

# **Draft Supplemental Remedial Investigation & Feasibility Study**

## **Volume 2: FS Report**

### **Whatcom Waterway Site Bellingham, Washington**

**Prepared by:**

**The RETEC Group, Inc.  
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**RETEC Project Number: PORTB-18876**

**Prepared for:**

**The Port of Bellingham  
1801 Roeder Avenue  
Bellingham, Washington 98225**

**Public Review Draft**

**October 10, 2006**

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**October 10, 2006**

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# 1 Feasibility Study Introduction

This document is Volume 2 of the *Draft Supplemental Remedial Investigation and Feasibility Study* (RI/FS) for the Whatcom Waterway Site. Together with the companion *Draft Supplemental Environmental Impact Statement* (EIS), the RI/FS document describes the investigation of the Whatcom Waterway site, describes and evaluates a range of potential remedial alternatives, and identifies the preferred approaches for conducting site cleanup.

The preceding *Remedial Investigation Report* (Volume 1) describes the nature and extent of contamination, describes the environmental setting at the site, and concludes with a conceptual model of the site. This document (Volume 2) contains the evaluation of cleanup technologies and alternatives that can be used to conduct cleanup of the site. This document was prepared consistent with the requirements of the Model Toxics Control Act (MTCA) regulations and the Sediment Management Standards (SMS).

This document concludes with the identification of preferred alternatives that best meet regulatory requirements and that provide the best overall cleanup approaches for the Whatcom Waterway site. After considering public comment, the RI/FS will be finalized, and the Department of Ecology (Ecology) will preliminarily select a cleanup alternative for the site. The preliminarily selected cleanup alternative will be articulated for public review in a draft Cleanup Action Plan (CAP). Following public review of the CAP, the cleanup will move forward into design, permitting, construction and long-term monitoring.

## 1.1 Site Description and Background

The Whatcom Waterway site is located within Bellingham Bay. The locations and characteristics of the site are shown in Figure 1-1. Property ownership is summarized in Figure 1-2.

The site includes aquatic lands that have been impacted by contaminants historically released from industrial waterfront activities, including mercury discharges from the former Georgia Pacific (GP) chlor-alkali plant. The chlor-alkali plant was constructed by GP in 1965 to produce chlorine and sodium hydroxide for use in bleaching and pulping wood fiber. The chlor-alkali plant discharged mercury-containing wastewater into the Whatcom Waterway during the late 1960s and 1970s. Initial environmental investigations of the site identified mercury in sediment at concentrations that exceed applicable standards, as well other contaminants from industrial releases.

The main state law that governs the cleanup of contaminated sites is the Model Toxics Control Act (MTCA). When contaminated sediments are involved, the cleanup levels and other procedures are also regulated by the Sediment Management Standards (SMS). MTCA regulations specify criteria

for the evaluation and conduct of a cleanup action. SMS regulations dictate the standards for cleanup. Under both laws, a cleanup must protect human health and the environment, meet environmental standards in other laws that apply, and provide for monitoring to confirm compliance with site cleanup levels.

The key MTCA decision-making document for site cleanup actions is the remedial investigation and feasibility study (RI/FS). In the RI/FS, different potential alternatives for conducting a site cleanup action are defined. The alternatives are then evaluated against MTCA remedy selection criteria, and one or more preferred alternatives are selected. After reviewing the RI/FS study, and after consideration of public comment, Ecology then selects a cleanup method and documents that selection in a document known as the Cleanup Action Plan. Following public review of the CAP, the cleanup will move forward into design, permitting, construction and long-term monitoring.

The RI/FS process for the Whatcom Waterway site was initiated under Ecology oversight in 1996 consistent with Agreed Order DE 95TC-N399. The RI/FS study process initially included detailed sampling and analysis in 1996 and 1998. These sampling events formed the basis for development of an RI/FS report in 2000.

In parallel with the 2000 RI/FS activities, the Bellingham Bay Comprehensive Strategy Environmental Impact Statement (EIS) was prepared. The EIS was both a project-specific EIS, evaluating a range of cleanup alternatives for the Whatcom Waterway site, and a programmatic EIS, evaluating the Bellingham Bay Comprehensive Strategy. The Comprehensive Strategy was developed by an interagency consortium known as the Bellingham Bay Demonstration Pilot (Pilot). The Pilot brought together a partnership of agencies, tribes, local government, and businesses known collectively as the Pilot Work Group, to develop a cooperative approach to expedite source control, sediment cleanup and associated habitat restoration in Bellingham Bay. As part of the approach, the Pilot Work Group developed a Comprehensive Strategy that considered contaminated sediments, sources of pollution, habitat restoration and in-water and shoreline land use from a Bay-wide perspective. The strategy integrated this information to identify priority issues requiring action in the near-term and to provide long-term guidance to decision-makers. The Comprehensive Strategy was finalized as a Final Environmental Impact Statement in October 2000 prepared under the State Environmental Policy Act (SEPA). It was a companion document to the 2000 RI/FS for the Whatcom Waterway site.

Since 2000, the Bellingham Waterfront has undergone a series of dramatic land use changes, including the closure of the GP pulp mill and chemical plant, the sale of 137 acres of GP-owned waterfront property to the Port of Bellingham (Port), additional property ownership changes in the Central Waterfront Area, and City of Bellingham/Port land use planning initiatives

that shift waterfront uses from industrial to mixed-use development and zoning.

This RI/FS incorporates the results of environmental investigations conducted since completion of the original RI/FS in 2000, updates previously evaluated cleanup alternatives, and describes and evaluates new cleanup alternatives that reflect changes in land use. The EIS companion document to this RI/FS is also currently available for public review. This RI/FS, the companion EIS and public comment on both documents will inform Ecology’s preliminary selection of a cleanup alternative for the Whatcom Waterway site. The preliminary selected alternative will be articulated for public review in a draft Cleanup Action Plan (CAP). Following public review of the CAP, the cleanup will move forward into design, permitting, construction and long-term monitoring.

## **1.2 Document Organization**

This document is intended to be read in conjunction with the site Remedial Investigation report (Volume 1) and in conjunction with the companion Draft Supplemental EIS document (bound separately). This document contains periodic references to those other two documents.

This Feasibility Study was prepared consistent with the process defined under MTCA and SMS for identification of a preferred cleanup alternative. The organization of this document is as follows:

- **Summary of Key RI Findings:** Section 2 summarizes the key findings of the Remedial Investigation, including the Conceptual Site Model developed as part of the RI.
- **Cleanup Requirements:** Section 3 of the document then summarizes cleanup requirements for the site. These requirements include a definition of site cleanup levels and remedial action objectives that are to be met by the cleanup action. Also defined in Section 3 are the regulations and requirements other than those in MTCA and SMS regulations that are addressed by the cleanup and its implementation. Future permits or approvals that may be required for cleanup implementation are identified in that section.
- **Sediment Site Units:** In Section 4, the site is divided geographically into a series of “Site Units” that have different characteristics and that may warrant different types of cleanup based on these characteristics.
- **Technology Screening:** After definition of site units and cleanup requirements, Section 5 screens available technologies that could potentially be used to conduct site cleanup. The technology screening evaluates which of those technologies are most

appropriate to site conditions, consistent with Ecology and EPA guidance for contaminated sediment sites. Technologies that are retained after this screening process are then carried forward for the development of comprehensive cleanup strategies addressing the site. Because multiple potential strategies are analyzed in the Feasibility Study, these cleanup strategies are described in this document as “cleanup alternatives.”

- **Description of Cleanup Alternatives:** This Feasibility Study evaluates eight different cleanup alternatives. Each of these alternatives is described in detail in Section 6 of this report. The elements of the cleanup are described, along with a description of how each alternative achieves compliance with the cleanup requirements specified in Section 3. Each alternative uses a different combination of the cleanup technologies from Section 5.
- **MTCA & SMS Evaluation of Alternatives:** Consistent with MTCA and SMS regulations, each remedial alternative is evaluated against a set of defined criteria. The analysis is complex and addresses many factors required under the regulations as described in Section 7. From the MTCA and SMS regulatory analysis, preferred alternatives are identified, representing the alternative(s) that rank best overall among the evaluated alternatives.
- **Summary of EIS Evaluation:** Section 8 summarizes the findings of the companion EIS analysis.
- **Summary and Conclusions:** A summary and the conclusions of the Feasibility Study are provided in Section 9. References are included in Section 10 and appropriate backup information is attached as appendices.

## 2 Summary of Key RI Findings

This section provides a brief summary of the key findings of the Remedial Investigation (Volume 1 of this RI/FS), including the Conceptual Site Model (CSM) developed for the Whatcom Waterway site. The CSM provides a concise summary of the findings of the remedial investigation and is presented in Section 8 of the RI Report.

All information contained in this section is described in greater detail in Volume 1 of this RI/FS report. The reader should refer to that document for the detailed information on which the CSM is based.

### 2.1 Contaminants and Sources

As measured by relative concentration and frequency of detection, the principal contaminants in the site sediments are mercury, 4-methylphenol and phenol. Table 2-1 summarizes the principal contaminants and sources for the Whatcom Waterway site. The table includes a summary of the status of source control activities.

- **Mercury Contamination is Predominantly from Historical Sources:**  
The primary source of mercury within the Whatcom Waterway site sediments was the discharge of mercury-containing wastewaters from the chlor-alkali plant between 1965 and the 1970s. This historic source of mercury contamination has been controlled. Following initial pollution control upgrades by GP in the early 1970s, direct discharge of chlor-alkali plant wastewaters to the Whatcom Waterway was terminated. Then in 1999 the chlor-alkali plant was closed by GP, eliminating the generation of mercury-containing wastewater. The restoration of the Log Pond area in 2000 and 2001 controlled the secondary source of mercury, by capping impacted sediments in this area. Some regional and natural sources of mercury continue to exist, but these natural and regional sources are not expected to result in exceedances of Site screening levels.
- **Phenolic Compounds are Predominantly from Historical Sources:**  
The primary sources of phenolic compounds within the Whatcom Waterway Site sediments include historical wood products handling and log rafting, historical pulp mill discharges prior to implementation of primary and secondary wastewater treatment, and potential lesser contributions from historical stormwater and wastewater discharges. These sources have been controlled. Wood products handling activities are less common than there were historically, and additional regulatory and permitting requirements minimize the potential for discharges of wood wastes to sediments. Pulp mill wastewater discharges were better controlled after the

1960s and 1970s, and discharge of process wastewaters to the Whatcom Waterway was terminated in 1979. The pulp mill was closed by GP in 2000, terminating the discharge of pulp and chemical plant wastewaters to the aerated stabilization basin (ASB).

Because primary contamination sources have been controlled, the main focus of the remaining site cleanup actions will be to address secondary contamination sources, the residual contamination in sediments at the site.

A number of other contaminated sites are located in the vicinity of the Whatcom Waterway site and are being address by Ecology. These sites do not represent a current source control concern for Whatcom Waterway site sediments or surface water quality.

## 2.2 Nature and Extent of Contamination

The nature and extent of contamination impacts within the Whatcom Waterway site have been conclusively determined through over a decade of intensive investigations as part of the RI/FS and Bellingham Bay Pilot activities. These investigations in turn build on previous studies performed by academic researchers, regulatory agencies and local industry and government. The result is a wealth of knowledge about site conditions, and the factors that influence the selection of a final site cleanup.

The findings of the site investigations are the focus of the RI report. Table 2-2 provides a quick summary of the principal RI activities and their findings. These findings are graphically displayed in the Conceptual Site Model in Figures 2-1 and 2-2. Site screening levels discussed in this section are defined in Section 4 of the RI Report.

- **Waterway Sediments:** The Whatcom Waterway sediments generally consist of a layer of soft, silty, impacted sediments. The elevation and thickness of the impacted layer varies with location, but is generally between 2 and 10 feet in thickness. The sediments are thickest in historically dredged and filled areas along the Inner Waterway. The impacted Waterway sediments are subject to natural recovery by ongoing deposition of clean sediments. Except in some high-energy, nearshore areas offshore of the ASB, the impacted sediments are covered by a layer of clean sediments. These clean sediments have been naturally deposited, and the surface sediments of the bioactive zone comply with sediment screening levels protective of environmental receptors. This process of natural recovery is expected to continue into the foreseeable future. Mercury concentrations within the site subsurface sediments are typically in the low part-per-million range, and average subsurface mercury concentrations decrease with distance from the Log Pond source area. Phenolic compounds

are also present in the Waterway in the low part-per-million range. The highest phenolic concentrations were detected in subsurface sediments within the Inner Waterway, near the historic pulp mill effluent discharge locations from the 1950s and 1960s. The impacted sediments are underlain by clean, native sandy sediments of varying thicknesses.

- **Log Pond Sediments:** The Log Pond area was the site of the historic mercury-containing wastewater discharge from the chlor-alkali plant during the 1960s and 1970s. Subsurface sediments in this area contain the highest mercury levels present at the site. Ecology determined that removal of these sediments was not technically practicable. This area was remediated by capping as part of an Interim Action that was implemented in 2000 and 2001. Sediment monitoring since that time has demonstrated that the cap is performing well, and is successfully preventing underlying contaminants from migrating upward through the cap. Monitoring of groundwater discharges in the cap area has demonstrated no ongoing impacts to surface water quality or cap conditions from the adjacent chlor-alkali plant upland areas. Biological monitoring has demonstrated that the capped area has recovered biological functions for benthic and epibenthic organisms, for juvenile salmonids and shellfish. Tissue monitoring has demonstrated that bioaccumulation risks have been successfully controlled, and crab tissue sampled from the area is not significantly different from crab tissue collected from clean reference sites. Some wave-induced erosion has been noted at the shoreline edges of the cap, and enhancements to these areas will be required to prevent cap recontamination and to maintain the long-term protectiveness of the remedy. The Feasibility Study includes proposed cap enhancements as part of the final remedial alternatives for the Whatcom Waterway site.
- **ASB Areas:** Figure 2-2 provides a graphical summary of the conditions in the ASB area. The ASB was originally constructed as a stone, sand and clay berm, enclosing a basin dredged in 1978. Some impacted sediments exist underneath portions of the berm. However, the berm consists primarily of clean materials imported at the time of construction. Testing and engineering evaluations have shown that the berm materials are of sufficient quality for reuse. A thick layer of wastewater treatment sludges has accumulated within the ASB. These sludges are soft, flocculant, high-organic materials containing elevated levels of mercury, phenolic compounds and other contaminants. However, the sludges have not significantly impacted the clean native sands underlying the basin. The evaluation of potential remedial alternatives for the ASB area will take into account the special



physical and chemical properties of the ASB materials, and the potential future uses of the ASB area.

- **Starr Rock Area:** Site investigations have documented the nature and extent of contamination present at the former Starr Rock dredge disposal site. This area is located in a deep-water, low energy portion of the Whatcom Waterway site. Natural recovery has occurred in this area, with impacted mercury and phenol-impacted sediments being covered by clean sediments. There are no current exceedances of site screening levels in this area.

## 2.3 Fate and Transport Processes

Sediments within the Whatcom Waterway site are acted upon by natural and anthropogenic forces that affect the fate and transport of sediment contaminants. Significant fate and transport processes evaluated as part of the RI include the following:

- **Sediment Natural Recovery:** Processes of natural recovery have been extensively documented within the Whatcom Waterway site. Sediments in most areas of the site are stable and depositional, and clean sediments continually deposit on top of the sediment surface. RI investigations have documented depositional rates and have verified that patterns of deposition and natural recovery are consistent throughout most site areas. The exception to this general observation is in nearshore, high-energy areas where recovery rates are reduced by the resuspension of fine-grained sediments. In all other areas of the site, cleaner sediments are consistently observed on top of impacted sediments. As part of the 2000 RI/FS, site data and recovery models were used to produce quantitative estimates estimate natural recovery rates. These estimates were then empirically verified by resampling surface sediments and comparing observed recovery rates with model predictions.
- **Erosional Processes:** The effects of wind/wave erosional forces represent the principal natural process affecting sediment stability. RI investigations and FS engineering evaluations have identified high-energy, nearshore areas where the natural deposition of fine-grained sediments does not occur, or occurs at slower rates. In these areas, fine-grained sediments can be resuspended, mixed and/or transported by wave energy. The erosional forces vary with location, water depth, sediment particle size and shoreline geometry. These forces are minimal in deep-water areas which represent the majority of the Whatcom Waterway site. The FS incorporates analyses of erosional forces in consideration of site remediation areas and applicable technologies.

- **Navigation Dredging and Shoreline Infrastructure:** Navigation dredging and the construction of associated shoreline infrastructure have been prominent features of the Whatcom Waterway site, and have shaped the current site lithology. The RI/FS includes extensive discussion of historic and future navigation and infrastructure issues that could affect the fate of site sediments. The FS incorporates potential future dredging activities as part of the evaluation of the long-term effectiveness of the remedial alternatives. The companion EIS document assesses the inter-relationships between site cleanup decisions and community land use and habitat enhancement objectives, consistent with the requirements of SEPA regulations and the goals of the Pilot.
- **Other Processes:** As part of the evaluation of sediment stability, the RI included a discussion of bioturbation, prop wash and anchor drag. These processes can result in periodic disturbances of the sediment column, and can enhance mixing of surface sediments with underlying sediments. These processes are all ongoing and are incorporated in the empirically measured rates and performance of natural recovery. However, they are relevant in the evaluation of the long-term stability of subsurface sediments. Prop-wash in particular will affect sediment stability in near-shore navigation areas. These factors are incorporated into the FS analysis of remedial alternatives.

## 2.4 Exposure Pathways and Receptors

Section 4 of the RI report discusses the principal environmental receptors and exposure pathways applicable to the Whatcom Waterway site. That section also discusses the site screening levels that are used to evaluate protection of these receptors. Exposure pathways and receptors are illustrated in Figures 2-1 and 2-2, and are summarized in Table 2-4.

- **Protection of Benthic Organisms:** The primary environmental receptors applicable to the Whatcom Waterway site consist of sediment-dwelling organisms. These benthic and epibenthic invertebrates are located near the base of the food chain and are important indicators of overall environmental health. Both chemical and biological monitoring are used to test for potential toxic effects. Chemical and biological standards specified under SMS are used to screen for such effects. The use of SMS whole-sediment bioassays provides an ability to test for potential synergistic effects between multiple chemicals, and to test for potential impacts associated with parameters that may not have been measured as part of chemical testing.

- **Protection of Human Health:** Mercury is one of the primary contaminants present at the Whatcom Waterway site. Mercury can be converted to methylmercury, which in turn can bioaccumulate through the food chain. As part of the 2000 RI/FS a bioaccumulation screening level (BSL) was developed that would be protective of both recreational and tribal fishing and seafood consumption practices as described in Section 4 of the RI Report. The BSL was developed using conservative exposure assumptions, to ensure that the value would be protective. An additional degree of protectiveness has been obtained in the way that the BSL is applied to the site decision-making. Specifically, the BSL has been applied as a “ceiling” value for all surface sediments at the site, including individual data points or clusters. This application provides a substantial additional degree of protectiveness, because it is the area-weighted average sediment mercury concentration that drives biological risks. Area-weighted average concentrations within the Whatcom Waterway site are currently between two and three times lower than the BSL itself. The FS considers remediation of all areas exceeding the BSL on a point-by-point basis, even though the area-weighted average is already below the BSL. This application of the BSL further reduces the potential risks associated with the site. The result is to maintain a robust level of protectiveness, in excess of that required to protect human health under reasonable assumptions.
- **Protection of Ecological Health:** As with human health, ecological receptors can be impacted by mercury bioaccumulation. However, the application of the BSL to cleanup at the site ensures protectiveness to ecological receptors. The protectiveness of the BSL to ecological receptors was evaluated in several ways as part of the RI process. First, the protectiveness of the BSL was evaluated against potential marine mammal exposures. The Second, bioaccumulation testing has been performed on sediments from the Whatcom Waterway site at concentrations exceeding the BSL, demonstrating no significant bioaccumulation at these sediment concentrations. Third, tissue monitoring has been performed at the site as part of the Log Pond Interim Action. That monitoring has shown that compliance with the BSL prevents the accumulation of mercury in crab tissue in comparison to clean reference areas. Based on these three lines of evidence, the compliance with the mercury BSL and with SMS criteria for benthic organisms results in protection of ecological receptors.
- **Other Considerations:** The FS includes evaluations of remedial technologies that may trigger new exposure pathway and receptor risks. For example, dredging of impacted sediments triggers short-term risks at the point of dredging and in material handling areas,

and during transport of these materials to the disposal site. Additional exposure pathways and receptors are potentially affected at the location of dredge material disposal. The RI included engineering testing that was focused on providing empirical data necessary to evaluate these additional exposure pathways and receptor risks. These data are then used as part of the FS, in conjunction with applicable regulatory guidelines and requirements, to evaluate the feasibility, protectiveness and costs of different remedial strategies.

## 3 Cleanup Requirements

This section describes the cleanup requirements that must be met by the cleanup of the Whatcom Waterway site. Consistent with MTCA and SMS requirements, this section addresses three types of requirements:

- **Cleanup Levels (Section 3.1):** Cleanup levels represent the numeric and/or narrative standards that must be met by a cleanup action in order for it to be considered successful. These standards are based on MTCA and SMS requirements.
- **Remedial Action Objectives (Section 3.2):** Remedial action objectives are narrative statements about the types of actions that must be performed to ensure compliance with the cleanup levels.
- **Potentially Applicable Laws (Section 3.3):** In addition to the requirements of the SMS and the MTCA, many other laws potentially apply to sediment cleanups.

These requirements are described below, and in the tables of this section. Technologies capable of meeting these requirements are then screened in Section 5, and cleanup alternatives are developed and ranked in Sections 6, 7 and 8.

### 3.1 Site Cleanup Levels

The Whatcom Waterway site is defined by contaminated sediment. Cleanup levels applicable to sediments are defined by SMS regulations as described in Section 3.1.1 below. Some cleanup alternatives may trigger the applicability of cleanup levels for other media, particularly soil and groundwater. These potentially-relevant cleanup levels are described in Section 3.1.2.

#### 3.1.1 Sediment Cleanup Levels

SMS regulations govern the identification and cleanup of contaminated sediment sites and establish two sets of numerical chemical criteria against which surface sediment concentrations are evaluated. The more conservative Sediment Quality Standards (SQS) provide a regulatory goal by identifying surface sediments that have no adverse effects on human health or biological resources. The minimum cleanup level (MCUL) (equivalent to the Cleanup Screening Level or CSL), represents the regulatory level that defines minor adverse effects.

The SQS is Ecology's preferred cleanup standard, though Ecology may approve an alternate cleanup level within the range of the SQS and the MCUL if justified by a weighing of environmental benefits, technical feasibility, and

cost. Chemical concentrations or confirmatory biological testing data may define compliance with the SQS and MCUL criteria.

The primary cleanup levels for the Whatcom Waterway site are defined as the SQS, as measured using bioassay testing procedures. Chemical numeric standards may also be used to evaluate SQS, but bioassays are given preference under SMS regulations because they are considered a more direct and representative measure of potential biological effects. The bioassay test methods that may be used to evaluate compliance with the SQS are defined in current Ecology regulations and guidance and include tests using the amphipod, larval or juvenile polychaete tests.

Based on the series of sediment investigations performed for surface and subsurface sediments in 1996, 1998, and 2002, the key constituents of concern for the sediments in the Whatcom Waterway site areas include mercury and phenolic compounds. The chemical SQS for mercury is 0.41 mg/kg. The chemical MCUL for mercury is 0.59 mg/kg. These levels apply to total mercury, which is the parameter measured directly in the RI chemical testing program. The main phenolic compound detected at elevated concentrations at the site was 4-methylphenol. The SQS and MCUL values for 4-methylphenol are both 0.67 mg/kg. The phenolic compounds phenol and 2,4-dimethylphenol were noted sporadically in surface sediments. The SQS and MCUL values for 2,4-dimethylphenol are both 0.029 mg/kg.

In addition to the evaluation of benthic effects and compliance with the SQS, cleanup levels at the site must protect against other adverse effects to human health and the environment, including food chain effects associated with the potential bioaccumulation of mercury. As described in the RI report, a site-specific BSL of 1.2 mg/kg mercury was developed as part of the RI/FS process. This BSL provides an area-wide average concentration of mercury in sediments that is protective of subsistence-level human consumption of seafood from Bellingham Bay. Bioaccumulation testing performed as part of the RI/FS and related studies has demonstrated that sediment mercury concentrations below this value do not present a risk of food chain effects to ecological receptors. Ecology has conservatively applied the BSL as a cleanup level that must be met for surface sediments within the site, whether or not the area-wide average concentration of mercury exceeds the BSL. This conservative application of the BSL by Ecology provides a substantial additional level of protectiveness to site cleanup decisions.

Consistent with the SMS regulations, sediment cleanup levels apply to the sediment bioactive zone. Previous studies performed as part of the RI/FS documented that this zone consists of the upper 12 centimeters of the sediment column. The cleanup levels do not directly apply to subsurface sediments, but remedial action objectives require that the potential risks of the exposure of deeper sediments be considered and be minimized through the implementation of the cleanup action.

### 3.1.2 Cleanup Levels for Other Media

Under certain remedial scenarios, the sediments at the site could also be regulated under other programs with regulatory cleanup levels different from SMS criteria, or could potentially impact other media. For example, if the sediments were excavated and were reused as upland soil, then MTCA soil and/or groundwater cleanup levels could be relevant. Additional criteria considered include state and federal water quality criteria, the Puget Sound Dredged Disposal Analysis program (PSDDA), the State of Washington Dangerous Waste Regulations, and the federal Resource Conservation and Recovery Act (RCRA). Table 3-1 summarizes cleanup levels for media other than sediment that may be applicable to various remedial alternatives.

## 3.2 Remedial Action Objectives

Based on the site conditions and current regulations, remedial goals applicable to the site include the following:

- **Surface Sediments:** Use appropriate technologies including active and/or passive measures to ensure compliance with site cleanup levels as defined in Section 3.1 for the sediment bioactive zone
- **Subsurface Sediments:** Where subsurface sediments have the potential to become exposed, use appropriate technologies including active and/or passive measures to ensure long-term compliance with site cleanup levels in the bioactive zone as defined in Section 3.1
- **Applicable Laws:** Ensure that implementation of the remedial action complies with other applicable laws.

