Back-up Alternative** |
|---|---|---|
| *Corridor of Outfall Construction* | Alternative 3: Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill | Alternative 4: Mechanical Dredging with Treatment at Holnam Cement |
| *1990 Sediment Cap* | *These sediments were remediated in 1990 and are not further evaluated* | |
| *Sediments Inshore of 1990 Sediment Cap* | | |
| Remediation Area A | Alternative 3: Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill | Alternative 4: Mechanical Dredging with Treatment at Holnam Cement |
| Remediation Area B | Alternative 3: Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill | Alternative 4: Mechanical Dredging with Treatment at Holnam Cement |
| *Sediments Offshore of 1990 Sediment Cap* | | |
| Remediation Area C | Alternative 5: Containment by Thin-Layer Capping | Alternative 2: Natural Recovery |
| Remediation Area D | Alternative 5: Containment by Thin-Layer Capping | Alternative 2: Natural Recovery |
| Remediation Area E | Alternative 5: Containment by Thin-Layer Capping | Alternative 3: Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill |

**Table ES-2.** Costs for preferred and backup alternative, with and without backfilling.

| | 1 | 2 |
|---|---|---|
| ***Sediment Group Remediation Area*** | **Preferred Alternative** | **Back-up Alternative** |
| Corridor of Outfall Extension | Alternative 3: Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill | Alternative 4: Mechanical Dredging with Treatment at Holnam Cement |
| Cost of Alternative<br>Cost with Backfill | $255,647<br>$268,692 - $327,491 | $280,476<br>$293,521 - $352,320 |
| Remediation Area A | Alternative 3: Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill | Alternative 4: Mechanical Dredging with Treatment at Holnam Cement |
| Cost of Alternative<br>Cost with Backfill | $1,137,618<br>$1,200,688 - $1,484,961 | $1,257,660<br>$1,320,730 - $1,605,003 |
| Remediation Area B | Alternative 3: Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill | Alternative 4: Mechanical Dredging with Treatment at Holnam Cement |
| Cost of Alternative<br>Cost with Backfill | $218,581<br>$229,524 - $278,838 | $239,409<br>$250,352 - $299,666 |
| Remediation Area C | Alternative 5: Containment by Thin-Layer Capping | Alternative 2: Natural Recovery |
| Cost of Alternative<br>Cost with Backfill | $127,169 - $249,625<br>NA | $100,000<br>NA |
| Remediation Area D | Alternative 5: Containment by Thin-Layer Capping | Alternative 2: Natural Recovery |
| Cost of Alternative<br>Cost with Backfill | $104,744 - $126,125<br>NA | $100,000<br>NA |
| Remediation Area E | Alternative 5: Containment by Thin-Layer Capping | Alternative 3: Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill |
| Cost of Alternative<br>Cost with Backfill | $106,625 - $147,500<br>NA | $1,004,562<br>$1,060,085 - $1,310,343 |
| **Total All Areas**<br>**Total for All Areas With Back** | $1,950,384 - 2,135,096<br>$2,037,442 - $2,614,540 | $2,982,377<br>$3,124,688 - $3,767,332 |

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| | |
|---|---|
| AET | Apparent Effects Threshold |
| ASTM | American Society for Testing and Materials |
| CAD | Confined Aquatic Disposal |
| CERCLA | Comprehensive Environmental Response Compensation and Liability Act |
| CEQ | Council on Environmental Quality |
| CLP | Contract Laboratory Program |
| CSL | Cleanup Screening Level |
| CSO | Combined Sewer Overflow |
| CV | Cold Vapor Atomic Absorption Spectrometry |
| DGPS | Differential Global Positioning System |
| DW | Denny Way |
| Ecology | Washington Department of Ecology |
| EPA | U.S. Environmental Protection Agency |
| GFAA | Graphic Furnace Atomic Absorption Spectrometry |
| HPAH | High Molecular Weight Polycyclic Aromatic Hydrocarbon |
| ICP | Inductively Coupled Plasma |
| KCWTD | King County Wastewater Treatment Division |
| LADS | Lightweight Aggregate for Dredged Sediments |
| LAET | Lowest Apparent Effects Threshold |
| LCS | Laboratory Control Samples |
| LPAH | Low Molecular Weight Polycyclic Aromatic Hydrocarbon |
| Metro | Municipality of Metropolitan Seattle (now King County) |
| ML | Maximum Level |
| MLLW | Mean Lower Low Water |
| MS/MSD | Matrix Spike/Matrix Spike Duplicate |
| MSS | Marine Sample Systems |
| NAD | North American Datum |
| NEPA | National Environmental Policy Act |
| PCB | Polychlorinated Biphenyls |
| PSDDA | Puget Sound Dredged Disposal Analysis |
| PSEP | Puget Sound Estuary Program |
| QA | Quality Assurance |
| QC | Quality Control |
| RCRA | Resource Conservation and Recovery Act |
| RPD | Relative Percent Difference |
| SAD | Strong Acid Digestion |
| SAP | Sampling and Analysis Plan |
| SEA | Striplin Environmental Associates, Inc. |
| SEPA | State Environmental Policy Act |
| SL | Screening Level |
| SMS | Sediment Management Standards |

| | |
|---|---|
| SQS | Sediment Quality Standards |
| TOC | Total Organic Carbon |
| VOA | Volatile Organics Analysis |
| WAC | Washington Administrative Code |
| WADNR | Washington Department of Natural Resources |

# 1. INTRODUCTION

The primary goal of the Denny Way/Lake Union Combined Sewer Overflow (untreated CSO) Control Project is to control the Denny Way CSO to State CSO standards (CSOs occur on average once per year per outfall). This reduction is a substantial reduction from the current level of 51 untreated CSO discharges per year. Accordingly, King County is proposing to construct two outfalls at the existing Denny Way CSO, in Seattle, Washington. Both of the proposed outfalls will terminate in Elliott Bay. One outfall will be a 100 foot (ft) extension of the existing CSO to an approximate water depth of -20 ft mean lower low water (MLLW) to discharge untreated CSO on average once per year. The second, separate outfall will be approximately 500 ft of pipe constructed parallel to the extension of the existing CSO to an approximate water depth of -60 ft MLLW to discharge treated flows an average of 15 times per year (ranging from 8 to 20 times per year).

As part of the construction project, a sediment quality characterization was conducted offshore of the existing CSO in September, 1997. The purpose of this study was to evaluate present conditions and to serve as a baseline for the implementation of a lease of subtidal property from the Washington Department of Natural Resources (WADNR). The data generated during the sediment characterization study also served the ancillary purposes of a preliminary evaluation of disposal options for material excavated during construction and providing information needed for this remediation plan. This remediation plan evaluates the alternative methods of remediation and handling of the sediment that will be excavated during the outfall construction project, and for other adversely affected sediment in the vicinity of the Denny Way CSO.

## 1.1 Site Description

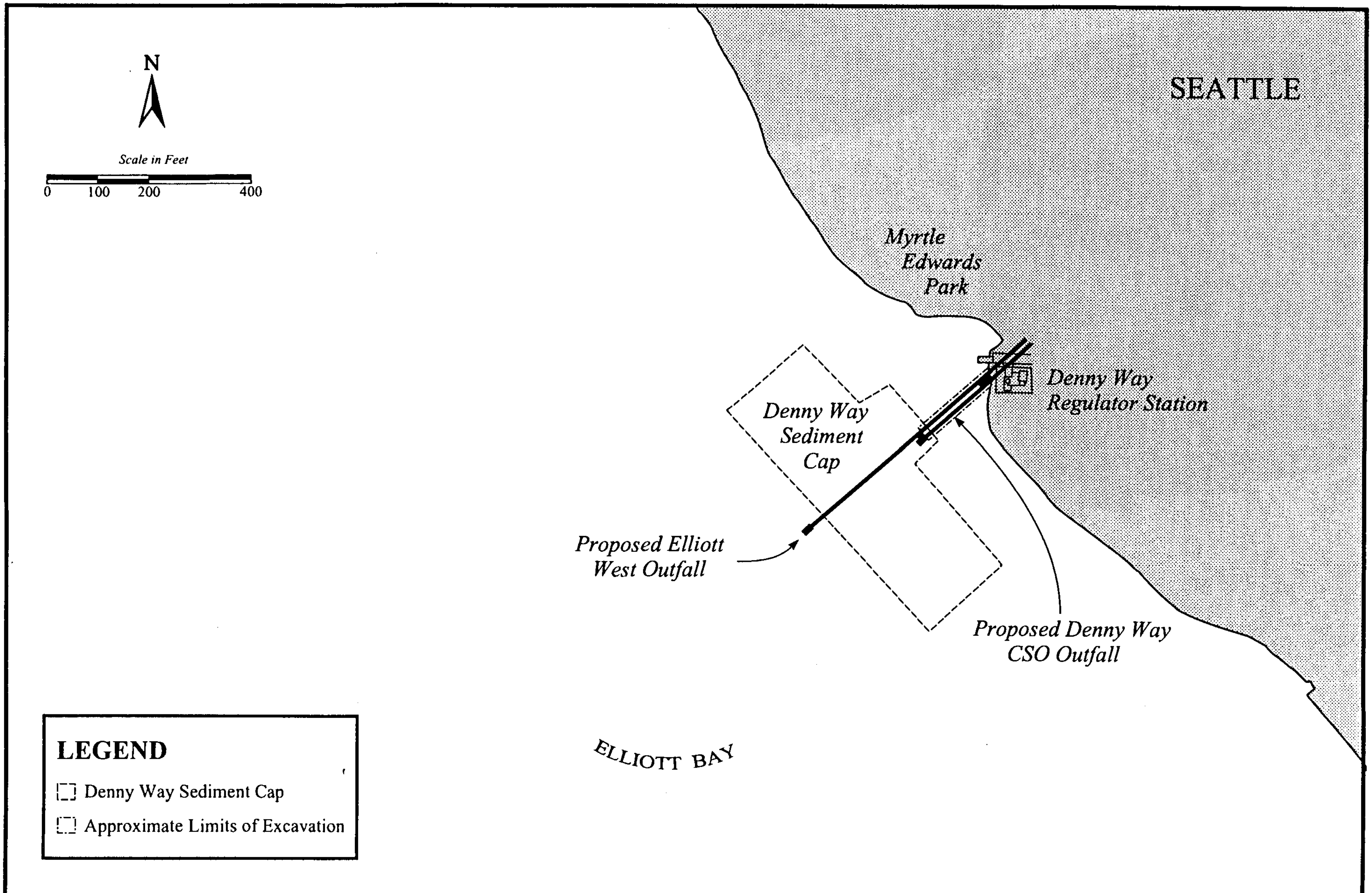
The existing Denny Way CSO lies in Myrtle Edwards Park in Seattle, as shown on Figure 1-1. The existing outfall discharges into the intertidal zone of Elliott Bay. West and further offshore of the existing outfall is the Denny Way sediment cap. The sediment cap, placed in 1990 to contain contaminated sediments, extends from -15 ft to -50 ft MLLW and covers approximately 3 acres of subtidal land. The 1997 sediment characterization applies to areas surrounding the cap as well as areas within the construction corridor that may require excavation during construction (SEA 1998).

## 1.2 Past Uses and Studies

The waters seaward of the Denny Way CSO have been receiving discharges since 1895 (Metro 1995) when the City of Seattle constructed two untreated sewage outfalls. These outfalls, one of which was Denny Way, operated until 1969, when the Elliott Bay interceptor line was installed along the Seattle waterfront. At that time, the Denny Way outfall was converted to a CSO.

Several studies have investigated possible environmental effects associated with the operation of the historic sewer line and the present CSO (Armstrong et al. 1978; Tomlinson et al. 1980; Malins et al. 1980; Chapman et al. 1982; Comiskey et al. 1984; Romberg et al. 1984; Tetra Tech 1988; Romberg et al. 1987; Metro 1995).

In addition to the studies investigating environmental effects that are possibly attributable to the long-term operation of the Denny Way CSO, studies have been recently conducted detailing the sediment quality on the 1990 Denny Way Cap (Metro 1995, King County 1996 & 1998). Although sediment quality at four fixed locations on the cap is well understood, areas on the cap in the construction corridor and the areas surrounding the cap needed to be characterized to evaluate institutional and remediation options. As a result, a sediment characterization study was conducted in 1997 to assess existing conditions in the vicinity of the Denny Way CSO and to evaluate present sediment quality at and adjacent to the CSO outfall construction corridor. This sediment characterization forms the basis for evaluating site sediments against regulatory screening criteria. Data from the evaluation was used to define potential remediation areas. Remediation technologies and process options were evaluated with respect to the physical attributes (e.g., water depth, slope and sediment grain-size) and the type of contamination within each remediation area.




Striplin Environmental Associates

Figure 1-1

Proposed Outfall Alignment, Denny Way/Lake Union CSO Control Project

Denny Way Remediation Plan

Oct 1998

DWRP Figure 1-1.xar

# 2. SEDIMENT CHARACTERIZATION AND DEFINITION OF REMEDIATION AREAS

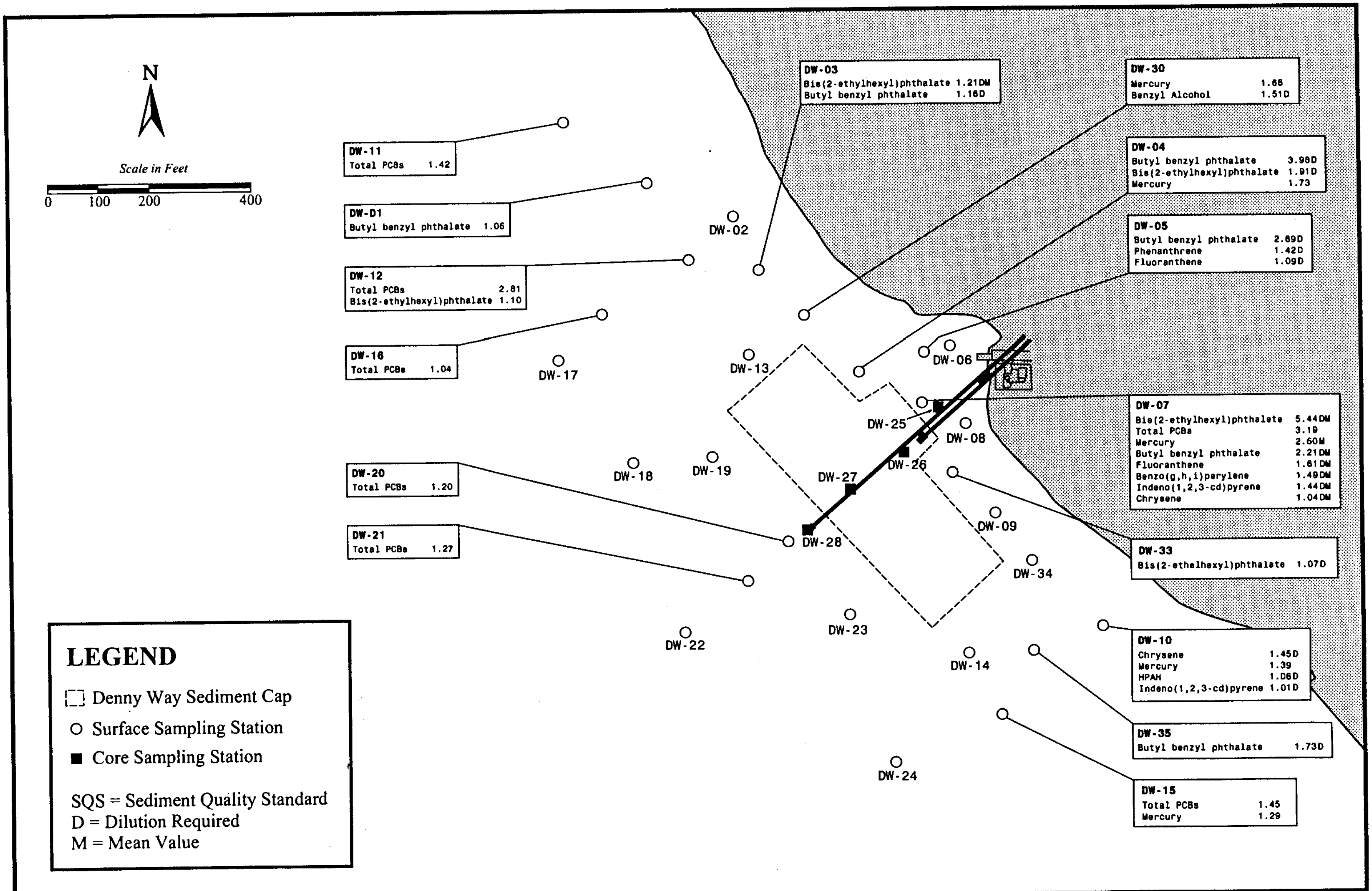
## 2.1 1997 Sediment Characterization

A sediment characterization study of the Denny Way site was conducted in September, 1997. Data collected from the study was compared against Puget Sound Dredged Disposal Analysis (PSDDA) and Sediment Management Standards (SMS) criteria. The results are detailed in SEA 1998.

This study characterized both surface (0-10 cm) and subsurface sediments in the outfall construction corridor, and sediments inshore and offshore of the existing sediment cap. Surface sediment chemical data are compared to SMS criteria only and are used to identify the areas that potentially need remediation. Core sample data are evaluated with respect to both PSDDA and SMS criteria. The purpose of the PSDDA evaluation is to determine whether any sediments are suitable for open-water disposal at the Elliott Bay PSDDA dredged material disposal site. The purpose of the SMS evaluation of the core samples is to determine the vertical extent of contamination within the sediment column. Once the vertical extent of contamination is identified, the depth to which sediments need to be remediated can be determined.

## 2.2 PSDDA Characterization along the Outfall Construction Corridor

Sediments within the corridor of outfall construction were sampled using a vibracorer. The core samples were composited in 2-foot vertical sections, analyzed, and compared to PSDDA screening criteria for open-water disposal. Of the stations cored, one station (DW-25) (Figure 2-1) lies within the corridor of outfall construction that will be excavated. The results of the PSDDA screening indicate that, in the top 8 feet, the PSDDA screening level (SL) was exceeded for total DDTs. The results of the screening of data against PSDDA criteria are summarized in Table 2-1. There were no maximum level (ML) exceedances. According to PSDDA, biological testing would need to be conducted on these sediments to determine their suitability for open-water disposal. The sediments underlying the top 8 feet of the sediment column have no PSDDA SL exceedances and appear suitable for open-water disposal without further testing. If bioassay testing results indicate no adverse biological impacts, then the top 8 feet of sediment in the vicinity of DW-25 is suitable for open-water disposal.




| | | | |
|---|---|---|---|
| TRIPLIN Environmental Associates | Figure 2-1 | Detected Chemicals Exceeding SQS in Denny Way/Lake Union CSO Project Surface Sediments and Exceedance Factors | Denny Way Remediation Plan |
| | | | Oct 1998 — DWRP Figure 2-1.xar |

**Table 2-1.** Summary of Denny Way/Lake Union CSO Project PSDDA Chemical Evaluation. Parentheses indicate exceedances of the detection limit.

| Station | Sample ID | Sample Depth (below mudline) | Number of SL Exceedances (<ML) | Number of ML Exceedances | Suitable for Open-Water Disposal Without Further Testing | Unsuitable for Open-Water Disposal Without Biological Testing | Could be Suitable for Open-Water Disposal With Biological Testing |
|---|---|---|---|---|---|---|---|
| DW-25 | DW-25-SED-0-2 | 0-2 ft | 6(5) | 0 | no | yes | yes |
| | DW-25-SED-2-4 | 2-4 ft | 6(5) | 0 | no | yes | yes |
| | DW-25-SED-4-8 | 4-8 ft | 6(5) | 0 | no | yes | yes |
| | DW-25-SED-8-10.5 | 8-10.5 ft | 0 | 0 | yes | NA | NA |
| DW-26 | DW-26-SED-0-3 | 0-3 ft | 2(1) | 0 | no | yes | yes |
| | DW-26-SED-3-7 | 3-7 ft | 16(6) | 3 | no | yes | no |
| | DW-26-SED-7-11 | 7-11 ft | 0 | 0 | yes | NA | NA |
| | DW-26-SED-11-13 | 11-13 ft | 0 | 0 | yes | NA | NA |
| DW-27 | DW-27-SED-0-3 | 0-3 ft | 1 | 0 | no | yes | yes |
| | DW-27-SED-3-7 | 3-7 ft | 2 | 0 | no | yes | yes |
| | DW-27-SED-7-11 | 7-11 ft | 0 | 0 | yes | NA | NA |
| | DW-27-SED-11-14 | 11-14 ft | 0 | 0 | yes | NA | NA |
| DW-28 | DW-28-SED-0-2 | 0-2 ft | 1 | 0 | no | yes | yes |
| | DW-28-SED-2-4 | 2-4 ft | 0 | 0 | yes | yes | NA |
| | DW-28-SED-4-8 | 4-8 ft | 0 | 0 | yes | yes | NA |
| | DW-28-SED-8-12 | 8-12 ft | 0 | 0 | yes | yes | NA |
| | DW-28-SED-12-14 | 12-14 ft | 0 | 0 | yes | yes | NA |

NA = Not Applicable

PSDDA - Puget Sound Dredged Disposal Analysis

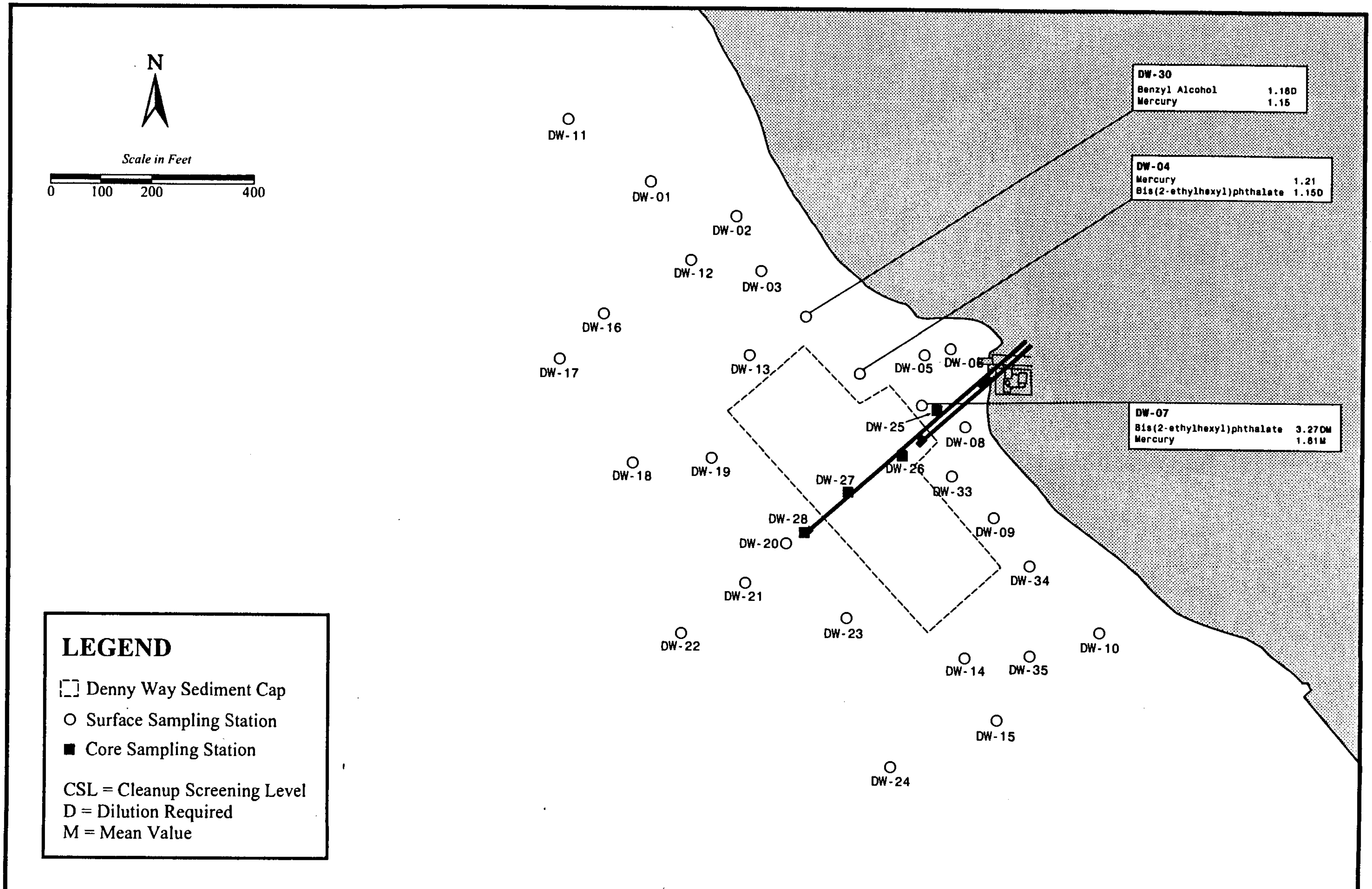
SL - PSDDA Screening Level, ML - PSDDA Maximum Level

The top 3 feet of sediment at DW-26 is suitable for open-water disposal without further testing; however, the sediments below that level are unsuitable for open-water disposal due to ML exceedances. The top 2 feet of sediment farther offshore from the outfall corridor, defined by stations DW-27 and DW-28, are unsuitable for open-water disposal unless biological testing indicates no adverse biological effects. As presently planned, the outfall pipes will "daylight" between DW-25 and DW-26 at -10 ft MLLW. In water depths greater than -10 ft MLLW, the extension would be laid on the sediment surface. Excavation in water depths greater than -10 ft MLLW will be limited to 3 to 5 feet below mudline for installation of pile caps and pipe cradle supports.

