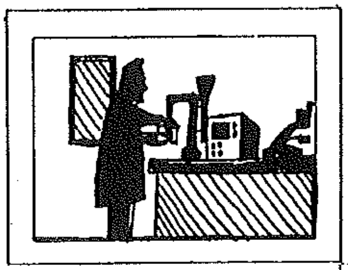
Standards for Confined Disposal of Contaminated Sediments

WASHINGTON STATE DEPARTMENT OF ECOLOGY



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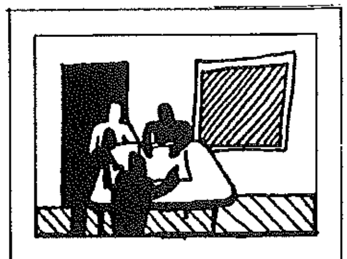

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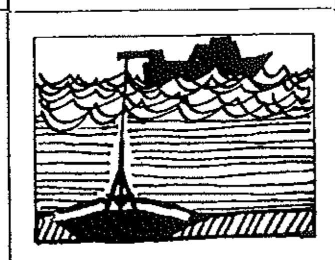

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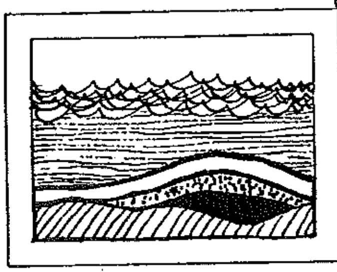

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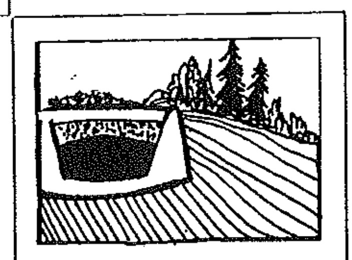

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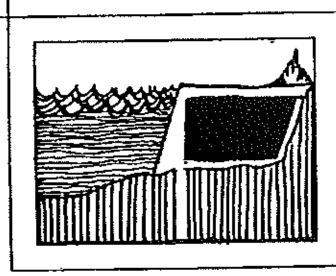

Nearshore

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Standards for Confined Disposal of Contaminated Sediments

Development Documentation

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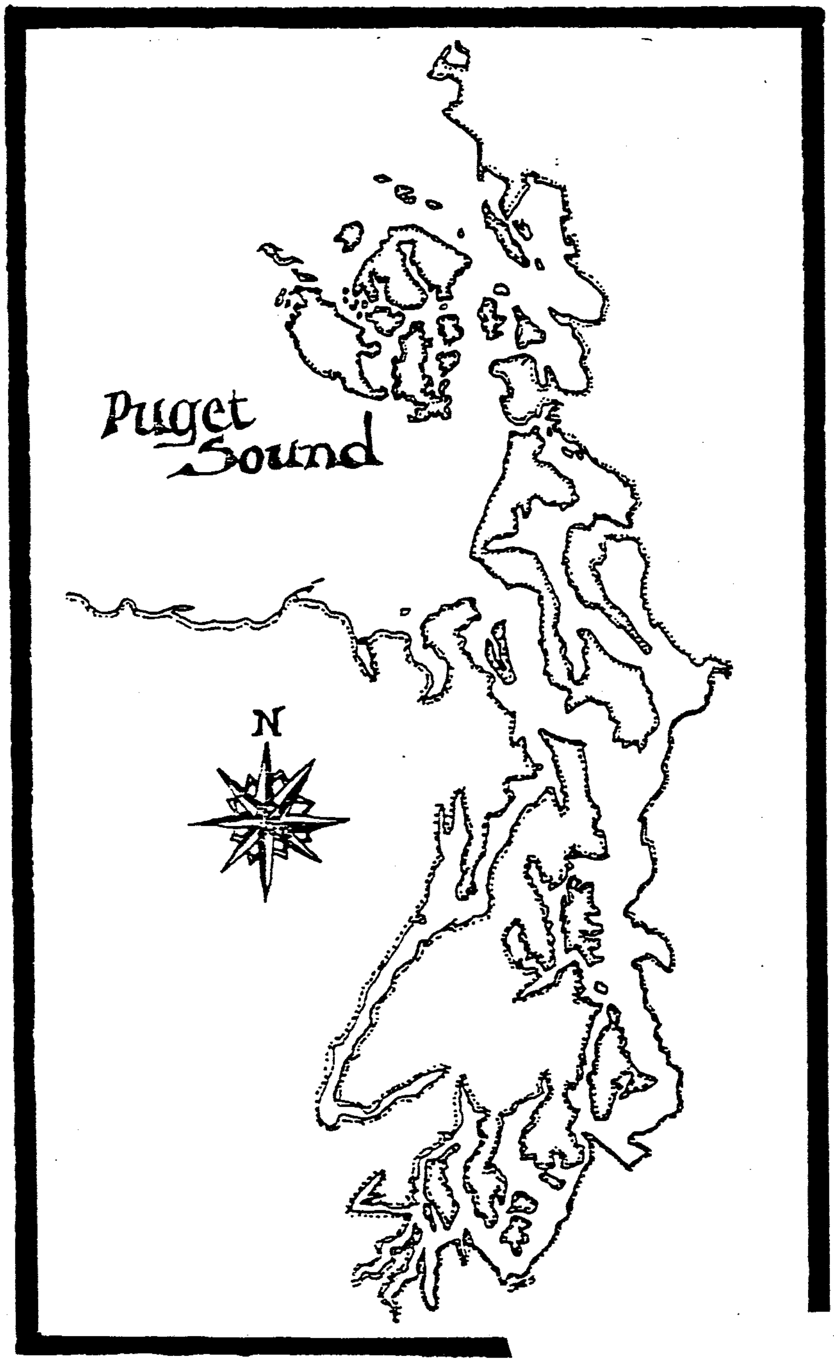
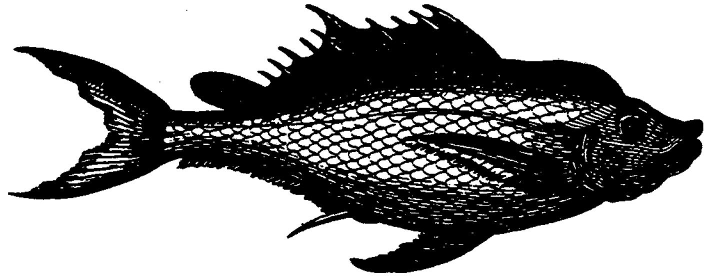
GLOSSARY OF ABBREVIATIONS

ADDAMS	Automated Dredging and Disposal Alternatives Management System
BRAT	Benthic Resource Assessment Technique
CAAP	Confinement Alternative Assessment Procedure (formerly PASS, Prototype Alternative Selection Strategy)
CAD	Confined Aquatic Disposal
CERCLA	Comprehensive Environmental Response and Liability Act
CWA	Clean Water Act
DMASS	Dredged Material Alternative Selection Strategy
DNR	(Washington State) Department of Natural Resources
DO	Dissolved Oxygen
D.W.	Dangerous Waste (as defined by WAC 173-303)
EA	Environmental Assessment
EP Tox	Extraction Procedure Toxicity Test
EPA	United States Environmental Protection Agency
GPS	Global Positioning System
HH	Halogenated Hydrocarbons
MFS	Minimum Functional Standards
MLLW	Mean Low Low Water (level)
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
PAH	Polycyclic Aromatic Hydrocarbon
PSDDA	Puget Sound Dredged Disposal Analysis
PSEP	Puget Sound Estuary Program
PSWQA	Puget Sound Water Quality Authority
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
S-4	Element S-4 of the Puget Sound Water Quality Management Plan (PSWQA 1988) addressing confined disposal of contaminated sediments
S.C.	Site Condition
TAG	Technical Advisory Group
TCLP	Toxicity Characteristic Leaching Procedures
TPH	Total Petroleum Hydrocarbon
TTA	Traditional Taxonomic Analysis
WAC	Washington Administrative Code
WQC	Water Quality Criteria
WQS	Water Quality Standards

introduction





1. INTRODUCTION

1.1 PURPOSE

One element in a strategy to restore and preserve the health and vitality of Puget Sound as a marine environment involves the sediments, or mud, on the bottom. Studies show that numerous contaminants bind to sediment particles and can cause harm to organisms living in benthic environments. These in turn can become human health risks through seafood consumption and other pathways. Because sediments are regularly dredged off the bottom to allow shipping and other activities, the need to govern the disposal of contaminated sediments was recognized by the Washington State Legislature.

The Puget Sound Water Quality Management Plan (1987, 1989) called for the State Ecology Department to develop several programs to address various sediment issues. Among these programs was promulgation of "Standards for Confined Disposal of Contaminated Sediments." The plan mandates that confined disposal standards be in place by July 1990.

This report is educational and documents the approach taken in developing recommended standards for the confined disposal of contaminated sediments. It provides an introduction and compendium of dredging and disposal information as applied around Puget Sound; it documents the steps taken and factors considered in developing standards. Recommended "standards" are in a separate user's handbook, and in Chapter 9 of this report.

The Confined Disposal "Standards" Ecology is writing will:

- Be a blend of numeric criteria and procedural guidelines by which confined disposal project proposals can be evaluated

- Combine the best elements of existing knowledge and past practice in confined disposal siting

- Blend "effects-based" approaches (which require extensive testing) with "technology-based" approaches that rely on carefully engineered confinement facilities

- Clarify the current maze of overlapping jurisdictions, providing step-by-step guidelines for the disposal process

- Be designed to strengthen, by standardization of methods, the data available on environmental effects of these materials in various confined disposal settings

- Not be site specific; but will apply to all confined disposal projects in the Puget Sound basin.

What Sediments do these Standards Address?

Contaminated sediments requiring confined disposal are identified as those exceeding the limits established for conventional unconfined disposal (i.e. Puget Sound Dredged Disposal Analysis (PSDDA) (1988, 1989) criteria for open-water disposal), but with contaminant levels less than Dangerous Waste standards (WAC 173-303). Since a PSDDA equivalent for the upland environment does not exist, these standards also define a process for determining if dredged material is acceptable in conventional unconfined upland disposal sites (i.e. unlined landfills). This document does not attempt to define "PSDDA-type" criteria for the upland and nearshore environments. Much of what are referred to as "contaminated sediments" are in fact only mildly contaminated in terms of concentration of toxic materials. However, since environmental effects can be ascribed to the levels present in some sediments, special handling seems appropriate and necessary.

Other Sediment Contamination Issues

Ecology is conducting several related activities to collectively address sediment contamination problems in Puget Sound. Ecology's Sediment Management Unit is also working on:

- Development of criteria for sediment contamination
- Studying feasibility of multi-user confined disposal sites
- Development of sediment impact zone criteria
- Researching effects to the marine environment by open-water disposal of wastes not regarded as "contaminated."

Separate reports are available on these efforts from Ecology.

1.2 ORGANIZATION OF REPORT

This report documents the approach we took to develop recommended standards for the confined disposal of contaminated sediments. It contains background information that was considered in developing the recommended standards. Chapters 4-7 describe the major elements that are combined into "alternatives." Once combined, these "alternatives" were analyzed and compared to select recommended "standards". These include:

- Potential sediment characterization tests
- Alternative dredging, transport, and disposal techniques
- Alternative disposal site designs
- Alternative monitoring schemes.

Chapter 8 describes the method we developed for selecting recommended standards among the various alternatives. Chapter 9 is one of the most important chapters in the report because it documents the recommended standards (for functional designs) and why they were selected. Chapter 10 describes the effects-based design standards and how they will be applied to customized designs. Chapter 11 reviews the small project standards and what type of projects qualify for them. Chapter 12 describes a method for comparing the costs of several disposal options, and presents cost estimates for the functional designs for each disposal environment.

The remaining chapters are ancillary information on how the standards were developed. Chapter 13 describes the existing confined disposal studies reviewed as part of the standards development. Chapter 14 discusses potential beneficial uses for contaminated dredge material. Chapter 15 describes a public involvement strategy for the next step in the S-4 process. This strategy is consistent with the new rule-making procedures adopted by Ecology.

A glossary of technical terms specific to this project is presented in Chapter 18. Review of these terms will greatly assist any review of this report.

A knowledge of the background leading to these recommended standards will help readers understand how they were developed and what their scope includes. The rest of this chapter describes the primary background issues:

- Section 1.3, **Ecology's S-4 Process,** provides an overview of the steps Ecology has taken to have a contractor develop recommended standards. It includes work efforts that took place during Phase 1 of the process, and describes coordination and participation amongst affected groups/agencies during the development of the standards.

- Section 1.4, **Functional and Effects-Based Designs,** are two types of designs that are developed for the disposal environments that we evaluated. This section presents the fundamental differences between the two philosophies behind these types of design. The details of each design are presented in Chapters 9 and 10.

- Section 1.5, **Decision Model,** describes the Decision Model that was developed for project proponents (and Ecology) to follow in determining the best disposal environment and/or site design. The Decision Model provides a framework for the standards. An understanding of the Decision Model is essential to understanding what the standards encompass.

1.3 PROJECT HISTORY

After Ecology accepted the charge to develop standards, a two-phase project was initiated in 1988. The focus of both phases was providing a technical foundation on which sound policy decisions could be made.

One of the first steps was convening a technical advisory group (TAG). The TAG included representatives from industry, government (local, state, and federal), and environmental organizations. These representatives had a background in contaminated sediment confined disposal issues and will be affected by the regulations. Indian tribes were also invited to participate. The TAG met approximately every six weeks to discuss issues related to S-4 and provides feedback to Ecology on the technical direction of the project.

The TAG helped provide direction to the process by reviewing and commenting on Ecology's contractor's products. These comments influenced technical decisions that were made and/or directed attention to specific technical areas they felt were most important.

1.3.1 Phase 1 of S-4 Standards Development

The steps in the Phase 1 effort developed the knowledge base and an initial decision model. Those steps are as follows:

- Review of existing literature
- Technology information exchange with the Corps of Engineers Waterways Experiment Station
- Cursory review of confined disposal projects in Puget Sound.

The results of the Phase 1 work are summarized in a final report (URS 1989). The Decision Model is described in detail in Section 1.5.

The volume of contaminated sediment likely to require confined disposal was projected during Phase 1. Approximately 1.9 million cubic yards of dredged material will need confined disposal over the next three years (1989-1992), and 4 to 7 million cubic yards over the next 12 years (1989-2000). This assessment verified that there are substantial quantities of sediment requiring confined disposal, and that a regulatory decision-making approach for dealing with them is warranted.

1.3.2 Phase 2 of S-4 Standards Development

Phase 2 built on the knowledge base developed in Phase 1, and culminates with the development of recommended functional design standards with effects-based alternatives. The scope of the standards range from initial characterization requirements for the dredged material to monitoring requirements at the disposal site. For steps in between, the standards include dredging requirements and disposal site design requirements. These dredging standards are included because of different impacts to water quality with specific dredging techniques. Therefore, standards for dredging were also necessary, even though the language in the PSWQA's Management Plan says only "standards for confined disposal of contaminated sediments." Ecology has the authority under Water Pollution Control Act (RCW 90.48) to add these requirements.

The Phase 2 work was separated into five discrete technical elements:

- Alternatives Evaluation Procedure
- Alternatives for EIS Process
- Technical Studies Review
- Beneficial Uses/Literature Update
- Public Education/Involvement.

The Alternatives Evaluation Procedure and Alternative Standards represent the main part of the Phase 2 work. The other three elements are subordinate pieces to the Phase 2 effort.

Alternatives Evaluation Procedure

We developed a procedure to evaluate relative costs and environmental protection among alternatives. This procedure was based on the Dredged Material Alternative Selection Strategy (DMASS) (Cullinane et al. 1986). Adaptations included assignment of weighting factors to those criteria that are most important and the option of assigning a zero ranking to any criteria, which eliminates that alternative in the final ranking. Cost factors are also considered. The results of this effort are presented in detail in Chapter 9, Confinement Alternative Assessment Procedure (CAAP).

Alternative Standards

In developing the standards, we identified testing, transport, design, and monitoring options. We structured these into "alternatives", each affording a particular level of environmental protection. We then evaluated the alternatives using CAAP elements to determine a recommended standard in each disposal environment.

The range of possibilities we evaluated are presented in Chapters 4, 5, and 6. The recommended alternatives are those which will afford the best protection for the least cost. Concurrently, we were completing three other tasks that influenced how the alternatives were shaped, and which were selected. These other tasks were:

- Refinement of the decision model

- Establishing siting guidelines

- Developing a cost comparison procedure for the various disposal options

The results of these tasks are presented in Chapters 1, 3, and 12, respectively.

Technical Studies

A technical evaluation of information on existing Puget Sound disposal sites was conducted to compare current practices against the recommended standards. This comparison helped determine which current practices should or should not be carried forth in the recommended standards. The results are summarized in Chapter 13.

Beneficial Uses/Literature Update

We examined the potential beneficial uses of dredged material. This beneficial uses review is presented in Chapter 14. We also updated the literature review done in Phase 1. This update focused on contaminated disposal literature from the National Research Council's Symposium on Contaminated Marine Sediments (released after the Phase 1 effort was complete). All significant findings are incorporated in the development of alternatives and selection of preferred functional designs.

Public Education/Involvement

Another Phase 2 task addressed how to educate the public about confined disposal problems and proposed solutions. This work focused on dealing with the issue once the recommended standards are available, but before final standards are promulgated into regulation. Our recommendations are presented in Chapter 15.

1.3.3 Next Phases of S-4 Standards Development

The next step in the process is to prepare a draft environmental impact statement and draft regulation. Prior to developing the draft regulation, Ecology will convene a confined disposal work group that will address the significant regulatory issues that need to be resolved before the standards are proposed as a formal rule. The draft regulation is scheduled for December 1989.

Following the draft regulation, there will be public review and Administrative Procedure Act review. The target date for adopting the standards as a regulation is July 1990.

1.4 FUNCTIONAL AND EFFECTS-BASED DESIGNS

One of Ecology's primary objectives was developing disposal standards for contaminated sediments that are both straightforward and flexible. A straightforward approach provides a well-defined pathway (testing, site design, and monitoring) for the confined disposal process. The "functional design" alternatives meet this goal. However, flexibility is also necessary. If proponents have disposal sites they want to use, or their material has some unique characteristics, they have the option of developing a custom, or "effects-based design" and demonstrating it will provide sufficient environmental protection.

Most dredged material requiring confined disposal is only slightly contaminated, relative to the range of material addressed by the confined disposal standards (i.e. from exceeding levels that are acceptable for unconfined conventional disposal to classification as Dangerous Waste under WAC 173-303). Therefore, we determined the functional design should address that relatively low range of contamination and not address all levels of contamination up to the state-defined dangerous waste level. Figure 1.1 shows the range of contamination that the functional design will cover. The functional design was not increased to cover a higher level of contamination primarily because of cost. The increase in cost to construct a site would be significantly greater than the increase in the volume of sediment that could be accommodated by the more conservative design because a majority of dredged material is only slightly contaminated.

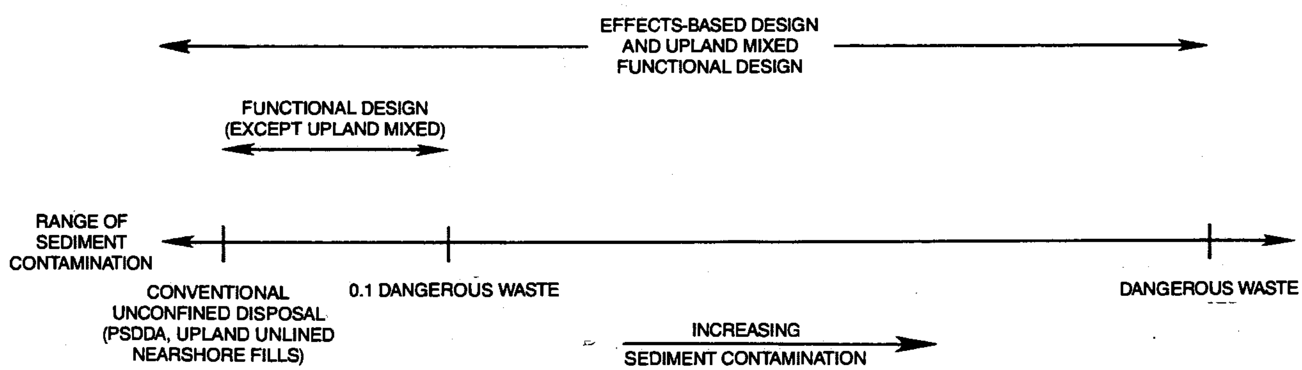


Figure 1.1 Conceptual level of sediment contamination addressed by the functional and effects-based designs.

The effects-based design is intended to cover the range of sediment contamination, from sediments clean enough to be disposed using conventional unconfined disposal criteria to dangerous waste classification (Figure 1.1). It is a customized approach. If proponents think their material is less contaminated than the functional design's range, they can consider an effects-based design that is not as stringent. For small-volume projects, implementing the functional design may be preferable to the extensive testing required for an effects-based design. Conversely, a proponent's sediment may be more contaminated than the functional design's contamination range, in which case they would be required to do an effects-based design. Since the effects-based design is a customized approach, we cannot identify the specific design feature requirements. Instead, we have identified the type of tests that will be required to demonstrate that an effects-based design provides the same level of protection as the functional design.

In many projects, it is likely that only some of the samples from an entire project will exceed the functional design standards. Separation of a project into management units is acceptable and may occur frequently. The Sediment Characterization Process (see Chapter 4) is designed to identify management units that meet either functional or effects-based design. Following this determination, a proponent has the option to either divide their project or have the entire project go to effects-based design.