These remedial action objectives are used in subsequent sections of the Feasibility Study to assist in the development, evaluation and ranking of remedial alternatives. The analyses conducted in Sections 7 and 8 of this report ensure that these remedial action objectives are achieved by the preferred remedial alternatives.

## 3.3 Potentially Applicable Laws

In addition to the requirements of the SMS and the MTCA, many other laws potentially apply to sediment cleanups. These other potential regulatory requirements are listed in Tables 3-1 through 3-3 and are discussed briefly below. Applicable laws will be discussed in further detail for the selected cleanup action at the time the Cleanup Action Plan is completed.

### 3.3.1 Project Permitting and Implementation

Table 3-2 summarizes regulatory requirements that may impact project permitting and implementation. For actions conducted under a MTCA Order

or a Consent Decree, the project would be exempt from state and local permits and procedural requirements. However, MTCA requires compliance with the substantive provisions of these regulatory programs. MTCA does not contain a procedural exemption from federal permitting.

Construction projects are subject to environmental impact review under SEPA and/or NEPA regulations. The SEPA review for the cleanup of the Whatcom Waterway site is being completed by Ecology through the Draft Supplemental Bellingham Bay Comprehensive Strategy EIS; companion document to the RI/FS. NEPA review will be completed in the future at the time of project permitting by the Corps of Engineers.

The City is currently updating their State-mandated Shoreline Master Plan (SMP) which regulates and manages uses and activities within 200 feet of the shorelines of the City. Shoreline regulations defer to Ecology for site-specific review of cleanup actions conducted under MTCA, provided that those actions are consistent with the substantive requirements of the Shoreline Master Program. The City and Port are working with the Bellingham community to ensure that the land use vision articulated in the Waterfront Vision and Framework Plan is reflected in the SMP update. The SMP update is expected to be completed in early 2007.

As part of the Cleanup Action Plan development, a request will be made to the City of Bellingham and the Department of Fish and Wildlife for a written description of their substantive permit requirements for the preliminary selected remedy. This additional information will be included in the Cleanup Action Plan.

Federal permitting for in-water construction can be implemented under either a Federal 404 Individual permit, or under a Nationwide 38 permit. The federal permitting process includes review of issues relating to wetlands, tribal treaty rights, threatened and endangered species, habitat impacts, and other factors. It is anticipated that the cleanup of the Whatcom Waterway site will be performed using a Federal 404 Individual permit. Where appropriate, that permit will include related actions (e.g., updates to shoreline infrastructure, habitat enhancement projects).

### **3.3.2 Treatment and Disposal**

Table 3-3 summarizes regulatory requirements potentially applicable to sediment treatment or disposal alternatives.

In-water containment, treatment, or disposal options are affected by a series of permits and evaluation criteria including those of the Clean Water Act and the Rivers and Harbors Act, as well as the Washington Hydraulics Code. Dredged material disposal at PSDDA disposal sites or beneficial use of dredged material are regulated by the Dredged Materials Management Program (DMMP) Guidelines.



Alternatives involving sediment disposal on state-owned lands require use authorizations from the Washington Department of Natural Resources (WDNR). These are provided consistent with requirements of state regulations and the state constitution. Where disposal occurs on private lands or as part of a multi-user disposal site, the disposal could be regulated by a series of agreements specific to that disposal facility. Use authorizations or other property-owner agreements can be required for some activities on privately-owned or state-owned aquatic lands.

As shown in Table 3-3, upland off-site disposal options are regulated under the state Solid Waste Regulations (WAC 173-303 and WAC 173-350). For alternatives involving sediment treatment or upland handling, air emissions regulations may apply. These requirements result in limitations on materials accepted by fixed treatment facilities. Requirements such as dust control result from these regulations for upland sediment handling activities.

## **Water Management**

For remediation alternatives involving water generation, the discharge of generated waters may be regulated under state and federal regulations. Discharges from upland areas to surface waters require permits under restrictions of the National Pollutant Discharge Elimination System (NPDES) program. Discharges to the sanitary sewer are subject to pretreatment standards and local discharge standards and permitting.

## **Puget Sound Dredged Material Management Program**

In Puget Sound, the open water disposal of sediments is managed under DMMP. This program is administered jointly by the US Army Corps of Engineers, the US Environmental Protection Agency, the WDNR, and Ecology. The DMMP has developed the PSDDA protocols which include testing requirements to determine whether dredged sediments are appropriate for open-water disposal. The DMMP has also designated disposal sites throughout Puget Sound. While some PSDDA characterization work has been performed at the Whatcom Waterway site, if a remedial alternative is ultimately selected by Ecology that includes PSDDA disposal of sediments, additional characterization work will be required. Use of PSDDA facilities would need to comply with other DMMP requirements including material approval, disposal requirements and payment of disposal site fees.

## **Solid Waste and Dangerous Waste Criteria**

Sediments that are dredged and transferred to upland management may be subject to additional profiling requirements and/or other requirements under federal RCRA regulations and under Washington State Dangerous Waste regulations. However, as described in the RI, state-only toxicity designations and federal TCLP and listing criteria have been evaluated as part of the RI/FS activities and are not anticipated to impact Whatcom Waterway sediment disposition.

The Whatcom County Health Department has primary jurisdictional responsibility for the regulation of solid wastes in the county. They must implement, as minimum standards, the state Solid Waste Handling Standards (WAC 173-350).

The Solid Waste Handling Standards are applicable to and apply specific requirements and permitting for the handling of contaminated soils and “*contaminated dredged material*” (WAC 173-350).

- “*Contaminated dredged material*” means dredged material resulting from the dredging of surface waters of the state where contaminants are present in the dredged material at concentrations not suitable for open water disposal and the dredged material are not dangerous wastes and are not regulated by section 404 of the Federal Clean Water Act (P.L. 95-217).

Sediments managed in other Solid Waste facilities must comply with applicable permit requirements for the receiving facility. Some landfills may require elimination of free liquids from sediments prior to landfill disposal, whereas other facilities are permitted to accept wet sediments for use as daily cover.

## 4 Sediment Site Units

This FS evaluates potential cleanup alternatives for the Whatcom Waterway site. At most cleanup sites, the application of remediation technologies varies across the site, with different technologies being applied to appropriate site areas to accomplish overall site remediation. The division of the site into different areas or “Sediment Site Units” is performed in this section consistent with the requirements of the Sediment Management Standards. In accordance with the SMS, these units are “based on consideration of unique locational, environmental, spatial, or other conditions” (WAC 173-204-200(25)).

This section describes the sediment site units (site units) that are used for the FS, and discusses the characteristics of each of those units. Key characteristics of each site unit that are relevant to the application of remedial technologies and/or the evaluation of remedial alternatives are discussed. These characteristics are described in four groups:

- **Physical Factors** including bathymetry, sediment particle size and texture, wood material distribution, wind and wave energies, and the characteristics of adjacent shorelines
- **Land Use and Navigation** including upland zoning, shoreline infrastructure, navigation uses, natural resources, ongoing waterfront revitalization activities, and potential interrelationships between cleanup considerations and these factors
- **Natural Resources** including the types of existing aquatic habitats within the site unit
- **Contaminant Distribution**, including patterns of surface and subsurface contamination and relative contaminant concentrations.

Figure 4-1 shows the Whatcom Waterway site units used in this FS. These site units are generally consistent with the site units used in previous FS analyses performed in 2000 and 2002. Site units have been numbered 1 through 8 as shown on Figure 4-1. Characteristics of each of the site units are described below.

### 4.1 Outer Whatcom Waterway (Unit 1)

The Outer Whatcom Waterway includes portions of the Whatcom Waterway located offshore of the Bellingham Shipping Terminal. Unit 1 is divided into three subareas:

- **Units 1A and 1B:** These sub-areas are located offshore of the Bellingham Shipping terminal and connect the outer portions of the Whatcom Waterway to deepwater areas of Bellingham Bay

- **Unit 1C:** This portion of the Waterway is located immediately adjacent to the Bellingham Shipping Terminal. Based on bathymetry, this unit is subdivided into Units 1C1, 1C2 and 1C3.

#### **4.1.1 Physical Factors**

The Outer Whatcom Waterway consists of deep-water areas of the Whatcom Waterway navigation channel. Current water depths in this area vary from approximately 30 feet to greater than 36 feet. These depths are largely the result of historical dredging activities in the Waterway.

Sediments in the Outer Waterway are dominated by fine particle size distributions (silts and clays), with a total fines content generally greater than 80 percent. The TOC content of the sediments is generally between 1 and 5 percent, consistent with average TOC distribution for the site.

The bathymetry in most areas of the Outer Waterway is relatively flat, with slopes flatter than 10H:1V. However, slopes become significant along the outer edges of the Waterway, including at the Bellingham Shipping Terminal. The shoreline at the Bellingham Shipping terminal is an engineered slope, including a pile-supported concrete bulkhead and areas of armored slope.

#### **4.1.2 Land Use and Navigation**

Navigation uses in Units 1A and 1B of the Outer Waterway are largely transitory, with vessels entering and exiting the Waterway. Vessels are generally not anchored in these areas, and there are no permanent dock structures or mooring dolphins.

In contrast, the areas of Unit 1C include berths for vessels at the Bellingham Shipping Terminal. Propwash effects from vessel traffic are potentially significant at Unit 1C from vessel berthing activities, including both operations of tug boats and potentially the use of bow thrusters on some vessels. Some areas of coarse sediment have been identified along the Unit 1C shoreline near the berth, consistent with fines redistribution common with prop wash effects. Shell accumulations common in berth areas (caused by shells falling from sea life encrusted on dock pilings) may also affect observed particle sizes in this area.

A federal navigation channel is located in the Outer Waterway. As described in the RI Report, federal navigation channels represent a conditional agreement between the Corps of Engineers and a local entity (the “local sponsor,” in this case the Port of Bellingham) under which the federal government shares the cost and assists with the implementation of certain defined navigation maintenance activities. The limits of the federal commitment are defined geographically by the dimensions of the “project.” For the Outer Waterway, the project depth is defined as 30 feet below mean

lower low water (MLLW) and the width varies from 263 feet in Unit 1C to 363 feet in Units 1A and 1B.

Figure 4-2 illustrates the essential characteristics of the federal channel and berth areas applicable to Unit 1C of the Outer Waterway. The water depths are maintained at or slightly below the “project depth” of 30 feet in the federal channel areas. The federal channel boundaries are offset from the wharf areas by approximately 50 feet. This “berth” area is defined along the inshore edge by the “pierhead line” and along the offshore edge by the federal channel boundary. Depths in this area are maintained by local interests. Construction is generally prohibited in areas offshore of the pierhead line, and is regulated by the Corps of Engineers and the Coast Guard.

As shown in Figure 4-2, the maintenance of water depths and navigation access in the Unit 1C berth area requires maintenance of substantial shoreline infrastructure. That infrastructure includes bulkheads, engineered armored slopes and over-water wharves that provide for mooring and loading/unloading of vessels moored at the berths. In order to meet the economic needs test of the Corps of Engineers maintenance dredging program, upland land uses are restricted and are designated in Unit 1-C for appropriate water-dependent uses, consistent with the federal channel designation.

The Bellingham Shipping Terminal has been used since the early 1900s for cargo shipping and warehousing activities. The Port recently completed an analysis of federal channel and infrastructure issues in development of Port Commission Resolution 1230 in May of 2006. That Resolution affirmed the intent of the Port to preserve and maintain the current federal channel dimensions in the Outer Waterway area to support deep draft navigation and commercial uses (e.g., use by appropriate institutional users such as the Coast Guard or NOAA). The shoreline infrastructure required for operation of a shipping terminal is present in this area, though significant maintenance and potential upgrades may be required prior to resumption of deep draft uses.

### **4.1.3 Natural Resources**

The areas of the Outer Waterway are composed largely of deepwater aquatic areas. No areas of existing premium nearshore aquatic habitat (shallow-water habitat with appropriate elevation, substrate, wave energy and other characteristics to maximize the benefits of the habitat to juvenile salmonids) are located in the Outer Waterway area. Shallow-water nearshore habitats in the Outer Waterway area are limited to under-dock areas along the Bellingham Shipping Terminal.

### **4.1.4 Contaminant Distribution**

Surface sediments within the Outer Waterway comply with the SMS. All of the surface samples collected recently in this area have passed bioassay testing

(Figure 2-3), and no exceedances of the site-specific BSL for mercury were noted in the most recent sampling round.

Subsurface sediment concentrations in the Outer Waterway are generally quite low (Figures 2-4 and 2-5). As described in Section 7.2 of the RI Report, previous sediment testing suggests that the sediments in Units 1A and 1B may be suitable for open-water disposal or beneficial reuse. In the areas of Unit 1C, sediment contaminant levels are higher, likely precluding these sediments from open water disposal.

## 4.2 Inner Whatcom Waterway (Units 2 and 3)

The Inner Waterway extends from the Bellingham Shipping Terminal to the head of the Waterway at Roeder Avenue. The Roeder Avenue Bridge crosses the waterway at that location and precludes navigation further upstream. The Inner Waterway has been subdivided into two units designated “Unit 2” and “Unit 3.” Each of these site units has been further subdivided:

- **Unit 2A:** Shoaled areas at the head of the 30-foot portion of the 1960s federal navigation channel
- **Unit 2B:** An area between the Whatcom Waterway and the ASB that has been considered for future construction of an access channel as part of ASB marina reuse
- **Unit 2C:** Deep areas of Unit 2, including portions of the federal channel where water depths currently exceed 24 feet below MLLW
- **Unit 3A:** An emergent tideflat area located at the head of the Waterway, adjacent to the Roeder Avenue Bridge
- **Unit 3B:** The shoaled area of the 18ft federal channel in between the emergent tideflat of Unit 3A and Unit 2A.

The characteristics of these Inner Waterway areas are described below.

### 4.2.1 Physical Factors

The water depths within the Inner Waterway vary greatly. Existing water depths range from greater than 30 feet below MLLW, to intertidal areas that are exposed at low tide. Areas of shallow-water habitat are predominantly located in Unit 3A at the head of the channel and along the berth areas on either side of the federal channel.

The bathymetry of the federal channel is relatively flat. However, sideslopes along either side of the waterway steepen in the berth areas. Historically these side-slopes were hardened with infrastructure for industrial water-dependent

uses. Most shorelines include armored slopes, bulkheads and over-water wharves. However, much of the Inner Waterway shoreline infrastructure is in fair to poor condition. In portions of the Central Waterfront, bulkheads have failed in part or in full, and portions of wharves have collapsed. The state of repair for shoreline infrastructure varies parcel by parcel along the waterway.

Currently, the effective water depths for the Inner Waterway are controlled by the restrictions of the federal navigation channel. Construction is not allowed past the pierhead line, so the water depths at the pierhead line establish the effective water depth for the Inner Waterway. That effective water depth varies from less than zero (in areas where sediments at the pierhead line have shoaled and are exposed at low tide) to a maximum of approximately 22 feet below MLLW. Though the project depth for portions of the federal channel is 30 feet, this depth is not currently maintained in any berth areas, and is not supported by requisite shoreline infrastructure in most areas. Most of the shoreline infrastructure in the Central Waterfront area and near the head of the waterway was established when the waterway project depth was 18 feet. The ability to establish and maintain the full project depth is restricted by the relatively narrow width of the waterway and the existing shoreline conditions.

Sediment texture in the Inner Waterway is generally dominated by fine sediments. The total fines content of Inner Waterway sediments is generally in excess of 80 percent. However, berth areas are armored with rubble, asphalt debris and armor stone in most areas. Sand and gravel are present in some emergent tideflat areas at the head of the waterway, and in beach areas along-side portions of the waterway.

Whatcom Creek enters the Whatcom Waterway upstream of the Roeder Avenue Bridge. Salinities of the inner waterway vary with tide stage and flood level of Whatcom Creek, as freshwater discharges from the creek and mixes with saline waters of Bellingham Bay.

## **4.2.2 Land Use and Navigation**

Like the Outer Waterway, the Inner Waterway has historically been used for industrial water-dependent uses. As described in the RI Report (Section 3.3.3) the federal navigation channel was initially established in the early 1900s, and was updated most recently in 1958 in support of industrial waterfront uses. Portions of the Inner Waterway were deepened in the 1960s to comply with the updated channel dimensions, but other portions were never deepened due to the lack of supporting berth area water depths and requisite shoreline infrastructure. The width of the Waterway is constrained by developed fill areas and upland features adjacent to the Waterway.

As described in the RI Report, the Port recently completed an analysis of federal channel and infrastructure issues in development of Port Commission Resolution 1230 during May of 2006. That Resolution was developed in response to inconsistencies between the community revitalization objectives

as articulated in the Waterfront Futures Group Vision and Framework Plan, and the land use constraints associated with the federal channel within the Inner Waterway area. Specifically, the Resolution stated that the development of new industrial land uses, deep berthing areas, shoreline bulkheads and deep draft navigation infrastructure as required to establish a federal interest in future channel maintenance in this area is inconsistent with the community vision for multiple waterfront uses in the Inner Waterway area, including public shoreline access, habitat enhancement, transient moorage and mixed-use redevelopment. The Resolution articulated that greater benefits could be achieved through operation of a locally-managed, multi-purpose channel in the Inner Waterway, in a manner responsive to the community vision. The Port Resolution followed a previous Port and DNR Memorandum of Understanding completed during 2005, including a proposal to update harbor area and Whatcom Waterway channel dimensions.

Port Resolution 1230 proposed that the portion of the federal navigation channel within the Inner Waterway be de-authorized, and subsequently managed as a locally managed multi-purpose channel from the Bellingham Shipping Terminal inward to the Roeder Avenue Bridge. The Port formally requested the Washington State Congressional Delegation to include language in appropriate legislation to de-authorize the Inner Waterway portion of the Whatcom Waterway federal channel. Congressional approval of de-authorization is expected to occur during late 2006. The de-authorization will not affect the Outer Waterway (i.e., the area at and offshore of the Bellingham Shipping Terminal).

Figure 4-3 illustrates the type of shoreline infrastructure that has been considered for the Inner Waterway as part of Port marine infrastructure planning efforts. The figure was developed by the Port as part of the federal channel and marine infrastructure review activities during 2005 and 2006. The design concept (Figure 4-3) includes shoreline public access and navigation improvements compatible with area mixed use zoning and redevelopment planning. The use of softened shorelines along the sides of the waterway, rather than industrial wharves and bulkheads, has been proposed to help restore natural shoreline functions where compatible with planned navigation uses. Navigation depths within the Inner Waterway are to be maintained appropriate to the channel widths and updated shoreline infrastructure, and would most likely range between 18 to 22 feet below MLLW. During the Bellingham Demonstration Pilot, the area within Unit 3A was identified as a priority location for maintenance and enhancement of premium shallow-water habitat. A former wharf structure was removed by the City as part of cleanup and restoration actions in this area. Preservation of the emergent tideflat in this area was proposed as part of the preferred alternative from the 2000 EIS, and its preservation was referenced as part of the materials supporting Port Resolution 1230.



Throughout much of the Inner Waterway, the historic industrial infrastructure present along the shorelines results in lower-value habitats in nearshore areas, due to the presence of shading, over-water structures, bulkheads and steep armored slopes. The stated objectives of Port Resolution 1230 and its supporting materials were to support the implementation of habitat enhancement and salmon recovery efforts within the Inner Waterway, including the replacement of industrial shoreline infrastructure with shoreline treatments such as those in Figure 4-3 where practicable.

The navigation needs associated with Unit 2B are controlled by the future reuse of the ASB. As described below, the ASB area has been identified in Port and City planning efforts for development of a new waterfront marina. Planning efforts have focused on the ability to develop an environmentally sustainable marina, including integrated public access and habitat enhancement elements in the design concept. All of the recent design concepts for the marina (Figure 4-4) have identified Unit 2B as the optimum location for construction of a marina access channel. This location is preferred because it minimizes the disruption of shallow-water habitat areas (current features and potential future habitat enhancements) offshore of the ASB, and it would make use of existing navigation infrastructure within the Whatcom Waterway.

### **4.2.3 Natural Resources**

The Inner Waterway includes a mixture of deepwater areas, and areas of emergent shallow-water habitat. Shallow-water habitat areas at the head of the Waterway and along portions of its sides are valuable forage and refuge areas as part of migration corridors for juvenile salmonids.

The preservation and enhancement of these areas was identified as a priority action under the Demonstration Pilot. However, the ability to accomplish this action is subject to balancing of habitat needs with infrastructure and navigation requirements.

### **4.2.4 Contaminant Distribution**

With the exception of localized areas adjacent to the Colony Wharf site, surface sediments within the Inner Waterway comply with SMS bioassay criteria. Mercury concentrations are in most cases below the site-specific BSL (see Figure 2-3). While subsurface contaminant concentrations are relatively low (Figure 2-4 and 2-5), previous testing has indicated that sediments removed from the Inner Waterway are unlikely to be suitable for open water disposal or beneficial reuse (RI Report, Section 7.2).

## **4.3 Log Pond (Unit 4)**

The Log Pond area was remediated as part of an Interim Remedial Action, completed by GP in 2000 and early 2001. The Log Pond action included placement of a sediment cap to remediate site sediments, and additional actions to enhance nearshore aquatic habitat in that area. Multiple rounds of

monitoring have been performed, documenting the success of that action, including Year 1, Year 2 and ongoing Year 5 monitoring. However, some enhancements to shoreline edges of the Interim Action cap are required to minimize potential cap erosion, and enhance the long-term stability of the cap. These additional actions are described in Appendix D of this Feasibility Study.

### **4.3.1 Physical Factors**

The Log Pond was created as various fills were placed around the area. It was used for log handling and was the location of the original wastewater outfall from the GP chlor-alkali plant to Bellingham Bay, prior to construction of the ASB. An interim cleanup action consisting of the construction of a combination sediment cap and habitat enhancement was completed in the GP Log Pond in 2001.

Prior to the Interim Action, the Log Pond had a bottom elevation that was typically approximately -10 feet MLLW, with slopes up to the shorelines, and down to approximately -26 feet MLLW at the intersection with the Whatcom Waterway. During the Interim Action, approximately 42,000 cubic yards of sediment were placed, with thicknesses ranging up to 6 feet, with a typical design thickness of greater than 3 feet, and an average thickness as placed of 3 to 4 feet. This brought the bottom elevation up so that it was generally on the order of -3 to -4 feet MLLW, and sloped up to the shorelines, and down to the Whatcom Waterway.

Currently, there are very few structures within the Log Pond. A pile-supported conveyor system exists along the Bellingham Shipping Terminal shoreline, a dolphin (i.e., cluster of pilings) is located within the log pond, and there are numerous pilings along the shoreline. A wharf extends to the southwest, in front of the Log Pond along a portion of the Waterway.

The shoreline prior to the interim action was generally composed of riprap and concrete rubble slopes and wooden and steel sheet-piling bulkheads down to a depth of approximately -5 feet MLLW. These shorelines were left in place through construction.

The sediments in the GP Log Pond prior to the interim action ranged from sandy to very sandy organic silt and clay with a slightly clayey sand with some gravel near the shoreline. The solids content of the sediments ranged from approximately 25 to 40 percent, with an average around 30 to 35 percent. In the northeast end of the pond, a large (>50 percent) content of shell fragments was noted.

The material placed as part of the Interim Action consisted of beneficially reused dredge materials from two sources. The first was navigational dredging spoils from the Swinomish Channel near La Conner, Washington. This material was a sand, with less than 4 percent fines, and 1 to 8 percent

gravel. The other material used was dredge material from the Squalicum Creek Waterway in Bellingham. This material was generally classified as a silty clay. A grab sample taken during the 2001 construction indicated that the material was an organic clay, and contained 5 percent sand, 78 percent silt, and 17 percent clay.

TOC concentrations in the GP Log Pond prior to the interim action ranged from 2.7 to 15 percent, with an average of approximately 6 to 10 percent. TOC measurements were not made of the Swinomish Channel materials. The Squalicum Creek materials were approximately 1.5 to 1.7 percent TOC. The current surface in the GP Log Pond is largely these Squalicum Creek materials.

As described in Appendix D, the Log Pond is partially sheltered from prevailing winds. However some westerly winds can enter the Log Pond and subject portions of the shoreline to erosive forces. Remaining areas of the shoreline are protected from these wind and wave forces, though northerly winds and vessel wakes can produce some smaller waves. Cap monitoring has shown good long-term stability for the majority of the cap area. Some erosion effects have been noted in limited shoreline areas of the cap. Enhancements to the shoreline conditions to provide for long-term stability of these areas under site wind and wave conditions are presented in Appendix D and will be implemented as part of the final remedial action for the site.

### **4.3.2 Land Use and Navigation**

As its name implies, Unit 4 was historically used as a log pond for lumber and pulp mill operations. These uses have been discontinued since the Interim Remedial Action.

The Log Pond has been designated for cleanup and habitat restoration uses. Some public access enhancements to upland shoreline areas are likely as part of future New Whatcom redevelopment activities. These uses would likely include development of a shoreline promenade along portions of the Log Pond. No in-water navigation uses are contemplated for the Log Pond, with the exception of potential use by small hand-carry boats (i.e., kayaks).

### **4.3.3 Natural Resources**

Monitoring of the Log Pond Interim Action cap has confirmed the use of the restored area by juvenile salmonids, juvenile Dungeness crabs and other aquatic organisms and marine mammals.

Some eel grass colonization has occurred since implementation of the Interim Action. However, the colonization has been limited to date to a relatively small number of established blades. A pilot program has been funded under the Bellingham Bay Demonstration Pilot to enhance natural colonization rates through seeding of the area with eel grass. This pilot test is ongoing.

### 4.3.4 Contaminant Distribution

As described in Appendix I of the RI Report, the Log Pond Interim Action has attained compliance with surface sediment cleanup levels throughout most of the area. No migration of contaminants upward through the cap or through cap porewater has been observed.

A localized area of recontamination was noted in the southwest corner of the Log Pond, adjacent to an area of shoreline not included in the Interim Action cap boundaries. As described in Appendix D, shoreline enhancements to this area will be performed as part of the final remedial action, including extension of the cap area to include this adjacent area, and placement of appropriately-graded materials to ensure long-term stability of the cap edges.