## 2.3 Sediment Management Standards (SMS) Evaluation of Surface Sediment Chemistry

The results of the 1997 sediment characterization were compared to the Sediment Management Standards (SMS) in WAC173-204 (Ecology 1991). The results of this comparison are summarized in Table 2-2. Surface sediments are defined as the top 10 cm of the sediment column. For sediments with concentrations below the Sediment Quality Standards (SQS) and Cleanup Screening Level (CSL) criteria, no further action is necessary. Surface sediments having chemical concentrations that exceed the Sediment Quality Standards (SQS) are considered to have minor adverse biological effects. For sediments with SQS exceedances, biological testing can be conducted to prove that there are no adverse biological effects. If this testing demonstrates that the sediments do not cause adverse effects to marine biota, no remediation is necessary. If biological tests indicate that the sediment meets evaluation criteria, no further action is necessary. If sediments fail the biological tests, the sediments become candidates for remediation. Under interagency agreement (1995), sediments with SQS exceedances that have not undergone biological testing may be temporarily excluded from active remediation; however, the site remains on Ecology's list of Sites of Potential Concern. Sediments with contaminant concentrations between SQS and CSL are considered candidates for remediation. However, sediments with chemical concentrations in excess of the SQS, but less than the CSL, may also be considered for no action other than periodic monitoring. It should be noted that a goal of this remediation plan is to justify a phased approach to cleanup, if warranted, rather than suggesting that no work should be done for sediments with chemical concentrations between the SQS and CSL.

The Cleanup Screening Level (CSL) is the concentration at which adverse biological effects are predicted. For the purposes of this remediation plan, surface sediments containing chemicals whose concentration exceeds the CSL will be considered for active remediation. Results of screening against the SMS SQS and CSL criteria are presented in Figures 2-1 and 2-2. These figures show the stations with SQS and CSL exceedances along with the factor of the exceedance. Stations with surface sediments that exceed the CSL are all located immediately inshore of the existing sediment cap, at depths of -20 to -4 ft MLLW.




| | | | |
|---|---|---|---|
| Striplin Environmental Associates | Figure 2-2 | Detected Chemicals Exceeding CSL in Denny Way/Lake Union CSO Control Project<br>Surface Sediments and Exceedance Factors | Denny Way Remediation Plan<br>Oct 1998 / DWRP Figure 2-2.xar |

**Table 2-2**. Summary of Denny Way/Lake Union CSO Project SMS Chemical Evaluation. Parentheses indicate the no chemicals were detected but the detection limit exceeded SMS criteria.

| Sample ID | Sample Depth | TOC (%) | Number of SQS Exceedances (<CSL) | Number of CSL Exceedances | Remediation or Further Testing not Necessary | Candidates for Remediation Without Further Testing | Removal or Treatment Necessary |
|---|---|---|---|---|---|---|---|
| DW-01-SED-0 | 0-10 cm | 2.5 | 2 | 0 | no | yes | no |
| DW-02-SED-0 | 0-10 cm | 3.9 | 0 | 0 | yes | NA | NA |
| DW-03-SED-0 | 0-10 cm | 3.2M | 2 | 1(1) | no | yes | no |
| DW-04-SED-0 | 0-10 cm | 2 | 1 | 3(1) | no | yes | yes |
| DW-05 | 0-10 cm | 1.2 | 5(2) | 2(2) | no | yes | no |
| DW-06 | 0-10 cm | 0.79 | 1(1) | 4(4) | no | yes | no |
| DW-07-SED-0 | 0-10 cm | 0.9M | 6 | 6(4) | no | yes | yes |
| DW-08 | 0-10 cm | 2 | 2(2) | 1(1) | no | yes | no |
| DW-09 | 0-10 cm | 3.5M | 0 | 0 | yes | NA | NA |
| DW-10-SED | 0-10 cm | 3.2 | 7(3) | 4(4) | no | yes | no |
| DW-11-SED-0 | 0-10 cm | 1.2 | 1 | 0 | no | yes | no |
| DW-12-SED-0 | 0-10 cm | 1.6 | 2 | 0 | no | yes | no |
| DW-13-SED-0 | 0-10 cm | 2.6 | 0 | 0 | yes | NA | NA |
| DW-14-SED-0 | 0-10 cm | 1.3 | 0 | 0 | yes | NA | NA |
| DW-15 | 0-10 cm | 2.3 | 2 | 1(1) | no | yes | no |
| DW-16-SED-0 | 0-10 cm | 1.3 | 1 | 0 | no | yes | no |
| DW-17-SED-0 | 0-10 cm | 1.7 | 0 | 0 | yes | NA | NA |
| DW-18-SED-0 | 0-10 cm | 4.1 | 0 | 0 | yes | NA | NA |
| DW-19-SED-0 | 0-10 cm | 2.4 | 0 | 0 | yes | NA | NA |
| DW-20-SED-0 | 0-10 cm | 1.7 | 1 | 0 | no | yes | no |
| DW-21-SED-0 | 0-10 cm | 2.3 | 1 | 0 | no | yes | no |
| DW-22-SED-0 | 0-10 cm | 3.1 | 0 | 0 | yes | NA | NA |
| DW-23-SED-0 | 0-10 cm | 3.2M | 0 | 0 | yes | NA | NA |
| DW-24 | 0-10 cm | 1.6 | 0 | 0 | yes | NA | NA |
| DW-30 | 0-10 cm | 1.8 | 0 | 3(1) | no | yes | yes |

**Table 2-2**. Summary of Denny Way/Lake Union CSO Project SMS Chemical Evaluation. Parentheses indicate the no chemicals were detected but the detection limit exceeded SMS criteria.

| Sample ID | Sample Depth | TOC (%) | Number of SQS Exceedances (<CSL) | Number of CSL Exceedances | Remediation or Further Testing not Necessary | Candidates for Remediation Without Further Testing | Removal or Treatment Necessary |
|---|---|---|---|---|---|---|---|
| DW-33 | 0-10 cm | 2.3 | 3(2) | 0 | no | yes | no |
| DW-34 | 0-10 cm | 2.3M | 0 | 0 | yes | NA | NA |
| DW-35 | 0-10 cm | 1.3 | 2(1) | 1(1) | no | yes | no |
| DW-29-SED-0-2 | 0-2 ft | 1.5 | 2(1) | 1 | no | yes | no |
| DW-29-SED-2-4 | 2-4 ft | 1.8 | 0 | 1 | no | yes | no |
| DW-29-SED-4-6 | 4-6 ft | 0.98 | 1(1) | 0 | yes | NA | NA |
| DW-29-SED-6-8 | 6-8 ft | x | x | x | yes | NA | NA |
| DW-30-SED-0-2 | 0-2 ft | 0.84 | 1(1) | 0 | yes | NA | NA |
| DW-30-SED-2-4 | 2-4 ft | 1.3 | 0 | 0 | yes | NA | NA |
| DW-30-SED-4-6 | 4-6 ft | 0.91 | 1(1) | 0 | yes | NA | NA |
| DW-31-SED-0-2 | 0-2 ft | 3 | 14(3) | 2(1) | no | yes | yes |
| DW-31-SED-2-4 | 2-4 ft | 2.2 | 9(3) | 2(1) | no | yes | yes |
| DW-31-SED-4-6 | 4-6 ft | 3.3 | 12(9) | 7(5) | no | yes | yes |
| DW-31-SED-6-8 | 6-7 ft | 4.8 | 2 | 0 | no | yes | no |
| DW-32-SED-0-2 | 0-2 ft | 2.1 | 5(3) | 0 | no | yes | no |
| DW-32-SED-2-4 | 2-4 ft | 2 | 4(3) | 0 | no | yes | no |
| DW-33-SED-0-2 | 0-2 ft | 1.1 | 1(1) | 0 | yes | NA | NA |
| DW-33-SED-2-4 | 2-4 ft | 0.6 | 2(2) | 0 | yes | NA | NA |
| DW-33-SED-4-6 | 4-6 ft | 0.49M | 2(2) | 0 | yes | NA | NA |
| DW-33-SED-6-8 | 6-8 ft | x | x | x | NA | NA | NA |
| DW-34-SED-0-2 | 0-2 ft | 1.3 | 0 | 0 | yes | NA | NA |
| DW-34-SED-2-4 | 2-4 ft | 0.42 | 1(1) | 0 | yes | NA | NA |
| DW-34-SED-4-6 | 4-6 ft | 0.37 | 2(2) | 0 | yes | NA | NA |
| DW-35-SED-0-2 | 0-2 ft | 3M | 1 | 0 | no | yes | no |
| DW-35-SED-2-4 | 2-4 ft | 1.8 | 1 | 2(1) | no | yes | yes |

**Table 2-2**. Summary of Denny Way/Lake Union CSO Project SMS Chemical Evaluation. Parentheses indicate the no chemicals were detected but the detection limit exceeded SMS criteria.

| Sample ID | Sample Depth | TOC (%) | Number of SQS Exceedances (<CSL) | Number of CSL Exceedances | Remediation or Further Testing not Necessary | Candidates for Remediation Without Further Testing | Removal or Treatment Necessary |
|---|---|---|---|---|---|---|---|
| DW-35-SED-4-6 | 4-6 ft | 2 | 0 | 3(1) | no | yes | yes |
| DW-35-SED-6-8 | 6-8 ft | 0.44 | 0 | 0 | yes | NA | NA |
| DW-36-SED-0-2 | 0-2 ft | 2.2 | 2 | 0 | no | yes | no |
| DW-36-SED-2-4 | 2-4 ft | 2.1 | 2 | 0 | no | yes | no |
| DW-36-SED-4-6 | 4-6 ft | 5.7 | 0 | 0 | yes | NA | NA |
| DW-36-SED-6-8 | 6-8 ft | x | x | x | NA | NA | NA |
| DW-37-SED-0-2 | 0-2 ft | 1 | 6(3) | 1(1) | no | yes | no |
| DW-37-SED-2-4 | 2-4 ft | 0.91 | 2(1) | 0 | no | yes | no |
| DW-37-SED-4-6 | 4-6 ft | 0.32 | 4(4) | 0 | | | |

[1] Sample analyzed for sulfides only; remaining sample jars archived.

[2] Sample analyzed for VOCs and sulfides; remaining sample jars archived.

TOC = Total Organic Carbon

PSDDA - Puget Sound Dredged Disposal Analysis

SMS - Sediment Management Standards

SL - PSDDA Screening Level, ML - PSDDA Maximum Level, SQS - SMS Sediment Quality Standards, CSL - SMS Cleanup Screening Level

NA=Not Applicable

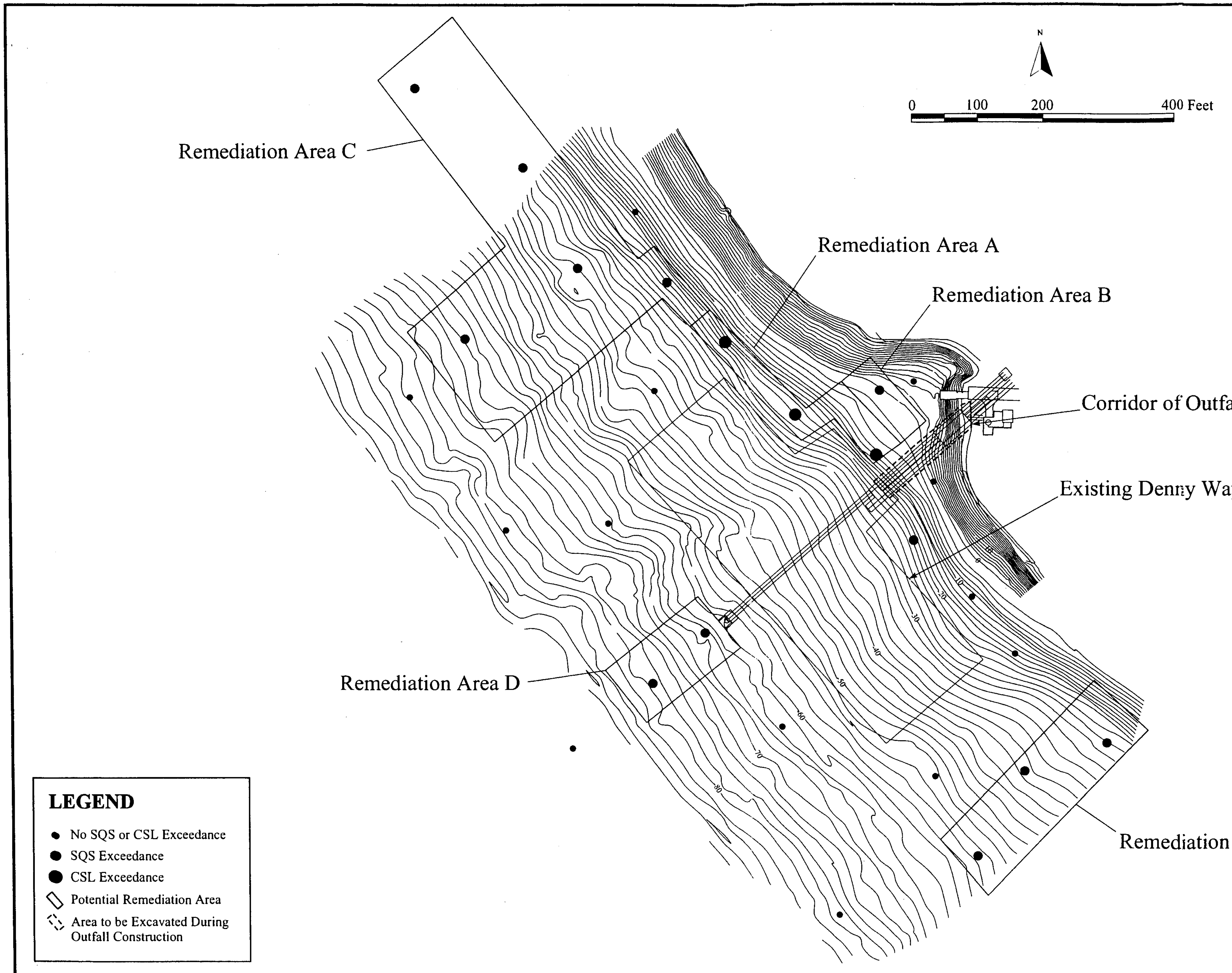
Stations with chemical concentrations exceeding the SQS criteria, but less than the CSL, are located offshore of the cap and in a small area inshore of the cap.

## 2.4 Delineation of Remediation Areas

Based on the screening of Denny Way surface sediment chemistry against the SQS and CSL criteria set forth in the Sediment Management Standards (WAC 173-204), areas exceeding SQS and CSL levels were identified. Stations containing contaminants at concentrations above the SQS, but less than the CSL, are grouped separately from those stations having contaminant concentrations higher than the CSL. Using this information, remediation areas are defined based on the type of exceedance (SQS only or CSL), the proximity of stations with exceedances to other stations with and without exceedances, and the proximity of stations with exceedances to physical features such as the shoreline and the existing Denny Way Sediment Cap. Further, the shape and size of the remediation areas are defined to accommodate the remediation technologies applicable to the site. For example, remediation areas are, to the extent possible, defined to be rectangular, parallel to the shoreline, and are nominally divided into 50-foot wide cells. The size and orientation of the proposed remediation areas is readily adaptable to dredging (an applicable removal technology). Remediation Areas are shown on Figure 2-3.

Figure 2-3

Denny Way / Lake Union
CSO Control Project
Potential Remediation Areas




| Denny Way / Lake Union CSO Control Project | Oct 1998 | DWRP Figure 2-3.xar |
|---|---|---|

# 3. APPLICABLE LAWS AND REGULATIONS PERTAINING TO REMEDIATION AND ALTERNATIVES

## 3.1 Identification of Applicable Laws and Regulations

This section identifies the laws and regulations that apply to the remediation of sediments at the Denny Way CSO. These include federal, state and local regulations that may affect any phase of remediation for the Denny Way CSO. Applicable laws and regulations are presented in the order in which they may affect the construction project.

## 3.2 Laws and Regulations that Define Need for Potential Remediation

These are the laws and regulations that establish the requirement for study and, if applicable, the remediation of sediments in the vicinity of the Denny Way CSO, along with the sediments to be excavated during construction. .

### *3.2.1 Consent Decree No. C90-395 WD, U.S. District Court, Western District of Washington State*

This decree settled a lawsuit brought forth by the National Oceanic and Atmospheric Administration (NOAA) and other Trustees against the City of Seattle and the KCWTD (formerly Metro) to cover damages to natural resources attributable to releases into Elliott Bay and the Duwamish River from CSOs and storm drains. The suit was filed by NOAA under its authority as natural resources trustee as authorized in the Comprehensive Environmental Response Compensation and Liability Act (CERCLA). Filing suit with NOAA were the U.S. Fish and Wildlife Service, Washington State Department of Ecology, the Muckleshoot Tribe, and the Suquamish Tribe (the Trustees). This decree required the City and KCWTD to expend a total of $24 million for source control, remediation, and habitat restoration to mitigate the alleged damages.

### *3.2.2 Comprehensive Environmental Response Compensation and Liability Act (CERCLA), 42 USC 9601 and National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR 300*

CERCLA and NCP establish national policy for environmental investigations and cleanups. CERCLA (better known as Superfund) and the NCP also detail the procedures for identification and remediation of sites that are listed as the most contaminated sites in the nation. This list is called the National Priorities List (NPL). The Denny Way CSO is not a NPL site. Under CERCLA, the EPA oversees and directs investigations and cleanups. It also allows trustees for natural resources to evaluate and seek compensation for damages to natural resources. As natural resource trustee, NOAA filed the suit which led to the Consent Decree (3.2.1.). Other than providing the authority for the Trustees, major portions of CERCLA are not applicable to the Denny Way CSO.

### *3.2.3 Model Toxics Control Act (MTCA), Chapter 70.105D RCW and Chapter 173-340 WAC*

MTCA is the Washington State law that identifies potential areas for cleanup and defines the methods for investigating sites, the cleanup standards, and goals. Ecology is responsible for administering the standards, updating them on a regular basis, and listing the sites that contain hazardous materials, which pose a potential threat to human health and the environment. This act provides the authority for establishment of the criteria set forth in the Sediment Management Standards (a subsequent applicable regulation). The Denny Way CSO site is included in Ecology's Sediment Management Standards Sediment Site List (1996). MTCA is considered an applicable regulation for the Denny Way CSO, as its defines the process and the regulations that govern cleanup procedures and cleanup standards.

## 3.3 Laws and Regulations that Establish Cleanup Criteria and Study Requirements

### *3.3.1 Sediment Management Standards (SMS) 173-204 WAC*

The Sediment Management Standards are developed and enforced by Ecology under the provisions in the Water Pollution Control Act (90.48 RCW) and the Model Toxics Control Act (MTCA 90.105D RCW). These standards establish sediment quality criteria for freshwater, estuarine, and marine sediments in the State of Washington. The standards are biological effects-based and derived from Apparent Effects Thresholds (AETs). The SMS define two criteria: the lower Sediment Quality Standard (SQS) below which no adverse effects are expected and above which minor adverse effects are expected, and the higher Cleanup Screening Level (CSL or also called the minimum cleanup level - MCUL) above which adverse biological effects are expected. The SMS also define the procedure for site rankings and requirements for sediment cleanups (173-204-570 and 173-204-580 WAC). The regulation is applicable to remediation of the intertidal and subtidal sediments at Denny Way and will be used to define potential areas of remediation and cleanup goals.

### *3.3.2 Puget Sound Estuary Program (PSEP)*

This program, instituted under the National Estuaries Program, defines Puget Sound as an estuary of national significance, for which a comprehensive management plan is required. PSEP is managed by EPA, Puget Sound Water Quality Authority (PSQWA) and Native American Tribes of Washington. The Puget Sound Water Quality Management Plan of 1991 serves as the Puget Sound Comprehensive Management Plan. Sections of the comprehensive plan that are applicable to the Denny Way CSO site are: the Contaminated Sediment and Dredging Action Plan, the Municipal and Industrial

Discharges Plan, and the Stormwater and Combined Sewer Overflows Action Plan. The Puget Sound Protocols, which were developed under PSEP, define methods to standardize the collection and analysis of Puget Sound marine environmental data. These acts have no formal regulatory authority but are considered and treated only as guidance. They have no applicability to the Denny Way CSO site.