Functional and effects-based designs are presented in more detail in Chapters 9 and 10.

1.5 THE DECISION MODEL FOR CONFINED DISPOSAL OF CONTAMINATED SEDIMENTS

The decision model illustrates the process by which proponents and regulators determine the most appropriate disposal environment and disposal site design for their dredged material. Once a proponent has determined that the standards are applicable to their material, the decision model shows the steps for deciding how to dispose of the material. Beyond the steps shown in the decision model are permitting and detailed engineering design for the disposal site. The overall confined disposal process and role of the decision model are illustrated in Figure 1.2.

The decision model provides an overview, but does not substitute for agency coordination. During each step in the decision-making process proponents should be discussing their project with Ecology and other regulatory agencies. This coordination can prevent wasted time and unnecessary delays when reaching the final step in the process (see Figure 1.2).

The decision model has four basic steps:

- Site Review
- Sediment Characterization
- Disposal Environments/Designs
- Alternative Comparison

An overview of the model is presented in Figure 1.3. Through the model, a proponent can gain an understanding of the testing and design requirements necessary to obtain permits for confined disposal. Typically, proponents will begin the confined disposal decision process in one of two scenarios:

1) Have a preferred disposal site they want to use, or

2) Do not have a preferred site, but want to minimize time and cost to complete their project.

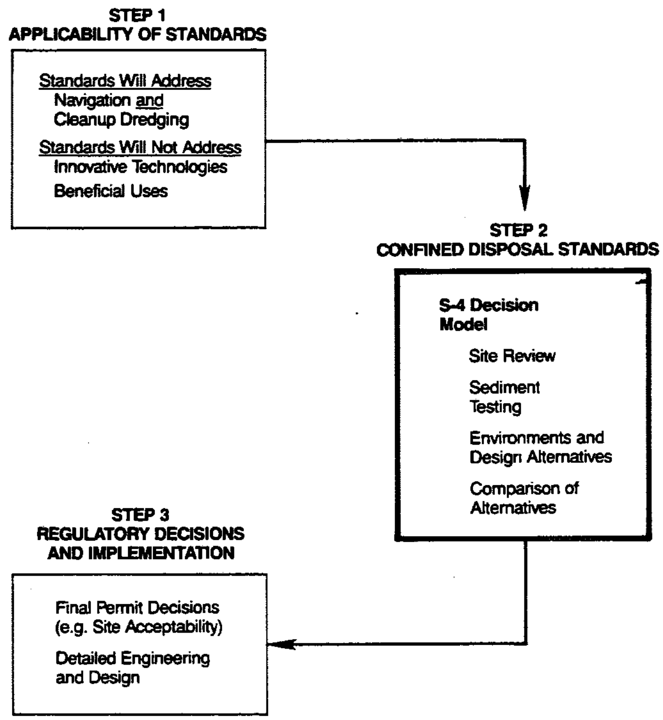


Figure 1.2 Role of the Decision Model in the overall confined disposal process.

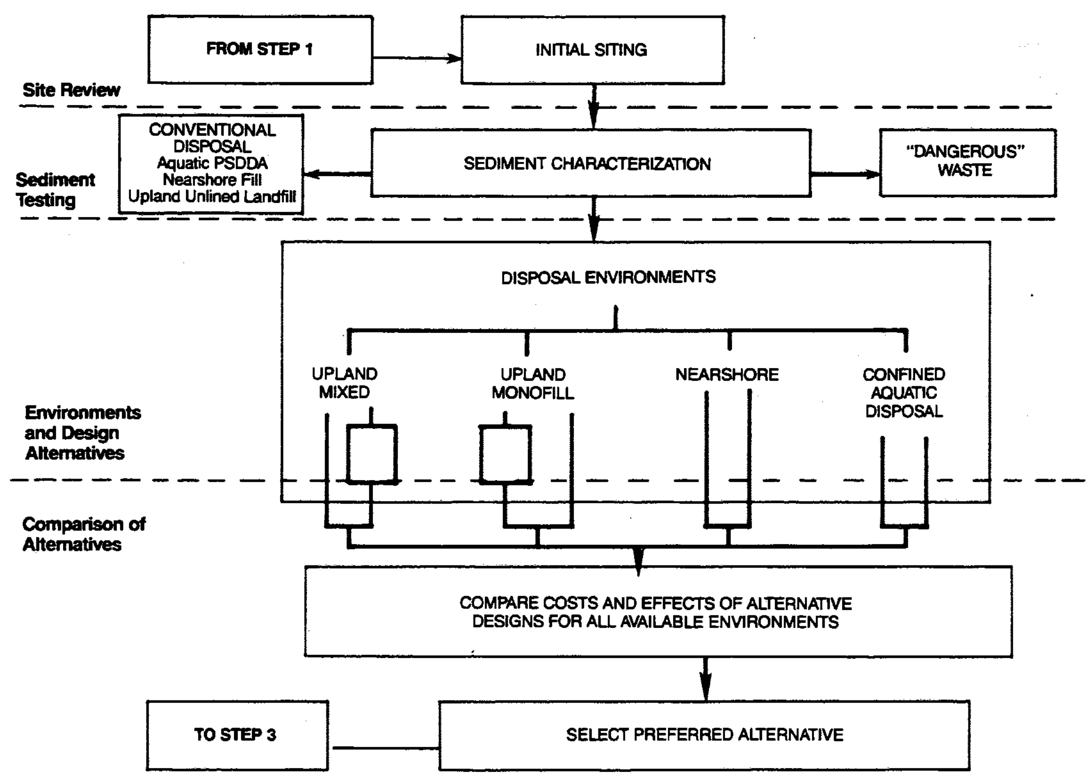


Figure 1.3 Overview of the Decision Model used in the confined disposal selection process.

The first scenario is the likely one for major ports needing maintenance and navigation dredging. Under this scenario the model will:

- Identify the best site conditions for the disposal environment a proponent is considering.
- Identify the types of characterization needed to determine if a preferred site is acceptable.
- Identify the design features required in a functional design for the disposal environment a proponent is considering.
- Determine what features require modification for a proponent's preferred site.
- Provide a means for comparing a proponent's site against a functional design (if it does not qualify for one), or against alternate disposal environment.

The second scenario is less likely for a major dredge proponent, but is a realistic situation for smaller projects. Under this scenario the model will:

- Identify the range of sites that could be used for a proponent's situation, and provide information on desirable site features.
- Identify the range of tests that may be needed, and allow a proponent to determine which tests to perform during initial characterization.
- Determine whether or not a proponent qualifies for the functional design and in which disposal environments.
- Provide a method for comparing costs and environmental protection.

The decision made in each step in the model affects how a proponent will carry out the next step. For example, the results of the site review step will direct the type of tests required in the next step, initial characterization. This step-by-step concept becomes more obvious in the following detailed explanations of each step in the model.

1.5.1 Site Review Step

This is the first step of the model and leads directly into initial characterization (see Figure 1.4). The information for making decisions in this step is presented in Chapter 3. The purpose of this step is three-fold:

1. Identify relevant regulations that could eliminate a site from consideration.

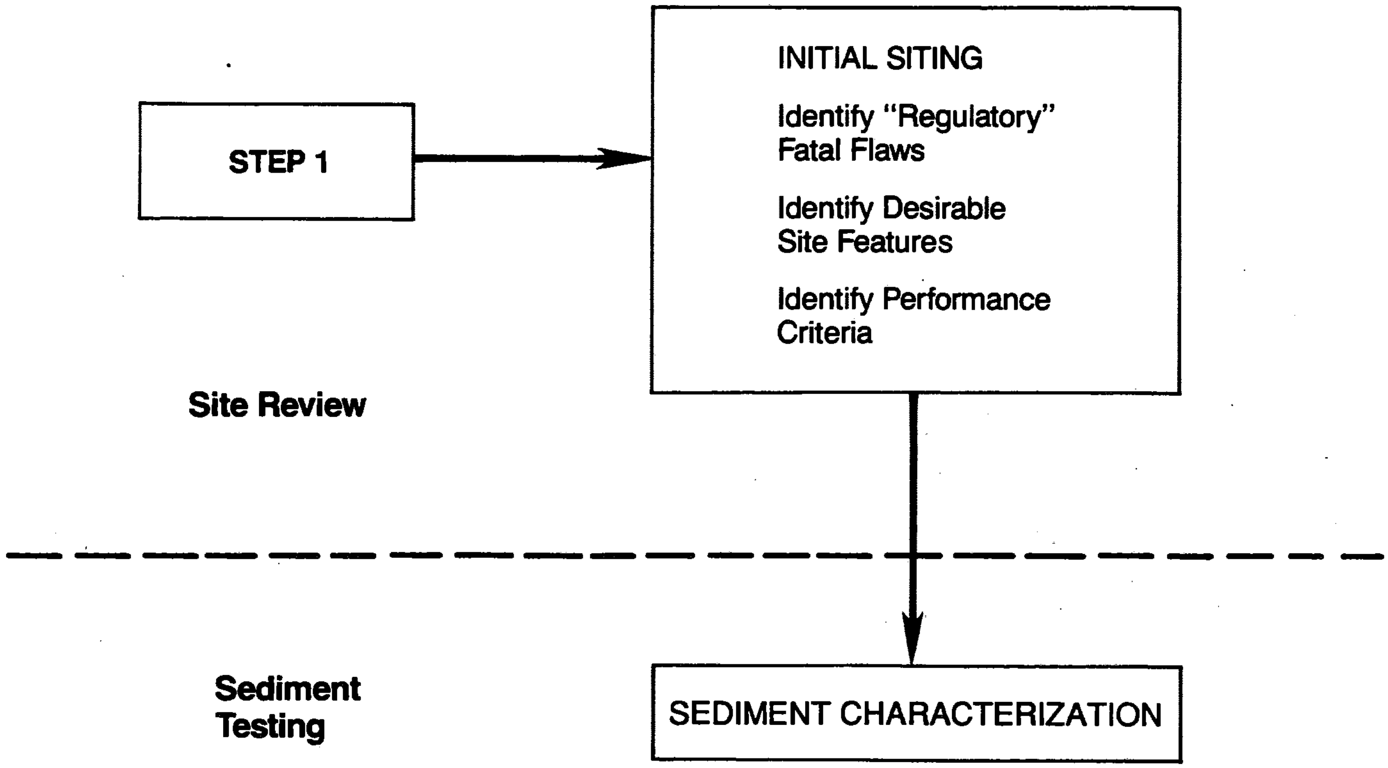


Figure 1.4 Overview of the site review step in the Decision Model.

2. Identify desirable site features, for each disposal environment, that will enhance the site's ability to serve as a functionally designed confined disposal area.

3. Identify performance criteria that are essentially minimum requirements for the functional design at each disposal environment. If a site does not meet these criteria, it is not a functional design candidate.

In land-based disposal siting, this step in the process would typically direct you to a preferred disposal site. Land-based siting typically takes a number of candidate sites, applies siting criteria to them, and then arrives at a preferred site. However, that is **not** the role of the site review step in the decision model. Site review provides information on desireable site features and minimum requirements for a functional design. At the completion of the site review step, proponents will know what sites are still available to them. The proponent may have eliminated some specific sites for functional design reasons.

For proponents beginning with a preferred site for land-use reasons, site review determines if a functional design is feasible at their site. It also identifies the site features that make disposal preferable in that environment. Based on the results of this step, a proponent should know if their site meets the performance criteria, or has a glaring weakness. If a weakness is identified, a proponent can consider how that weakness could be overcome with an effects-based design that provides equivalent environmental protection.

For proponents that enter into the model without a preferred site, this step in the model will guide them in what to look for in a site, and will highlight features that are requirements if a proponent wants to use the functional design method.

1.5.2 Sediment Characterization Step

This is the second step of the model and leads into selecting a disposal environment and site design (see Figure 1.5). The information used to make decisions in this step of the model are presented in Section 9.1, **Sediment Characterization,** of Chapter 9. The purpose of this step is two-fold:

1. Identify the testing and interpretation requirements for the dredge material.

2. Structure the testing so that a proponent has some control over the number of tests that are required.

This step in the model will allow a proponent to determine if their sediments are subject to these confined disposal standards. These standards are intended to cover a range of contamination from exceeding conventional unconfined disposal to state-defined dangerous waste levels. Conventional unconfined disposal includes placing dredged material at PSDDA sites and at demolition debris upland sites.

At this step in the model, a proponent can make a decision regarding the number and types of tests required. The standards will identify tests and interpretation requirements specific to each disposal environment (Figure 9.1). This step was intentionally structured to minimize testing requirements by making the requirements specific to disposal environments. A proponent has the flexibility to conduct only those tests that are required for a specific disposal environment or can conduct tests for all of the environments. Existing data on the nature of sediments may be substituted for new tests, providing the data satisfy testing requirements.

Proponents that enter this step of the model with a preferred site that still appears viable may want only to test specifically for that environment. They run the risk, however, of having their preferred site deemed not feasible later in the process and having to re-sample sediments for more initial characterization. This additional initial characterization would be for disposal environments that were not investigated originally. While limiting the tests selected in this step does potentially involve some risk, proponents should have a good indication of whether or not their site is viable for two reasons:

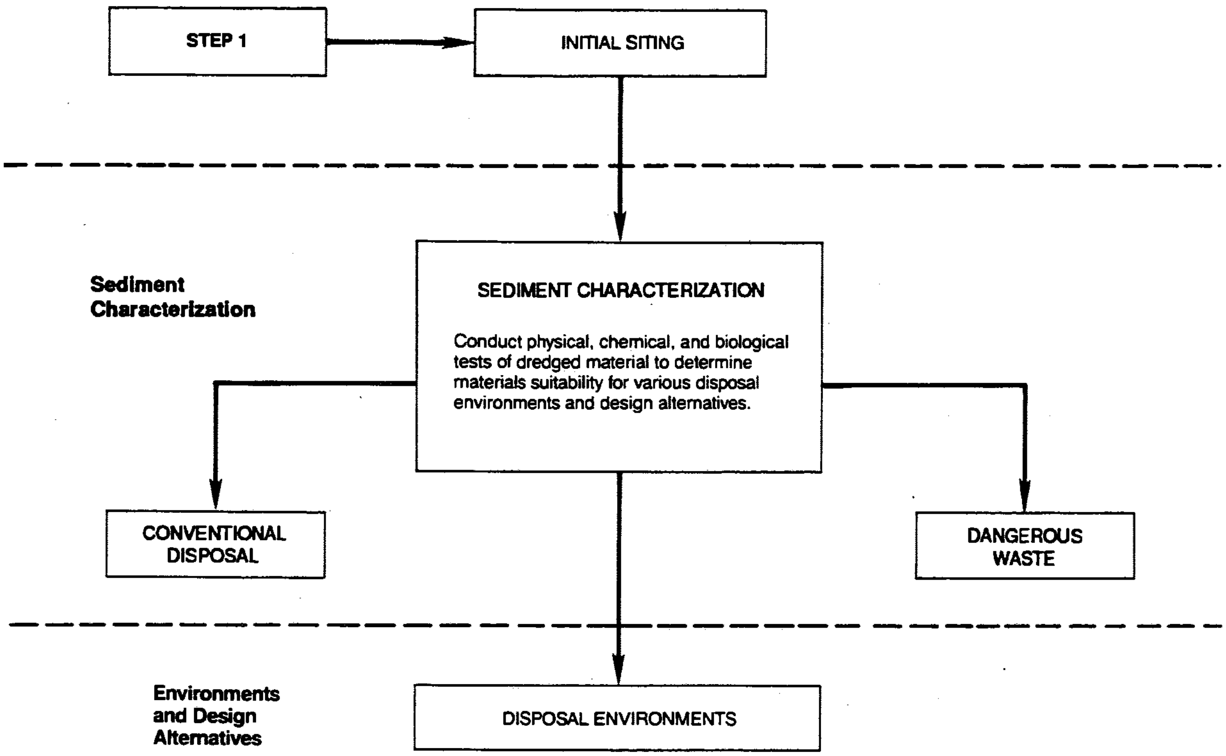


Figure 1.5 Overview of the sediment characterization step in the Decision Model.

1. Proponents will have reviewed existing information about the nature of their dredge material.

2. Proponents will know their site's functional design requirements and then estimate how much, if any, their project deviates from these.

Proponents entering this step of the model without a preferred site can keep their options open by conducting a range of tests applicable to various environments. The trade-off for the proponent is the expense and time of the various tests against the ability to keep various disposal options open.

Since all proponents are likely to take advantage of PSDDA's unconfined open-water disposal sites, this step in the process is built around the assumption that proponents will do PSDDA tests of their sediments. However, it is conceivable that proponents will know they do not qualify for open-water unconfined disposal based on existing information. In this situation proponents may reduce their testing requirements. Characterization tests are identified in a way that easily differentiates them from PSDDA requirements.

1.5.3 Disposal Environments and Design Alternatives

This step in the process identifies the design requirements for the environments and alternatives under consideration (see Figure 1.6). As the third step, it leads into the final comparison step. The information used to make decisions in this step is presented in Sections 9.2 through 9.5 of Chapter 9. The purpose of this step is to consider a variety of design alternatives and arrive at a preferred design for a proponent's site.

Due to the number of potential design requirements that could be identified, this is a major step in the model. These requirements include four disposal environments (CAD, nearshore, upland monofill, and upland mixed fill) and at least two alternatives within each environment (functional and effects-based). Proponents need only identify design requirements for those environments/alternatives they are pursuing. There no need to develop design requirements for all permutations in this step of the model. The functional design alternatives are presented in Chapter 9. The effects-based design testing requirements are discussed in Chapter 10.

The comparison of alternatives step in the model is where a proponent must weigh design requirements. These requirements encompass all phases of design including how the material is dredged and transported and the site's design and monitoring requirements. If a proponent is considering an effects-based design, meeting with Ecology for design review is encouraged. This will ensure that the final step in the model, comparison of alternatives, is done with alternatives that reflect the way the project will be permitted.

1.5.4 Alternatives Comparison

This is the final step in the model; it determines what design is carried forward into the permitting and detailed design phase of the confined disposal process (see Figure 1.7). Decisions in this step are based on environmental protection and cost. The cost comparison methodology is presented in Chapter 12. The purpose of this step is to:

1. Select a disposal environment and design that is most appropriate for a proponent's dredge project.

2. Ensure that the design selected provides adequate environmental protection and is cost effective.

This step is where a proponent and regulatory agency can compare between disposal environments, or can compare between alternatives within an environment. If a proponent is only comparing between functional designs of various disposal environments, then cost becomes the main determining factor. The functional designs for the various environments provide adequate environmental protection.