## 4.4 Areas Offshore of ASB (Unit 5)

The area offshore of the ASB is a relatively shallow-water area, the majority of which has not been dredged for navigation uses. This area of the site is designated as Unit 5. Unit 5 is subdivided in to three subareas:

- **Unit 5A:** Deeper water areas offshore of the ASB
- **Unit 5B:** High-energy nearshore areas on the “shoulder” of the ASB. Some sediments within this area have mercury concentrations that remain above site cleanup levels
- **Unit 5C:** Shallow-water areas along the southeastern shoulder of the ASB, adjacent to the Inner Waterway.

### 4.4.1 Physical Factors

Water depths within Unit 5 vary by area. In Unit 5B the depths are shallow, ranging from approximately 6 feet to approximately 12 feet below MLLW. Similarly, Unit 5C water depths are shallow, ranging from approximately 2 feet below MLLW along the edge of the ASB, to depths of approximately 18 feet below MLLW along the Whatcom Waterway.

Water depths in Unit 5A vary from relatively deepwater (up to 26 feet below MLLW) offshore areas, to shallow water areas adjacent to the ASB (as shallow as 4 feet below MLLW). Depths shoal gradually, consistent with natural bathymetric conditions within the Bay. The depth contours along the Whatcom Waterway edges of these areas have been affected by historic dredging patterns within the Waterway.

The sediments within Unit 5 range from fine-grained sediments in deepwater areas, to sandy sediments with some gravel in shallow-water, high-energy areas of Unit 5B. The particle size distribution is controlled by area wave energies as described in Appendix C.

Current wave energies in Unit 5C are lower due to the partial sheltering of this area by the ASB structure and the Bellingham Shipping Terminal.

#### **4.4.2 Land Use and Navigation**

The shoulder areas of the ASB were historically used for log rafting, prior to construction of the ASB. Future navigation use of these areas is considered limited by water depths and the lack of available upland adjacent to these areas.

The Port plans to develop an environmentally sustainable marina within the ASB. The marina has been included in the Port's Comprehensive Scheme of Harbor Improvements as described below (Section 4.7). However, navigation features within Unit 5 are not contemplated due to anticipated conflicts between such uses and habitat preservation and enhancement objectives. The priority uses within Unit 5 are those associated with habitat enhancement opportunities.

The modification of this area to construct nearshore habitat benches along this portion of the shoreline was considered as part of the 2000 Comprehensive Strategy EIS, and has been incorporated into design concepts for the ASB marina (Figures 4-4 and 4-5). However, no modifications to this area have been completed to date.

#### **4.4.3 Natural Resources**

The Habitat Restoration Documentation Report (BBWG, 1999) identified Unit 5 shoreline areas as salmonid migration corridors, though depths and wave energies are not currently optimal for the development of premium nearshore habitat quality.

#### **4.4.4 Contaminant Distribution**

Throughout most of Unit 5 the surface sediments comply with the SMS. Subsurface sediment concentrations are relatively low as shown in Figures 2-4 and 2-5. However, wave energies within Unit 5B are higher than in other areas and recent sampling in 2002 indicates that, while sediments in this area do not exceed bioassay criteria established under SMS, the site-specific mercury BSL is exceeded in Unit 5B (Figure 2-3).

### **4.5 Areas Near Bellingham Shipping Terminal (Unit 6)**

Unit 6 consists of the aquatic lands to the south and southeast of the Whatcom Waterway and Bellingham Shipping Terminal. This area has been subdivided into three subareas:

- **Unit 6A:** Deepwater areas of Unit 6 that comply with sediment cleanup levels

- **Units 6B and 6C:** Deepwater and intermediate-depth areas near the former barge dock where exceedances of bioassay criteria were noted during recent sampling in 2002.

#### **4.5.1 Physical Factors**

Most of Unit 6 consists of deepwater areas, with elevations greater than 18 feet below MLLW. However, shallow-water areas are located immediately adjacent to the Bellingham Shipping Terminal. The shorelines in this area consist of engineered slopes, armored to resist wind and wave erosion.

Sediments in deepwater areas of Unit 6 consist of fine-grained sediments typical of the Whatcom Waterway site. The total fines content typically exceeds 80 percent. TOC levels range from 1 to 5 percent, consistent with average Whatcom Waterway site conditions.

#### **4.5.2 Land Use and Navigation**

Navigation uses in Unit 6 have historically included log rafting, barge traffic and tug boat mooring. Some prop wash effects may be significant in this area, depending assuming future barge and tug uses.

Two docks are located within Unit 6, including the barge dock and the former GP Chemical dock. The northern side of Unit 6 is bounded by the back side of the Bellingham Shipping Terminal wharf structure.

Some dredging activities have historically been performed in Unit 6, including dredging for establishment of cargo terminal berth areas, as well as dredging to obtain fill material for use in development of the Bellingham Shipping Terminal. Regular maintenance dredging such as that considered for the Whatcom Waterway areas is not expected. As described above for the Outer Waterway, the Bellingham Shipping Terminal will likely remain under industrial water-dependent use for the foreseeable future, including potential reuse by institutional users and/or cargo operations.

#### **4.5.3 Natural Resources**

Like Unit 5, the area within Unit 6 was identified in the Habitat Restoration Documentation Report (BBWG, 1999) as a salmonid migration corridor, though depths, wave energies and substrates were not optimal. Habitat values in this area are also constrained by navigation infrastructure needs of the Bellingham Shipping Terminal, including the presence of over-water wharves and armored shorelines.

#### **4.5.4 Contaminant Distribution**

The principal contaminants historically identified in the Unit 6 area are phenolic compounds. The primary sources of these compounds appear to be from historical log rafting activities. Natural recovery processes for these

materials include both deposition and burial, as well as biodegradation (phenolic compounds are biodegradable under both aerobic and anaerobic conditions).

During sediment testing in 2002, a single failure was noted in an amphipod bioassay test performed at station AN-SS-30 (see Figure 2-5). Mercury levels were below the numeric SQS in this sample. No bioassay exceedances or elevated mercury levels were noted in other areas of Unit 6 during 2002 sampling activities.

## **4.6 Starr Rock (Unit 7)**

Starr Rock consists of a sediment disposal area used for management of sediments dredged from the Whatcom Waterway and adjacent berth areas during the late 1960s. The area was designated for sediment disposal under project Corps of Engineers permits. The area is located in submerged offshore areas near the natural Starr Rock navigation obstruction. This area is designated as Unit 7.

### **4.6.1 Physical Factors**

Water depths in Area 7 range from a low of approximately 20 feet below MLLW to a maximum of approximately 40 feet. Due to its deepwater location, Unit 7 is not subject to significant wave energies. Sediments in this area are predominantly fine-grained materials, with total fines contents of greater than 80 percent. Like most areas of the Whatcom Waterway, the TOC content of sediments in this area is generally between 1 and 5 percent. Localized deposits of woody materials were noted, with some TOC contents exceeding 5 percent.

### **4.6.2 Land Use and Navigation**

Historic navigation uses in Unit 7 were limited to log rafting. These uses were discontinued in the 1970s with the development of Boulevard Park nearby. Future navigation uses in Unit 7 are not anticipated other than transit uses by recreational vessels. Deepwater navigation is restricted in this area due to the proximity of the natural shallow-water obstruction at Starr Rock, and by the lack of adjacent upland navigation support facilities.

### **4.6.3 Natural Resources**

Unit 7 consists of a deepwater habitat area and has not been identified as premium habitat for salmonids or other aquatic species.

### **4.6.4 Contaminant Distribution**

The surface sediments within Unit 7 comply with the SMS. Surface sediments in this area do not contain any exceedances of the site-specific mercury BSL, and no exceedances of SMS criteria were noted in sediment bioassays during the 2002 sampling event (Figure 2-3).

## 4.7 ASB (Unit 8)

Unit 8 consists of the interior of the ASB. This facility was constructed by GP in 1978 for treatment of wastewater from pulp and tissue mill operations.

### 4.7.1 Physical Factors

The ASB is approximately 1,000 feet wide north-south, and varies from approximately 1,000 to 1,400 feet wide east-west. The ASB berms enclose Unit 8 and separate it from Bellingham Bay. The ASB berms enclose an area of approximately 28 acres.

Figures 2-2 and 4-5 show schematic cross-sections of the ASB berm. Additional cross-sections of the ASB area are included in the RI Report (RI Figures 3-6 and 3-8). The berm was constructed of quarried sand and stone materials placed at the time of construction. The interior of the ASB was dredged to depths approximately 15 feet below MLLW. A bentonite material was used to reduce the permeability of the berm and make it suitable for wastewater containment uses. An asphalt surface was placed around the berm interior edges to prevent wind and wave erosion of the berm structure. The outer edges of the berm are armored with stone to protect against wave erosion. Wastewater elevations within the ASB are maintained by active pumping at approximately 19 to 20 feet above MLLW. This elevation is significantly higher than the water elevations in Bellingham Bay, and provides hydraulic head necessary to discharge treated wastewater by gravity flow through the GP-owned, NPDES-permitted outfall.

Since construction of the ASB facility, biotreatment sludges have accumulated in the ASB. These sludges are soft, wet and are extremely high in TOC content. The solids content of these materials is less than 30 percent and averages about 14 percent. The TOC content is very high, averaging between 30 and 50 percent. The sludges consist of pulp solids and microbial biomass produced during biotreatment of facility wastewaters.

In contrast to the ASB sludges, the berm materials consist primarily of clean coarse sand obtained from quarry sites during ASB construction. These materials were tested for physical properties and chemical properties as part of the Remedial Investigation activities. Sediments underlying the ASB also consist of sandy materials.

The exterior of the ASB was constructed with a final cover of large armoring rock, generally of 300 to 4,400 pounds. These exterior slopes were constructed between 2.5 and 3:1 (H:V). The interior slopes are finished at slopes of approximately 2.5:1 (H:V).

### 4.7.2 Land Use and Navigation

The ASB facility was constructed by GP for treatment of wastewater and stormwater. It also provides cooling water management for the Encogen



energy production facility. These uses are expected to continue through June of 2008, consistent with Port-GP agreements. After that time these uses are likely to be discontinued.

The ASB has been identified by the Port as the preferred site in Bellingham Bay for construction of a new marina facility (Makers, 2004). The preference for the site was based on several factors, including the ability to develop a marina with net gains in both habitat and public access opportunities. The development of a marina in the ASB was included in the 2004 Waterfront Futures Group Vision and Framework Plan, and in the Port's 2004 update to its Comprehensive Scheme of Harbor Improvements. The development of a marina in the ASB was a key element of the Port's purchase of the GP properties in 2005, and is also a key element of Port-City plans for redevelopment of the New Whatcom redevelopment area, as stated in the Port-City Interlocal Agreement of May 2006. Preliminary design concepts for a marina have been developed between 2004 and 2006, incorporating public access and habitat enhancements. Some of these concepts are illustrated in Figures 4-4 and 4-5.

The earliest marina design concepts shown in Figure 4-4 were developed as part of the Waterfront Futures Group. The community preference was that public access features to be located on portions of the breakwater surrounding the new marina. A modified design concept was developed by the Port integrating the Waterfront Futures Group concepts with modifications to the original concept made after consultations with resource agencies and project stakeholders. Modifications included relocation of the marina entrance, and the incorporation of habitat enhancement and fish passage features in subaqueous portions of the breakwater. Additional analyses were conducted as part of a waterfront design charette during March of 2006. That charette included resource agencies and community representatives, and resulted in further development of the design concept for integrated marina, public access and habitat enhancement uses. Some of the design concepts developed at the design charette are included in Figure 4-4.

Figure 4-5 illustrates some of the changes that have been contemplated for the ASB berm structure as part of marina reuse. These changes assume that Waterway cleanup activities remove the ASB sludges from the site. The clean berm materials can then be partially removed from the area for reuse in cleanup and habitat enhancement activities. The berms would be modified to reduce overall height and width consistent with marina breakwater requirements. Public access amenities may be included in the berm, potentially including a shoreline promenade, landscape features and other enhancements. Habitat enhancements may be included in the berm including nearshore habitat benches on either the inner or outer areas of the berm. Marina facilities would be located in deepwater areas inside the ASB area. The final design will depend on optimization of navigation, public access and

habitat uses and will be developed in future design and permitting for area reuse.

The City also evaluated the ASB for potential future stormwater or wastewater treatment uses, but it determined that it is not well suited for these uses due to its location, elevation, and the operational characteristics of the current GP-owned outfall structure.

### **4.7.3 Natural Resources**

Currently the ASB is used as a wastewater treatment lagoon, and the area has no significant existing natural resources or habitats. The area is segregated from the marine environment by the ASB berms. The water within the ASB consists of industrial wastewater, and the ASB interior shorelines are lined with asphalt.

### **4.7.4 Contaminant Distribution**

As described in the RI Report, the ASB sludges contain the highest contaminant levels of all of the materials requiring remediation. Contaminant levels include elevated mercury levels from chlor-alkali plant wastewaters, but also contain very high levels of phenolic compounds and other inorganic and organic contaminants including cadmium, zinc, phthalates and polynuclear aromatic hydrocarbon (PAH) compounds. Average subsurface sediment quality data for the ASB sludges (0.4-4 ft depth interval) are summarized in Figures 2-4 and 2-5.

As described in section 4.7.1, the ASB sludges are soft, wet and have very high TOC contents. In portions of the ASB, a layer of contaminated sediments is located at the transition between the ASB sludges and underlying clean sediments.

Materials in the ASB berms were directly tested as part of Remedial Investigation Activities. The berm sands were free from anthropogenic contaminants and were suitable for material reuse, provided that ASB sludges are first removed so that the materials can be safely accessed. Some contaminated sediments are present in a thin layer of sediments at the pre-construction mud-line, beneath the ASB berm materials as shown in Figure 2-2.

## **4.8 I&J Waterway Sediment Site**

The I&J Waterway sediments were sampled as part of the RI activities. Mercury associated with the Whatcom Waterway site is present at low levels in subsurface sediments in this area (Figure 2-4). However, testing as part of the RI showed that mercury concentrations did not exceed SMS biological criteria in surface sediments, and characterization of subsurface sediments has shown that the mercury levels do not exceed allowable levels for open-water disposal or beneficial reuse. In contrast, contamination of surface sediment

with phthalates, nickel, wood waste and other contaminants from localized historical releases has been shown to be present in excess of SMS standards in the I&J Waterway area.

During 2003 and 2004, Ecology determined that the sediments at the head of the I&J Waterway represent a distinct contamination area that was best managed as a separate sediment cleanup site. As described in the RI Report (RI Section 6.1.3) a separate RI/FS is being conducted for this area under an Agreed Order between the Port and Ecology. Based on its management as a separate site, the I&J Waterway is not carried forward as a site unit for the Whatcom Waterway FS.

Outside of the I&J waterway sediment site, the sediments within the I&J waterway are not subject to further remedial action, because surface sediments do not exceed SMS cleanup levels, and further remedial action is not required to address impacted subsurface sediments. Testing performed during the Remedial Investigation showed that subsurface sediments within the outer portion of the federal navigation are suitable for open-water disposal. Ongoing channel maintenance activities conducted by the Corps of Engineers includes material characterization provisions that address future management of the sediments in this area.

# 5 Screening of Remedial Technologies

Under MTCA, the development of a cleanup plan requires that technologies capable of meeting cleanup objectives are screened, and then assembled into remedial alternatives. These are then evaluated, compared and preferred alternative(s) are identified. Section 3 presented the site cleanup goals and remedial action objectives for the Whatcom Waterway site. This section reviews available cleanup technologies, and selects a range of technologies to be retained for development of cleanup alternatives as described in Section 6.

The screening of remedial technologies provided in this section is performed using the process defined in the SMS guidance (Ecology, 1991). First, the range of potential technologies available for remediation of site contaminants is reviewed. Then, available technologies are screened for overall effectiveness, implementability and relative cost to identify a short-list of potentially applicable technologies for further evaluation.

The technologies that can be used to address contaminated sediments, as discussed in the SMS guidance (Ecology, 1991), and the ARCS (USEPA, 1994) are described in the following sections:

- Institutional Controls (Section 5.1)
- Natural recovery (Section 5.2)
- Containment (Section 5.3)
- Sediment Removal (Section 5.4)
- Sediment Disposal and/or Reuse (Section 5.5)
- *Ex situ* Treatment (Section 5.6)
- *In situ* Treatment (Section 5.7)

MTCA regulations place a preference on the use of permanent cleanup methods such as removal, disposal or treatment relative to those that manage contaminants in place using institutional controls, natural recovery and/or containment. This preference is reflected in regulatory evaluation criteria which are described and applied in Sections 6 and 7.

Sections 5.1 through 5.7 describe each of the technologies evaluated during technology screening, including information on the technology effectiveness, implementability and cost. Retained technologies to be carried forward in development of remedial alternatives are summarized in Section 5.8.

## 5.1 Institutional Controls

Institutional controls are mechanisms for ensuring the long-term performance of cleanup actions. They are applicable to most remedies where contaminants are not completely removed from the site. Institutional controls involve

administrative/legal tools to document the presence of contaminated materials, regulate the anthropogenic disturbance/management of these materials, and provide for long-term care of remedial actions including long-term monitoring. Institutional controls have been successfully applied during remediation projects at Puget Sound sites including the Foss Waterway in Tacoma, the Lockheed and Todd Shipyards Operable Units at Harbor Island.

For sediment remediation projects, permitting review procedures constitute institutional controls. For any aquatic construction project (e.g., dredging in a berth area) environmental reviews are conducted by permitting agencies including the Corps of Engineers, the Department of Ecology, and other resource agencies. These reviews include a review of area files relating to sediment conditions, and requirements to address materials management and water quality.

Additional institutional controls may be implemented as appropriate, depending on the preferred remedial alternative ultimately selected by Ecology. Such additional controls could include restrictive covenants for platted tidelands, use authorizations for state-owned aquatic lands, and/or documenting the site remedial action in County property records, Corps and regulatory agency permit records and/or records maintained by the State of Washington for state-owned aquatic lands.

Institutional controls can be highly effective, implementable, and cost-effective provided that the remedial action for which the institutional controls are implemented is consistent with area land and navigation uses. In cases where the proposed remedial action is in conflict with land use and navigation uses, conflicts can result that jeopardize the effectiveness of institutional controls or that require mitigation.

Institutional Controls have been carried forward in the Feasibility Study for alternatives development.

## **5.2 Natural Recovery**

Natural recovery of contaminated sediment may occur over time and may lower the surface concentrations of sediment contaminants. Natural recovery of sediments in the Whatcom Waterway area has been well documented by the historical record of declining surface concentrations of mercury over the past 25 years. Section 6.2 of the RI Report contains a discussion of site natural recovery data. Natural recovery includes three processes that contribute to the cleanup of surface sediments. These processes include the following:

- 1) Physical processes, such as sedimentation/deposition and mixing
- 2) Biological degradation processes that cause reductions in the mass, volume, and/or toxicity of contaminants through biodegradation or biotransformation

3) Chemical processes, including oxidation/reduction and sorption.

As discussed in the Remedial Investigation report, natural recovery through the physical process of sediment deposition has been highly effective at restoring sediment quality in the bioactive zone throughout much of the Whatcom Waterway site.

Biological processes include bacterial or fungal degradation or transformation of organic chemicals into less toxic forms. These processes may be effective for volatile and semivolatile organic compounds in well-aerated sediments. Metals concentrations would not be expected to decrease through biological processes, although the natural production of sulfides may result in the formation of metal-sulfide complexes, thereby limiting the bioavailability of certain metals (EPA 2000e). Biological processes may produce long-term reductions of organic constituents, such as phenolic compounds.

Chemical processes include the preferential sorption of organic compounds to naturally occurring carbon and humic sources within the sediments, as well as changes in redox potential and chemical precipitation reactions that chemically bind contaminants to sediments and reduce their toxicity. For example, many metal compounds form stable precipitates with hydrogen sulfides in sediments.

All of these processes (physical, biological, chemical) can occur together and contribute to overall recovery of sediment systems.

## **5.2.1 Monitored Natural Recovery**

Monitored natural recovery (MNR) relies on natural recovery processes coupled with monitoring to ensure that recovery achieves stated cleanup levels and remedial action objectives. Natural recovery is defined as the effects of natural processes that permanently reduce risks from contaminants in surface sediments (Apitz et al. 2002) and that effectively reduce or isolate contaminant toxicity, mobility, or volume. Monitoring of these processes is conducted to determine their effectiveness within a prescribed time frame.

MNR is a risk management alternative that relies upon natural environmental processes to permanently reduce exposure and risks associated with contaminated sediments (Davis et al. 2004). MNR can be implemented as a sole alternative, but is more frequently combined with other active measures and institutional controls. MNR differs from No Action in that, by definition, it must include source control, appropriate assessments including modeling, and long-term monitoring to verify the remedy effectiveness (Palermo 2002; Apitz et al. 2002).

The potential for natural recovery of sediment is determined through multiple lines of evidence related to the biological, physical, and chemical processes described above. A thorough assessment of natural recovery was performed

as part of the 2000 RI/FS (Hart Crowser and Anchor Environmental, 2000). This assessment showed that natural recovery was occurring at the site, which has since been verified during additional sampling events in 2002, as evidenced by the decreasing surface sediment concentrations.

Where MNR has been applied successfully, the demonstration of sediment deposition (burial) and contaminant attenuation (reduction) processes have been major determinants of MNR. MNR has been applied as a portion of the remedy in conjunction with active remedies at many Puget Sound sites, including the Puget Sound Naval Shipyard site in Bremerton, Washington (Palermo 2002) and portions of the Commencement Bay site in Tacoma, WA (EPA 1989). Performance at these sites have shown the technology to be effective and implementable when applied in suitable areas. Costs of the technology are primarily associated with implementation of institutional controls and long-term monitoring.

## **5.2.2 Enhanced Natural Recovery**

ENR involves the placement of a thin layer of clean material over areas with relatively low contaminant concentrations to speed up, or enhance, the natural recovery processes already demonstrated to be occurring at a site. Under ENR, thin layers of clean sand or sediments are placed over areas where natural recovery processes are occurring. The new material reduces the restoration time-frame required for natural recovery to be effective and comply with site cleanup levels (OSWER 2004). ENR has been used in Puget Sound both as a sole remedy and in conjunction with removal actions to aid in the management of post-dredging contaminant residuals. ENR frequently also includes a long-term monitoring component as with MNR. ENR has been selected as a remedy component at Superfund sites in Commencement Bay (Tacoma, Washington) and Eagle Harbor (Bainbridge Island, Washington) (Thompson et al. 2003).

Enhanced natural recovery has been highly effective in managing residual sediment left following dredging. In this case, the dredging operation is designed to remove the majority of the contaminated sediment. However, all dredging technologies leave some residual materials on the dredged surface, at times resulting in short-term non-compliance with the site cleanup level. ENR can be used to address this residual provided that the quantity of the residuals is minimized through the use of best practices during dredging.

For purposes of the Feasibility Study, only MNR has been carried forward for alternatives development. ENR is retained in the context of post-dredge residuals management, but not as a discrete remedial technology.

## **5.3 Containment**

Containment involves either confining the contaminated sediments in place or confining dredged materials within a disposal facility after removal.

Containment technologies have been used extensively in remediation of contaminated sediments elsewhere in Puget Sound.

### 5.3.1 Sediment Capping

Capping is a well-developed and documented cleanup alternative in the Pacific Northwest and nationally. One of the first, and best-documented, examples of capping occurred in 1984, when contaminated fine-grained sediment dredged from the LDW navigation channel between Kellogg Island and the Duwamish Diagonal CSO and storm drain was disposed of in a borrow pit in the West Waterway; that material was capped with clean sand dredged from the LDW's upper turning basin (Sumeri 1984, 1989; USACE 1994). As recently as 1995, monitoring demonstrated that the capped contaminated sediment remained effectively isolated (USACE et al. 1999). Numerous other caps have been successfully placed in Puget Sound, including the capping of the Log Pond during the Interim Remedial Action at the Whatcom Waterway site.

Capping isolates contaminants from the overlying water column and prevents direct contact with aquatic biota. Cap placement as a remedial alternative assumes source control to protect against cap recontamination. If the potential for scour from river currents or propeller wash exists, the cap must be designed in a way that protects it from these disruptive forces.

Caps may be used in different ways as part of a remedial action:

- ***In Situ* Capping** is defined as the placement of an engineered subaqueous cover, or cap, of clean isolating material over an *in situ* deposit of contaminated sediment (EPA 1994, 2002; NRC 1997, 2001; Palermo et al. 1998a, 1998b). Such engineered caps are also called isolation caps. *In situ* caps are generally constructed using granular material, such as clean sediment, sand, or gravel. Composite caps can include different types and multiple layers of granular material, along with geotextile or geomembrane liners. Reactive caps can include the addition of contaminant-sorbing or blocking materials. *In situ* capping may be considered as a sole remedial alternative or may be used in combination with other remedial alternatives (e.g., removal and MNR).
- ***In Situ* Capping After Partial Removal** is an option involving placement of an *in situ* cap over contaminated sediments that remain in place following a partial dredging action that removes contaminated sediment to some specified depth. This can be suitable in circumstances where capping alone is not feasible because of habitat, navigation or land use requirements that necessitate a minimum water depth. *In situ* capping with partial dredging can also be used when it is desirable to leave deeper contaminated sediment capped in place so as to preserve bank or



shoreline stability, or where dredging of the materials creates excessive disruption or water quality impacts. When *in situ* capping is used with partial dredging, the cap is designed as an engineered isolation cap, because a portion of the contaminated sediment deposit is not dredged.

## Cap Construction Methods

Various equipment types and placement methods have been used for capping projects, including placement using hopper barges at larger, open-water sites and both hydraulic and mechanical systems for placement at nearshore or shallow-water sites.

An important consideration in the selection of placement methods is the need for controlled, accurate placement of capping materials. Slow, uniform application that allows the capping material to accumulate in layers is often necessary to avoid displacement of or mixing with soft underlying contaminated sediments. Slow application also minimizes the resuspension of contaminated material into the water column (Cunningham et al. 2001).

