DRAFT

SUPPLEMENTAL FEASIBILITY STUDY

WHATCOM WATERWAY SITE
BELLINGHAM, WASHINGTON

Prepared for

Georgia-Pacific West, Inc.
300 W. Laurel Street
Bellingham, WA 98225

Prepared by

Anchor Environmental, L.L.C.
1411 4th Avenue, Suite 1210
Seattle, Washington 98101

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EXECUTIVE SUMMARY

The Whatcom Waterway Area (WW Area) consists of intertidal and subtidal aquatic lands within and adjacent to the Whatcom and I&J Street Waterways in Bellingham, Washington (Figure 1). Mercury and several constituents associated with wood materials (4-methylphenol and phenol) have been detected in sediment samples collected within this area at concentrations that exceed state Sediment Management Standards (SMS) chemical criteria. Georgia-Pacific West, Inc. (G-P) previously performed a detailed remedial investigation/feasibility study (RI/FS) of the site under the oversight of the Washington Department of Ecology (Ecology). The study provided data, analysis, and engineering evaluations to develop and evaluate a set of feasible cleanup alternatives for the WW Area. The final RI/FS report was published in July 2000, and was a companion document to the Bellingham Bay Comprehensive Strategy Environmental Impact Statement (EIS), finalized in October 2000.

The Bellingham Bay Comprehensive Strategy Final EIS was developed by the interagency Bellingham Bay Demonstration Pilot (Pilot) Work Group, and evaluated a bay-wide planning element, the Bellingham Bay Comprehensive Strategy, as well as a range of specific remedial action alternatives that are consistent with the Strategy. The remedial action alternatives address priority sediment cleanup and source control sites in Bellingham Bay, including the WW Area.

As described in the Final EIS, the Preferred Near-Term Remedial Action Alternative for the WW Area included:

1) Maximum practicable removal of contaminated subsurface sediments from the Whatcom Waterway navigation channel
2) Disposal of such sediments in a confined aquatic disposal (CAD) facility sited near the Cornwall Avenue Landfill in inner Bellingham Bay, with provisions for possible removal of the CAD in the future, contingent upon regulatory approval
3) Confinement of contaminated sediments outside navigation areas below a cap
4) Integration of habitat restoration and protection objectives into confinement designs
5) Treatment of a portion of dredged sediments, contingent on viability at the time of dredging
6) A long-term operation, monitoring, maintenance and adaptive management commitment.

When the final RI/FS and EIS were published in 2000, the inner Bellingham Bay CAD (with removal provisions) was identified by the Work Group as the most practicable option for disposal of contaminated sediments within the Bay. However, in late 2001, following closure of the pulp mill and associated operations at its Bellingham facility, G-P determined that 21 acres of the 29-acre Aerated Stabilization Basin (ASB), previously needed for wastewater treatment, could be made available as a disposal facility for sediments dredged from the WW Area and other suitable sites in Bellingham Bay. Pending Ecology (Industrial Section) approval of wastewater treatment modification plans, the remaining 8 acres of the ASB (including outfall structures) would be modified to serve as a smaller secondary treatment unit for the Bellingham Tissue Mill.

This Supplemental FS for the WW Area presents a review of key technical considerations associated with the ASB disposal option, and specifically as a modification of the Preferred Near-Term Remedial Action Alternative summarized above. This review includes evaluations of short- and long-term water quality impacts, disposal site stability, and other key considerations, along with comparisons to the nine sediment remediation alternatives previously evaluated in the RI/FS. When viewed together, the alternatives present the broad range of potential remediation, habitat enhancement, and land use options available within the WW Area, and highlight tradeoffs associated with implementation of different alternatives, consistent with SMS and Pilot objectives. This Supplemental RI/FS for the WW Area is a companion document to the Supplemental EIS, which evaluates the potential adverse environmental impacts associated with a Modified Near-Term Remedial Action Alternative.

While this Supplemental FS evaluates the Preferred Near-Term Remedial Action Alternative from the Final EIS, as modified by the substitution of the ASB for a CAD, it is important to note that, in the absence of the Pilot effort, the preferred sediment remediation alternative for the WW Area would necessarily focus only on statutory selection criteria set forth in the SMS. In consideration of the statutory criteria comparisons, as summarized in the RI/FS and in this Supplemental FS, the likely recommendations for WW Area sediment remediation would include elements of short-term natural recovery, capping, and limited dredging. The site-specific alternatives incorporating these technologies and process options are consistent with SMS selection factors and comply with statutory requirements. However, consistent with the

Pilot, the Modified Preferred Near-Term Remedial Action Alternative achieves multiple goals including habitat restoration and land use actions in an effective, cost-efficient way. From a regulatory standpoint, Ecology will ultimately select the remedy for the Whatcom Waterway Site.

1 INTRODUCTION

The Whatcom Waterway Area (WW Area) consists of intertidal and subtidal aquatic lands within and adjacent to the Whatcom and I&J Street Waterways in Bellingham, Washington (Figure 1). Historically, mercury and phenolic compound concentrations detected in sediment samples collected within the WW Area have exceeded Sediment Quality Standards as defined in the Washington State Sediment Management Standards (SMS; Chapter 173-204 WAC). This section summarizes the background of the WW Area investigations, and the organization of this Supplemental Feasibility Study (FS).

1.1 Background

Since the 1960s, the Georgia-Pacific Corporation (G-P) has owned and operated a pulp and paper mill located directly adjacent to the WW Area. Beginning in 1965, wastewaters containing mercury were discharged to the Whatcom Waterway from the mill's chlor/alkali plant. Mercury discharges from the mill have been controlled for more than 20 years through process changes and wastewater treatment controls. Pulp Mill wastewater primary treatment was begun in 1972, minimizing discharges of woody materials. The direct discharge of wastewater to the Whatcom Waterway was discontinued in 1979. The chlor/alkali plant was permanently closed in 1999.

In January 1996, G-P and the Washington State Department of Ecology (Ecology) entered into an Agreed Order to perform a Remedial Investigation/Feasibility Study (RI/FS) of the WW Area sediments, pursuant to the Washington State Model Toxics Control Act (MTCA; Chapter 173-340 WAC; RCW 70.105D.050[1]). The RI/FS provides data, analysis, and engineering evaluations to enable Ecology to select a preferred sediment cleanup action alternative that is protective of human health and the environment and considers local site development plans.

Ecology approved the RI/FS Project Plans (Hart Crowser 1996) for the WW Area on August 27, 1996. The Project Plans specified those tasks and management strategies necessary to support and complete the RI/FS, and set forth project objectives and decision criteria. Sampling and analysis activities were initiated by G-P shortly after Ecology's approval—including sampling of surface and subsurface sediments, suspended particulate matter, seep and outfall discharges, and physical surveys of the waterways and inner Bay. In November

1996, additional water quality sampling was added to the RI program, as detailed in Addenda Nos. 1 and 2 to the Project Plans (Hart Crowser 1997a and b). In August 1998, co-located samples were collected in the WW Area to confirm the findings of the 1996 study. These samples (Addendum No. 3) and additional samples in the Starr Rock area were collected in accordance with approved work plans (Anchor 1998a and 1998b). The aggregate sampling and analysis data, along with engineering evaluations of a range of cleanup alternatives for the WW Area, are presented in the final RI/FS report (Anchor and Hart Crowser 2000).

The Bellingham Bay Demonstration Pilot Project (Pilot), which encompasses the WW Area as well as other sediment cleanup sites in Bellingham, is an initiative of the Cooperative Sediment Management Program. The Pilot Project Work Group (Work Group) is made up of 15 federal, state, and local entities addressing and coordinating contaminated sediment cleanup needs with other key management issues in Puget Sound. The Pilot was designed to expand opportunities for achieving multiple goals in Bellingham Bay, including source control, sediment cleanup, sediment disposal, habitat restoration, and aquatic land use elements. The Work Group's planning efforts, including identification of a Preferred Near-Term Remedial Action Alternative, are presented in the Bellingham Bay Comprehensive Strategy Environmental Impact Statement (EIS), finalized in October 2000 (Ecology 2000). The WW Area RI/FS was a companion document to the EIS.

As described in the EIS, the Preferred Near-Term Remedial Action Alternative for the WW Area included:

1) Maximum practicable removal of contaminated subsurface sediments from the Whatcom Waterway navigation channel
2) Disposal of such sediments in a confined aquatic disposal (CAD) facility sited near the Cornwall Avenue Landfill in inner Bellingham Bay, with provisions for possible removal of the CAD in the future, contingent upon regulatory approval
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6) A long-term operation, monitoring, maintenance and adaptive management commitment.

When the final RI/FS and EIS were published in 2000, the inner Bellingham Bay CAD (with removal provisions) was identified by the Work Group as the most practicable option for disposal of contaminated sediments within the Bay. However, in late 2001, following closure of pulp mill and associated operations at its Bellingham facility, G-P determined that 21 acres of the 29-acre Aerated Stabilization Basin (ASB), previously needed for wastewater treatment, could be made available for use as a disposal facility for sediments dredged from the WW Area and other suitable sites in Bellingham Bay. Pending Ecology approval of wastewater treatment designs, the remaining 8 acres of the ASB (including outfall structures) would be modified to serve as a smaller secondary treatment unit for the Bellingham Tissue Mill.

This Supplemental FS for the WW Area presents a review of key technical considerations associated with the ASB disposal option, and specifically as a possible modification of the Preferred Near-Term Remedial Action Alternative summarized above. This review includes evaluations of short- and long-term water quality impacts, disposal site stability, and other key considerations, along with comparisons to the nine sediment remediation alternatives previously evaluated in the RI/FS. When viewed together, the alternatives present the broad range of potential remediation, habitat enhancement, and land use options available within the WW Area, and highlight tradeoffs associated with implementation of different alternatives, consistent with SMS and Pilot objectives. This Supplemental RI/FS for the WW Area is a companion document to the Supplemental EIS, which evaluates the potential adverse environmental impacts associated with a Modified Near-Term Remedial Action Alternative.

1.2 Report Organization

The WW Area RI/FS (Anchor and Hart Crowser 2000) presents detailed results of the sampling and analysis program set forth in the approved RI/FS Work Plan and addenda. The RI/FS also includes detailed evaluations of a wide range of potential cleanup actions at the site. This Supplemental FS builds upon but does not duplicate the results of the RI/FS – the reader is referred to the RI/FS for a more complete discussion of site characterization data, analysis, and engineering evaluations. The contents of the WW Area RI/FS (published in four volumes) are summarized below:

- Section 1.0 - Executive Summary
- Section 2.0 - Remedial Investigation Introduction
- Section 3.0 - Inner Bellingham Bay Physical Characteristics
- Section 4.0 - Sediment Chemical Determinations
- Section 5.0 - Confirmatory Bioassay Determinations
- Section 6.0 – Screening Level Assessment of Mercury Bioaccumulation
- Section 7.0 - Natural Resources in Bellingham Bay
- Section 8.0 - Source Control and Recontamination Evaluation
- Section 9.0 - Sediment Natural Recovery Evaluation
- Section 10.0 - Feasibility Study Introduction
- Section 11.0 - Sediment Cleanup Requirements
- Section 12.0 - Establishment of Site Sediment Units
- Section 13.0 - Identification and Assembly of Cleanup Technologies
- Section 14.0 - Evaluation of Cleanup Action Alternatives
- Section 15.0 - References

Appendices A – J to the WW Area RI/FS provide additional information supporting the RI, and Appendices K – N provide additional information supporting the FS.

As discussed above, this Supplemental FS is focused on a modification of the Preferred Near-Term Remedial Action Alternative presented in the Final EIS (Ecology 2000), specifically substitution of the ASB for the CAD (and associated removal provisions) as a sediment disposal facility. The remainder of this report is organized as follows:

- Section 2.0 - Sediment Cleanup Requirements
- Section 3.0 - Identification and Assembly of Cleanup Technologies
- Section 4.0 - Detailed Evaluation of Cleanup Action Alternatives
- Section 5.0 - References

Figures and Tables are presented at the end of the text.

Appendices provide supporting project documentation and are organized as follows:

- Appendix A - Cost Estimates: Remedial Alternatives A through J

2 SEDIMENT CLEANUP REQUIREMENTS

The SMS sets forth a sediment cleanup decision process for identifying contaminated sediment areas and volumes, and determining appropriate cleanup responses. The SMS governs the identification and cleanup of contaminated sediment sites and establishes two sets of numerical chemical criteria against which surface sediment concentrations are evaluated. The more conservative Sediment Quality Standard (SQS) provides a regulatory goal by identifying surface sediments that have no adverse effects on human health or biological resources. The Minimum Cleanup Level (MCUL), numerically equivalent to the Cleanup Screening Level (CSL), represents the regulatory level for 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 or human health risk evaluations may define compliance with the SQS or MCUL criteria.

This section presents a review of SMS criteria comparisons, excerpted from the WW Area RI/FS (Anchor and Hart Crowser 2000). Recent interim remedial actions and monitoring results at the G-P Log Pond are also summarized.

2.1 Sediment Management Standards – Criteria Comparisons

Based on the findings of the RI/FS (Anchor and Hart Crowser 2000), chemicals of potential concern identified in surface (0 to 15 centimeters [cm]) sediments at the WW Area include mercury, 4-methylphenol, phenol, and wood material. Those chemicals or deleterious substances were regularly detected in surface sediments at concentrations that exceeded existing SQS and MCUL chemical criteria.

Sediment samples from 40 site locations were submitted during the conduct of the RI/FS for confirmatory biological testing to verify or refute sediment toxicity predicted on the basis of sediment chemical concentrations or the presence of wood material (Anchor and Hart Crowser 2000). As set forth in the Whatcom Waterway RI/FS Project Plans, all surface samples that exceeded the MCUL chemical criterion for mercury (0.59 milligrams per kilogram dry weight [mg/kg]) or other SMS chemicals were submitted for confirmatory biological testing. In addition, consistent with a 1997 SMS Clarification Paper (Kendall and

Michelsen 1997), confirmatory biological testing was also performed on samples collected within the general WW Area that exceeded 20 percent wood material by volume.

Sixty percent of the sediment samples submitted for biological testing (collected from 24 locations) were determined to be non-toxic (i.e., did not exceed SQS minor biological effects criteria). The remaining 40 percent of the locations exceeded SQS biological effects criteria, though only 15 percent (six locations) exceeded the MCUL based on more than minor biological effects. Sediment toxicity was not correlated with mercury or with other chemical parameters. The spatial distribution of observed sediment toxicity in the WW Area is depicted on Figure 2.

Areas of the site that contained the highest mercury concentrations (greater than 1.2 mg/kg) were also considered for cleanup to address potential bioaccumulation risks to human health and to high trophic level wildlife receptors. Although the maximum fish and shellfish tissue concentrations detected in the WW Area are below benchmark concentrations protective of tribal fishers and sensitive wildlife, sediments exceeding the derived bioaccumulation screening level for mercury of 1.2 mg/kg have the potential to contribute to bioaccumulation (Anchor and Hart Crowser 2000). Cleanup necessary to comply with sediment toxicity criteria would only be slightly expanded to address potential human health and wildlife food web concerns.

Potential remediation areas were delineated using confirmatory biological testing data and bioaccumulation screening level comparisons to address food web concerns. Prospective remediation areas delineated in this manner are depicted on Figure 2.

2.2 G-P Log Pond Interim Action

In late 2000 and early 2001, G-P implemented a combined sediment cleanup/habitat restoration action at the G-P Log Pond, part of the WW Area (Figure 1). The integrated remediation and habitat restoration project was designed in a manner consistent with the Preferred Near-Term Remedial Action Alternative described in the Final EIS (Anchor 2000; Ecology 2000), and was performed as an Interim Remedial Action under the authorities of MTCA, as set forth in an Agreed Order for this action between G-P and Ecology. The project was also authorized under Clean Water Act Permit No. 2000-2-00424 administered by the U.S. Army Corps of Engineers (Corps).

G-P prepared a Completion Report for the Log Pond project in May 2001 (Anchor 2001a). The Completion Report described the placement of approximately 43,000 cubic yards (CY) of clean cap/habitat restoration material from regional maintenance dredging projects into the Log Pond. Relatively fine-grained, clean Bellingham Bay (Squalicum Waterway) dredge materials were used to construct the final Log Pond surface. The total placed thickness ranged from approximately 0.5 feet along the cap perimeter (e.g., adjacent to structures) to 10 feet within the interior of the project area (Figure 3). Nearly all of the Log Pond received more than 3 feet of cap/habitat restoration material, tapering to less than 0.5-foot-thick along the perimeter, consistent with the Agreed Order and associated remedial design (Anchor 2000). The Log Pond remedial/restoration project converted 1.8 acres of deep subtidal, 2.7 acres of shallow subtidal mudflat/debris, and 1.1 acres of low intertidal riprap, all of which previously exceeded MCUL criteria, into 2.7 acres of shallow subtidal and 2.9 acres of low intertidal clean silt and sand habitat. The construction project appears to have achieved its intended goal of restoring shallow subtidal and low intertidal habitat to the Log Pond.

Consistent with the requirements of the Agreed Order and Corps permit, G-P performed Year 1 post-construction monitoring within the Log Pond beginning shortly after completion of in-water construction activities, in order to verify the integrity and performance of the cap, and to document the development of habitat functions within the Log Pond. The results of Year 1 monitoring, presented in Anchor (2001b), are summarized below:

- Surface sediment physical monitoring within the Log Pond verified that the cap/habitat surface has maintained its integrity following construction, and has now developed suitable strength to generally resist further erosion.
- Sampling at the margins of the Log Pond cap documented continued attainment of surface water and sediment quality protection objectives within the nearshore seepage zone of the cap. These data also verify remedial design predictions of limited mobility of mercury within the Log Pond cap/habitat embankment.

- All chemical concentrations in both surface and subsurface zones of the cap/habitat layer were well below SQS chemical criteria. Moreover, samples collected 1.0 to 1.5 feet above the bottom of the cap were also below SQS chemical criteria, indicating that the capping method implemented successfully minimized mixing of underlying contaminated sediments into the bottom of the clean cap. These data also verify that chemicals have not migrated vertically into the cap/habitat layer.
- Biological monitoring data revealed that within several months of construction, epibenthic and benthic biomass, species richness, diversity and evenness within the Log Pond recovered to regional (Chuckanut Bay) reference values, consistent with remedial design predictions of rapid re-colonization.
- Juvenile crab tissue monitoring performed at the Log Pond approximately six months after completion of construction further verified that the cap was effective in controlling bioaccumulation exposures. Expected site-wide reductions in adult crab mercury concentrations (relative to 1997 baseline levels) will be evaluated beginning in Spring 2003.

Physical, chemical, and biological monitoring of the Log Pond will continue during Years 2, 5, and 10 to document the long-term effectiveness of the remedial/habitat restoration action.

The Log Pond Interim Action will be reviewed by Ecology as part of the development of a Cleanup Action Plan for the entire WW Area. Ecology will determine at that time whether the Log Pond Interim Action is sufficient to act as an element of the final remedy for the Whatcom Waterway Site.

3 IDENTIFICATION AND ASSEMBLY OF CLEANUP TECHNOLOGIES

The RI/FS (Anchor and Hart Crowser 2000) developed a range of cleanup alternatives for possible application to the WW Area. The identification and assembly of cleanup technologies into site-specific alternatives followed both SMS guidance and additional direction provided by Ecology. The results of the cleanup technology and process option screening evaluations are presented in Sections 3.1 and 3.2. Screening of potential sediment disposal sites is summarized in Section 3.3. Finally, retained technologies are assembled into cleanup alternatives in Section 3.4. The subsequent Section 4.0 of this Supplemental FS presents a detailed evaluation of each alternative relative to MTCA/SMS evaluation criteria.

3.1 Identification and Screening of General Response Actions

As discussed more fully in the RI/FS, there are three forms (response actions) of remediation that can be performed on contaminated sediments:

- Natural recovery
- Containment
- Treatment

Natural recovery of contaminated sediment may occur over time through a combination of physical, chemical, and biological processes that lower the surface concentrations. Natural recovery of sediments in the WW Area has been well documented by the historical record of declining surface concentrations of mercury over the past 25 years (Anchor and Hart Crowser 2000). Thus, natural recovery is a demonstrated phenomenon and was incorporated into several of the alternatives considered in the RI/FS.