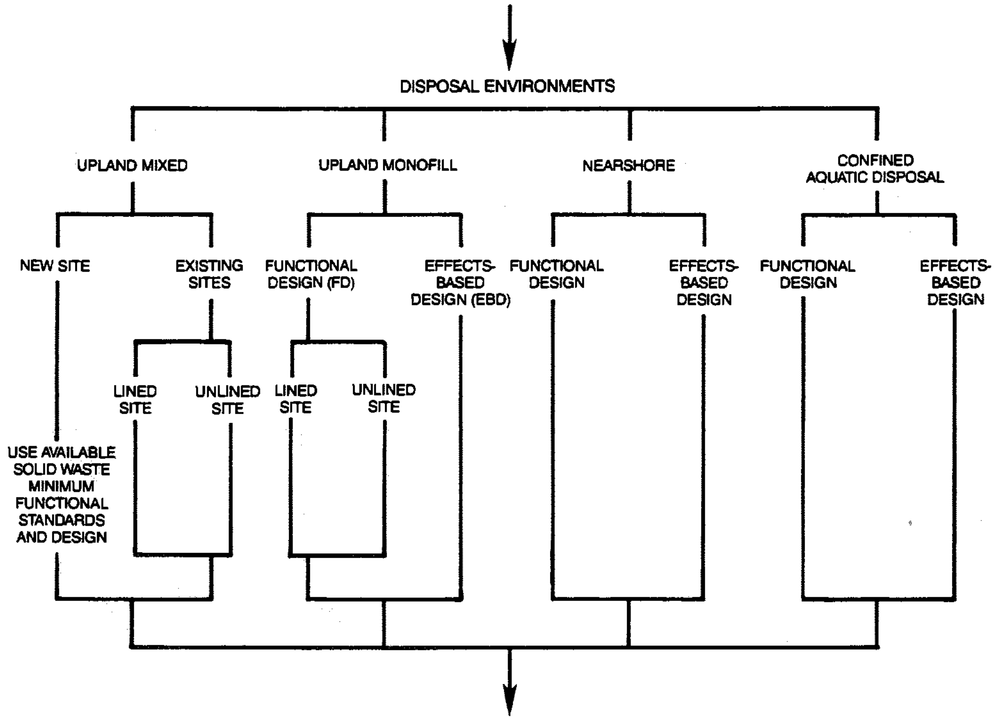


Figure 1.6 **Overview of the disposal environments and site design step in the Decision Model.**

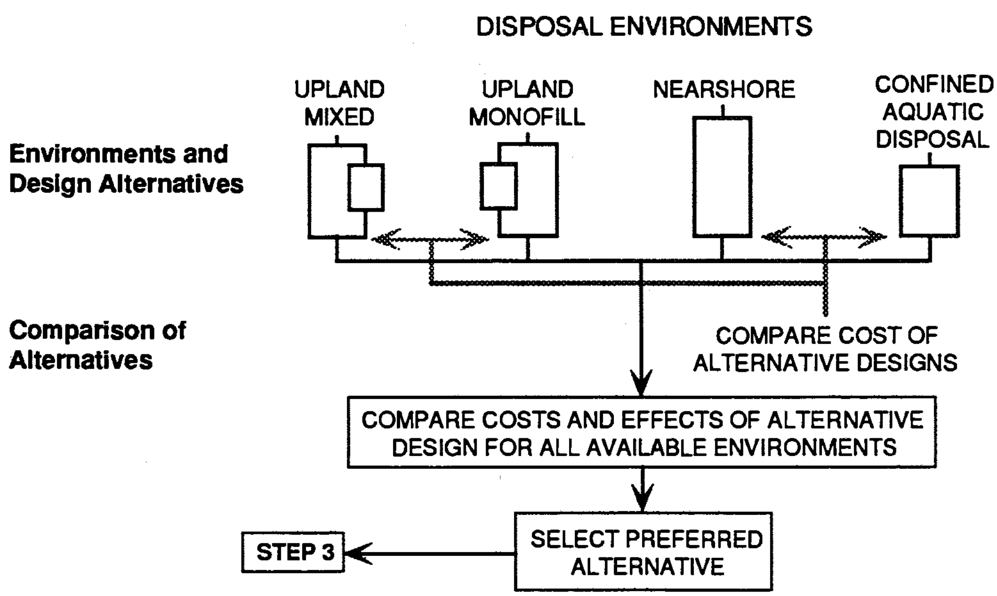
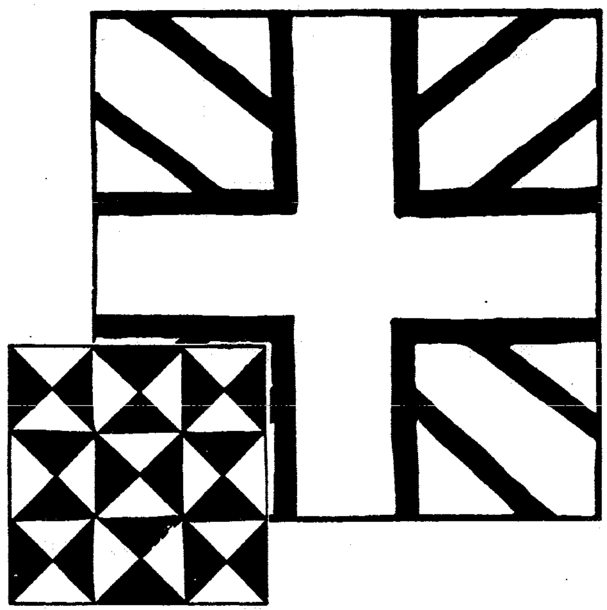
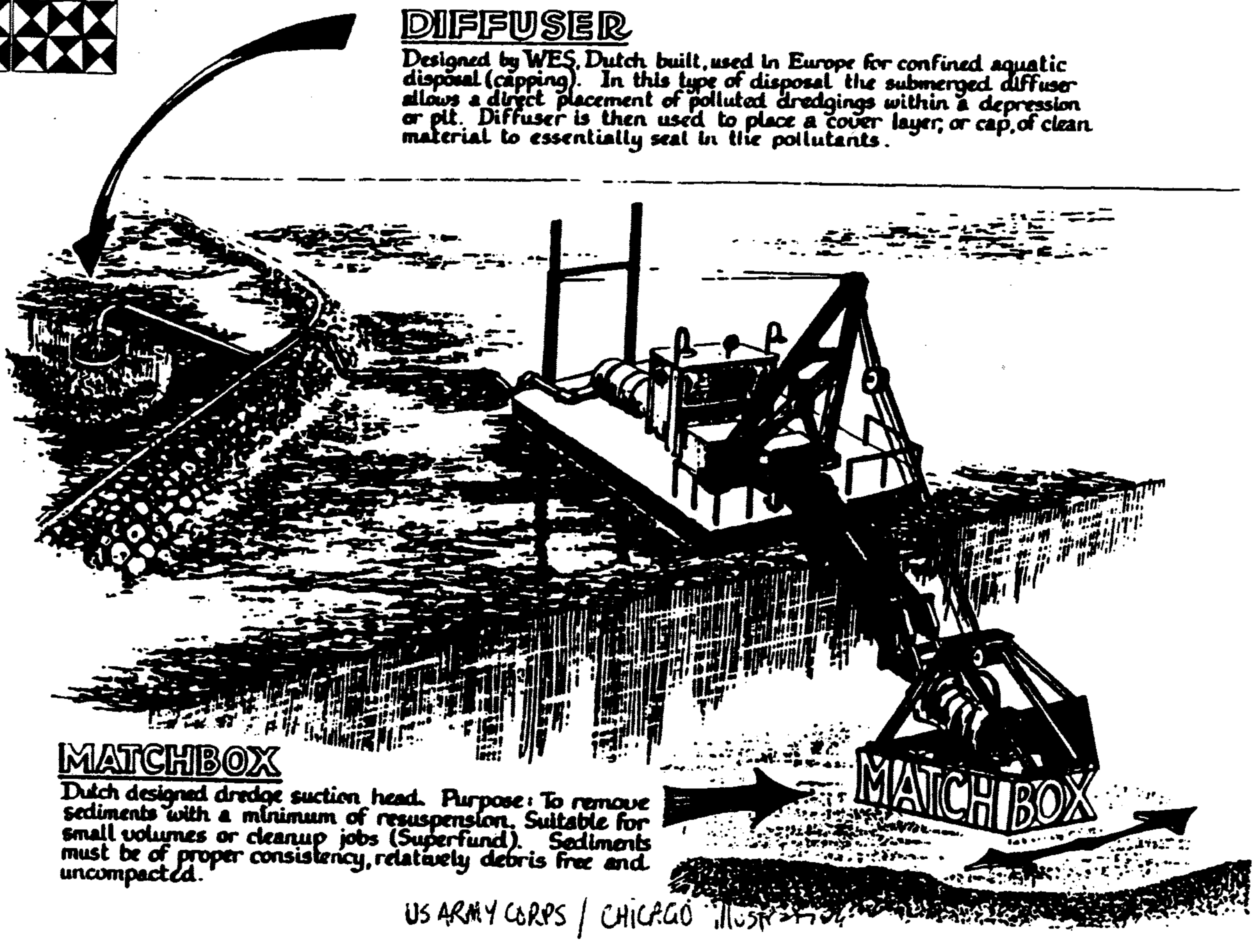


Figure 1.7 **Overview of the alternatives comparison step in the Decision Model.**

If a proponent is comparing between different design alternatives within the same disposal environment, then both environmental protection and cost become determining factors in the selection process. Environmental protection is addressed by the interpretation of the effects-based design tests and by the pathway control features present or absent in the effects-based designs.





Dredging Technology & Disposal Environments

2. DREDGED MATERIAL OVERVIEW

2.1 INTRODUCTION

Understanding the standards for the confined disposal of contaminated sediments requires an awareness of contaminant pathways in various disposal environments, and how different dredging methods work. The purpose of this chapter is to provide an overview that will help readers better understand the confined disposal standards.

Various technologies are available for dredging, transport, and disposal of contaminated material. These various methods differ in the ways they affect the environment, and how much they cost. This chapter describes available dredging methods, material transport techniques, and disposal environments where dredge material is commonly placed.

Section 2.2, **Summary of Disposal Environments,** describes the three basic disposal environments where dredge material is routinely placed. It also summarizes the transport pathways where contaminant loss can potentially occur within each disposal environment.

Section 2.3, **Summary of Dredging Methods,** provides an overview of available dredging equipment, and describes the two basic types of dredging: mechanical and hydraulic. Their ability to prevent sediment loss is also summarized. Dredging industry representatives were consulted to help ensure that control measures are feasible with equipment available to West Coast contractors and that methods are cost effective.

2.2 DISPOSAL ENVIRONMENTS

When dealing with contaminated material, some type of confinement is needed that provides isolation of the contaminated material, and prevents contaminant release. Depending on the disposal environment, the confinement measures vary to correspond with the major transport pathways.

There are three primary disposal environments where dredged material is typically disposed:

- Aquatic
- Nearshore
- Upland

2.2.1 <u>Aquatic</u>

Aquatic sites for contaminated dredged material are typically referred to as Confined Aquatic Disposal (CAD) sites. The major transport pathways associated with a CAD site are depicted in Figure 2.1). The primary pathway is contaminant migration through the cap and re-exposure of contaminants to the marine environment. Chemical migration

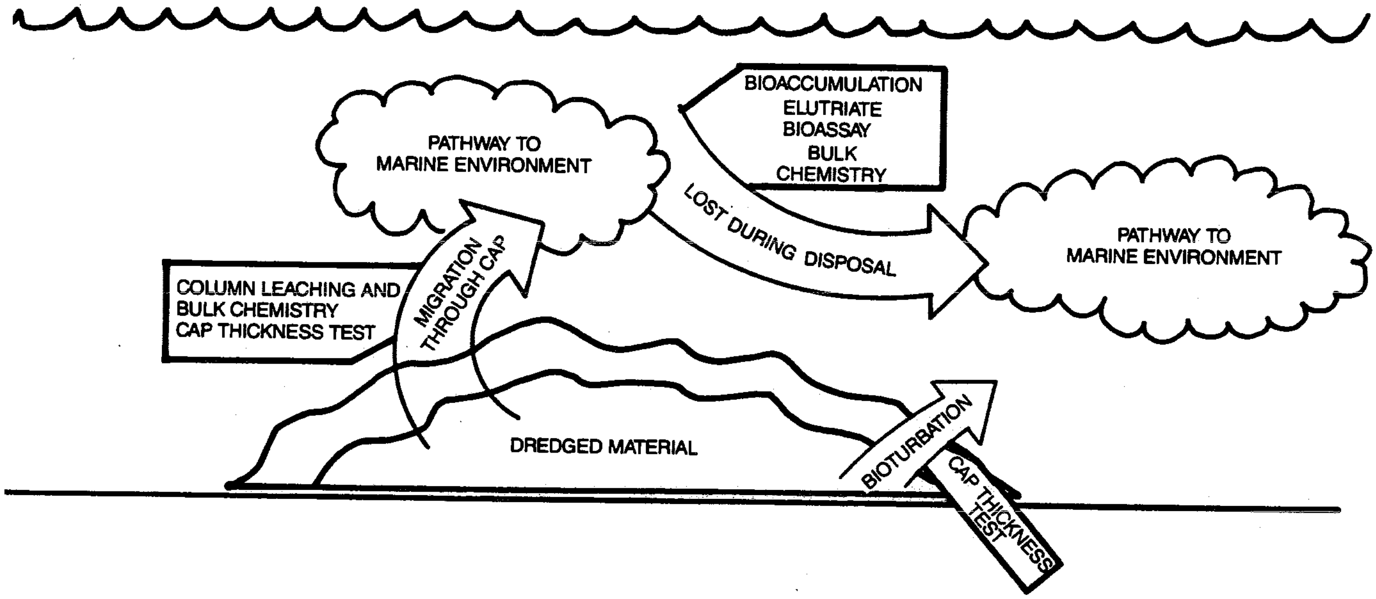


Figure 2.1 Exposure pathways associated with capped aquatic disposal.

through the cap has the potential to occur in a soluble form via diffusion, in a solid form via bioturbation or cap erosion, and in a gaseous form via breakdown of the organic products in the contaminated dredged material and gas migration through the cap. The primary component of site design that accounts for these pathways is cap thickness. Other factors such as the physical and chemical quality of the cap, depth of the site, topography of the site, and currents at the site also play a role in confining the contaminants and preventing migration through the cap.

2.2.2 Nearshore

Nearshore disposal sites for contaminated sediments typically involve placing the material in the shallow subtidal/intertidal environment surrounded by a berm/dike to reduce or possibly prevent its exposure to the marine environment. Nearshore fills can be accomplished by either excavating a portion of the nearshore and creating space for the disposal site, or by filling an existing indentation.

The use of a berm between the fill and the marine environment prevents direct contact between contaminated sediment and marine organisms. The main pathway of concern then becomes soluble contaminants diffusing across the berm face into the marine environment (Figure 2.2). Control mechanisms limiting contaminant diffusion include confining the sediments to the saturated zone where they will remain anaerobic, limiting the release rate (hydraulic conductivity) of the contaminated material itself, and building a physical barrier into the berm. Minor pathways of concern include effluent runoff from the site to the adjacent aquatic environment during site construction, and release from the site surface into the adjacent environment. These two pathways are commonly controlled by effluent control procedures and surface caps, respectively. Surface caps tend to be extremely thick for nearshore fills since the final grade is typically raised above high tide levels to provide future site use opportunities.

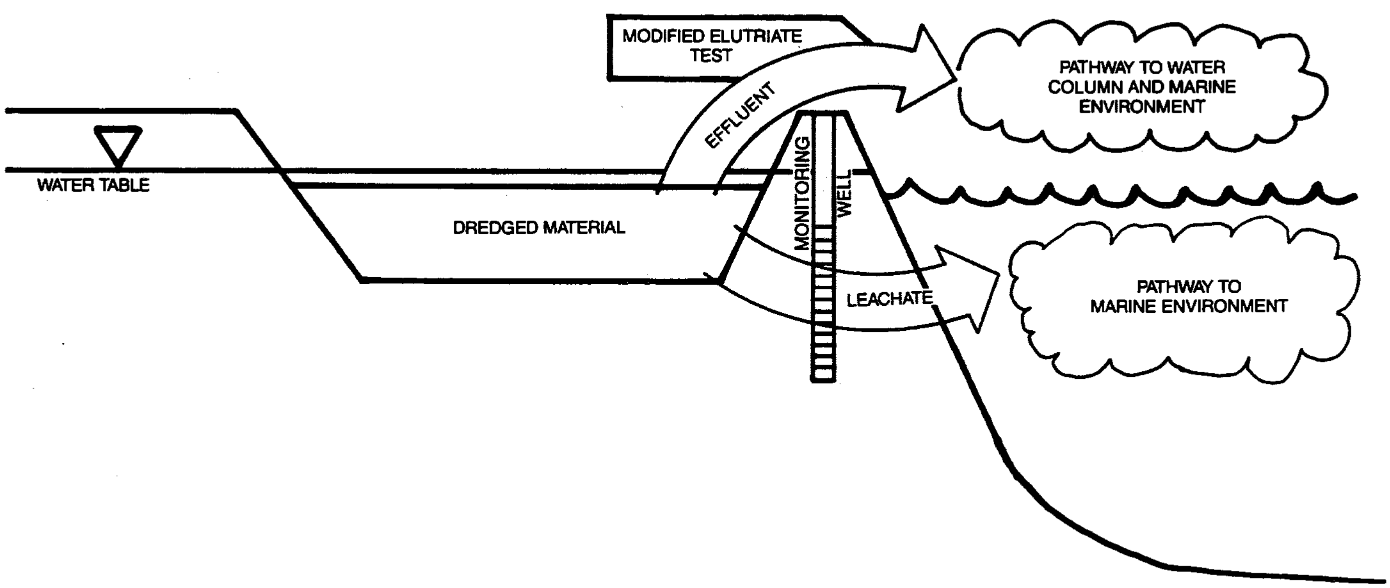


Figure 2.2 Exposure pathways associated with nearshore disposal.

2.2.3 Upland

Upland disposal sites for contaminated sediments vary in rigor of design with level of contamination. Major pathways of concern in the upland environment are depicted in Figure 2.3. These pathways include leachate from the site to the underlying groundwater, biological uptake at the site surface, surface water runoff from the site, and airborne emissions from the site. Site features such as liners, caps, leachate collection and treatment systems, and surface water runoff collection systems can account for these pathways.

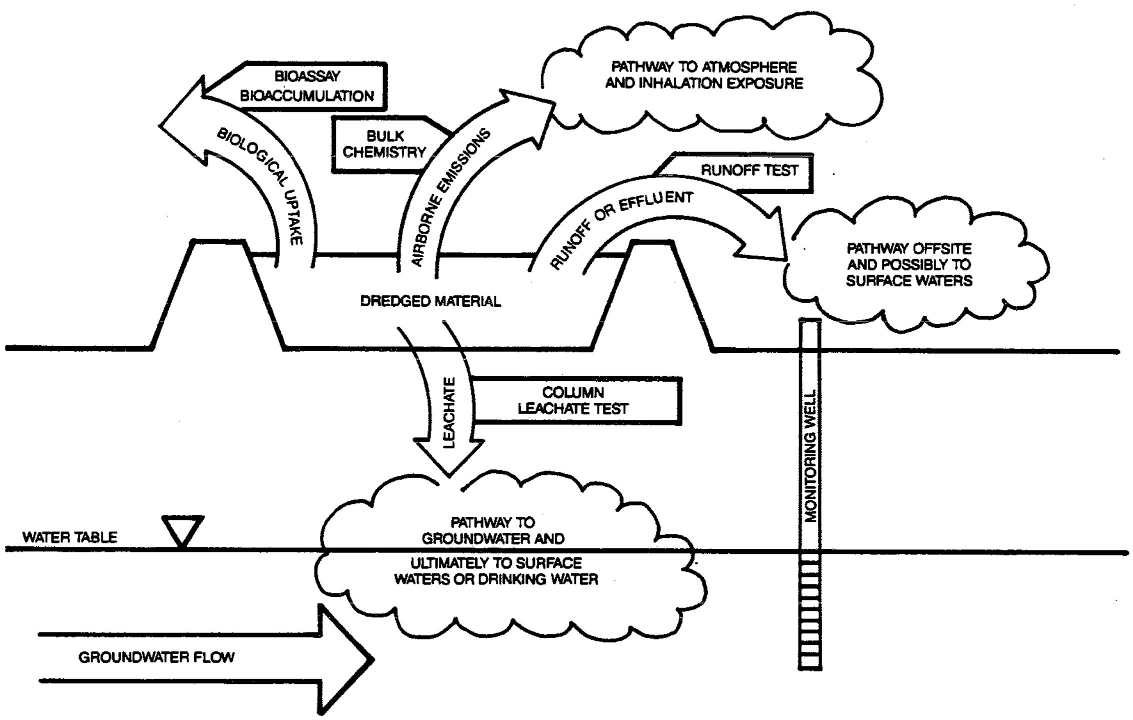


Figure 2.3 Exposure pathways associated with upland disposal.

One of the complicating factors in developing the standards for upland disposal is taking into consideration existing upland disposal regulations. New standards should be consistent with existing regulations. However, existing regulations are written for land-originating materials, and their applicability to dredged materials does not often readily apply. Also, in Washington State new standards for upland disposal have been developed and are in the process of being phased in (that is, existing facilities not in compliance with new regulations have a "grace period" to modify their site to be in compliance).

Ecology is addressing these and other concerns through an interagency work group and intra-agency coordination efforts.

2.3 DREDGING METHODS

Most dredges can be subdivided by two basic types–hydraulic and mechanical. Figure 2.4 is a breakdown of basic dredge types. In addition, other special-purpose dredges have been developed in recent years and will be discussed later in this section.

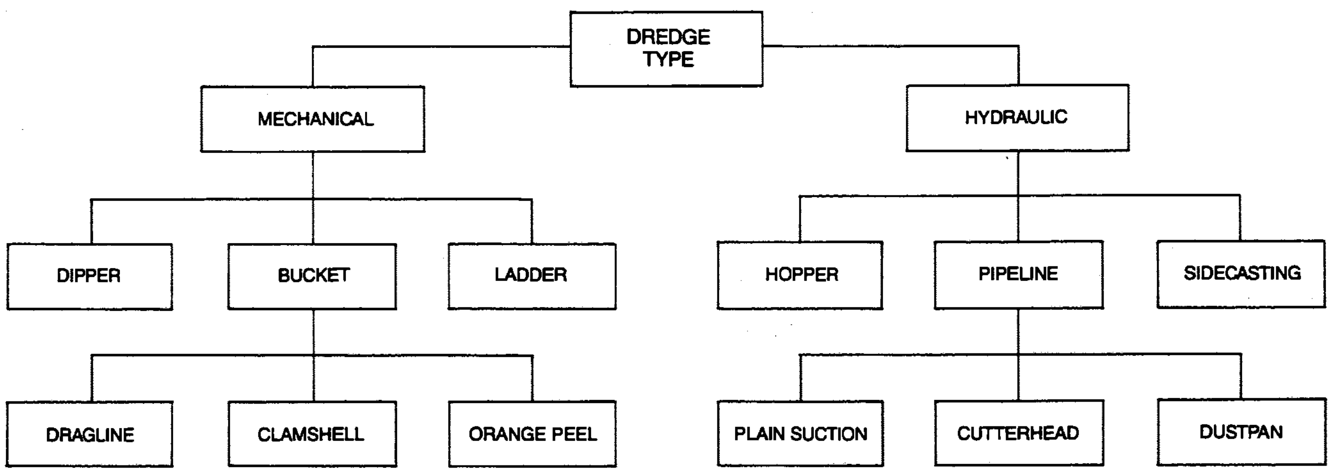


Figure 2.4 Breakdown of the basic types of dredges

2.3.1 Conventional Hydraulic Dredges

Conventional hydraulic dredges are characterized by their use of a centrifugal pump to entrain bed sediments in a liquid slurry form, pull the sediments from the bed by suction through the pump impeller then transport and discharge sediments into the disposal area. The two major types of hydraulic dredges are pipeline and hopper. They are further categorized by their method of excavating and transporting material. The contaminant pathways associated with hydraulic dredges are depicted in Figure 2.5.