Granular cap material can be handled and placed in a number of ways. Mechanically dredged materials that have been dewatered and soils that have been excavated from an upland site or quarry have relatively little free water. These materials can be handled mechanically in a dry state until released into the water over the contaminated site. Mechanical methods (such as clamshells or release from a barge) rely on gravitational settling of cap materials in the water column and are highly effective at shallow and intermediate depths such as those within the Whatcom Waterway site. Granular cap materials can also be entrained in a water slurry and carried wet to the contaminated site, where they are discharged into the water column at the surface or at depth. These hydraulic methods offer the potential for a more precise placement, although the energy required for slurry transport must be controlled at the point of release to prevent resuspension of contaminated sediment. Armor layer materials (stone materials placed to resist cap erosion) can be placed from barges or from the shoreline using conventional equipment, such as clamshells.

## Capping Decision Factors

The principal design considerations for capping as a remedial alternative for contaminated sediments are that the cap must remain physically stable, and that the contaminants are effectively isolated. The National Research Council (NRC 1997) provided additional decision factors that encourage use of capping as a cleanup technology include the following

- Contaminant sources have been sufficiently abated to prevent re-contamination of the cap
- Contaminants are of moderate to low toxicity and mobility

- MNR is too slow to meet remedial action objectives (RAOs) in a reasonable time frame
- Cost and/or environmental effects of removal are very high
- Suitable types and quantities of cap materials are available
- Hydrologic conditions will not compromise the cap if designed appropriately
- Weight of the cap can be supported by the physical properties of the underlying sediments
- The application of the cap is compatible with current and/or future navigation and land uses in the cap area
- Site conditions do not necessitate removal of contaminated sediment.

A well-designed, properly constructed and placed cap over a contaminated surface, along with effective long-term monitoring and maintenance, can prevent direct contact by aquatic biota by providing long-term isolation of contaminated sediments. The cap can also prevent contaminant flux into the surface water. Incorporation of habitat elements into the cap design can provide an improvement or restoration of the biological community.

One advantage of capping is that the potential for contaminant resuspension and the risks associated with dispersion of contaminated materials during construction are relatively low. With capping, the sediments are contained in-place, and do not require additional treatment and/or offsite disposal. Most capping projects use conventional and locally-available materials, equipment, and expertise. For this reason, in certain cases the *in situ* capping option may be implemented more quickly and may have much lower short-term risks than options involving removal and disposal or treatment. Depending on the location of the cap, the type of construction, and the availability of materials, a cap may be readily repaired, or enhanced if necessary.

Capping designs must anticipate and protect against potential disturbance events such as storm events and propeller wash. These events are factored into the remedy selection, design, institutional controls, and monitoring to ensure long-term integrity of the cap. To provide erosion protection, it may be necessary to use cap materials that are different from native bottom materials. This can benefit or improve the habitat quality in the cap areas, and the project design and permitting must consider these potential habitat impacts and/or benefits.

Palermo et al. (2002) and the EPA (OSWER 2004) provided additional considerations to ensure effective and implementable design, placement, and long-term maintenance of a cap over contaminated sediments that include:

- Evaluation of navigation and land use priorities in the cap area
- The impacts and/or benefits to habitat by cap placement should be considered, including changes to depth and substrate type
- The composition and thickness of the cap components comprise the cap design. A detailed design effort for any selected capping remedy should address all pertinent design considerations
- The cap should be designed to provide physical and chemical isolation of the contaminated sediments from benthic organisms
- The cap should be physically stable from scour by hydraulic conditions including currents, flood flow, propeller wash, etc.
- The cap should provide isolation of the contaminated sediments from flux or resuspension into the overlying surface waters
- The cap design should consider operational factors such as the potential for cap and sediment mixing during cap placement, resuspension during placement, and variability in the placed cap thickness
- The cap design should incorporate an appropriate factor of safety to account for uncertainty in site conditions, sediment properties, and migration processes.

Capping costs vary with the design of the cap. Costs of capping are associated with cap design, construction, institutional controls and long-term monitoring. Capping has been carried forward in the Feasibility Study for alternatives development.

### **5.3.2 Confined Nearshore Disposal**

A Confined Nearshore Disposal (CND) facility or a “nearshore fill” is an engineered containment structure that provides for dewatering and permanent storage of dredged sediments. CNDs feature both solids separation and landfill characteristics (EPA 1994a). Containment of contaminated sediments in CNDs is generally viewed as a cost-effective remedial option at Superfund sites (EPA 1996b). Interest in CNDs for disposal of contaminated dredged sediment has led both the USACE and the EPA to develop detailed guidance documents for their construction and management (USACE 1987, 2000; EPA 1994, 1996; Averett et al 1988; Brannon et al 1990).

CND facilities involve creation of a sediment containment area that has a final filled surface located above tidal elevations. CNDs are commonly known as nearshore fills, because they involve filling of aquatic areas and conversion of those areas to upland use.

CNDs have a good performance record in Washington State. These include the Milwaukee Waterway, Eagle Harbor East Operable Unit, and the recent Blair Waterway Slip 1 Nearshore CND. However, their use has been declining due to habitat considerations, and the availability of other options such as Confined Aquatic Disposal that accomplish sediment containment without eliminating aquatic habitat.

Potential CND facilities were evaluated in the Final Disposal Siting Documentation Report (Siting Documentation Report; BBWG, 1998) during the work of the Bellingham Bay Pilot. The Pilot analysis concluded that use of a CND site would be implementable and effective. The area offshore of the Cornwall Avenue Landfill and the GP Log Pond were evaluated in this report as potential locations for a CND.

Use of the Aerated Stabilization Basin (ASB) as a CND was not included in the original Siting Documentation Report because it was anticipated that the ASB would indefinitely continue use as a wastewater treatment basin. Since that time, GP has substantially reduced its operations in Bellingham, including closure of its pulp mill, chemical plant and chlor-alkali plant. In 2001, GP identified a portion of the ASB as being available for siting of a CND facility for containment of dredged sediments from the Whatcom Waterway. The use of the ASB for construction of a CND facility was identified as an element of a preferred remedial alternative in a Supplemental Feasibility Study (Anchor, 2002).

If the ASB was used for construction of a CND, a berm would be constructed across the CND, segregating a portion of the CND which would continue to be used for wastewater treatment from the portion which would be used for disposal of sediments. Dredged sediments would be placed inside the disposal section of the ASB, along with any ASB sludges from the “outer” portion of the facility. Cleaner sediments and new structural fill soil would be placed above the sediments to form a cap and working surface above the sediments. The 2002 Supplemental Feasibility Study identified a proposed fill area that would occupy approximately 20 acres. The ASB CND option received significant comment during public review of the 2002 Supplemental Feasibility Study, including opposition from the Port and City due to land use considerations.

The ASB nearshore fill option has been carried forward in the Feasibility Study for evaluation as part of the current Feasibility Study. As described in Section 4.7.1, the ASB sludges are soft, wet and have very high TOC contents. If managed as part of a nearshore fill, these sludges would be

subject to primary and secondary consolidation, and would likely produce methane during anaerobic decomposition.

### **5.3.3 Confined Aquatic Disposal**

Confined Aquatic Disposal (CAD) facilities are similar to CNDs. Like CND facilities, CAD facilities are constructed in in-water areas and are used to contain sediment dredged from other areas. However, the surface of the CAD facility is constructed so that its final elevation retains overlying aquatic uses. In some cases the CAD surface is designed with a surface that provides enhanced habitat conditions.

CAD sites have been successfully applied in the Duwamish West Waterway for dredged sediments in 1984. In addition, a CAD was recently used as for the disposal of contaminated sediments dredged from Pier D at the Puget Sound Naval Shipyards in Bremerton, Washington.

Potential Confined Aquatic Disposal options were evaluated in the Siting Documentation Report of the Bellingham Bay Demonstration Pilot (BBWG, 1998). This report determined that CADs for contaminated sediments from Bellingham Bay would be implementable and effective. Three potential CAD sites were identified, an area offshore of the Cornwall Avenue landfill, the area within the Log Pond, and an area in sediment Unit 5 offshore of the ASB facility.

The evaluation of disposal siting alternatives conducted during the Bellingham Bay Demonstration Pilot developed an option for a CAD facility located adjacent to the Cornwall Avenue Landfill. Properly constructed, the CAD option provided a potential method of enhancing the quantity of premium nearshore habitat in the facility area. If this site were selected, a containment berm would be constructed near the subtidal portions of the Cornwall Avenue Landfill. Dredged sediments would be placed behind the berm, and the site would be capped with approximately three feet of clean fill. The finished grade of the area inside the berm could range from approximately -10 to -2 feet MLLW elevation, which would be suitable for use as subtidal habitat. The CAD surface would be protected from erosion using a hard leading edge that would reduce the energy of incoming waves, and allow for potential colonization of the cap surface by eel grass.

A range of CAD facility sizes for the Cornwall area was evaluated, including containment volumes ranging from approximately 260,000 to 1,000,000 cubic yards of sediment. The final footprint, costs and habitat benefits of a facility would vary with its size. The smaller size facilities were generally less cost-effective than those with larger (i.e., at least 500,000 cubic yard) capacities. The use of a Cornwall CAD site for containment of sediments dredged from the Whatcom Waterway was identified as a preferred alternative during the 2000 EIS process.

The Cornwall CAD option is retained for further consideration as part of the current Feasibility Study.

## **5.4 Sediment Removal**

Contaminated sediments can be removed, typically through dredging or excavation. After removal, the sediments must be managed, a process that can include dewatering, treatment and/or disposal. In some cases, the physical and chemical properties of sediments allow them to be beneficially reused.

Dredging is commonly used for both maintenance of navigation channels and removals of contaminated sediments. Dredging is typically either mechanical dredging, which removes sediments by digging them using a bucket, or hydraulic dredging, which mechanical means to loosen sediments and then uses water suction to remove and transport the loosened sediments. Excavation of sediments is a variant of mechanical dredging, and is typically used in certain situations where it may be more effective than other means of dredging.

Dredging is such a commonly used technology, and has been applied to multiple sediment remediation projects in Puget Sound, such as the Hylebos Waterway in Tacoma and the Duwamish Waterway in Seattle. After removal of sediments, the sediments must be appropriately managed using containment, beneficial reuse, disposal, or treatment.

Removal refers to excavation or dredging of sediments. The discussion of removal process options herein integrates site knowledge, practical dredging experience, dredging sediment case studies, and demonstrated successful application under similar conditions. The following documents include practical information relating to sediment remediation projects in the United States:

- Assessment and Remediation of Contaminated Sediments (ARCS) Program, Remediation Guidance Document (EPA 1994b)
- Review of Removal, Containment and Treatment Technologies for Remediation of Contaminated Sediment in the Great Lakes (Averett et al. 1990)
- Removal of Contaminated Sediments: Equipment and Recent Field Studies (Herbich 1997)
- Innovations in Dredging Technology: Equipment, Operations, and Management, USACE DOER Program (McLellan and Hopman 2000)
- Dredging, Remediation, and Containment of Contaminated Sediments (Demars et al. 1995).

Dredging has been used for remediation at many Puget Sound projects of a similar scale to the Whatcom Waterway Site. Some recent projects include: the 2004 Duwamish/Diagonal Way Combined Sewer Overflow (CSO) and Storm Drain Early Action Removal Project, the 1999 Norfolk CSO Early Action Removal Project, both located in the Duwamish Waterway, and the 2004 Harbor Island East Waterway Sediment Phase 1 Cleanup Project, located at the mouth of the Duwamish. The latter project was a relatively large-scale removal project, dredging from a 20-acre area, with disposal of 200,000 cubic yards (cy) of sediment to an upland landfill and another 59,000 cy to the Elliott Bay Disposal Area. Two additional sediment remediation projects located within the Harbor Island Superfund Site involve dredging contaminated sediments using a closed bucket, with landfill disposal of wet sediments. These are the Lockheed Shipyard Sediment Operable Unit (dredging 130,000 cy with disposal at an upland landfill and capping of deeper sediments) and the Todd Shipyard Operable Unit (dredging 200,000 cy with disposal at an upland landfill and capping of under-pier areas). Finally, the cleanup of the Hylebos Waterway within the Commencement Bay Superfund site includes dredging combined with multiple forms of sediment management including upland disposal and confined nearshore disposal.

#### **5.4.1 Overview of Removal Options**

For the purposes of this FS, dredging is defined as the removal of sediment in the presence of overlying water (subtidal and intertidal) utilizing mechanical or hydraulic removal techniques and operating from a barge or other floating device. Excavation is defined as the dry or shallow-water removal of sediment using typical earth moving equipment such as excavators and backhoes operating from exposed land or wharves. Depending on the location of the sediments being removed, there may be some overlap in the equipment used for dredging and excavation. For example, a barge mounted excavator could reach over into a shallow area to remove sediments, or a shore-based crane with a long boom could reach out into deeper water and dredge these sediments.

There are two major types of dredges, mechanical and hydraulic. Mechanical dredges function by digging into the sediments with a bucket, similar to a land-based process. Hydraulic dredges function by loosening sediments with a mechanical device, and then “vacuuming” the sediments along with large quantities of entrained water, and transporting the resulting dredge slurry in a pipeline to an area where the solids and liquids can be separated for subsequent management.

Mechanical dredges remove material at near *in situ* conditions, with lower levels of water entrainment. The dredged material is taken up through the water column to a barge for transport. Mechanical dredges may be used for a wide range of material types (loose to hard consolidated and compacted material). A subset of mechanical dredges, excavators, are often used to pre-

remove large debris prior to dredging, or are used in difficult to access, shallow, and backwater areas.

Hydraulic dredges remove material as a low-density slurry; with water entrainment ratios commonly exceeding 10 to 1 (i.e., 10 cubic yards of water are entrained during the removal of 1 cubic yard of in-place sediment). The slurried dredged material is transported through a pipeline to a selected land-based dewatering facility. Hydraulic dredges are typically used for relatively loose, unconsolidated material with little debris, and where the slurry can be separated and the generated water can be managed in a cost-effective and environmentally sound manner.

Dredging in the United States is typically conducted by one of these basic methods (i.e., mechanical, hydraulic or excavation) depending upon accessibility, the volume of sediment to be removed, the disposal option selected, and site conditions. Dredging operations use not only the dredging equipment, but also significant other equipment for work over the water and management of the removed sediment. A typical dredge system includes:

- Point of dredging components include the cutterhead, auger screw, dustpan, and matchbox of hydraulic dredging systems, as well as various mechanical means, such as clamshell or backhoe excavator buckets for mechanical dredging systems.
- Support components include the support barge or pontoon, jack-up platforms, amphibious systems, monitoring and confirmation sampling equipment, and positioning systems.
- Discharge components include pumps, pipelines, dewatering and water treatment facilities, barges, and transport.

Selection of dredging equipment and methods used for a site depend on several factors, including: physical characteristics of the sediments to be dredged, the quantity and dredge depth of material, distance to the disposal area, the physical environment of the dredge and disposal areas (especially tidal range), contaminant concentrations in the sediment, method of disposal, production rates required for removal, equipment availability, amount and type of debris present, ability to manage produced waters, and cost (EPA 2004).

## **5.4.2 Mechanical Dredging**

A mechanical dredge typically consists of a suspended or manipulated bucket that bites the sediment and raises it to the surface via a cable, boom, or ladder. The sediment is deposited on a haul barge or other vessel for transport to disposal sites. Mechanical dredges have been the principal tool used for environmental dredging in Puget Sound.



Under suitable conditions, mechanical dredges are capable of removing sediment at near *in situ* densities, with almost no additional water entrainment in the dredged mass and little free water in the filled bucket. A low water content is important if dewatering is required for ultimate sediment treatment or upland disposal, as well as to minimize water quality impacts at the point of dredging.

Clamshell buckets (open, closed, hydraulic-actuated), backhoe buckets, dragline buckets, dipper (scoop) buckets, and bucket ladder are all examples of mechanical dredges. Dragline, dipper (scoop), and bucket ladder dredges are open-mouthed conveyances and are generally considered unsuitable where sediment resuspension must be minimized to limit the spread of sediment contaminants (EPA 1994a).

- **Clamshell Dredges:** The clamshell bucket dredge, or grab dredge, is widely used in the United States and throughout the world. It typically consists of a barge-mounted floating crane maneuvering a cable-suspended dredging bucket, with or without teeth. A heavy bucket with teeth can dig harder sediments than can a lighter bucket without teeth. The crane barge is held in place for stable accurate digging by deploying vertical spuds into the sediment. The operator lowers the clamshell bucket to the bottom, allowing it to sink into the sediment on contact. The bucket is closed, then lifted through the water column to the surface, swung to the side, and emptied into a waiting haul barge. When loaded, the haul barge is moved to shore where a second clamshell unloads the barge for rehandling and/or transport to treatment or disposal facilities. Clamshell dredges work best in water depths less than 100 feet to maintain production efficiency. Using advanced positioning equipment (e.g., differential global positioning systems [DGPS]), dredging accuracy is on the order of 1 foot horizontally and 0.5 foot vertically. Clamshell buckets are designated by their digging capacity when full and range in size from less than 1 cy to more than 50 cy. A conventional clamshell bucket may not be appropriate for removal of contaminated sediments in some areas. Conventional buckets have a rounded cut that leaves a somewhat “cratered” sediment surface on the bottom. This irregular bottom surface increases the need to overdredge to achieve a minimum depth of cut, and multiple passes to achieve adequate removal. Furthermore, the conventional open clamshell bucket is prone to sediment losses during retrieval. Recent innovations in bucket design have reduced sediment resuspension potential by enclosing the bucket top. Also, buckets can be fitted with tongue-in-groove rubber seals to limit sediment losses through the bottom and sides. Finally, local Puget Sound dredging contractors have recognized the need to minimize resuspension while using a clamshell bucket,

and have developed modifications to both their equipment and to the operations to reduce sediment loss.

- **Environmental Dredge:** A recent development in the environmental dredging field has been the advent of specialty level-cut buckets. These buckets offer the advantages of a large footprint, a level cut, the capability to remove even layers of sediment, and, under careful operating conditions, reduced resuspension losses to the water column. A level-cut bucket reduces the occurrence of ridges and winnows that are typically associated with conventional clamshell buckets. The Cable Arm™ bucket is one such environmental bucket that has been successfully demonstrated for contaminated sediment removal. Several of the Puget Sound area dredging companies own and use Cable Arm closed buckets (Wang et al. 2003). Local projects where the closed buckets have been used include Pier D at the Puget Sound Naval Shipyard in Bremerton, and at the East Waterway of the Duwamish River. Environmental buckets have been shown to be effective in loose sands and in low-solids soft-sediments. The light construction of the bucket makes it unsuitable for dredging dense or native material (Wang et al. 2003).
- **Excavator Dredges:** This is a subset of mechanical dredges, which includes barge-mounted backhoes and/or excavators, both of which have limited reach capability (maximum depth typically less than 40 feet). Excavators can also be used for dry excavation after the overlying water is removed. Special closing buckets are available to reduce sediment losses and entrained water during excavation. A conventional excavator bucket is open at the top, which may contribute to sediment resuspension and loss during dredging, although careful operation can minimize losses. Various improved excavating buckets have been developed that essentially enclose the dredged materials within the bucket prior to lifting through the water column. A special enclosed digging bucket, the Horizontal Profiling Grab (HPG), was successfully used on the large excavator – the Bonacavor (C. F. Bean Corp.) for remediation of highly contaminated sediment at the Bayou Bonfouca Site (Slidell, Louisiana) (NRC 1997), and was recently used for dredging contaminated sediments in the Hylebos Waterway in Tacoma. The bucket has a capacity of 4.5 cubic meters and can operate in water depths up to 13 meters. Dredged material removed by backhoe exhibits much the same characteristics as for clamshell dredging, including near *in situ* densities and limited free water.

### 5.4.3 Hydraulic Dredging

Hydraulic dredges remove and transport large quantities of dredged materials as a pumped sediment-water slurry. The sediment is dislodged by mechanical agitation, cutterheads, augers, or by high-pressure water or air jets. The loosened slurry is then vacuumed into the intake pipe by the dredge pump and transported over long distances through the dredge discharge pipeline. A key difference between hydraulic dredging and mechanical dredging is the generation of a high volume of contaminated water during hydraulic dredging. That water must be treated before discharge to ensure that the quality of the surface-water body is not compromised by the dredging activity, and to protect against sediment recontamination.

Common hydraulic dredges include three main categories: the conventional pipeline dredge (round cutterhead, horizontal auger cutterhead, open suction, bucket wheel, dust pan, etc.), the self-propelled hopper dredge, and sidecasting dredge (EPA 1994; Herbich 2000). A sidecasting dredge takes dredged material excavated from the sediments and “side casts” the material from the dredge to adjacent shoreline areas. It can be used to replenish beaches, but is not used for environmental dredging.

Hydraulic dredges have four key components: the dredgehead, which is in contact with and digs the sediment, a support structure (wire or ladder) for the head assembly, the hydraulic pump to provide suction, and the pipeline that carries sediment slurry away from dredging operations. Specialty hydraulic dredges are available that limit resuspension losses at the dredgehead and increase the solids content of the dredged slurry. These include the auger-, cleanup-, airlift-, and refresher-type dredges. Hydraulic dredges are rated by discharge pipe diameter, ranging from smaller portable machines in the 6- to 16-inch category, to large 24- to 30-inch dredges. Two commonly used hydraulic dredges are the pipeline and cutterhead types.

- **Suction Dredge:** Suction dredges are open-ended hydraulic pipes that are limited to dredging soft, free flowing, and unconsolidated material. Because suction dredges are not equipped with any kind of cutting devices, they produce very little resuspension of solids during dredging. However, the presence of trash, logs, or other debris in the dredged material will clog the suction and greatly reduce the effectiveness of the dredge (Averett et al. 1990). Suction dredges have been used with limited success in the Northwest for difficult access areas such as the underpier areas of the Sitcum Waterway Superfund Site (Tacoma, Washington) and at the Port of Portland T4 Pencil Pitch Removal Project (Portland, Oregon), often with diver assistance.
- **Cutterhead Dredge:** The hydraulic pipeline cutterhead suction dredge is the most commonly used method in the United States, with approximately 300 operating nationwide. The cutterhead is

considered efficient and versatile (Averett et al. 1990). It is similar to the open suction dredge, but is equipped with a rotating cutter surrounding the intake of the suction pipe. The combination of mechanical cutting action and hydraulic suction allows the dredge to work effectively in a wide range of sediment environments. Resuspension of sediments during cutterhead excavation is strongly dependent on operational parameters such as thickness of cut, rate of swing, and cutter rotation rate. Proper balance of operational parameters can result in suspended sediment concentrations as low as 10 milligrams per liter (mg/L) in the vicinity of the cutterhead. More commonly, cutterheads produce suspended solids in the 50 to 150 mg/L range (10 to 20 percent solids by weight) (EPA 1994b). Slurry uniformity and density are controlled by the cutterhead and suction intake design and operation. By pivoting the spuds used to anchor the barge in place, the dredge “steps” or “sets” forward for the next swing. Cutterhead dredges have been used at numerous sites in the Northwest and nationally, including the Sitcum Waterway Superfund Site (Washington), Lower Fox River (Wisconsin), and New Bedford Harbor (Massachusetts). Dredge residuals with cutterheads can be as much as a foot in thickness, and are frequently greater than ½ foot.

- **Auger Dredge:** The horizontal auger dredge is a relatively small portable hydraulic dredge designed for projects where a small (50 to 120 cy/hr) discharge rate is desired. In contrast to a cutterhead, the auger dredge is equipped with horizontal cutter knives and a spiral auger that cuts the material and moves it laterally toward the center of the auger, where it is picked up by the suction. There are more than 500 horizontal auger dredges in operation. A specialized horizontal auger dredge has been used at the Manistique Harbor Superfund site (Manistique, Michigan), the Marathon Battery Superfund site (Massena, New York), and the Lake Jarnsjon sediment remediation site (Sweden)
- **Specialty Dredges:** A number of specialty hydraulic dredges have been used at cleanup sites, including but not limited to the following:
  - ▶ The Toyo™ pump is a proprietary electrically driven compact submerged pump assembly that is maneuvered into position using a derrick barge. This pump is capable of high solids production in uncohesive sediment and can be equipped with a rotating cutter or jet ring to loosen sediment. This is a lower head pump that typically discharges through 6- to 12-inch-diameter pipes and may require a booster pump for long pipeline distances. Typically, slurry discharges are at a density

of approximately one-third the *in situ* density. This specialty dredge was used at the mouth of the Hylebos Waterway (Tacoma, Washington, Area 5106) to remove 32,000 cy of contaminated sediment and pumped into the Blair Slip 1 CND between October 2002 and March 2003.

- ▶ The Pneuma™ pump is a proprietary pump developed in Italy that uses a compressed air and vacuum system to transport sediments through a pipeline. It may be suspended from a crane or barge and generally operates like a cutterhead dredge. This specialty pump was used at the Collingwood Harbor Project (Ontario, Canada) demonstration dredging project (EPA 1994a).
- ▶ The Mudcat™, a proprietary dredge device, was fitted with a vibrating auger head assembly and positive displacement pump specifically designed to excavate difficult, very soft material from the Sydney Tar Ponds (Nova Scotia). The dredge unit was modified to float in very shallow water and was moved using onshore winching cables and pulleys. Mudcats™ are one of the most commonly employed dredging units in the country, and have been used at various environmental dredging projects including the Manistique Harbor, Michigan; SMU 56/57 in the Lower Fox River Wisconsin; and at the New Bedford PCB remedial action site.

#### **5.4.4 Dewatered Excavations**

Excavation refers to the removal of sediments in the absence of overlying water, as with upland excavation. This often involves the use of conventional excavating equipment, and is generally restricted to removal of contaminated sediment and debris in shallow-water environments, dry excavations (areas that are bermed, then dewatered for access by land-based equipment), or during low tides. Dewatering of an area for dry dredging involves hydraulic isolation/removal of surface water using: (1) earthen dams, (2) sheet piling, or (3) rerouting the water body. Although normally land based, excavators can be positioned on floating equipment (e.g., spud barge) for dredging in shallow environments.