Containment involves either confining the contaminated sediments in place or confining dredged materials within a disposal site after removal. Containment technologies have been used extensively and successfully in remediation of contaminated sediments elsewhere in Puget Sound (Sumeri 1996). Thus, containment is a proven technology and was incorporated into alternatives considered in the RI/FS.

Treatment technologies can potentially reduce contaminant concentration, contaminant mobility, and/or toxicity of the sediments. Most prospective treatment technologies rely on *ex situ* methods that first require sediment removal, followed by chemical destruction, conversion, separation, extraction, or stabilization. Treatment techniques are still being evaluated at the national and regional levels, and are being assessed by EPA, the Corps, and Ecology in various demonstration projects. Although treatment technologies are technically feasible, the potential implementability and effectiveness in applications to contaminated sediments have not yet been proven, and in many cases are considered unlikely. Specifically, the high sediment volumes in the WW Area would be extremely difficult to address using any of the available treatment technologies. Further, the existing concentrations of mercury present in sediments within the WW Area (low part-per-million levels), along with the reduced treatment efficiencies reported at these levels for many of the technologies, further limits the effectiveness of treatment technologies as may be applied in this case. In addition, effective "treatment" does not destroy mercury, but rather converts it to less mobile forms (e.g., through physical and/or chemical stabilization). Finally, if a sediment treatment alternative were to be explored for development and implementation within the WW Area or elsewhere on the West Coast, venture capital may need to be made available in the private sector in order to make it economically feasible. Considering the potential scale of operations in the WW Area, these technologies would likely not be potentially available for another 5 to 6 years. For these reasons, treatment of sediments was not carried forward for more detailed analysis in the RI/FS.

3.2 Assessment of Cleanup Technologies

As described in Ecology's Sediment Cleanup Standards User Manual, the identification of applicable remedial technologies and process options for each general response action should initially consist of a broad evaluation of the applicable remedial technologies that are available and effective in remediating threats identified at the site. Process options are screened on the basis of the following criteria:

- **Effectiveness** – Ability to handle estimated volumes and meet cleanup levels, ability to reduce potential human health and environmental risks, and reliability
- **Implementability** – Technical and administrative feasibility, such as the ability to obtain permits for offsite actions and availability of treatment, storage, and disposal facilities
- **Cost** – Differences among process options within particular technology types.

The RI/FS presented a review of natural recovery, *in situ* and *ex situ* containment technologies and process options, and concluded that subject to the MTCA balancing of environmental benefits and costs, these technologies are implementable and cost effective (Anchor and Hart Crowser 2000). Therefore, the following process options were carried forward for more detailed evaluation in the RI/FS:

- **Natural Recovery**
- ***In Situ* Containment**
- ***Ex Situ* Containment:**
    - Mechanical dredging and transport
    - Upland confined disposal
    - Nearshore confined disposal
    - Confined aquatic disposal

While hydraulic dredging and transport (consisting of a hydraulic suction pipeline with a rotating cutterhead attached to the suction intake) was considered in the RI/FS, this process option was not carried forward for evaluation because a large local confined disposal facility (CDF) was not available at the time the RI/FS was completed. However, this Supplemental FS evaluates a large local CDF, the G-P ASB, which may now be made available for use as a disposal facility for sediments dredged from the WW Area and other suitable sites in Bellingham Bay. With the availability of this large local CDF, water quality requirements could be met at the disposal site and reasonable production rates achieved with hydraulic dredging and transport. As described in more detail in Section 4.2.1 of this Supplemental FS, sediment resuspension rates at the point of dredging for cutterhead dredges are typically threefold lower than mechanical dredges. Thus, where their application is appropriate, use of hydraulic dredges may provide additional water quality protection during construction. Since the hydraulic dredging process option is implementable and cost-effective when used in conjunction with the G-P ASB, it was carried forward for further evaluation in this Supplemental FS.

3.3 Disposal Site Identification and Screening

The RI/FS presented a "short list" of prospective disposal sites that were identified through an evaluation process conducted by the Work Group (BBWG 1998). The G-P ASB was not available at the time the Work Group evaluation was conducted. However, application of the evaluation criteria used in the process to the G-P ASB, results in a ranking at least as high as the other disposal sites short-listed. That is, use of the G-P ASB as an upland CDF provides a range of benefits, including: 1) little or no additional infrastructure requirements; 2) relatively minor construction risks; 3) long-term effectiveness; 4) opportunities to achieve multiple objectives (i.e., remediation of portions of the G-P ASB and subsequent redevelopment); as well as other attributes.

Consistent with the RI/FS conclusion that CDFs are implementable and cost-effective, and with the relative ranking of the G-P ASB under the Work Group disposal identification and screening process, the G-P ASB was carried forward for further consideration in this Supplemental FS.

3.4 Assembly of Different Cleanup Technologies

A variety of potentially applicable response actions, remedial technologies, and process options for the WW Area were screened as summarized above, and those technologies that would be effective and implementable were identified. These technologies were then combined to formulate the range of remedial alternatives presented and evaluated in the RI/FS and the new remedial alternative presented and evaluated in this Supplemental FS.

The cleanup technologies suitable for each sediment site unit (SSU) within the WW Area can be grouped in numerous combinations (see Anchor and Hart Crowser [2000] for a more complete discussion of individual SSUs). However, the remedial alternatives are limited to compatible cleanup technologies that protect human health and the environment. The technologies applied to each SSU also need to be complementary when implemented in combination. Finally, the alternatives were designed to be consistent with Subarea Strategies for different regions of Bellingham Bay (Ecology 2000). As discussed in the RI/FS (Anchor and Hart Crowser 2000), preliminary habitat mitigation requirements and restoration priorities, key land use concerns, and sediment cleanup priorities were blended into the alternatives. This was used to form the primary basis of the remedial alternatives.

The remediation action alternatives evaluated in the RI/FS and this Supplemental FS represent a wide spectrum of potentially appropriate remedial technologies and process options. These alternatives include different combinations of natural recovery, capping, removal, and disposal. When viewed together, the alternatives present a full range of potential remediation options available within the WW Area, and highlight tradeoffs associated with implementation of different remedial technologies, consistent with the objectives of the RI/FS. However, it should be noted that elements of all of the alternatives are subject to modification, based on ongoing agency, landowner, and public review.

The remedial alternatives were also designed to be fully consistent with the Integrated Near-Term Remedial Action Alternatives developed by the Work Group and presented in the Bellingham Bay Comprehensive Strategy Final EIS (Ecology 2000). The Work Group used a consensus-based decision making approach to identify and assemble a range of bay-wide cleanup alternatives, including alternatives addressing the WW Area. Differences between the alternatives involve cleanup volumes, disposal methods, habitat restoration opportunities, and aquatic land use implications, all of which are addressed in the Final EIS and Supplemental EIS.

Following are brief descriptions of each of the alternatives carried forward into the detailed FS evaluation in the RI/FS and this Supplemental FS, arranged in order of generally increasing removal/disposal volumes and costs. Near-Term Remedial Action Alternatives evaluated in the Final EIS and Supplemental EIS are provided in parentheses for cross-referencing. The RI/FS presents a more detailed description of Alternatives A through I. Chapter 4 of this Supplemental FS presents a more detailed evaluation of Alternative J.

Note that since completion of the RI/FS, and interim sediment remediation/habitat restoration action was implemented at the G-P Log Pond (see Section 2.2 of this Supplemental FS). As a result, the RI/FS remedial alternatives have changed slightly. The remedial alternative summary descriptions that follow reflect the Log Pond interim action.

- **Remedial Alternative A: No Action (Pilot No. 1)**. Under this alternative, there would be no sediment cleanup, habitat restoration, monitoring activities, or land use actions. The exiting Log Pond cap would be maintained, and the existing Bay sediments would continue to recover naturally over time.

- **Remedial Alternative B: Source Control & Natural Recovery with Capping**. All "action" alternatives evaluated in the RI/FS and this Supplemental FS (i.e., Alternatives B through J) include source controls. This alternative would utilize natural recovery in those parts of the WW Area that are predicted to naturally achieve SQS criteria within approximately 3 years (by 2005), which is as rapid as biological resources could potentially recover at the site following a more active cleanup (e.g., dredging). Those areas of the site that are not predicted to recover, and which occur outside of the navigation channel, would be capped with a 1- to 3-foot sand layer. A relatively small area in the middle of the Whatcom Waterway that is predicted to recover by 2005, partly as a result of resuspension-related transport, would be left to recover naturally. Other site units within the WW Area that currently exceed the mercury bioaccumulation screening level (BSL; 1.2 mg/kg) would be capped to accelerate the natural recovery process. The existing sediment remediation/habitat restoration cap placed in the Log Pond as an interim action would be maintained. All cleanup areas of the site would be monitored to document sediment recovery using a combination of chemical and biological testing methods. No dredging would occur under this alternative. A layout of Alternative B is presented in Figure 4.

- **Remedial Alternative C: Capping & Removal to Improve Navigation (Log Pond Nearshore CDF)**. This alternative combines capping and limited dredging within the middle of the Whatcom Waterway navigation channel to achieve SQS criteria throughout the WW Area. As in Alternative B, those areas of the site that are not predicted to recover (using conservative modeling assumptions), and which occur outside of the navigation channel, would be capped with a 1- to 3-foot sand layer. No further action would be undertaken in the outer Whatcom Waterway reach where surface sediments currently meet SQS criteria and where channel depths are consistent with the federally authorized elevations.

  Surface and subsurface sediments within the middle of the Whatcom Waterway adjacent to the G-P Log Pond would be dredged to a depth of at least 5 feet below the currently authorized channel depths. Since subsurface contaminants would still be present below the dredge depth, the dredge cut would be capped with a 2-to-3-foot clean sand layer, resulting in a final channel elevation at least 2 feet below the authorized depth. This dredge-and-cap action would leave sufficient tolerance to allow unencumbered future maintenance dredging of the authorized federal channel in this area, considering typical overdredge allowances. No action would be undertaken at the head of the Whatcom Waterway (i.e., above Station 15+00), as this area (currently exceeding SQS but below MCUL biological criteria) would be left to recover naturally to below the SQS by 2005.

An estimated 160,000 CY of sediments would be dredged under this alternative. Dredged sediments could be reused to create a nearshore CDF in the G-P Log Pond. Excess sediments that do not fit into the nearshore fill would be disposed at an off-site upland landfill. Habitat mitigation actions including at least 6 acres of area-for-area replacement by fill removal and/or acquisition and enhancement at high priority habitat creation sites would be performed as a part of implementation of this alternative. A layout of Alternative C is presented in Figure 5.

- **Remedial Alternative D: Capping & Removal to Improve Navigation (Upland Disposal)**. This alternative is identical to Alternative C except that all of the dredged material would be disposed at an upland landfill instead of in the G-P Log Pond nearshore CDF. The dredge material would either be reused to restore a wetland habitat at the Whatcom-Skagit Phyllite Quarry, or, alternatively, disposed at the Roosevelt Regional landfill. The existing sediment remediation/habitat restoration cap placed in the Log Pond as an interim action would be maintained. A layout of Alternative D is presented in Figure 6.

- **Remedial Alternative E: Capping & Removal to Achieve Authorized Channel Depths (CAD Disposal) (Pilot No. 2A)**. The overall objective of this alternative is to achieve SQS criteria in the WW Area while concurrently maintaining existing navigation channels, minimizing dredging and disposal of contaminated sediment, and maximizing the areal extent and diversity of intertidal aquatic habitat by using caps and CAD facilities. Enough material would be dredged from the Whatcom Waterway to remove contaminated sediments from the existing federal channel (including overdredge allowances) in all areas of the waterway that are currently used for navigation. Except for the extreme head of the Whatcom Waterway that currently contains mudflat habitat, surface and subsurface sediments throughout much of the waterway would be dredged to a depth of at least 5 feet below the currently authorized channel depths. However, no further action would be undertaken in the outer Whatcom Waterway reach where surface sediments currently meet state standards and where channel depths are consistent with the federally authorized elevations. Other contaminated sediment areas would be capped with a 1-to-3-foot clean sand layer. In this alternative a 3-acre area of mudflat and adjacent shallow subtidal habitat would be left intact at the head of the Whatcom Waterway. The existing sediment remediation/habitat restoration cap placed in the Log Pond as an interim action would be maintained.

Approximately 360,000 CY of contaminated sediment from navigation areas within the Whatcom Waterway would be dredged. In this alternative, the sediment disposal capacity would be provided by a 400,000 to 500,000 CY CAD sited in the Starr Rock/Cornwall area. The Starr Rock/Cornwall CAD could also be implemented as a multi-user disposal facility to contain contaminated sediments that may be dredged from other sites in Bellingham Bay. The CAD would provide opportunities for concurrent habitat restoration. Largely because of the CAD, approximately 42 acres of subtidal area would be converted into intertidal habitat. A layout of Alternative E is presented in Figure 7.

- **Remedial Alternative F: Capping & Removal to Achieve Authorized Channel Depths (Upland Disposal) (Pilot No. 2B)**. The overall objective of Alternative F is to achieve SQS criteria in the WW Area while maintaining existing navigation channels and minimizing dredging and disposal of contaminated sediment. This alternative includes the same amount of dredging as Alternative E, but would dispose of the materials at one or more off-site upland landfills. Other contaminated sediment areas would be capped with a 1-to-3-foot clean sand layer. The existing sediment remediation/habitat restoration cap placed in the Log Pond as an interim action would be maintained.

  All dredged sediments would be offloaded on shore, dewatered as necessary to facilitate transport, and hauled by rail, truck, and/or barge outside of the Bellingham Bay watershed to upland disposal facilities. Approximately 360,000 CY of contaminated sediment from navigation areas within the Whatcom Waterway would be dredged. In this alternative, the Whatcom-Skagit Phyllite Quarry or the Roosevelt Regional Landfill would provide the sediment disposal capacity. A layout of Alternative F is presented in Figure 8.

- **Remedial Alternative G: Full Removal from Navigation Areas (CAD Disposal) (Pilot No. 2C)**. The overall objective of this alternative is to achieve SQS criteria in the WW Area, allowing for possible future deepening of the navigation channels, and maximizing the areal extent and diversity of intertidal aquatic habitat by using caps and CAD facilities. Unlike Alternative E, minimizing dredging and disposal volumes is not a primary objective of Alternative G. Contaminated sediments that are located within the Whatcom Waterway, even if present below the currently authorized depths, would be dredged, removing potential encumbrances to channel deepening, should such a deepening project be undertaken in the future. Dredging would be performed throughout the Whatcom Waterway, including a 1-acre area at the head of the waterway. The extreme head of the Whatcom Waterway near the former Citizens Dock, consisting of a 2-acre area of mudflats that has formed naturally within this area, would be left intact. The existing sediment remediation/habitat restoration cap placed in the Log Pond as an interim action would be maintained.

  Approximately 760,000 CY of contaminated sediment from navigation areas within and adjacent to the Whatcom Waterway would be dredged. In this alternative, the sediment disposal capacity would be provided by a 800,000 to 1,000,000 CY CAD sited in the Starr Rock/Cornwall area. The Starr Rock/Cornwall CAD could also be implemented as a multi-user disposal facility to contain contaminated sediments that may be dredged from other sites in Bellingham Bay. The CAD would provide concurrent habitat restoration. Largely because of the CADs, approximately 63 acres of subtidal area would be converted into intertidal area. A layout of Alternative G is presented in Figure 9.

- **Remedial Alternative H: Full Removal from Navigation Areas and Partial Removal from the G-P ASB and Starr Rock Areas (Upland Disposal) (Pilot No.**

2D). Similar in some respects to Alternative G, the overall objective of Alternative H is to achieve SQS criteria in the WW Area, allowing for potential future deepening of the navigation channels. This alternative includes dredging of those areas included in Alternative G, but also includes the dredging of an additional 300,000 CY of sediments exceeding the site-specific BSL criteria that are located offshore of the G-P ASB and at the former Starr Rock disposal site. The dredged sediments would be disposed at one or more off-site upland landfills. Other contaminated sediment areas would be capped with a 1-to-3-foot clean sand layer. The existing sediment remediation/habitat restoration cap placed in the Log Pond as an interim action would be maintained.

All dredged sediments would be offloaded on shore, dewatered as necessary to facilitate transport, and hauled by rail, truck, and/or barge outside of the Bellingham Bay watershed to upland disposal facilities. Approximately 1,100,000 CY of contaminated sediment from the WW Area would be dredged. In this alternative, the sediment disposal capacity would occur at the same upland disposal facilities described for Alternative F. A layout of Alternative H is presented in Figure 10.

- **Remedial Alternative I: Full Removal from Public Lands (Upland Disposal) (Pilot No. 2E)**. The overall objective of Alternative I is to completely remove all contaminated sediment from public lands within the WW Area, and totally avoid disposal in the aquatic environment. The existing sediment remediation/habitat restoration cap placed in the Log Pond as an interim action would be maintained. This alternative would also allow for possible future deepening of the navigation channels and state-owned harbor areas. Like Alternative H, avoiding disposal in the aquatic environment is a primary objective. With the exception of sediments located immediately adjacent to the existing G-P wastewater pipeline and at the Log Pond, dredging would be performed within all reaches of the WW Area, including the extreme head of the federal channel, encompassing the former Citizens Dock and associated mudflat areas. All dredged sediments would be offloaded on shore, dewatered as necessary to facilitate transport, and hauled by rail and/or truck outside of the Bellingham Bay watershed to upland disposal facilities. Approximately 1,900,000 CY of contaminated sediment from the WW Area would be dredged. In this alternative, the sediment disposal capacity would be provided by the same upland disposal facilities described for Alternative F. A layout of Alternative I is presented in Figure 11.

- **Remedial Alternative J: Full Removal from Navigation Areas (G-P ASB Upland Disposal) (Supplemental EIS Modified Preferred Near-Term Remedial Action Alternative)**. Similar in some respects to Alternative G, the overall objective of Alternative J is to achieve SQS criteria in the WW Area, allowing for potential future deepening of the navigation channels, but avoiding disposal in the aquatic environment. Sediments in the navigation areas would be removed using hydraulic cutterhead dredges, and material would be disposed at the G-P ASB upland CDF. Existing habitat at the head of Whatcom Waterway would be protected, while accommodating public access improvements as proposed by the City of Bellingham. The existing sediment remediation/habitat restoration cap placed in the Log Pond as an interim action would be maintained.

  Whatcom Waterway would be dredged, including the maximum practicable removal of contaminated sediments from the federal channel, providing for future navigation flexibility. Steep slopes at Starr Rock would also be dredged. Where technically feasible, all contaminated sediments in the mid and outer Whatcom Waterway Federal Channel would be removed. The exception would be a relatively small volume of materials immediately adjacent to the G-P wastewater pipeline. Depending on final design, the total dredge volume from the Whatcom Waterway may approach approximately 760,000 CY. Prospective dredging areas located in the outer Whatcom Waterway navigation channel (e.g., units 1A and 1B; approximately 170,000 CY) would be evaluated during remedial design to determine whether sediments in these areas may meet regulatory criteria for unconfined, open-water disposal. Sediments meeting appropriate criteria may be beneficially reused either within the inner Bay for fills to enhance habitat function, or as ASB cap materials. Dredged material that does not meet these criteria would require confined disposal in the ASB.

Dredged sediments from the Whatcom Waterway Site would be disposed within the ASB, with a potential of also disposing of suitable sediments dredged from other sediment cleanup sites in Bellingham Bay. The specific layout of the ASB facility would be determined during remedial design, and is estimated to have a 760,000 CY disposal capacity. Contingent upon the final dredge plan for the WW Area, and if at least a portion of sediments in Units 1A and 1B are suitable for beneficial reuse, the ASB facility will likely have sufficient capacity to accept suitable sediments dredged from other areas of Bellingham Bay (e.g., Harris Avenue Shipyard).

Sediments in the G-P Log Pond would continue to be confined below the existing thick cap, converting previously subtidal habitat to intertidal aquatic habitat (Section 1.2). Adjacent upland remedial activities would be designed to ensure continued production of surface water and sediments.

Contaminated sediments located offshore of the G-P ASB, at Starr Rock, and within the Port Log Rafting area, would be confined below a 1- to 3-foot-thick cap. Nearshore contaminated sediments within these areas could have additional appropriate sediment placed to create salmonid migratory corridor habitats and accomplish habitat restoration. Target habitats are gently sloping gravel/cobble beaches transitioning into gently sloping shallow subtidal and mudflats (nominal slopes of 10H:1V). The specific layout of capping and habitat corridors in these areas would be determined during remedial design. All capped and confined sediment areas would have operation, monitoring, maintenance and adaptive management commitment, with associated funding assurance. A layout of Alternative J is presented in Figure 12.