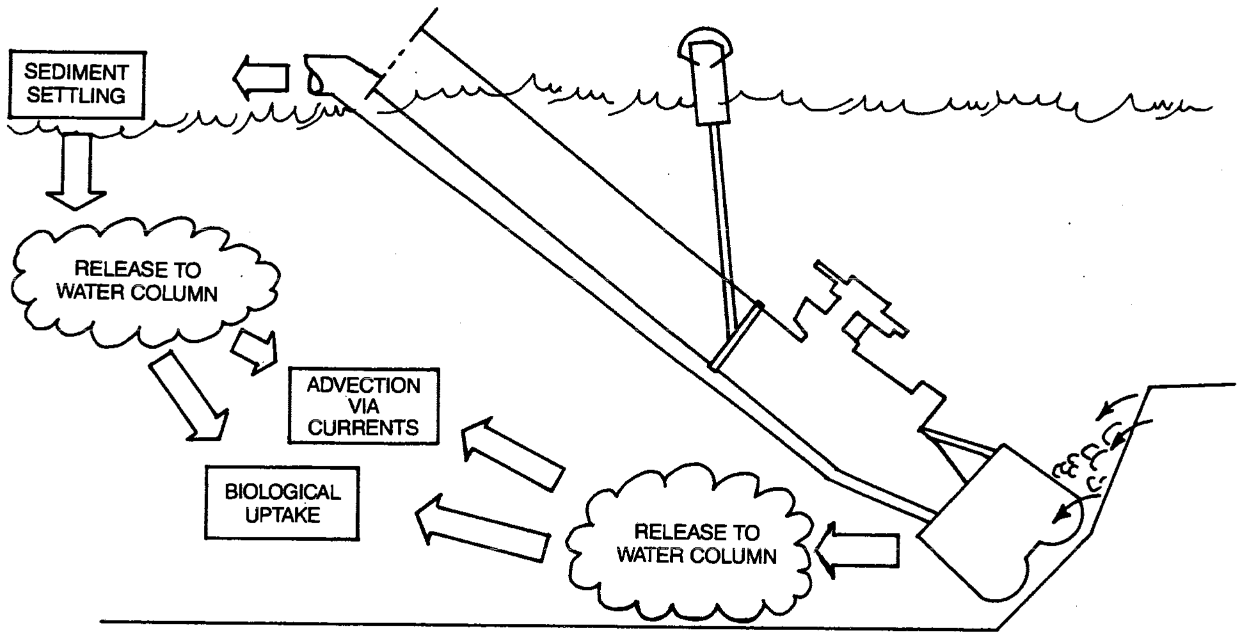


Figure 2.5 Exposure pathways associated with hydraulic dredging and transport of contaminated sediments.

Hydraulic Pipeline Cutterhead Dredge

The hydraulic pipeline dredge uses a centrifugal pump to entrain dredged solid materials in high velocity water. This dredge then pumps the slurry through a pipeline either directly or indirectly to the deposition area (Figure 2.6).

The most common and versatile pipeline dredge is the cutterhead. The cutterhead dredge is equipped with an active rotating cutterhead (excavator) surrounding the intake of the suction line. As the dredge swings on an arc, the cutterhead excavates and carries the bottom materials into the influence of the high velocity water at the suction intake. At the suction intake, the solids are entrained, passed through the dredge pump to the discharge line and on to the deposition area through a combination of floating and shore pipeline (Huston 1970; Turner 1984; Corps 1983, 1988).

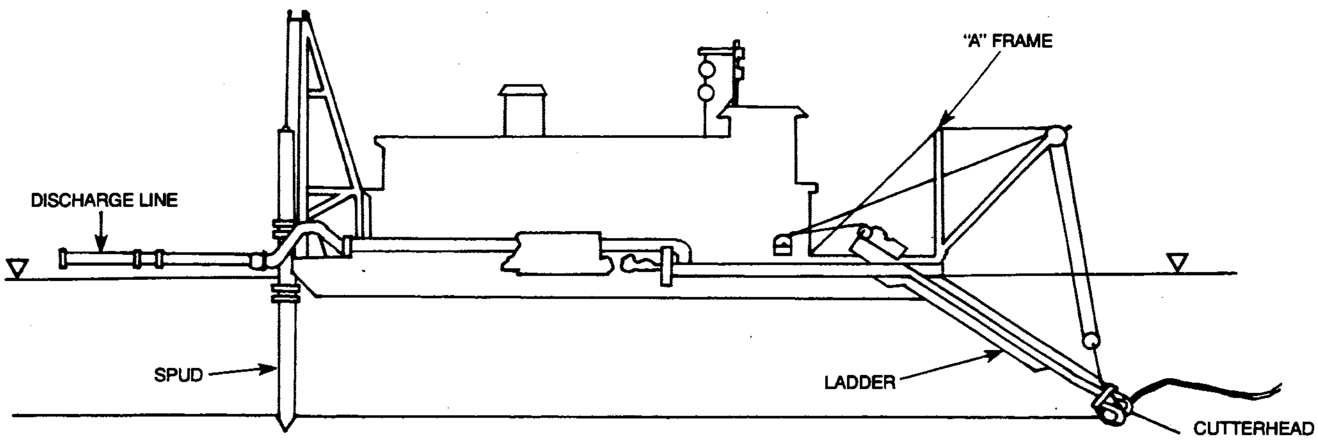


Figure 2.6 The hydraulic pipeline cutterhead dredge

The cutterhead dredge is held in position by two spuds at the stern of the dredge. Only one spud can be down while swinging. The dredge is swung from port to starboard alternately, while passing the cutterhead through the bottom material until the proper depth is achieved. Depth of the dredge cut can be controlled by limiting the angle of the cutterhead ladder. The dredge advances by "walking" itself forward on the spuds (Figure 2.7).

Although the cutterhead dredge was developed to loosen densely packed deposits and eventually cut through soft rock, it can excavate a wide range of materials including clay, silt, sand, and gravel. Variations of the cutterhead dredge, such as the bucket wheel dredge, can dredge harder materials (Figure 2.8) (Turner 1984; Corps 1988).

Because the cutterhead and the working spud directly contact the waterway bed and the discharge pipeline floats on or near the water surface, the cutterhead dredge is most suitable for maintaining harbors, canals, and outlet channels where wave heights are not excessive.

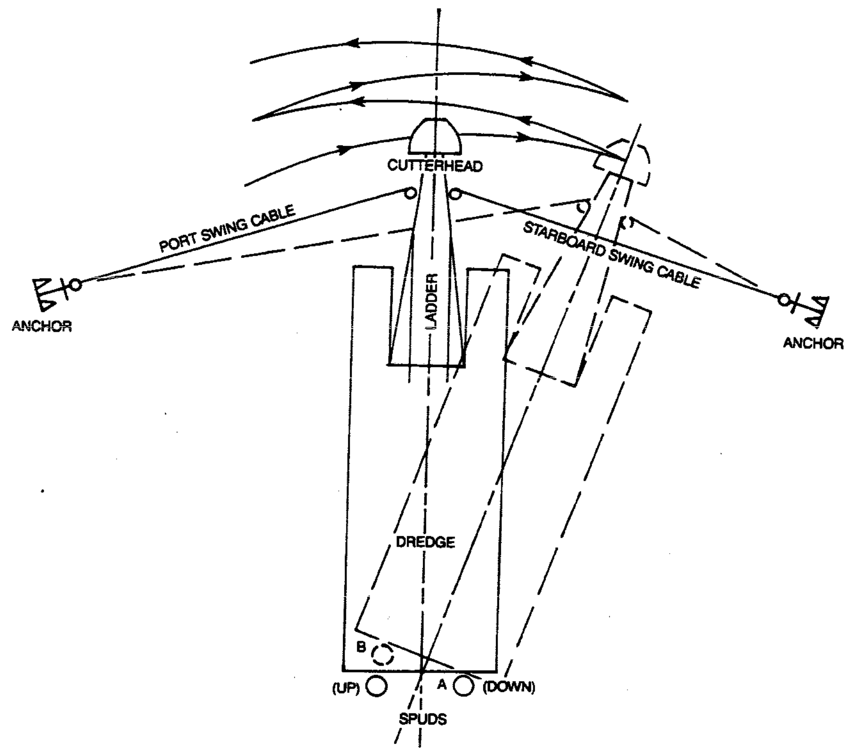


Figure 2.7 Operation of a cutterhead dredge

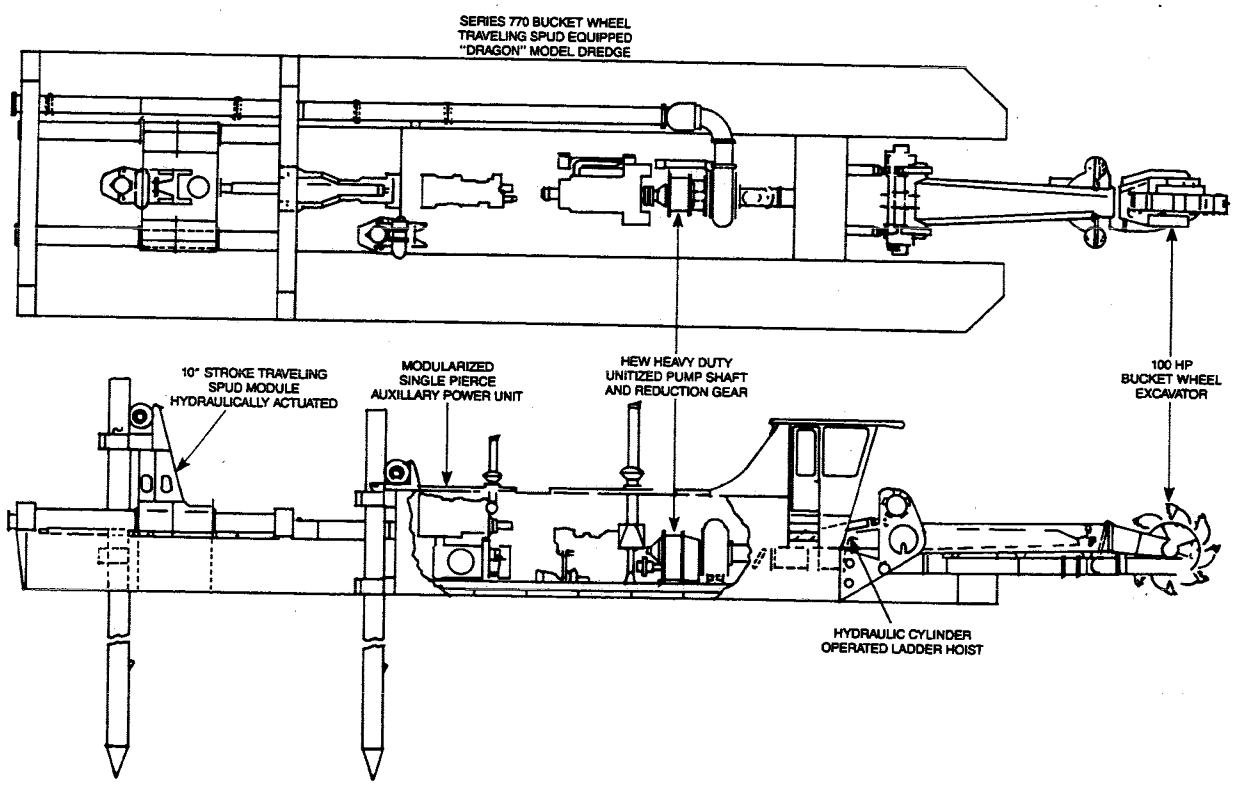


Figure 2.8 The bucket wheel dredge

Transport Method. The cutterhead pipeline dredge pumps sediment into a pipeline for transport to a disposal site. Discharge pipelines can include floating pipeline supported by pontoon floats, submerged pipe, and shore pipe. The maximum length of pipeline is determined by the dredge horsepower and the pumped material characteristics. A booster pump along the pipeline may be necessary for long pipeline distances. Systems involving more than one or two booster pumps are usually impractical, due to their frequent down time. If one booster in the system fails, the entire system must be shut down until the booster is repaired.

If no disposal site is located within the pipeline distance, the pipeline can be discharged into a barge, which in turn must be towed to a suitable disposal area and discharged. Discharge by hydraulic pipeline to an open-water disposal site can be done using a discharge anchor barge to position the pipe. The rate of discharge should be controlled to prevent jetting existing material and unnecessary sediment dispersal on the disposal site bed. Controlling discharge also eliminates the potential for mud waves caused by the discharge flow. Use of a submerged diffuser on the discharge line has proven effective for this purpose (Neal et al. 1978; Larson 1989).

Sediment Fate. The bottom sediments are agitated by the cutterhead in the dredging process and create a turbidity plume near the bottom of the water column. Sediment release is defined here as an action that differs from sediment loss.

The amount of turbidity depends on the rotating speed of the cutterhead, the cutterhead swing velocity, the degree of overcutting, and the depth of cut relative to the cutterhead diameter. Loss of sediments during the dredging operation is also a function of the sediment grain size. Sediments of concern are predominantly identified in four size ranges, sandy gravels, silty sands, sandy silts and fine grained silts or clays. Sediment loss and release characteristic of each grain size range are described in Appendix A.

Cutterhead dredge field studies were conducted in 1983 to evaluate the effect of operational parameters on sediment suspension and dredge production (Hayes 1984). The parameters included the following:

- Swing speed
- Cutter tip speed
- Depth of cut.

<u>Another operational factor that contributes significantly to increased turbidity is the dredging technique of undercutting</u>. This technique involves excavating the shoal bank to full project depth and allowing large volumes of cut bank material to cave into the cutterhead. <u>The application of controlling cut depth to 1.5 times the cutterhead diameter or less limits these sources of suspended sediment</u> (see Appendix A).

Dewatering. Sediment excavated by pipeline cutterhead dredge is entrained into a slurry consisting of 10-20% solids by dry weight. The slurry is usually piped into a diked disposal area designed for slurry retention time adequate to allow settling of solids and clean water withdrawal over a discharge weir (Figure 2.9). The rate of material delivery

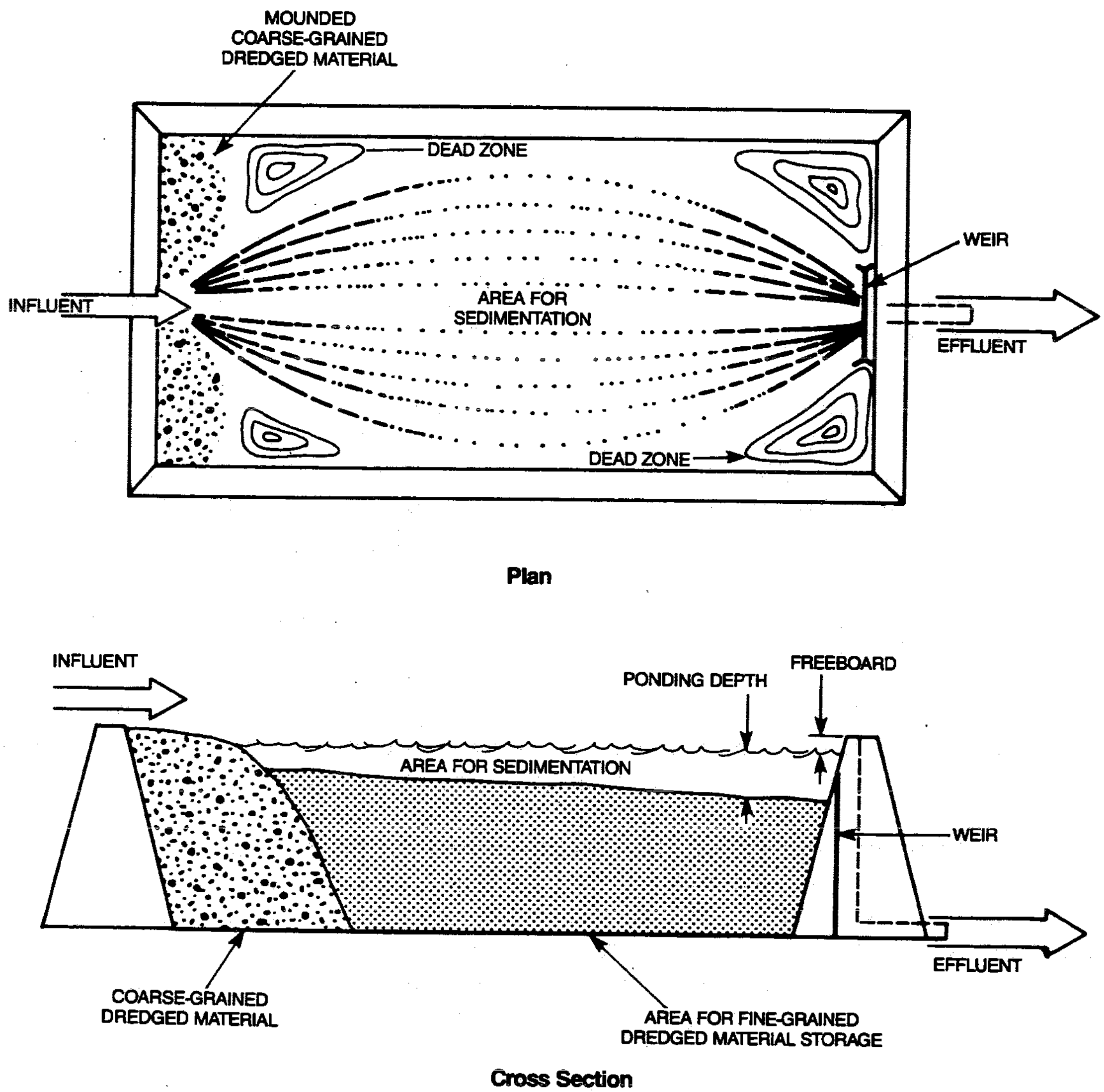


Figure 2.9 Conceptual diagram of a hydraulic pipeline dredged material containment area

to the site is a function of the dredge pipeline diameter, dredge horsepower, and other factors (see Appendix A). The effluent that returns to the water body can exhibit suspended solids concentrations of approximately 100-200 mg/L. Basin design methods, weir design methods, and operation techniques are used to minimize mass release in the dewatering process (Haliburton 1978; Huston 1970; Palermo 1978; Corps 1983, 1988).

Sand and gravel sediments have high porosity and are quick draining. They will rapidly dewater after leaving the discharge pipeline. Sediments with higher silt contents will tend to segregate in the disposal area leading to irregular soil conditions after dewatering. Finer sediments will be carried towards the overflow weir, often resulting in areas of very poor soil quality which are, in turn, difficult to dewater.

Methods of dewatering and drying of fine sediments following disposal and decanting of the surface waters have been investigated by the Waterways Experiment Station, U.S. Corps of Engineers under the Dredged Material Research Program. Conclusions from that investigation and subsequent field prototype tests have demonstrated that continuous trenching is the most cost effective method of fine-grained sediment dewatering. Continuous trenching is a straightforward process whereby a trench or drainage ditch is developed in the wetted, soft sediments following dredge disposal. As the surface sediments dry and begin to crack the trench's depth is increased. This cracking allows further subsurface drying. The process is continued until the deposited material is adequately dry for removal, use as dike material, use as cover materials, or transfer to final disposal areas.

Hydraulic Pipeline Suction Dredge

Not all hydraulic pipeline dredges are equipped with an active cutterhead. Pipeline dredges can also operate without the cutterhead, using a straight suction to remove sediments. Most pipeline dredges that do not use cutterhead use some method of fluidizing or entraining the bed sediments with water to enhance pump suction removal. This is typically done by the use of water jets located near or at the suction entrance. These dredges can dredge only loose materials such as gravels, sand, and unconsolidated fine sediments.

One type of hydraulic pipeline suction dredge is a dustpan dredge. The dustpan dredge is modified straight suction dredge. It uses a widely flared dredging head along which are mounted pressure water jets. The jets dislodge and agitate the sediments which are then captured in the dustpan head as the dredge itself is winched forward into the excavation. The dredge does not move by arc swing and walking spud action as does the conventional cutterhead dredge.

Contractors on the West Coast have used existing pipeline dredges as straight suction dredges by replacing the cutterhead assembly with a flexible rubber pipe at the suction mouth. The flexible pipe is centered in a ring of jet nozzles that fluidized the bed sediments for more efficient removal.

Transport Method. Hydraulic pipeline suction dredges transport sediment through discharge pipelines. The dustpan dredge is specifically built to pump on short, low lift discharge lines. Conventional dredges have a greater lift and pumping distance capability.

Sediment Fate. While a properly designed and operated cutterhead will excavate and move bed sediments toward the suction mouth efficiently, rotation of the cutter suspends a portion of the bed sediments. By using the suction without rotating the cutter, suspension could be reduced by about 50% (Yagi et al. 1975).

Hopper Dredge

The trailing suction dredge (hopper dredge) is a self-propelled ocean-going vessel 180 to 550 ft long compartmented into several hoppers. The most common configuration has two dragarms, one on each side of the ship, mounted outboard and connected to the hull near the center of buoyancy to minimize the effect of the sea-state (Figure 2.10). There are other configurations involving only one dragarm mounted on one side of the vessel or at the stern on the ship's centerline.