Various track-mounted excavators have been developed to access shallow water marsh environments for dike construction, dredge material disposal operations, pipeline crossings, and have been adapted for intertidal dredging excavation. Conventional backhoes, crane buckets, dragline, and other excavator types have been adapted to self-propelled, tracked assemblies that can travel over low bearing capacity soils and shallow water environments. These systems work optimally in shallow water depths and emergent shoreline and tide flats. The production capacity of these excavators is generally

limited, and depends upon the bearing capacity of the intertidal sediments and the size equipment needed for the dredge areas.

Two specialty excavators are the Amphibex and Aquarius amphibious excavators. These are barge-mounted backhoes, capable of turning 360 degrees. These systems work optimally in water depths of 8 to 13 feet, but can also work on emergent shoreline and tide flats, according to the manufacturers. The excavators are mounted atop barges that have been fitted with “legs” with cylindrical wheels that provide mobility. The Amphibex amphibious excavator can operate in either straight mechanical or hydraulic transport modes. The Aquarius amphibious excavator only operates in mechanical dredging and transport modes. The DRE Technologies – Dry Dredge integrates a closed bucket mechanical dredge with a positive displacement pump for high solids dredged material transport.

### **5.4.5 Dredging Decision Factors**

Selection of the appropriate type of dredging technologies and their potential effectiveness is dependent upon more than one variable. Significant operating parameters and constraints considered in selecting and applying appropriate dredging equipment include sediment characteristics, site conditions, potential for sediment resuspension and transport, use of turbidity barriers, amount and type of debris, equipment availability, and removal accuracy. As noted previously, production rates, and water management will be key in determining the size of equipment selected. Work sequencing and management are also important factors to consider during the remedial design. Each of these variables is discussed below.

#### **Sediment Characteristics**

The physical characteristics of the sediments, including particle size, density, cohesion (strength), and plasticity (stickiness), interact and affect dredge performance and efficiency (USACE 1995). These factors should be considered when selecting dredge types, designing sediment dewatering facilities, calculating settling rates, and planning other aspects of remedial activities. Rocks and debris, if present, can interfere with dredging and delay the cleanup process, often creating more water quality resuspension problems. A combination of hydraulic and mechanical dredging has been used for some cleanup projects (Sitcum Waterway, Washington; Black River, Ohio; Marathon Battery, St. Lawrence River, New York; Lake Jarnsjon, Sweden) where debris interfered with large-scale dredging or access was difficult. Recent sediment dredging projects have incorporated pre-removal of boulders, wood timbers, and other debris using excavator equipment prior to initiating dredging (Grasse River, Massena, New York; GM Foundry/St. Lawrence River, New York). This requires a complete investigation (debris survey) to identify where debris is present.

## **Sediment Accessibility**

Difficult to access areas (i.e., near pilings, floating docks/marinas, riprap slopes, and between pilings and bulkheads) may require use of specialized equipment to adequately remove contaminated sediments. Recent projects have included multiple removal techniques in the remedial design to address these difficulties. For example, the Port of Vancouver Copper Spill Project (Vancouver, Washington) used a hydraulic cutterhead dredge in open areas with 0.5 feet of overdredge and diver-assisted suction dredging in underpier areas. The Port of Portland T4 Pencil Pitch Site (Portland, Oregon) used a shrouded environmental clamshell bucket for open-water areas, while nearshore and underpier areas were excavated with an airlift pump. Yet another example includes the Wyckoff/West Eagle Harbor Superfund Site where environmental clamshell buckets were used for open-water areas and backhoes were used for underpier areas at low tide. Typically, the dredging of under-pier areas is inefficient and leaves significant dredge residuals. Capping is typically incorporated into the remedial design for these areas. The method carried forward in the FS will depend upon sediment removal volumes, site access, upland space capacity for dewatering, and disposal.

## **Staging Areas & Logistics**

Shoreline access is also a factor. Adequate space is required to establish shoreline staging areas for equipment, water pumps, dewatering equipment, personnel, sand cap material, and offloading/onloading of barge and dredge equipment. Availability of land-based space for support operations may factor into the selection of dredge type. To protect migrating salmonids, the USFWS limits the period in which in-water construction can be performed to certain “fish windows.” Dredging can also be limited by the ability to transport, dewater, and dispose of excavated material. A significant limiting constraint for dredging is the availability of on-land property for staging and support activities, as well as disposal options (i.e., ability to transport dredged sediments to the disposal site at a rate equivalent to that of the dredging production rate).

## **Resuspension Potential**

A major consideration for dredge design is the capability for removing targeted sediments with a minimum amount of sediment resuspension and loss during dredging (Anchor 2003; Averett 1997; Averett et al. 1999; Havis 1988). Sediment resuspension is unavoidable to some extent, regardless of the type of dredge employed, but can be minimized with operational techniques (e.g., controlling the dredge speed or cycle time). Although several specialty dredges (Cable Arm™ Bucket, Bonacavor) have been developed to reduce sediment resuspension, proper operation by an experienced contractor is an important factor to minimizing contaminant loss. The degree of sediment resuspension is also dependent on site conditions and variables, including sediment properties and size fractions (ability to resuspend), river flow hydraulics and hydrodynamics (extent of offsite

transport), and ambient water quality (chemical partitioning into the water column). Data recently compiled for Scenic Hudson (Cleland 2000) and the Los Angeles Contaminated Sediments Task Force (Anchor 2003) determined that hydraulic and pneumatic dredges generally resuspend less sediment than mechanical dredges at the point of dredging. However, this benefit is offset by the much higher water entrainment encountered in the dredged material, the difficulty in managing dissolved-phase contaminants in the dredged materials, and in many cases the greater residuals at the point of dredging.

## **Sediment Residuals**

All in-water removal operations will leave behind some level of residual contamination after completion of dredging. Although resuspension, with subsequent resettling is one factor that can influence the residual concentrations of contaminants, other factors such as the type and size of dredging equipment, level of operator skill, positioning equipment used during dredging, and the substrate type and bottom topography all combine to influence the post-dredging residuals. Managing dredging residuals is difficult simply because the dredge operator cannot see and manage the removal operation. A commonly observed phenomenon in both hydraulic and mechanical dredging is the creation of furrows or ridges between passes of the dredge equipment. The substrate and topography can greatly influence residuals. Where bedrock or hard clay underlies contaminated sediments, complete removal to low residual concentrations is both difficult and costly. When dredging on a slope, material often slumps and flows after being undercut during a removal path, resulting in recontamination of the just-dredged area. Hydraulic dredges generate residuals when the cutterhead is placed too low in the sediment or if the rate of advancement is too fast; both causing sloughing of the side cuts.

In recent years, dredging contractors have become more experienced and sophisticated at minimizing residuals. Bid documents prepared for remedial dredging include both horizontal and vertical specifications to account for uncertainty in the dredging footprint, and often specify a minimal number of passes within the footprint to achieve complete removal. However, residuals have been observed at sites after multiple dredge passes. Overlap between dredging lanes is often required, as well as the use of computer-aided positioning equipment and software, such as WINOPS, to ensure accurate and complete coverage of the dredge footprint. Matching the appropriate equipment to the dredging conditions, coupled with water quality monitoring during removal, aids in minimizing resuspension and recontamination. Even with these controls, dredging operations can still leave behind contaminant concentrations indicative of residuals at the conclusion of operations. The design should consider procedures for residuals management as part of any dredging design, and the limitations of dredging to achieve a clean final surface should be considered as part of remedial alternatives evaluation and cleanup decision-making. In short, dredging is an imperfect technology and



typically leaves some degree of residual contamination, even with the use of best practices to minimize that residual.

## **Application of Turbidity Barriers**

Turbidity barriers are specialized equipment that can be used as an engineering control to minimize downstream transport and loss of suspended solids during dredging operations. Because of their inherent logistical difficulties, they are typically employed where experience has shown that other operational controls cannot adequately meet water quality criteria. Turbidity barriers can be placed into two categories: structural and non-structural. Structural barriers are semi-permanent or permanent features to control the movement of sediment. The most common type is the sheet pile wall, a series of interlocking steel sections driven into the sediment to the same depth below mudline. This technology is expensive but effective in rivers with strong currents and/or tidal action and very high contaminant levels. It is often used in nearshore areas for dewatering and dry excavation. Non-structural, flexible barriers include oil booms, silt curtains, and silt screens. They are less expensive, easy to set up, and more movable than the structural barriers. Oil booms are utilized where dredged material may release oil residues on the water surface. Silt curtains are impervious fabrics that block, deflect, or substantially minimize the flow of water and suspended sediments. Silt screens are semi-permeable fabrics that allow water to pass while impeding the flow of coarse- to medium-grained fractions of the suspended load. Silt screens and curtains are typically suspended by floatation devices at the water surface and secured vertically in-place by a ballast chain within the lower hem of the skirt and anchored to the river bottom. These barrier systems are relatively cheap and easy to re-locate, but are limited by water depth (less than 21 feet), strong river currents (less than 1.5 feet/sec), and tidal cycles. Tidal ranges within the Whatcom Waterway can be as much as 16 feet and limit the effectiveness of screens or curtains.

## **Sediment Debris**

The amount and type of debris to be found in the dredge zone will influence the type of dredging equipment and affect the production rate. Examples of debris include sunken logs, large rocks, shopping carts, engine blocks, rope, chain, concrete chunks, sunken boats, propane tanks, pilings, dolphins, rip rap, and other materials. Debris may also clog hydraulic dredge cutter or suction heads and pipeline, causing an increase in resuspension and requiring a temporary shutdown to remove the obstruction, thereby slowing the production rate. Debris can also inhibit the full sealing of mechanical dredge buckets, which causes loss of sediment during the buckets vertical ascent through the water column and increases the rate of resuspension. The loss of sediment and the extra time devoted to handling and disposing of debris reduces the production rate.

## **Equipment Availability**

Availability of dredging equipment is an important consideration. A number of floating clamshell dredges and small hydraulic dredges are available in the Puget Sound region. Large construction backhoes and equipment barges are also available. However, many of the specialty dredges discussed herein are not available locally and/or would require transport to the area or fabrication of new dredging equipment and a period of time to acquire operating experience. Conditions within the Whatcom Waterway site are not expected to require specialty equipment.

## **Dredge Accuracy and Removal Rates**

Dredging accuracy is of significant importance in environmental dredging projects to ensure removal of contaminated sediments, minimize the volume of uncontaminated sediments removed, and minimize the number of passes required. Recent advances in dredging technology have included high-precision GPS location control. Several differential GPS units are used in the dredging operation, and placed on the barge and the dredge bucket or hydraulic cutterhead itself to provide a three-dimensional, real-time orientation of the equipment. High-resolution measurements provide the operator with real-time, sub-meter location precision and accuracy. These data, coupled with computer location software, allow the operator to know: (1) exactly where the dredge is collecting sediment from, (2) the amount of overlap needed to remove a swath of sediment, and (3) the exact depth of each dredge cut. In the past, system inaccuracies required remedial designs to operate on the order of 4-foot dredge prisms. With precision equipment and navigational aids, dredge operators can consistently operate to depth prisms of 0.5 foot or less with reliable accuracy. Removal efficiency is the capability for removing the target contaminated sediment layer in a single (or minimum number of) pass(es) with the dredge equipment, while minimizing the quantity of over dredged material to be treated and disposed. The costs and schedule for environmental dredging are largely dependent on the amount of sediment to be removed and the rate of removal. The rate of removal is affected by several variables, including water depth, type of excavation (wet or dry), the number and sizes of dredges used, the dredge operational speed, and the capacity of transport barges for mechanical and/or sediment dewatering, and water treatment systems for hydraulic dredging. Uncontrollable factors also affect the removal rate, such as passing ships and navigation restrictions, adverse weather conditions, unexpected presence of debris or bedrock, noise level restrictions, seasonal “fish window” restrictions, and tribal fishing rights.

## **Management of Entrained Water**

Another decision factor is water management, and the practicality of managing large volumes of water associated with dredged material that will require collection and treatment prior to discharge of return flow to the Bay. The water volumes range from small amounts of free water and drainage

arising from mechanically-dredged sediment to significant continuous volumes associated with return flow from a hydraulic dredge.

Hydraulic dredging would create large quantities of dredge slurry and entrained water. That contaminated water would ultimately be discharged back to Bellingham Bay. Assuming typical operating parameters (i.e., a controlled 2,000 cubic yard per day dredge production rate, a 10:1 water to sediment ratio and either one or two dredge units operating simultaneously) the hydraulic dredging would result in discharge of between 4 million and 8 million gallons per day of produced dredge waters to the Bay. The ability to treat and dispose of this continuously-generated water in a cost-effective and environmentally sound manner is a pre-requisite for the successful application of hydraulic dredging for large project areas. In some cases, the conditions under which hydraulic dredging and water management are performed can result in biogeochemical mobilization of bound sediment contaminants, such as at the Lavaca Bay, Texas dredging project. Bloom and Lasorsa (1999) report that high concentrations of methylmercury were released during separation of dredged material and entrained water from a hydraulic dredging event. The amount of methylmercury released was greater than could be accounted for by sediment pore water or bound methylmercury, suggesting that methylation of mercury was promoted by the conditions associated with the dredging and phase separation activities.

Dredging programs must consider the quantity and quality of waters to be generated, and must provide for management of water quality impacts to maintain the effectiveness of the dredging activity. In some cases dredging is not effective because these secondary impacts cannot be reliably controlled.

## **Contractual Issues and Operator Experience**

The need exists for appropriately structured cleanup contracts, skilled operators, and preparation time for the operators to become familiar with the site. Adequate site characterization from the RI/FS process is typically supplemented during remedial design, and in some cases during the project bidding process. The characterization data relevant to dredging contracts include (1) the vertical extent of contaminated sediment requiring removal, (2) ship traffic and current/tidal ranges, and (3) the expected range of sediment physical properties (i.e., density, grain size, plasticity). These factors affect contractor costs, equipment selection and dredging procedures. The contractual agreements between the project engineer and the general contractor/dredge contractor are equally important. The emphasis should be carefully placed on the quality of removal, environmental protection and cost-effectiveness of the whole cycle of dredging, transport and disposal, not solely on the speed/cost of removal. Otherwise, cost-cutting measures taken at the point of dredging can result in significant environmental problems and cost control issues with the downstream activities (i.e., dredge material disposal, residuals management). During the selection process, the experience and skill

of equipment operators should be evaluated and included as part of a contractor pre-qualification process.

In addition to selecting skilled and experienced contractors to conduct a dredging operation, operator experience can be managed in part by performance-based contracts to help ensure compliance with environmental monitoring and criteria. These contracts should allow the contractor flexibility to select or modify dredge equipment in order to meet the project objectives, but require compliance with the overall project objectives, including water quality goals. In the case of Puget Sound area projects, such as the Sitcum Waterway and Wyckoff/West Eagle Harbor projects, the contractor was aware of the project objectives, given flexibility to meet these objectives, and held accountable through performance-based contracting. Coupled with performance-based contracting and skilled operators is the requirement for skilled and knowledgeable independent oversight, as well as an adequate water quality monitoring program. Project oversight and contract management provide independent verification of achievement of project goals and objectives. The water quality monitoring program provides immediate feedback on the overall performance to both the dredging and oversight contractors.

## **5.5 Sediment Disposal and Reuse Options**

If sediments are to be removed by dredging and not contained on site, then they must be disposed off-site or beneficially reused. Potential disposal and reuse options are described below.

### **5.5.1 Subtitle D Landfill Disposal**

Dredged sediments containing elevated constituent levels can be disposed at permitted upland landfills. The solid waste landfills that manage refuse from households and businesses are known as Subtitle D facilities, because they are regulated under Subtitle D of the federal solid waste regulations. These landfills require “daily cover” to be placed over solid wastes at the end of each day of filling. Contaminated soils and sediments like those of the Whatcom Waterway can be used as daily cover at these facilities. This type of disposal is described in this Feasibility Study as “Subtitle D Landfill Disposal.”

A recent study by the US Army Corps of Engineers (USACE, 2003) identified upland disposal in a commercial landfill as the preferred alternative for management of contaminated sediment in Puget Sound. A typical process would include offloading sediments from the point of dredging to an upland staging area, loading sediments into transportation from an upland staging area, transportation of the sediments to the landfill, and disposal in the landfill. For low-solids sediments, it may be desirable to decrease the volume and mass of sediments disposed in the landfill through dewatering, provided that this can be accomplished cost-effectively and in an environmentally protective manner. The exact management and treatment train depends on the

volume of sediments to be disposed, the sediment properties, the required production rate, and the dredging method.

The Disposal Siting Documentation Report identified the Roosevelt Regional Landfill as a potential upland disposal site. The landfill is located in Roosevelt, Washington approximately 220 miles by rail from Bellingham. For use of this disposal site, dredged sediments would be offloaded from barges and loaded into railcars for transport to Roosevelt. The offloading could take place in Bellingham at a facility constructed to accommodate the sediment offloading and shipment, or at an already constructed facility, such as those in Seattle and Tacoma.

The Columbia Ridge landfill located in eastern Oregon is also available for management of dredged materials, and like the Roosevelt landfill is capable of managing sediments containing free liquids. The current capacity of the Roosevelt Regional Landfill and the Columbia Ridge landfill are on the order of several million cubic yards of sediment.

Other Subtitle D disposal sites located in Western Washington are generally limited to the management of materials that pass paint-filter tests for free liquids. This results in additional requirements for dewatering and/or solidification of the dredged materials for shipment to these alternative facilities.

The Subtitle D disposal option was retained for further evaluation in the Feasibility Study. Remedial alternatives development and cost estimation were based on pricing for transportation and disposal of materials to landfills permitted to accept wet dredged sediment materials.

## **5.5.2 New Upland Disposal Sites**

For development of remedial alternatives and cost estimates, only existing facilities permitted to accept impacted sediments were used. It is possible that a new upland disposal site may be developed by a third party and would be available for use for sediment disposal.

An example of a potential new upland disposal site is the analysis conducted during the Bellingham Bay Demonstration Pilot of the Whatcom-Skagit Phyllite Quarry. The Whatcom-Skagit Phyllite Quarry is a soon to be closed quarry located approximately 15 miles from the site. If used for disposal of dredged sediments, a Washington Solid Waste permit would likely be required to construct a disposal facility in the quarry. The quarry would be graded, and a liner and leachate collection system constructed. Dredged sediments would be offloaded from barges in Bellingham, potentially dewatered, and transported to the quarry. After all sediments had been placed in the quarry, the sediments would be graded, and a cover constructed over the sediments. A wetland similar to those surrounding the site may be constructed over the cover. In the long term, leachate from the sediments

would be collected, treated if necessary, and discharged to the City of Burlington sewer system. The capacity of the Whatcom-Skagit Phyllite Quarry was assessed at approximately 200,000 to 240,000 cubic yards of sediment. The final unit costs for disposal at the Phyllite Quarry would likely be similar to or in excess of Subtitle D disposal options. The availability and public acceptability of the option are not certain.

Other disposal facilities not currently certified as Subtitle D landfills could alternatively be suitable for use at the time of project implementation. These could potentially include some disposal facilities in British Columbia that are not directly subject to U.S. regulations, but rather are regulated by Canadian and/or provincial regulations. Use of these types of alternative disposal facilities would need to be approved by the Department of Ecology. These types of facilities are not necessarily precluded from use during the project, but were not used for cost analysis or development of remedial alternatives in the Feasibility Study.

### **5.5.3 PSDDA Disposal and Beneficial Reuse**

In Puget Sound, the open water disposal of aquatic sediments is managed under the Puget Sound Dredged Material Management Program (DMMP). This program is administered jointly by the US Army Corps of Engineers, the US Environmental Protection Agency, the Washington Department of Natural Resources, and the Washington Department of Ecology. Under the DMMP, six aquatic disposal sites (PSDDA sites) have been created in Puget Sound, and several more outside Puget Sound. The PSDDA site typically used for Bellingham Bay maintenance dredging projects is located in Rosario Straits. The PSDDA sites are monitored by Washington Department of Natural Resources to ensure that the sediments placed in these sites do not pose unacceptable impacts in the long term.

In order to dispose of sediments in one of the sites, the sediments are first characterized to ensure that they meet the criteria for disposal at the PSDDA site. For removed sediments that exceed PSDDA criteria, alternative containment, treatment and/or disposal options must be used. The appropriate permits are obtained for the dredging work, and an application made for disposal in the PSDDA site. Washington Department of Natural Resources reviews the application and determines if the sediments may be disposed in the PSDDA site. If approved for PSDDA disposal, a Site Use Authorization will be issued. The applicant can then dredge their project and dispose of the material in the PSDDA site. A fee is paid by the applicant for use of the disposal site.

The PSDDA program has also developed guidance for the beneficial reuse of clean dredged materials. Reuse options must be compatible with the chemical and physical properties of the materials, and with applicable regulatory requirements.

## 5.5.4 Regional Multi-User Disposal Sites

At some point in the future, a multi-user sediment disposal site may be developed within the greater Puget Sound area. Significant efforts have been expended both within Bellingham Bay, and within the greater Puget Sound region to evaluate the potential design, location, operating procedures and long-term care requirements associated with such a facility. These efforts were supported by multiple environmental and resource agencies, and included programmatic evaluations by the Army Corps of Engineers, WDNR and other agencies. A multi-user disposal site scenario was pursued as part of the 2000 RI/FS and EIS, and was identified as an element of the preferred remedial alternative identified in those studies. However, the multi-user disposal site proved infeasible due to implementability barriers and associated costs. To date, the development of multi-user disposal sites within Bellingham Bay or Puget Sound has been unsuccessful.

There is no active proposal for development of a specific multi-user site that is likely to produce a completed site within the next three to five years. Lacking a specific regional multi-user disposal site, the regional disposal site option was not carried forward in the Feasibility Study. The potential for development of a project-specific disposal site is addressed by the Cornwall CAD and ASB CND options evaluated in the Feasibility Study.

## 5.6 *Ex Situ* Treatment

Treatment is a preferable remedy for long-term effectiveness under MTCA. However, with the exception of certain technologies such as dewatering and solidification, the feasibility of most treatment technologies has not yet been demonstrated for application to contaminated sediments. The Cooperative Sediment Management Program (CSMP), a consortium of federal and state agencies formed in 1994 to oversee the management of Puget Sound sediments, recently initiated a study to assess the feasibility and practicability of developing a multi-user treatment program or facility to help manage contaminated sediments in Puget Sound.

As part of the CSMP, a recent study by Ecology on the viability of sediment treatment in Puget Sound concluded that a centralized sediment treatment facility was economically feasible, though a combination of public and private capital would be required to develop such a facility (SAIC, 2001). Also as part of the CSMP, the US Army Corps of Engineers conducted a feasibility study for siting of a contaminated sediment management facility in Puget Sound, which included both disposal sites and treatment. This study concluded that because of the availability and interest from several upland landfills, that disposal in an existing commercial upland landfill provided the best approach for management of contaminated sediments expected to be generated from cleanup projects in Puget Sound (USACE, 2003). These studies and the general lack of demonstrated effectiveness of treatment of sediment indicate that treatment is not likely to be a viable option for

sediments from the Whatcom Waterway, unless a new technology or capital source for a new treatment facility is identified.

Nevertheless, the treatment technologies that have been evaluated are described below. For each technology, agency technology reviews by EPA (1994 and 1999) have been supplemented with additional technology reviews performed for this project.

### 5.6.1 Dewatering & Volume Reduction

Sediment dewatering can include mechanical and passive methods. Mechanical dewatering involves the use of equipment such as centrifuges, hydrocyclones, belt presses, and plate and frame filter presses to remove moisture from the sediments. Passive dewatering (also referred to as gravity dewatering) involves the gravity separation of water and solids in a sedimentation basin. Treatment of wastewater generated during sediment dewatering may be required to meet water quality requirements for either discharge to a municipal wastewater treatment system, or back to surface water. Dewatering can be considered active treatment to the extent that it reduces the volume or toxicity of an impacted material.

#### Mechanical Dewatering

Mechanical dewatering equipment physically forces water out of sediment, and are typically paired with hydraulic removal systems. Four techniques are typically considered for dewatering dredged sediments: centrifugation, diaphragm filter presses, belt presses, and hydrocyclones.

- **Centrifugation** uses centrifugal force to separate liquids from solids. Water and solids are separated based upon density differences. The use of a cloth filter or the addition of flocculent chemicals assists in the separation of fine particles.
- **Hydrocyclones** are continuously-operated devices that use centrifugal force to accelerate the settling rate and separation of sediment particles within water. Hydrocyclones are cone shaped. Slurries enter near the top and spin downward toward the point of the cone. The particles settle out through a drain in the bottom of the cone, while the effluent water exits through a pipe exiting the top of the cone.
- **Diaphragm filter presses** are filter presses with an inflatable diaphragm, which adds an additional force to the filter cake prior to removal of the dewatered sediments from the filter. Filter presses operate as a series of vertical filters that filter the sediments from the dredge slurry as the slurry is pumped past the filters. Once the filter's surface is covered by sediments, the flow of the



slurry is stopped and the caked sediments are removed from the filter. Filter presses are very costly and labor intensive.

- **Belt presses** use porous belts to compress sediments. Slurries are sandwiched between the belts, resulting in high pressure compression and shear, which promotes the separation. Flocculents are often used to assist the removal of water from the sediments. The overall dewatering process usually involves gravity-draining free water, low pressure compression, and finally high pressure compression. Belt presses can be fixed based or transportable. They are commonly used in sludge management operations at municipal and industrial wastewater treatment plants.

Mechanical dewatering is considered potentially cost-effective for application to low-solids materials such as the ASB sludges, and has been retained for consideration in the Feasibility Study for these materials. Volume reduction in the ASB sludges could significantly reduce disposal volumes, tonnages and costs. Application of mechanical dewatering to other medium and high solids materials such as the sediments outside the ASB is unlikely to be cost-effective.

## 5.6.2 Acid Extraction

The acid extraction process selectively extracts targeted metals while non-regulated metals theoretically remain in the treated soil or sediment. Under optimal conditions, metals can be concentrated from the process and may be suitable for recycling.