Detailed analyses of Alternatives A through I are presented in Chapter 14 of the original RI/FS. Detailed analysis of Alternative J is presented in Section 4.0 of this Supplemental FS.

4 DETAILED EVALUATION OF CLEANUP ACTION ALTERNATIVES

This section outlines the criteria used to evaluate all 10 project alternatives outlined in Section 3.4 above. A detailed comparative analysis of the cleanup alternatives is presented.

4.1 Evaluation Criteria For Alternatives

Each of the 10 cleanup alternatives listed in Section 3.4 was assessed against SMS/MTCA criteria (Ecology, 1991). Relevant criteria included in the evaluation can be grouped into three categories:

- Overall Environmental Quality
- Ability to be Implemented
- Cost Effectiveness

Each of these criteria categories is summarized below.

4.1.1 Overall Environmental Quality

Overall environmental quality is evaluated based on the following:

- **Compliance with Cleanup Standards and Applicable Laws**. The assessment against this criterion describes how the alternative complies with applicable cleanup standards and laws.
- **Protection of Human Health and the Environment**. The evaluation assesses the degree to which the cleanup alternative may perform to a higher level than regulatory criteria, and also considers the on-site and off-site risks resulting from implementation of the alternative.
- **Reasonable Restoration Time Frame**. As defined in MTCA (Chapter 173-340-360[6]), this criterion evaluates when cleanup criteria will be met and potential risks alleviated, and when natural resources will be restored to baseline levels. The practicability of achieving a shorter time frame is also assessed with this criterion.
- **Use of Permanent Solutions**. As defined in MTCA (Chapter 173-340-360[5]), a permanent solution is one in which the cleanup standards can be met without further action being required at any site involved with the cleanup action. Among the retained containment technologies included in this RI/FS, the MTCA

preference for permanent solutions ranks sediment disposal at an engineered containment facility higher than *in situ* containment.

- **The Degree to which Recycling, Reuse, and Waste Minimization are Employed**. This assessment investigates the extent that recycling, reuse, and waste minimization are employed. These factors not only include the recycling and reuse of any removed materials, but also the degree to which construction materials are reused and recycled. For example, after a CDF is filled, it may be reused for habitat creation or upland redevelopment. Or, capping material may consist of clean dredged sediments from a navigation project in the area. Waste minimization includes the extent that wastes generated as part of the remedial action are reduced in volume.
- **Short-term Effectiveness**. The assessment against this criterion examines the effectiveness of alternatives in protecting human health and the environment during the construction and implementation of the alternative.
- **Long-term Effectiveness**. The long-term effectiveness assessment generally examines the degree of certainty that the alternative will be successful on a long-term basis. Factors constituting long-term effectiveness include long-term reliability, a consideration of the magnitude of residual human health and biological risks, the effectiveness of controls for ongoing discharges, the ability to manage treatment residues, and the consideration of disposal site risks.
- **Net Environmental Benefits**. This criterion evaluates overall benefits to the natural environment that result from the alternative, such as restoration of water quality, habitat, and fisheries; and people's use of the environment, such as public access, recreation, aesthetics, spiritual and cultural values and the ability to use the land in the future. Important factors in this evaluation are significant short-term and long-term environmental consequences, significant irrevocable commitments of natural resources, significant environmental impacts that cannot be mitigated, and habitat restoration provided by the alternative. The Bellingham Bay Comprehensive Strategy EIS and Supplemental EIS have been designed to further investigate these and other environmental impacts. The EIS and Supplement also include additional sites, actions, and evaluation criteria to address baywide strategic environmental planning and project integration to

incorporate sediment cleanup, source control, sediment disposal, habitat restoration, and shoreline property management components.

4.1.2 Ability to be Implemented

This evaluation criterion considers the following:

- **Implementabilit**y. This assessment includes an evaluation of technical feasibility, availability of disposal facilities, the potential for land owner cooperation, required services, required materials, administrative requirements, regulatory requirements, schedule, monitoring requirements, accessibility, operation and maintenance, and the ability to integrate existing facility operations with current or potential cleanup actions. This assessment evaluates the technical and administrative feasibility of alternatives and the availability of required goods and services.
- **The Degree to which Community Concerns are Addressed**. This assessment provides for the inclusion of the community's preferences among or concerns about alternatives. Since the public has not yet commented on this Draft Supplemental FS, this component of the evaluation is reserved.

4.1.3 Cost Effectiveness

Costs in this Supplemental FS were evaluated on a net present worth basis. Capital cost estimates include both direct and indirect (overhead, etc.) costs, costs associated with engineering and administration and a 30 percent contingency factor to account for construction conditions not currently identified. Habitat mitigation and operation and maintenance costs, and other foreseeable costs are also included. Appendix N of the RI/FS presents the detailed cost estimates for Remedial Alternatives A through I. However, an update of these estimates is provided in Appendix A of this Supplemental FS, along with a detailed cost estimate for Remedial Alternative J. The cost estimates for Remedial Alternatives A through I have been updated to reflect the Log Pond interim sediment remediation/habitat restoration action, and a quoted 10 percent reduction in tipping fees at the Roosevelt Regional Landfill for disposal of contaminated sediment. Because of the complexities of landowner interest determinations, the long-term costs of property easements have not been included in this Supplemental FS.

As set forth in MTCA (Chapter 173-340-360[5]), a cleanup action shall not be considered practicable if the incremental cost of the cleanup action is substantial and disproportionate to the incremental degree of protection it would achieve over a lower preference cleanup action. When selecting from among two or more cleanup action alternatives that provide a sufficient and equivalent level of protection, as defined above, preference may be given to the least cost alternative, subject to an evaluation of public concerns and technical uncertainties.

4.2 Technical Analysis of Cleanup Elements

The original RI/FS presents an analysis of Remedial Alternatives A through I (Anchor and Hart Crowser 2000). The section below provides a summary of the technical analysis of Remedial Alternative J. Short-term water quality considerations at the point of dredging and disposal are discussed, followed by a summary of upland CDF design considerations.

4.2.1 Sediment Resuspension During Dredging

Dredging operations are often associated with sediment release at the point of dredging, with resultant short-term water quality impacts including localized turbidity and associated contaminant concentrations, and reduction in dissolved oxygen levels (McLellan et al. 1989, Herbich and Brahme 1991). By generating contaminated sediment residuals that remain after successive dredging passes, sediment resuspension can also complicate effective removal of contaminated sediments.

Given that sediment loss rates associated with the operation of mechanical dredges are, on average, greater than those of hydraulic cutterheads (see below), Remedial Alternative J may provide significant short-term water quality and implementability benefits, relative to the other removal alternatives. However, while hydraulic cutterhead dredging is the prospective method of removal for the major portion of WW Area sediments, it should be noted that the potential presence of buried logs and debris in this area will complicate cutterhead operations, and may require the periodic use of mechanical (e.g., clamshell bucket) equipment to effect complete removal. Dredging of steep slopes at Starr Rock (approximately 2,000 CY) may also require the use of mechanical equipment. Sediment resuspension is briefly reviewed below.

The Corps' Dredging Operations and Environmental Research (DOER) program recently developed an approach for estimating suspended sediment-source strength or resuspension rates associated with typical operation of mechanical and hydraulic cutterhead dredges. The Corps' approach, described in Johnson and Parchure (2000), uses empirical measurements of suspended sediment loss rates from a range of comparable dredging operations, to provide estimates of sediment resuspension that could reasonably be expected under prospective future dredging scenarios. While various predictive modeling approaches were evaluated by DOER, they concluded that relatively simple one-dimensional models provided loss rate estimates that were equally as accurate as more complex operation-based models. The one-dimensional models recommended by DOER were based on an empirical project-specific source strength parameter, variously defined by different investigators as a "turbidity generation unit" (TGU) (Nakai 1978), a "suspension parameter" (S) (Pennekamp et al. 1996), or a "resuspension factor" (R) (Hayes and Wu 2001). DOER compiled the available project-specific "TGU" data (from 20 separate dredging projects) and "S" data (from an additional 23 dredging projects) for use in water quality analyses of prospective dredging actions. Hayes and Wu (2001) recently published additional "R" data for five other dredging projects, and provided supporting documentation of their field and analytical data (Hayes 2001).

Although conceptually equivalent, the various one-dimensional source strength parameters defined by different investigators (i.e., TGU, S, and R) are not directly comparable, in part because of differences in reporting units (e.g., mass/volume versus mass/mass), as well as potential mathematical inconsistencies, particularly relative to the original TGU formulations (see Hayes and Wu 2001). The relationship between these parameters is generally as follows:

$$R = S/d_{sub} = TGU/(K \times d_{sub})$$

where:

R = resuspension factor (% dry weight basis) (Hayes and Wu 2001)

S = suspension parameter (kg dry/m^3 *in situ*) (Pennekamp et al. 1996)

d_{sub} = *in situ* dry density (kg dry/m^3) (Holtz and Kovacs 1981)

TGU = turbidity generation unit (kg dry/m^3 *in situ*) (Nakai 1978)
K = % of particles with diameter <74 um / % of particles too fine to settle in current

For the purpose of this resuspension analysis, available source strength data were normalized to a dry weight (i.e., R) basis. A summary of reported project-specific "R" values for available studies of hydraulic cutterhead and mechanical dredging operations at different sites is presented in Table 1.

Since Nakai (1978) did not present details of the dredging projects in his paper, including the values of "K" used in project-specific calculations, the potential maximum range of this parameter was estimated based on reported grain size statistics. In addition, if site-specific dry density (d_{sub}) was not reported, this value was estimated based on general grain size relationships (Holtz and Kovacs 1981).

The "TGU" and "R" values reported by both Nakai (1978) and Hayes and Wu (2001), respectively, did not exhibit any consistent relationship with the size (diameter) of the cutterhead, such that for the purpose of this Supplemental FS all reported cutterhead values from different size dredges may be considered equally representative of prospective future cutterhead operations within the WW Area. Further, since a relatively wide range of material types is present within the WW Area (Anchor and Hart Crowser 2000), resuspension rates for the different sediment types summarized in Table 1 were all considered representative of conditions at the site. All the project-specific resuspension data summarized in Table 1 for 10-inch to 24/36-inch cutterhead dredges, along with associated data uncertainties, were used as input to a Monte Carlo analysis (@RISK software; using uniform, triangular, or Gaussian distribution assumptions as reported in the original reports).

The cumulative probability plot of resuspension rates "R" associated with typical operation of hydraulic and mechanical dredges, derived from the Monte Carlo analysis, is presented in Figure 13. The estimated mean "R" value for hydraulic dredging operations is approximately 0.58 percent, while that of mechanical dredges is roughly threefold higher at approximately 1.9 percent (dry weight basis). The statistical range of reported/estimated "R" values likely reflects the inherent variability in dredging operations, as reported in the available literature. Nevertheless, based on the available empirical data, sediment resuspension rates are clearly lower for hydraulic cutterhead dredges, as compared with mechanical dredges. Thus, the use of hydraulic cutterhead dredges in Remedial Alternative J is expected to provide significant short-term water quality and implementability (reduced contaminated sediment residuals) benefits, relative to the other removal alternatives. More detailed analysis of potential water quality impacts at the point of dredging, and the development of conservation measures as needed to ensure environmental protection, would be performed during remedial design.

4.2.2 G-P ASB Upland CDF Design Considerations

The G-P ASB was constructed in 1978, and has been used since that time for secondary wastewater treatment, particularly for G-P's former pulp mill operations. Currently, the ASB provides secondary treatment for G-P's Bellingham Tissue Mill. In late 2001, following closure of pulp mill and associated operations at its Bellingham facility, G-P determined that 21 acres of the 29-acre ASB could be made available for use as a disposal facility for sediments dredged from the WW Area and other suitable sites in Bellingham Bay. Pending Ecology approval of wastewater treatment designs, the remaining 8 acres of the ASB (including outfall structures) would be modified to serve as a smaller secondary treatment unit for the Bellingham Tissue Mill. The entirety of the ASB upland CDF will reside on private lands owned by G-P.

A representative cross-section of the constructed ASB and adjoining areas is presented in Figure 14, extending from the Whatcom Waterway, though the ASB, and into the I&J Waterway. The existing containment berm was constructed with an impermeable clay liner to contain wastewaters within the ASB, up to a maximum elevation of approximately +23 feet MLLW (normal pond elevation is +20 feet MLLW). The integrity of the berm in preventing seepage to the adjacent waterways has been confirmed by G-P through seepage monitoring performed as part of the National Pollution Discharge Elimination System (NPDES) operating permit for the facility. Ecology may require additional seepage monitoring as part of remedial design.

Based on an initial comparison of the G-P ASB with other similar CDFs in the Puget Sound region, the existing engineered berm system at the ASB appears structurally adequate to effectively contain sediments, even during design-level seismic events. A more detailed geotechnical engineering analysis would be performed during remedial design to verify the long-term protectiveness of the ASB, and to determine the need for further buttressing.

The outer face of the containment berm is presently armored with a riprap protective layer designed to withstand peak storm wave forces. The Preferred Near-Term Remedial Action Alternative described in the Final EIS included construction of more gently sloping gravel/cobble beaches along the margins of the ASB, transitioning into shallow subtidal mudflats in this area, integrated with subtidal caps (Ecology 2000). The specific layout of capping and habitat corridors in this area would be determined during remedial design.

Separation of the 8-acre ASB (including outfall structures), which would provide secondary treatment unit for the Bellingham Tissue Mill, from the 21-acre sediment disposal facility would likely be accomplished by installing a vertical sheet piling bulkhead near the southern portion of the existing ASB (Figure 12). The sheet piling would need to have sufficient strength, embedment into underlying native soils, and permeability controls to isolate the ASB from adjacent contaminated sediments. Although an earthen berm could also be used to accomplish separation, such a structure would significantly reduce the available sediment disposal capacity within the ASB. Existing sheet piling and other flow control structures present within the ASB would be retained to maximize residence time and sediment settling within the facility. Details of the ASB facility would be developed during remedial design.

Dredged sediments from the WW Area that are discharged into the ASB via hydraulic pipeline would undergo sedimentation, resulting in a thickened deposit of material overlain by clarified water (supernatant). The supernatant from the disposal area would be decanted by an overflow weir (likely integrated into the sheet pile design) and discharged into the modified 8-acre secondary treatment facility, where it would be combined with treated effluent from the Bellingham Tissue Mill before being discharged through the existing offshore diffuser outfall.

All NPDES discharge limitations applicable to the ASB treatment facility outfall would need to be met during (and following) the sediment disposal period. It should be noted that because of the significant reduction in effluent as a result of reduced plant operations, future NPDES limitations for TSS and possibly other constituents would be significantly less than current ASB limitations. Based on preliminary analysis of treatment and discharge requirements for the modified 8-acre facility, total suspended solids (TSS) discharge from the sediment disposal/settling facility would need to be maintained below approximately 2,500 pounds per day in order to ensure that prospective future NPDES permit limits are not exceeded (C. Hilarides, G-P, personal communication 2001). Appropriate discharge limitations from the ASB during the remedial action/sediment disposal period will be developed as part of remedial design, consistent with state and federal regulations.

During the sediment disposal period, the quality of effluent from the ASB sediment disposal facility would be dependent upon many factors, most of which are not constant during disposal. In order to develop preliminary operating parameters (e.g., production rates) for the ASB that would ensure water quality protection, the Corp's SETTLE model (Design of Confined Disposal Facilities for Solids Retention and Initial Storage, Version 3.0; Corps 1991) was run for a range of disposal conditions. These analyses provided an estimated range of TSS concentrations and loadings discharged from the ASB during placement, focusing on reasonable worst case conditions during critical disposal periods. Model assumptions and input parameters are summarized in Table 2.

The preliminary SETTLE model analyses, presented in Table 2, indicate that to meet ASB water quality (outfall discharge) requirements, up to a 16-inch hydraulic dredge could operate continuously. However, a larger 26-inch dredge could be operated approximately 12 hours per day and still achieve water quality requirements. A 16-inch dredge could maintain a longer daily disposal period and a higher average operating efficiency during the project duration, relative to a 26-inch dredge. Depending on contractor preferences, either dredge could be used at the WW Area. Both the 16-inch and 26-inch dredges are capable of achieving production rates ranging from roughly 30,000 to 80,000 CY/week, while still meeting water quality/effluent limitations. Thus, both dredges are capable of completing dredging of approximately 760,000 CY in the WW Area within a 2- to 5-month time frame. More detailed site-specific column settling tests and SETTLE model runs would be performed during remedial design to ensure water quality protection.

Assuming sediments are placed into the ASB up to elevation +18 feet MLLW, the estimated disposal capacity of the ASB is approximately 760,000 CY. The disposal capacity curve for the ASB (excluding bulking and consolidation considerations; see below) is depicted on Figure 15. Contingent upon the final dredge plan for the WW Area (determined during remedial design), and if at least a portion of sediments in Units 1A and 1B are deemed suitable for beneficial reuse, the ASB facility will likely have sufficient capacity to accept suitable sediments dredged from other areas of Bellingham Bay (e.g., Harris Avenue Shipyard).

The amount of settlement that will occur in the foundation soils beneath the ASB, solids confined in the basin of the ASB, and in dredged sediments disposed within the ASB, will have a direct impact on the capacity of the ASB as an upland CDF. Foundation soils adjacent to the ASB have been characterized by a range of soil borings advanced for the WW Area RI/FS (Anchor and Hart Crowser 2000) and the Roeder Avenue Landfill RI/FS (ReTec 2001). These borings reveal that approximately 10 to 15 feet of compressible soft silt and clay underlie the ASB, which in turn are underlain by a less compressible stiff silt and clay unit (Figure 14). Based on analyses and observations of similar sediments in the Puget Sound region (e.g., Port of Tacoma 1992), these compressible materials may consolidate within several months of disposal to roughly 90 percent of their initial thickness (i.e., depressing the existing bottom elevation of the ASB by roughly 1.0 to 1.5 feet), under the additional weight (overburden pressure) associated with placement of sediment and capping material within the ASB. If consolidation occurs uniformly over the 21-acre ASB disposal footprint, compression of foundation soils could provide an additional capacity within the ASB of roughly 30,000 to 50,000 CY. More detailed geotechnical analyses would be performed during remedial design to provide accurate estimates of the magnitude and time rate of foundation settlement within the ASB, including potential differential settlement near the existing berms. As discussed above, these analyses would also evaluate the seismic stability of the existing berm system, to ensure that the CDF will withstand (i.e., with possible damage but without failure) an earthquake that has an approximate 500-year recurrence interval (i.e., 10 percent chance of being exceeded in 50 years). Seismic performance criteria are discussed in more detail in the WW Area RI/FS (Anchor and Hart Crowser 2000). If necessary, a combined buttress/habitat bench could be designed for the perimeter of the ASB to ensure the stability of the fill during strong seismic motion.

Secondary treatment solids currently present at the bottom of the ASB may also consolidate under the additional overburden pressure associated with placement of sediment and capping material within the ASB. These solids are comprised mostly of biological process residues (bacterial cell mass), though they also contain mill process effluent settleable solids not removed by primary treatment. Evaluation of the chemical characteristics of these solids has been performed by G-P as part of NPDES permit monitoring requirements and maintenance dredging of accumulated secondary treatment solids (most recently in late 1999). Chemical analysis of these solids detected mercury ranging from 0.4 to 9.7 mg/kg (C. Hilarides, G-P, personal communication 2001), similar to mercury concentrations in the prospective WW Area dredge prism Moreover, no potentially leachable mercury was detected in secondary solids using the toxicity characteristic leachate procedure (TCLP; less than 0.005 mg/L). All chemical constituents detected in the secondary treatment solids (including metals and chlorinated dibenzodioxins/dibenzofurans) have been below MTCA screening levels for industrial sites. A detailed review of the geophysical and chemical characteristics of secondary treatment solids would be performed as part of remedial design to confirm the suitability of these solids remaining in the bottom of the ASB disposal site.