## 3.4 Laws and Regulations for Disposal of Materials Removed During Remediation

### *3.4.1 Resource Conservation and Recovery Act (RCRA), 42 USC 6901 and 40 CFR 260 et Seq.*

RCRA was enacted to regulate the management of hazardous waste; to ensure safe treatment, storage, and disposal of wastes; and to provide resource recovery from the environment by controlling hazardous wastes from "cradle to grave." Because the state has been authorized to implement both Subtitles C and D of RCRA, the only regulations under the federal program would be those developed under the Hazardous and Solid Waste Act (HSWA) amendments for which EPA has not delegated authority to the state (e.g., land disposal restrictions). RCRA Subtitles C and D of CFR 268 are applicable for upland disposal of sediments.

### *3.4.2 Washington Dangerous Waste Regulations, Chapter 70.105 RCW and 173-303 WAC*

These regulations implement the State's authority under the federal Resource Conservation and Recovery Act (RCRA). 173-303 WAC establishes which materials removed during remediation are considered dangerous or hazardous wastes. These regulations also detail requirements for handling, treatment, manifest, disposal, and storage of substances defined as dangerous or hazardous. None of the sediments considered for construction or remediation at the Denny Way CSO site are classified as hazardous waste.

### *3.4.3 Solid Waste Management Act, Chapter 79.95 RCW and 173-304 WAC*

The Solid Waste Management Act defines the State of Washington's policy on solid waste disposal and 173-304 WAC defines the regulations for solid waste disposal. These regulations will be applicable when considering upland disposal of sediments excavated during remediation. The 1995 revisions to the Solid Waste Management Act created a "problem-least" subcategory, which includes dredged sediments unsuitable for open-water disposal. To the extent possible, emphasis will be placed on complying with Washington's goal of reuse and recycling set forth in 70.95 WAC.

### *3.4.4 NPDES Permit Program, 33 USC 1251, 40 CFR 123, Chapter 90.48 RCW and Chapter 173-220 WAC*

The Clean Water Act, Section 402, requires EPA to review and grant permits for any discharge of designated pollutants into navigable waters of the U.S. By enacting the Water Pollution Control law (90.58 RCW) and associated regulations (173-220 WAC), the State of Washington meets federal requirements to issue NPDES permits. Any waters generated from dewatering of excavated sediments that are discharged into Elliott Bay are subject to NPDES permitting through the State of Washington and EPA. However, water from such activity released to a sanitary sewer would not require an NPDES permit, but rather, approval from King County Wastewater Treatment Division.

### *3.4.5 Water Quality Standards for the Surface Waters of the State of Washington, Chapter 90.48 RCW and 173-201A WAC*

WAC-201A defines surface water quality standards for the State of Washington pursuant to the Water Pollution Control Act (90.48 RCW) and the Clean Water Act (33 USC 1251). Surface water quality criteria are established for a set of pollutants and are applicable to remediation of the Denny Way CSO site.

## 3.5 Laws and Regulations Applicable to Implementing Remediation and Local Ordinances

### *3.5.1 National Environmental Policy Act (NEPA) 42 USC, 4321 et Seq. And 40 CFR 1500 et seq.*

NEPA establishes and sets forth the national policy for environmental protection and preservation. The Council on Environmental Quality (CEQ) provides executive guidance on federal responsibility, implementation and specific requirements for documentation. Federal agencies must comply with NEPA pursuant to CEQ (40 CFR Parts 1500-1508). NEPA is applicable to construction and remediation at the Denny Way CSO site. NOAA is the lead federal agency for the sediment remediation NEPA process. NOAA, or a third party, will prepare an Environmental Assessment (EA) and publish it in the Federal Register. EPA is the lead federal agency for the Denny Way Project construction NEPA process. A Finding of No Significant Impact (FONSI) was issued in July 1998, and the NEPA process for predesign of the outfalls is complete.

### *3.5.2 State Environmental Policy Act (SEPA) Chapter 43. 21C RCW and Chapter 197-11 WAC*

SEPA establishes the State's environmental policy for protection and preservation of the environment. Chapter 43.231C defines the law, and 197-11 WAC is the administrative code to implement the law. Ecology is the lead state agency for SEPA and will review and respond to the NEPA EA. Local jurisdictions (i.e., counties and municipalities) are also required to institute the procedures and policies of SEPA. If a FONSI is issued by the lead federal agency, Ecology is likely to adopt the NEPA document. Approval through the NEPA/SEPA process is necessary prior to the issuance of the permits needed for remediation of the Denny Way CSO site. King County is the lead agency for the Denny Way Project construction SEPA process. A final environmental impact statement for the outfalls was issued in July 1998, based on predesign.

### *3.5.3 Shoreline Management Act, Chapter 90.58 RCW and 173-14 WAC*

Chapter 90.58 RCW defines the Shoreline Management Act and 173-14 WAC provides the regulations to implement 90.58 RCW. This act requires that the proponent of any substantial development within 200 feet of the high water mark of the shoreline obtain multiple permits if the proposed development or action interferes with the normal use of the shoreline. Permits are granted by the local jurisdiction. In this case, the Seattle Planning Department of Land and Construction would issue the substantial development permit, with copies being sent to the State's Attorney General and to Ecology for review. State concerns regarding permit issuance are presented to the shoreline hearings board. Depending on the nature of the program and special circumstances, two additional permits may be issued; a variance permit and a conditional use permit.

### *3.5.4 National Historic Preservation Act, Chapter 27.34 RCW, Chapter 27.44 RCW and Chapter 27.53 RCW*

These acts prohibit the disturbance of any Native American historical sites or any other historic or prehistoric site without a permit, and, if required, oversight from the proper departments or tribal authorities. Because portions of the shoreline at the Denny Way CSO site have been extensively reworked and excavation for the outfall construction terminates in native sediments, it is unlikely that the actions associated with remediation and outfall construction will result in any disturbance of historically or prehistorically significant artifacts. Should any artifacts be uncovered, appropriate authorities and federally-recognized tribal authorities will be immediately notified.

King County has completed treatment and monitoring plans for archeological resources and historic properties. Areas for monitoring during construction have also been identified. King County is working with the Advisory Council of Historic Preservation, the Environmental Protection Agency, the Army Corps of Engineers, and the Washington Office of Archeology and Historic Preservation to complete and sign a Programmatic Agreement to protect archaeological and historical resources during construction of the Denny Way Project.

### *3.5.5 Washington Hydraulic Code, Chapter 75.20 RCW and Chapter 220-110 WAC*

The Washington Hydraulic Code and the accompanying regulation define the requirements pertaining to any activity that would use, obstruct, alter, or impact the seabed or the natural flow of marine or fresh waters. The Washington Department of Fish and Wildlife would review the hydraulic project proposal. The general project plan and complete construction plans at or below the established high water mark would be evaluated for the protection of fish and aquatic life and compliance with SEPA. If the Department of Fish and Wildlife determines that the proposed project has any indirect or direct deleterious effect on fish, the project will be denied unless sufficient mitigation can be assured. This regulation is applicable to the Denny Way outfall construction, as well as the site remediation.

### *3.5.6 State Aquatic Lands Management Act, Chapter 79.90 RCW and 332-30 WAC*

This act sets forth the State of Washington land use policy and is implemented through 332-30 WAC. The Department of Natural Resources administers and authorizes the uses of state-owned land. The beds of navigable waters, harbors, and state-owned tidelands and shorelands are under the authority of WADNR. WADNR Aquatic Lands Division is empowered to review and authorize proposed use of state-owned aquatic lands. Use of state-owned aquatic lands, if approved, will entail a contract with WADNR, with terms and limited conveyance of rights. Operating practices and performance standards for the lease of state-owned lands are defined in 332-30 WAC. Lease and use of WADNR lands will be required for portions of the Denny Way project.

### *3.5.7 Shoreline Master Program, Title 25 King County Code*

As required by 173-26-080 WAC, King County, City of Seattle is to develop and implement a Shoreline Master Program which regulates shoreline development to ensure compliance with the goals of environmental protection, maximum beneficial land use, view protection, water use, and access. The Shoreline Master Program is applicable to all phases of remediation at the Denny Way CSO site and governs the standards for dredging and material placement along the shoreline.

## 3.6 Definition of Cleanup Standards

The Washington Sediment Management Standards (WAC 173-204) define the standards to which sediments at the Denny Way CSO site will be remediated. Specifically, the cleanup goal is to reduce sediment contaminant levels less than the SQS. The SQS is the level below which no adverse biological effects are predicted.

# 4. IDENTIFICATION AND SELECTION OF REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS

This chapter identifies all the available technologies and remediation process options which are capable of meeting remediation goals at the Denny Way CSO site.

## 4.1 Identification of Remediation Processes and Technologies

The remediation processes and the technologies available for use at the Denny Way CSO site are outlined in the following section. This detailed listing is compiled from local and national projects, literature surveys, and correspondence with regulatory agencies. Remediation of intertidal and subtidal sediments poses logistical difficulties not found in land-based projects, which limits the range of applicable remediation processes. The following remediation technologies are considered for this project:

- No Action
- Natural Recovery
- Excavation
- Treatment
- Containment
- Disposal Options After Removal

Table 4-1 lists remediation process options for each remediation technology considered for this project.

Several treatment process options were eliminated from consideration, including in-situ stabilization (e.g., solidification and vitrification) and in-situ treatment. Although these processes may be possible at the Denny Way CSO site, they are not demonstrated or proven technologies in subaqueous or marine systems. Before these process options are implemented, basic research and pilot studies would need to be conducted to prove their efficacy which would make them significantly more expensive, time consuming, and difficult to permit than other readily available technologies.

**Table 4-1.** Remedial process options identified for each remediation technology.

| Remediation Technology | Remedial Process Option | Process Option Types | Results of Initial Screening |
|---|---|---|---|
| *No Action* | - | - | Retained for Baseline Comparison |
| *Natural Recovery* | - | - | Retained for Detailed Evaluation |
| *Excavation* | Mechanical Dredging | - | Retained for Detailed Evaluation |
| | Hydraulic Dredging | - | Eliminated from Further Consideration |
| *Treatment* | Bioremediation | - | Eliminated from Further Consideration |
| | Mechanical Treatment | Soil Washing | Eliminated from Further Consideration |
| | Thermal Treatment | | |
| | | Holnam Cement Plant | retained for detailed evaluation |
| | | Portable Thermal Plants | |
| | | LADS | Eliminated from Further Consideration |
| | | Incineration | Eliminated from Further Consideration |
| *Containment* | In-situ Capping | | |
| | | Thin Layer | |
| | | Thick Layer | Eliminated from Further Consideration |
| | | Inverted | Eliminated from Further Consideration |
| | Confined Aquatic Disposal (CAD) | - | Eliminated from Further Consideration |
| | Nearshore Confined Disposal | - | Eliminated from Further Consideration |
| *Disposal Options after Removal* | Landfills | | |
| | | RCRA Subtitle D Landfill | Retained for Detailed Evaluation |
| | | Municipal Landfill Closure | Eliminated from Further Consideration |
| | | Hazardous Waste Landfill | Eliminated from Further Consideration |
| | | Construction Backfill | Eliminated from Further Consideration |
| | | Other Disposal Locations | Eliminated from Further Consideration |
| | | Open Water Disposal | Eliminated from Further Consideration |

RCRA=Resource Conservation and Recovery Act
LADS=Lightweight Aggregate from Dredged Sediments

## 4.2 Criteria for the Selection of Technologies and Process Options

To select the most technically appropriate and cost-effective remediation technologies and process options, the following performance criteria are used:

- **Technical Effectiveness**. Will the remediation technology and process options be able to cleanup the site and achieve cleanup goals?

- **Implementability**. Can the remediation technology and process option be both implemented on site and permitted by regulatory authorities? Will the technology be logistically difficult to implement at the site? Will the remediation technology and process option conflict with regulatory or land-use requirements and based on policy, be difficult to obtain permits?

- **Cost-Effectiveness**. What are the costs of each technology and process option relative to their implementabilty and efficacy? Remediation technologies having a high relative cost in relation to the benefit received will be eliminated from further consideration.

- **Adverse Impacts**. Will natural resources, historic sites, existing land uses, and/or aesthetic values be adversely impacted? Technologies that may cause adverse impacts, which can not be easily or effectively mitigated, will be eliminated from further consideration.

Each remediation technology and process option is preliminarily screened against these criteria to identify those that will be most applicable and beneficial to the remediation of the Denny Way CSO site.

### *4.2.1 No Action*

Under this option, no activities would be conducted at the site. There would be no change in existing uses or practices, and no monitoring would be conducted. The No Action technology does not remove or isolate the contaminated sediments nor does it reduce the contaminant levels within the sediment. This option is opposite to WADNR and Ecology preferences for removal of contaminated sediment. This option is low in cost, as no actions will be undertaken. Although no action is not considered effective for cleaning up the Denny Way CSO site, it is retained for further evaluation to serve as a baseline for comparison to other remediation alternatives.

### *4.2.2 Natural Recovery*

This remediation option is similar to no action, with the exception that studies would be conducted to determine whether, over time, sediment contamination would be reduced to levels below regulatory criteria through natural sedimentation, biodegradation, and chemical degradation. This option may have limited merit for two technical reasons: 1) the low sedimentation rates at the site (0.3 to 1.0 cm/year) would require long time periods to achieve isolation and, 2) the presence of persistent chemicals such as PCBs and heavy metals (e.g., mercury, silver) at the site. The technical implementability of this option requires no action other than periodic monitoring; however the option would be difficult to permit for areas of CSL exceedances, as it is in contrast to both Ecology and WADNR preferences to remove contaminants. The costs for natural recovery are less than for other remediation options involving removal, treatment, or isolation. Monitoring and modeling would be required and are the cost items associated with this option. This option is carried forward for remediation of sediments with concentrations between the SQS and CSL.

### *4.2.3 Excavation*

Excavation technology may be used solely or in tandem with other remediation technologies and processes. Excavation options are identified and evaluated below.

#### *4.2.3.1 Mechanical Dredging*

The Sediment Characterization Report identifies contaminants at concentrations above regulatory criteria to a depth of 8 feet below mudline, which is well within the capability of excavation by mechanical dredges. This method would be technically effective in removing the contaminated sediment from the site. Mechanical dredges excavate sediments by lowering a clamshell or cable arm bucket to the seafloor and removing a "bite" of sediment. Depending on the size of the bucket and the depth of the cut, the amount of water removed with the sediment can be minimized. The technology is proven and well understood. Because of its widespread application, mechanical dredging is easily permitted and complies with Ecology and WADNR preference for removal. The impacts from mechanical dredging are well known and can be easily mitigated. Costs are known, and though higher than the cost of no action, natural recovery, or some types of isolation, are minimal due to the widespread use and availability of equipment. This option is further considered for detailed evaluation.

#### *4.2.3.2 Hydraulic Dredging*

This technology is proven to be technically effective at removing sediments to the depth of observed contamination, 8 feet below mudline. Hydraulic dredging is a commonly employed and well understood technology which suggests that it is likely to be permitted. Hydraulic dredging uses suction to remove sediment in a sediment-water slurry. Large amounts of water are entrained during dredging (up to 90%), which creates logistical problems for dewatering, handling, and rehandling of hydraulically-dredged material. Large upland areas will be needed for rehandling and dewatering unless the dredged material is discharged directly into a specially designed containment barge for storage and treatment of entrained water. The costs of excavation by hydraulic dredge are similar to those for mechanical dredging; however, there is also a significant cost associated with rehandling and dewatering of the material. Some of the sediments to be excavated along the corridor of outfall construction are located in the intertidal zone. A hydraulic dredge could access the intertidal area only during a high tide. Because the hydraulic dredge operates by suction, the sediment must be covered with water. Thus, this excavation option is not considered further for the Denny Way CSO site.

### *4.2.4 Treatment Options*

#### *4.2.4.1 Bioremediation*

Bioremediation relies on living organisms, typically bacteria, to process and degrade organic contaminants. It is an effective technology for a range of organic contaminants; however, it is ineffective in remediating contaminants such as PCBs and heavy metals, which are not broken down during respiration. Because the Denny Way CSO site contains PCBs, silver, and mercury, this technology is considered of limited effectiveness for the site sediments. Bioremediation, although proven in other systems, would need to be evaluated to determine its effectiveness in remediating chemicals other than the persistent organics and metals. Contaminated sediments would have to be excavated, handled, treated, and reworked at a nearby storage and rehandling facility. This would result in a significant cost relative to other options. Because of concerns about effectiveness, the additional logistics of implementability, and the high costs of treatment and testing , bioremediation is eliminated from further consideration.

#### *4.2.4.2 Mechanical Treatment (Soil Washing)*

Soil washing involves excavating sediment and then washing it to remove organic and inorganic contaminants. This method appears to have the most potential for sediments containing large amounts of sand where the contaminants, which are typically bound to fine-grained particles, can be effectively washed away. Little information is available on the applicability of this technology to dredged sediments which means significant research and pilot testing would be required to prove its efficacy. Therefore, soil washing would probably be difficult to implement and permit. In addition, as the sediment would have to be excavated (dredged), transported, washed, and rehandled, this option would be difficult and costly to implement. For these reasons, this option is removed from further evaluation.

*4.2.4.3 Thermal Treatment*

Holnam Cement Plant

Sediments excavated from the Denny Way CSO site may potentially be used by Holnam Cement as material for the production of cement. Using a rotary kiln process, the raw materials (Denny Way sediments) are raised to high temperatures (over 2000° F) and the organic contaminants in the sediment are burned off. The material becomes partially molten in this process, with heavy metals immobilized in the heavier residue in the kiln ("clink"). The residue is then ground to desired size and combined with gypsum to produce cement. This process would effectively recycle the materials removed from the Denny Way CSO site.

Thermal treatment at Holnam is implementable as it has been proven effective and has been permitted for past sediment remediation projects. The logistics of this treatment option are achievable, as Holnam is also a wet processing facility and can accept saturated dredged sediments. Holnam is also a short distance (within 5 miles) from the Denny Way CSO site which minimizes transport time and costs. Sediments excavated from the Denny Way CSO site may be suitable for treatment at Holnam depending on the results of mineral analyses. Holnam requires that sediments for thermal treatment have alkali and halide concentrations of less than 1% by weight, which means that salt in the saltwater may be a problem. There are constraints on implementability as Holnam Cement can only accept a maximum of 20,000 cubic yards of sediment for treatment. Also, Holnam may not accept any sediment if their capacity is already full. The costs associated with this option are comparable to the costs of disposal by landfilling. This disposal option is retained for further evaluation.

Portable Thermal Plants

This process involves the use of a portable thermal treatment plant. While this technology is effective for most organic contaminants, it does not immobilize heavy metals. This option would be difficult to implement logistically as it would require a nearby rehandling and treatment site. Costs associated with this option are high due to equipment transport and site requirements. For these reasons, this option is removed from further consideration.

Lightweight Aggregate from Dredged Sediments (LADS)

This process uses dredged sediment to produce aggregate for cement production by the rotary kiln process. The rotary kiln process removes and/or immobilizes contaminants in the dredged material. This process is essentially the same process as used at Holnam, except the rotary kiln would be located on a barge or at the site. The processing facility would be located near the site, with a portable rotary kiln mounted on a barge or located nearshore. Although effective in theory, this process has not been demonstrated and is therefore considered developmental or experimental. It has limited implementability in terms of both permitting (likely to be difficult due to the experimental nature) and logistics (locating, transport, or construction of a portable plant). Costs associated with this option are high. For these reasons, this option is removed from further evaluation.

Thermal Incineration

This process is based on the same basic principles as the rotary kiln process and has been proven effective at removing contaminants. Sediments excavated from the site would be brought to an incineration plant for treatment. Because of the lack of incineration plants in the Northwest and the high costs to construct one, this option is removed from further evaluation.

### *4.2.5 Containment Options*

#### *4.2.5.1 In-Situ Capping*

This option involves placing a layer of clean sediment over the contaminated sediment, thereby isolating or reducing the amount of contaminants in the surface sediment. Surface sediments are classified as the top 10-cm of the sediment, which corresponds to the biologically active zone, as defined in the Sediment Management Standards.

<u>Thin-layer Capping</u>

This option entails placing a thin-layer of clean sediment over the contaminated sediment. Thin-layer caps are typically 0.5 to 1 ft thick. The goal of this option is to reduce contaminant levels in the biologically active zone. Thin-layer capping initially isolates the underlying contaminated sediment but over time the cap sediment is recolonized and mixed with underlying sediment through bioturbation. A goal of thin-layer capping is to preserve a part of the resident benthic infaunal community prior to cap placement. In thin-layer capping, parts of the existing benthic infaunal community may survive by burrowing through the thin-layer cap and reestablishing themselves at the sediment-water interface. This process accelerates the rate of benthic recolonization relative to thick-layer capping.

This option is also called enhanced natural recovery, as the sedimentation rate is anthropogenically enhanced by the placement of a thin cap. The technical effectiveness of this option is sensitive to contaminant levels and source control. Contaminant levels may not be reduced below regulatory levels if there are initial high concentrations of contaminants at the site or a continual input of contaminants. Studies at other capping sites in Puget Sound have indicated that thin-layer cap placement can be effective at isolating the underlying contaminated sediment (Romberg et al. 1995, USACE 1994). In areas where navigation is a concern, thin-layer capping may be preferable to thick-layer capping. The seafloor elevation is lower for a thinly capped area (greater water depth) than for a thick cap. In areas where anchorage is concentrated, anchors may scrape across a thin layer cap and possibly damage the cap, which could expose the underlying material. In low energy environments, thin-layer caps may provide the same isolation benefit as thick-layer caps while using less sediment. In high energy environments, thin-layer caps may be not be technically effective because of erosion. To prevent erosion, the cap may be covered with armoring material such as rocks and rip-rap. The size of the armoring would be determined based on the wave and current energies present at the site. This option is evaluated further for sediments with exceedances between the SQS and CSL. For those portions of the Denny Way CSO site located in high energy environments (e.g., the intertidal zone), this option is further evaluated only when covered by a protective armoring.

Thick Layer Capping

In thick layer capping, a relatively thick deposit of clean sediment is placed over the contaminated sediments to isolate them from the biologically active zone. In thick layer capping the benthic infaunal community is completely smothered and recolonization proceeds from the surface, with the recruitment and settling of new organisms. In Puget Sound, a 3-foot thick cap has been used for several projects. This option has been proven to be technically effective in nearshore areas throughout the Sound including a cap placed at the Denny Way CSO site in 1990. To date, sediment caps have proven effective at isolating the underlying contaminated sediment (Romberg 1995; USACE 1994).