The process is semi-continuous and consists of three key treatment steps: physical separation, chemical extraction, and liquids processing. In the physical separation step, the dredged sediments are segregated at a land-based facility into various size fractions (typically using a 1/16 to 1/4 inch screen), to exclude relatively clean coarse materials such as sands and gravels from further treatment. The chemical extraction step typically consists of a multistage solvent extraction which utilizes proprietary additives in an acidic solvent to preferentially remove target metals. A slurry consisting of sediment and the acidic solvent is vigorously agitated in closed-top tanks to ensure thorough contact between the sediment and solution. Mechanical mixing and/or air sparging accomplish the agitation. The rate at which the metal ions are solubilized and enter the liquid phase is determined by controlling the residence time, solid particle size, degree of agitation, and the extraction solution composition. The optimal solvent/additives formulation, the required number of stages, and the key operating parameters are site specific and are determined by performing bench-scale treatability studies.

In the liquids processing step, the metal-laden solvent may be treated by filtration and electro-chemical processes to selectively recover the metal

contaminants in a concentrated form. The solvent is treated and recycled back to the chemical extraction portion of the process.

To date, slurry extraction technology has been used at upland soil sites containing very high concentrations of target metals and much lower volumes of contaminated materials. The presence of organic materials and naturally occurring metals (e.g., iron) that are typical of Whatcom Waterway sediments are of significant concern when applying this process, and can affect performance and increase costs.

A "ballpark" cost estimate per unit of sediments treated, including upland disposal of residues is approximately \$200 to \$500 per cubic yard of in situ sediment (EPA, 1999). This technology was not considered effective or implementable for application at the Whatcom Waterway site.

### **5.6.3 Phytoremediation**

Phytoremediation includes a variety of processes that use natural or genetically altered terrestrial plant species to accomplish chemical transformation, accumulation in plant tissue, and/or volatilization to the atmosphere.

In previous experimentation and pilot-scale testing specific to soils with relatively high mercury concentrations, gene isolation and introduction methods have been used to genetically engineer various plant species to accomplish such transformations. For example, strains of "hyperaccumulator" species such as Yellow poplar and cattail have been developed that release enzymes into soils, geochemically converting (over several steps) the metal compounds which are then transpired through the plant tissue, and released into the atmosphere (Phytoworks, Inc., unpublished data, 1998). The potential health hazards associated with application of this technology would need to be addressed in any full-scale operation.

Use of phytoremediation technologies within the Whatcom Waterway Area would require transfer of sediments to an upland treatment/disposal facility, and spreading of the sediments in a relatively thin layer (e.g., up to several feet thick) that would be seeded with freshwater or brackish hyperaccumulator species. Currently, field-scale phytoremediation of mercury soils has only been performed in the southeast (characterized by relatively long growing seasons), though bench-scale testing is currently underway in other areas of the U.S. Similar to the acid extraction technology, these sites have contained much higher concentrations and much lower volumes of contaminated materials than those present in the Whatcom Waterway site.

Based on these previous applications, a range of plant tissue manipulations, bench-scale laboratory analysis, and pilot-scale testing would likely be necessary to determine the feasibility of this process for application to the Whatcom Waterway site. Finally, because low-level contaminant residues

could continue to persist in the treated material, the final residue may still require containment or upland landfill disposal.

A ballpark cost estimate per unit of sediments treated, including upland disposal of residues, would likely exceed roughly \$200 per cubic yard of in situ sediment and the technology would require very large areas for implementation. This technology is not considered effective or implementable for application at the Whatcom Waterway site.

#### **5.6.4 Soil/Sediment Washing**

Soil/sediment washing is a water-based, volumetric reduction process whereby chemicals such as mercury are extracted and concentrated into a smaller residual volume using physical and chemical methods. Similar to the acid extraction process summarized above, an initial physical separation step is used at a land-based facility to exclude relatively clean coarse materials such as sands and gravels from further treatment. Subsequently, chemical extraction agents are added to the water-based “washing” medium, and may include surfactants, chelating agents, coagulants, flocculants, and pH modifiers. Under optimal conditions, the washing process permits concentration of hazardous chemicals into a residual liquid (water-based) product representing 10 to 30 percent of the original sediment volume. However, these volumetric reductions can become more difficult to achieve for sediments such as those within the Whatcom Waterway Area, which typically contain more than 80 percent fines. The presence of woody materials, also characteristic of subsurface sediments in the Whatcom Waterway Area, may further reduce the effectiveness of soil/sediment washing. The residual liquid (water-based) product produced by the soil/sediment washing process requires further treatment and disposal. Chemical extraction is discussed above, while thermal treatment and stabilization are described below. In some cases, the wastewater may be discharged to an off-site treatment plant or may be treated and discharged to Bellingham Bay. A “ballpark” cost estimate per unit of sediments treated, including treatment of residues, may range from approximately \$100 to \$500 per cubic yard of in situ sediment, depending on site conditions (EPA, 1999). Like Phytoremediation, the residual sediments are likely to contain constituent levels that would restrict reuse options and would require disposal of the treated residuals. This technology is not considered implementable or cost-effective for application to the Whatcom Waterway site.

#### **5.6.5 Thermal Desorption**

Several vendors have developed and commercialized medium-temperature thermal desorption processes for removing mercury from soils and sediments. However, none of these technologies are permitted for application in the Puget Sound region. The process can recover a range of inorganic forms of mercury, if mercury recovery is performed. Lower cost forms of the technology volatilize mercury into the atmosphere.

In the higher-cost version of the process, soils/sediments are blended with a proprietary additive, which promotes decomposition of stable mercury compounds, and the blended sediments are then loaded into a batch-operated furnace for processing. Thermal processing is divided into two stages: feed drying and mercury desorption. The furnace temperature is ramped to a temperature at which moisture in the feed can be removed with minimum volatilization of mercury. During this stage, the process off gas is routed through a gas filtration system. After the feed has been dried, the furnace temperature is raised to, and held at, a temperature at which the mercury is driven off as a dry vapor. In this stage, the process gas stream is routed through a heat exchanger to condense metallic mercury from mercury vapor before the gas is routed through a gas filtration system. The operating temperature for the process typically ranges from 300 to 1,400 degrees Fahrenheit, depending on the moisture content of the soil/sediment and other site characteristics. The furnace and air handling components are typically protected by secondary containment, which operates under an air treatment system separate from that of the process air.

The medium-temperature thermal desorption process has been used successfully to remediate a range of upland soil sites containing mercury and other metals. Typically, these sites have contained much higher concentrations (e.g., hazardous waste mercury sludges) and much lower volumes of mercury-containing materials than those present in the Whatcom Waterway site. Considering the relatively high moisture content of Whatcom Waterway sediments, relative to upland soils, a "ballpark" cost estimate per unit of sediments treated, including disposal of residues, is approximately \$500 to \$2,000 per cubic yard of in situ sediment (EPA, 1999). This technology is not considered cost-effective for application at the Whatcom Waterway site.

## **5.6.6 Light Weight Aggregate Production**

Several commercial ventures have developed processes that use mostly or all contaminated sediments as the raw material to produce light weight aggregate (LWA) with 30 percent less weight than regular rock but with the same strength. Typical LWA is made by heating pellets of compacted sediment (supplemented with clay or shale as required) to about 1,100 °C in a kiln. The material tends to break along fracture lines and therefore has inherent weak points.

A typically process flow consists of the following steps: 1) screen or filter dredged sediments to separate out sands, gravels, and other coarse materials; 2) grind, mix (possibly with clay or shale), and dry the material; 3) process the material through an extruder to make homogenous pellets; 4) further dry the pellets (optional); 5) process the pellets through a kiln; and 6) cool the pellets prior to transport and use.

Some of the issues that would need to be addressed in a full-scale application of LWA production include: 1) energy required to run the plant and possible

use of waste heat in the drying process at a fixed plant location; 2) transportation costs; 3) kiln temperatures of 1,100 °C may not be sufficient to destroy all organic contaminants; 4) the limited regional “market” for contaminated sediment treatment that may result in increased costs; and 5) the atmospheric release of volatile mercury from the treatment process would likely result in an unacceptable health risk. Given these parameters, a "ballpark" cost estimate per unit of sediments treated could range from approximately \$100 to \$200 per cubic yard of in situ sediment, depending on operating parameters, air emissions control requirements, availability of a reuse market for LWA.

Production of LWA from dredge materials is not considered implementable or cost-effective for application at the Whatcom Waterway site.

### **5.6.7 Plasma Vitrification**

Several companies are currently developing higher-temperature processes in which contaminated sediments may be converted to a useful glass product by direct injection into the plume of a high-power, non-transferred-arc plasma torch (McGlaughlin et al., 1999). The sediments are first pretreated by conventional sorting and washing processes to remove large particles and debris, and to reduce the salt content. The sediment is then partially dewatered to produce a slurry or paste with as low a moisture content as possible while still being pumpable. Fluxing agents such as lime and soda ash are then added to adjust the final properties of the glass to be produced (melting point, viscosity, thermal expansion, and leachability). The mixture is then melted in the plasma reactor at temperatures exceeding 2,000 °C. The resulting molten glass for many sediments is granulated, producing an aggregate product which typically has low leachability. The glass product may then be used as the feedstock for a variety of products, including sandblasting grit, fiberglass, insulation fiber, roofing granules, and road aggregate. However, residual constituent concentrations can limit reuse options, and the current excess of recycled glass materials negatively affects the down-stream economics of this process. Without potential revenue from the sale of tile, this treatment process is not cost-effective. For high production facilities, a “ballpark” cost estimate per unit of sediments treated is approximately \$150 to 200 per cubic yard of in situ sediment (McGlaughlin et al., 1999). This technology is not considered implementable or cost-effective for application at the Whatcom Waterway site.

### **5.6.8 Stabilization/Solidification**

Solidification involves mixing a chemical agent with dredged sediments to absorb moisture. Portland cement, pozzolan fly ash, fly ash/Portland cement mixtures, and lime kiln dust are common additives. The chemical agent and sediments may be mixed in a pug mill or in a contained area (e.g., a roll off box or pit) using an excavator, depending upon sediment production rates and work space areas. Solidification is commonly used for sediments that have

been partially dewatered by another means. Mechanically-dredged sediments can sometimes be solidified directly. Solidification is not a practical method for dewatering hydraulically-dredged sediments in the absence of thickening the solids by some other means, because the amount of chemical agent required becomes cost prohibitive. Requirements for solidification vary depending on the requirements of the disposal site or subsequent treatment option, the properties of the dredged materials, and also on the extent of previous dewatering conducted.

A number of different companies have developed manufacturing technologies for producing construction-grade cements or lightweight aggregate materials from a wide variety of contaminated waste materials, including sediments. Using various proprietary additives and processes, metals and organic chemicals can be immobilized and sequestered within the stabilized sediment. The material can be transformed into construction-grade cement. However, stabilization is typically conducted as part of a disposal step (i.e., as pretreatment of highly-impacted materials prior to disposal) rather than as a true material reuse application.

While stabilization has been used successfully using relatively coarse soils and sediments, the fine-grained characteristics of Whatcom Waterway sediments (i.e., greater than 80 percent fines) would require the addition of sand and/or gravel material to achieve typical structural requirements. Further, the presence of woody debris and other organic materials that are typical of Whatcom Waterway sediments are of significant concern when applying this process, and can substantially affect performance and increase costs. Finally, since the stabilization process does not permanently destroy chemical contaminants, the permanence (e.g., long-term durability) of the stabilized matrix would need to be addressed in bench-scale testing.

A ballpark cost estimate per unit of sediments treated is approximately \$100 per cubic yard of in situ sediment (EPA, 1999), and a large disposal area or reuse area for the solidified material would be required. Washington state regulations (MTCA requirements and State Solid Waste Management Regulations) could further limit the ability to reuse the materials as construction subgrade or controlled density fill, and would likely require the materials to be managed as a solid waste. This technology is not considered implementable or cost-effective for application at the Whatcom Waterway site.

## **5.7 *In Situ* Treatment**

Multiple bench and pilot-scale studies have evaluated potential *in situ* treatment technologies for sediment. These have included nutrient enhanced biological degradation, chemical oxidation, and stabilization. None of these studies has proven effective to date. However, a detailed screening was conducted for each of two in situ technologies. The first is an *in situ* treatment

technology specifically intended for removal of metals from impacted sediments and sludges. The second technology is a type of capping known as “reactive capping.”

### **5.7.1 Electro-Chemical Reductive Technology**

Electro-chemical reductive technology (ECRT) was originally developed in Europe. The technology is based on imposing a direct electrical current with a superimposed alternating energy current via in situ electrodes, to optimize and utilize the electrical capacitance properties of soil and sediment particles.

The technology purports to be capable of oxidizing organic chemicals *in situ*, and concurrently enhancing the mobility of metals such as mercury, resulting in metal precipitation onto the electrodes. To date, the technology has been applied at one sediment site in Europe containing elevated concentrations of mercury and other metals. However, the technology has not yet been applied on a full scale in the U.S.

A pilot test of ECRT was performed at the Log Pond area of the Whatcom Waterway site, as described in Section 7.3 of the RI Report. However, it was found to be ineffective at achieving mercury removal. This technology is not considered sufficiently effective for application at the Whatcom Waterway site.

### **5.7.2 Reactive Caps**

Reactive capping is a developing technology that incorporates catalytic, sequestering, or blocking agents into the sediment cap design. This may be done by specification of a total organic carbon content in the applied cap, or through additions of materials that have been shown to be effective in dechlorination, sequestering of metals or recalcitrant hydrocarbons, or providing a seal against contaminant migration through a cap.

In recent Puget Sound projects, organic carbon additions have included application of granulated anthracite to the Pacific Sound Resources RA1 cap, addition of peat mixed with the sand cap in the Head of the Thea Foss Waterway project (DOF 2004), and the addition of granular activated carbon to the cap at the Olympic View Restoration Area. At the Olympic View Restoration area, high TOC materials mixed with sand was placed as part of the lower layer of an isolation cap to protect against PCBs and dioxins. This “high TOC/sand” layer was 6 inches thick. The material was not thought of as a reactive cap, but was placed as a precautionary barrier (K. Keeley, EPA, personal communication). The cap design followed the standard USACE guidance calculations for caps. According to the design document, the GAC used was a “common commercial-grade product” mixed at 4 percent by volume (1.5 percent by weight) (Hart Crowser 2002).

A major demonstration of several of the more active-addition reactive cap designs is now underway on the Anacostia River in Washington, DC (HSRC 2004). The objective of the Anacostia River demonstration project, which began field trials in spring 2004, is to provide information on the design, construction, placement and effectiveness of these augmented caps. The cap methods selected for use in the pilot demonstration included multiple augmentation materials. AquaBlok™, a commercial product designed to enhance chemical sequestering (e.g., through TOC amendments to the cap) and to reduce permeability at the sediment-water interface. AquaBlok™ is not recommended for application in saline environments. Apatite is a material added to encourage precipitation and sorption of metals. Coal and/or coke breeze materials were added because they can strongly adsorb hydrophobic organic contaminants such as PCBs.

Based on the success of the Log Pond cap at preventing migration of sediment contaminants upward through the cap, there does not appear to be a need to apply reactive cap technology at the Whatcom Waterway site. Reactive cap technology was not retained for application at the site.

## 5.8 Summary of Retained Technologies

As described in Sections 5.2 through 5.7 above and as indicated in Table 5-1, the following remedial technologies were considered sufficiently effective, implementable, and cost-effective for use in the development of remedial alternatives:

- **Monitored Natural Recovery:** The effectiveness of natural recovery at reducing surface concentrations of mercury within the site has been demonstrated. The use of Monitored Natural Recovery as part of a remedial strategy for the site is considered effective and implementable. This technology is retained for use in the development of remedial alternatives.
- **Containment by Capping:** Capping is effective, implementable and cost-effective, and is retained for use in the development of remedial alternatives. Land use, navigation patterns and physical factors will be considered in the discussion of capping feasibility for specific site areas.
- **On-Site Containment:** Section 5.3 addresses potential on-site containment options for contaminated sediments that maybe generated during site remediation. These include the development of a CAD site adjacent to the Cornwall Avenue Landfill and the development of a CND within the ASB. These containment options are retained for use in the development of remedial alternatives.



- **Removal by Mechanical Dredging:** Mechanical dredging using appropriate equipment is retained for use in the development of remedial alternatives. Mechanical dredging is the most commonly used form of dredging for implementation of site cleanup projects, and appropriate equipment and skilled operators are available from within the region.
- **Removal by Hydraulic Dredging:** Hydraulic dredging was retained for use in the development of remedial alternatives, particularly for potential removal of ASB sludges, or for localized work within the Whatcom Waterway. Any application of hydraulic dredging would need to provide for management of sediment debris, minimization of dredging residuals, and methods for managing produced dredge slurry and separated waters in a cost-effective and environmentally protective manner.
- **Removal by Excavation:** Excavation of sediments without overlying water is retained for use in the development of remedial alternatives for specific portions of the site such as the ASB that could potentially be dewatered. Wet excavation using an articulated dredge is also retained for consideration. This method could be used in both confined and exposed portions of the site.
- **Treatment for Volume Reduction:** For low-solids sediments such as the ASB sludges, treatment for volume reduction using centrifuges, hydrocyclones or other mechanical dewatering equipment is retained for use in the development of remedial alternatives. Treatment for volume reduction is not retained for medium to high solids sediments such as those from areas outside of the ASB.
- **Subtitle D Landfill Disposal:** Contaminated sediments may be disposed at a permitted off-site subtitle D disposal facility. This disposal option is retained by use in the development of remedial alternatives.
- **PSDDA Disposal and/or Beneficial Reuse:** In specific areas of the site, sediments may be suitable for PSDDA disposal or beneficial reuse. These disposal and reuse options are retained for use in the development of remedial alternatives.
- **Institutional Controls:** Institutional controls are effective, implementable and cost-effective and are carried forward for use in the development of remedial alternatives.

## 6 Description of Remedial Alternatives

This section includes a description of the eight remedial alternatives. The alternatives were developed using the technologies selected during the technology screening (Section 5). Table 6-1 provides a concise summary of the remedial alternatives and the technologies applied from Section 5. The information in this section provides for each of the alternatives:

- a detailed description of the cleanup actions performed in each portion of the Site;
- a discussion of the management options used for dredged materials generated by the cleanup action;
- a summary of the costs and schedule of the cleanup alternative;
- a discussion of potentially significant changes to existing habitat conditions associated with implementation of the cleanup action; and
- land use and navigation considerations relevant to the cleanup action.

**Table 6-1 Concise Summary of Remedial Alternatives & Technologies Applied**

Alternative Number	Probable Cost (\$million)	Institutional Controls	Monitored Natural Recovery	Containment	Removal & Disposal	Treatment	Reuse & Recycling
Alt. 1	\$8	Yes	Yes	Yes	—	—	—
Alt. 2	\$34	Yes	Yes	Yes	—	—	—
Alt. 3	\$34	Yes	Yes	Yes	—	—	—
Alt. 4	\$21	Yes	Yes	Yes	Yes	—	—
Alt. 5	\$42	Yes	Yes	Yes	Yes	Yes	Yes
Alt. 6	\$44	Yes	Yes	Yes	Yes	Yes	Yes
Alt. 7	\$74	Yes	Yes	Yes	Yes	Yes	Yes
Alt. 8	\$146	Yes	Yes	Yes	Yes	Yes	Yes

Table 6-2 provides a detailed description of each of the eight remedial alternatives described in this section. Figures 6-1 through 6-9 illustrate the design concept of each of the alternatives. Detailed cost and engineering assumptions are provided in Appendices A and B.

## 6.1 Alternative 1

Alternative 1 uses containment, monitored natural recovery and institutional controls to comply with SMS cleanup levels and MTCA cleanup requirements. Alternative 1 is illustrated in Figure 6-1. Alternative 1 makes the least use of active remedial technologies of all of the evaluated alternatives.

### 6.1.1 Actions by Site Unit

Cleanup actions under Alternative 1 are described below by site area. The application of active cleanup measures and institutional controls is detailed in Table 6-2 for each Site Unit:

- **Outer Whatcom Waterway (Unit 1):** Under Alternative 1, no dredging or capping will be performed in the outer portion of Whatcom Waterway. Surface sediments in this area currently comply with SMS criteria. Subsurface impacted sediments would remain in place beneath the clean surface sediments. Some reduction in waterway depth would result under this alternative. Future channel maintenance would likely be restricted beneath elevations of approximately 26 feet below MLLW in order to avoid resuspension of impacted subsurface sediments. This depth restriction would need to be addressed in Waterway planning and site institutional controls.
- **Inner Whatcom Waterway (Units 2 & 3):** As with the Outer Whatcom Waterway, no dredging or capping would be performed in the Inner Whatcom Waterway under Alternative 1. The majority of this area has naturally recovered, with some surface contamination remaining in nearshore berth areas along the Colony Wharf portion of the Central Waterfront site. Additional recovery time will be required to achieve full restoration of this area. Reductions in waterway depths will accompany the use of natural recovery in the Inner Whatcom Waterway areas. The effective waterway depth will vary as shown in Figure 6-1. Additional recovery modeling would be required as part of Cleanup Action Plan development and/or remedial design to verify the applicability of natural recovery for this area.
- **Log Pond (Unit 4):** The Log Pond area was previously remediated as part of an Interim Action implemented in 2000. Subsequent monitoring has demonstrated the protectiveness of the subaqueous cap, and the effectiveness of habitat enhancement actions completed as part of that project. Actions in this area will be limited to enhancements to the shoreline edges of the cap, to ensure long-term stability of the cap edges. These enhancements are described in Appendix D of this report.

- **Areas Offshore of ASB (Unit 5):** Exceedances of site-specific cleanup goals within Unit 5-B will be remediated using sub-aqueous capping. Appendix C describes the design concept for this area, including methods to maintain cap stability in a manner compatible with anticipated permitting requirements. The remaining areas of Unit 5 comply with site-specific cleanup goals. No sediment capping or dredging is proposed for these areas at this time. Additional evaluations of sediment stability will be conducted as part of engineering design. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels. Additional measures will be taken in this area only if engineering design evaluations indicate that such measures are required.
- **Areas Near Bellingham Shipping Terminal (Unit 6):** The area south of the barge docks at the Bellingham Shipping (Units 6-B and 6-C) contains exceedances of SMS cleanup levels. This area will be remediated using a deep-water sub-aqueous cap. Final water depths in this area will be greater than -18 feet MLLW in most areas, consistent with shoreline infrastructure and navigation uses historically conducted there. The cap will be constructed of coarse granular materials and will be designed to resist potential prop-wash erosion effects. The remaining portions of Unit 6 comply with site-specific cleanup goals. No sediment capping or dredging is proposed for these areas. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels.
- **Starr Rock (Unit 7):** Sediments in the Starr Rock area currently comply with site-specific cleanup levels. No sediment capping or dredging is proposed for these areas. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels.
- **ASB (Unit 8):** The sludges within the ASB will be remediated using a thick sub-aqueous cap. Prior to cap placement, the treatment equipment (aerators, weirs, etc.) would be removed from the ASB. The conceptual design for the cap includes a nominal 3-foot layer of sandy capping material, with coarse materials placed in nearshore areas where wind-driven wave action may be significant. If the ASB is to be used for future stormwater/cooling water treatment, then the ASB would need to either remain connected to the current GP-owned outfall, or be provided with an alternate, appropriate-sized discharge outfall. Other modifications may be required depending on planned future uses.

## 6.1.2 Sediment Disposal

No sediment dredging is included in Alternative 1. All impacted sediments are managed in-place using containment technologies (capping) and monitored natural recovery. No sediment disposal sites are required under this alternative.

## 6.1.3 Costs & Schedule

Alternative 1 is the lowest cost of the eight evaluated alternatives. The total probable cost of Alternative 1 is \$8 million. Most of this cost is associated with the capping of the ASB sludges and the two impacted harbor areas. Additional costs are included to provide for long-term monitoring of capping and natural recovery areas (Appendices A and B).

The construction activities in Alternative 1 can likely be completed within a single construction phase. The capping activities in the two impacted harbor areas would be completed during appropriate times of the year when the potential for impacts to juvenile salmonids is minimized. These construction “fish windows” are typically specified as part of project permitting requirements. Because the ASB area is not connected to Bellingham Bay, the capping activities within the ASB will not necessarily be time-limited by the “fish windows”.

Monitoring of capped and natural recovery areas will occur under Alternative 1. Previous recovery analyses performed as part of the Remedial Investigation suggest that 5 and 10 years may be required for the sediment areas near the Colony Wharf portion of the Central Waterfront site. Site-specific recovery modeling would be required as part of Cleanup Action Plan development or remedial design to verify the effectiveness of this alternative. Appendix A includes unit cost and volume assumptions for Alternative 1.

## 6.1.4 Changes to Existing Habitat Conditions

Significant changes to existing habitat conditions that will occur as a result of implementing Alternative 1 are summarized in Table 6-2 and include the following:

- **Outer Whatcom Waterway (Unit 1):** Alternative 1 does not change habitat conditions in the Outer Whatcom Waterway.
- **Inner Whatcom Waterway (Units 2 & 3):** Under Alternative 1, no dredging is conducted within the Inner Whatcom Waterway areas, and additional shoaling would occur as part of monitored natural recovery. These processes result in preservation and enhancement of the quantity of shallow-water aquatic habitat.
- **Log Pond (Unit 4):** Construction of shoreline enhancements consistent with the design concept in Appendix D will result in

changes to substrate type and elevations in shoreline edges of the cap.

- **Areas Offshore of ASB (Unit 5):** The design concept for the sediment cap at the shoulder of the ASB (Unit 5-B; design concept included in Appendix C) results in an increase in sediment elevation from between -6 to -10 feet MLLW to elevations between -3 to -6 feet MLLW. The measures applied in the Appendix C design concept to reduce wave energy and stabilize the cap surface are expected to enhance habitat quality by facilitating the growth of aquatic vegetation. These changes are consistent with the Bellingham Bay Comprehensive Strategy which identifies the development of “habitat benches” along this portion of the shoreline to enhance habitat quality for migrating juvenile salmonids. Alternative 1 does not result in any changes to habitat conditions in Units 5A and 5C.
- **Areas Near Bellingham Shipping Terminal (Unit 6):** The cap in the barge dock area (Unit 6-B & C) is to be constructed in deep water and is not expected to significantly modify existing habitat quality. Alternative 1 does not involve any changes to habitat conditions in Unit 6A.
- **Starr Rock (Unit 7):** Cleanup activities under Alternative 1 do not modify existing habitat conditions at Starr Rock.
- **ASB (Unit 8):** Alternative 1 does not change the existing habitat conditions for the ASB. The ASB sludges will be capped, and this area will remain isolated from Bellingham Bay.