The consolidation of dredged sediments placed within the ASB will depend on a number of factors, including bulking of sediments during hydraulic dredging, the permeability and drainage characteristics of disposed sediments, and the rate at which sediments are placed within the ASB. Based on design analyses and construction observations at other similar CDFs in the Puget Sound region (e.g., Port of Tacoma 1992), hydraulically dredged sediments often reconsolidate within the CDF to their *in* *situ* density within several months of placement. Again, detailed geotechnical analyses would be performed during remedial design to provide accurate estimates of the magnitude and time rate of settlement of sediments placed within the ASB.

Following placement of sediments to be confined within the CDF (i.e., up to a maximum consolidated elevation of roughly +18 feet MLLW), capping materials would be placed to raise the grade to the surrounding uplands elevation of approximately +23 feet MLLW. If the CDF is not filled to capacity with contaminated sediments, suitable clean dredge materials (e.g., from outer Whatcom Waterway units 1A and 1B) could be used to construct a primary cap up to elevation +18 feet MLLW. The top 5 feet of the cap would be constructed using structural fill materials (sand and gravel).

As described in the WW Area RI/FS (Anchor and Hart Crowser 2000), the Corps, EPA and others have developed detailed procedures to address long-term water quality protection requirements of CDFs (Palermo et al. 1998a and 1998b). In order to provide for an early assessment of the protectiveness of CDFs in Bellingham Bay, subsurface core samples from the central Whatcom Waterway (containing the highest mercury concentrations) were collected during the RI/FS to assess potential contaminant mobility. However, only very low concentrations of contaminants (including mercury) were detected in the sediment leachate samples, particularly in tests that are representative of the ASB CDF. Based on these preliminary results, no water quality controls are likely necessary at the G-P ASB to ensure water quality protection. Moreover, all leachate generated by the ASB during the dewatering/consolidation period (and thereafter) would be discharged into the secondary treatment unit, prior to being discharged through an offshore diffuser.

A detailed long-term water quality assessment of the disposal site would be performed during remedial design, using the results of site-specific thin-layer column leachate testing (Myers et al. 1996, Fuhrman 1997). These evaluations would include analysis of potential short-term increases in contaminant mobility during hydraulic dredging, along with detailed assessment of sediment settling within the ASB. Concurrent with remedial design, potential modifications of the ASB would be evaluated by Ecology under its existing NPDES authorities, to ensure that the facility continues to provide required wastewater treatment for G-P's Bellingham Paper Mill. As discussed above, preliminary evaluations suggest that water quality controls (e.g., surface paving) are not likely to be required at the ASB upland CDF to ensure its protectiveness.

Under MTCA, in those situations where hazardous substances remain on-site at concentrations above applicable cleanup levels, institutional controls such as deed restrictions or restrictive covenants may be required to protect the integrity of the remedial action and prevent exposure to contaminants remaining at the site. However, based on data collected during the RI/FS (Anchor and Hart Crowser 2000), sediment concentrations within WW Area Alternative J dredge prism (Figure 12) are below prospective Method B MTCA soil cleanup levels for unrestricted land uses, particularly if water quality is already addressed (see above). For example, the MTCA Method B (unrestricted land use) cleanup level for mercury in soil to protect from potential soil contact exposures is 18 mg/kg (Ecology 2001), while the maximum sediment mercury concentration within the Alternative J dredge prism is 12 mg/kg. Thus, MTCA restrictive covenants (WAC 170-340-440(4)(a)) may not be applicable to the ASB CDF. The need for and/or scope of institutional controls would be determined during remedial design.

4.3 Detailed Analysis of Cleanup Alternatives

The results of the detailed analysis of each cleanup alternative were used to compare the alternatives and identify key tradeoffs. This approach to assessing the alternatives was designed to provide agencies, stakeholders, and the public with sufficient information to adequately compare the alternatives, select an appropriate remedy for the WW Area, and demonstrate compliance with SMS remedy requirements. The RI/FS (Anchor and Hart Crowser 2000) presents a technical analysis of key assessment factors of Alternatives A through I, and the reader is referred to that document for the specifics of the assessment. The sections below present the assessment of Alternative J, concluding with a summary evaluation of all 10 alternatives relative to each criterion listed above in Section 4.1.

4.3.1 Remedial Alternative J: Full Removal from Navigation Areas (G-P ASB Upland Disposal) (Supplemental EIS Modified Preferred Near-Term Remedial Action Alternative)

Description

The overall objective of Alternative J is to achieve SQS criteria in the WW Area, allowing for potential future deepening of the navigation channels, but avoiding disposal in the aquatic environment. Sediments being dredged from the federal channel would be removed using hydraulic cutterhead dredges, and would be disposed at the G-P ASB upland CDF (estimated 760,000 CY disposal capacity; see Figure 14). Steep slopes at Starr Rock (approximately 2,000 CY) would likely be dredged using mechanical equipment, and the material offloaded into the G-P ASB via a barge. Contingent upon the final dredge plan for the WW Area, and if at least a portion of sediments in Units 1A and 1B are suitable for beneficial reuse, the G-P ASB facility will likely have sufficient capacity to accept suitable sediments dredged from other areas of Bellingham Bay (e.g., Harris Avenue Shipyard). G-P is the landowner of the ASB upland CDF and therefore would retain the responsibility for managing the disposal site. Existing habitat at the head of Whatcom Waterway would be protected, while accommodating public access improvements as proposed by the City of Bellingham. The overall layout of Alternative J is presented in Figure 12.

Sediments in the G-P Log Pond would continue to be confined below the existing thick cap, converting previously subtidal habitat to intertidal aquatic habitat (Section 1.2). Adjacent upland remedial activities would be designed to ensure continued protection of surface water and sediment. Contaminated sediments located on the Bellingham Bay side of the G-P ASB, at Starr Rock, and within the Port Log Rafting area, would be confined below a 1- to 3-foot-thick cap. Nearshore contaminated sediments within these areas, also including areas on the Whatcom Waterway side of the G-P ASB, could have additional appropriate sediment placed to create salmonid migratory corridor habitats and accomplish habitat restoration. The specific layout of capping and habitat corridors in these areas would be determined during remedial design. All capped and confined sediment areas would have operation, monitoring, maintenance and adaptive management commitment.

Evaluation

An assessment of Cleanup Alternative J against the FS evaluation criteria is summarized below.

Overall Environmental Quality

- **Compliance with Cleanup Standards and Applicable Laws**. Alternative J would comply with MTCA and with other applicable cleanup standards and laws. All areas that currently exceed SQS criteria would be remediated either by containment (*in situ* capping) or with engineered confinement (G-P ASB).

- **Protection of Human Health and the Environment**. Alternative J would provide overall protection of human health and the environment by removing or capping contaminated sediments within the Waterway. Relative to other alternatives that utilize mechanical dredging (e.g., Alternatives E through I), the use of hydraulic dredges in Alternative J reduces short-term water quality impacts associated with removal. The construction of caps prevents the exposure of contaminated sediments to aquatic life.

- **Reasonable Restoration Time Frame**. Alternative J, by design, would achieve cleanup goals (SQS criteria) within a period similar to or faster than the other alternatives (within approximately 3 years, or by 2005). Relative to other alternatives with a similar amount of dredging (e.g., Alternative G), use of the G-P ASB as a disposal facility in Alternative J would allow dredging to commence earlier, since most of the disposal site infrastructure is already in place.

- **Use of Permanent Solutions**. Alternative J includes active containment (i.e., *in situ* capping or engineered confinement) of all areas of the site that currently exceed SQS criteria. Engineered confinement, applied in this alternative to the Starr Rock area, and sediments dredged from the Whatcom Waterway, is a more permanent technology than *in situ* containment. Alternative J applies the most permanent technology to higher concentration (mercury and phenolics) sediments present within the prospective Whatcom Waterway remedial action area, and uses *in situ* containment for lower concentration sediments present within other areas of the site.

- **The Degree to which Recycling, Reuse, and Waste Minimization are Employed**. Under this alternative, there is a potential to reuse clean dredge material for cap construction. This practice has occurred on other Puget Sound capping projects (Sumeri 1996). The amount of waste generated is moderate, however all dredged sediments would be placed into the G-P ASB facility. Once the ASB is filled and capped, it would remediate existing contaminated materials present at depth within the ASB (greater than 15 feet below finished grade), and would also provide an opportunity for upland redevelopment. Using dredge material in this manner constitutes a beneficial reuse.

- **Short-term Effectiveness**. Under Alternative J, most of the dredging would be completed with a hydraulic cutterhead and the dredge material delivered by hydraulic pipeline to the G-P ASB. As presented in Section 4.2.1 above, sediment resuspension rates are lower for hydraulic cutterhead dredges, as compared with mechanical dredges. Thus, the use of hydraulic cutterhead dredges in this alternative to accomplish removal of sediments (with the exception of debris and a relatively small volume of material at Starr Rock) is expected to provide significant short-term water quality and implementability (reduced contaminated sediment residuals) benefits, relative to the other removal alternatives. Worker and community risks associated with the dredging, transport, and disposal would be minimal (BBWG 1998).

  During construction of caps, contaminated sediments are not disturbed or redistributed into the water column; this eliminates potential environmental impact. Also, since the contaminated sediments remain in place, the risk of exposure or potential threats to workers and the community are minimal. With cap placement, remedial objectives are met immediately.

- **Long-term Effectiveness**. Under this alternative, a moderate amount of dredging would be conducted to remove contaminated sediments. The risk remaining after implementation of the dredging and fill activities would be negligible. As discussed in Section 4.2.2, long-term water quality risks associated with confined disposal in the ASB CDF are minimal.

The long-term risk associated with a cap generally involves the erosion or removal of the clean sediment layer. Day to day hydrodynamics and tidal conditions are not expected to disturb the constructed cap. The cap would be designed to resist propeller wash or other disruptive events. Cap monitoring would be required to confirm the integrity of the cap over time.

- **Net Environmental Benefits**. Relative to the other alternatives evaluated, this alternative has moderate environmental benefits. Under this alternative, there would be no net loss of aquatic habitat. Limited conversion of habitat would occur as a result of dredging the navigable reaches of the middle Whatcom Waterway and capping other areas of the site. Habitat in the capping areas could be converted from subtidal to shallow subtidal habitat and from shallow subtidal to low to high intertidal habitat. The existing cap at the Log Pond was constructed to achieve a net gain of functional aquatic habitat (Section 1.2). The Supplemental EIS more fully evaluates the environmental impacts associated with this alternative.

Ability to be Implemented

- **Implementability**. Hydraulic dredging and pipeline disposal of dredged sediments within the G-P ASB rank high in terms of implementability. Area contractors have successfully completed relatively large contaminated sediment removal projects using hydraulic dredges (e.g., Port of Tacoma 1992); these projects required few additional operating measures outside of a typical navigational dredging project. Construction monitoring, such as water quality and post dredge sediment sampling, would be completed to assist the contractor during dredge operations.

  In deep areas, caps would be placed with a bottom dump barge. Where the water depth is shallow or obstructions are anticipated, caps would be constructed with a clamshell bucket. Cap construction is a common remedial activity in Puget Sound (Sumeri 1996) and ranks high in terms of implementability. Bathymetric surveys would be conducted pre- and post-construction to verify the thickness of the cap. The necessary equipment and materials for cap placement are available in the Puget Sound area.

The substantive provisions of various permit requirements would need to be addressed as part of implementation of this alternative. For Alternative J, these requirements would likely include: Section 10 of the Rivers and Harbors Act; Sections 401 and 404 of the Clean Water Act; Water Quality Certification under Chapter 90.48 RCW; Hydraulic Project Approval under Chapter 75.20 RCW; and Bellingham Bay Shoreline Master Program requirements. The Corps' 1978 Clean Water Act permit to G-P for construction of the ASB (Permit No. 071-OYB-2-004368), along with other approvals required for that action, included off-site mitigation for permanent habitat losses that resulted from construction. Federal Clean Water Act permitting for dredging, transport/placement, and capping actions under Alternative J would likely be performed as part of a Nationwide 38 permit for the entire WW Area cleanup action.

Actions taken during the implementation of Alternative J would improve authorized navigation uses within the remediation areas. Following construction, navigation depths in the Whatcom Waterway from the mouth to Station 3+00 would be at or below -32 feet MLLW, at least 2 feet lower than the currently authorized channel depth of -30 feet MLLW. Between Station 15+00 and Station 62+00, the navigation channel would be dredged to depths of approximately 38 to 40 feet below MLLW, considerably deeper than the authorized channel depth. Dredging to this depth would likely obviate the need for future institutional controls such as an agreement between G-P and the U.S. Army Corps of Engineers.

Cost Effectiveness

- **Cost**. Appendix A of this Supplemental FS summarizes the estimated capital and O&M costs for Alternative J. The estimated cost of this alternative is $23.8 million, excluding land costs.

- **Cost Effectiveness**. Alternative J has the highest cost effectiveness of the 10 alternatives evaluated, since it removes a relatively large volume of contaminated sediments (760,000 CY) at relatively low cost ($23.8 million). The total cost is similar to Alternatives C, D, and E, which remove less material from the Whatcom Waterway.

4.4 Comparative Analysis of Alternatives

In this section, a comparative analysis of each alternative is presented. Table 3 summarizes the detailed evaluation of the cleanup alternatives.

- **Compliance with Cleanup Standards and Applicable Laws**. All alternatives except Alternative A comply with MTCA and with other applicable cleanup standards and laws. All areas that are not predicted to naturally recover would be actively remediated. Areas remediated by natural recovery are predicted to recover by 2005.

- **Protection of Human Health and the Environment**. All alternatives except Alternative A are protective of human health and the environment.

- **Reasonable Restoration Time Frame**. Alternatives B, C, D, and J are anticipated to achieve restoration goals (SQS criteria) most rapidly, within 3 years (roughly 2005; natural recovery estimates are provided in the original RI/FS). Alternatives E, F, and G will require an additional 1 to 2 years to implement, in part because of the time required to construct the CAD site or an upland offloading facility. Natural recovery alone (Alternative A) may achieve SQS criteria in all areas of the site within the next 5 to 10 years, but its limited incorporation into Alternatives B through D is not likely to affect the overall restoration time frame. The time frame for implementation of Alternatives H and I may be limited to some degree by available landfill capacity and/or rail transport capacity. Sediment transport and disposal may add up to 3 and 5 years to the sediment cleanup schedule for Alternatives H and I, respectively.

- **Use of Permanent Solutions**. Alternatives G, H, I, and J use more permanent engineered confinement technologies including CADs and upland CDFs to a greater degree than the other alternatives evaluated. However, by combining the most permanent technologies (engineered confinement in CADs) applied to the highest concentration sediments present within the WW Area, with *in situ* containment applied to lower concentration sediments, Alternative E achieves only a slightly lower degree of "permanence" as defined by MTCA. Because of their reliance on capping to remediate some of the highest concentration sediments within the WW Area, Alternatives B, C, D, and F are less permanent. Finally, since it relies extensively on natural recovery, Alternative A is the least permanent of the alternatives evaluated.

- **The Degree to which Recycling, Reuse, and Waste Minimization are Employed**. Alternative I provides the lowest degree of recycling, reuse or waste minimization due to relatively extensive dredging and disposal at the Roosevelt Landfill. The remaining alternatives rank medium to high with respect to this criteria, due to either minimizing the amount of removal or by reusing the dredged material as fill for upland development or aquatic/wetland habitat creation.

- **Short-term Effectiveness**. Alternatives A, B, and J have the highest short-term effectiveness, either due to: 1) maximum use of *in situ* containment and limited mechanical dredging (Alternatives A and B); or 2) use of hydraulic dredging methods with lower sediment resuspension potential and related risks (Alternative J; Section 4.2.1). Alternatives C through G have intermediate short-term effectiveness, while Alternatives H and I scored the lowest with respect to this criterion due to the extensive amount of dredging (increasing chances for more water column impacts likely associated with dredging events) and the multiple handling required (higher likelihood of community and worker impacts with off-site upland transport).

- **Long-term Effectiveness**. Alternative A has the lowest long-term effectiveness since some sediment areas of the site may require an extended period for full natural recovery. Alternatives B, C, and D have medium to medium-to-high long-term effectiveness due in large part to the use of natural recovery in some areas of the site. Alternatives E through J have high long-term effectiveness due to the use of engineered CDFs. Alternatives E and G rely on CADs for disposal, which provide a near-optimal environment to minimize contaminant leaching, while Alternatives F, H, I and J rely on upland CDFs, including leachate collection and treatment.

- **Net Environmental Benefits**. Relative to the other alternatives evaluated, Alternatives E and G present the greatest opportunity for significant net environmental benefits. Under these alternatives, subtidal substrates at the CAD sites would be converted to shallow subtidal and/or low intertidal elevations, providing an opportunity to create 30 to 50 acres of eelgrass habitat that previously (historically) existed within the inner Bellingham Bay area. Alternatives B, C, D, F and J provide intermediate environmental benefits, while Alternatives H and I scored lower because of the concurrent conversion of approximately 8 to 12 acres of intertidal and shallow subtidal habitat to deeper subtidal sediments (greater than -10 feet MLLW). Alternative A would provide the least net environmental benefits. The Bellingham Bay Comprehensive Strategy Final EIS and Supplemental EIS more fully evaluate the environmental impacts associated with alternatives E through J.

- **Implementability**. Alternatives A, B, and J would be the easiest to implement due either to: 1) limited dredging and disposal (Alternatives A and B); or 2) use of the existing G-P ASB as a CDF (Alternative J). Alternatives E and G also scored relatively high with respect to this criterion, pending the availability of aquatic lands at the CAD sites. Alternatives C, D, and F would have medium implementability, owing in part to the perceived difficulties in obtaining landowner agreements for these alternatives. Alternatives H and I would have the lowest implementability due to the extensive dredge volume involved and upland transport requirements.

- **Cost Effectiveness**. Alternatives A and B are the least expensive (up to $5 million), due to the limited active remediation involved. Alternatives C, D, E and J are the next lowest priced alternatives ($19 to $24 million), because of the relatively low dredge volumes (Alternatives C and D), or the use of cost-effective CAD or ASB facilities (Alternatives E and J, respectively). However, these alternatives are roughly 4 to 5 times the cost of Alternative B. Alternatives F and G are the next highest priced set of alternatives ($34 to $36 million) at nearly 2 times the cost of Alternatives C and D (due mainly to the increase dredge volume or the use of upland disposal sites). Alternative H is the second highest priced at 2 to 3 times the cost of the previous set of alternatives. Alternative I is the most expensive, nearly twice that of Alternative H. This is due to the extensive use of dredging and upland disposal.

Costs in this RI/FS were evaluated on a net present worth basis, including direct and indirect costs, engineering, habitat mitigation, long-term operation and maintenance, administration, and a 30 percent contingency factor to account for construction conditions not currently identified. Because of the complexities of landowner interest determinations, the long-term costs of property easements for disposal and/or mitigation have not been included in this Supplemental FS.

As set forth in MTCA (Chapter 173-340-360[5]), a cleanup action shall not be considered practicable if the incremental cost of the cleanup action (including land costs if known) is substantial and disproportionate to the incremental degree of protection it would achieve over a lower preference cleanup action. When selecting from among two or more cleanup action alternatives that provide a sufficient and equivalent level of protection, preference may be given to the least cost alternative, subject to an evaluation of public concerns and technical uncertainties.

4.5 Identification of a Preferred Alternative

The sections above (and the RI/FS; Anchor and Hart Crowser 2000) present and evaluate 10 sediment remediation alternatives that represent a wide range of potentially appropriate remedial technologies and process options. These alternatives include different combinations of natural recovery, capping, removal, and disposal, and also reflect the work of the Pilot. When viewed together, the alternatives present the broad range of potential remediation, habitat enhancement, and land use options available within the WW Area, and highlight tradeoffs associated with implementation of different alternatives, consistent with the objectives of the FS.

The Pilot is designed to expand opportunities for achieving multiple goals in Bellingham Bay, using comprehensive strategic environmental planning and project integration to efficiently and effectively address multiple objectives including contaminated sediment cleanup, sediment disposal, habitat restoration, source control, and shoreline property management. The Comprehensive Strategy integrates each of these elements into a coordinated approach. In the Final EIS (Ecology 2000) and accompanying Supplemental EIS, the environmental consequences of implementing the Comprehensive Strategy, including many of the sediment remediation alternatives presented herein, is analyzed. This Supplemental RI/FS for the WW Area is a companion document to the Supplemental EIS.