Erosion and recontamination are the greatest uncertainties associated with caps. One potential source of surface contaminants to the Denny Way CSO site will be minimized when the CSO outfall is extended. There are no significant currents other than wave action in the vicinity of the Denny Way CSO site but a cap placed in the intertidal zone has to be engineered to take into account the erosive force of wave action. In terms of logistics, there are no significant obstacles to implementability at this site. There is precedent for capping at this and other sites in Puget Sound within the past two years (ASARCO and Eagle Harbor West Harbor Operable Unit). However, this option conflicts with Ecology and WADNR preference for removal. Therefore, permitting, while feasible, is likely to be difficult. Costs associated with thick-layer capping will be minimal, providing that clean capping materials can be obtained from local dredging projects. To cover the same area, thick layer capping requires a larger volume of sediment than thin-layer capping. While the implementation costs would be low, there would be long-term costs associated with monitoring and maintenance of the cap. In low energy environments, data suggest that thin-layer caps may afford the same effectiveness as thick-layer caps while requiring less cap material and causing less impingement on navigable water depths. Thick-layer capping is not considered for further evaluation because it is felt that thin-layer capping is preferable at this site.

Inverted Capping

This option involves excavating contaminated surface sediments and the underlying clean sediments. The contaminated sediments are placed at the bottom of the excavated area and then covered with the clean sediments. This option has little precedent in Puget Sound. Its implementability is difficult in terms of both permitting and logistics because of the need to stockpile and rehandle sediment at the site prior to disposal. Contaminated sediment would remain onsite, which conflicts with Ecology and WADNR preference for removal. In addition, the dredged sediment would have to be stockpiled near the site, which would conflict with existing land use and could cause an undesirable impact. Although the unit costs for the dredging component of inverted capping would be similar to those for other excavation options, a significantly greater volume of sediment would have to be dredged, stockpiled, and rehandled which would further increase costs. This option is removed from further evaluation due to costs and logistical difficulties.

*4.2.5.2 Confined Aquatic Disposal (CAD)*

Isolation by CAD entails excavation of the contaminated sediment, in-water disposal at a designated CAD site, and then capping the contaminated sediment with clean sediment. CAD has been proven effective in shallow water areas with minimal current and hydrodynamic disturbances. Locating, permitting, and constructing a CAD site would be difficult due to navigation, aquatic land ownership, and navigational constraints around the site and elsewhere in Elliott Bay. Although CAD is a cost-effective option for sites having large volumes of contaminated sediments, the costs for siting, constructing, and permitting a CAD facility is prohibitive for a project with small volumes of contaminated sediment, such as Denny Way. This option is eliminated from further evaluation for these reasons.

*4.2.5.3 Nearshore Confined Disposal*

This option involves the construction of a confined disposal facility (CDF) in a nearshore area. Typically, a wall or berm is constructed on the water side of the CDF with land providing containment on the opposite side. The size of the berm and the area it surrounds are determined to provide either capacity for sediment disposal or to create an upland for a specific use (e.g., a container terminal). Once the contaminated sediment is placed within the CDF, it is capped with clean sediment to the desired elevation. This technology has proven to be effective in a variety of projects in the northwest. For this to be a viable option, a local waterfront development project that plans to use, or benefits from, a nearshore CDF would need to be involved in the permitting and the construction process. Numerous cost and liability issues would be difficult to resolve in order to utilize a second or third party CDF. Without an existing CDF or one that will be constructed in the near term, permitting of this option is unlikely. Designing, permitting, and constructing a nearshore CDF is a lengthy process and may not coincide with King County's construction schedule for outfall extension and remediation. This option is removed from further evaluation for the above reasons.

### *4.2.6 Disposal Options After Removal*

Disposal options for sediments excavated during either outfall construction or remediation are discussed below. For each of the options, sediments from the Denny Way CSO site require excavation, dewatering, offloading, and potential stockpiling and rehandling, in addition to transportation to the disposal facility.

#### *4.2.6.1 RCRA Subtitle D Landfills*

This disposal option is proven as an effective technology. It is implementable in terms of permitting although logistics would be more difficult due to the need for a nearby handling and loading facility. The costs for this option are known. Sediments from the Denny Way CSO site are suitable for this disposal option. This option is considered for further evaluation for sediments excavated during outfall construction and for sediments excavated during remediation.

#### *4.2.6.2 Hazardous Waste Landfill*

This disposal option is a proven effective technology. It is similar to the RCRA Subtitle D option, however, materials classified as hazardous may be disposed at an appropriate hazardous waste landfill. Implementation would be similar to RCRA Subtitle D landfills for permitting. Sediments from the Denny Way CSO site were evaluated and found not to be hazardous. The costs for this option are greater than RCRA subtitle D landfills, therefore making this option less cost effective for the same level of technical effectiveness as RCRA Subtitle D landfill. This option is eliminated from further evaluation.

#### *4.2.6.3 Municipal Landfill Closure Material*

The technical effectiveness of this option is unknown along with the ability to permit this option. This option requires further testing to evaluate whether sediments from the Denny Way CSO site are suitable as landfill closure material. Candidate landfills for closure in the region have not been identified. For this option to be implementable, landfill closure would need to coincide with outfall construction and remediation. For these reasons, this option is eliminated from further evaluation; however, should a candidate landfill be identified in the timeframe of either outfall construction or remediation, this option may be re-evaluated as a disposal option.

#### *4.2.6.4 Multi-User Disposal Site (MUDS)*

This program would establish multi-user disposal sites for contaminated sediments at specific regions within Puget Sound. MUDS could consist of nearshore CDFs, CADs, or upland CDFs. This program is in development and is not likely to be instituted prior to construction and remediation at the Denny Way CSO site. At present, costs and liabilities for this option are unknown. Although it represents a feasible disposal option in the future, this option is eliminated from further consideration.

*4.2.6.5 Other Upland Disposal Sites*

This option involves the disposal of contaminated sediments at a non-landfill upland site. Upland sites, which have been utilized by other projects, include golf courses and farmlands. This option would require significant study and research to address technical effectiveness and to locate a suitable upland site. The ability to implement this option is unknown, as a suitable site has not been located and permitting would be difficult due to the unproven nature of this option. For the above reasons, this option is eliminated from further consideration.

## 4.3 Alternatives for Further Evaluation

Based on the preliminary evaluation of remediation technologies and process options in Section 4.2, coupled with the planned outfall construction, the following remediation technologies and process options have been retained for further evaluation and development as remediation alternatives:

No Action for sediments not in the outfall construction corridor

Natural Recovery for sediments not in the outfall construction corridor

Excavation by Mechanical Dredging with Disposal at RCRA Subtitle D landfill

Excavation by Mechanical Dredging with Thermal Treatment at Holnam Cement

Containment by In-Situ Thin-layer Capping for sediments not in the outfall construction corridor.

# 5. SCREENING OF ALTERNATIVES

## 5.1 Identification of Alternatives

In Section 4, remediation technologies and process options were identified and preliminarily screened to determine those that were potentially applicable to the Denny Way CSO extension project. The following remediation technologies and process options were selected for further evaluation and are now carried forward as alternatives:

Alternative 1: No Action for sediments not in outfall construction corridor

Alternative 2: Natural Recovery for sediments not in outfall construction corridor

Alternative 3: Excavation by Mechanical Dredging with Disposal at RCRA Subtitle D Landfill

Alternative 4: Excavation by Mechanical Dredging with Thermal Treatment at Holnam Cement

Alternative 5: Containment by In-situ Thin-layer Capping for sediments not in the corridor of outfall construction.

## 5.2 Development of Alternatives

The identified alternatives are evaluated and compared using the criteria in 173-204-560 WAC. Prior to the detailed screening of alternatives, a conceptual model for each remediation alternative is developed. By developing a conceptual model for each alternative, assumptions can be identified, and each alternative can be more completely evaluated. The following key assumptions were made for developing conceptual designs:

1. The runoff or effluent generated during the dewatering of mechanically dredged sediment would be permitted for discharge into Elliott Bay.

2. Suitable upland facilities would be available for stockpiling, dewatering and rehandling those sediments excavated during construction and remediation. The identification and selection of suitable upland sites near the project area is not addressed in this remediation plan. A suitable site would be accessible by both barge and motor vehicle; be of sufficient size to accommodate construction, rehandling and transport equipment; be near the Denny Way CSO site; and be located in an area where it would not conflict or impact other land uses.

### 5.3 Remediation Areas and Sediment Groups

Due to the large areal extent of the Denny Way CSO site, the plans for outfall construction, past remediation actions, and existing surface and subsurface sediment chemistry, the Denny Way CSO site is divided into four distinct sediment groups for remediation plan development and potential phasing of remediation.

1. Sediments within the corridor of outfall construction. This sediment will be excavated as part of outfall construction.

2. The 1990 sediment cap. This sand cap was placed in 1990 as an interim remediation solution. It is identified only as a geographic reference point and is not evaluated further in this remediation plan because the condition of the cap has been evaluated under a separate monitoring program that sampled surface sediments at 4 stations in 1990, 1991, 1992, 1994 and 1996. The station closest to the outfall has the highest chemical levels and exceeds the sediment standards CSL value for bis(2-ethylhexyl)phthalate (Romberg and Wilson, 1998). One additional sampling event is anticipated to complete the 10 year monitoring plan and it is possible this event could provide the data to determine where additional sediment remediation is needed on the sediment cap.

3. Sediments inshore of the existing sediment cap. These sediments are located in shallow water and are further divided and discussed as Remediation Areas A and B. Remediation Area A has surface sediments with CSL exceedances while Remediation Area B has surface sediments with SQS exceedances. These areas are physically constrained by the 1990 sediment cap and the existing shoreline. In addition, these areas would be potentially subject to wave action.

4. Sediments offshore of the cap. These sediments are north, south and west of the existing sediment cap and are delineated into Remediation Areas C, D, and E. Each of these remediation areas has surface sediment chemistry exceeding SQS criteria. There were no CSL exceedances in these areas.

These sediment groups are further divided into individual remediation areas, which are shown in Figure 5-1. Table 5-1 identifies sediment groups, remediation areas within each sediment group, and the remediation alternatives carried forward for evaluation. The criteria for defining preliminary remediation areas are described in Section 2.4. The sediments lying within a remediation area have contaminant concentrations in excess of either the SQS or CSL, and are therefore candidates for remediation. To the extent possible, remediation areas were defined as being 50 ft wide; however, portions of Remediation Areas A and C are defined as at 35 ft in width because of impingement on the existing rip-rapped shoreline. For alternatives involving excavation, the removal of sediments contained in the side slopes from the dredge cut would result in the excavation of a significantly larger area than shown in the remediation area boundary. This is not a

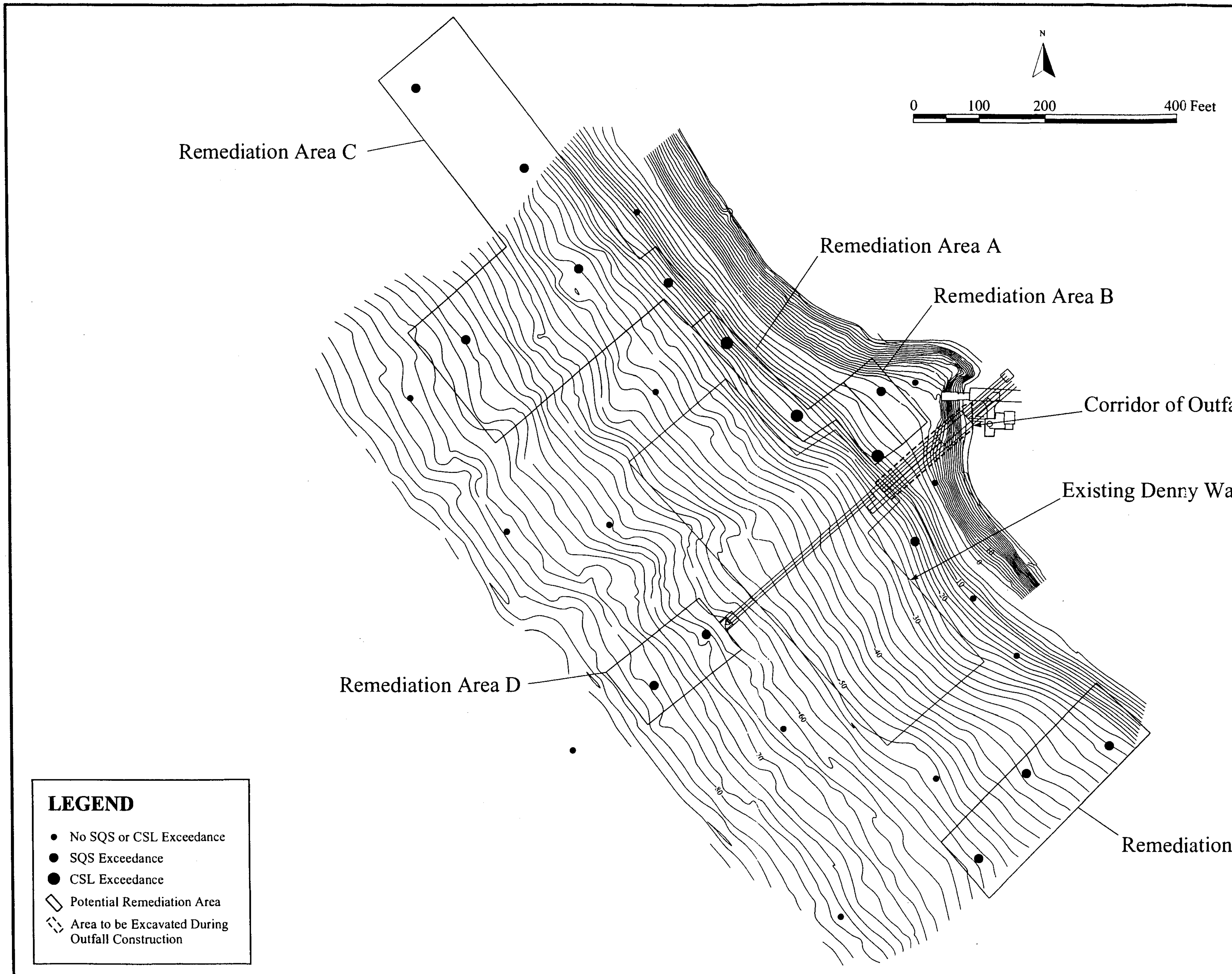
**Table 5-1.** Sediment groups, remediation areas, and alternatives carried forward for detailed evaluation.

| | ALTERNATIVES | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| ***Sediment Group*** ***Remediation Area*** | **No Action** | **Natural Recovery** | **Mechanical Dredging with RCRA Disposal** | **Mechanical Dredging with Treatment at Holnam** | **Thin-Layer Capping** |
| *Corridor of Outfall Construction* | NA | NA | X | X | NA |
| *1990 Sediment Cap* | *These sediments were remediated in 1990 and are not further evaluated* | | | | |
| *Sediments Inshore of 1990 Sediment Cap* | | | | | |
| Remediation Area A | X | X | X | X | X |
| Remediation Area B | X | X | X | X | X |
| *Sediments Offshore of 1990 Sediment Cap* | | | | | |
| Remediation Area C | X | X | X | X | X |
| Remediation Area D | X | X | X | X | X |
| Remediation Area E | X | X | X | X | X |

NA=Not Applicable

Figure 5-1

Denny Way / Lake Union
CSO Control Project
Potential Remediation Areas



concern for the corridor of outfall construction because, as currently planned, sheet piles would surround the excavation area which would prevent the formation of side slopes from sloughing.

## 5.4 Remediation Alternatives Evaluated for Each Sediment Group

The remediation alternatives carried forward from Section 4 were evaluated for each remediation area. Table 5-1 summarizes the remediation alternatives evaluated for each remediation area and sediment group. Table 5-2 summarizes sampling locations within each Remediation Area along with chemicals exceeding CSL and/or SMS criteria. Figures 2-1 and 2-2 show sampling locations.

### *5.4.1 Sediments Within the Corridor of Outfall Construction*

Sediments along the corridor of outfall construction will be excavated during the trenching of the outfall pipe. The contractor selected for outfall construction will determine the excavation method. For the sediments located along the outfall construction corridor, the evaluation will focus on disposal options and implementability. For the purposes of this plan, it is assumed that excavation in the corridor of outfall construction would be by mechanical dredging.

### *5.4.2 Sediments Inshore (East) of the Sediment Cap*

#### *5.4.2.1 Remediation Area A*

This area has surface sediment chemistry exceedances of the CSL. Remediation alternatives evaluated for this area include 1: No Action, 2: Natural Recovery, 3: Mechanical Dredging with Disposal at a RCRA Subtitle D Landfill, and 4: Mechanical Dredging with Treatment at Holnam Cement. Remediation alternative 5: Thin-Layer Capping is not considered suitable for this remediation area as sediments with CSL exceedances would be left in place which conflicts with WADNR and Ecology preference for removal. Therefore this alternative is not further evaluated.

#### *5.4.2.2 Remediation Area B*

This area has surface sediment chemistry exceedances of the SQS. Remediation alternatives evaluated for this area include 1: No Action, 2: Natural Recovery, 3: Mechanical Dredging with Disposal at a RCRA Subtitle D Landfill, 4: Mechanical Dredging with Treatment at Holnam Cement, and 5: Containment by Thin-Layer Capping.

**Table 5-2.** Detected Chemicals and Chemical Concentrations that Exceeded SMS Criteria in Denny Way/Lake Union CSO Control Project Surface Sediments.

| Sample ID | Chemical | Concentration (dry weight) |
|---|---|---|
| *CSL Exceedances* | | |
| **Remediation Area A** | | |
| DW-04-SED-0 | Mercury | 0.711 mg/kg |
| | Bis(2-ethylhexyl)phthalate | 1800D µg/kg |
| DW-07-SED-0 | Bis(2-ethylhexyl)phthalate | 2300DM µg/kg |
| | Mercury | 1.07M mg/kg |
| DW-30 | Benzyl Alcohol | 86D µg/kg |
| | Mercury | 0.68 mg/kg |
| *SQS Exceedances* | | |
| **Remediation Area A** | | |
| DW-04-SED-0 | Butyl benzyl phthalate | 390D µg/kg |
| DW-07-SED-0 | Total PCBs | 345M µg/kg |
| | Butyl benzyl phthalate | 60D µg/kg |
| | Fluoranthene | 2325DM µg/kg |
| | Benzo(g,h,i)perylene | 415DM µg/kg |
| | Indeno(1,2,3-c,d)pyrene | 440DM µg/kg |
| | Chrysene | 1030DM µg/kg |
| **Remediation Area B** | | |
| DW-05 | Butyl benzyl phthalate | 170D µg/kg |
| | Phenanthrene | 1700D µg/kg |
| | Fluoranthene | 2100D µg/kg |
| **Remediation Area C** | | |
| DW-01-SED-0 | Butyl benzyl phthalate | 130 µg/kg |
| DW-03-SED-0 | Bis(2-ethylhexyl)phthalate | 1825DM µg/kg |
| | Butyl benzyl phthalate | 160DM µg/kg |
| DW-11-SED-0 | Total PCBs | 204 µg/kg |
| DW-12-SED-0 | Total PCBs | 540 µg/kg |
| | Bis(2-ethylhexyl)phthalate | 830 µg/kg |
| DW-16-SED-0 | Total PCBs | 163 µg/kg |
| **Remediation Area D** | | |
| DW-20-SED-0 | Total PCBs | 245 µg/kg |
| DW-21-SED-0 | Total PCBs | 350 µg/kg |
| **Remediation Area E** | | |
| DW-10-SED | Chrysene | 5100D µg/kg |
| | Mercury | 0.571 mg/kg |
| | Indeno(1,2,3-c,d)pyrene | 1100D µg/kg |
| | HPAH | 25992D µg/kg |
| DW-35 | Butyl benzyl phthalate | 111D µg/kg |
| DW-15 | Total PCBs | 400 µg/kg |
| | Mercury | 0.53 mg/kg |

SMS - Sediment Management Standards
SQS - SMS Sediment Quality Standards
CSL - SMS Cleanup Screening Level

D - Dilution Required
M - Mean of replicate samples

### *5.4.3 Sediments Offshore of the Existing Cap*

#### *5.4.3.1 Remediation Areas C, D and E*

The same set of remediation alternatives are evaluated for each of Remediation Areas C, D, and E. These areas have surface sediment chemistry exceedances of the SQS. Remediation alternatives evaluated for these areas include 1: No Action, 2: Natural Recovery, 3: Mechanical Dredging with Disposal at a RCRA Subtitle D Landfill, 4: Mechanical Dredging with Treatment at Holnam Cement, and 5: Containment by Thin-Layer Capping.

## 5.5 Conceptual Design of Remediation Alternatives

### *5.5.1 Alternative 1: No Action*

No remediation actions or institutional controls would be implemented according to this alternative. All sediments would remain onsite, no monitoring would occur, and source control would not be implemented. This alternative is not applicable to the corridor of outfall construction as it will be excavated during trenching activities for outfall construction.

#### *5.5.1.1 Sediments Inshore of the Cap*

Under the no action alternative, surface sediments having CSL exceedances in Remediation Area A and SQS exceedances in Remediation Area B would remain in place. Long-term monitoring of sediment quality would not occur. Only monitoring mandated by operational permits would be conducted.

#### *5.5.1.2 Sediments Offshore of the Cap*

Under the no action alternative, surface sediments in Remediation Areas C, D, and E having SQS exceedances would remain in place. Long-term monitoring of sediment quality would not occur. Only monitoring mandated by operational permits would be conducted.

### *5.5.2 Alternative 2: Natural Recovery*

Natural recovery is evaluated for sediments inshore of the existing sediment cap and for sediments offshore of the sediment cap. In this alternative, natural sedimentation (i.e., burial), biological mixing, and natural degradation are the processes that individually or in combination, may improve surface sediment quality over time. Published sedimentation rates for the area surrounding the Denny Way CSO range from 0.7 cm to 1.4 cm of accumulation per year (Metro 1995). The natural sedimentation rate in the absence of the

CSO outfall was estimated to be 0.25 cm/year (Metro 1995). Sedimentation along the Seattle waterfront, nearest to the Denny Way CSO site, is estimated to be 0.19 cm/year based on sediment core data and 0.63 cm/year based on sediment trap data (EBDRP 1995). For the purpose of this evaluation, natural recovery is modeled at sedimentation rates of 0.3 cm/year, 0.6 cm/year and 1.0 cm/yr. A simple box model with full mixing to 10 cm is assumed. For SMS contaminants that are normalized to total organic carbon, it was assumed that the TOC concentration of naturally deposited sediment is equal to the TOC concentration in the present sediment column. Although active remediation would not occur, institutional controls and long-term monitoring would be implemented under the natural recovery alternative.