### 6.1.5 Land Use & Navigation Considerations

Significant land use and navigation considerations associated with the implementation of Alternative 1 are summarized in Table 6-2 and include the following:

- **Outer Whatcom Waterway (Unit 1):** Alternative 1 conflicts with existing and planned navigation uses in the Outer Whatcom Waterway. The presence of residual impacted sediments will impact the effective water depth of the terminal area. Current depths range from about 30 feet to over 35 feet below MLLW, but dredging will be required in the future to maintain navigation depth. Such dredging would resuspend impacted sediments unless the dredging were precluded below the current mudline. This would effectively limit the usable and maintainable water depth in this area to a minimum of approximately 25 feet below MLLW.

- **Inner Whatcom Waterway (Units 2 & 3):** The Inner Whatcom Waterway area has highly variable mud-line elevations. Shoaling is present particularly at the head of the waterway (near the Roeder Avenue bridge) and along the berth areas of the Central Waterfront shoreline. Effective water depths (the usable water depth along the current pierhead line) in this area vary from about -7 feet MLLW to areas that are exposed at low tide. The use of natural recovery as the remedial strategy for these areas under Alternative 1 would limit usable water depths to current conditions, with an additional measure of shoaling required to permit continuance of natural recovery and protect against resuspension of underlying contaminated sediments. Future docks or floats could be constructed in deeper waterway areas, however; the portion of the Waterway useable for navigation would be significantly less than under other project alternatives, resulting in conflicts in some areas with planned navigation and land use improvements (section 4.1.2). Further, Alternative 1 does not stabilize Inner Whatcom Waterway shorelines, resulting in potential additional use limitations in unstable shoreline areas.
- **Log Pond (Unit 4):** Consistent with property restrictive covenants, the uses of the Log Pond have been restricted to uses that do not expose capped sediments. This remains unchanged under this alternative and is consistent with planned land uses in nearby areas. Public access (i.e., shoreline promenade) along the Log Pond shoreline is anticipated as part of future area-wide redevelopment activities.
- **Areas Offshore of ASB (Unit 5):** The design concept for the sediment cap at the shoulder of the ASB (Unit 5-B; design concept included in Appendix C) results in an increase in sediment elevation from between -6 to -10 feet MLLW to elevations between -3 to -6 feet MLLW. The measures applied in the Appendix C design concept to reduce wave energy and stabilize the cap surface are expected to enhance habitat quality by facilitating the growth of aquatic vegetation. These changes are consistent with the Bellingham Bay Comprehensive Strategy which identifies the development of “habitat benches” along this portion of the shoreline to enhance habitat quality for migrating juvenile salmonids. The construction of a cap in this area using the proposed design concept does not conflict with current or planned uses of the ASB, or with navigation uses in surrounding areas. Appropriate navigation aids would likely be required in perimeter areas of the cap and habitat bench to prevent inadvertent groundings of small recreational vessels. The water depths in this area are already shallow enough that larger vessels are precluded from this area.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** The cap in the barge dock area (Unit 6-B & C) will reduce navigation depths in this area by approximately 3 feet (final cap thickness to be determined in final design and permitting). This change will not preclude navigation uses in this area, but will need to be incorporated into future navigation and infrastructure planning for the area.
- **Starr Rock (Unit 7):** Cleanup activities under Alternative 1 are consistent with current and anticipated navigation and land uses at Starr Rock.
- **ASB (Unit 8):** The ASB has been identified in previous land use studies as the preferred location for development of a future environmentally sustainable marina with integrated public access and habitat enhancement features (Figure 4-4). Alternative 1 conflicts with this planned use.

## 6.2 Alternative 2

Alternative 2 uses monitored natural recovery, institutional controls and containment technologies to comply with SMS cleanup levels and MTCA cleanup requirements. However, unlike Alternative 1, dredging of sediments from within the Whatcom Waterway channel is conducted. These sediments are managed in a new Confined Aquatic Disposal (CAD) facility that would be developed offshore of the Cornwall Avenue Landfill. The Cornwall CAD site location was selected during the 2000 EIS after evaluation of potential alternative locations. The design concept for alternative 2 is shown in Figure 6-2.

### 6.2.1 Actions by Site Unit

Alternative 2 represents a modification of the preferred alternative from the 2000 RI/FS and EIS process. These analyses were based on continued industrial uses of the Central Waterfront and New Whatcom areas. These analyses also assumed that future land uses would comply with the restrictions applicable to continued maintenance of the 1960s federal navigation channel. Current zoning and land use planning have changed, necessitating re-evaluation of the site remedial alternatives.

- **Outer Whatcom Waterway (Unit 1):** Under Alternative 2, the outer portion of the waterway would be dredged to a minimum depth of 35 feet below MLLW. Where technically feasible, the dredging depths would be increased to allow dredging to the base of the impacted sediments in the channel areas. Anticipated dredge depths vary from 35 feet below MLLW to about 41 feet below MLLW. The sediments removed during this dredging would be barged to the Cornwall CAD site location, and placed within the



containment facility. The sediments from Units 1A and 1B would be used in upper portions of the CAD site, and the facility would be completed as described below. Some capping may be required in areas that are not technically feasible to dredge (to be determined during remedial design and permitting). Dredging methods used for the Outer Whatcom Waterway would likely be mechanical, reducing the entrained water management concerns applicable to hydraulic dredging, and producing dredge materials with physical properties appropriate for CAD site management. Detailed dredging and construction procedures and alternatives would be evaluated in project design and permitting.

- **Inner Whatcom Waterway (Units 2 & 3):** Under Alternative 2, sediment dredging would be performed as necessary to provide for future use and maintenance of the 1960s federal navigation channel to the head of the waterway. The 1960s federal channel boundaries specify a water depth of 30 feet below MLLW from the Port terminal area to Maple Street. A depth of 18 feet is specified from Maple Street to the head of the waterway. In the Outer Whatcom Waterway, the dredging cut would be established at an elevation at least 35 feet below MLLW. This would remove sediments where technically feasible, and would provide sufficient overdepth to allow residual sediments to be capped without impeding future maintenance of the federal channel. The design concept assumes a cap thickness of 3 feet over dredged areas with residual subsurface sediment impacts. Due to historical encroachment of shoreline fills on the federal channel boundaries, many of the Inner Whatcom Waterway shoreline areas have fill and bulkheads located near or at the pierhead line. Most of these bulkheads would require replacement and/or substantial upgrades in order to maintain shoreline stability in these areas during and after dredging. Most docks and bulkheads along the Central Waterfront shoreline were constructed historically when the channel depth was shallower (18 feet below MLLW) and these docks and bulkheads would need to be either removed or replaced in order to accommodate federal channel dredging and future use. After dredging, the effective water depth (water depth at the pierhead line) will vary with location along the shoreline. The effective water depth will be controlled mostly by the type of shoreline infrastructure (i.e., nearshore fill, docks and bulkheads) that is established there. Without substantial infrastructure investments in shoreline modifications, bulkheading and dock reconstruction, the effective water depth for the head of the waterway will be significantly less in most areas than the federal channel project depth. This alternative is inconsistent with planned use of the Inner Whatcom Waterway, as described in Section 4.2.1. Planned use of the Inner Whatcom Waterway includes providing

waterfront uses that combine public access, habitat enhancement and navigation uses in a manner consistent with the current-mixed use waterfront zoning. The remedial costs of this alternative address only sediment removal. The costs of the shoreline infrastructure required to improve the effective waterway depth would be borne by area redevelopment actions.

- **Log Pond (Unit 4):** The Log Pond area was previously remediated as part of an Interim Action implemented in 2000. Subsequent monitoring has demonstrated the protectiveness of the subaqueous cap, and the effectiveness of habitat enhancement actions completed as part of that project. Actions in this area will be limited to enhancements to the shoreline edges of the cap, to ensure long-term stability of the cap edges. These enhancements are described in Appendix D of this report.
- **Areas Offshore of ASB (Unit 5):** Exceedances of site-specific cleanup goals within Unit 5-B will be remediated using subaqueous capping. Appendix C describes the design concept for this area, including methods to maintain cap stability in a manner compatible with anticipated permitting requirements. The remaining areas of Unit 5 comply with site-specific cleanup goals. No sediment capping or dredging is proposed for these areas at this time. Additional evaluations of sediment stability will be conducted as part of engineering design. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels. Additional measures will be taken in this area only if engineering design evaluations indicate that such measures are required.
- **Areas Near Bellingham Shipping Terminal (Unit 6):** The area south of the barge docks at the Bellingham Shipping (Units 6-B and 6-C) contains exceedances of SMS cleanup levels. This area will be remediated using a deep-water sub-aqueous cap. Final water depths in this area will be greater than -18 feet MLLW in most areas, consistent with shoreline infrastructure and navigation uses historically conducted there. The cap will be constructed of coarse granular materials and will be designed to resist potential propwash erosion effects. The remaining portions of Unit 6 comply with site-specific cleanup goals. No sediment capping or dredging is proposed for these areas. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels.
- **Starr Rock (Unit 7):** Sediments in the Starr Rock area currently comply with site-specific cleanup levels. No sediment capping or dredging is proposed for these areas. These areas will be monitored

to document the continued effectiveness of natural recovery at complying with cleanup levels.

- **ASB (Unit 8):** The ASB will will be remediated using a thick sub-aqueous cap. Prior to cap placement, the treatment equipment (aerators, weirs, etc.) would be removed from the ASB. The conceptual design for the cap includes a nominal 3-foot layer of sandy capping material, with coarse materials placed in nearshore areas where wind-driven wave action may be significant. If the ASB is to be used for future stormwater/cooling water treatment, then the ASB would need to either remain connected to the current GP-owned outfall, or be provided with an alternate, appropriate-sized discharge outfall. Other modifications may be required depending on planned future uses.

## 6.2.2 Sediment Disposal

Unlike Alternative 1, Alternative 2 involves substantial sediment dredging. The sediments dredged from the Waterway areas will be managed by containment in a new Confined Aquatic Disposal (CAD) area adjacent to the Cornwall Avenue landfill. The design concept estimates disposal of approximately 472,000 cubic yards of sediments dredged from the Outer and Inner Whatcom Waterway areas, and an additional 113,000 cubic yards of sediments dredged from Units 1A and 1B.

The Cornwall CAD site location was identified through the Bellingham Bay Pilot process, after evaluation of balancing criteria including costs, navigation, land use and habitat factors. The CAD location was incorporated into the range of remedial alternatives discussed in the 2000 RI/FS. The principal benefit of the Cornwall location as identified under the Pilot was the ability to create nearshore aquatic habitat using the CAD design approach. The geography of the area requires initial construction of an armored containment berm, prior to placement of the dredged materials within the site. Armoring of the outer edges of the berm is required to ensure long-term stability of the completed structure under anticipated wave energy and erosion conditions.

During filling of the CAD site, the containment berms would be constructed above tidal elevations. Sediments would be loaded into the facility and allowed to consolidate. The design and permitting for the CAD site would optimize sediment handling and offloading procedures to ensure compliance with water quality criteria near the CAD site location.

After the facility has been filled to design capacity, a capping layer of clean sediments would be placed to provide the final cap surface. The capping sediments will need to be appropriately sized and the cap edges will need to be appropriately constructed to resist wave-induced erosion.

Long-term monitoring and maintenance and institutional controls for the CAD facility would be required as part of the remedy. The construction of the CAD facility would also require coordination with the Cornwall Avenue Landfill and RG Haley cleanup sites, located adjacent to the CAD site location.

### **6.2.3 Costs & Schedule**

The probable costs of Alternative 2 are \$34 million. In order of decreasing cost, this estimate addresses dredging and CAD site disposal of Waterway sediments, capping costs for the ASB and harbor areas, enhancements to the Log Pond shoreline, and provisions for long-term monitoring. Long-term monitoring costs are higher than under Alternative 1, because of the additional monitoring and periodic maintenance required for the completed CAD facility (Appendices A and B).

As described above, the costs for Alternative 2 do not include the costs for upgrading shoreline infrastructure in the Inner Whatcom Waterway as necessary to stabilize shoreline conditions and support the navigation use of the Waterway berth areas. Because the 1960s channel dimensions were never fully implemented and because of encroachment along the pierhead lines, substantial infrastructure investments would be required in shoreline areas to achieve target navigation depths and complete implementation of this alternative consistent with the requirements of an industrial channel (see Figure 4-2). These costs are associated with shoreline modifications, bulkhead replacements and dock replacements, and would need to be provided as part of shoreline redevelopment actions in order to complete the cleanup in a coordinated manner. The funding and design of these shoreline actions would need to be completed in parallel with the Whatcom Waterway cleanup in order to provide for CAD-site disposal of sediments from Waterway berth areas. Otherwise, the dredging in the Waterway would be limited by side-slope stability and construction setbacks, and would generally avoid dredging activities in berth areas. Residual sediments in the berth areas would be capped pending any future redevelopment of the shoreline area. Future shoreline modifications that involved sediment generation would likely be required to manage that sediment by upland landfill disposal. Such future costs are not included in Alternative 2.

The construction activities in Alternative 2 can likely be completed within four construction seasons. With the exception of the ASB area, work activities would be confined to appropriate “fish windows.” Because the ASB area is not connected to Bellingham Bay, the capping activities within the ASB will not necessarily be time-limited by the “fish windows.”

Monitoring of capped and natural recovery areas will occur under Alternative 2. Monitoring will also be performed at the CAD site to ensure long-term effectiveness of the sediment containment.

## 6.2.4 Changes to Existing Habitat Conditions

The significant changes to existing habitat conditions that will occur as a result of implementing Alternative 2 are summarized in Table 6-2 and include the following:

- **Outer Whatcom Waterway (Unit 1):** Alternative 2 includes dredging of the Outer Waterway areas. However, this dredging occurs in deep water and does not significantly affect shallow-water habitat areas.
- **Inner Whatcom Waterway (Units 2 & 3):** Under Alternative 2, dredging of the Inner Whatcom Waterway is conducted consistent with the boundaries of the 1960s federal channel. This requires the removal of emergent shallow-water habitat at the head and along the sides of the channel. Further, to achieve target dredge depths and navigation conditions, the shorelines must be hardened with bulkheads and other infrastructure similar to that shown in Figure 4-2. The application of this shoreline infrastructure would further reduce the existing quality of nearshore aquatic habitat within the Inner Whatcom Waterway.
- **Log Pond (Unit 4):** Construction of shoreline enhancements consistent with the design concept in Appendix D will result in changes to substrate type and elevations in shoreline edges of the cap.
- **Areas Offshore of ASB (Unit 5):** The design concept for the sediment cap at the shoulder of the ASB (Unit 5-B; design concept included in Appendix C) results in an increase in sediment elevation from between -6 to -10 feet MLLW to elevations between -3 to -6 feet MLLW. The measures applied in the Appendix C design concept to reduce wave energy and stabilize the cap surface are expected to enhance habitat quality by facilitating the growth of aquatic vegetation. These changes are consistent with previous the Bellingham Bay Comprehensive Strategy which identifies the development of “habitat benches” along this portion of the shoreline to enhance habitat quality for migrating juvenile salmonids. Alternative 2 does not result in any changes to habitat conditions in Units 5A and 5C.
- **Areas Near Bellingham Shipping Terminal (Unit 6):** The cap in the barge dock area (Unit 6-B & C) is to be constructed in deep water and is not expected to significantly modify existing habitat quality. Alternative 2 does not involve any changes to habitat conditions in Unit 6A.

- **Starr Rock (Unit 7):** Cleanup activities under Alternative 2 do not modify existing habitat conditions at Starr Rock.
- **ASB (Unit 8):** Alternative 2 does not change the existing habitat conditions for the ASB. The ASB sludges will be capped, and this area will remain isolated from Bellingham Bay.
- **Cornwall CAD Area:** Alternative 2 involves the creation of a confined aquatic disposal facility near the Cornwall Avenue Landfill. Such a facility will involve the conversion of a significant area of deep-water habitat to shallow-water habitat. The final area, elevation and quality of this shallow-water habitat will vary depending on the final design of the facility.

### 6.2.5 Land Use & Navigation Considerations

Significant land use and navigation considerations associated with the implementation of Alternative 2 are summarized in Table 6-2 and include the following:

- **Outer Whatcom Waterway (Unit 1):** Alternative 2 is consistent with current and planned land and navigation uses. The alternative allows for continued maintenance of the federal shipping channel in this area. Some infrastructure maintenance and/or upgrades would likely be required at the shipping terminal to support dredging there.
- **Inner Whatcom Waterway (Units 2 & 3):** Community land use planning efforts have emphasized the need to provide for multiple waterfront uses in the Inner Whatcom Waterway area. These uses include shoreline public access, habitat enhancement and navigation uses in a manner consistent with the mixed-use waterfront zoning. This alternative conflicts with these planned land and navigation uses. In order to support deep dredging of the 1960s industrial channel, substantial shoreline infrastructure upgrades are required. These upgrades are inconsistent with habitat enhancement actions in these same areas. Secondly, the land uses necessary to justify Corps participation in future channel maintenance likely conflict with mixed-use redevelopment and shoreline public access objectives. Some navigation uses such as transient moorage may be precluded, or may be significantly restricted in the Inner Whatcom Waterway areas. This contrasts with other FS Alternatives (i.e., Alternatives 4, 5 and 6) that assume the application of a mixed-use channel within the Inner Whatcom Waterway.
- **Log Pond (Unit 4):** Consistent with property restrictive covenants, the uses of the Log Pond have been restricted to uses that do not



































































































































































































mitigated, but are intrinsic to this alternative. Like all of the remediation alternatives, cleanup implementation will result in some adverse impacts under SEPA category 4 (air and noise impacts), though these can be mitigated through compliance with applicable regulatory requirements and best practices. Alternative 3 will involve dredging at the head of Whatcom Waterway, raising a potential for disturbance of historical or cultural resources (SEPA category 5). These impacts would need to be mitigated through appropriate planning, archaeological monitoring and/or other measures.

- **Alternative 4:** Alternative 4 is expected to comply with MTCA cleanup requirements, protecting water quality and environmental health. Unlike previous alternatives 1-3, Alternative 4 conducts remediation of the Inner Whatcom Waterway area consistent with the multi-purpose waterway concept. Capping and stabilization of Inner Whatcom Waterway shorelines will be accomplished as part of the implementation of this alternative, in a manner consistent with planned land and navigation uses in this area. Alternative 4 therefore achieves net beneficial impacts under SEPA category 1 (geology, water, environmental health). There are some habitat impacts under Alternative 4, but these are offset by habitat gains through preservation and construction of nearshore habitat. Alternative 4 produces a net beneficial impact under SEPA category 2 (fish & wildlife). Under SEPA category 3 (land use, navigation & shoreline public access), this alternative results in net adverse impacts that cannot be mitigated. The alternative avoids the deep dredging and associated shoreline infrastructure requirements of Alternatives 2 and 3, and hence avoids navigation and land use conflicts in the Inner Whatcom Waterway. However, the capping of the ASB sludges results in direct conflicts with planned aquatic reuse of this area. The land use and navigation impacts of Alternative 4 cannot be mitigated, and are intrinsic to this alternative. Like all of the remediation alternatives, cleanup implementation will result in some adverse impacts under SEPA category 4 (air and noise impacts), though these can be mitigated through compliance with applicable regulatory requirements and best practices. Alternative 4 will involve dredging in the Whatcom Waterway, but dredging at the head of Whatcom Waterway is minimized, increasing protection for potential historical or cultural resources. Potential impacts under SEPA category 5 can be mitigated through appropriate project design and archeological review.
- **Alternative 5:** Alternative 5 is expected to comply with MTCA cleanup requirements, protecting water quality and environmental health. Like Alternative 4, this alternative conducts remediation of

the Inner Whatcom Waterway area consistent with the multi-purpose waterway concept. Dredging, capping and stabilization of Inner Whatcom Waterway shorelines will be accomplished as part of the implementation of this alternative, in a manner consistent with planned land and navigation uses in this area. Alternative 5 therefore achieves net beneficial impacts under SEPA category 1 (geology, water, environmental health). There are some habitat impacts under Alternative 5, but these are offset by a substantial net gain in the quantity of nearshore habitat. In addition to the habitat improvements included in Alternative 4, Alternative 5 accomplishes remediation of the ASB, and the ASB is reconnected to the surface waters of Bellingham Bay. This increases open-water habitat by approximately 28 acres, and introduces nearly 4,500 linear feet of salmonid migration corridor in an area formerly cut off from Bellingham Bay. Alternative 5 produces a net beneficial impact under SEPA category 2 (fish & wildlife). Under SEPA category 3 (land use, navigation & shoreline public access), this alternative results in net beneficial impacts. The alternative accomplishes implementation of the multi-purpose channel concept, including deep dredging at the Bellingham Shipping Terminal, and dredging, capping and shoreline stabilization in the Inner Whatcom Waterway. Shorelines in this area are reconstructed in a manner consistent with planned mixed use redevelopment of the Inner Whatcom Waterway. Remediation of the ASB facilitates planned aquatic reuse of this area for construction of a marina with integrated public access and habitat enhancements. Like all of the remediation alternatives, cleanup implementation will result in some adverse impacts under SEPA category 4 (air and noise impacts), though these can be mitigated through compliance with applicable regulatory requirements and best practices. Alternative 5 will involve dredging in the Whatcom Waterway, but dredging at the head of Whatcom Waterway is minimized, increasing protection for potential historical or cultural resources. Potential impacts under SEPA category 5 can be mitigated through appropriate project design and archeological review.

- **Alternative 6:** Most elements of Alternative 6 are identical to those of Alternative 5. Alternative 6 results in net beneficial impacts under the first three of the SEPA categories, and results in mitigated impacts under the fourth and fifth category. The main difference between Alternative 6 and Alternative 5 is the increased use of dredging near the Bellingham Shipping Terminal. This increased dredging is compatible with planned navigation and land uses, and does not result in requirements for new shoreline infrastructure. The deeper dredging does not trigger new habitat impacts, because the dredging is confined to deep-water areas. As

a result, the additional dredging does not result in new adverse impacts under SEPA categories. In fact, the additional dredging provides additional benefits under the third SEPA category (land use, navigation & shoreline public access) by supporting potential future deepening of the Outer Whatcom Waterway, should that be required in the future.

- **Alternative 7:** Alternative 7 is expected to comply with MTCA cleanup requirements, protecting water quality and environmental health. However, the alternative requires deep dredging within the Inner Whatcom Waterway area, which will destabilize project shorelines. This shoreline destabilization represents a net adverse impacts under SEPA category 1 (geology, water, environmental health) that will require mitigation. Mitigation will include the construction of bulkheads and hardened shoreline infrastructure to prevent shoreline collapse and permit use and maintenance of target dredge depths. Probable costs for the construction of this deep draft infrastructure are estimated at \$30 million, not including long-term maintenance. Alternative 7 is likely to produce mitigated adverse impacts under SEPA category 2 (fish & wildlife), through anticipated impacts to existing shallow-water, nearshore habitat. As with Alternatives 5 and 6, nearshore habitat improvements are accomplished as part of the remediation of the ASB, and construction of a sediment cap offshore of the ASB. This additional habitat is expected to offset the destruction of nearshore habitat at the head and along the sides of the Whatcom Waterway. Additional habitat mitigation is not likely to be required under Alternative 7. Under SEPA category 3 (land use, navigation & shoreline public access) Alternative 7 is expected to result in net adverse impacts. The deep dredging and associated shoreline infrastructure requirements of this alternative are inconsistent with planned mixed-use redevelopment of the Inner Whatcom Waterway. The bulkheads and other infrastructure are in direct conflict with planned habitat enhancements, and the construction of deep draft infrastructure will be in conflict with community land use planning efforts. The use restrictions associated with the 1960's federal channel also conflict with local priorities for public shoreline access and environmental enhancements in the Inner Whatcom Waterway areas. These land use and navigation impacts cannot be mitigated, but are intrinsic to this alternative. Like all of the remediation alternatives, cleanup implementation will result in some adverse impacts under SEPA category 4 (air and noise impacts), though these can be mitigated through compliance with applicable regulatory requirements and best practices. Alternative 7 will involve dredging at the head of Whatcom Waterway, raising a potential for disturbance of historical or cultural resources (SEPA category 5). These impacts would need to be mitigated through

appropriate planning, archaeological monitoring and/or other measures.

- **Alternative 8:** Alternative 8 is expected to comply with MTCA cleanup requirements, protecting water quality and environmental health. However, the alternative requires deep dredging within the Inner Whatcom Waterway area, which will destabilize project shorelines. This shoreline destabilization represents a net adverse impacts under SEPA category 1 (geology, water, environmental health) that will require mitigation. Mitigation will including the construction of bulkheads and hardened shoreline infrastructure to prevent shoreline collapse and permit use and maintenance of target dredge depths. Probable costs for the construction of this deep draft infrastructure are estimated at \$30 million, not including long-term maintenance. Alternative 8 is likely to produce net adverse impacts under SEPA category 2 (fish & wildlife), through anticipated impacts to existing shallow-water, nearshore habitat. As with Alternatives 5 and 6, nearshore habitat improvements are accomplished as part of the remediation of the ASB. However, Alternative 8 converts nearshore habitat to deep-water habitat in areas offshore and adjacent to the ASB. These conversions represent net adverse impacts to juvenile salmonid habitat. In addition to the destruction of nearshore habitat at the head and along the sides of the Whatcom Waterway, Alternative 8 is likely to result in a net adverse impacts to fish and wildlife. Additional habitat mitigation is likely to be required under Alternative 8. Under SEPA category 3 (land use, navigation & shoreline public access) Alternative 8 is expected to result in net adverse impacts. The deep dredging and associated shoreline infrastructure requirements of this alternative are inconsistent with planned mixed-use redevelopment of the Inner Whatcom Waterway. The bulkheads and other infrastructure is in direct conflict with planned habitat enhancements in this area, and the construction of deep draft infrastructure will be in conflict with area redevelopment planning. The use restrictions associated with the 1960's federal channel also conflict with local priorities for public shoreline access and environmental enhancements in the Inner Whatcom Waterway areas. These land use and navigation impacts cannot be mitigated, but are intrinsic to this alternative. Of the evaluated remediation alternatives, implementation of Alternative 8 will result in the greatest adverse impacts under SEPA category 4 (air and noise impacts), though these can be mitigated through compliance with applicable regulatory requirements and best practices. Alternative 8 will involve dredging at the head of Whatcom Waterway, raising a potential for disturbance of historical or cultural resources (SEPA category 5). These impacts



would need to be mitigated through appropriate planning, archaeological monitoring and/or other measures.