Through the Pilot and associated public review processes, a new preferred bay-wide sediment remediation alternative may be identified. However, while this Supplemental FS evaluates the Preferred Near-Term Remedial Action Alternative from the Final EIS, as modified by the substitution of the ASB for a CAD, it is important to note that, in the absence of the Pilot effort, the preferred sediment remediation alternative for the WW Area would necessarily focus only on statutory selection criteria set forth in the SMS. In consideration of the statutory criteria comparisons, as summarized in the RI/FS and in this Supplemental FS, the likely recommendations for WW Area sediment remediation would include elements of short-term natural recovery, capping, and limited dredging (e.g., Alternative E). The site-specific alternatives incorporating these technologies and process options are consistent with SMS selection factors and comply with statutory requirements. However, consistent with the Pilot, the Modified Preferred Near-Term Remedial Action Alternative achieves multiple goals including habitat restoration and land use actions in an effective, cost-efficient way. From a regulatory standpoint, Ecology will ultimately select the remedy for the Whatcom Waterway Site.

5 REFERENCES

Anchor, 1998a. Addendum No. 3, Remedial Investigation/Feasibility Study Project Plans, Whatcom Waterway Area, Bellingham, Washington. Prepared for Georgia-Pacific West Corporation, Bellingham, Washington. Prepared by Anchor Environmental, L.L.C., Seattle, Washington. October 1998.

Anchor, 1998b. Supplementary Investigation of Surface Sediments, Boulevard Park/Starr Rock Area, Bellingham, Washington. Prepared for the Washington State Department of Ecology, Seattle, Washington, and the Port of Bellingham, Bellingham. Prepared by Anchor Environmental, L.L.C., Seattle, Washington. October 1998.

Anchor, 2000. Interim Remedial Action: Log Pond Cleanup/Habitat Restoration – Engineering Design Report. Prepared for Georgia Pacific West, Inc., Bellingham, Washington. Prepared by Anchor Environmental, L.L.C., Seattle, Washington. July 2000.

Anchor, 2001a. Interim Remedial Action: Log Pond Cleanup/Habitat Restoration – Completion Report. Prepared for Georgia Pacific West, Inc., Bellingham, Washington. Prepared by Anchor Environmental, L.L.C., Seattle, Washington. May 2001.

Anchor, 2001b. Year 1 Monitoring Report. Interim Remedial Action, Log Pond Cleanup/Habitat Restoration Project, Bellingham, Washington. Prepared for Georgia Pacific West, Inc., Bellingham, Washington. Prepared by Anchor Environmental, L.L.C., Seattle, Washington. December 2001.

Anchor and Hart Crowser, 2000. Remedial Investigation/Feasibility Study, Whatcom Waterway Site, Bellingham, Washington, prepared for Georgia-Pacific West, Inc. by Anchor Environmental, LLC and Hart Crowser, Inc. July 2000.

BBWG, 1998. Final Disposal Siting Documentation Report: Bellingham Bay Demonstration Pilot Project Work Group. Prepared by Anchor Environmental, L.L.C. September 1998.

Corps, 1991. SETTLE - Design of Confined Disposal Facilities for Solids Retention and Initial Storage, Version 3.0. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Ecology, 1991. Sediment Cleanup Standards User Manual. December 1991. Washington Department of Ecology, Olympia, Washington.

Ecology, 2000. Final Environmental Impact Statement. Report prepared for Bellingham Bay Demonstration Pilot Project by Anchor Environmental, LLC. October 2000.

Ecology, 2001. Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation. CLARC Version 3.1. Publication No. 94-145, Washington Department of Ecology Toxics Cleanup Program. Updated November 2001.

Fuhrman, R.L., 1997. Leaching Test Guidance for Dredged Material Disposal Activities. U.S. Army Corps of Engineers CECW-OD, Washington, D.C. December 29, 1997.

Hart Crowser, 1996. Final Remedial Investigation/Feasibility Study Work Plan, Sampling and Analysis Plan, Quality Assurance Project Plan and Health and Safety Plan: Whatcom Waterway Site, Bellingham, Washington. Prepared for Georgia-Pacific West, Inc., by Hart Crowser, Seattle, WA. September 3, 1996.

Hart Crowser, 1997a. Addendum No. 1 to Project Plans Whatcom Waterway Site Remedial Investigation/Feasibility Study, Bellingham, Washington, February 14, 1997, J-4478-05.

Hart Crowser, 1997b. Addendum No. 2 to Project Plans Whatcom Waterway Site Remedial Investigation/Feasibility Study, Bellingham, Washington, June 30, 1997, J-4478-05.

Hayes, D. and P. Wu, 2001. Simple Approach to TSS Source Strength Estimates. Western Dredging Association Proceedings, WEDA XXI, Houston, TX, June 25-27, 2001. 11 pp.

Hayes, D., 2001. Personal communication with Clay Patmont, Anchor Environmental, September 18, 2001.

Herbich, J.B. and S.B. Brahme, 1991. Literature Review and Technical Evaluation of Sediment Resuspension During Dredging. Contract Report HL-91-1. Center of Dredging Studies, Texas A&M University, College Station, TX. January 1991.

Hilarides, C., 2001. Analytical data and engineering calculations pertaining to the G-P ASB. Georgia-Pacific West, Inc., Bellingham, WA.

Holtz, R.D. and W.D. Kovacs, 1981. An Introduction to Geotechnical Engineering. Prentice-Hall, New Jersey. 733 pp.

Johnson, B.H. and T.M. Parchure, 2000. Estimating Dredging Sediment Resuspension Sources. Dredging Operations and Environmental Research (DOER) Technical Notes Collection (TN DOER-E6), U.S. Army Engineer Research and Development Center, Vicksburg, MS. 9 pp.

Kendall, D. and T. Michelsen, 1997. Management of wood waste under Dredged Material Management Programs (DMMP) and the Sediment Management Standards (SMS) Cleanup Program. Agency Review Draft SMS Clarification Paper, Washington State Department of Ecology, Olympia, Washington, presented at 1997 Sediment Management Annual Review Meeting.

McLellan, T.N., R.N. Havis, D.F. Hayes, and G.L. Raymond, 1989. Field Studies of Sediment Resuspension Characteristics of Selected Dredges. Technical Report HL-89-9, Environmental Laboratory, Department of the Army, Vicksburg, MS. April 1989.

Meyers, Tommy, E. Brannon, M. James, and Cynthia Price, 1992. Recent developments in leachate testing and evaluation. Miscellaneous Paper D-92-2. Vicksburg, MS: U.S. Army Engineer Waterways Experiment Station.

Nakai, O. 1978. Turbidity Generated by Dredging Projects. Proceedings of the 3rd U.S./Japan Experts Meeting, EPA-600/3-78-084. pp. 31-47.

Palermo, M.R., J.E., Clausner, M.P. Rollings, G.L. Williams, T.E., Myers, T.J. Fredette, and R.E. Randall, 1998a. "Guidance for subaqueous dredged material capping," Technical Report DOER-1, U.S. Army Engineer Waterway Experiment Station, Vicksburg, Mississippi.

Palermo, M., Maynord, S., Miller, J., and Reible, D. 1998b. "Guidance for *In-Situ* Subaqueous Capping of Contaminated Sediments," EPA 905-B96-004, Great Lakes National Program Office, Chicago, Illinois.

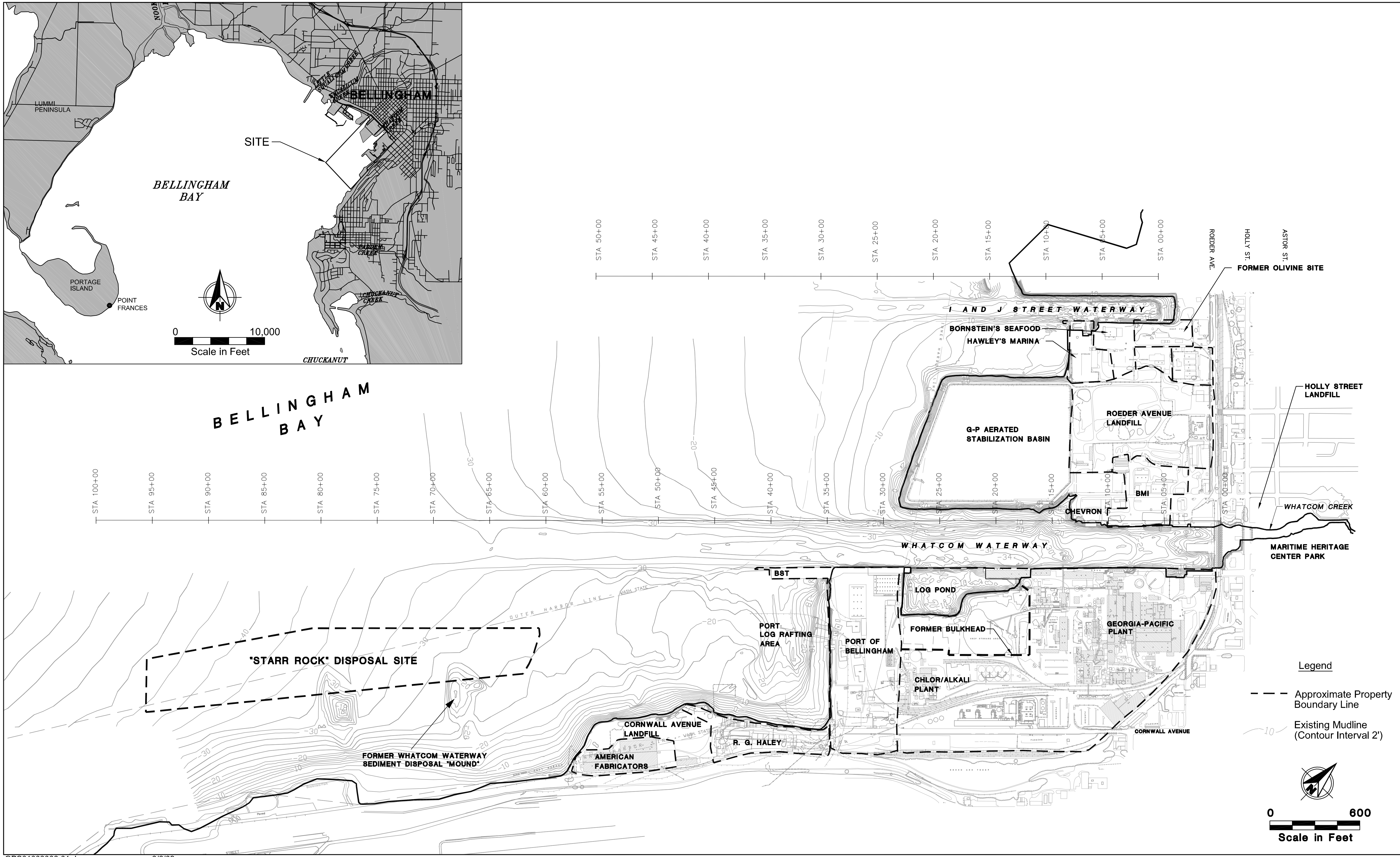
Pennekamp, J.G.S., R.J.C. Epskamp, W.F. Rosenbrand, A. Mulle, G.L. Wessel, T. Arts, and I.K. Deibel, 1996. Turbidity Caused by Dredging: Viewed in Perspective. Terra et Aqua 64: 10-17 pp.

Port of Tacoma, 1992. Sitcum Waterway Remediation Project: Phase 1 Pre-Remedial Design Evaluation and Phase 2 Preliminary Evaluation of Remedial Options Report. September 30, 1992.

ReTec, 2001. Remedial Investigation and Feasibility Study, Roeder Avenue Landfill, Bellingham, Washington, Draft Report prepared for the Port of Bellingham by ThermoRetec Consulting Corporation. October 1, 2001.

Sumeri, 1996. Dredged Material is Not Spoil: A Report on the Use of Dredged Material in Puget Sound to Isolate Contaminated Sediments. Western Dredging Association Seventeenth Annual Meeting. June 11-14, 1996.

APPENDIX A
COST ESTIMATES: REMEDIAL ALTERNATIVES B THROUGH J



GPS01003006-01.dwg 3/6/02

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Figure 1
Vicinity Map
Whatcom Waterway

Figure 2
Prospective Sediment Cleanup Areas
(SQS and MCUL)
Whatcom Waterway RI/FS

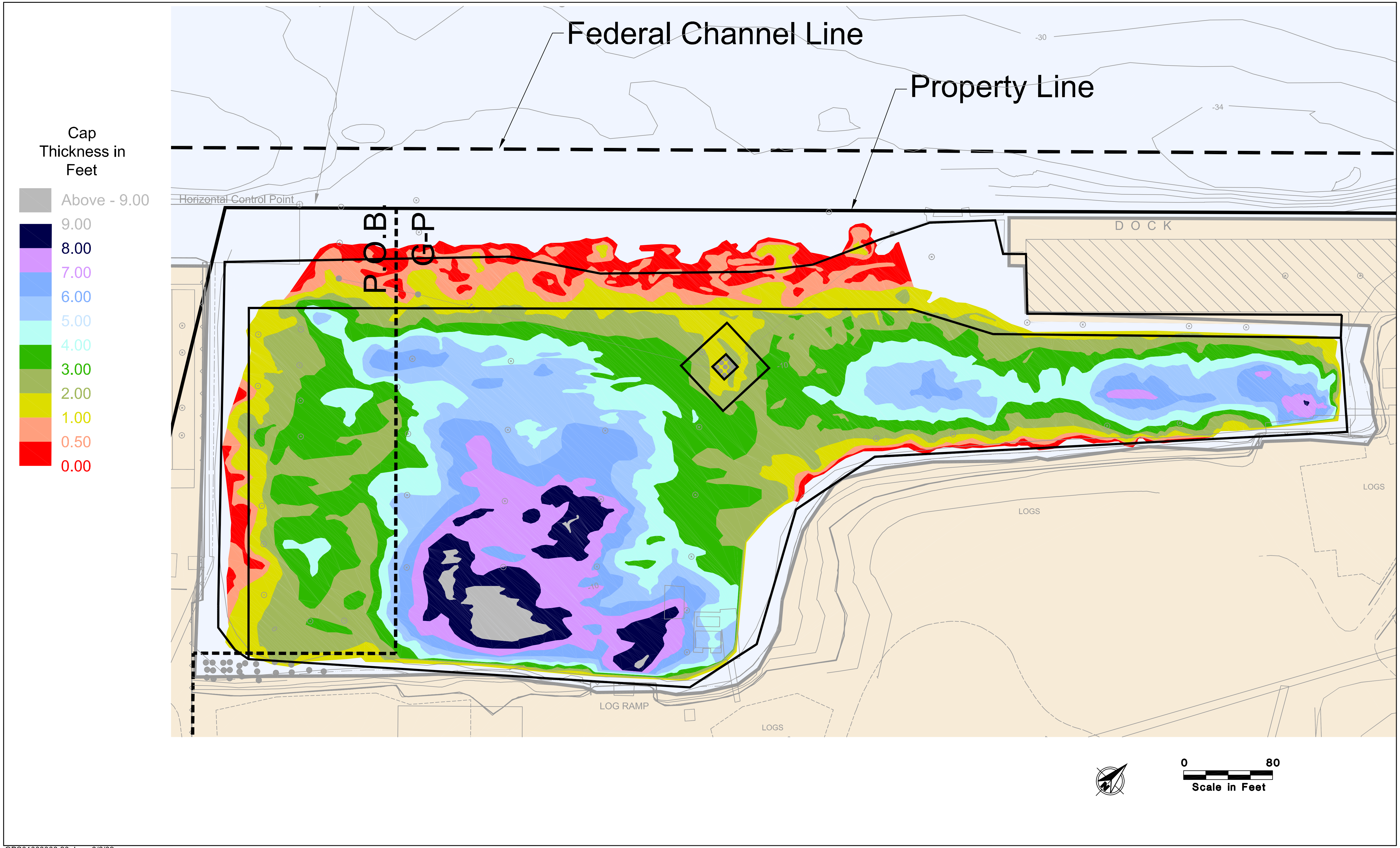

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Figure 3
Total Cap/Habitat Layer Thickness - October 2001
Log Pond Cleanup and Habitat Restoration

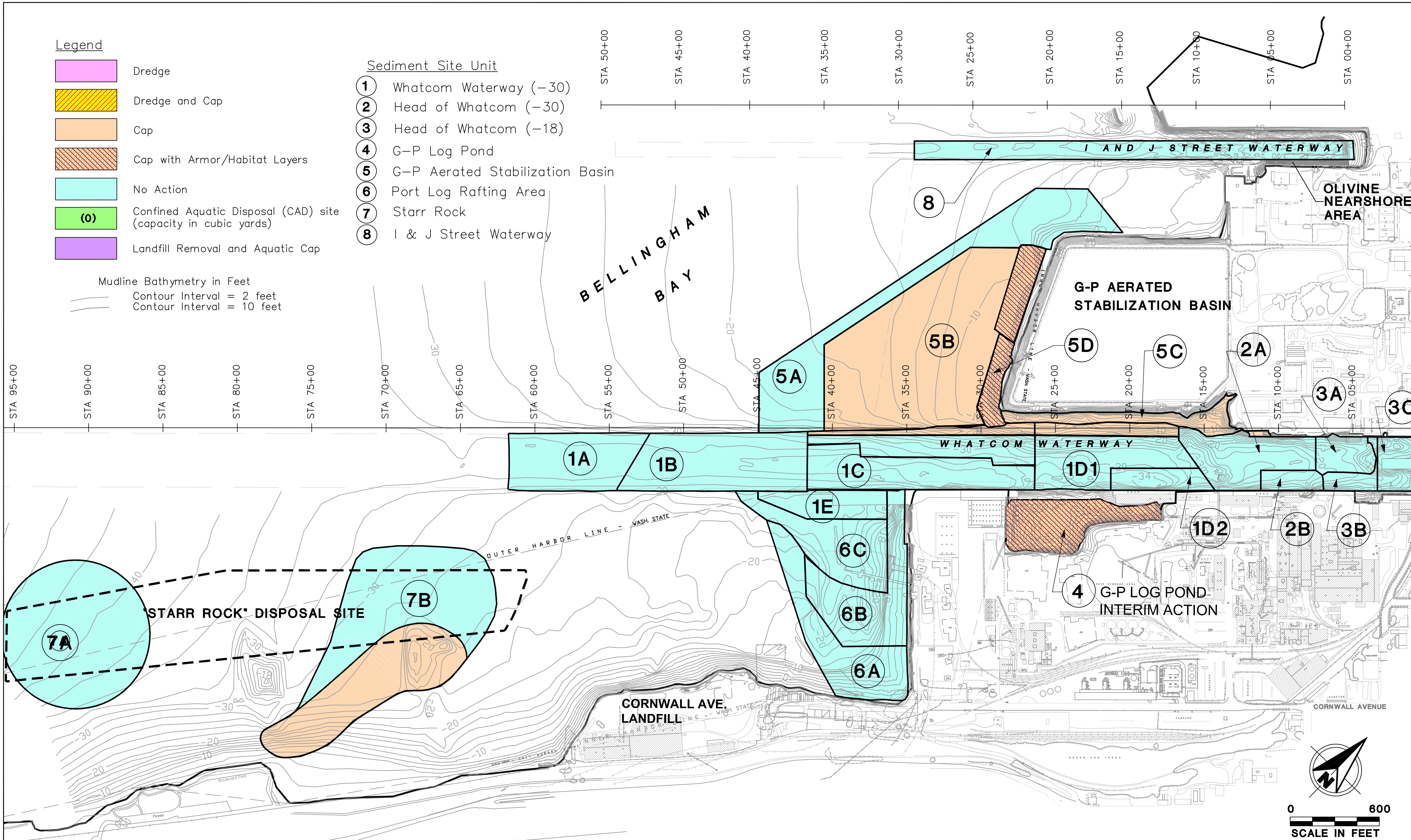

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Figure 4
Remedial Alternative B
Whatcom Waterway RI/FS