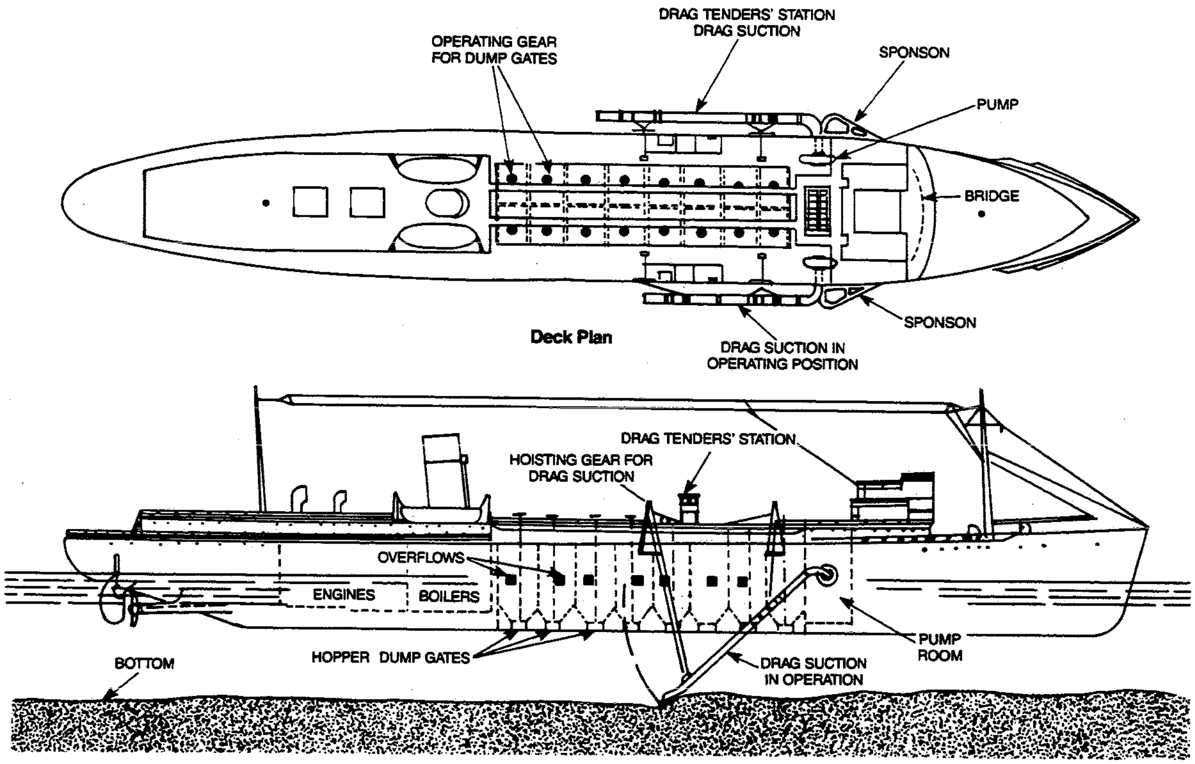


Figure 2.10 Typical hopper dredge

The hopper dredge is typically not constructed with active dragheads, and it is most efficient in excavating loose, unconsolidated materials. Each dragarm has its own draghead for contact with the bottom and, with minor exceptions, is served by its own pump. Each pump discharges into the distribution system that can allow either or both pumps to direct the effluent to any of several hopper compartments.

Hopper dredges are used mainly for maintenance dredging in exposed harbors and shipping channels where traffic and surface wave conditions rule out stationary dredges. The materials excavated by hopper dredges cover a wide range. However, the hopper dredge is most effective in removing maintenance dredged material, or material shoaled into a channel after dredging has been completed. While specifically designed drags are available for use in raking and breaking up compacted materials, hopper dredges are seldom used for removal of that type of sediment. Hopper dredges are expected to operate at times under hazardous conditions caused by fog, rough seas, and heavy traffic encountered in congested harbors and river channel entrances.

Transport Method. The hopper dredge does not need any additional equipment to transport collected sediments. Instead, the material is pumped directly into the hoppers, and when the hoppers are full it is transported to the dump site. Most common practice is to dump the material through the bottom of the hoppers, like a bottom-dump haul barge. Some dredges are equipped to pump the hoppers out through a shore pipeline to a designated disposal site, or to pump into a bypass system that will directly sidecast it overboard beyond the channel limits (Figure 2.11) (Huston 1970; Mohr 1974; Tavolaro 1984).

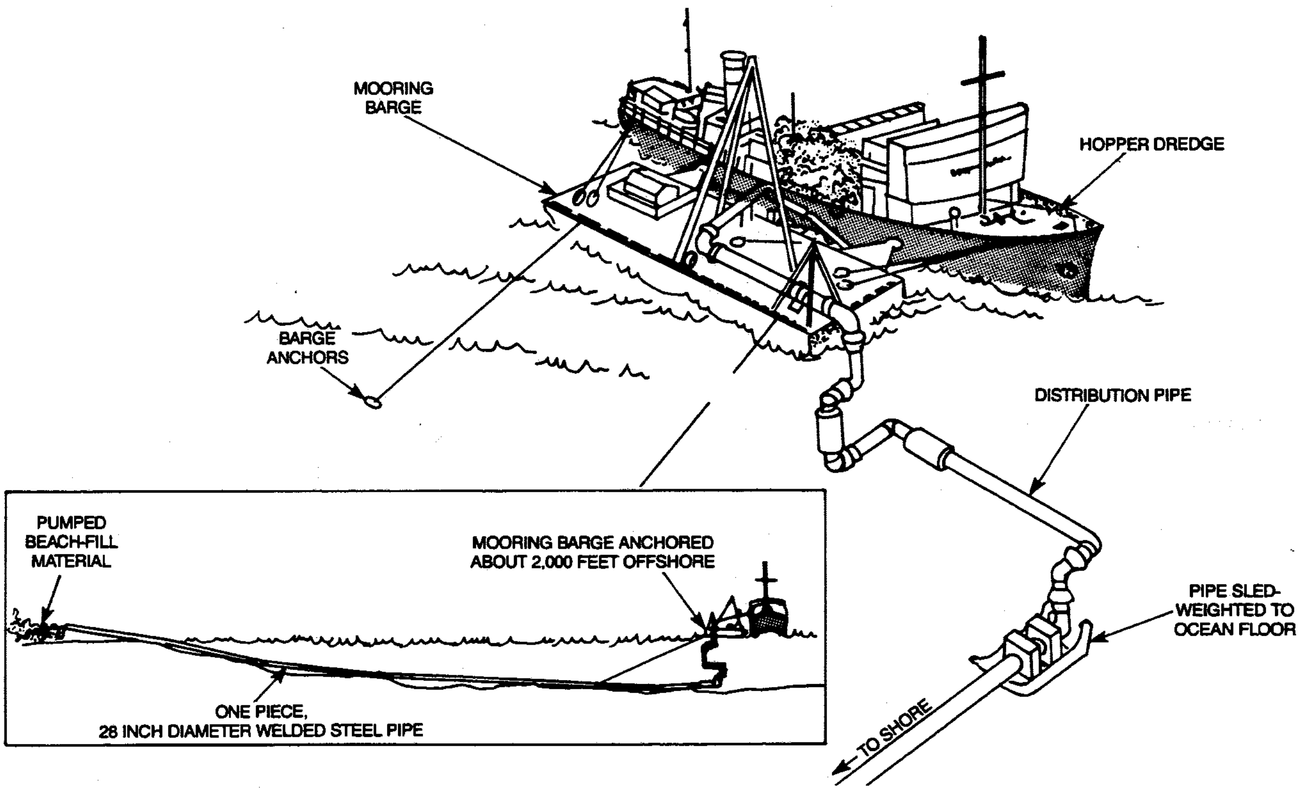


Figure 2.11 Hopper dredge, showing distribution pipe to shoreline

Sediment Fate. Sources of sediment loss during hopper dredge operations include dragarm action and the practice of pumping into the hoppers past overflow (Cullinane et al. 1988). Hopper dredges typically remove bottom sediments by dragging a large flat draghead and using hydraulic suction to remove the sediments. Bottom sediments are agitated by the dragarm in the dredging process, but the mass release is less than that of cutterhead dredge, or less than 1% of total sediment dredged (Hayes 1985).

Overflow of material from the hopper produces by far the most sediment resuspension (Cullinane et al. 1988). Sediment resuspension with overflow can be decreased by reducing the flow rate of solids being pumped into the hopper during latter stages of the hopper filling operation. This operational procedure is done by raising the dragarms to the surface elevation of the bed sediments during the final hopper filling phase. Use of this technique has reduced the solids content in the overflow by 50% while maintaining a much higher loading efficiency than could be achieved by no overflow (Cullinane et al. 1988). In most operations, pumping is limited to overflow thus stopping the resuspension problem. However, this process can raise the unit cost of hopper dredging substantially.

Sediment release by bottom dumping of the hoppers is subject to loss or mass release. The amount of loss depends on the type of material and the depth of the bottom at the disposal site. As the material is passed through the water column, water is entrained and a turbidity plume is created in the water column. The deeper the depth of fall, the more water will be entrained by the material.

A silty material, being more cohesive, will entrain less water than a sandy material. Very little entrainment occurs in silts that have a moisture content of less than 100%. Studies have shown that sand will spread out over a large area on the bottom in a dense blanket, but will remain stable in that configuration. A silty material will exhibit less spreading and the mound that is created on the bottom will have steeper side slopes. These steep slopes will tend to slowly settle and slump.

Dewatering Methods. The sediment excavated by hopper dredge is entrained into a slurry consisting of 10-20% solids by weight. The material may or may not have a chance to settle in the hopper, depending on the settling time of the material and the time of travel to the disposal site. For modern hopper dredges, a very high percentage of sand will be retained in the hopper with the fines tending to be washed overboard as the hoppers fill up in the final stages of loading.

2.3.2 Conventional Mechanical Dredge

Conventional mechanical dredges use some form of bucket to excavate and elevate bottom material. These dredges excavate bottom sediment at in-situ densities. They do not transport the material to the ultimate deposition area except in the infrequent instances where material can be deposited by sidecasting on to a bank, behind a dike or seawall, or back into the water immediately adjacent to a waterway. Normally, the mechanical dredge deposits into a haul barge, which then transports the material to the dump. The contaminant transport pathways associated with mechanical dredging are depicted in Figure 2.12.

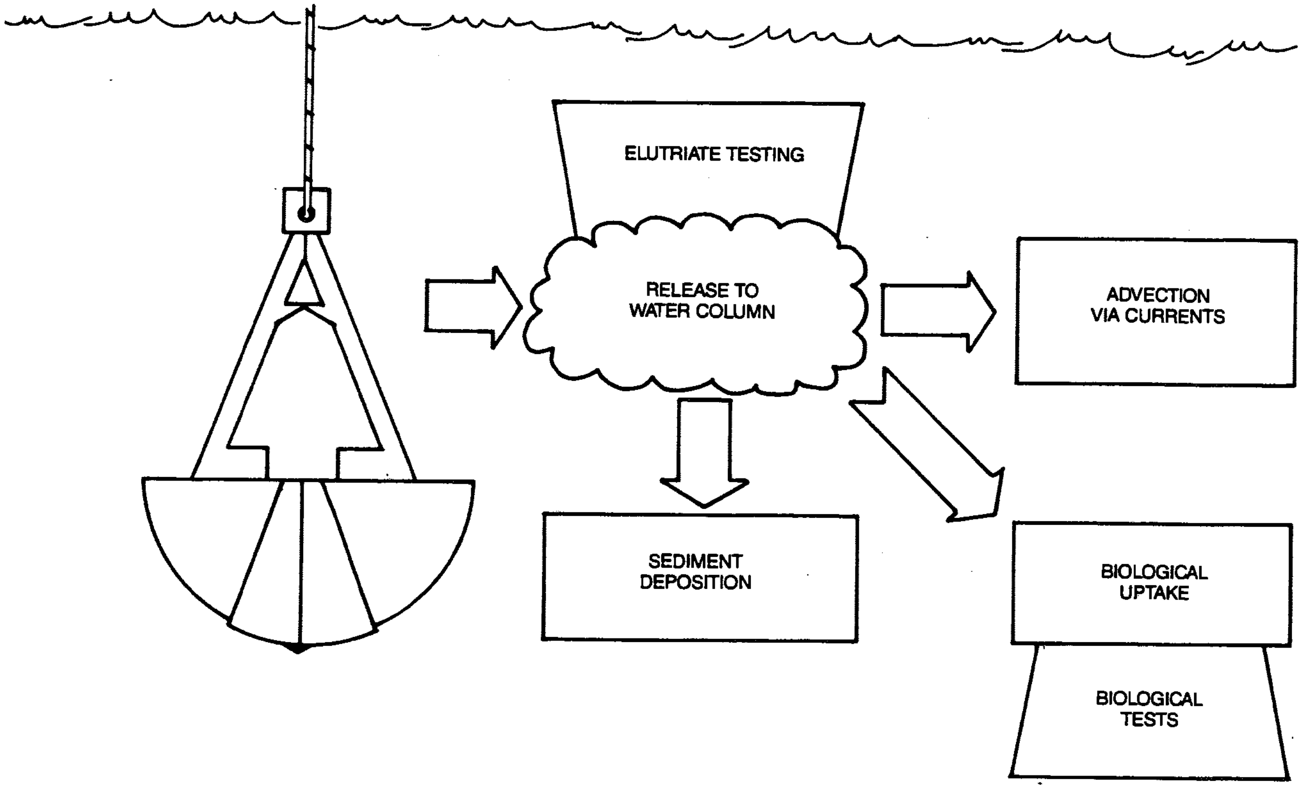


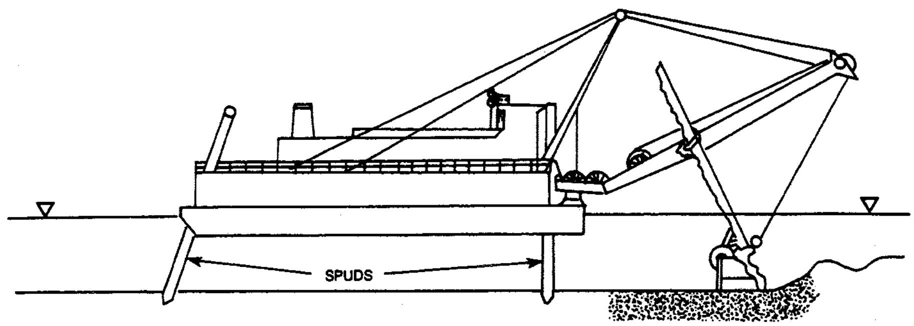
Figure 2.12 Exposure pathways associated with dredging and transport of contaminated sediments.

Mechanical dredges can be broken down into three sub-groups as a function of how their buckets are connected to the dredge:

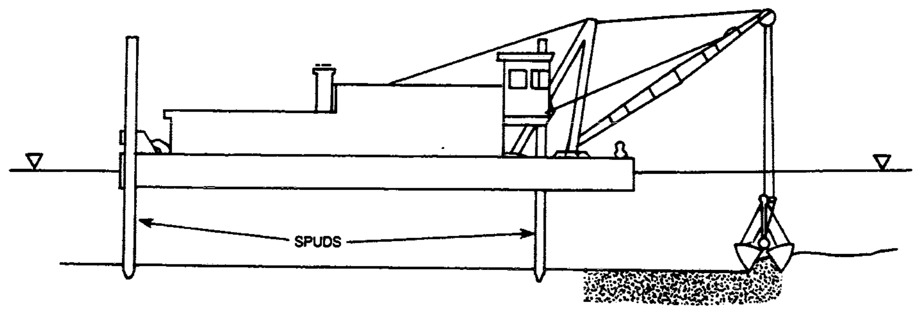
- Wire rope connected (grab/bucket)
- Structurally connected (dipper)
- Chain and structurally connected (bucket ladder).

Examples of wire-rope-connected dredges are the dragline, clamshell, and orange peel dredges. Examples of structurally connected dredged are the power shovel and back hoe dredges. A chain and structurally connected dredge is the bucket ladder or bucket line dredge. Bucket dredges differ from the other mechanical dredges by dredging continuously with multiple buckets mounted on an endless chain. The most common types of mechanical dredges are the clamshell dredge and the dipper dredge (Figure 2.13).

Mechanical dredges may be used to excavate most types of materials except for the most cohesive consolidated sediments and solid rock. Material in the bucket can be lost in the operation due to hoisting turbulence, rapid drainage of entrained water, and slumping of the material heaped above the rim. Specially designed "watertight" buckets can be used when dredging contaminated sediments to minimize these losses under certain



Dipper Dredge



Bucket Dredge

Figure 2.13 The dipper dredge and bucket dredge (clamshell)

dredging conditions (Cullinane et al. 1988; Herbich 1988). Mechanical dredges are effective for work near bridges, docks, wharves, pipelines, piers, or breakwater structures because they do not require much area to maneuver. The dredging process can be controlled accurately, thus minimizing risk to adjacent structures.

Clamshell Dredge

Transport Method. A clamshell dredge can either release the sediment in a side-casting area (in-water or upland) or, more commonly, it can place the sediment in a barge for disposal off site (Figure 2.14).

Sediment Fate. Sources of sediment loss to the waterway can be attributed to the six following sources (Corps 1986):

- Sediment resuspension at bucket impact
- Subsequent removal from the bottom
- Sediment erosion from the open-top and mud-covered bucket surfaces as the bucket is hauled upward through the water column

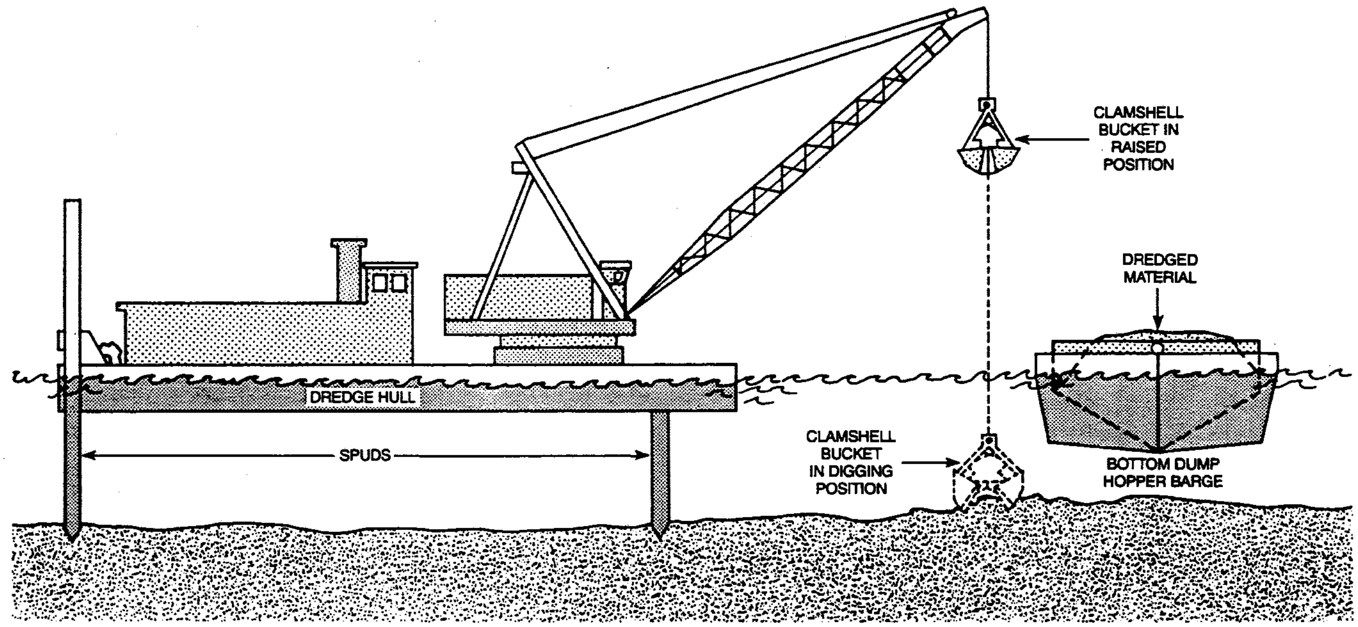


Figure 2.14 Bucket dredge with bottom dump barge for off-site disposal

- Once clear of the water surface, additional losses occur through rapid drainage of entrapped water and slumping of material heaped above the rim
- Bucket dragging across the bottom of a completed cut to smooth out the irregular surfaces can produce substantial bottom turbidity
- Accidental or intentional overflowing of disposal barges and spillage or leakage from the barge can result in sediment losses.

The operation of the dredge can be modified slightly to reduce sediment resuspension. One method is use of a "watertight" clamshell bucket, and another is by slowing the retrieval and lowering of the bucket through the water column. Operation monitoring of a watertight bucket demonstrated that equivalent sediment suspension occurred in the water column for both conventional and watertight buckets. However, the watertight clamshell results in a more concentration resuspension of sediments near the bed while the conventional open bucket tends to distribute the turbidity throughout the water column. Slowing the bucket retrieval rate is a marginally more effective in reducing resuspension. Both of these operation modifications reduce the dredge's production rate. Generally higher unit costs can be associated with using this type of mechanical dredging (see Appendix A) (Herbich 1988). Controlled dredging operations by mechanical clamshell dredge result in sediment loss approaching 1-2% (Tavolaro 1984).

Debris Removal. Debris removal is a dredging concern since debris can cause equipment damage, reduced production rates, and cause disposal problems. In prototype contract documents, submerged debris has been defined as floatable debris or debris which by virtue of its size can prevent the bucket from effective grab and retrieval of excavated sediments. Typical methods of debris removal involve a debris barge which is transported to an off-loading site. A floating debris boom is placed around the site to prevent loss of debris dropped in the water.

Dewatering Methods. Material excavated by a clamshell dredge can either be placed directly into a diked disposal site or be barged to a disposal site. This disposal site can either be in water, allowing for the bottom dumping of material, or upland, which requires that the material be rehandled and placed in the upland area. The material is excavated at approximately in-situ density, and excess water is minimal. Dewatering methods are similar to the methods described for the hydraulic dredges. A continuous trenching approach is effective with clamshell dredges.

Dipper Dredge

Transport Methods. The dipper dredge can either release the sediment in a side-casting area (in-water or upland) or it can place the sediment in a barge for disposal offsite. If the scow is allowed to overflow, which is normal dredging practice, mass release can be about 0.8%. This release can be controlled by not allowing overflow of the barge.