*5.5.2.1 Natural Recovery for Sediments Inshore of the Denny Way Sediment Cap*

In this alternative, natural sedimentation and biological mixing would play important roles in sediment remediation. Each of the three stations in Remediation Area A has a CSL exceedance for mercury. Mercury, a heavy metal, is not subject to biological or chemical degradation. It is possible for mercury and other heavy metals to leave the sediment system by biouptake and bioaccumulation processes. The only natural recovery process that can improve sediment quality without undesirable biological effects is sedimentation.

To model natural recovery, an estimate of mercury concentrations in recently deposited sediment is needed. In the absence of sediment trap data representative of the Denny Way CSO site, the concentration of mercury in recently deposited sediments is estimated based on mercury concentrations measured during 1992 and 1994 monitoring of the 1990 sediment cap. Metro (1995, King County 1996), noted that mercury was present in surface sediments of the Denny Way cap, at concentrations of up to 50% (21 mg/kg) of the SQS. Assuming that the cap had low concentrations of mercury when placed, the increase in mercury concentrations is attributed to the deposition of new sediment. The mercury concentrations measured on the cap in the 1992 and 1994 monitoring studies were up to 50% of the SQS, therefore it was assumed that the mercury concentration of recently deposited sediment was at least 50% of the SQS. A mercury concentration of 75% of the SQS (30 mg/kg) was used in the natural recovery modeling to provide a conservative estimate of natural recovery (the surface sediment concentration was increased by a 50% uncertainty factor). There are a number of uncertainties associated with these mercury concentrations, as the reported values are near the reliable detection limits, and it is questionable whether the surface sediments (0-2 cm) of the cap are wholly comprised of recently deposited sediments. The use of this higher mercury concentration for natural recovery modeling will slow the rate of recovery but is warranted given the lack of representative sediment trap data and the low levels of mercury reported.

Sediments throughout the Elliott Bay waterfront have mercury present. At this time it is unclear whether mercury is deposited from resuspension of the surrounding sediments adjacent to the Denny Way CSO site or due to the existing CSO. As a result, present concentrations are used as the basis for future deposition although construction of the new outfall could reduce any CSO contribution in the future.

Based on this cursory analysis, sediments within Remediation Area A could not naturally recover to concentrations below the SQS in the ten-year recovery window. Natural recovery does not appear to be a technically effective method for remediating sediments in Remediation Area A and is removed from further consideration.

Natural recovery for Remediation Area B is modeled using butylbenzyl phthalate that was measured at a concentration 2.89 times the SQS. Using the same natural recovery model parameters and an influx of new sediment containing butylbenzyl phthalate at a conservative level of 75% of the SQS (based on cap monitoring data), natural recovery to levels below the SQS would not occur in Remediation Area B over a ten-year recovery period. Because it is not technically effective for this area, natural recovery is removed from further consideration.

#### *5.5.2.2 Natural Recovery of Sediments Offshore of the Denny Way Cap*

Sediments offshore of the Denny Way cap, Remediation Areas C, D, and E, have contaminant concentrations in surface sediments that exceed the SQS. No CSL exceedances were observed in these areas.

Natural recovery was modeled for each station in Remediation Area C. Butylbenzyl phthalate, bis(2-ethylhexyl)phthalate, and total PCBs were the contaminants exceeding the SQS by the largest amounts. It was assumed that sediments deposited during natural recovery had concentrations of butylbenzyl phthalate and bis (2-ethylhexyl) phthalate equal to 75% of the SQS while input of PCBs was assumed to be at 50% of the SQS. Based on this modeling, Station DW-01 and DW-16 would naturally recover in a ten year period, even with the conservative sedimentation rate of 0.3 cm/yr. Stations DW-03 and DW-11 may naturally recover using the less conservative sedimentation rate of 0.6 cm/yr. Station DW-12 would not naturally recover over a 10 year period.

Both sampling stations in Remediation Area D have PCB concentrations that slightly exceed the SQS. Using the same input parameters and model as for other remediation areas, natural recovery of Remediation Area D would only occur at a sedimentation rate of 0.6 cm/year or greater.

Stations in Remediation Area E have chrysene, butylbenzyl phthalate, and PCB concentrations exceeding the SQS. Using the same input parameters, natural recovery of Remediation Area E could not occur in a ten-year time period.

Based on this cursory modeling, natural recovery is further considered for only portions of Remediation Areas C and D.

### *5.5.3 Alternative 3: Mechanical Dredging with RCRA Subtitle D Disposal*

This alternative would remove contaminated sediments by using a specially designed mechanical dredge. Contaminated sediments would be excavated by mechanical dredge, stored on a barge, transported to an upland rehandling facility, stockpiled and rehandled at the upland facility, and then transported to a RCRA Subtitle D landfill for disposal. Mechanical dredging is capable of excavating all construction-related sediments and all sediments identified for remediation.

A typical mechanical dredge would employ a clamshell-type bucket operated from a barge-mounted crane to excavate sediment. During mechanical dredging, the clamshell bucket would be repeatedly lowered to the seafloor and brought to the surface. During each cycle, a "bite" of sediment would be removed, brought to the surface, and placed in a second barge for storage until transport and disposal. The area and volume removed by each bite of the clamshell depends on the size and volume of the bucket. Clamshell buckets from 2 to 5 cubic yards in capacity are the likely candidates for use at the site. This process would be repeated until the intended area and volume of sediment was excavated.

The Denny Way CSO site is adjacent to Myrtle Edwards park in the northern part of the downtown Seattle waterfront. There are no navigational constraints preventing a crane barge, disposal barge, or tug from reaching the site. Water depths at the site range from the intertidal zone to -70 ft MLLW. A barge-mounted dredge would have draft-related operational constraints at the shallowest areas of the site and may be restricted to working at high tide. The shallowest stations may be reached with a crane from shore, however a shore-based crane could not be used to excavate sediments offshore of the cap. To avoid the cost of mobilizing two different cranes, the use of a barge mounted dredge is assumed, as it can reach all sediments considered for excavation. If remediation occurs after outfall construction, the new outfall extension may pose navigational constraints for the excavation of sediments in the shallow areas near the outfall.

All of the remediation areas at the Denny Way CSO site have a sloping seafloor. Slopes are approximately perpendicular to the shoreline. A contractor will typically lay out a dredging plan, with the dredge area subdivided into cells. Cells are often oblong with the cell width corresponding to the maximum lateral reach (side to side) of the mechanical dredge. For this plan, a standard dredge cell width is considered to be 50 ft. In a sloped area, the long axis of a dredge cell is typically parallel to the bathymetric contours. This minimizes the volumes dredged while minimizing adjustments to the bucket rigging and wire out. The time needed to dredge the cell is thereby reduced in comparison to running the dredge cell up or down the slope.

In dredging a slope, a mechanical dredge will make a stair-step cut. This is a result of the dredge producing a horizontal surface after removing sediment. The required depth of dredging will remove all contaminated sediment. The minimum cut is defined as the smallest thickness of sediment to be dredged that will remove all of the contaminated sediment to the required depth. Typically, in addition to the minimum cut, an area is also overdredged due to limitations in equipment precision and to ensure that all contamination is removed. The elevation of the seafloor after the minimum plus overdredge cut are removed defines the elevation for the dredge cell. As the dredge works upslope in the dredge cell, more material is removed (the minimum plus overdredge cut plus the amount of sediment contained in the depth difference between the sediment surface at the minimum cut and the upslope cut).

For areas that have surface sediments with exceedances of sediment quality criteria, a one foot dredge cut is used. In addition, a one foot overdredge is applied to ensure that all required contaminated sediment is removed. This results in 2 feet of sediment being excavated for those areas with surface sediment criteria exceedances.

In areas having both surface and subsurface sediments that exceed sediment quality criteria, the depth of dredging would be to an elevation at or below the extent of contamination. Table 5-3 lists the remediation areas, the amount of sediment to be removed, potential dredge volumes in each area, along with the range of water depths in each area. Figures 5-2 through 5-5 show preliminary dredge plans and cross-sections for each remediation area.

*5.5.3.1 Calculation of Sediment Volumes*

The volume of sediment contained in each remediation area was calculated. The volumes calculated for each remediation area represent the in-situ amount of sediment within the remediation area that would be removed by excavation. The amount of sediment in side slopes is included in this calculation. Side slopes were assumed to be 1:2 (rise:run, angle of repose of = 27°) and were treated as simple prismatic solids. No side slopes were assumed for the corridor of outfall construction as, at present, plans are to bound the excavation corridor with sheetpiles thereby preventing the sloughing of the side walls. The volumes provided for each remediation area represent the estimated volumes for independently excavating that remediation area. Should adjacent remediation areas be excavated in tandem, the total volume removed would be less than the sum of the volumes provided in this plan. This is due to the side slopes of one remediation area projecting into an adjacent area (e.g., Remediation Areas A and B). As a result, a portion of one remediation area may be removed as part of the sideslope material during the excavation of an adjacent remediation area. The conceptual dredge plan and the resultant volumes are for the purposes of this remediation plan. A formal dredge plan would need to be written at the time of construction/remediation and as a result actual volumes may change based on scope and phasing of construction/remediation activities.

The volumes provided in this plan represent in-situ volumes except when noted as a bulked volume. Bulked volumes are calculated using a 10% swell factor and are

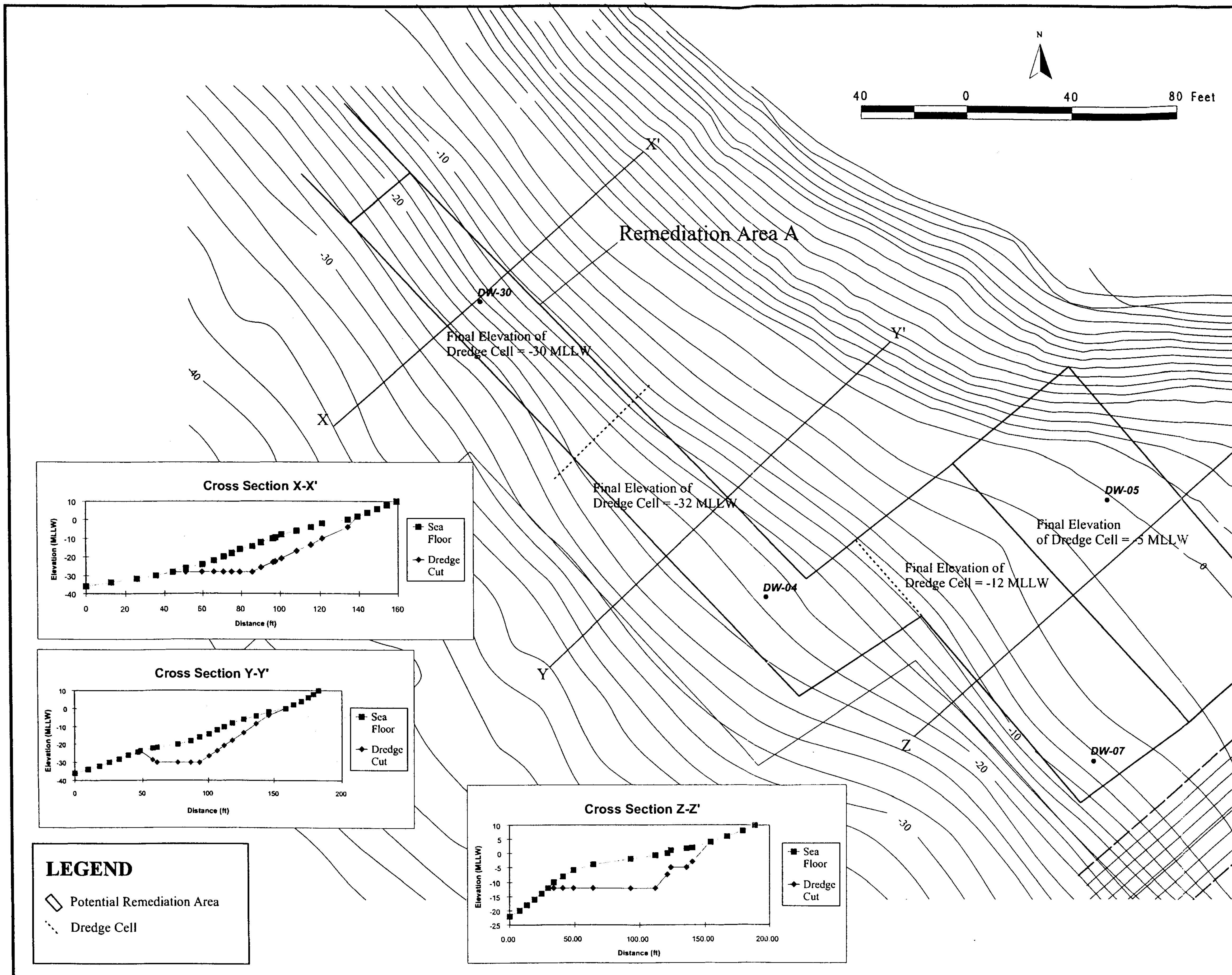
**Table 5-3.** Remediation Areas, Exceedances and Potential Volumes of Sediments for Remediation

| REMEDIATION AREA | AREA (sq.ft) | EXCEEDANCE | CHEMICALS | MAX EF | VOLUME (cubic yards) | WATER DEPTH (ft.) | DREDGE DEPTH (ft below mudline) |
|---|---|---|---|---|---|---|---|
| Corridor of Outfall Extension | | PSDDA SL | DDT | 3.91 | 2,420 | -10 to +15 | 0-20 |
| Area A | 20,097 | CSL | Mercury | 1.81 | 11,700 | -28 to -2 | |
| | | | Benzyl Alcohol | 1.18 | | | |
| | | | Bis (2-ethylhexyl) Phthalate | 3.27 | | | |
| Area B | 7,387 | SQS | Butyl Benzyl Pthalate | 2.89 | 2,030 | -2 to +4 | 2 to 8 |
| | | | Phenanthrene | 1.42 | | | |
| | | | Fluoranthene | 1.09 | | | |
| Area C | 135,681 | SQS | Total PCBs | 2.81 | 41,050 | -74 to -26 | 2 |
| | | | Butyl Benzyl Phthalate | 1.16 | | | |
| | | | Bis (2-ethylhexyl) Phthalate | 1.21 | | | |
| Area D | 19,375 | SQS | Total PCBs | 1.27 | 4,200 | -80 to -59 | 2 |
| Area E | 40,700 | SQS | Total PCBs | 1.45 | 10,300 | -60 to -14 | 2 |
| | | | Mercury | 1.39 | | | |
| | | | Chrysene | 1.45 | | | |
| | | | Butyl Benzyl Phthalate | 1.73 | | | |
| | | | Indeno(1,2,3,-cd)Pyrene | 1.01 | | | |
| | | | HPAH | 1.08 | | | |

EF=Exceedance Factor (chemical concentration/criteria)
Criteria=PSDDA Screening Level (SL); SMS Sediment Quality Standard (SQS);SMS Cleanup Screening Level (CSL)
PSDDA=Puget Sound Dredged Disposal Analysis; SMS=WA State Sediment Managment Standards

Figure 5-2

Denny Way / Lake Union
CSO Control Project
Remediation Areas A & B




Denny Way / Lake Union CSO Control Project | July 1998 | DWRP Figure 5-2.xar

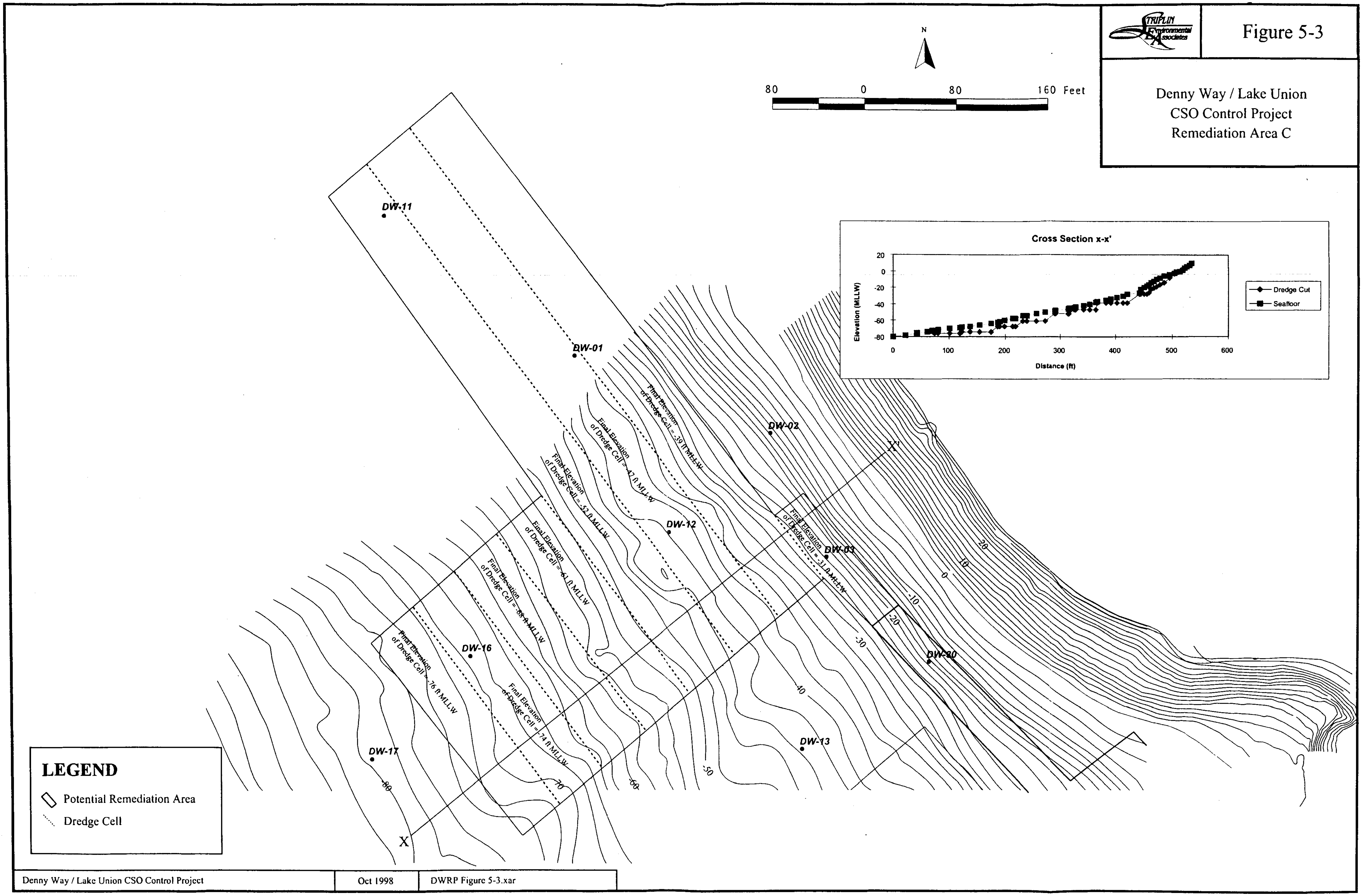
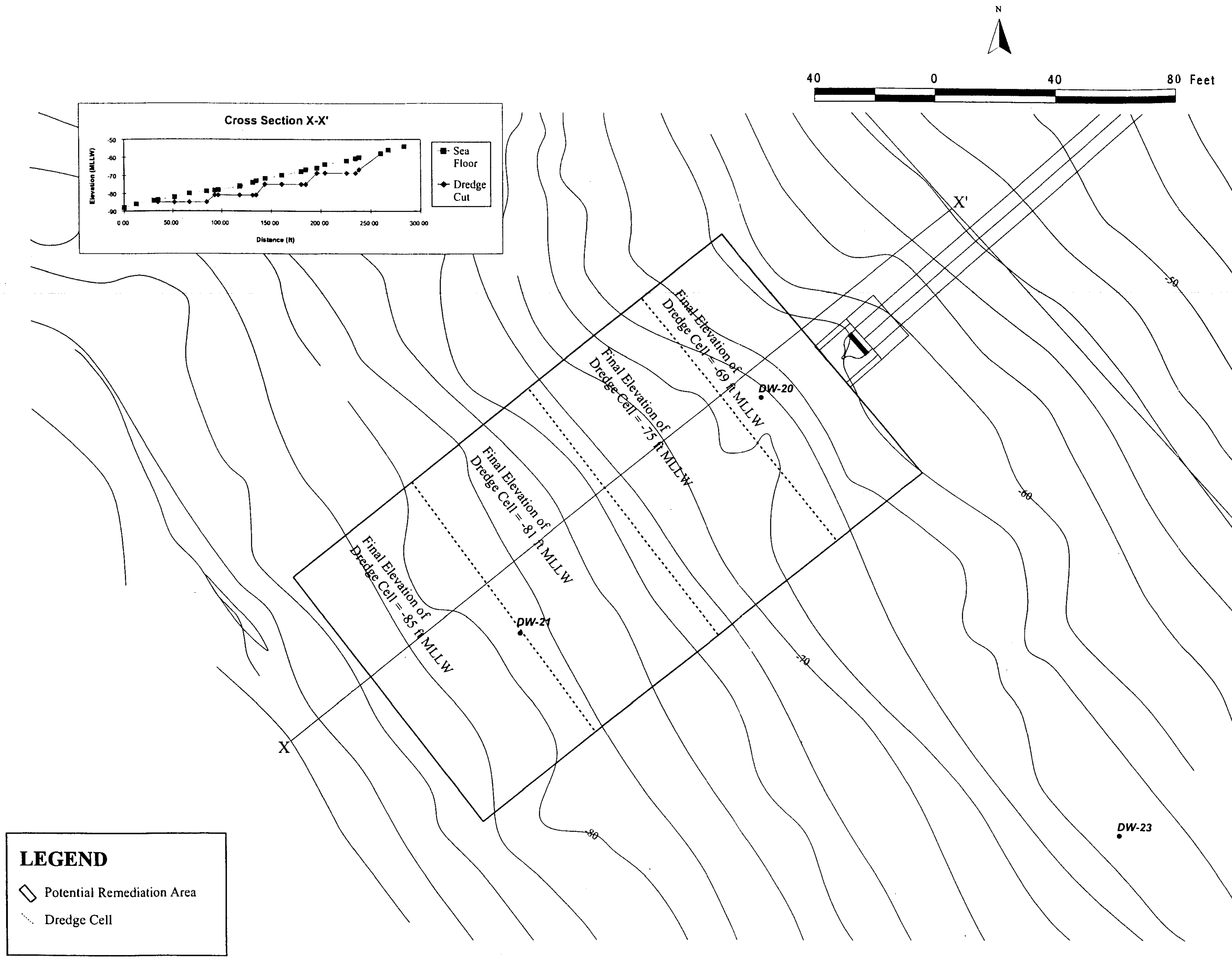