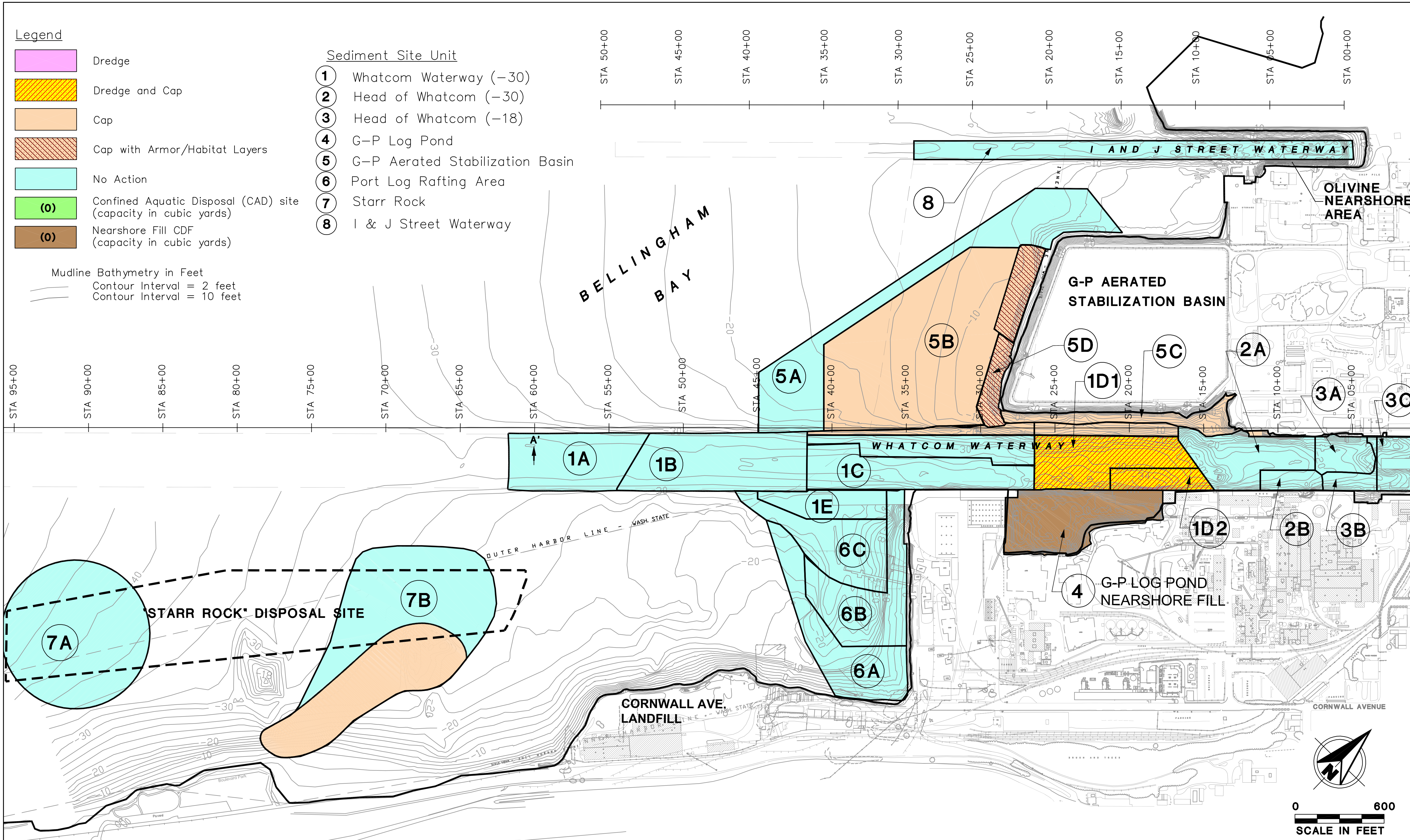

Figure 5
Remedial Alternative C
Whatcom Waterway RI/FS

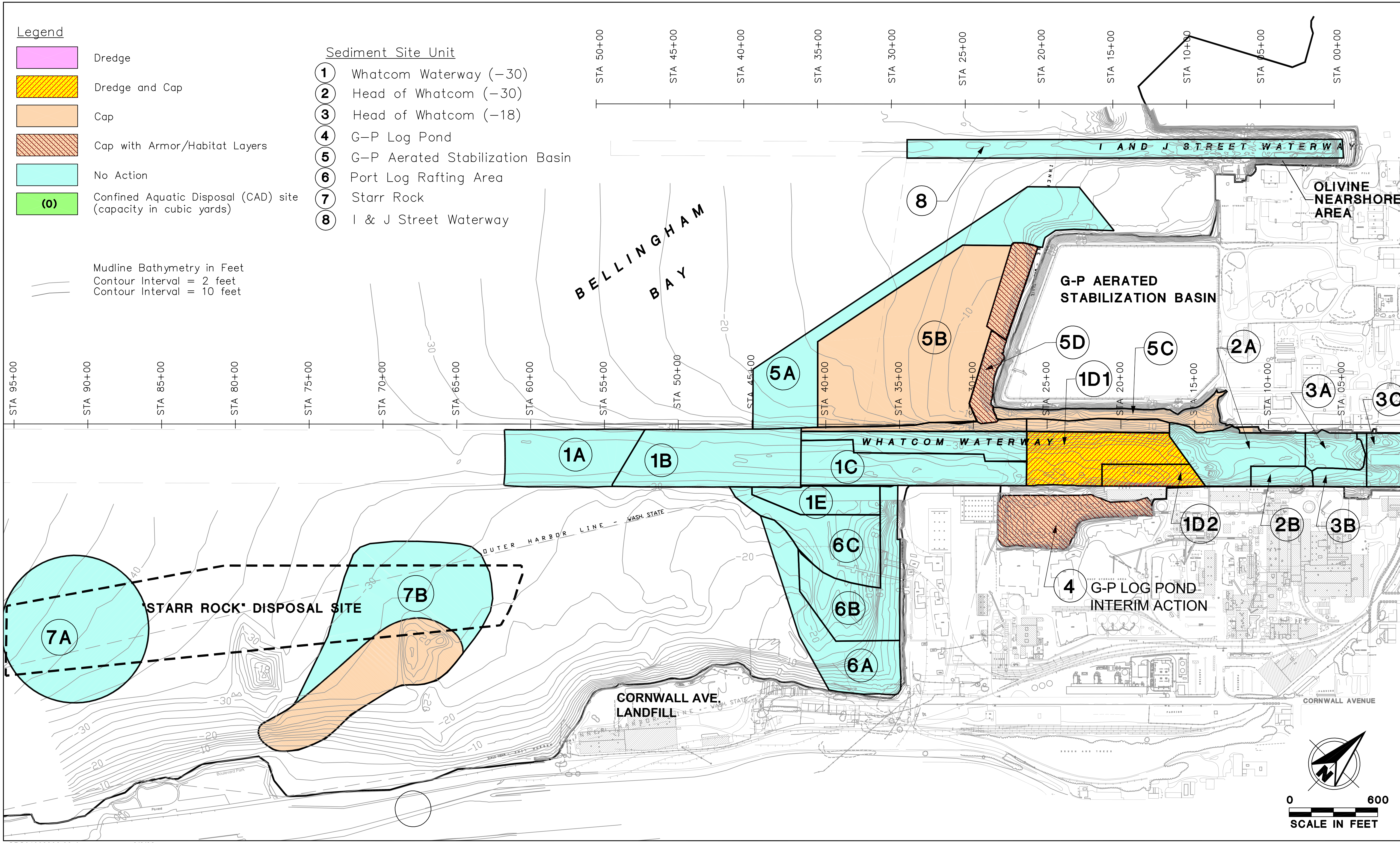

Figure 6
Remedial Alternative D
Whatcom Waterway RI/FS

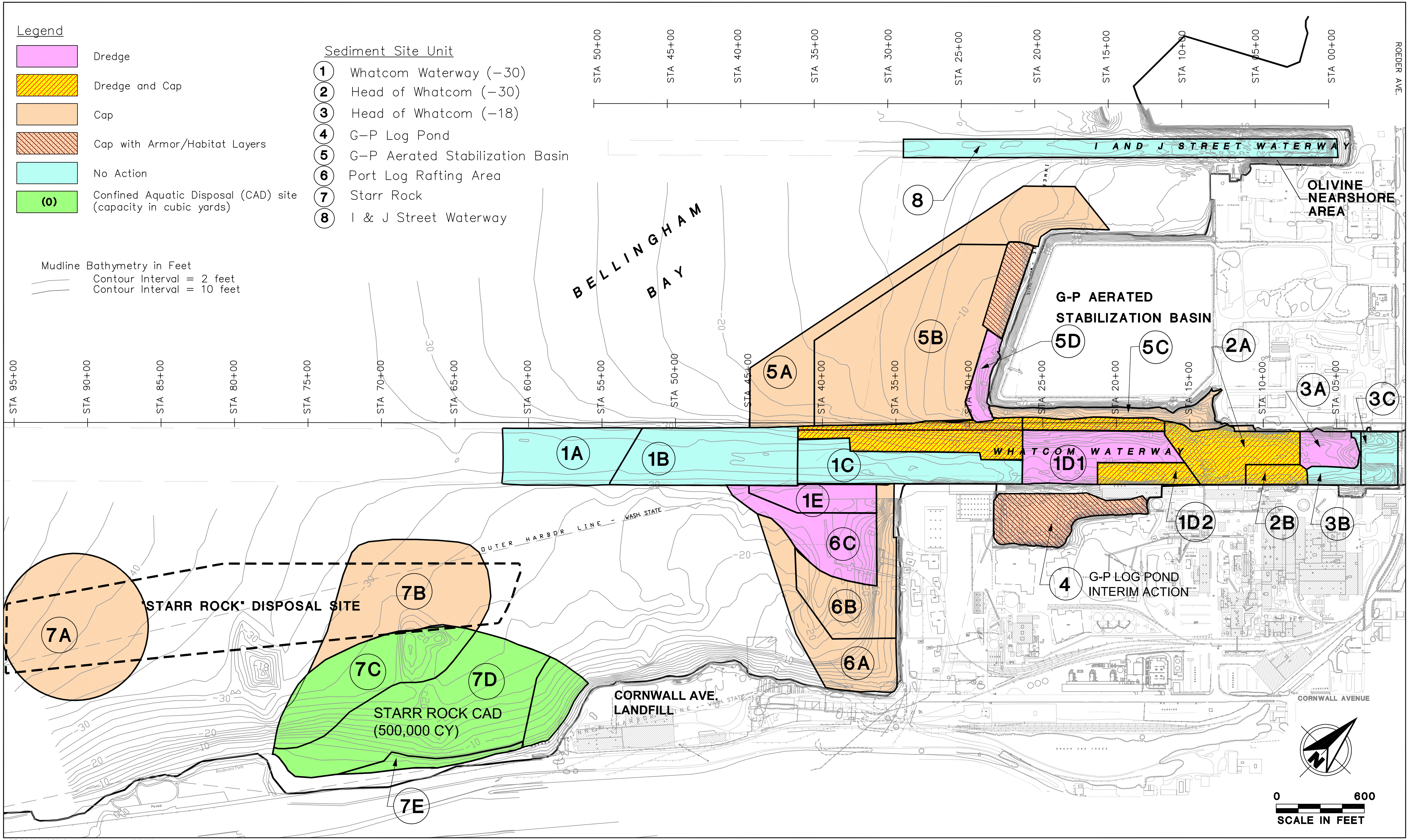

Figure 7
Remedial Alternative E
Whatcom Waterway RI/FS

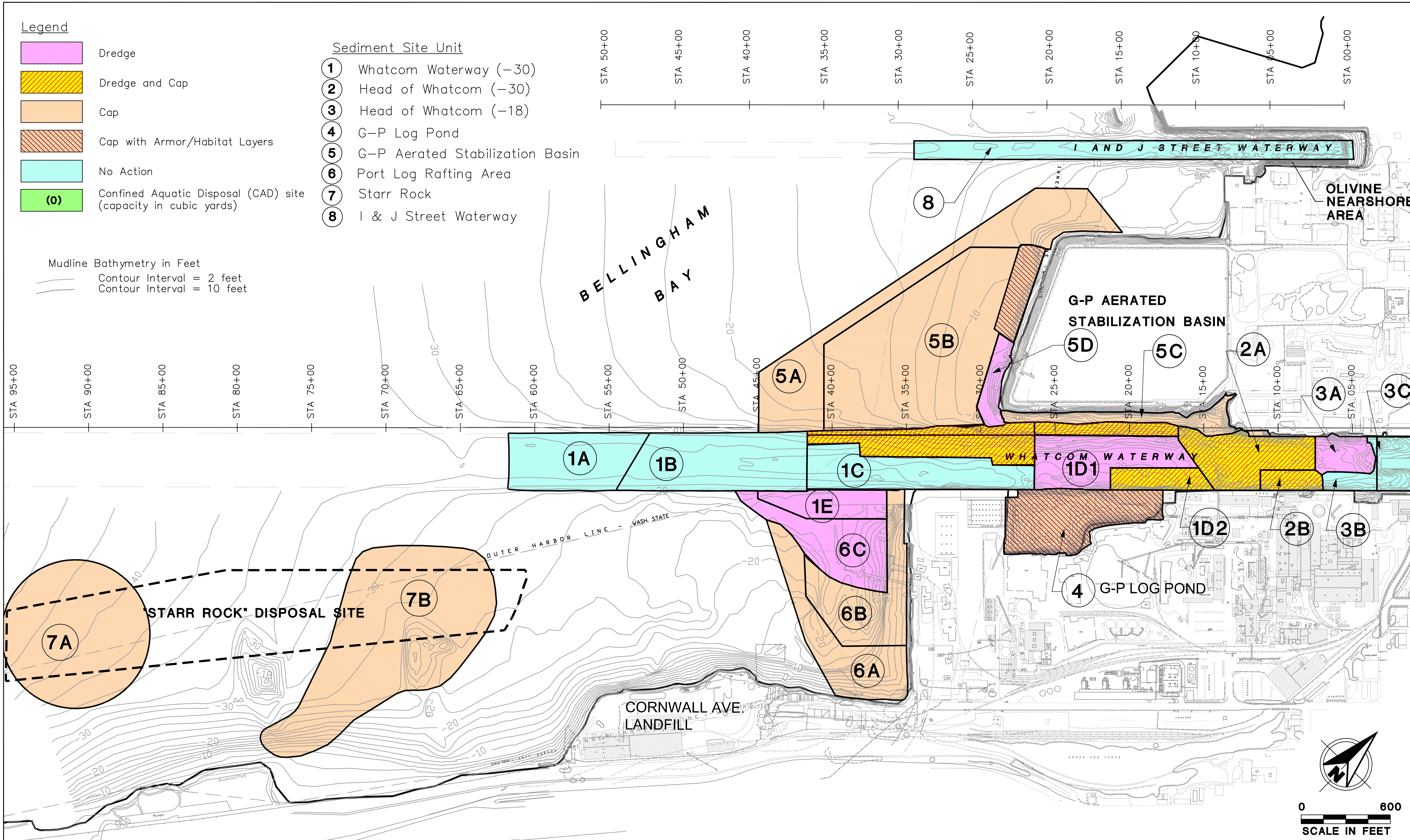

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Figure 8
Remedial Alternative F
Whatcom Waterway RI/FS