Sediment Fate. The best use of the dipper dredge is for excavating hard, compacted materials, boulders and cobbles, and rock or other solid materials after blasting. Although it can be used to remove most bottom sediments, the violent action of this type of equipment may cause considerable sediment disturbance and resuspension during maintenance digging of fine-grained material. Because it is difficult to retain soft, semi-suspended fine-grained materials in the buckets of dipper dredges, a significant loss of the fine-grained material occurs when the bucket is hoisted.

Dewatering. Since the dipper dredge excavates hard materials at an almost in-situ water content, the excess water in the transport barge is minimal. The dewatering methods are the same as for the clamshell dredge.

2.3.3 Specialized Dredges

Special-purpose dredging systems have been developed in recent years in the United States and abroad to pump dredged material slurry with a high solids content or to minimize the resuspension of sediments. Most of these systems are not intended for use on typical maintenance operations. However, they may provide alternative methods for unusual dredging projects such as removal of chemical "hot spots" (Herbich 1988).

Availability of this equipment is extremely limited, with several of the systems being a single prototype (see Appendix A).

Pneuma or Oozer Dredge

The pneumatic "pneuma-" or "oozer-" dredge can dredge sediments at slurry densities approaching in-situ concentrations (Figures 2.15 and 2.16). The operating principle involves use of compressed air and valving as the intake and pumping mechanism.

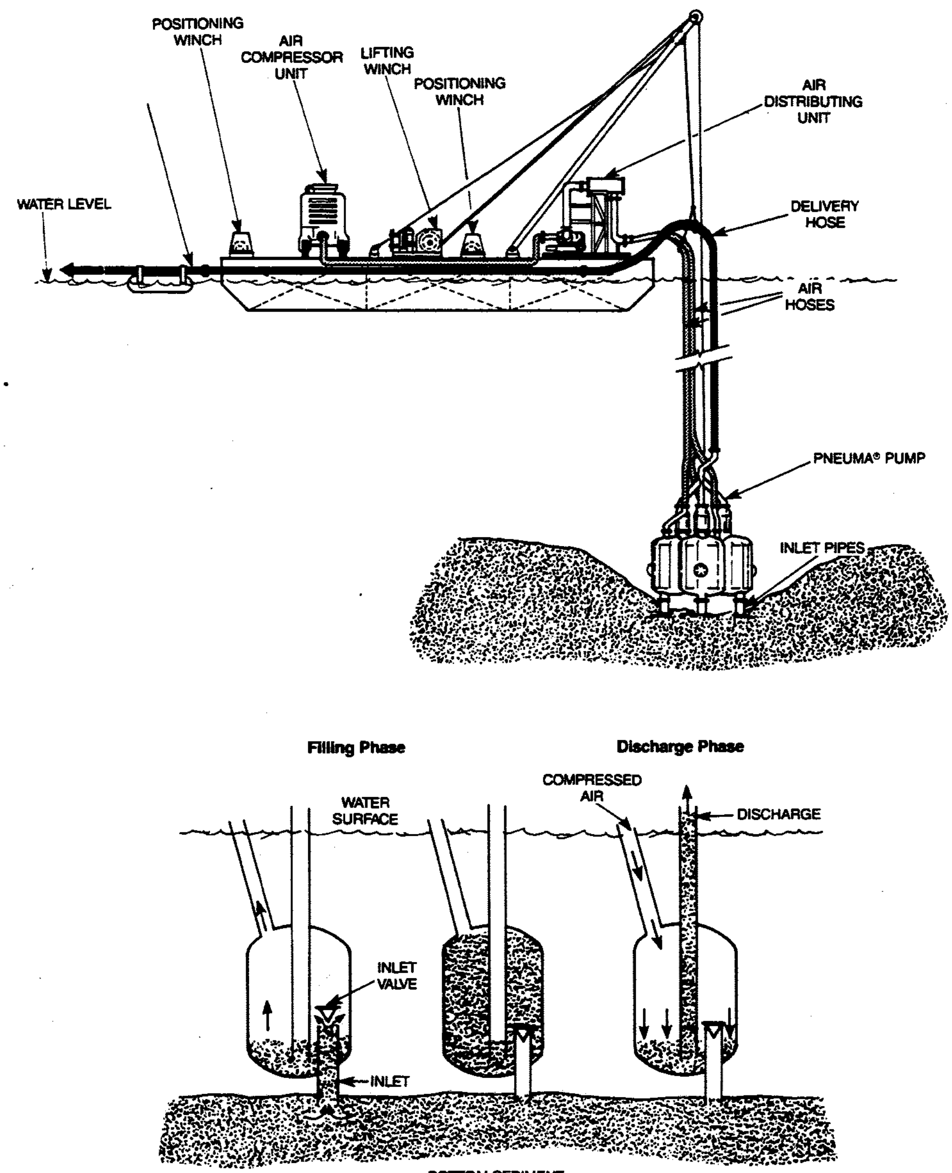
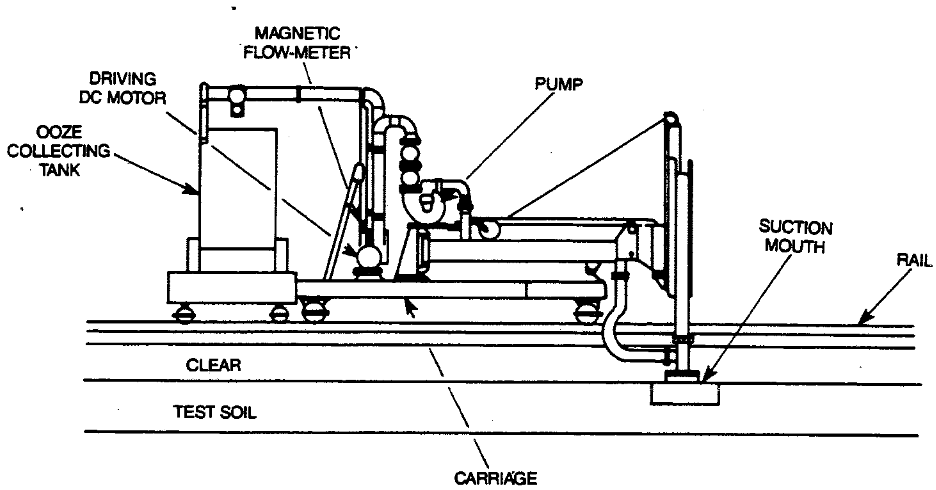
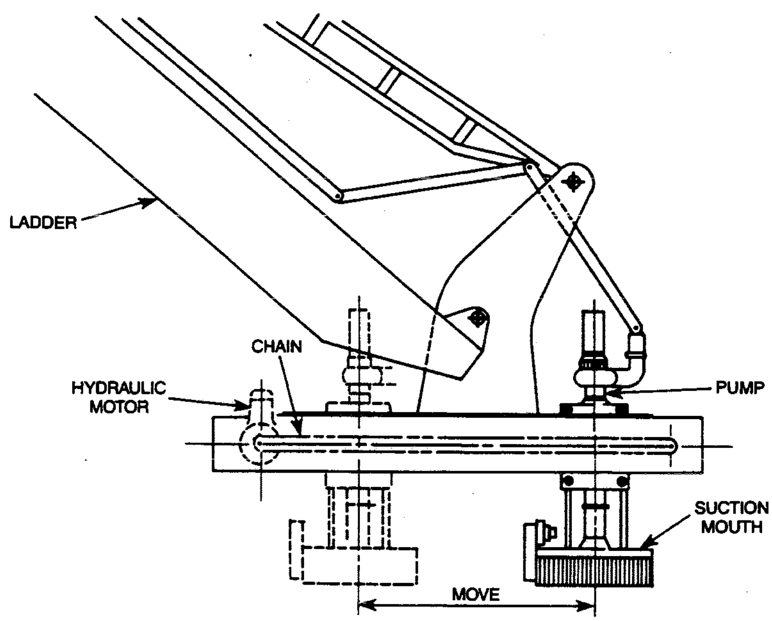


Figure 2.15 The pneumatic pump ("pneuma") system



The oozer dredge, showing overall system



Close-up of suction-mouth, pump and ladder orientation

Figure 2.16 The oozer dredge system

The conditions around the dredging system (the thickness of the sediment being dredged, the bottom elevation after dredging, as well as the amount of resuspension) are monitored by high-frequency acoustic sensors and an underwater television camera. Only very limited demonstration of these dredges has been made in the United States, but they have been extensively used in Europe and Japan. The use of compressed air as the transport forcing mechanism severely reduces the feasible length of pipeline distances from dredge to fill area.

Because the pneuma/oozer is used on special purpose jobs, it will generally represent a significantly higher cost dredging method than pipeline or clamshell dredging. Because this is a specialized type of dredge, its use will result in high mobilization costs.

"Mud Cat" Dredge

The "Mud Cat" is a small pipeline dredge (usually with an 8-inch to 10-inch diameter discharge line). Typically, it is equipped with a horizontal cutterhead with knives and spiral augers that cut the material and move it laterally toward the center of the augers where it is picked up by suction (Figure 2.17).

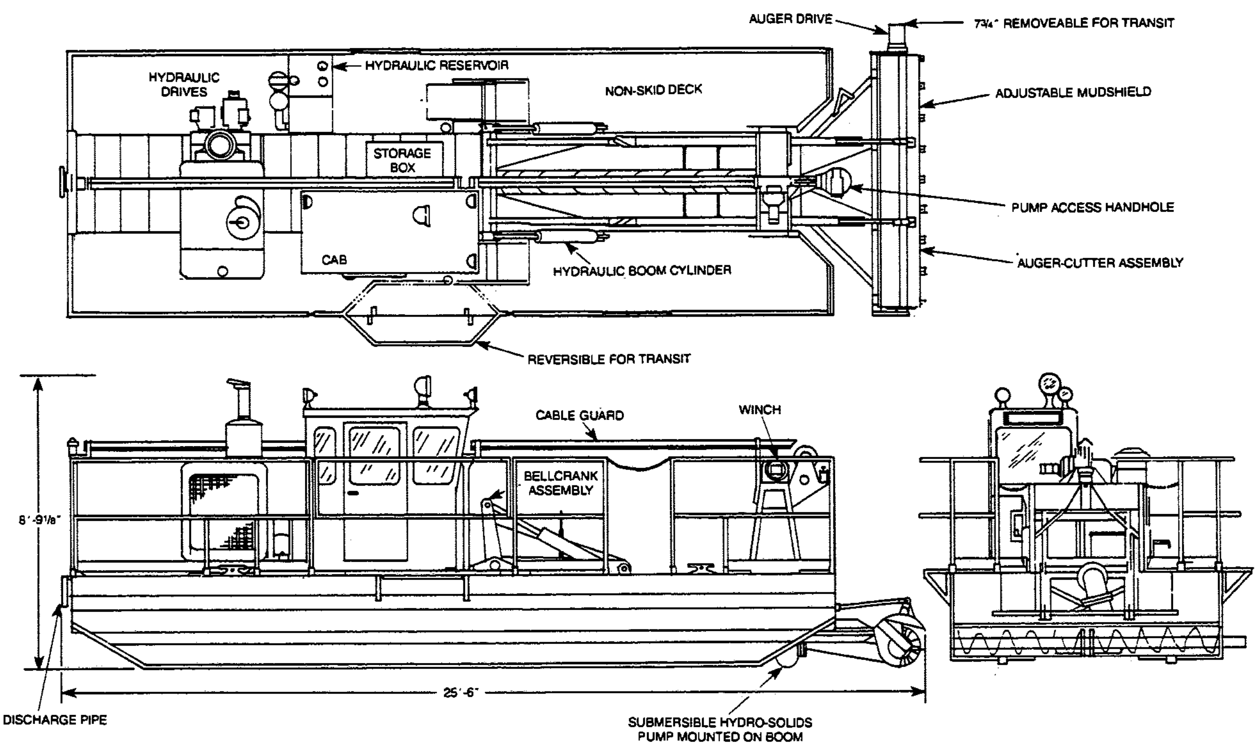


Figure 2.17 The "Mudcat" dredge

Clean-up System

To reduce or minimize resuspension of the sediment, Toa Harbor Works, Japan has developed a unique "Clean-up" system for dredging highly contaminated sediment (Figure 2.18). The "Clean-up" head consists of a shielded auger that collects sediment as the dredge swings back and forth and guides it toward the suction of a submerged centrifugal pump. To minimize sediment resuspension, the auger is shielded and a movable wing covers the sediment as it is being collected by the auger. Sonar devices indicate the

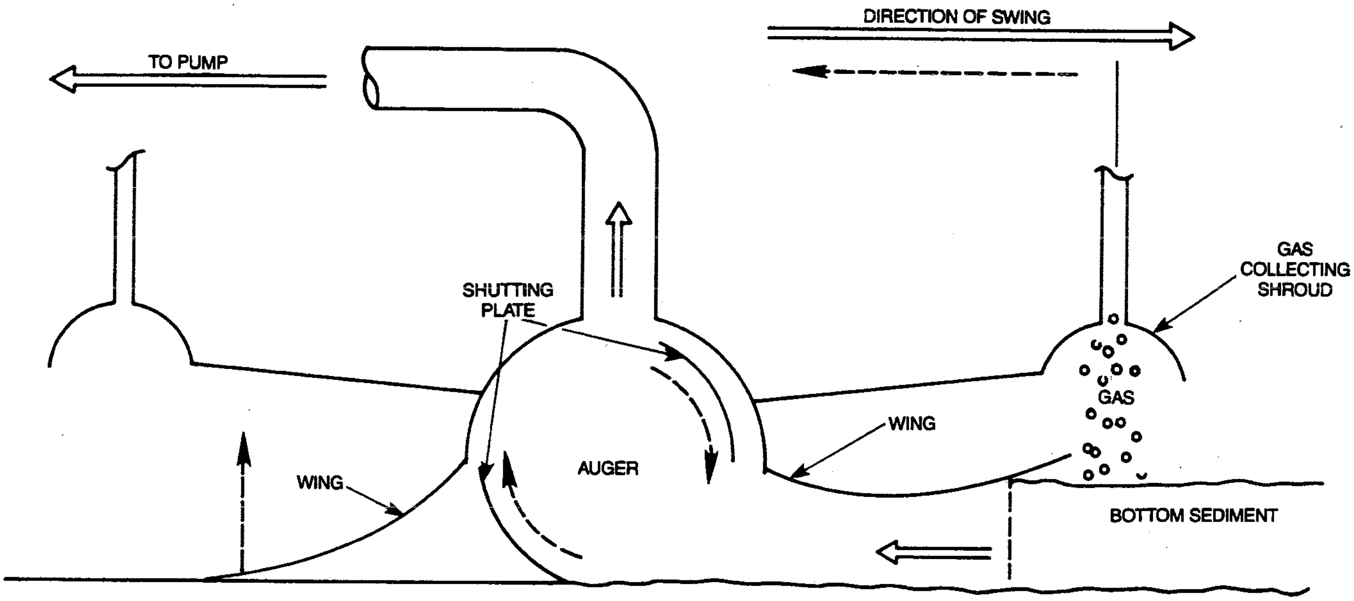


Figure 2.18 The "Clean-up" system

elevation of the bottom. An underwater TV also indicates the amount of material being resuspended during a particular operation.

Because the "Clean-Up" dredge is used on special purpose jobs, it will generally cost more than pipeline or clamshell dredging. And since this is a specialized type of dredge, it also has higher mobilization costs.

Refresher System

The "Refresher" dredge was developed for removal of contaminated materials. The dredge material is confined by a specially-designed flexible enclosure that completely covers the cutter, preventing escape of sediments to the outside of the immediate dredging area (Figure 2.19).

Because the "Refresher" dredge is used on special purpose jobs, it will generally cost more than pipeline or clamshell dredging. Since this is a specialized type of dredge, its use may require high mobilization costs.

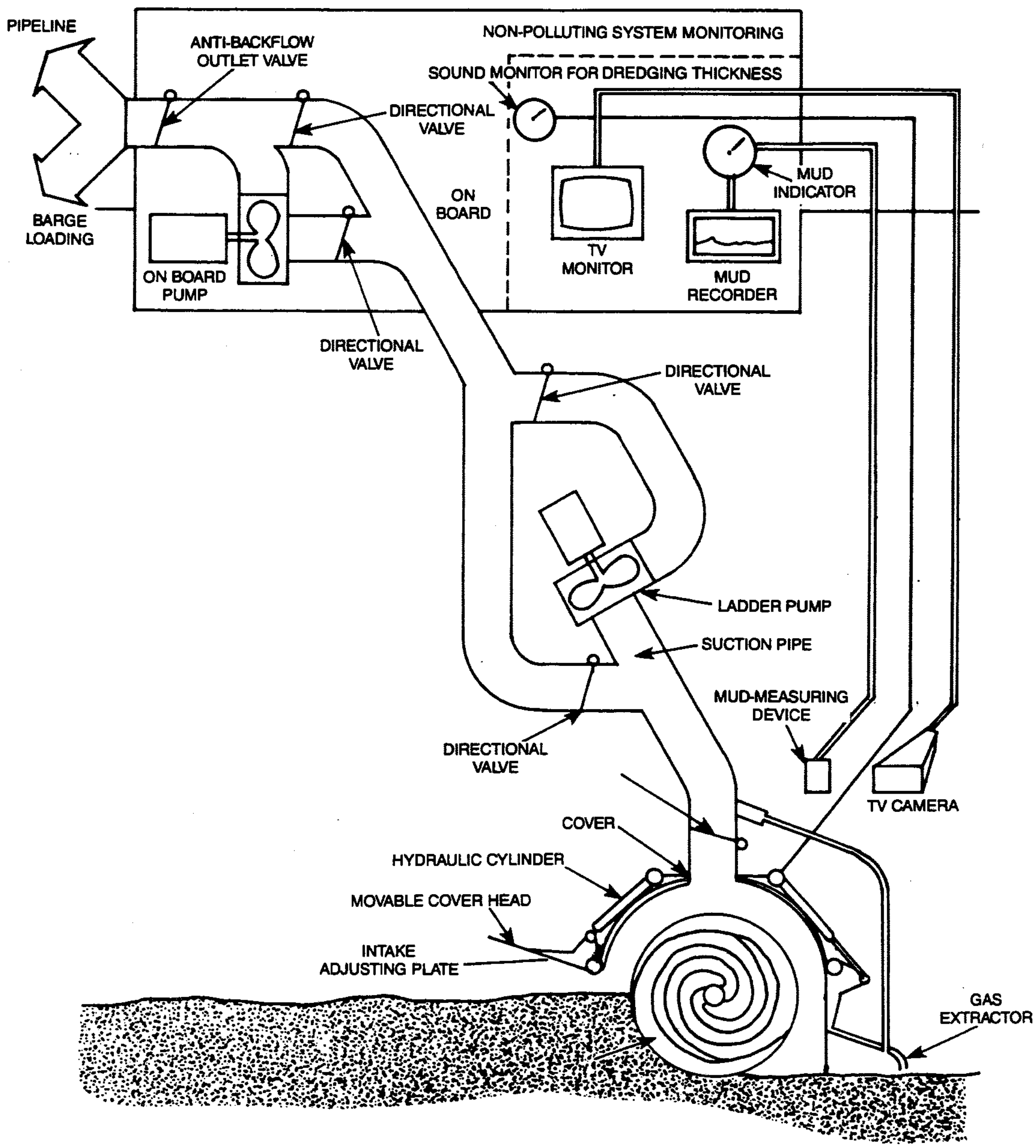


Figure 2.19 The "Refresher" dredge

Siting Guidelines

THE FISHERMAN from DAS STÄNDEBUCH by JOST AMMAN, 1568

3. SITING GUIDELINES

3.1 INTRODUCTION

Site review is the first step in the decision model process for determining the most appropriate confined disposal environment for contaminated sediments (see Figure 1.4). The purpose is to identify a range of sites or the best site conditions for the disposal environment(s) a proponent is considering. The availability and suitability of disposal sites will influence other steps in the confined disposal process, including sediment characterization requirements and the cost and effectiveness of alternative site designs for the available environments. (An overview of the decision model for confined disposal and the role of siting guidelines in this process is presented in Figure 1.3, and is described in Section 1.5).

The siting guidelines were developed as a tool for use by proponents in discerning the relative values of available disposal sites. The guidelines are based on applicable regulations and legislation, as well as functional site design requirements. The guidelines are not intended to be used as a pass or fail criteria or to select a preferred site. Instead, they provide a common basis for discussion among regulatory agencies and project proponents and will assist in distinguishing favorable sites and identifying concerns to be addressed in the final design. A proponent using the siting guidelines to evaluate candidate sites will be able to:

- Identify fatal flaws and major problems for a site that warrant dismissal from future consideration
- Choose between the functional design and effects-based design based on the characteristics or features of a site.
- Help guide the proponent's decision in the next step of the process, which is determining the appropriate tests for initial characterization.

3.1.1 What the Guidelines Provide

These guidelines provide an overview of the criteria to be considered in evaluating possible disposal sites.

Section 3.2, **Advisory Review,** provides an overview of regulatory framework affecting in-water, nearshore and upland disposal sites in Puget Sound. In particular, the guidelines identify legislation on contaminated sediment disposal siting.

Section 3.3, **Siting Restrictions**, summarizes key legislation from Section 3.2. Several existing laws, policies, or programs administered by regulatory bodies can delay or deny site approval. This section briefly summarizes laws that would eliminate a site in conflict.

Section 3.4, **Siting Considerations,** identifies key subjects for site consideration. These key subjects are ranked from most-preferred to least-preferred. Subjects of major consideration incorporate difficult-to-define concerns or those with an apparent high social value.

Section 3.5, **Performance Criteria,** establish preliminary site suitability for functional design. The inability of a site to meet or exceed functional design criteria indicates final site approval will be done under the effects-based design process.