Figure 5-3
Denny Way / Lake Union
CSO Control Project
Remediation Area C
N
80 0 80 160 Feet
Cross Section x-x'
Elevation (MLLW)
Distance (ft)
Dredge Cut
Seafloor
DW-11
DW-01
DW-02
DW-12
DW-03
DW-20
DW-16
DW-17
DW-13
Final Elevation of Dredge Cell = -39 ft MLLW
Final Elevation of Dredge Cell = -47 ft MLLW
Final Elevation of Dredge Cell = -52 ft MLLW
Final Elevation of Dredge Cell = -61 ft MLLW
Final Elevation of Dredge Cell = -68 ft MLLW
Final Elevation of Dredge Cell = -76 ft MLLW
Final Elevation of Dredge Cell = -74 ft MLLW
Final Elevation of Dredge Cell = -31 ft MLLW
X
X'
LEGEND
Potential Remediation Area
Dredge Cell
Denny Way / Lake Union CSO Control Project
Oct 1998
DWRP Figure 5-3.xar

Figure 5-4

Denny Way / Lake Union
CSO Control Project
Remediation Area D



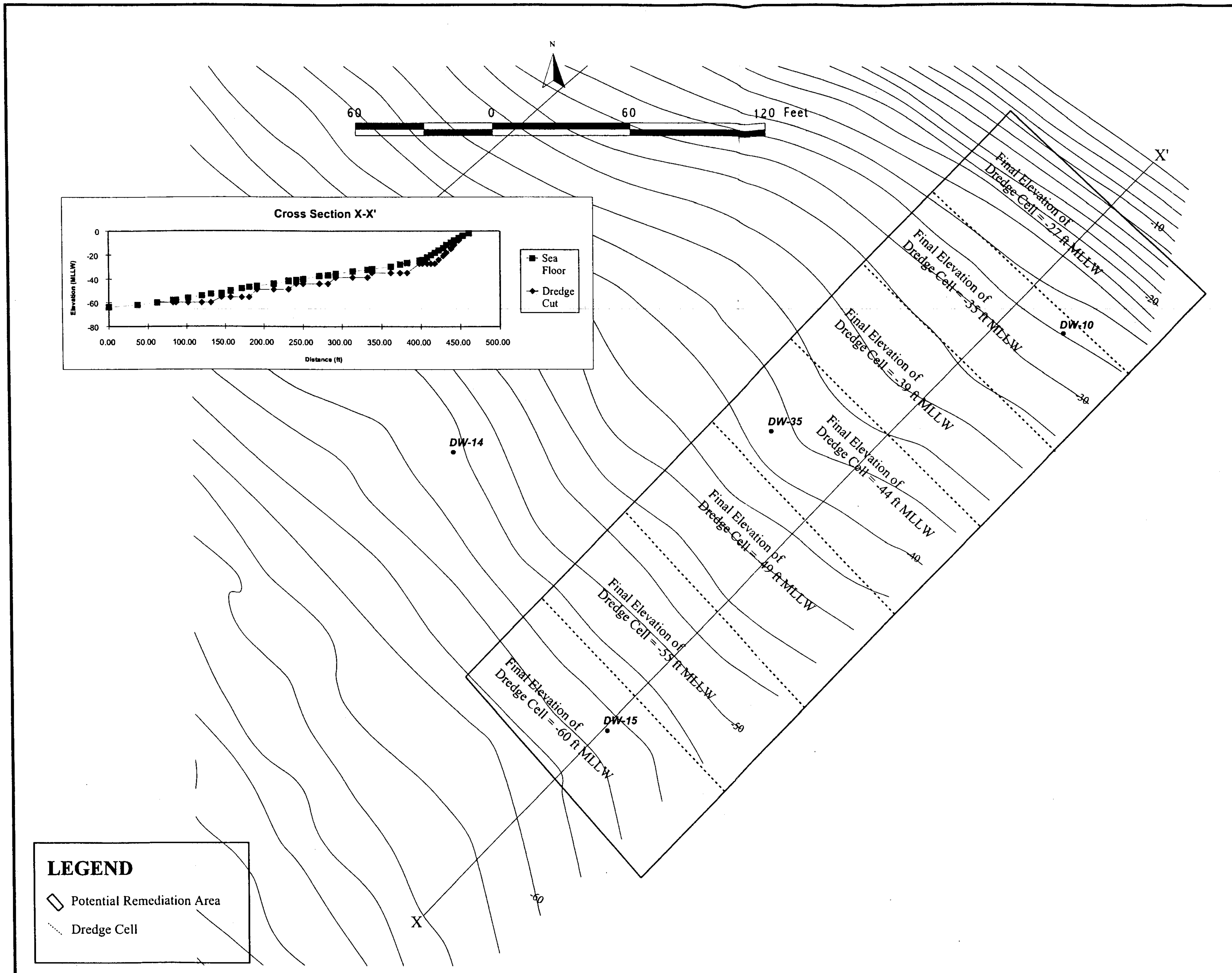



Figure 5-5

Denny Way / Lake Union
CSO Control Project
Remediation Area E

presented merely for stockpiling and transport considerations. Estimated costs are calculated using in-situ sediment volumes, as disposal fees are typically incurred as tonnage rather than volume. The estimated cost for each remediation area and alternative were calculated assuming that each remediation area was treated independently. By treating each remediation area individually, remediation of a given area may be decoupled from outfall construction or other remediation. The costs provided in this plan are in present-day dollars. Cost escalation is not applied due to the uncertainty in remediation schedule and the volatility of monetary and market factors. Unit costs used for cost estimates in this plan are a mix of representative costs incurred in other similar, recent projects and cost quotations from vendors.

*5.5.3.2 Sediments Within the Corridor of Outfall Construction*

Sediments in the corridor of outfall construction will be excavated. The volume of material to be removed in the corridor of outfall construction is 2,420 cubic yards.

*5.5.3.3 Sediments Inshore of the Existing Sediment Cap*

Remediation Areas A and B are inshore of the existing sediment cap. Figure 5-2 shows the remediation areas, preliminary dredge cells used for estimating remediation volumes, and a final elevation of the dredge cell after dredging. The dredge areas presented in this plan are for the purpose of developing a remediation strategy, project dredge plans would need to be developed if dredging is a selected and approved as a remediation option.

Remediation Area A contains surface and subsurface sediments that exceed CSL criteria whereas Remediation Area B contains surface sediments that are less than the CSL but greater than the SQS. The volume of sediment contained in Remediation Area A is 11,700 cubic yards while Remediation Area B contains 2,030 cubic yards of sediment. Applying a 10% bulking factor, the total bulked volume for each area is 12,870 and 2,233 cubic yards, respectively. A typical dredge cell width of 50 ft is used for remediation areas not adjacent to physical constraints (e.g., the rip-rapped shoreline and the existing sediment cap). Side slopes due to excavation were assumed to be 1:2 (27° angle of repose). Due to the seafloor slope and the angle of repose for the dredge cuts, considerable material in excess of the minimum cut needs to be excavated. If mechanical dredging is used to excavate Remediation Areas A and B, and remediation occurs after outfall construction, a logistical constraint may be introduced due to the difficulties of maneuvering, anchoring, and dredging around the outfall. Also, dredging immediately adjacent to the outfall could pose a risk of damage to the outfall.

*5.5.3.4 Sediments Offshore of the Existing Sediment Cap*

Remediation Areas C, D, and E are located offshore of the existing sediment cap and have surface sediments that exceed SQS criteria. The remediation areas, dredge cuts and final elevations after dredging are shown in Figures 5-3 through 5-5. The cumulative volume of sediment in these areas is 55,550 cubic yards. Applying a 10% bulking factor, the anticipated bulked volume is 61,105 cubic yards. Side slopes due to excavation were assumed to be 1:2 (27° angle of repose). Due to the seafloor slope and the angle of repose for the dredge cuts, considerable material in excess of the minimum cut needs to be excavated.

### *5.5.4 Alternative 4: Mechanical Dredging with Treatment at Holnam Cement*

Conceptually, this alternative is similar to the mechanical dredging and upland disposal alternative, however instead of transporting the sediment to a RCRA Subtitle D landfill, the excavated sediment would be transported to Holnam Cement for thermal treatment (kiln) and used as a raw material in the production of cement. Treatment at Holnam is considered for sediments from Remediation Areas A, B, C, D, and E along with the corridor of outfall construction. This alternative, like Alternative 3, requires excavation. The discussion of volumes and excavation parameters in Sections 5.5.3 also apply to this alternative. Unlike disposal at a RCRA Subtitle D landfill, Holnam may not accept sediment due to their present inventory of aggregate, batching, and schedule. In addition, Holnam will only accept sediments with a total mineral salts concentration of less than 1% (mineral salts are measured as sodium, potassium, magnesium, fluorine and chlorine). An additional x-ray fluorescence analysis would need to be conducted on bulk excavated sediment prior to acceptance at Holnam. As sediments from the Denny Way CSO site are from marine waters, sodium and chlorine will be abundant constituents in the interstitial waters of the dredged material. Sediments from a recently remediated marine, intertidal site were tested and accepted by Holnam (P. Fugelvand, personal communication). Whether the sediments from the Denny Way CSO site will be suitable as cement stock can only be determined from the minerals analysis.

In addition to the minerals analyses, advance planning is required to ensure that Holnam will accept the sediment for treatment due to their batch schedule. Furthermore, Holnam has a 20,000 cubic yard total capacity for the stockpiling of sediments prior to treatment and cement production. The rate at which Holnam uses sediment in cement production ranges from 0 to 10,000 cubic yards per month and averages approximately 3,000 cubic yards per month (D. Lahaie, personal communication). The combined volume of all sediments which could potentially be excavated during remediation of the Denny Way CSO site is 71,000 cubic yards. The potential volume of sediments from the Denny Way CSO site far exceeds the capacity at Holnam. As a result, other disposal/treatment alternatives must be considered in conjunction with Holnam due to the uncertainties associated with sediment suitability for acceptance at Holnam; whether Holnam will accept sediment based on their schedule and present inventory; and the constraints on the total volume of material they can accept.

### *5.5.5 Alternative 5: Containment by Thin-Layer Capping*

This alternative accomplishes remediation by covering contaminated surface sediments with a thin layer of clean sediments, less than 3 feet thick. For the Denny Way CSO site, a thin-layer cap would likely provide the same level of effectiveness as a thick-layer cap in areas with low hydrodynamic energies. In high wave and current energy regimes, thin-layer capping may not be successful due to remobilization and erosion of the cap, unless the cap is armored with rock or other suitable material. A thin-layer cap would have less effect upon navigable water depths and would require less cap sediment during remediation.

Thin-layer capping can also be referred to as enhanced natural recovery when the sediment is placed in thin enough increments such that the resident benthic infauna are not buried too deeply and can reestablish contact with the sediment-water interface. A goal of enhanced natural recovery is the survival of some or all of the resident infauna in order to expedite benthic recolonization of the capped area.

Thin-layer capping is considered only for those sediments inshore and offshore of the existing sediment cap that have exceedances between the SQS and CSL (Remediation Areas B, C, D, and E). Placing a sediment cap over sediments with CSL exceedances (Remediation Area A) would conflict with Ecology and WADNR policy of removal.

Caps are typically constructed by placing a layer of clean sediment over the contaminated sediment. In many projects, a bottom dump or split hull barge is used to place the capping sediments. Material used for capping can come from upland sites (sands) or be dredged material. The 1990 Denny Way sediment cap was constructed using sandy dredged material from maintenance dredging of the Duwamish River turning basin. Sands are the preferred material for cap construction. Sands can be placed more evenly than silts or clays and are more resistant to erosion due to their coarser grain size. Silts and clays are frequently cohesive and therefore more difficult to place at uniform discharge rates.

To place a sediment cap at the Denny Way CSO site, it was assumed that sandy material would be brought to the site by barge. Clean dredged sediment from maintenance projects represents a cost-effective, suitable material. In addition, the use of dredged material for cap material represents a beneficial use of the dredge material. The barge containing the capping sediments would be transported to the site by tugs. Once onsite, assuming a split hull scow is used, the doors to the scow would be opened gradually for discharge of the capping material at a controlled rate. The barge would be piloted across the target remediation area to ensure that all sediments within the remediation area were covered with capping sediment.

Alternative methods of cap placement are the use of a flat deck barge and pushing or washing the sediment off the barge. To reduce turbidity, cap sediments may also be placed using a clamshell bucket. The rate of cap sediment application with these methods is slower and longer than that of a split-hull scow, however, thinner layers of dredged material can be placed.

Limitations on cap placement at the Denny Way CSO site would be a function of water depth, as up to 8 feet of water is needed for a partially loaded split-hull barge to reach the

### *6.2.4 Long-term Effectiveness*

This alternative may be effective in the long-term for portions of Remediation Area C and all of Remediation Area D. The critical variables are the sedimentation rate and the quality of the sediment deposited. Preliminary natural recovery modeling indicates that a portion of Remediation Area C and all of Remediation Area D surface sediments will be brought to concentrations below the SQS in ten years, assuming sedimentation rates of 0.3 to 0.6 cm a year, full mixing, and deposition of sediment with contaminant concentrations of 75% of the SQS. Presumably, contaminant burdens in recently deposited sediment will decrease with the construction of the Denny Way outfall. Counteracting the reduction in contaminants is the likely decrease in sedimentation rate that would accompany the extension of the outfall. Metro (1995) estimated a net sedimentation rate of 0.25 cm/year in the absence of the present outfall.

### *6.2.5 Implementability*

The difference between natural recovery and no action is study and periodic monitoring of the remediation areas with SQS exceedances. In terms of logistics, natural recovery would be easily implementable. There would be no site impacts beyond those already present when this alternative is implemented. There are no permitting requirements for instituting this alternative. Precedent has been established for natural recovery of sediments with SQS exceedances.

### *6.2.6 Cost*

The estimated cost for this alternative is presented as a lump sum of $200,000. Itemized costs are provided in Table 6-1. These costs cover the studies to determine the sedimentation rates along with more detailed natural recovery modeling. There would also be costs associated with monitoring at years 5 and 10 of the natural recovery period.

### *6.2.7 Community Concerns*

Community concerns regarding contaminated sediments could be voiced over the 10 year recovery period.

### *6.2.8 Recycling, Reuse, and Waste Minimization*

This alternative would not employ any recycling or reuse of materials, as the only action is continued study. This alternative would minimize waste generated from the site, as no sediment would be excavated.

**Table 6-1.** Estimated Cost for Remediation by Natural Recovery

| ITEM/ACTIVITY | UNIT | UNIT COST | QUANTITY | COST |
|---|---|---|---|---|
| Pre-Remedial Design Sediment Study | Lot | 100,000 | 1 | 100,000 |
| Year 5 Monitoring | Lot | 30,000 | 1 | 30,000 |
| Year 10 Confirmation Sampling | Lot | 30,000 | 1 | 30,000 |
| Subtotal | | | | 160,000 |
| Contingency | | 25% | | $40,000 |
| Total Cost | | | | 200,000 |

## 6.3 Alternative 3: Mechanical Dredging with Upland Disposal at RCRA Subtitle D Landfill

For this alternative, sediments would be mechanically dredged using a barge-mounted crane equipped with a clamshell bucket. Dredged sediments would be loaded into a second barge, brought to a rehandling facility, offloaded, and then loaded into lined and covered trucks or rail cars. The sediments would then be transported to a RCRA Subtitle D landfill for disposal. This alternative is evaluated for sediments within the corridor of outfall construction, sediments with CSL exceedances (Remediation Area A), and sediments exceeding only SQS criteria (Remediation Areas B, C, D, and E).

### *6.3.1 Protection of Human Health and the Environment*

This alternative, when completed, is protective of human health and the environment, as all sediments having concentrations in excess of the SQS would be removed. This eliminates both the environmental and human health exposure pathways; however, during construction, this alternative poses potential risks to human health (e.g., worker exposure, dermal contact) and the environment (e.g., suspension and transport of contaminated sediment during dredging). Controls would be instituted during dredging, dewatering, and transport activities to minimize worker contact; to minimize the resuspension of sediments; and to ensure that dredged material and water are properly treated and/or disposed of.

Following excavation, dewatering, and offloading, these sediments would be transported to a RCRA Subtitle D landfill for disposal. During transport, contaminated sediments would be contained in lined and covered trucks or rail cars to reduce the hazard to human health and the environment. Once deposited at the landfill the sediments would be contained and isolated, thereby posing no further risk to human health or the environment.

### *6.3.2 Compliance with Cleanup Standards and Applicable Laws*

This alternative would comply with applicable laws and cleanup standards, as all sediment with exceedances of the SQS would be removed. Prior to commencing construction and remediation, permits would be issued for shoreline construction, water quality impacts, and effluent discharge. Controls would be instituted during construction/remediation to ensure that all applicable water quality criteria are met.

### *6.3.3 Short-term Effectiveness*

This alternative is technically effective in the short-term for removing contaminated sediment and the risks they pose. This alternative poses potential risks to human health (e.g., worker exposure, dermal contact) and the environment during construction (e.g., suspension and transport of contaminated sediment during dredging).

During dredging, the bucket would be lowered and raised from the seafloor repeatedly in order to remove the sediment. As the bucket removes sediment and is raised through the water column, there is the potential for sediment resuspension and washing, which may have an adverse impact on water quality and serve as a mechanism for the transport of sediment-bound contaminants to other parts of the site. Migration of dredging-related suspended sediments may be mitigated by using specially designed buckets. Alternatively, mitigation may also be provided by the deployment of silt curtains, which inhibit the movement of resuspended sediment off-site. Remediation areas at the Denny Way CSO site lie in water depths ranging from -80 ft MLLW to the intertidal zone. For remediation areas in shallow water, silt curtains may be an effective control. The efficacy of silt curtains diminishes with increasing water depth. In deep water, the bucket needs to be raised through more water, which increases the chance for washing and resuspension of contaminated sediment during dredging.

Mechanical dredging poses a possible risk to human health because of the potential for workers to come into contact with contaminated dredged material during dredging, offloading, and rehandling. There is minimal risk to the public, since all offloading and rehandling would be done at a predetermined rehandling facility that would be closed to the public. Sediments would be transported to the landfill in lined trucks or rail cars to further minimize the potential for exposure. A small risk persists due to the possibility of leakage or spillage during transport. Exposure of workers to contaminated dredged sediments can be minimized by instituting safety practices and using proper protection.

### *6.3.4 Long-term Effectiveness*

This alternative would be effective in the long-term, as all contaminated sediment would be removed from the site. All sediments would be sent to an appropriate landfill in accordance with RCRA Subtitle D (e.g., Olympic View in Bremerton, WA; Columbia Ridge in Arlington, WA; Roosevelt Regional Landfill, Goldendale, WA).

### *6.3.5 Implementability*

This alternative is readily implementable. Mechanical dredging is a proven, reliable technology, which is readily available through numerous local dredging contractors. As a proven technology, this alternative is also likely to be permitted without problems. A barge mounted clamshell dredge would be used. There are no physical obstacles at the site that would prevent the deployment of a tug, dredge, and barge tandem. However, logistical difficulties due to vessel draft requirements would be encountered in Remediation Areas A and B, which are located within the shallow waters inshore of the existing sediment cap. These difficulties would be exacerbated at low tides. Sediments would be dredged by clamshell and then deposited into a second barge for transport to a rehandling facility, where they would be stockpiled, rehandled, and transported to an upland disposal facility.

Although mechanical dredging is a reliable and proven technology, there are some site features that may affect its success in some remediation areas. Portions of Remediation Areas C and E as well as the entire Remediation Area D lie in relatively deep water, -50 ft to -80 ft MLLW. Dredging in deeper water will increase the cycle time between deployments of the clamshell, thereby increasing the time and cost to dredge these areas. The barge- mounted dredge is usually set on a fixed 4-point mooring over a dredge cell and then advanced along the cell by adjusting the scope on each mooring. The time spent and the difficulty associated with scoping and mooring a barge in deeper water is significantly greater than comparable efforts in shallow water, although dredging in deep water is routinely accomplished.

The sediments in this area are predominantly sands with increasing amounts of fine-grained material (silts and clays) with water depth. Because of greater amounts of interstitial water, the finer grained sediments would require more dewatering than sandy sediment. They also pose a greater risk of resuspension and transport during dredging. It is anticipated that the dredged sediment would be dewatered on the transport barge and the waters generated during dewatering would be filtered before discharging into Elliott Bay.