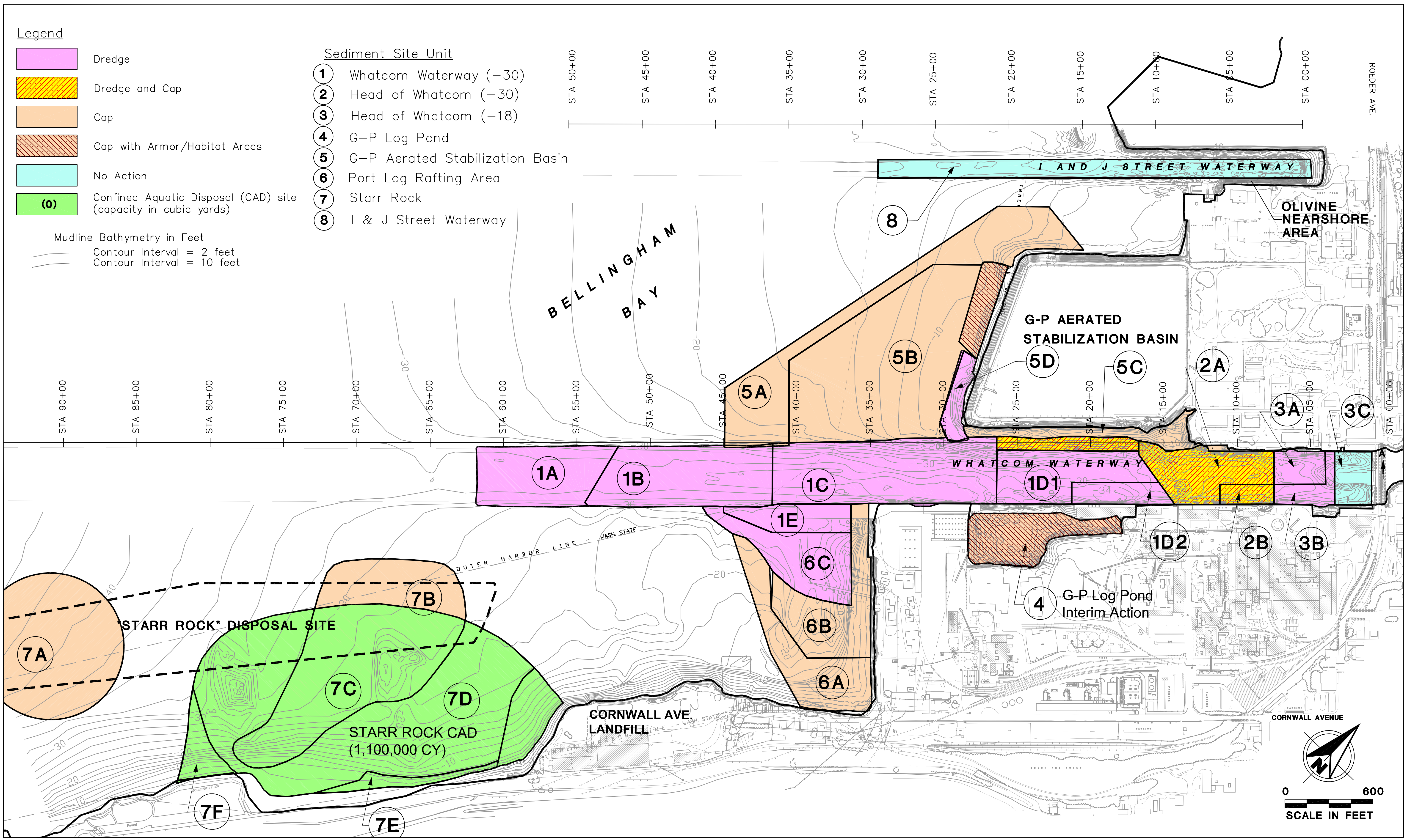


Figure 9
Remedial Alternative G
Whatcom Waterway RI/FS

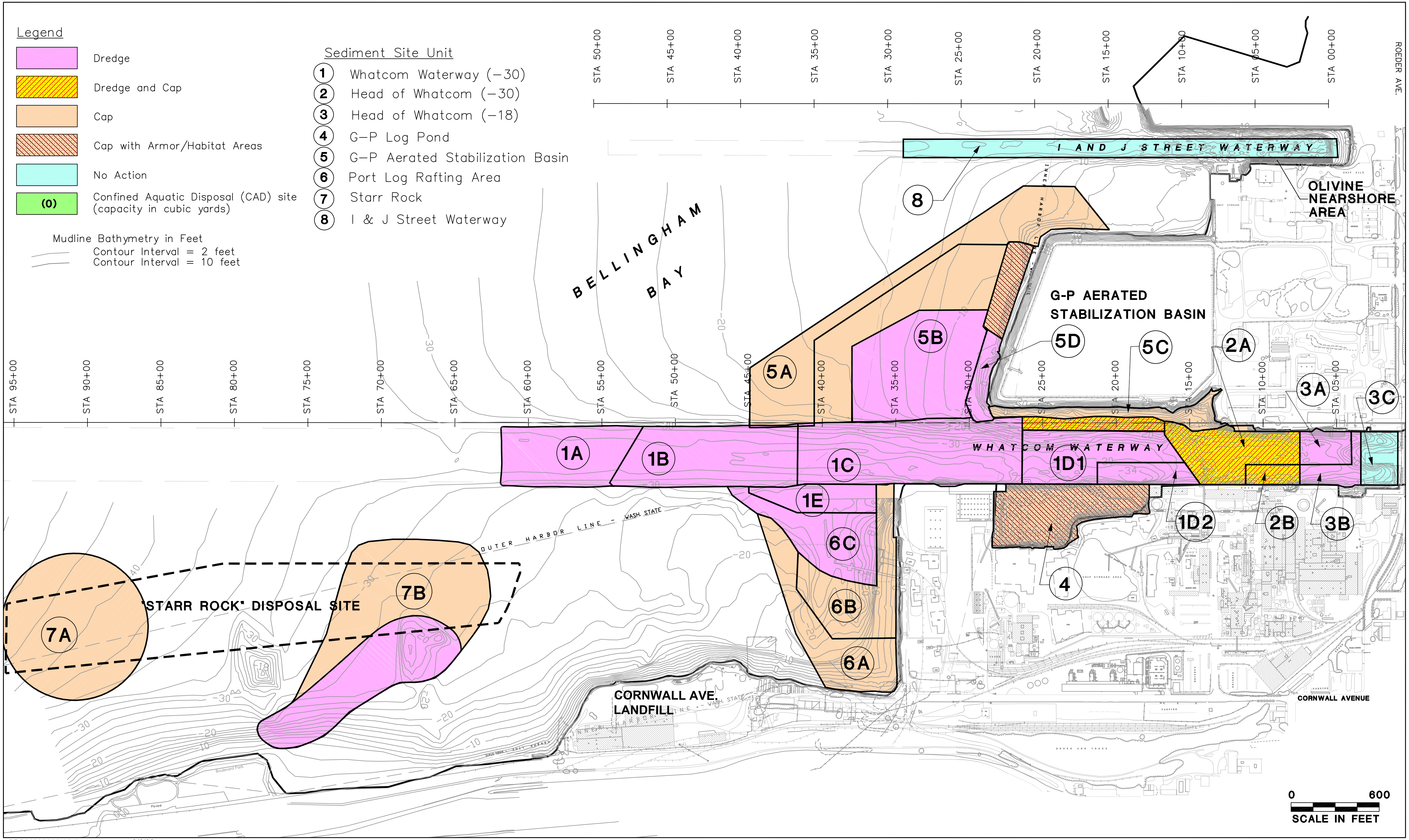


Figure 10
Remedial Alternative H
Whatcom Waterway RI/FS

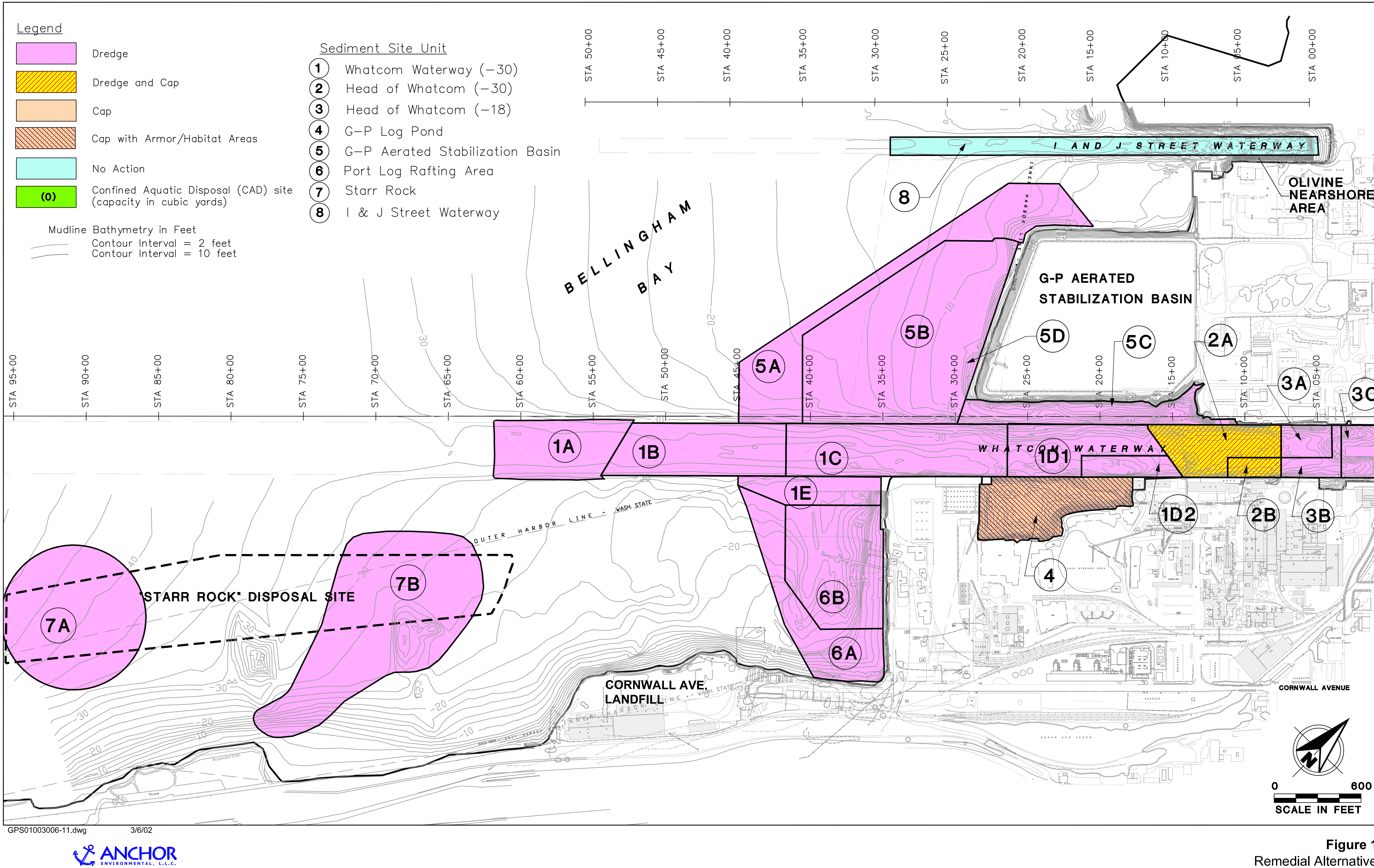


Figure 11
Remedial Alternative I
Whatcom Waterway RI/FS

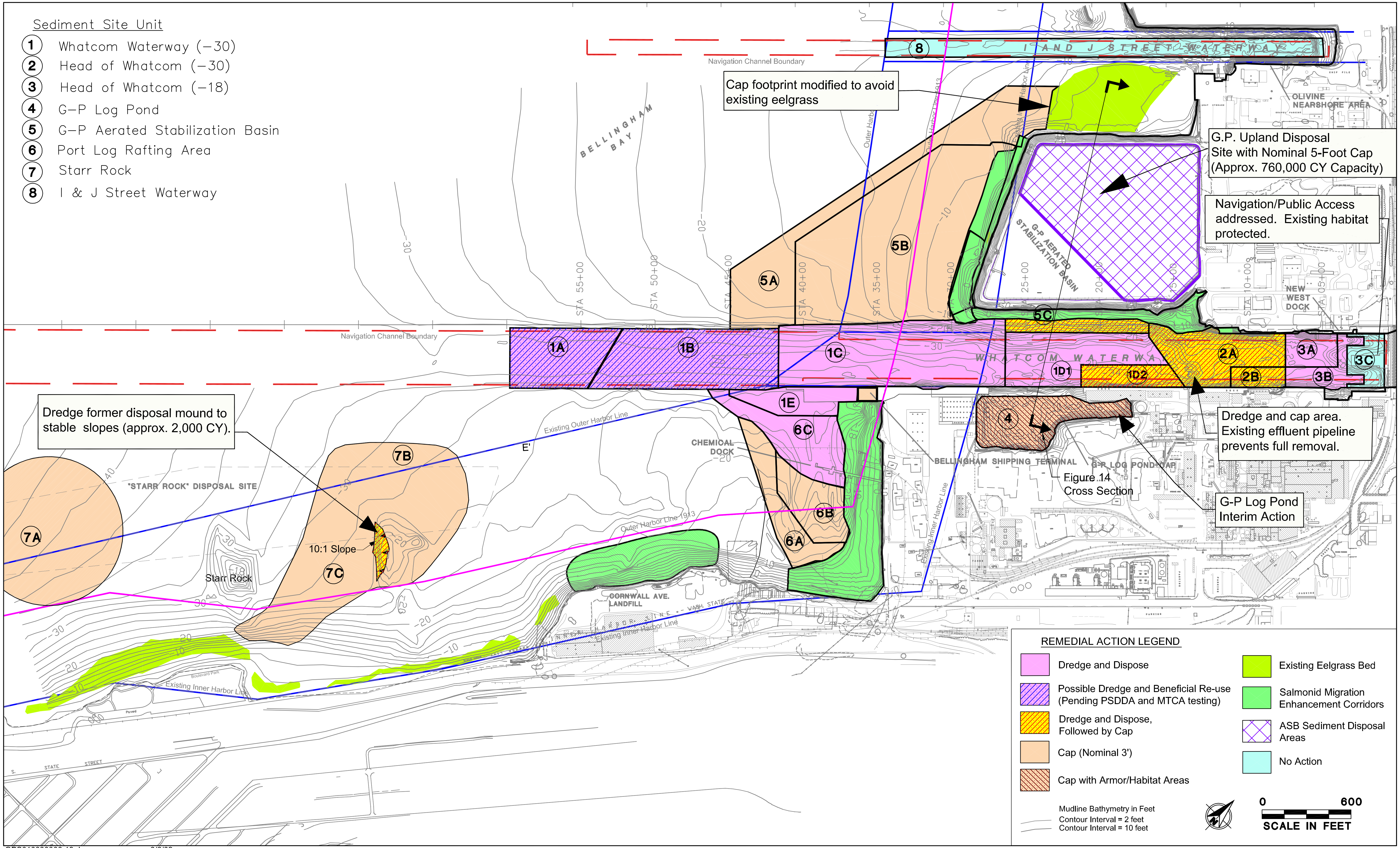
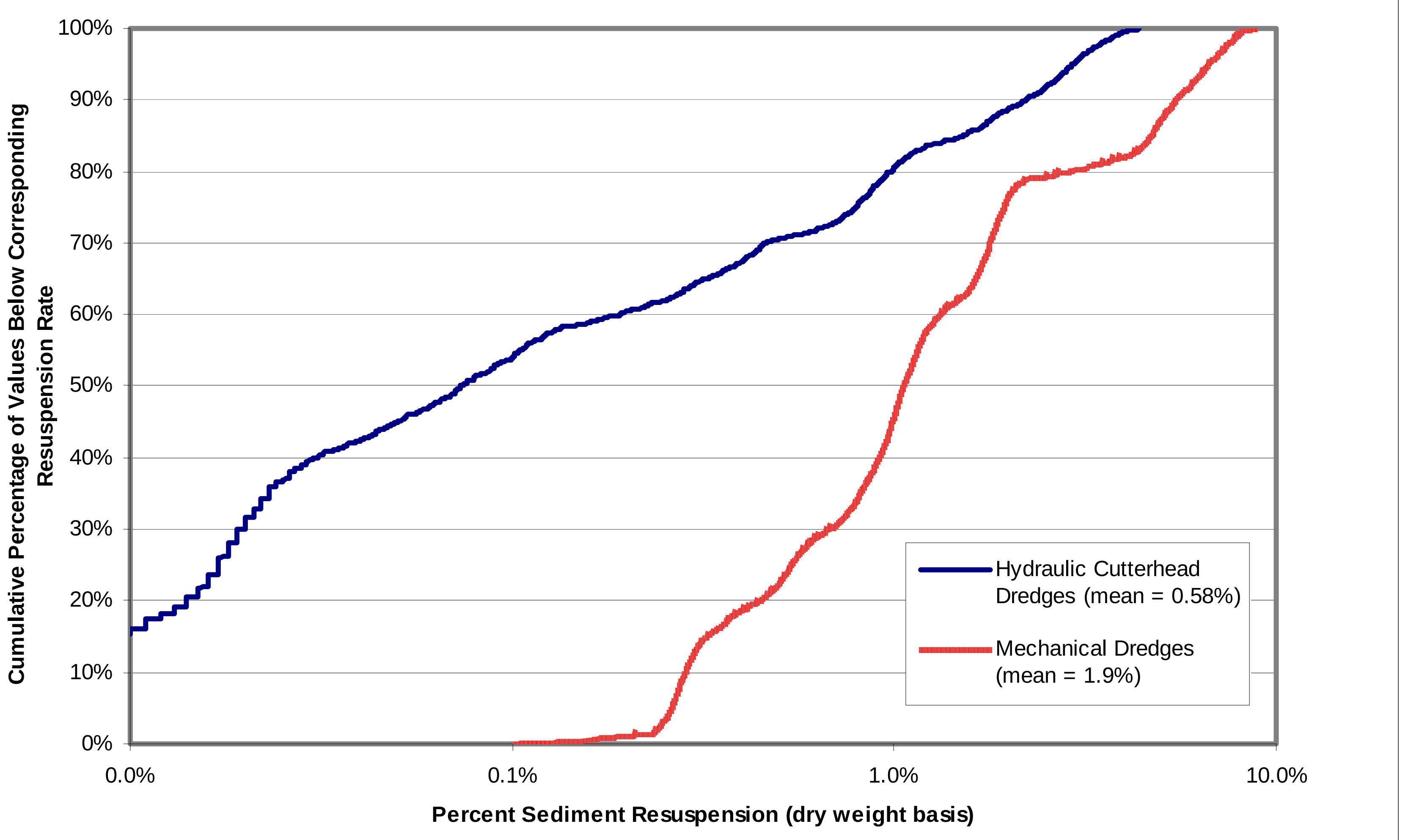
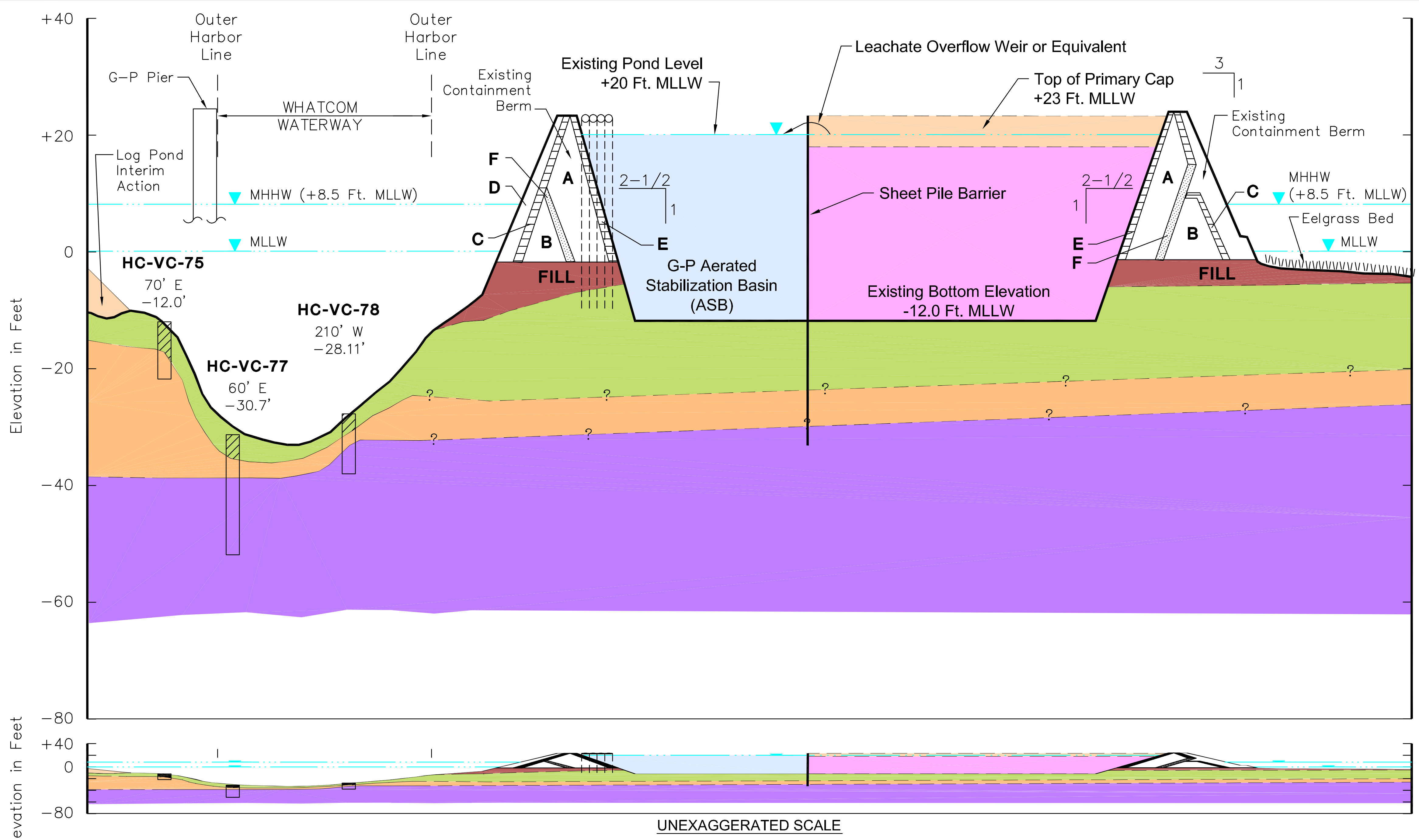


Figure 12
Remedial Alternative J
Whatcom Waterway RI/FS

Figure 13. Overall Distribution of Reported Resuspension Rates for Different Dredges (data sources and Monte Carlo simulation parameters presented in Table 1)





Horizontal Scale in Feet: 0 — 200 — 400

Vertical Scale in Feet: 0 — 20 — 40

Veritcal Exaggeration x 10

Existing Berm Composition:

- **A** Dredged Sand and Fill
- **B** Quarry Rock
- **C** Riprap
- **D** Armour Rock
- **E** Inner Dike Dressing (Cobbles, Crushed Pit Run, Sand, Bentonite Slurry/Clay)
- **F** Crushed Rock and Filter Blanket

Old Mudline

Sea Level

Scale in Feet: 0 — 200 — 400

HC-VC-74 Core Number

290' E / -4.2 Offset Distance and Direction / Elevation in Feet MLLW

Mudline Elevation / Bottom of Core Drive — Depth of SQS Exceedences for Mercury and Phenols

- Dredged Material from Remedial Activities in Bellingham Bay
- Minimum 5-Foot-Thick Sand/Gravel Cap
- Construction Fill consisting of SAND and GRAVEL with varying amounts of debris.
- Recent Deposits of very soft, (soupy), black SILT with sand, wood, and plant fragments.
- Pre-Dredge Fluvial Deposits of (medium dense), gray, non-silty to silty, fine to medium SAND with scattered shell fragments, gravel, and silt lenses.
- Glacial Marine Outwash deposits of (stiff), gray, silty CLAY with scattered gravels and sand lenses.

Notes:
1. Contacts between soil units are based upon interpolation between borings and represent our interpretation of subsurface conditions based on currently available data.
2. Inferred sediment contacts and lithology changes are gradual and may vary. Refer to core logs in Appendix A for detailed descriptions and elevations.
3. G-P Biotreatment Lagoon schematics based on Corps inspection records and permit plans, May 1977. As-built drawings may differ from cross section plan.
4. Vertical datum based on Mean Lower Low Water Datum (MLLW) Sea Level = 0 feet.
5. Drawing modified from electronic file provided by Hart Crowser entitled "44780616.dwg", dated June 29, 1998.