3.1.2 What the Guidelines Do Not Provide

These guidelines as prepared are not intended to be a stand-alone decision making tool for site selection and design. The guidelines will not replace the existing environmental review processes and an additional permit process is not envisioned. Instead, these guidelines support and inform the existing permit and environmental review processes.

These guidelines are a preliminary and general overview approach to contaminated sediment disposal site evaluation. They will not apply equally to all proposed project descriptions since any project may vary in size, timing, character of its materials, and other factors that create differing impacts. For example, small volume projects create different effects than large volume projects or sediments with varying levels and types of contaminants have varied disposal effects.

3.1.3 How to Apply Guidelines

As a proponent compares candidate sites against the siting guidelines it is important they understand what statutes and permits they will be required to comply with. A proponent should not expect to actually obtain permits during the siting guidelines step. Awareness of permitting requirements, however, is crucial in terms of evaluating a site's potential acceptability.

An applicant may use the restrictions identified in siting considerations and the criteria for functional design as a checklist to indicate a degree of site acceptability. This would also indicate the emphasis of site conditions imposed on design detail necessary to obtain permit approval.

The permit reviewer (regulating agency) will not use the siting guidelines as a means for permit denial. By applying the siting considerations and criteria for functional design, permit review can evaluate a site and identify the potential need for mitigation. This evaluation is preliminary in the decision-making process and will be typically followed by a more detailed analysis, NEPA, and SEPA.

3.2 ADVISORY REVIEW

Legislation and regulations will directly affect the siting of a disposal area for contaminated dredged sediments. This section highlights selected relevant federal and state statutes, regulations and policies. This overview summary is taken from the legal review done as part of Phase I studies (URS 1989). The laws selected for analysis are the existing laws with the most general influence on the management of Puget Sound contaminated sediments. Additional information can be found in the Phase I review (URS 1989).

The regulatory structure which must be considered during dredged material disposal site siting is extensive and overlapping. However, though the various laws, policies, and regulations vary in specific content, their intent is common. Protection of human and wildlife environments are the key shared objectives of the regulatory framework. These objectives apply to both siting dredged material disposal areas, as well as the corrective action of removing the sediments of concern from their open environment.

Proposed regulations, other state and federal laws that may affect projects more subjectively, and laws from local jurisdictions are not included in this summary. In addition, this review does not analyze the various permit application and appeal processes.

The regulatory framework affecting in-water, nearshore, and upland contaminated dredged material disposal in Puget Sound involves federal, state, and local agencies. These agencies are charged with upholding specific statutes, regulations, and policies. For dredged material disposal projects, the permitting process is the primary mechanism by which these agencies exercise their responsibilities. Consideration of this regulatory framework is essential for siting in-water, nearshore, and upland dredged material disposal areas.

3.2.1 Key Federal Regulations

The Clean Water Act Section 404/The Rivers and Harbors Act Section 10

The U.S. Army Corps of Engineers (Corps) is the lead federal agency for administering two federal laws affecting dredging and dredged material disposal. Section 10 of the *Rivers and Harbors Act*, approved in 1899, requires approval of construction activities in navigable waters by the Secretary of the Army. Section 404 of the *Federal Water Pollution Control Act Amendments (1972)*, as amended by the *Clean Water Act* of 1977, requires a permit for the discharge of dredged or fill material into the waters of the United States. These permits, known as Section 10/404, may be processed concurrently when both dredging and disposal/filling are necessary to construction, as is often the case with in-water or nearshore disposal.

All parties, including federal agencies, are subject to regulation under Section 10 and Section 404. Separate regulations, however, govern the Corps' own dredging and disposal activities.

Section 10. A Section 10 permit is required for any dredging activity in navigable water, regardless of the location of the disposal site. For purposes of Section 10, navigable waters generally are those U.S. waters below the mean high water mark, or those used or usable for interstate or foreign commerce.

Section 404. A Section 404 permit is required only for point source discharges of dredged or fill material into navigable waters or wetlands. Therefore, in evaluating candidate sites, a proponent should consider whether or not a 404 permit will be required. A Section 404 permit is required when dredged material is disposed in either an aquatic or nearshore environment. It is also required when dredged material will be hydraulically placed in an upland environment and effluent from the disposal will be returned to navigable waters. This can occur where dredged material that is not dewatered is placed in nearshore or upland disposal sites.

The Clean Water Act (CWA) has the authority over "waters of the United States." This is a broader authority than suggested in the Rivers and Harbors Act Section 10. CWA Section 502(7) defines "navigable waters" to mean "the waters of the United States, including the territorial seas." The Corps' administrative definition of "waters of the United States" extends to all waters, including lakes, streams, mudflats, wetlands and sloughs, "the use, degradation or destruction of which" could affect interstate or foreign commerce. This definition includes wetlands adjacent to these waters. Section 404, therefore, covers a broader category of areas and activities than Section 10.

Each Section 404 permit must specify a disposal site. Under Section 404(c), the Administrator of the Environmental Protection Agency (EPA) has developed, in conjunction with the Secretary of the Army, guidelines for evaluating specific proposed aquatic or nearshore disposal sites. EPA retains oversight authority regarding the Corps' decision to issue a permit and may veto permit approval whenever it determines that the discharge of dredged or fill materials would have an "unacceptable adverse effect" on municipal water supplies, shellfish beds and fisheries, wildlife, or recreational areas.

The 404 Guidelines evaluate potential disposal sites based on potential impacts on the physical, chemical, and biological characteristics of the aquatic environment. The 404 Guidelines specify four conditions for any permit.

1. There must be no other practicable alternatives that would have less adverse impacts on the aquatic environment.

2. The disposal must not result in violations of applicable state water quality standards, toxic effluent standards, or marine sanctuary requirements.

3. The disposal must not cause or contribute to significant degradation of the waters of the United States.

4. The permit applicant must show that all appropriate and practicable steps have been taken to minimize potential adverse impacts of the discharge on the aquatic environment.

After considering the 404 Guidelines and input from U.S. Fish and Wildlife Service and others, the Corps makes a final decision based on whether the activity to be permitted is in compliance with 404(b)(1) guidelines. Thereafter, a review is conducted and findings made whether the proposed activity would be in the "public interest." In contrast, the Corps decision to issue a Section 10 permit is based solely on this "public interest" review. Public interest review also includes compliance with other federal laws. The Corps has substantial authority to require mitigation to avoid, minimize, rectify, reduce, or compensate for resource losses. In addition, Corps regulations require that the Corps consider more than 30 federal environmental laws, regulations, policies and executive orders. Unless "categorically excluded," the Corps must conduct a NEPA "environmental assessment" (EA). EAs determine whether the proposal could have "significant environmental impacts" requiring more detailed study in an environmental impact statement. (See NEPA/SEPA discussion following.)

Numerous state and federal agencies, Indian tribes, and other interested parties may review and comment on the Corps permit decision. These parties may also use the Corps permit public notice to instigate their own permit or review programs. In Washington, the Department of Ecology comments officially to the Corps on the state's position on coastal management consistency.

Endangered Species Act of 1973. The *Endangered Species Act* of 1973 (as amended), Section 8, requires federal agencies to ensure their actions do not jeopardize endangered or threatened species or their critical habitats. If a project would likely affect an endangered species, consultation with U.S. Fish and Wildlife Service and National Marine Fisheries Services is required to conserve such species and their critical habitats.

Resource Conservation and Recovery Act/Solid Waste Disposal Act

Dredged materials covered in these confined disposal standards are not considered solid or hazardous waste. The Federal Resource Conservation and Recovery Act (RCRA) regulates the generation, treatment, storage and disposal of solid and hazardous wastes. In general, RCRA governs management of the waste streams, while the federal Superfund authorizes cleanup of areas already contaminated by past practices involving hazardous substances. RCRA establishes guidelines for solid waste plans, but leaves management to the state. RCRA also establishes federal standards for generating, treating, sorting, and disposing of hazardous waste.

EPA's solid waste regulations appear in 40 CFR 240-257. The key provisions are:

1. Part 241-Guidelines for the Land Disposal of Solid Waste. This provision addresses all aspects of solid waste disposal, including site selection, facility design, water and air quality considerations, gas control, vector control,

aesthetics, cover material compaction, safety considerations, recordkeeping, and exclusion of specific solid wastes.

2. Part 257-Criteria for Classification for Solid Waste Facilities and Practices. This provision defines eight criteria used to determine when a solid waste disposal site will be considered an "open dump" for purposes of a state's solid waste management plan under RCRA.

The Washington State Department of Ecology is authorized as the state agency for implementing RCRA in the state. Also, Washington state defines a broader category of wastes as "hazardous" than the federal RCRA program.

National and State Environmental Policy Acts

The National Environmental Policy Act (NEPA) and the State Environmental Policy Act (SEPA) require all government agencies to identify and control environmental impacts resulting from their actions. These actions include planning, permitting, or funding decisions on the management and disposal of dredged sediments. These laws specifically overlay other laws and government programs. They apply only to a project or activity subject to a permit approval or governmental decision. NEPA and SEPA indirectly govern agency decisions by requiring all decisions to take environmental factors into account. NEPA governs activities of federal agencies and departments. SEPA covers the activities of state and local government, including local legislative bodies.

NEPA and SEPA are enforced by environmental impact analyses. Actions subject to environmental review first undergo an environmental assessment (NEPA) or state environmental checklist (SEPA). Projects determined to have no significant impact may have various mitigative measures placed on their permits or approvals. Projects with potential significant environmental impact must prepare an environmental impact statement.

Neither NEPA nor SEPA contain any specific requirements for the management and disposal of contaminated sediments. Both acts are intended to address gaps and overlaps in the existing regulatory structure. An agency may condition or deny any proposal. However, such decisions must be based upon specific environmental policies designated by the agency and the decision necessary to mitigate or avoid environmental effects identified in the environmental documents. For instance, the Washington State Office of Archaeology and Historical Preservation, in coordination with the Federal Advisory Council on Historical Preservation, has the authority to review project proposals to determine whether or not there are potential effects on archaeological or historical resources. If impacts are anticipated, appropriate mitigation measures can be required.

3.2.2 Key State Regulations

The Clean Water Act Section 401/The Washington Water Pollution Control Act

Washington State's 401 Certification Program. Section 401 of the Clean Water Act requires state certification that any federally-permitted project discharging into U.S. waters will not violate federal and state effluent limits or water quality criteria. Section 401 certification is a precondition to compliance with Section 404 guidelines. Compliance with guidelines is required before receiving a Section 404 permit for disposal of dredged or fill material. The 401 certification is required when dredged material is to be placed in an aquatic or nearshore environment. It may be required when dredged material is hydraulically placed in an upland environment where return flows may affect navigable waters. Navigable waters under the 401 certification are generally interpreted broadly, including wetlands, mudflats, sloughs, and other areas also considered under the 404 review.

The Washington State Department of Ecology is the agency for certifying under Section 401 that a proposed discharge will comply with the applicable provisions of state and federal water quality laws. Under the Section 401 certification program, Ecology certifies and may condition the Section 404 permit. Ecology may use any requirement or policy of state law that protects aquatic habitat and beneficial uses in conditioning the Section 404 permit under Section 401.

The Washington Solid Waste/Hazardous Waste Management Acts

Washington's hazardous waste and solid waste programs are carried out by Ecology, under RCW Chapter 70.105 and WAC 173-303 for hazardous wastes and RCW Chapter 70.95 and WAC 173-304 for solid wastes. The applicable state programs depend on the categorization of the waste. Specific procedures are outlined in WAC 173-303 to determine whether a waste is "dangerous" or "extremely hazardous." If it qualifies as either, it is subject to the dangerous waste regulations and must be treated or disposed at a permitted or approved hazardous waste facility. Dredged materials covered in this standard are not considered as dangerous or extremely hazardous.

The Washington Solid Waste Management Act. The purpose of Washington State's Solid Waste Management Act is twofold:

- To prevent the indiscriminate disposal of solid wastes by specifying treatment, recycling and disposal standards, and implementing a permit system
- To ensure that there is adequate planning for the management and disposal of solid wastes.

The Act assigns primary responsibility for adequate solid waste handling to local government, reserving to the state the functions necessary to assure effective statewide programs. The Act also delegates the permit and enforcement program for specific waste management facilities to the county or city board of health. Ecology reviews local decisions for compliance with applicable laws and regulations.

The Solid Waste Management Act requires a permit from the jurisdictional health department for the maintenance, establishment, substantial alteration, expansion or improvement of a solid waste disposal site or facility. The goal of the solid waste regulations is to set minimum performance standards for solid waste handling. It requires best available technology for siting solid waste facilities. It also requires available and reasonable methods for designing, constructing, operating, and closing solid waste handling facilities. These methods are referred to as "Minimum Functional Standards."

The 1985 revisions to these standards created a category of "problem wastes". Problem wastes include dredged materials that are unsuitable for open-water disposal, not dangerous wastes, and not being disposed under a Corps Section 404 permit. The upland disposal of these problem wastes requires a permit from the jurisdictional health department. In summary, all upland disposal of unsuitable sediments requires jurisdictional health department permits. However, not all upland disposal activities require Section 404 permits.

The Minimum Functional Standards for solid waste landfills focus on the disposal facility, not the disposal material. They do not provide specific siting, design, or monitoring standards for problem wastes disposed as dredged material.

The Washington Hazardous Waste Management Act. Classification of dredged material as a dangerous waste would subject the generators and transporters of the material, and the operators of a treatment, storage and disposal facility, to detailed requirements and restrictions under the dangerous waste regulations.

Any material qualifies as a "dangerous waste" under the dangerous waste regulations if it is a solid waste and is found to be "dangerous." The dangerous waste regulations apply regardless of whether disposal occurs on land or in open water. Dredged material would be considered a dangerous waste if it meets the following criteria:

- Listed on the regulations' dangerous waste lists (WAC 173-303-081)
- Exhibits one or more dangerous waste characteristics (WAC 173-303-090, having to do with ignitability, corrosivity, reactivity, and toxicity)
- Found to be toxic, persistent or mutagenic (WAC 173-303-101 through 103).

Specific procedures are outlined in WAC 173-303 to determine whether a waste is "dangerous" or "extremely hazardous." If it qualifies under either classification, it is subject to the dangerous waste regulations and must be treated or disposed at a permitted or approved hazardous waste facility. <u>A "dangerous waste" will not qualify for disposal as established in these confined sediment disposal standards</u>.

Hydraulics Project Approval, State Department of Fish and Wildlife.

A State Hydraulics Project Approval permit is required for actions affecting the natural flow of waters. The permit application must be acted upon within 30 days after receipt of the full permit application, including determination of compliance under SEPA. The State Departments of Fisheries and Wildlife, for an in-water or nearshore disposal area, are concerned with impacts on foodfish and shellfish. Recommendations for mitigation will be made as well as monitoring project effects.

Washington Aquatic Lands Act

The Department of Natural Resources (DNR) has proprietary authority to manage the state's aquatic lands in trust for the public. DNR has the power to lease aquatic lands for development and to rent or be paid for the use of aquatic lands for discharge of dredged material. Aquatic or nearshore disposal sites can be subject to DNR's management. However, DNR does not directly control upland disposal of dredged material, except on state-owned lands.

Washington Shoreline Management Act

The Washington Shoreline Management Act, RCW Chapter 90.58, requires a permit for any "substantial development" within the shorelines of the state. The Act defines "shorelines of the state" to include designated water bodies and their submerged beds within the state's territorial limits and all land areas 200 ft landward of ordinary high water and adjacent wetlands. Local jurisdictions have responsibility for overseeing compliance with Washington State's Shoreline Management Act of 1971. Ecology's Shorelands Program oversees and reviews municipalities' plans and decisions as well as provides an avenue for appeals. This is the formal mechanism for determining compliance with Federal Coastal Zone Management Act compliance.

Preferential uses for shorelines, as designated in the Act, are (in their order of preference):

1. Recognize and protect the state-wide interest over local interest
2. Preserve the natural character of the shoreline
3. Result in long-term over short-term benefit
4. Protect the resources and ecology of the shoreline
5. Increase public access to publicly-owned areas of the shorelines
6. Increase recreational opportunities for the public in the shoreline
7. Provide for any other element as defined in (the Act) deemed appropriate or necessary.

Construction of an aquatic or nearshore confined disposal site requires a Substantial Development Permit (given that the project exceeds the $2,500 minimum value). Each jurisdiction has responsibility for ensuring that the intent of WAC 173-14 regarding substantial development within shorelines is met. The Shoreline Management Act guidelines also specify that "shoreline areas are not to be considered for sanitary landfills or the disposal of solid waste." The guidelines do not define solid waste. If solid waste is defined as it is in the state Solid Waste Management Act, contaminated dredged material unsuitable for open-water disposal is included. However, contaminated material as defined in the proposed confined disposal standards may be exempted from this requirement.

The affected local jurisdiction may issue a shoreline substantial development permit if the proposed use is consistent with both the local Shoreline Master Program and the policies of the Shoreline Management Act. Local zoning and land use requirements are integrated with the Shoreline Master Program process.

The Puget Sound Water Quality Authority

In 1985 the Washington state legislature established the Puget Sound Water Quality Authority (PSWQA). PSWQA is responsible for adopting a comprehensive management plan (the Plan) for Puget Sound and for preparing a biennial "State of the Sound" report. The Plan is responsible for specifying recommendations for a "program of dredged spoil disposal, including interim measures for disposal of dredge spoil material from or into Puget Sound."

PSWQA reviews and comments on the consistency of major agency activities with the Plan and has the power to participate in administrative and subsequent judicial proceedings with respect to such actions. Inconsistent agency actions may be challenged by the Authority although such challenges are rare and reserved for situations where the action:

- Is critical to implementation of the Plan
- Is in direct and substantial conflict with the Plan
- Entails significant adverse water quality impacts which cannot be mitigated
- Will have multiple effects or implications for various water quality issues or programs.

Puget Sound Dredged Disposal Analysis (PSDDA)

The Puget Sound Dredged Disposal Analysis (PSDDA) program establishes guidelines for use of open-water unconfined disposal sites for dredged material. This program is a federal-state consensus program that derives basic authority from the Clean Water Act. Participating agencies include the Corps of Engineers, Ecology, DNR, and EPA. It is appropriate to note that PSDDA forms an important base on which implementation of the plan and subsequent development of confined disposal standards has evolved. The participating agencies carry out recommendations on the following:

- Disposal site selection
- Material evaluation procedures

- Disposal site management
- Disposal site environmental monitoring
- Dredged material data management.

PSDDA has developed comprehensive procedures for sampling and testing dredged material to ensure that disposal sites conditions meet site management objectives. The PSDDA guidelines require a general assessment of existing sediment toxicity, followed by biological testing, if chemicals of concern are above PSDDA chemical screening values and existing biological data is inadequate. Chemical and biological data for dredged material must not exceed PSDDA chemical and biological guideline values for the material to be considered suitable for unconfined open-water disposal.

PSDDA also addresses siting and monitoring requirements for open-water disposal sites. The sediment characterization, siting and monitoring guidelines developed under PSDDA have been adopted as part of the Puget Sound Water Quality plan. PSDDA offers a basis for identifying sediments suitable for unconfined disposal. Therefore, much of the discussion on screening requirements presented in Section 9.1 uses PSDDA as a base.

Superfund Sites

The federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the Washington State Model Toxics Control Act are designed to clean up sites contaminated by hazardous substances. These federal and state acts potentially apply to contaminated sediments, in situ or during dredging, if those sediments are located within designated cleanup sites under these laws. "Hazardous substances" under both acts are defined more broadly than "hazardous wastes" under RCRA or "dangerous wastes" under the Washington Hazardous Waste Management Act.

Other Regulations

Religious and cultural resource laws and regulations will affect siting, but applicability will vary with location. Relevant Native American religious use (e.g. Native American Religious Freedom Act) must be included in site review.

Various local regulations regarding groundwater protection, floodways, storm drainage, access, and other physical parameters must be considered during the siting process. These are addressed through city and county local ordinances and permit requirements. For instance, a fill and grading permit is required for a nearshore contained disposal site and project applicants must assess floodplain effects in accordance with Federal Emergency Management Agency criteria.

3.3 SITING RESTRICTIONS

Dredged material disposal sites at in-water, nearshore and upland sites in Puget Sound are restricted by existing regulations and laws. The regulatory framework was described in Section 3.2. This section reviews the regulations with the greatest potential to affect siting dredged material disposal areas. It also identifies the regulation(s) most likely to provide concerns or "fatal flaws" during a general siting process.

Aquatic and Nearshore Sites

The regulations most affecting the selection of in-water disposal areas are the Clean Water Act Section 404 and the Rivers and Harbors Act Section 10. The wording of the Section 404 guidelines suggests four potential "fatal flaws" for siting in-water areas for dredged material:

1. There must be no other practicable alternatives that would have less adverse impacts on the aquatic environment.

2. The disposal must not result in violations of applicable state water quality standards, toxic effluent standards, or marine sanctuary requirements.

3. The disposal must not cause or contribute to significant degradation of the waters of the United States.

4. The permit applicant must show that all appropriate and practicable steps have been taken to minimize the potential adverse effects of the discharge on the aquatic environment.

Endangered Species Act of 1973, (as amended), Section 8. This act requires federal agencies to ensure their actions do not jeopardize endangered or threatened species or their critical habitats. If demonstration is made that a project would be likely to affect an endangered species, consultation with U.S. Fish and Wildlife Service and National Marine Fisheries Services is required to ensure that such species and their critical habitats be conserved. The identification of endangered species habitat on (or perhaps near) a site could be a fatal flaw to permitting a site for disposal of dredged material.