### *6.3.6 Cost*

The estimated cost for this alternative is presented by Remediation Area and as a total for all Remediation Areas. Itemized costs are provided in Table 6-2.

| | |
|---|---|
| Mobilization | $50,000 |
| Engineering/Bid/Mgt | $200,000 |
| Corridor of Outfall Construction | $255,647 |
| Remediation Area A. | $1,137,618 |
| Remediation Area B | $218,581 |
| Remediation Area C | $3,927,042 |
| Remediation Area D | $453,168 |
| Remediation Area E | $1,004,562 |
| Total For All Remediation Areas | $7,246,618 |

**Table 6-2.** Estimated Costs for Remediation by Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill

| ITEM | UNIT | | UNIT COST | QUANTITY | COST |
|---|---|---|---|---|---|
| ***Preconstruction*** | | | | | |
| Mobilization/Demobilization | LS | | $50,000.00 | 1 | $50,000.00 |
| Engineering Report/Bid Preparation/Accounting | LS | | $200,000.00 | 1 | $200,000.00 |
| ***Dredging Corridor of Outfall Extension*** | | | | | |
| Mechanical Dredging and Offloading | CY | | $15.00 | 2420 | $36,300.00 |
| Rehandling | CY | | $2.00 | 2420 | $4,840.00 |
| Transport and Disposal at RCRA Subtitle D Landfill | CY | | $53.40 | 2420 | $129,228.00 |
| Pre and Post Dredging Bathymetric Surveys | EA | | $2,000.00 | 2 | $4,000.00 |
| Water Quality Monitoring | LS | | $3,000.00 | 1 | $3,000.00 |
| Post-Dredge Confirmatory Sediment Sampling | LS | | $12,000.00 | 1 | $12,000.00 |
| Subtotal | | | | | $189,368.00 |
| Bonding | | 10% | | | $18,936.80 |
| Contingency | | 25% | | | $47,342.00 |
| *TOTAL* | | | | | $255,646.80 |
| ***Dredging Remediation Area A*** | | | | | |
| Mechanical Dredging and Offloading | CY | | $15.00 | 11700 | $175,500.00 |
| Rehandling | CY | | $2.00 | 11700 | $23,400.00 |
| Transport and Disposal at RCRA Subtitle D Landfill | CY | | $53.40 | 11700 | $624,780.00 |
| Pre and Post Dredging Bathymetric Surveys | EA | | $2,000.00 | 2 | $4,000.00 |
| Water Quality Monitoring | LS | | $3,000.00 | 1 | $3,000.00 |
| Post-Dredge Confirmatory Sediment Sampling | LS | | $12,000.00 | 1 | $12,000.00 |
| Subtotal | | | | | $842,680.00 |
| Bonding | | 10% | | | $84,268.00 |
| Contingency | | 25% | | | $210,670.00 |
| *TOTAL* | | | | | $1,137,618.00 |
| ***Dredging Remediation Area B*** | | | | | |
| Mechanical Dredging and Offloading | CY | | $15.00 | 2030 | $30,450.00 |
| Rehandling | CY | | $2.00 | 2030 | $4,060.00 |
| Transport and Disposal at RCRA Subtitle D Landfill | CY | | $53.40 | 2030 | $108,402.00 |
| Pre and Post Dredging Bathymetric Surveys | EA | | $2,000.00 | 2 | $4,000.00 |
| Water Quality Monitoring | LS | | $3,000.00 | 1 | $3,000.00 |
| Post-Dredge Confirmatory Sediment Sampling | LS | | $12,000.00 | 1 | $12,000.00 |
| Subtotal | | | | | $161,912.00 |
| Bonding | | 10% | | | $16,191.20 |
| Contingency | | 25% | | | $40,478.00 |
| *TOTAL* | | | | | $218,581.20 |

**Table 6-2.** Estimated Costs for Remediation by Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill

| ITEM | UNIT | | UNIT COST | QUANTITY | COST |
|---|---|---|---|---|---|
| ***Dredging Remediation Area C*** | | | | | |
| Mechanical Dredging and Offloading | CY | | $15.00 | 41050 | $615,750.00 |
| Rehandling | CY | | $2.00 | 41050 | $82,100.00 |
| Transport and Disposal at RCRA Subtitle D Landfill | CY | | $53.40 | 41050 | $2,192,070.00 |
| Pre and Post Dredging Bathymetric Surveys | EA | | $2,000.00 | 2 | $4,000.00 |
| Water Quality Monitoring | LS | | $3,000.00 | 1 | $3,000.00 |
| Post-Dredge Confirmatory Sediment Sampling | LS | | $12,000.00 | 1 | $12,000.00 |
| Subtotal | | | | | $2,908,920.00 |
| Bonding | | 10% | | | $290,892.00 |
| Contingency | | 25% | | | $727,230.00 |
| *TOTAL* | | | | | $3,927,042.00 |
| ***Dredging Remediation Area D*** | | | | | |
| Mechanical Dredging and Offloading | CY | | $20.00 | 4200 | $84,000.00 |
| Rehandling | CY | | $2.00 | 4200 | $8,400.00 |
| Transport and Disposal at RCRA Subtitle D Landfill | CY | | $53.40 | 4200 | $224,280.00 |
| Pre and Post Dredging Bathymetric Surveys | EA | | $2,000.00 | 2 | $4,000.00 |
| Water Quality Monitoring | LS | | $3,000.00 | 1 | $3,000.00 |
| Post-Dredge Confirmatory Sediment Sampling | LS | | $12,000.00 | 1 | $12,000.00 |
| Subtotal | | | | | $335,680.00 |
| Bonding | | 10% | | | $33,568.00 |
| Contingency | | 25% | | | $83,920.00 |
| *TOTAL* | | | | | $453,168.00 |
| ***Dredging Remediation Area E*** | | | | | |
| Mechanical Dredging and Offloading | CY | | $15.00 | 10300 | $154,500.00 |
| Rehandling | CY | | $2.00 | 10300 | $20,600.00 |
| Transport and Disposal at RCRA Subtitle D Landfill | CY | | $53.40 | 10300 | $550,020.00 |
| Pre and Post Dredging Bathymetric Surveys | EA | | $2,000.00 | 2 | $4,000.00 |
| Water Quality Monitoring | LS | | $3,000.00 | 1 | $3,000.00 |
| Post-Dredge Confirmatory Sediment Sampling | LS | | $12,000.00 | 1 | $12,000.00 |
| Subtotal | | | | | $744,120.00 |
| Bonding | | 10% | | | $74,412.00 |
| Contingency | | 25% | | | $186,030.00 |
| *TOTAL* | | | | | $1,004,562.00 |
| **TOTAL FOR ALL AREAS** | | | | | $7,246,618.00 |

LS=Lump Sum
CY=Cubic Yard
EA=Each

*Mobilization costs assume a lump sum for an upland rehandling area.
An Upland rehandling area has not been identified and as a result a conservative estimate is applied.

### *6.3.7 Community Concerns*

Community concerns, if any, will become evident at the conclusion of the 30-day public review and comment period required by NEPA/SEPA. At this time, public concerns about any of the potential remediation alternatives will be submitted to the proponents for evaluation.

### *6.3.8 Recycling, Reuse, and Waste Minimization*

This alternative does not minimize waste, as all excavated sediment would be sent to a landfill. This alternative does not reuse or recycle sediments.

## 6.4 Alternative 4: Mechanical Dredging with Treatment at Holnam Cement.

This alternative is conceptually identical to Alternative 3: Mechanical Dredging with Disposal at a RCRA Subtitle D Landfill except that the sediments would be thermally treated at Holnam Cement rather than landfilled. In addition, dredged sediments may be barged directly to Holnam Cement rather than transport by truck or rail car.

### *6.4.1 Protection of Human Health and the Environment*

Protection of the environment would be nearly identical to that described in Section 6.3.1 with the exceptions that the contaminants in the dredged sediment will be either destroyed or immobilized during the thermal treatment, and that worker exposure will be minimized if the dredged sediment were barged directly to Holnam Cement.

### *6.4.2 Compliance with Cleanup Standards and Applicable Laws*

Compliance would be identical to that described in Section 6.3.2.

### *6.4.3 Short-term Effectiveness*

Short-term effectiveness would be identical to that described in Section 6.3.3 with the exception that risks to workers and the public may be minimized by barging the dredged sediment directly to Holnam Cement, thereby minimizing worker exposure during rehandling and exposure of the public from an upland rehandling facility and transport over public roads.

### *6.4.4 Long-term Effectiveness*

Long-term effectiveness would be identical to that described in Section 6.3.4 with the exception that contaminants would be either destroyed or immobilized during thermal treatment rather than be landfilled.

### *6.4.5 Implementability*

Dredging is readily implementable and would be identical to that described in Section 6.3.5.

Constraints which may affect the implementability of this alternative are the ability of Holnam to take sediments excavated during construction and remediation of the Denny Way CSO site due to their batching schedule; present inventory; the possibility that some or all of the dredged sediment may not be chemically suitable for use in the production of cement and therefore would not be accepted at Holnam; and the limited 20,000 cubic yard total capacity of sediment at Holnam. As a result, any thermal treatment of sediments during the remediation of the Denny Way CSO site would need to be carefully coordinated with respect to the schedule and present inventory at Holnam. Also, the total volume of sediments identified in Remediation Areas A, B, C, D, and E far exceeds the capacity of Holnam (71,700 cubic yards of sediment and 20, 000 cubic yards of capacity at Holnam). Due to these uncertainties and volume constraints, treatment at Holnam could only be considered for a portion of the sediments from the Denny Way CSO site, and a second preferred alternative must be in place should the dredged sediments prove unsuitable for cement production or not be accepted by Holnam for other reasons.

### *6.4.6 Cost*

The estimated cost for this alternative is provided by Remediation Area and as a total for all of the Remediation Areas. Itemized costs are provided in Table 6-3.

| | |
|---|---|
| Mobilization | $50,000 |
| Engineering/Bid/Mgt | $200,000 |
| Corridor of Outfall Construction | $280,476 |
| Remediation Area A. | $1,257,660 |
| Remediation Area B | $239,409 |
| Remediation Area C | $4,348,215 |
| Remediation Area D | $496,260 |
| Remediation Area E | $1,110,240 |
| | |
| Total For All Remediation Areas | $7,982,260 |

**Table 6-3.** Estimated Costs for Remediation by Mechanical Dredging and Treatment at Holnam Cement

| ITEM | UNIT | UNIT COST | QUANTITY | COST |
|---|---|---|---|---|
| ***Preconstruction*** | | | | |
| Mobilization/Demobilization | LS | $50,000.00 | 1 | $50,000.00 |
| Engineering Report/Bid Preparation/Accounting | LS | $200,000.00 | 1 | $200,000.00 |
| ***Dredging Corridor of Outfall Extension*** | | | | |
| Mechanical Dredging and Offloading | CY | $15.00 | 2420 | $36,300.00 |
| Rehandling, Transport, and Treatment at Holnam | CY | $63.00 | 2420 | $152,460.00 |
| Pre and Post Dredging Bathymetric Surveys | EA | $2,000.00 | 2 | $4,000.00 |
| Water Quality Monitoring | LS | $3,000.00 | 1 | $3,000.00 |
| Post-Dredge Confirmatory Sediment Sampling | LS | $12,000.00 | 1 | $12,000.00 |
| Subtotal | | | | $207,760.00 |
| Bonding | 10% | | | $20,776.00 |
| Contingency | 25% | | | $51,940.00 |
| *TOTAL* | | | | $280,476.00 |
| ***Dredging Remediation Area A*** | | | | |
| Mechanical Dredging and Offloading | CY | $15.00 | 11700 | $175,500.00 |
| Rehandling, Transport, and Treatment at Holnam | CY | $63.00 | 11700 | $737,100.00 |
| Pre and Post Dredging Bathymetric Surveys | EA | $2,000.00 | 2 | $4,000.00 |
| Water Quality Monitoring | LS | $3,000.00 | 1 | $3,000.00 |
| Post-Dredge Confirmatory Sediment Sampling | LS | $12,000.00 | 1 | $12,000.00 |
| Subtotal | | | | $931,600.00 |
| Bonding | 10% | | | $93,160.00 |
| Contingency | 25% | | | $232,900.00 |
| *TOTAL* | | | | $1,257,660.00 |
| ***Dredging Remediation Area B*** | | | | |
| Mechanical Dredging and Offloading | CY | $15.00 | 2030 | $30,450.00 |
| Rehandling, Transport, and Treatment at Holnam | CY | $63.00 | 2030 | $127,890.00 |
| Pre and Post Dredging Bathymetric Surveys | EA | $2,000.00 | 2 | $4,000.00 |
| Water Quality Monitoring | LS | $3,000.00 | 1 | $3,000.00 |
| Post-Dredge Confirmatory Sediment Sampling | LS | $12,000.00 | 1 | $12,000.00 |
| Subtotal | | | | $177,340.00 |
| Bonding | 10% | | | $17,734.00 |
| Contingency | 25% | | | $44,335.00 |
| *TOTAL* | | | | $239,409.00 |
| ***Dredging Remediation Area C*** | | | | |
| Mechanical Dredging and Offloading | CY | $15.00 | 41050 | $615,750.00 |
| Rehandling, Transport, and Treatment at Holnam | CY | $63.00 | 41050 | $2,586,150.00 |
| Pre and Post Dredging Bathymetric Surveys | EA | $2,000.00 | 2 | $4,000.00 |
| Water Quality Monitoring | LS | $3,000.00 | 1 | $3,000.00 |
| Post-Dredge Confirmatory Sediment Sampling | LS | $12,000.00 | 1 | $12,000.00 |
| Subtotal | | | | $3,220,900.00 |
| Bonding | 10% | | | $322,090.00 |
| Contingency | 25% | | | $805,225.00 |
| *TOTAL* | | | | $4,348,215.00 |

**Table 6-3.** Estimated Costs for Remediation by Mechanical Dredging and Treatment at Holnam Cement

| ITEM | UNIT | | UNIT COST | QUANTITY | COST |
|---|---|---|---|---|---|
| ***Dredging Remediation Area D*** | | | | | |
| Mechanical Dredging and Offloading | CY | | $20.00 | 4200 | $84,000.00 |
| Rehandling, Transport, and Treatment at Holnam | CY | | $63.00 | 4200 | $264,600.00 |
| Pre and Post Dredging Bathymetric Surveys | EA | | $2,000.00 | 2 | $4,000.00 |
| Water Quality Monitoring | LS | | $3,000.00 | 1 | $3,000.00 |
| Post-Dredge Confirmatory Sediment Sampling | LS | | $12,000.00 | 1 | $12,000.00 |
| Subtotal | | | | | $367,600.00 |
| Bonding | | 10% | | | $36,760.00 |
| Contingency | | 25% | | | $91,900.00 |
| *TOTAL* | | | | | $496,260.00 |
| ***Dredging Remediation Area E*** | | | | | |
| Mechanical Dredging and Offloading | CY | | $15.00 | 10300 | $154,500.00 |
| Rehandling, Transport, and Treatment at Holnam | CY | | $63.00 | 10300 | $648,900.00 |
| Pre and Post Dredging Bathymetric Surveys | EA | | $2,000.00 | 2 | $4,000.00 |
| Water Quality Monitoring | LS | | $3,000.00 | 1 | $3,000.00 |
| Post-Dredge Confirmatory Sediment Sampling | LS | | $12,000.00 | 1 | $12,000.00 |
| Subtotal | | | | | $822,400.00 |
| Bonding | | 10% | | | $82,240.00 |
| Contingency | | 25% | | | $205,600.00 |
| *TOTAL* | | | | | $1,110,240.00 |
| **TOTAL FOR ALL AREAS** | | | | | $7,982,260.00 |

LS=Lump Sum
CY=Cubic Yard
EA=Each

*Mobilization costs assume a lump sum for an upland rehandling area.
An Upland rehandling area has not been identified and as a result a conservative estimate is applied.

### *6.4.7 Community Concerns*

Community concerns are identical to those described in Section 6.3.7.

### *6.4.8 Recycling, Reuse, and Waste Minimization*

This alternative meets the goals of recycling, reuse and waste minimization as all sediments would be treated, recycled, and reused as base material for the production of cement.

## 6.5 Alternative 5: Containment by Thin-Layer Capping

For this alternative, areas with surface sediments exceeding SQS but below the CSL would be covered with a thin-layer cap. Specifically, Remediation Areas B, C, D, and E are considered for thin-layer capping. Because placing a cap over sediments with CSL exceedances conflicts with Ecology and WADNR policy for removal, capping is not considered a suitable alternative for Remediation Area A, which has contaminant concentrations exceeding the CSL (Section 5.5.5). Remediation Area B is located in the intertidal zone and has a sandy beach habitat over portions. The placement of a thin-layer cap in Remediation Area B would alter the profile of the existing beach by raising it 1 foot in elevation. The profile of the existing sandy beach may represent equilibrium conditions between the sediment and hydrodynamic forces such as waves and currents. It is unknown whether the present beach profile changes seasonally with hydrodynamic conditions (e.g., increased incident wave energies associated with winter storms). Because of these factors, there may be the potential for erosion of a thin-layer cap placed at Remediation Area B. A control to prevent cap erosion in high energy environments is the placement of armoring over the cap, such as rocks or specifically designed concrete pieces.

The materials used to cap the surface sediments would be sands or sandy sediments dredged from a nearby project. For example, the U.S. Army Corps of Engineers dredges the turning basin on the Duwamish River every other year, and this has been used as a source of clean capping material on other sites in Puget Sound. Capping materials would be brought in by tug and barge and then deposited over the target remediation area. Most caps in the Puget Sound region have been placed by bottom-dump barges. Flat deck barges and placement of cap material from shore have also been used in other projects. The use of a bottom dump barge for cap construction would be limited to areas of navigable water depths. Depending on size and capacity, bottom-dump barges draw between 8 and 16 feet when fully loaded. For Remediation Area B, a shallow-draft, flat-decked barge can reach shallow areas and be run onto the beach for capping in the intertidal zone. Alternatively, cap material can be trucked to the site and placed with land-based heavy equipment. Target cap thickness for thin-layer capping is 1 foot.

### *6.5.1 Protection of Human Health and the Environment*

This alternative would protect human health and the environment by isolating the underlying contaminated sediments. Sediments within the biologically active zone would consist entirely of newly placed clean sediment. A short-term environmental impact would be associated with the placement of the capping material, as it buries benthic infauna that are resident at the site. The ability of benthic infauna to survive the placement of a cap is a function of the thickness of the cap material. By placing a thin-layer cap rather than a thick one, it is hoped that a portion of the infaunal community would survive cap deposition and subsequently speed benthic recolonization. To the extent possible, the sediment type (i.e., sand, silt) of the cap should be selected to match the native sediment as closely as possible without impairing the ability to construct the cap. The placement of a clean cap as new substrate would improve long-term habitat quality. By matching the cap sediment type to the native sediment, changes to benthic community structure would be minimized, as benthic infaunal communities are sensitive to sediment grain size. Should armoring be required over the thin-layer cap in a high energy environment, the benthic community would shift from a sandy/muddy community to a rock substrate community.

### *6.5.2 Compliance with Cleanup Standards and Applicable Laws*

This alternative would achieve cleanup goals by bringing surface sediments into compliance with SQS. A lease of subtidal aquatic lands would need to be obtained from the Department of Natural Resources Division of Aquatic Lands. WADNR administers state-owned aquatic (subtidal) lands.

### *6.5.3 Short-Term Effectiveness*

This alternative would be technically effective in the short-term in bringing surface sediment contaminant concentrations below the SQS. There would be little risk to the public or to the workers, as there would be no contact with any contaminated sediment. There would be a slight impact to the benthic infauna in the remediation areas from burial, but these areas would be expected to begin recolonizing within 6 to 12 months. Full recolonization may take several years, and will depend on recruitment, physical disturbances, survival of the existing community, and any changes in habitat.

### *6.5.4 Long-Term Effectiveness*

For low hydrodynamic energy environments, this alternative would be effective in the long-term, as contaminated sediments would be covered with clean sediments. In low energy environments, risks associated with this remedy are disturbance of the capped area by dredging, anchor drags, and deep-burrowing benthic infauna. In high energy environments, there would be significant risk that the cap material may be eroded and transported away from the capping area. To control this risk, the thin-layer cap may need to be armored with rock or other materials.

Like all remedies, thin-layer capping would be sensitive to source control at the site. Data suggests that the greatest risk to capping projects throughout the Puget Sound area has been due to recontamination from ongoing or single-event sources rather than remobilization and migration of underlying contaminants (USACE 1994, Romberg 1995). Source control would be expected to be achieved with the completion and start-up of the Denny Way project.

### *6.5.5 Implementability*

This alternative would be implementable with bottom-dump equipment at Remediation Areas C, D, and E. Remediation Area B is located in the intertidal zone, which requires use of either land-based equipment or a shallow-draft, flat-decked barge. Although there is a sandy beach present in Remediation Area B, armoring may be needed in addition to the cap to ensure that erosion by wave action does not compromise the efficacy of the cap. The placement of armoring over the cap would alter the sandy beach habitat to that of a rocky shore.

Cap construction would preferably be phased with a nearby dredging project so that clean, low-cost capping materials are readily available in the volumes needed. Clean sediments from a dredging project represent the most cost-effective capping materials as expenses incurred are related to the transport and placement of the dredged sediment rather than purchasing the material. Cap materials may also be purchased from upland sites. Although some of the Remediation Areas are nearshore, there are no navigational constraints that would prevent barges from reaching and placing sediment at Remediation Areas C, D, and E.

This alternative would be subject to both permitting and leasing requirements and therefore may require a longer permitting process than other alternatives. For Remediation Area B, the regulatory agencies would also need to agree to the replacement of the existing sandy beach habitat with that of rock armoring. From a permitting perspective, this may also prove difficult as the sandy beach in Remediation Area B in Myrtle Edwards Park represents one of the few stretches of sandy beach in the Seattle waterfront area.

There will be both short-term and long-term monitoring requirements to prove the efficacy of thin-layer capping. This alternative should be approved by the agencies, as only sediments with SQS exceedances that are located in low energy environments would be capped. Sediments having CSL exceedances would be removed in accordance with both WADNR and Ecology preference for removal.

### *6.5.6 Cost*

The costs associated with this alternative are summarized by Remediation Area. A total for all of the remediation areas considered for thin-layer capping is also provided. Due to the uncertainty of dredged material availability and the potential need to purchase sandy capping sediment from an upland source, a range of costs for cap sediment acquisition is incorporated in the costs presented. For Remediation Area B, the costs assume that the cap would be armored. Itemized costs for this alternative are provided in Table 6-4.

| | | | |
|---|---|---|---|
| Remediation Area B | $133,691 | to | $139,063 |
| Remediation Area C | $127,169 | to | $249,625 |
| Remediation Area D | $104,744 | to | $126,125 |
| Remediation Area E | $108,625 | to | $147,500 |
| Total For All Areas | $474,228 | to | $662,313 |

### *6.5.7 Community Concerns*

Community concerns, if any, will become evident at the conclusion of the 30-day public review and comment period required by NEPA/SEPA. At this time, public concerns about any of the potential remediation alternatives would be submitted to the proponents for evaluation.

### *6.5.8 Recycling, Reuse and Waste Minimization*

This alternative would recycle and reuse dredged material and would minimize the amount of waste generated during remediation as contaminated sediments above the SQS but below the CSL would be capped rather than dredged.

## 6.6 Comparison of Alternatives

In the preceding sections, each of the five alternatives was individually evaluated against the criteria set forth in the Sediment Management Standards, WAC 173-204-560 (4) (f) (iii). To determine which alternatives may be most successful in remediating the Denny Way CSO site, the five alternatives are ranked in their potential for satisfying each criterion defined in WAC 173-204-560 (4) (f) (iii).