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Figure 14
Typical Cross-Section
G-P ASB Confined Disposal Facility
Whatcom Waterway RI/FS

Figure 15. G-P ASB Disposal Capacity Curve

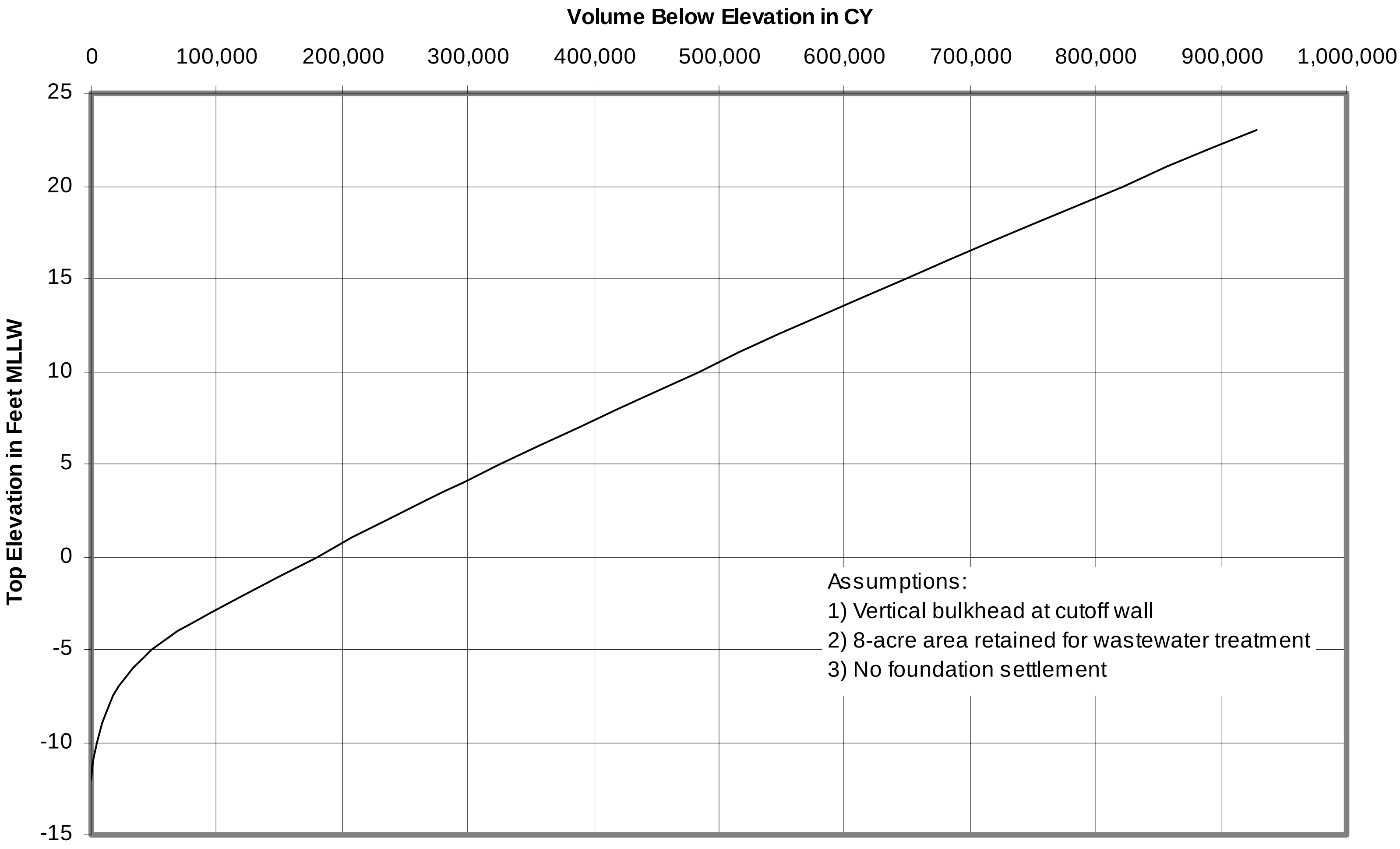

Table A-1 - Remedial Action Alternative B
Natural Recovery with Limited Capping
Whatcom Waterway Area

Item	Unit	Unit Cost	No. of Units	Total Cost
Mobilization/Demobilization	PERCENT	2%	$2,313,000	$35,000
Outer/Mid Whatcom Waterway - SSU 1				
- No Action	-	-	-	-
Head of Whatcom Waterway (30' Channel) - SSU 2				
- No Action	-	-	-	-
Head of Whatcom Waterway (18' Channel) - SSU 3				
- No Action	-	-	-	-
G-P Log Pond - SSU 4				
- Maintain existing Interim Action cap	-	-	-	-
G-P ASB - SSU 5				
- Cap	CY	$15.0	117,200	$1,758,000
Port Log Rafting Area - SSU 6				
- No Action	-	-	-	-
Starr Rock - SSU 7				
- Cap	CY	$15.0	37,000	$555,000
I&J Street Waterway - SSU 8				
- No Action	-	-	-	-
Disposal - No Material is Generated				
- Not Applicable	-	-	-	-
Engineering Design	PERCENT	10%	$2,313,000	$231,000
Construction Monitoring/Management	PERCENT	5%	$2,313,000	$116,000
Long-term Monitoring	LS	$300,000	1	$300,000
Contingency	PERCENT	30%	$2,995,000	$899,000
TOTAL ESTIMATED COST				$3,894,000

Table A-2 - Remedial Action Alternative C
Limited Dredging with Log Pond Disposal
Whatcom Waterway Area

Item	Unit	Unit Cost	No. of Units	Total Cost
Mobilization/Demobilization	PERCENT	2%	$12,472,000	$187,000
Outer/Mid Whatcom Waterway - SSU 1				
- Cap	CY	$15.0	108,000	$1,620,000
- Mechanical Dredge and Transport to Nearshore Fill	CY	$5.0	157,800	$789,000
Head of Whatcom Waterway (30' Channel) - SSU 2				
- No Action	-	-	-	-
Head of Whatcom Waterway (18' Channel) - SSU 3				
- No Action	-	-	-	-
G-P Log Pond - SSU 4				
- Maintain existing Interim Action cap	-	-	-	-
G-P ASB - SSU 5				
- Cap	CY	$15.0	117,200	$1,758,000
Port Log Rafting Area - SSU 6				
- No Action	-	-	-	-
Starr Rock - SSU 7				
- Cap	CY	$15.0	37,000	$555,000
I&J Street Waterway - SSU 8				
- No Action	-	-	-	-
Disposal - Log Pond Nearshore Fill				
- Rip rap training dikes	CY	$40.5	10,540	$427,000
- Berm construction	CY	$15.0	52,700	$791,000
- CDF cap	CY	$30.0	33,300	$999,000
- Bottom dump barge placement (below -5' MLLW)	CY	$1.5	0	$0
- Clamshell off of barge placement (above -5' MLLW)	CY	$12.5	92,700	$1,159,000
Disposal - Excess to Roosevelt Landfill				
- Offload, Haul, and Place at Roosevelt Regional Landfill	CY	$37.5	75,400	$2,828,000
Mitigation				
- Mitigation for lost/filled aquatic land	ACRE	$267,800	6	$1,546,000
Engineering Design	PERCENT	10%	$12,472,000	$1,247,000
Construction Monitoring/Management	PERCENT	5%	$12,472,000	$624,000
Long-term Monitoring	LS	$800,000	1	$800,000
Contingency	PERCENT	30%	$15,330,000	$4,599,000
TOTAL ESTIMATED COST				$19,929,000

Table A-3 - Remedial Action Alternative D
Limited Dredging with Upland Disposal
Whatcom Waterway Area

Item	Unit	Unit Cost	No. of Units	Total Cost
Mobilization/Demobilization	PERCENT	2%	$10,640,000	$160,000
Outer/Mid Whatcom Waterway - SSU 1				
- Cap	CY	$15.0	108,000	$1,620,000
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	157,800	$789,000
Head of Whatcom Waterway (30' Channel) - SSU 2				
- No Action	-	-	-	-
Head of Whatcom Waterway (18' Channel) - SSU 3				
- No Action	-	-	-	-
G-P Log Pond - SSU 4				
- Maintain existing Interim Action cap	-	-	-	-
G-P ASB - SSU 5				
- Cap	CY	$15.0	117,200	$1,758,000
Port Log Rafting Area - SSU 6				
- No Action	-	-	-	-
Starr Rock - SSU 7				
- Cap	CY	$15.0	37,000	$555,000
I&J Street Waterway - SSU 8				
- No Action	-	-	-	-
Disposal - Phyllite Quarry and/or Roosevelt				
- Offload, Haul, and Place at Roosevelt Regional Landfill	CY	$37.5	157,800	$5,918,000
Engineering Design	PERCENT	10%	$10,640,000	$1,064,000
Construction Monitoring/Management	PERCENT	5%	$10,640,000	$532,000
Long-term Monitoring	LS	$800,000	1	$800,000
Contingency	PERCENT	30%	$13,196,000	$3,959,000
TOTAL ESTIMATED COST				$17,155,000

Table A-4 - Remedial Action Alternative E
Removal and Capping to Achieve Authorized Channel Depths w/ CAD Disposal (Pilot No. 2A)
Whatcom Waterway Area

Item	Unit	Unit Cost	No. of Units	Total Cost
Mobilization/Demobilization	PERCENT	2%	$15,260,000	$229,000
Outer/Mid Whatcom Waterway - SSU 1				
- Cap	CY	$15.0	10,700	$161,000
- Mechanical Dredge and Transport to CAD	CY	$5.0	210,000	$1,050,000
Head of Whatcom Waterway (30' Channel) - SSU 2				
- Cap	CY	$15.0	34,800	$522,000
- Mechanical Dredge and Transport to CAD	CY	$5.0	80,000	$400,000
Head of Whatcom Waterway (18' Channel) - SSU 3				
- Cap	CY	$15.0	0	$0
- Mechanical Dredge and Transport to CAD	CY	$5.0	20,000	$100,000
G-P Log Pond - SSU 4				
- Maintain existing Interim Action cap	-	-	-	-
G-P ASB - SSU 5				
- Cap	CY	$15.0	136,200	$2,043,000
- Mechanical Dredge and Transport to CAD	CY	$5.0	10,000	$50,000
Port Log Rafting Area - SSU 6				
- Cap	CY	$15.0	48,900	$734,000
- Mechanical Dredge and Transport to CAD	CY	$5.0	40,000	$200,000
Starr Rock - SSU 7				
- Cap	CY	$15.0	149,600	$2,244,000
I&J Street Waterway - SSU 8				
- No Action	-	-	-	-
Disposal - Starr Rock CAD				
- Construct rip rap training dikes	CY	$40.5	26,800	$1,085,000
- Construct containment berm	CY	$15.0	134,000	$2,010,000
- Place CAD cap	CY	$15.0	261,185	$3,918,000
- Bottom dump barge placement (below -5' MLLW)	CY	$1.5	360,000	$540,000
- Clamshell off of barge placement (above -5' MLLW)	CY	$12.5	0	$0
- Construct rip rap reef	CY	$40.5	5,000	$203,000
Engineering Design	PERCENT	10%	$15,260,000	$1,526,000
Construction Monitoring/Management	PERCENT	5%	$15,489,000	$774,000
Long-term Monitoring	LS	$500,000	1	$500,000
Contingency	PERCENT	30%	$18,289,000	$5,487,000
TOTAL ESTIMATED COST				$23,776,000

Table A-5 - Remedial Action Alternative F

Removal and Capping to Achieve Authorized Channel Depths w/ Upland Disposal (Pilot No. 2B)
Whatcom Waterway Area

Item	Unit	Unit Cost	No. of Units	Total Cost
Mobilization/Demobilization	PERCENT	2%	$20,373,000	$306,000
Outer/Mid Whatcom Waterway - SSU 1				
- Cap	CY	$15.0	10,700	$161,000
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	210,000	$1,050,000
Head of Whatcom Waterway (30' Channel) - SSU 2				
- Cap	CY	$15.0	34,800	$522,000
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	80,000	$400,000
Head of Whatcom Waterway (18' Channel) - SSU 3				
- Cap	CY	$15.0	0	$0
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	20,000	$100,000
G-P Log Pond - SSU 4				
- Maintain existing Interim Action cap	-	-	-	-
G-P ASB - SSU 5				
- Cap	CY	$15.0	136,200	$2,043,000
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	10,000	$50,000
Port Log Rafting Area - SSU 6				
- Cap	CY	$15.0	48,900	$734,000
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	40,000	$200,000
Starr Rock - SSU 7				
- Cap	CY	$15.0	107,500	$1,613,000
I&J Street Waterway - SSU 8				
- No Action	-	-	-	-
Disposal - Upland				
- Offload, Haul, and Place at Roosevelt Regional Landfill	CY	$37.5	360,000	$13,500,000
Engineering Design	PERCENT	10%	$20,373,000	$2,037,000
Construction Monitoring/Management	PERCENT	5%	$20,373,000	$1,019,000
Long-term Monitoring	LS	$500,000	1	$500,000
Contingency	PERCENT	30%	$24,235,000	$7,271,000
TOTAL ESTIMATED COST				$31,506,000

Table A-6 - Remedial Action Alternative G
Full Removal from Navigation Areas (Pilot No. 2C)
Whatcom Waterway Area

Item	Unit	Unit Cost	No. of Units	Total Cost
Mobilization/Demobilization	PERCENT	2%	$23,324,000	$350,000
Outer/Mid Whatcom Waterway - SSU 1				
- Cap	CY	$15.0	42,800	$642,000
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	570,000	$2,850,000
Head of Whatcom Waterway (30' Channel) - SSU 2				
- Cap	CY	$15.0	34,000	$510,000
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	80,000	$400,000
Head of Whatcom Waterway (18' Channel) - SSU 3				
- Cap	CY	$15.0	0	$0
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	40,000	$200,000
G-P Log Pond - SSU 4				
- Maintain existing Interim Action cap	-	-	-	-
G-P ASB - SSU 5				
- Cap	CY	$15.0	146,700	$2,201,000
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	10,000	$50,000
Port Log Rafting Area - SSU 6				
- Cap	CY	$15.0	48,700	$731,000
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	60,000	$300,000
Starr Rock - SSU 7				
- Cap	CY	$15.0	145,900	$2,189,000
I&J Street Waterway - SSU 8				
- No Action	-	-	-	-
Disposal - Starr Rock CAD				
- Construct rip rap training dikes	CY	$40.5	46,240	$1,873,000
- Construct containment berm	CY	$15.0	231,200	$3,468,000
- Place CAD cap	CY	$15.0	437,785	$6,567,000
- Bottom dump barge placement (below -5' MLLW)	CY	$1.5	760,000	$1,140,000
- Clamshell off of barge placement (above -5' MLLW)	CY	$12.5	0	$0
- Construct rip rap reef	CY	$40.5	5,000	$203,000
Engineering Design	PERCENT	10%	$23,324,000	$2,332,000
Construction Monitoring/Management	PERCENT	5%	$23,324,000	$1,166,000
Long-term Monitoring	LS	$500,000	1	$500,000
Contingency	PERCENT	30%	$27,672,000	$8,302,000
TOTAL ESTIMATED COST				$35,974,000

Table A-7 - Remedial Action Alternative H

Full Removal from Navigation Areas and Partial Removal from G-P ASB Area w/ Upland Disposal (Pilot No. 2D)
Whatcom Waterway Area

Item	Unit	Unit Cost	No. of Units	Total Cost
Mobilization/Demobilization	PERCENT	2%	$51,222,000	$768,000
Outer/Mid Whatcom Waterway - SSU 1				
- Cap	CY	$15.0	0	$0
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	570,000	$2,850,000
Head of Whatcom Waterway (30' Channel) - SSU 2				
- Cap	CY	$15.0	34,100	$512,000
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	80,000	$400,000
Head of Whatcom Waterway (18' Channel) - SSU 3				
- Cap	CY	$15.0	0	$0
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	40,000	$200,000
G-P Log Pond - SSU 4				
- Maintain existing Interim Action cap	-	-	-	-
G-P ASB - SSU 5				
- Cap	CY	$15.0	77,700	$1,166,000
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	200,000	$1,000,000
Port Log Rafting Area - SSU 6				
- Cap	CY	$15.0	48,700	$731,000
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	60,000	$300,000
Starr Rock - SSU 7				
- Cap	CY	$15.0	107,500	$1,613,000
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$15.0	130,000	$1,950,000
I&J Street Waterway - SSU 8				
- No Action	-	-	-	-
Disposal - Upland				
- Offload, Haul, and Place at Roosevelt Regional Landfill	CY	$37.5	1,080,000	$40,500,000
Engineering Design	PERCENT	10%	$51,222,000	$5,122,000
Construction Monitoring/Management	PERCENT	5%	$51,222,000	$2,561,000
Long-term Monitoring	LS	$500,000	1	$500,000
Contingency	PERCENT	30%	$60,173,000	$18,052,000
TOTAL ESTIMATED COST				$78,225,000

Table A-8 - Remedial Action Alternative I
Full Dredging with Upland Disposal (Pilot No. 2E)
Whatcom Waterway Area

Item	Unit	Unit Cost	No. of Units	Total Cost
Mobilization/Demobilization	PERCENT	2%	$81,687,000	$1,225,000
Outer/Mid Whatcom Waterway - SSU 1				
- Cap	CY	$15.0	0	$0
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	570,000	$2,850,000
Head of Whatcom Waterway (30' Channel) - SSU 2				
- Cap	CY	$15.0	34,100	$512,000
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	80,000	$400,000
Head of Whatcom Waterway (18' Channel) - SSU 3				
- Cap	CY	$15.0	0	$0
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	90,000	$450,000
G-P Log Pond - SSU 4				
- Maintain existing Interim Action cap	-	-	-	-
G-P ASB - SSU 5				
- Cap	CY	$15.0	0	$0
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	470,000	$2,350,000
Port Log Rafting Area - SSU 6				
- Cap	CY	$15.0	0	$0
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	220,000	$1,100,000
Starr Rock - SSU 7				
- Cap	CY	$15.0	0	$0
- Mechanical Dredge and Transport to Upland Offload Facility	CY	$5.0	480,000	$2,400,000
I&J Street Waterway - SSU 8				
- No Action	-	-	-	-
Disposal - Upland				
- Offload, Haul, and Place at Roosevelt Regional Landfill	CY	$37.5	1,910,000	$71,625,000
Engineering Design	PERCENT	10%	$81,687,000	$8,169,000
Construction Monitoring/Management	PERCENT	5%	$81,687,000	$4,084,000
Long-term Monitoring	LS	$200,000	1	$200,000
Contingency	PERCENT	30%	$95,365,000	$28,610,000
TOTAL ESTIMATED COST				$123,975,000

Table A-9 - Remedial Action Alternative J

Full Removal from Navigation Areas (G-P ASB Upland Disposal) (Supplemental EIS Modified Preferred Near-Term Remedial Action Alterna

Whatcom Waterway Area

Item	Unit	Unit Cost	No. of Units	Total Cost
Mobilization/Demobilization	PERCENT	4%	$14,943,000	$598,000
Outer/Mid Whatcom Waterway - SSU 1				
- Cap	CY	$15.0	42,800	$642,000
- Hydraulic Dredge and Pipeline Transfer to G-P ASB	CY	$4.0	570,000	$2,280,000
Head of Whatcom Waterway (30' Channel) - SSU 2				
- Cap	CY	$15.0	34,000	$510,000
- Hydraulic Dredge and Pipeline Transfer to G-P ASB	CY	$4.0	80,000	$320,000
Head of Whatcom Waterway (18' Channel) - SSU 3				
- Cap	CY	$15.0	0	$0
- Hydraulic Dredge and Pipeline Transfer to G-P ASB	CY	$4.0	40,000	$160,000
G-P Log Pond - SSU 4				
- Maintain existing Interim Action cap	-	-	-	-
G-P ASB - SSU 5				
- Cap	CY	$15.0	146,700	$2,201,000
- Hydraulic Dredge and Pipeline Transfer to G-P ASB	CY	$4.0	10,000	$40,000
Port Log Rafting Area - SSU 6				
- Cap	CY	$15.0	48,700	$731,000
- Hydraulic Dredge and Pipeline Transfer to G-P ASB	CY	$4.0	60,000	$240,000
Starr Rock - SSU 7				
- Cap	CY	$15.0	145,900	$2,189,000
I&J Street Waterway - SSU 8				
- No Action	-	-	-	-
Disposal - G-P ASB Upland CDF				
- Internal sheet piling wall to separate disposal area from ASB	LF	$2,400	1,000	$2,400,000
- Silt curtains	LS	$150,000	1	$150,000
- Structural cap	CY	$22.0	140,000	$3,080,000
Engineering Design	PERCENT	10%	$14,943,000	$1,494,000
Construction Monitoring/Management	PERCENT	5%	$14,943,000	$747,000
Long-term Monitoring	LS	$500,000	1	$500,000
Contingency	PERCENT	30%	$18,282,000	$5,485,000
TOTAL ESTIMATED COST				$23,767,000

tive)