## 8.2 Pilot Comparative Analysis

In addition to its strict SEPA regulatory role, the EIS also evaluates each of the project alternatives for its consistency with the seven goals of the Bellingham Bay Demonstration Pilot. Consistency with these goals is not required under MTCA or SMS regulations. However, the Pilot Goals capture the results of over ten years of coordinated cleanup, source control and habitat restoration planning in Bellingham Bay. Alternatives that have a high degree of consistency with the Pilot goals are considered to provide greater overall benefits relative to the stated priorities of the Pilot team members.

### 8.2.1 Seven Pilot Goals

As described in the project EIS document, the Bellingham Bay Demonstration Pilot was established in 1996 with the stated mission to use a new cooperative approach to expedite source control, sediment cleanup and associated habitat restoration in Bellingham Bay. The Pilot Team included regulatory and resource agencies, the City of Bellingham, the Port of Bellingham, the Lummi Nation, the Nooksack Tribe and other key community groups and stakeholders. The Pilot included extensive community involvement and public outreach activities.

Using consensus-based decision-making, the Pilot Team established seven “baywide” goals that it wanted to ultimately achieve. The goals were formally adopted by the multi-agency work group in 1997, and these goals provide an additional benchmark against which the appropriateness of the preferred alternatives can be measured. The seven Pilot goals are as follows:

***Goal 1 -- Human Health and Safety:*** Implement actions that will enhance the protection of human health.

***Goal 2 – Ecological Health:*** Implement actions that will protect and improve the ecological health of the bay.

***Goal 3 – Protect and Restore Ecosystems:*** Implement actions that will protect, restore or enhance habitat components making up the bay’s ecosystem.

***Goal 4 – Social and Cultural Uses:*** Implement actions that are consistent with or enhance cultural and social uses in the bay and surrounding vicinity.

***Goal 5 – Resource Management:*** Maximize material re-use in implementing sediment cleanup actions, minimize the use of non-

*renewable resources, and take advantage of existing infrastructure where possible instead of creating new infrastructure.*

**Goal 6 – Faster, Better, Cheaper:** *Implement actions that are more expedient and more cost-effective, through approaches that achieve multiple objectives.*

**Goal 7 – Economic Vitality:** *Implement actions that enhance water-dependent uses of shoreline property.*

## 8.2.2 Pilot Ranking of Alternatives

As shown in Table 8-1, each of the alternatives was qualitatively ranked under each of the seven goals based on the ability of the alternative to further that goal. Qualitative rankings were applied as either “Low,” “Medium,” or “High.” A “high” ranking indicates that the alternative provides better progress toward that Pilot goal than other alternatives ranked as “Low,” or “Medium.” Composite rankings were then applied based on the average results of the seven individual rankings for each alternative.

The following discussion presents the composite Pilot rankings for each of the eight RI/FS alternatives, along with a summary of key differences among the alternatives. For additional discussion, refer to Section 5 of the EIS document.

- **Alternative 1:** Alternative 1 received a low composite ranking under the Pilot evaluation. The Alternative ranked medium for Goal 1 (human health & safety) and Goal 2 (ecological health). Though the cleanup is expected to comply with MTCA cleanup levels protective of human health and the environment, the alternative does not conduct cleanup using solutions considered to be permanent to the maximum extent practicable under MTCA, and hence does not receive a high ranking under these two goals. Alternative 1 was ranked medium under Goal 3 (habitat protection & restoration). Under Alternative 1, shallow-water habitat areas are preserved at the head and along the sides of the Inner Whatcom Waterway, and capping produces a beneficial change in sediment elevation and energy levels in the area offshore of the ASB. However, the alternative does not facilitate the removal of Inner Whatcom Waterway bulkheads or over-water structures as in Alternatives 5 and 6, nor does it achieve restoration of aquatic uses for the ASB as in Alternatives 5 through 8. Alternative 1 receives low rankings for Goal 4 (social & cultural uses), because the dredging plan for the Inner Whatcom Waterway is not consistent with land use and navigation planning for this area, and the capping of the ASB is inconsistent with planned aquatic reuse of the ASB. Alternative 1 ranks low for Goal 5 (resource management). Even though Alternative 1 conserves resources by minimizing construction activity, the alternative does not allow for reuse of clean ASB berm material, and it impedes the

continued use of the deep draft navigation infrastructure present at the Bellingham Shipping Terminal. For Goal 6 (faster, better, cheaper) Alternative 1 receives a low ranking. Though the alternative provides short-term cost savings over the other more costly alternatives, Alternative 1 does not address the long-term waterfront land and navigation uses. Therefore, this alternative is cheaper, but is not necessarily better. Under Goal 7 (economic vitality, shoreline land use) Alternative 1 receives a low ranking, because the alternative is not consistent with planned land or navigation uses for either the Whatcom Waterway or the ASB area.

- **Alternative 2:** Alternative 2 received a medium composite ranking under the Pilot evaluation. The Alternative ranked medium for Goal 1 (human health & safety) and Goal 2 (ecological health). Though the cleanup is expected to comply with MTCA cleanup levels protective of human health and the environment, the alternative does not conduct cleanup using solutions considered to be permanent to the maximum extent practicable under MTCA, and hence does not receive a high ranking under these two goals. Alternative 2 receives a high ranking under Goal 3 (habitat protection & restoration). Alternative 2 produces negative habitat impacts in the Inner Whatcom Waterway, through the removal of emergent shallow-water habitat from the head and sides of the waterway, the triggering of shoreline infrastructure requirements that further affect habitat quality in the Inner Whatcom Waterway, and through prevention of aquatic reuse of the ASB. However, Alternative 2 creates new premium shallow-water aquatic habitat at the Cornwall CAD facility, offsetting other habitat losses and providing an anticipated net gain of nearshore habitat. Alternative 2 receives a low ranking under Goal 4 (social and cultural uses) because the dredging plan for the Whatcom Waterway is not consistent with planned mixed-use redevelopment of this area, and because the alternative triggers shoreline infrastructure requirements that are in conflict with area land use and navigation priorities. The dredging performed under these alternatives results in potential disturbance to cultural or historical resources in the former Citizen’s Dock area at the head of Whatcom Waterway, and Alternative 2 also does not support planned aquatic reuse of the ASB. Alternative 2 receives a medium ranking under Goal 5 (resource management). Alternative 2 minimizes the use of non-renewable fuel resources required to transport dredged materials off of the waterfront. However, Alternative 2 triggers the creation of new infrastructure that will be costly to create, will produce redundancies with the existing infrastructure present at the Bellingham Shipping Terminal, and will be in conflict with community land use priorities for the Inner Whatcom Waterway. Alternative 2 receives a medium ranking under Goal 6 (faster, better cheaper). While the costs of the alternative are lower than those of the MTCA preferred alternatives, this cost-effectiveness is eliminated after the costs of additional shoreline

infrastructure requirements are taken into account. Further, the alternative does not capture new funding sources (i.e., marina revenues) which the Port plans to apply to offset a portion of the cleanup costs under Alternatives 5 through 8. Under Goal 7 (economic vitality, shoreline land use) Alternative 2 receives a low ranking, because the alternative is not consistent with planned land or navigation uses for either the Whatcom Waterway or the ASB area.

- **Alternative 3:** Alternative 3 receives a medium composite ranking under the Pilot evaluation. The Alternative ranked medium for Goal 1 (human health & safety) and Goal 2 (ecological health). The cleanup is expected to comply with MTCA cleanup levels protective of human health and the environment, but the alternative does not conduct cleanup using solutions considered to be permanent to the maximum extent practicable under MTCA. Alternative 3 receives a low ranking under Goal 3 (habitat protection & restoration). Alternative 3 produces negative habitat impacts in the Inner Whatcom Waterway, through the removal of emergent shallow-water habitat from the head and sides of the waterway, the triggering of shoreline infrastructure requirements that further affect habitat quality in the Inner Whatcom Waterway. The Alternative includes some enhancement of habitat quality offshore of the ASB, but does not enhance habitat to the extent conducted in other project alternatives. Alternative 3 receives a low ranking under Goal 4 (social and cultural uses) because the dredging plan for the Whatcom Waterway is not consistent with planned mixed-use redevelopment of this area, and because the alternative triggers shoreline infrastructure requirements that are in conflict with area land use and navigation priorities. The dredging performed under these alternatives results in potential disturbance to cultural or historical resources in the former Citizen's Dock area at the head of Whatcom Waterway, and Alternative 3 also does not support planned aquatic reuse of the ASB. Alternative 3 receives a medium ranking under Goal 5 (resource management). Alternative 3 minimizes the use of non-renewable fuel resources required to transport dredged materials off of the waterfront. However, Alternative 3 triggers the creation of new infrastructure that will be costly to create, will produce redundancies with the existing infrastructure present at the Bellingham Shipping Terminal, and will be in conflict with community land use priorities for the Inner Whatcom Waterway. Alternative 3 receives a medium ranking under Goal 6 (faster, better cheaper). While the costs of the alternative are lower than those of the MTCA preferred alternatives, this cost-effectiveness is eliminated after the costs of additional shoreline infrastructure requirements are taken into account. Further, the alternative does not capture new funding sources (i.e., marina revenues) which the Port plans to apply to offset a portion of the cleanup costs under Alternatives 5 through 8. Under Goal 7 (economic vitality, shoreline land use) Alternative 3 receives a low ranking, because the alternative is not

consistent with planned land or navigation uses for either the Whatcom Waterway or the ASB area. Alternative 3 creates new fill areas in the Central Waterfront that will be encumbered by geotechnical concerns and environmental use restrictions.

- **Alternative 4:** Alternative 4 ranked medium overall against the seven Pilot Goals. As with Alternatives 1-3, the alternative complies with cleanup standards, but does not use permanent solutions to the maximum extent practicable. This results in medium rankings under Pilot Goals 1 and 2. The ranking against Goal 3 (habitat protection & restoration) is medium. Alternative 4 preserves and restores some nearshore, shallow-water habitat within the Inner Whatcom Waterway and offshore of the ASB, but the alternative does not restore aquatic use of the ASB as under Alternatives 5 through 8. Alternative 4 earns a “medium” ranking under Goal 4 (social & cultural uses). The alternative provides for multiple uses of the Whatcom Waterway consistent with land use and navigation planning, and avoids disturbance of potential historical and cultural resources at the head of the Whatcom Waterway near former Citizen’s dock. However, the alternative does not support aquatic reuse of the ASB. Alternative 4 receives a medium ranking for Goal 5 (resource management). Alternative 4 reduces the non-renewable resources consumed during construction activities, and avoids the redundant shoreline infrastructure requirements of alternatives 2 and 3. However, Alternative 4 does not provide for reuse of clean ASB berm materials. Alternative 4 receives a medium ranking for Goal 6 (faster, better, cheaper). While the alternative can be implemented quickly, and the project is cost-effective, the alternative does not achieve restoration of aquatic uses within the ASB, and does not provide the degree of habitat, navigation and public access enhancements achieved by Alternatives 5 and 6. Further, the alternative does not capture the additional funding source (marina revenues) of these other alternatives. Alternative 4 achieves partial consistency with shoreline land use priorities, and receives a “medium” ranking under Pilot Goal 7 (economic vitality, shoreline land use). The alternative tailors the dredging and shoreline modifications within the Whatcom Waterway to the multi-purpose channel concept. However, the alternative is inconsistent with planned aquatic reuse of the ASB.
- **Alternative 5:** Alternative 5 receives a high composite ranking based on evaluation against the seven Pilot goals. Cleanup under Alternative 5 is conducted using solutions that are permanent to the maximum extent practicable under MTCA, resulting in high rankings under Goal 1 (human health & safety) and Goal 2 (ecological health). Alternative 5 receives a high ranking under Goal 3 (habitat protection & restoration) because it preserves nearshore, shallow water habitat within the Inner Whatcom Waterway and offshore of the ASB and restores aquatic use of the ASB. Under Alternatives 5 and 6, the ASB is cleaned up and

then reconnected to Bellingham Bay. This restores nearly 4,500 linear feet of salmonid migration corridor, and opens approximately 28 acres of open water habitat. The restoration of the ASB will represent one of the largest habitat restoration projects achieved in the Puget Sound area. Alternative 5 also ranks high under Goal 4 (social & cultural uses). The alternative provides for multiple uses of the Whatcom Waterway consistent with land use and navigation planning. The alternatives enhance social and cultural uses by directly supporting revitalization of the Bellingham waterfront. The cleanup actions within the ASB and the Whatcom Waterway are consistent with land use and navigation planning, while avoiding disturbance of potential historical and cultural resources at the head of the Whatcom Waterway near former Citizen's dock. Alternative 5 receives a "high" ranking under Pilot Goal 5 (resource management). The alternative uses significant energy resources to accomplish project construction. However, these resources are used appropriately to manage the most heavily-contaminated materials requiring cleanup, and the cleanup action provides for reuse of the clean ASB berm materials. Alternative 5 avoid the creation of redundant shoreline infrastructure that conflicts with area land use priorities. Under Goal 6 (faster, better, cheaper), Alternative 5 is ranked high because it provides a high-quality cleanup action consistent with planned land uses, while maintaining overall cost-effectiveness. The cleanup actions of Alternative 5 are more costly than Alternatives 1-4, but overall costs are reasonable if mitigation costs costs are considered as part of the analysis. Additionally, Alternative 5 provides for planned aquatic reuse of the ASB, which is expected to generate additional revenues (marina moorage fees) that help offset the costs of ASB sludge removal. Alternative 5 receives a high ranking for Goal 7 (economic vitality, shoreline land use) by enhancing water-dependent uses of shoreline property, providing for a full range of waterfront uses, and contributing to the revitalization of Bellingham Bay waterfront.

- **Alternative 6:** Like Alternative 5, Alternative 6 receives a high composite ranking relative to the seven Pilot goals. Most elements of Alternative 6 are the same as for Alternative 5. The principal difference is that Alternative 6 conducts additional deep dredging adjacent to the Bellingham Shipping Terminal, reducing the area of capping required within Whatcom Waterway. This additional dredging results in some increases to project costs, but with a corresponding potential benefit to future navigation uses at Bellingham Shipping Terminal, should additional navigation depths be required. Therefore, the additional costs of Alternative 6 do not affect rankings of the alternative under Goals 5 (resource management), or under Goal 6 (faster, better, cheaper). All other rankings are high, as in Alternative 5.
- **Alternative 7:** Alternative 7 receives a medium composite ranking relative to the seven Pilot Goals. Alternative 7 receives high rankings

for Goal 1 (human health & safety) and for Goal 2 (ecological health), because the level of cleanup meets or exceeds MTCA requirements. The use of dredging and upland disposal beyond the point considered the maximum extent practicable under MTCA does not affect the rankings against these goals, though it does impact the Goal 6. Alternative 7 receives a medium ranking under Goal 3 (habitat protection and restoration). Alternative 7 enhances habitat quality through aquatic reuse of the ASB, and through creation of a cap and habitat bench offshore of the ASB. However, the dredging of the 1960s industrial channel removes emergent shallow-water habitat at the head and along the sides of the Inner Whatcom Waterway, and triggers requirements for hardened shoreline infrastructure that further limit habitat quality in this area. The ranking of Alternatives 7 against Goal 4 (social & cultural uses) is low. The dredging of the 1960s federal channel and the associated requirements for hardened shoreline infrastructure are inconsistent with area land use and navigation planning, and could disturb historical or archaeological resources that may be present near the former Citizen's Dock area. Ranking under Goal 5 (resource management) is low, due to the higher consumption of non-renewable fossil fuel resources during dredging and infrastructure construction, and due to likely redundancy of newly-constructed infrastructure with existing infrastructure at the Bellingham Shipping Terminal. Alternative 7 receives a low ranking for Goal 6 (faster, better, cheaper) because costs of this alternative are substantially higher than those of Alternative 6, and environmental, land use and habitat benefits are equivalent or lower. This poor cost/benefit relationship is compounded when the costs of required shoreline infrastructure are incorporated into project estimates. Finally, Alternative 7 receives a low ranking for Goal 7 (economic vitality, shoreline land use) due to the poor cost-effectiveness of the alternative, and due to the conflicts between the alternative and planned land uses in the Inner Whatcom Waterway.

- **Alternative 8:** Alternative 8 receives a low composite ranking relative to the seven Pilot criteria. Rankings for Goal 1 (human health & safety) and for Goal 2 (ecological health) were high, because this alternative makes the greatest use of permanent solutions. However, the use of dredging and upland disposal beyond the point at which it is considered practicable under MTCA results in low rankings for Goal 6 (faster, better, cheaper). Alternative 8 receives a low ranking under Goal 3 (habitat protection and restoration). Alternative 8 removes emergent shallow-water habitat from the head and sides of the Inner Whatcom Waterway. In addition, Alternative 8 converts shallow-water habitat in the area offshore of the ASB to less-productive deep-water habitat, rather than enhancing habitat quality of this area as in preceding alternatives. Despite habitat enhancements conducted within the ASB, this alternative likely results in a net loss of premium nearshore aquatic habitat. The ranking of Alternatives 7 against Goal 4 (social & cultural

uses) is low. The dredging of the 1960s federal channel and the associated requirements for hardened shoreline infrastructure are inconsistent with area land use and navigation planning, and could disturb historical or archaeological resources that may be present near the former Citizen's Dock area. Ranking under Goal 5 (resource management) is low, because Alternative 8 has the highest consumption of non-renewable fossil fuel resources during dredging and infrastructure construction, and because the new shoreline infrastructure will likely be redundant with existing infrastructure at the Bellingham Shipping Terminal. Alternative 7 receives a very low ranking for Goal 6 (faster, better, cheaper) because costs of this alternative are over three times higher than the MTCA preferred alternative, without producing a significant enhancement to site environmental conditions or other benefits. This poor cost-effectiveness is compounded when the costs of required shoreline infrastructure are incorporated into project estimates. Finally, Alternative 8 receives a low ranking for Goal 7 (economic vitality, shoreline land use) due to the poor cost-effectiveness of the alternative, and due to the conflicts between the alternative and planned land uses in the Inner Whatcom Waterway.

### **8.3 Comparison of RI/FS and EIS Findings**

Table 8-1 summarizes the results of the EIS analysis. These findings can be compared to the results of the MTCA alternatives rankings shown in Table 7-2.

Based on the SEPA analysis as summarized in Section 8.1 above, most of the project alternatives will require mitigation measures over-and-above the elements of the MTCA remedy design concepts. Mitigation measures defined in the SEPA analysis should be considered as part of cleanup planning and implementation. Incremental costs of mitigation will affect the overall cost of each alternative. Alternatives 5 and 6 had net beneficial impacts or mitigated impacts under the SEPA criteria, indicating that required mitigation measures will be minimal for implementation of these alternatives.

The Pilot analysis of alternatives summarized in Section 8.2 is different from MTCA or SEPA in that it is not required under existing regulatory authorities. Consistency with the Bellingham Bay Comprehensive Strategy and the Pilot Goals is voluntary. However, the use of the Pilot goals provides an additional basis by which the qualitative benefits or short-comings of a remedial alternative can be measured. In general, the relative Pilot rankings were similar to the MTCA alternatives rankings. Alternatives 1 and 8 ranked lowest. Alternatives 2, 3, 4 and 7 ranked medium. Alternatives 5 and 6, which were the MTCA preferred remedial alternatives, also received the highest rankings against Pilot goals.



## 9 Summary and Conclusions

This Feasibility Study presents a comprehensive analysis of cleanup requirements applicable to the Whatcom Waterway site. After establishing Site Units and screening potentially applicable cleanup technologies, eight comprehensive cleanup alternatives were evaluated and ranked for compliance with regulatory requirements. The alternatives are described in detail in Section 6. The evaluation of alternatives under MTCA and SMS regulations is included in Section 7.

### 9.1 Description of the Preferred Alternatives

Based on the analysis described in Section 7, two preferred alternatives (Alternatives 5 and 6) have been identified. Key elements of the two MTCA Preferred Alternatives include the following:

- **Remedial Technologies:** Contaminated sediments are remediated using both active and passive remedial technologies including dredging, sediment treatment, upland Subtitle D disposal, reuse and recycling, capping, monitored natural recovery and institutional controls.
- **ASB Cleanup:** The ASB will be remediated by removing, treating and disposing of the accumulated sludges, the most impacted site materials requiring remediation. As part of the cleanup action, the ASB area will be remediated and restored to aquatic uses. The cleanup is consistent with plans for aquatic reuse of the ASB for construction of an environmentally sustainable marina with integrated habitat enhancement and public access improvements.
- **Whatcom Waterway Cleanup:** The Whatcom Waterway will be remediated consistent with the requirements of a locally-managed, multi-purpose channel. Sediment removal is conducted in the Outer Whatcom Waterway to maintain deep draft navigation uses with water depths of at least 30 feet, consistent with area land use planning and existing infrastructure at the Bellingham Shipping Terminal. The Inner Whatcom Waterway is managed to accommodate multiple uses including habitat enhancement, public shoreline access, and sustainable navigation uses consistent with area mixed-use zoning. The cleanup action is consistent with updates to the federal navigation channel that are being performed in accordance with Port Resolution 1230. Final effective water depths (the water depths available for use by vessels at the face of docks and navigation improvements) in the Inner Whatcom Waterway navigation areas will range from 18 to 22 feet. Under the updated channel dimensions, these effective water depths can be maintained without requiring the use of bulkheads, over-water

wharves and hardened shorelines common to deep draft navigation channels.

- **Cleanup of Other Site Areas:** Capping, monitored natural recovery and institutional controls will be applied to outlying areas of the site with low-level subsurface sediment impacts, and where those actions are consistent with planned land and navigation use. Capping in the ASB shoulder area (Unit 5-B) will result in enhancement of nearshore aquatic habitat in this area if implemented using the design concept from Appendix C.
- **Sediment Disposal:** Sediments and sludges removed from the site during the cleanup will be managed by upland disposal at off-site, permitted Subtitle D facilities, rather than by creating a new sediment disposal site on Bellingham Bay.

## 9.2 Basis for Alternative Identification

The preferred remedial alternatives were identified consistent with MTCA and SMS alternatives evaluation and remedy selection criteria. These criteria include the following:

- **Compliance with MTCA Threshold Criteria:** Both alternatives 5 and 6 comply with MTCA threshold criteria. The compliance of these alternatives with MTCA Threshold criteria is discussed in Section 7.2.
- **Use of a reasonable restoration time-frame:** Of the evaluated alternatives, Alternatives 5 and 6 have relatively short restoration time-frames of 5 to 6 years, including the time required for design, permitting and construction. The restoration time-frames for each of the evaluated alternatives are discussed in Section 7.2.
- **Use of Permanent Solutions to the Maximum Extent Practicable:** As described in Section 7.3, Alternatives 5 and 6 use permanent solutions to the maximum extent practicable, based on the findings of the MTCA disproportionate cost analysis. Alternatives 5 and 6 are both costly, with probable costs of \$42 million and \$44 million, respectively. However, significant environmental benefits are achieved through the investments required under these alternatives, and the costs are not disproportionate to these benefits. Other lower-cost alternatives provide a lower degree of environmental benefit than Alternatives 5 and 6. Higher-cost alternatives were determined to be impracticable, because their incremental costs were substantial and disproportionate to the incremental benefits of those alternatives.

In addition to the alternatives analysis conducted in this Feasibility Study, project alternatives were evaluated in the companion EIS document as described in Section 8. The EIS analysis included an evaluation of environmental impacts and potentially required mitigation measures consistent with SEPA regulations. The two preferred remedial alternatives were found to provide net beneficial impacts, and to include appropriate mitigation measures. Neither of the preferred alternatives resulted in adverse impacts that were not mitigated.

The companion EIS document also included an evaluation of the project alternatives against the goals of the Bellingham Bay Demonstration Pilot. Both Alternatives 5 and 6 were found to further each of the Pilot goals, and these alternatives were ranked highest of the eight evaluated alternatives. The high Pilot rankings indicate that Alternatives 5 and 6 have a high degree of consistency with the Bellingham Bay Comprehensive Strategy.

### **9.3 Implementation of Site Cleanup**

This RI/FS, the companion EIS document, and public comment on both documents will inform Ecology's preliminary selection of a cleanup alternative for the Whatcom Waterway site. The preliminary selected alternative will be articulated for public review in a draft Cleanup Action Plan (CAP). Following public review of the CAP, the cleanup will move forward into design, permitting, construction and long-term monitoring.

The Port has stated that it has the financial resources necessary to implement Alternative 5 or Alternative 6 in a timely manner. During completion of the 2004 and 2005 due diligence evaluations prior to purchase of the GP waterfront properties, the Port developed a funding plan for implementation of "Alternative K", on which the preferred remedial alternatives are based. That funding plan includes anticipated grant funding from Ecology's Solid Waste and Financial Assistance Program and funds from moorage revenues generated by planned aquatic reuse of the ASB.

The Port also believes that implementation of the preferred alternatives can be conducted in a manner that is consistent with and that directly supports waterfront revitalization efforts. Figure 9-1 illustrates conceptually how the preferred remedial alternatives can be integrated with ongoing waterfront revitalization efforts, as identified in the September 2006 New Whatcom Draft Framework Plan. Final details of the remedial alternatives and how they are integrated with land use planning will be subject to Ecology's cleanup decisions, project design and permitting, and the results of on-going land use planning efforts.

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**Appendix A**  
**Unit Cost and Volume Assumptions**

**Appendix B**  
**Remedial Cost Estimates**

## **Appendix C**

### **Habitat Bench Design Issues for Areas Offshore of ASB**

## **Appendix D**

### **Proposed Enhancements to Shoreline Conditions within the Log Pond**