### *6.6.1 Protection of Human Health and the Environment*

Alternative 1, No Action, does not provide protection of human health and the environment, though there would be improvements at the site due to the construction of the new outfalls. Alternative 2, Natural Recovery, also does not provide any protection

**Table 6-4.** Estimated Costs for Remediation by Thin-Layer Capping

| ITEM | UNIT | UNIT COST | UNIT COST (MAX) | UANTIT | COST (MIN) | COST (MAX) |
|---|---|---|---|---|---|---|
| ***Remediation Area B*** | | | | | | |
| Capping Sediment | CY | $0.00 | $10.00 | 450 | $0 | $4,500 |
| Transport/Placement | CY | $15.00 | $15.00 | 450 | $6,750 | $6,750 |
| State-Owned Aquatic Land Fee | CY | $0.45 | $0.00 | 450 | $203 | $0 |
| Cap Armoring Material | CY | $30.00 | $30.00 | 250 | $7,500 | $7,500 |
| Cap Armoring Placement | CY | $50.00 | $50.00 | 250 | $12,500 | $12,500 |
| Post Construction Sediment Monitoring | EA | $20,000.00 | $20,000.00 | 4 | $80,000 | $80,000 |
| Subtotal | | | | | $106,953 | $111,250 |
| Contingency | 25% | | | | $26,738 | $27,813 |
| Total | | | | | $133,691 | $139,063 |
| ***Remediation Area C*** | | | | | | |
| Capping Sediment | CY | $0.00 | $10.00 | 6300 | $0 | $63,000 |
| Transport/Placement | CY | $3.00 | $9.00 | 6300 | $18,900 | $56,700 |
| State-Owned Aquatic Land Fee | CY | $0.45 | $0.00 | 6300 | $2,835 | $0 |
| Post Construction Sediment Monitoring | EA | $20,000.00 | $20,000.00 | 4 | $80,000 | $80,000 |
| Subtotal | | | | | $101,735 | $199,700 |
| Contingency | 25% | | | | $25,434 | $49,925 |
| Total | | | | | $127,169 | $249,625 |
| ***Remediation Area D*** | | | | | | |
| Capping Sediment | CY | $0.00 | $10.00 | 1100 | $0 | $11,000 |
| Transport/Placement | CY | $3.00 | $9.00 | 1100 | $3,300 | $9,900 |
| State-Owned Aquatic Land Fee | CY | $0.45 | $0.00 | 1100 | $495 | $0 |
| Post Construction Sediment Monitoring | EA | $20,000.00 | $20,000.00 | 4 | $80,000 | $80,000 |
| Subtotal | | | | | $83,795 | $100,900 |
| Contingency | 25% | | | | $20,949 | $25,225 |
| Total | | | | | $104,744 | $126,125 |
| ***Remediation Area E*** | | | | | | |
| Capping Sediment | CY | $0.00 | $10.00 | 2000 | $0 | $20,000 |
| Transport/Placement | CY | $3.00 | $9.00 | 2000 | $6,000 | $18,000 |
| State-Owned Aquatic Land Fee | CY | $0.45 | $0.00 | 2000 | $900 | $0 |
| Post Construction Sediment Monitoring | EA | $20,000.00 | $20,000.00 | 4 | $80,000 | $80,000 |
| Subtotal | | | | | $86,900 | $118,000 |
| Contingency | 25% | | | | $21,725 | $29,500 |
| Total | | | | | $108,625 | $147,500 |
| **TOTAL FOR ALL AREAS** | | | | | $474,228 | $662,313 |

LS=Lump Sum
CY=Cubic Yard
EA=Each
*Placemnt of capping sediment in Area B is assumed to be by flat deck barge and mechanical placement. All other capping is assumed to be by split-hull barge.

of human health and the environment during the 10 year recovery period. Alternative 3, Mechanical Dredging with Disposal at a RCRA Subtitle D Landfill, provides protection of human health and the environment by removing all contaminated sediments from the site and placing them in a facility designed to isolate the contents from the environment. Alternative 4, Mechanical Dredging with Treatment at Holnam Cement, provides protection of human health and the environment by removing all contaminated sediments from the site, incinerating organic contaminants and immobilizing heavy metals as aggregate in cement. Alternative 5, Containment by Thin-Layer capping, provides protection of human health and the environment by isolating contaminated surface sediments with a layer of clean sediment; however, the contaminants remain on-site.

Protection Ranking: Alternative 3 & 4 > Alternative 5 > Alternative 2 > Alternative 1.

### *6.6.2 Compliance with Cleanup Standards and Applicable Laws*

Alternative 1, No Action, would not comply with cleanup standards but is in accordance with policy for sediments with SQS exceedances only. Alternative 2, Natural Recovery, may comply with both cleanup standards for a subset of the total area and applicable laws. For natural recovery, compliance with cleanup standards is dependent on sedimentation rates, natural chemical degradation and biodegradation of contaminants, and the chemical quality of new sediments deposited at the site. Therefore, it is uncertain whether natural recovery would be effective for the remediation areas at the Denny Way CSO site. Alternative 3, Mechanical Dredging with Disposal at a RCRA Subtitle D Landfill, complies with cleanup standards and requires permits to comply with applicable laws. Alternative 4, Mechanical Dredging with Treatment at Holnam Cement, complies with cleanup standards and requires permits to comply with applicable laws. Alternative 5, Containment by Thin-Layer Capping, complies with cleanup standards and applicable laws when sediments with only SQS exceedances are considered.

Compliance Ranking: Alternative 3, 4 & 5 > Alternative 2 >Alternative 1

### *6.6.3 Short-Term Effectiveness*

Alternative 1, No Action, is not effective in the short-term. Alternative 2, Natural Recovery, is not effective in the short-term. Alternative 3, Mechanical Dredging with Disposal at a RCRA Subtitle D Landfill, is effective in removing contaminated sediment. Adverse water quality impacts, migration of resuspended contaminated sediment, and worker exposure during remediation are some of the factors which could influence short-term effectiveness. These effects are easier to mitigate in Remediation Areas A and B, along with the inshore portions of Remediation Areas C and D, due to shallow water depths and sandy substrate. Alternative 4, Mechanical Dredging with Treatment at Holnam Cement, is effective in removing contaminated sediment. Adverse water quality impacts, migration of resuspended contaminated sediment, and worker exposure during dredging are some of the factors which could influence short-term effectiveness. These effects are easier to mitigate in the shallower remediation areas that have a sandy substrate. Water quality monitoring during dredging would be required for Alternatives 3 and 4. Alternative 5, Containment by Thin-Layer Capping, is effective in the short-term. Limited water quality monitoring may be required during cap placement.

Short-term Effectiveness Ranking: Alternative 5 > Alternative 3 & 4 > Alternative 2 > Alternative 1.

### *6.6.4 Long-Term Effectiveness*

Alternative 1, No Action, is not effective in the long-term. Alternative 2, Natural Recovery, may be effective in the long-term only for portions of Remediation Areas C and D, as only certain portions of these remediation areas are predicted to recover. Once the outfall is extended, the sedimentation rate at the Denny Way nearshore areas may diminish, reducing the potential long-term effectiveness of this alternative. Alternative 3, Mechanical Dredging with Disposal at a RCRA Subtitle D Landfill, is effective in the long-term, as all contaminated sediments would be removed from the site. In Alternative 3, the excavated sediment would be transported to a landfill designed for containment and isolation of disposed materials. Alternative 4, Mechanical Dredging with Treatment at Holnam Cement, is effective in the long-term, as all contaminated sediment is removed from the site. In this alternative, sediment is thermally treated, either incinerating contaminants or immobilizing them in aggregate for the production of cement. Alternative 5, Containment by Thin-Layer Capping, is effective in the long-term for Remediation Areas C, D, and E. Remediation Area B is situated in the intertidal zone and is subject to greater wave energies than the other, deeper areas. As a result, a thin-layer cap placed at Remediation Area B may be compromised by erosion in the long-term unless it is armored with a heavier, non-erodable material. For all sediments which are thin-layer capped, a risk persists due to possible re-exposure of underlying sediments from physical disturbances such as anchor dragging, construction, or other unforeseen activities. This risk will be minimized by considering only sediments with SQS exceedances for capping.

Long-term Effectiveness Ranking: Alternative 4 > Alternative 3 > Alternative 5 > Alternative 2 > Alternative 1.

### *6.6.5 Implementability*

Alternative 1, No Action, is easily implemented. Alternative 2, Natural Recovery, is easily implemented. Alternative 3, Mechanical Dredging with Disposal at a RCRA Subtitle D Landfill, is easily implemented, as there are many local dredging contractors and the technology is reliable and proven. The greatest logistical difficulty would be the location of a suitable rehandling facility. Permitting would be required. There are no difficulties anticipated with the permitting process, as mechanical dredging and RCRA Subtitle D disposal are known and proven. Alternative 4, Mechanical Dredging with Treatment at Holnam Cement, may be difficult to implement due to the constraints of the schedule and current inventory of Holnam Cement, the limited amount of sediment Holnam Cement can accept, and the chemical suitability of the dredged sediment for cement production. It is will not employ waste minimization, reuse, or recycling practices. Alternative 4, Mechanical Dredging with Treatment at Holnam Cement, will employ reuse and recycling practices. Alternative 5, Containment by Thin-Layer Capping, will employ waste minimization, reuse, and recycling practices by minimizing dredge waste, and reusing/recycling dredged material.

Waste Minimization/Reuse/Recycle Ranking: Alternative 5 > Alternative 4 > Alternative 2 > Alternative 1 > Alternative 3.

## 6.7 Preferred Alternatives

Based on the evaluation of each remediation area against the criteria set forth in 173-204-560 WAC, preferred alternatives were selected for each of the remediation areas. For the corridor of outfall construction and Remediation Areas A and B, excavation is the preferred option. The corridor of outfall construction and areas requiring pilecaps for the Elliott West outfall will also require excavation. Alternative 3: Mechanical Dredging and Disposal at RCRA Subtitle D Landfill and Alternative 4: Mechanical Dredging and Treatment at Holnam were the only alternatives with an excavation component. Each offers the same level of effectiveness. Alternative 4 ranks higher in some categories, though there is a large degree of uncertainty associated with this implementability of this option. For Alternative 3, there are no constraints on implementability. For this reason, Alternative 3: Mechanical Dredging and Disposal at RCRA Subtitle D Landfill is selected as the preferred alternative for the corridor of outfall extension and Remediation Areas A and B. Alternative 4: Mechanical Dredging and Treatment at Holnam is the back-up for these areas. Thin-layer capping was not selected as an alternative for Remediation Area B as it is expected to be difficult to permit and may conflict with existing land use as it one of the few stretches of sandy beach along the Seattle waterfront.

For remediation areas offshore of the existing sediment cap with only SQS exceedances, Remediation Areas C, D, and E, Alternative 5: Containment by Thin-Layer Capping is selected as the preferred alternative. In low energy environments this alternative is technically effective and protective of human health and the environment, and it is also more cost-effective than those alternatives utilizing excavation. Thin-layer capping was selected over natural recovery for Remediation Area C and D as thin-layer capping is more effective in both the short- and long-term. Natural recovery is the backup alternative for Remediation Areas C and D. The backup alternative for Remediation Area E is Alternative 3: Mechanical Dredging with Disposal at a RCRA Subtitle D Landfill. Natural recovery, based on cursory modeling, would not be technically effective at these areas. The preferred alternatives are itemized in Table 6-6. The costs for the preferred and backup alternatives are summarized in Table 6-7.

**Table 6-6.** Preferred and back-up alternatives for sediment groups, and remediation areas.

| *Sediment Group*<br>*Remediation Area* | 1<br>**Preferred Alternative** | 2<br>**Back-up Alternative** |
|---|---|---|
| *Corridor of Outfall Construction* | Alternative 3: Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill | Alternative 4: Mechanical Dredging with Treatment at Holnam Cement |
| *1990 Sediment Cap* | *These sediments were remediated in 1990 and are not further evaluated* | |
| *Sediments Inshore of 1990 Sediment Cap* | | |
| Remediation Area A | Alternative 3: Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill | Alternative 4: Mechanical Dredging with Treatment at Holnam Cement |
| Remediation Area B | Alternative 3: Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill | Alternative 4: Mechanical Dredging with Treatment at Holnam Cement |
| *Sediments Offshore of 1990 Sediment Cap* | | |
| Remediation Area C | Alternative 5: Containment by Thin Layer Capping | Alternative 2: Natural Recovery |
| Remediation Area D | Alternative 5: Containment by Thin Layer Capping | Alternative 2: Natural Recovery |
| Remediation Area E | Alternative 5: Containment by Thin Layer Capping | Alternative 3: Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill |

**Table 6-7.** Costs for preferred and backup alternative, with and without backfilling.

| | 1 | 2 |
|---|---|---|
| ***Sediment Group Remediation Area*** | **Preferred Alternative** | **Back-up Alternative** |
| Corridor of Outfall Extension | Alternative 3: Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill | Alternative 4: Mechanical Dredging with Treatment at Holnam Cement |
| Cost of Alternative | $255,647 | $280,476 |
| Cost with Backfill | $268,692 - $327,491 | $293,521 - $352,320 |
| Remediation Area A | Alternative 3: Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill | Alternative 4: Mechanical Dredging with Treatment at Holnam Cement |
| Cost of Alternative | $1,137,618 | $1,257,660 |
| Cost with Backfill | $1,200,688 - $1,484,961 | $1,320,730 - $1,605,003 |
| Remediation Area B | Alternative 3: Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill | Alternative 4: Mechanical Dredging with Treatment at Holnam Cement |
| Cost of Alternative | $218,581 | $239,409 |
| Cost with Backfill | $229,524 - $278,838 | $250,352 - $299,666 |
| Remediation Area C | Alternative 5: Containment by Thin-Layer Capping | Alternative 2: Natural Recovery |
| Cost of Alternative | $127,169 - $249,625 | $100,000 |
| Cost with Backfill | NA | NA |
| Remediation Area D | Alternative 5: Containment by Thin-Layer Capping | Alternative 2: Natural Recovery |
| Cost of Alternative | $104,744 - $126,125 | $100,000 |
| Cost with Backfill | NA | NA |
| Remediation Area E | Alternative 5: Containment by Thin-Layer Capping | Alternative 3: Mechanical Dredging and Disposal at a RCRA Subtitle D Landfill |
| Cost of Alternative | $106,625 - $147,500 | $1,004,562 |
| Cost with Backfill | NA | $1,060,085 - $1,310,343 |
| **Total All Areas** | $1,950,384 - 2,135,096 | $2,982,377 |
| **Total for All Areas With Backfill** | $2,037,442 - $2,614,540 | $3,124,688 - $3,767,332 |

## 6.8 Sequencing of Outfall Construction and Sediment Remediation.

The outfall corridor will be excavated as part of the outfall construction. Excavation of the outfall corridor and proper disposal of contaminated excavated material will occur during the CSO project timeframe regardless of the timing of the remediation of the remaining contaminated sediments.

The key milestones of the Marine Outfalls contract are listed below:

- Advertise for Bid August 1999
- Begin Construction July 2000 *(Beginning of Fisheries window)*
- Complete Construction March 2001 *(End of Fisheries window)*
- Denny Way CSO Outfall Operational July 2002
  *(Discharge at current conditions of approximately 50 times per year)*
- Project Completion April 2003
  *(Denny Way CSO Outfall (short outfall) will discharge untreated CSO once per year and Elliott West Outfall (long outfall) will discharge treated CSOs approximately 8-20 times per year.)*

The remediation of areas A, B, C, D and E is recommended to be implemented separately from the outfall construction and after the Denny Way/Lake Union CSO Project is completed in April 2003. By delaying remediation of these areas until after project completion, the risk of recontamination is avoided. Recontamination of the existing cap has occurred with bis(2ethylhexyl)phthalate above the CSL in the area closest to the existing outfall near Remediation Areas A and B. Once the project is on-line and results of additional sampling are acquired, portions of the existing sediment cap which have been recontaminated may also need to be remediated. Because of the location of the recontaminated cap near Remediation Areas A and B, it may be cost effective to remediate the cap in conjunction with cleanup of areas A and B.

The option of performing remediation of areas A and B in conjunction with the outfall was analyzed. There would possibly be some efficiencies in mobilization costs, however, the costs savings are not certain since it is possible that the work would occur over two construction seasons, eliminating the costs savings. Also, combining the remediation with the outfall would limit the ability to take advantage of the availability of clean dredge material from another site to be used as fill. It has been determined that remediation of Areas A and B in the future would not be significantly impeded by the prior construction of the outfall. The small potential cost savings of combining the remediation with the outfall construction does not justify the potential risk of recontamination.

Remediation Areas A and B can be cleaned up separately from areas C, D and E. A and B require dredge and fill while areas C, D and E require capping.

### 6.9 Recommended Sediment Remediation Strategy

The following sediment remediation strategy for the Denny Way CSO is recommended. The strategy is based on the information provided in this document and knowledge of other planning efforts.

Sediment remediation actions will commence after the Denny Project is completed and on-line and the source of contamination is controlled. CSO control is currently scheduled for 2003. The estimated sediment remediation project planning and construction costs and schedule has not yet been finalized, but will be included in the capital budget request in August 1999.

Cleanup of Remediation Areas A and B, which are located directly off the existing outfall, would be implemented immediately after the CSO control project is completed and facilities are functioning. Remediation of Areas A and B would be coordinated with the monitoring and response plan for the existing Denny Way cap. If the cap needs to be remediated after the Denny Project is on-line, the remediation action could either be added to the remediation effort for Areas A and B (this budget request); or the remediation effort for Areas C, D, and E (presented in the Sediment Management Plan); or submitted as a separate capital project budget request. Decisions on remediation of the existing cap will occur in 2003 when post-construction monitoring is complete.

The implementation schedule for Remediation Areas C, D and E will be developed in conjunction with King County's new sediment management program and is a function of priority, funding and the availability of clean dredged fill. King County is currently developing a sediment management plan (including the Denny Way CSO) under the CSO program. The program will identify costs and priorities of sediment remediation off CSOs and will be used to obtain project funding.

### 6.10 Recommended Sediment Remediation Monitoring and Contingency Plan

King County will provide post-construction monitoring of the existing Denny Way cap to evaluate any change in the concentration of contaminants that may have occurred during construction of the Denny Way/Lake Union CSO Control Project's two marine outfalls. Post-construction monitoring of the existing cap is proposed to include two surface grab stations north and two stations south away from the outfall pipes, and one surface grab station near the outfall alignment on the offshore side of the existing cap.

Past monitoring of the existing cap in 1996 showed the inshore area of the existing cap exceeded the sediment standard value for one chemical and would be in need of remediation. The likely alternative for remediation on the existing cap is to add more material as a thin-layer cap.

For Remediation Areas A and B, post-construction monitoring at surface grab stations located around the remediated areas will determine if contaminated sediments were dispersed during remediation and will serve as a baseline for determining recontamination.

Remediation of Areas C, D and E is being determined under King County's Sediment Management Plan. The final plan is expected in Summer 1999. These areas could be remediated as a separate project or be included in remediation of Areas A and B. In project-level planning, King County would include additional sampling around these areas to refine boundaries for cleanup. At the time of remediation, a monitoring program would be negotiated with Ecology to evaluate potential recontamination and to ensure the remediation areas remain intact.

Monitoring of the existing cap and any remediation areas capped would include evaluations of the chemical and physical properties of the caps. Grab samples from the surface of each capped area would be obtained and analyzed for SMS chemicals. The evaluation of the chemical composition of the cap's surface would assess if recontamination has occurred. Cores of the cap material would be obtained and analyzed for SMS chemicals to assess if the underlying contaminated sediments have migrated upward through the cap material. The cores of the cap would be used with other surface elevation monitoring stations to assess if the cap has eroded.

If the results of chemical analysis or thickness measurements indicate that the containment characteristics of a particular cap have been compromised, three options are available. (Additional concentrated confirmatory sampling to evaluate the areal extent of the affected cap should precede all of the following options.) One option is to add additional material to the surface of the cap. This option is appropriate for areas where the cap has been scoured or gouged, and the additional material replaces material that was dislodged. Another option is excavation, removal, and backfill with clean material. This option may be warranted where the damage to the cap indicates that the cap would continue to be subject to forces sufficient to compromise the cap. For example, if large anchors gouge the cap and this anchorage pattern is expected to continue or increase. The third option is to continue to monitor the affected cap. This option is appropriate if the damage to the cap is very localized and the impact to marine biota is not considered to be significant.

The monitoring and project experience from the existing Denny Way cap would be used to evaluate the significance of anchors damaging the cap and would be used to decide if the thin-layer caps recommended for Remediation Areas C, D, and E would be effective. Thin-layer caps are recommended in this alternatives evaluation based, in part, on the effectiveness of the thin-layer cap being the same as the thick-layer cap (typically 3 feet thick) in low energy environments. The major benefit of the thin layer cap is that it requires less material and causes less impingement on navigable water depth than a thick-layer cap. Based on discussions with WADNR, there are concerns about the potential for anchors from recreational boaters to drag along the bottom and possibly gouge through a thin-layer cap. Increasing the thickness would reduce the potential for anchors penetrating the cap. WADNR has indicated there are no concerns about limited navigable water depth in the vicinity of the Denny Way cap. An increase in cap thickness to a 3-foot depth would increase the cost for remediation of Areas C, D, and E from an estimated maximum of $523,250 (refer to Table 6-4) to $969,750 due to the threefold increase in cap materials.

# 7. BACKFILLING OF EXCAVATED AREAS

Remediation by dredging would remove sediments from the seafloor and result in a large depression at the excavated area. After remediation, the excavated areas would have to be filled and graded to approximately the same seafloor elevations that were present prior to remediation. This will preserve site habitat as well as covering the sediments exposed by dredging.

For the corridor of outfall construction, filling and grading of the excavated area will be accomplished as part of outfall placement. Remediation Area A would need to be filled and brought to grade because of its proximity to the shoreline and the steep dredge cuts attributable to the sloped seafloor. The volume of sediment to be removed from Remediation Area A is 11,700 cubic yards. To fill Remediation Area A after excavation, 14,625 cubic yards of clean material would be required, which equals the volume excavated plus an additional 25% for anticipated loss during placement. Remediation Area B would require 2,538 cubic yards of fill to be brought back to grade, including the anticipated loss of material during backfilling.

Remediation Area E may also require fill material after excavation since mechanical dredging is the back-up alternative. The volume of material needed to fill and grade Remediation Area E would be 12,875 cubic yards.

Materials used to backfill the excavated areas are similar to those used for thin-layer capping. Costs for acquisition and placement of backfill material are equivalent to costs for thin-layer capping materials. For the Denny Way CSO extension project, it is preferable that suitable dredged material be available from a nearby dredging project for use as fill material. Dredged material would likely be available in large quantities, be easily transported to the site, and would be the most cost effective source of fill material. For the cap placed at the Pier 53-55 Remediation Area, clean, sandy cap material was made available, transported, and placed by the Corps of Engineers for a cost of $3.00/cubic yard. The bulk of this cost was related to the transport and placement of the cap sediment (A. Sumeri pers. comm.). It may be possible to get fill material at or near these costs, providing there is a nearby Corps maintenance project. In addition to the transport and placement cost of dredged sediment as cap material, there would likely be a surcharge from WADNR for the placement of the cap sediment on state-owned aquatic lands (SOAL) (WADNR 1998). The surcharge from WADNR for cap sediments placed on SOAL would be equal to the disposal fees that would be charged if it were brought to a PSDDA open-water disposal site. The disposal fees for the PSDDA site is currently $0.45/cubic yard. Thus, the likely minimum cost of both cap and fill sediments would be $3.45, which represents the cost for the dredged material plus placement, and the disposal fees.

If material is not available from a local dredging project, or is not available in sufficient quantities, cap and fill sediments may need to be purchased and transported to the site prior to placement. Acquisition costs for sands range from $8.00 to $10.00/cubic yard. Transport and placement costs would be in addition to the purchase price and are estimated at $9.00/cubic yard. This would bring the costs for fill and cap materials to $19.00/cubic yard if dredged sediments were not readily available. Given the uncertainty associated with the source of both cap and fill material, a price range representing minimum and maximum costs is provided.

Costs for filling excavated remediation areas follow and assume a 25% contingency.

Remediation Area A: $69,399 - $347,343
Remediation Area B: $10,943 - $60,257
Remediation Area E: $55,523 - $305,781

These costs would be in addition to those required to remediate each area. Backfilling costs are presented with remediation costs in Section 6.6.

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