Clean Water Act Section 401. This act specifies that discharge into U.S. waters will not violate any applicable federal and state effluent limits or water quality criteria. Further, under the Section 401 certification program, Ecology certifies and may condition the Section 404 permit. Ecology may use any requirement or policy of state law that protects aquatic habitat and beneficial uses in conditioning the Section 404 permit under Section 401. The violation of federal or state effluent limits or water quality criteria could be considered fatal to a project site.

State Hydraulics Permit. This permit protects fisheries' migratory pathways and habitat. Interference with important habitat or migratory pathways that cannot be mitigated could prove to be a fatal flaw. Sometimes construction timing or "windows" for certain activities are used to avoid this problem.

The Shoreline Management Act issues permits for construction on or near the shoreline. The act gives certain preference for uses, and these preferences could be used to withhold a permit for a nearshore dredged material disposal area.

3.3.1 Summary

Each of the regulations summarized in this section have some potential to create a fatal flaw that would dismiss a candidate site from further consideration. The regulations most likely to produce a "fatal flaw" are considered to be the following:

- The Endangered Species Act, in the case of an identified endangered species affected by dredged disposal plans

- Section 404 of the Clean Water Act, particularly as applied to wetland areas

3.4 SITING CONSIDERATIONS

Factors ranging from land ownership and use to physical characteristics of the site are important in determining the suitability of a site for contaminated sediment disposal. This section identifies and discusses categories to be considered. Within each category, various scenarios are presented and evaluated. The scenarios are then listed in order of preference. Each disposal environment is addressed separately. The degree of applicability of that category to the disposal environment is also addressed, and summarized in Table 3.1.

3.4.1 Upland

Ownership/Acquisition Potential: This category provides an approach for comparison of sites based upon the availability of a selected property. Those sites already under ownership of the project proponent would be most desirable. Private ownership provides options for a negotiated acquisition or condemnation. Other types of potential ownerships are federal, tribal, state, and municipal.

The various ownership scenarios, in order of preference, are:

Project Proponent (most preferred consideration)
Private: negotiated acquisition
State
Federal
Private: condemnation

Ownership/acquisition potential is directly applicable to the upland disposal environment.

Site Capacity: Capacity should reflect both the short- and long-term needs of the project proponent or users.

Table 3.1. Applicability of siting categories to each disposal environment.

	Upland	Nearshore	Aquatic
Ownership/Acquisition Potential	Direct	Direct	None
Site Capacity	Direct	General	Limited
Site Parcel Assemblage	Direct	Direct	None
Geology	Direct	Limited	General
Soils	Direct	Limited	General
Topography	Direct	General	General
Groundwater	Direct	Limited	Limited
Surface Water	Direct	Limited	None
Flood Hazard	Direct	Limited	None
Precipitation	Direct	Limited	None
Noise	Direct	Limited	None
Biological - Fisheries	General	Direct	Direct
Terrestrial	Direct	Limited	None
Endangered Species	Direct	Direct	Direct
Zoning	Direct	Direct	Limited
Land Use Compatibility	Direct	Limited	None
Shoreline Designation	General	Limited	None
Cultural/Historical/Archaeological Resources	Direct	Direct	General
Direct Routes	Direct	Direct	Direct
Population Density	Direct	Limited	None
Aesthetics	Direct	Limited	None

The three capacity scenarios are:

Meets long- and short-term needs (most preferred consideration)
Meets short-term need only (least preferred consideration).
Does not meet long- or short-term need (least preferred consideration)

Site capacity is directly applicable to the upland disposal environment.

Site Parcel Assemblage: It is more desirable to locate the disposal site on a parcel of land owned by a single owner. The availability of information, communications, ease of acquisitions and mitigations would likely vary depending upon the number of property owners involved. The time involved in obtaining rights of entry for preliminary investigations is also important to the project. This category compares the various sites as to the ease with which the required parcels for the disposal site could be assembled.

The various site parcel scenarios, in order of preference, are:

Single owner (most preferred consideration)
2 to 3 owners.
4 to 5 owners
6 to 10 owners

More than 10 owners.

Site parcel assemblage is directly applicable to the upland disposal environment.

Geology: Stable geological conditions are essential to facility operation, prevention of upset conditions, and minimizing the effects on adjoining marine or upland properties. The best situation would be where underlying deposits provide firm, structural foundation conditions and are relatively impermeable (e.g. consolidated fine-grained soils or impermeable bedrock).

The various geology scenarios, in order of preference, are:

Bedrock overlain by minimum 15 ft of consolidated sediments
Bedrock overlain by between 5 to 15 ft of consolidated sediments
Bedrock (non-rippable) overlain by a thin soil cover less than 5 ft thick
Site within 200 ft of a Holocene fault
Site in a known subsidence area
Weak or unstable soils on site.

Geological conditions are directly applicable to the upland disposal environment.

Soils: This category refers to the grain size and thickness of the soil located above the area wide water table as well as its potential treatment capacity and on site usefulness. The grain size of the soils present beneath the site are important to potential groundwater and leachate movement and site operation.

For example, if a site has dominantly coarse soil adjacent to its groundwater net, then the potential for groundwater contamination or contaminant transport would be relatively high. A more highly rated site would have both fine- and coarse-grained soils. This soil mix provides greater potential for absorption and attenuation of leachate.

The various soils scenarios, in order of preference, are:

Both fine- and coarse-grained soils greater than 30 ft thick
Fine-grained soils greater than 30 ft thick
Fine-grained soils less than 30 ft thick
Coarse-grained soils only.

Soils considerations are directly applicable to the upland disposal environment.

Topography: Disposal site topography is important because of its effect on site access, site stability, and constructability. Site access is important for contaminated sediment delivery and site closure. A site's stability influences how well it confines material. For upland disposal, site integrity would be reflected in the potential for groundwater infiltration.

The stability and constructability refers to onsite placement and confinement of contaminants. At upland sites, a flat topography could result in a poor ratio of volume of onsite soil excavated for every volume of in-place contaminant placement.

The various ground elevation scenarios, in order of preference, are:

> Site ground elevations provide natural advantages for sediment placement and access
>
> Site ground elevations provide limited advantages for sediment placement and access
>
> Site ground elevations provide no apparent advantages for sediment placement and access
>
> Site ground elevations provide distinct disadvantages for sediment placement and access.

Site topography is directly applicable to the upland disposal environment.

Groundwater/Hydrologic Boundaries/Beneficial Use: The best location would be where groundwater in the site's vicinity has a low present and projected beneficial future use and where hydrologic boundaries are established. Situations where hydrologic boundaries are not fixed present uncertainties regarding future aquifer designations and the future extent of groundwater use.

The various groundwater boundary scenarios, in order of preference, are:

> Low present and projected future beneficial use with hydrologic boundaries established
>
> Moderate present and projected future beneficial use with hydrologic boundaries established
>
> Moderate present and projected future beneficial use without hydrologic boundaries established
>
> High present and projected future beneficial use.

Hydrologic boundaries are directly applicable to the upland disposal environment.

Surface Water: A site's proximity to surface water with high beneficial uses is important. An upland candidate site far from a surface water body that has low present or projected use would be a highly rated site. A poorly rated site would be one near a surface water body that has a high current and projected beneficial use. Surface water bodies can be contaminated by groundwater and surface water originating from the disposal site.

The various scenarios, in order of preference, are:

Minimal discharge to surface water
Discharge to surface waters
Discharge to special resource water

Surface water is directly applicable to the upland disposal environment.

Flood Hazard (Water Resources): Flood hazard information from federal agencies, from the County Comprehensive Plan, and from County Assessor maps will be used to determine the flood hazard potential for each site. Generally, the area of the 100-year flood plain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent flood plain areas, that must be kept free of encroachment so that a 100-year flood can be carried. The area between the boundary of the 100-year flood plain and the floodway is termed the floodway "fringe." Any development in the floodway fringe would require a Flood Zone Control Permit and would be subject to special development requirements.

The various flood hazard scenarios, in order of preference, are:

Outside of 100-year flood plain or elevated above flood plain

Within the floodplain and outside the floodway fringe of 100-year flood plain

Within floodway of the 100-year flood plain, floodway boundaries modification possible

Within floodway of the 100-year flood plain, no boundary adjustment or other indication of severe unmitigable flood hazard potential.

Flood hazards are directly applicable to the upland disposal environment.

Precipitation: As precipitation increases, leachate also increases. Larger amounts of leachate increase the likelihood and significance of effects from leachate migration.

The various precipitation scenarios, in order of preference, are:

Under 35 inches per year
Between 35 and less than 45 inches per year
Between 45 and less than 55 inches per year
Between 55 and less than 65 inches per year
65 inches or greater per year

Precipitation is directly applicable to the upland disposal environment.

Noise: Noise generated by operation of the facility could affect adjacent land uses. For example, because some activities are more sensitive to noise than others, the King County Noise Ordinance (KCC 12.88 et seq.) establishes maximum allowable environmental noise levels received by rural, residential, commercial, and industrial land uses. The scoring of this criterion is based on the distance to the most sensitive noise receptor.

The various scenarios, in order of preference, are:

No other ownership within 1,000 yd of footprint
All industrial land use
Commercial land use
Residential or rural land use.

Noise impacts are directly applicable to the upland disposal environment.

Biological - Fisheries: Siting considerations specify that sites must be evaluated for potential effects on fisheries resources. Fisheries resources would be affected either directly by construction activities or by long-term effects, primarily on water quality.

The various scenarios, in order of preference, are:

No streams/rivers within 5,000 ft or more of the site.
No streams/rivers within 500 ft of the site
No streams/rivers within the footprint of the site

Fisheries resources have a general applicability to the upland disposal environment.

Biological - Terrestrial Habitat: Significant habitat (onsite flora and fauna) differences could exist at the various sites considered for nearshore and upland disposal. The habitat can range from grass, forest, and wetlands to critical habitat for endangered species.

The various habitat scenarios, in order of preference, are:

Low habitat value
High habitat value
"Critical" habitat
Significant impacts to "critical" habitat.

Terrestrial habitats are directly applicable to the upland disposal environment.

Biological - Endangered Species: Under EPA's criteria, a landfill or a contaminated disposal site that would harm any endangered species of plant, fish, or wildlife listed under Section 4 of the Endangered Species Act is a fatal flaw. Similarly, the facility or operation cannot destroy a critical habitat of an endangered or threatened species as identified in 50 CFR 17. This category is designed to compare sites as to their potential effects on endangered and threatened species.

The various endangered species scenarios, in order of preference, are:

Absence of endangered species on site
Presence of endangered species on site/no impact projected
Presence of endangered species on site/impact projected.

Endangered species are directly applicable to the upland disposal environment.

Zoning: Under local zoning codes, disposal sites would be permitted only in certain zones as "conditional" uses. A conditional use is authorized only after a public hearing and a determination by the Planning Commission that a proposal will not unduly affect surrounding uses. Such development conditions typically are imposed to assure that any projected effects will be adequately mitigated. Sites located in zones where landfills are potentially allowed as conditional uses are given the highest rating. Sites that would require a rezone or a zone permitting conditional use authorization are given a lower rating. (If the facility is located on tribal lands or within the boundaries of an incorporated area, differing local zoning regulations would need to be considered.)

The various zoning scenarios, in order of preference, are:

Zoning requires conditional use permit
Complies with Comprehensive Plan but would require rezoning, conditional use permit and/or amendment to comprehensive plan
Requires amendment to comprehensive plan and rezoning.

Zoning issues are directly applicable to the upland disposal environment.

Compatibility with Nearby Land Uses: Land use near the site is an important consideration because some land uses are associated with activities more susceptible to effects from a confined disposal facility. An industrial land use would be most compatible with a confined disposal facility. The least compatible land uses would be residential land, land uses with sensitive receptors such as schools, nursing homes or hospitals, and recreational land. The type of recreational use that would be sensitive in the latter context is activity-oriented recreation with concentrated use patterns. "Vicinity" is defined as a .25 mile distance from any part of the property.

The various land use scenarios, in order of preference, are:

Heavy industry
Light industry
Mixed industrial
Forest, agriculture
Business park
Commercial
Residential land, activity-oriented recreational land, or institutional (schools, nursing homes, hospitals) facilities with sufficient opportunities for mitigation or buffering.

Land use is directly applicable to the upland disposal environment.

Shoreline Designation: Shoreline management master programs can have a significant effect upon the lengths of time required to obtain permits for facilities.

The two shoreline designation scenarios are:

Not within the jurisdiction of a local Shoreline Management Master Program
Within the jurisdiction of a local Shoreline Master Program.

Shoreline management master programs are generally applicable to the upland disposal environment.

Cultural/Historical/Archaeological Resources: The types of resources from sites on the National Register to areas identified as being of archaeological importance to Native Americans need to be identified. The Native American Religious Freedom Act should also be included in site review. In some cases, it may be possible to have the resource on site and provide appropriate buffering or other protective measures to minimize any potential project impacts. At the other extreme, construction of disposal site would destroy the resource.

The various National Register resources scenarios, in order of preference, are:

No resources of significant cultural value on site, access corridor and/or adjoining areas
No resources of significant cultural value on site or access corridor but low impact on adjoining areas
Impact on resources on site and/or access corridor
Would destroy cultural/historical archaeological resources on site and/or access corridor.

Cultural resources issues are directly applicable to the upland disposal environment.

Direct Routes: This category addresses transportation effects associated with the transport of dredged material. Site locations where dredged materials from a dredging site to rehandling sites and final disposal will affect areas through which transport carriers must travel. Such transport of materials could have potential secondary effects on safety, air quality and noise. The most desirable site in this category would be reached through low-density areas.

The various direct route scenarios, in order of preference, are:

Transport access through non-residential or very low density overland or waterway uses
Access through low-to-medium density overland development or waterway use
Access available only through high density development or high use waterway.

Direct transport routes are applicable to the upland disposal environment.

Population Density - Residential: Population density measures a proposed disposal site's potential effect on people. A site located in an area with low population density would have the least potential for affecting people. Under some conditions, potential effects on people may be minimized, allowing location in a more densely populated area. For example, a disposal site with direct access to major transportation routes can be extremely well buffered.

The various population density scenarios, in order of preference, are:

No house within a 1/4 mile radius of site
1-5 houses within a 1/4 mile radius
More than 5 houses within a 1/4 mile radius of site.

Population density is directly applicable to the upland disposal environment.

Aesthetics: Disposal operations could have potential visual effects. The effects can be either impairment of scenic vistas or the visibility of the disposal operation. The strength of these effects is related to the location and relative topography of a site and to the availability of buffers to screen the operations. Buffers can be naturally forested areas, topographic features and, in some instances, manmade. The most desirable site in this category would be one with no significant visual effects on an area.

The various aesthetics scenarios, in order of preference, are:

Short- and long-term operations not easily visible from offsite
Short-term operation easily visible from offsite
Long-term operation easily visible form offsite
Impairment of scenic vistas.

Another factor affecting aesthetics is the duration of operation. Short-term operation and long-term operation are both important considerations. The various short-term scenarios, in order of preference, are:

8 hrs/day
24 hrs/day.

The various long-term scenarios, in order of preference, are:

one to two years
two years or more.

Aesthetics are directly applicable to the upland disposal environment.

3.4.2 Nearshore

Ownership/Acquisition Potential: In the nearshore environment, disposal of dredged material typically involves a proponent's own property. Proponents commonly have an upland use targeted for the nearshore site. The disposal of dredged material there, coupled with a cap to desired grade, is often part of a proponents plan for long range site development. It is uncommon for proponents to look to property they do not own for disposal of their dredged material.

The various ownership scenarios, in order of preference, are:

- Project proponent
- Private
- State
- Federal

Ownership/acquisition potential is directly applicable to the nearshore disposal environment.

Site Capacity: Site capacity at nearshore sites are often dictated more by the future use/proposed development of the disposal site than they are by the volume of the target dredge project. Nearshore sites typically only consider the short-term volume in terms of capacity because they tend to be constructed (filled) as a one-time use. They on occasion will consider dredged materials from other projects if the timing of the material's availability meshes with the construction of the site. The site capacity scenarios, in order of preference are:

- Accommodates target dredge site, other sites in proponent's dredging plans, and other dredged material in the project vicinity
- Accommodates target dredge site and other sites in proponent's dredging plans
- Accommodates only target dredge site

Site capacity issues are generally applicable to nearshore disposal.

Site Parcel Assemblage: Site parcel scenarios and order of preference are the same as those described for the upland environment. Basically single-owner parcels are desirable because they are less complicated.

Geology: Geologic conditions have limited applicability in the nearshore environment. Conditions should be such that the site is stable (no risk of upset/failure), and that there is ample volume capacity in the saturated anaerobic zone where contaminated dredge materials will be placed. No specific order of preference is provided for geologic conditions since they have only limited applicability.

Soils: Soil conditions are similar to geologic conditions in that they have limited applicability at nearshore sites. The main concern is that they provide a suitable foundation for the confinement berm. Since they are of limited applicability, no specific order of preference for soil scenarios is presented.

Topography: Topography considerations for nearshore sites are how it influences the structural integrity of the confinement dikes and how it effects the engineering of berms for the containment of the material. Steep sloped sites would dictate high confinement dikes that may be difficult to build. Topography scenarios, in order of preference are:

Gently sloped sites
Moderately sloped sites
Steeply sloped sites

Topography issues are generally applicable to nearshore sites.

Groundwater/Water Table Depth/Permeability: Permeability and groundwater issues are key considerations for nearshore sites. Water table depth is not such a great concern since the primary transport mechanism is transport of leachate through the berm, not down into the groundwater. Groundwater-permeability scenarios in order of preference are:

Permeability of contaminated dredge material at least three orders of magnitude less than the berm material
Permeability of contaminated dredge material at least two orders of magnitude less than the berm material
Permeability of contaminated dredge material at least one order of magnitude less than the berm material

Permeability and transport mechanisms are directly applicable to nearshore sites. The functional design standards presented in this report require that the dredged material be less permeable than the berm material so it can act as the "throttle" on leachate rates. Without such control some type of impermeable barriers would be required in the berm. This is not directly a siting issue since it is possible to transport berm material to the site rather than use native material at the site. However, proponents should consider transport distance between site and adequate berm material.

Groundwater/Hydrologic Boundaries/Beneficial Use: Hydrologic boundaries and beneficial uses of groundwater aquifers is of limited applicability for nearshore sites. Aquifers in nearshore sites are typically Class III aquifers due to the brackish water influence of adjacent marine water bodies, and do not have much potential for beneficial use. Therefore, no order of preference scenarios are presented.

Surface Water: Surface water, in terms of upland surface waters such as streams, is generally not applicable at nearshore sites. Disposal sites are typically designed to have minimal discharges to surface waters. At nearshore sites, surface waters are typically diverted to the adjacent water body, not surface waters. Because of the limited applicability, no order of preference scenarios are presented.

Flood Hazard (Water Resources): This factor in general does not apply to nearshore sites. Nearshore site construction can only have flooding impacts when located in a channelized waterway or at mouth of river.

Precipitation: This factor has limited applicability to nearshore sites. No order of preference scenarios are presented since it is of limited applicability (but are similar to those presented in the upland section).

Noise: This factor has limited applicability to nearshore site. No order of preference scenarios are presented since it is of limited applicability (but are similar to those presented in the upland section).

Biological - Fisheries: This is an important siting issue that is directly applicable to nearshore sites. Sites should be in areas that are of relatively low habitat value, particularly for economically important species such as juvenile salmonids. Various scenarios in order of preference are:

Poor habitat, more than two miles from estuary
Poor habitat, less than two miles from estuary
Good habitat, more than two miles from estuary
Good habitat, less than two miles from estuary

Biological - Terrestrial Habitat: This factor has limited applicability since nearshore sites are typically in industrial setting where there is limited habitat value associated with the terrestrial environment. Wetlands are an obvious critical habitat that should be avoided. Aside from wetlands, there is no reason to list an order of preference since it is of limited applicability.

Biological - Endangered Species: This factor, for nearshore sites, is the same as that described for the upland environment.

Zoning: Zoning issues in the nearshore environment are similar to those described in the upland environment.

Compatibility with Nearby Land Uses: This factor has limited applicability in the nearshore environment. Since nearshore sites are typically in industrial areas, their compatibility with nearby uses is typically irrelevant. Therefore, no order of preference scenarios are presented.

Shoreline Designation: This has limited applicability for nearshore sites since they will almost always be within a Shoreline Master Program jurisdiction that will designate shoreline development and use. No order of preference scenarios are presented for this factor.

Cultural/Historical/Archaeological Resources: This factor is directly applicable to nearshore sites, and order of preference scenarios are the same as those presented for upland sites.

Direct Routes: This factor must consider pipeline and barge transport routes in evaluating site locations. Routes should be through low density uses, but if transport methods are such that they mitigate a high density use (i.e., submerged pipeline), then density is not an important factor. The various route scenarios, in order of preference are:

Transport through low density waterway and shoreline uses
Transport through medium waterway same use
Transport through high density waterway same use

Population Density - Residential: This factor has limited applicability to nearshore sites since most sites are in non-residential, industrial areas. No order of preference scenarios are presented.

Aesthetics: This factor has limited applicability to nearshore sites since most sites are in non-residential, industrial areas. No order of preference scenarios are presented.

3.4.3 Aquatic

Several of the siting factors that are applicable to the upland and nearshore environments are **not** applicable to the aquatic environment. The factors that are not applicable include:

Ownership/Acquisition Potential (applies only to Dept of Natural Resources)
Site Parcel Assemblage
Surface Water
Flood Hazard
Precipitation
Noise
Biological - Terrestrial Habitat
Compatibility with Nearby Land Uses
Shoreline Designation
Population Density - Residential
Aesthetics

The remaining factors that are applicable are described below.

Site Capacity: This factor has limited applicability. CAD sites are typically one-time use. No preference scenarios are presented for this factor.

Geology and Soils: These factors are generally applicable to CAD sites. The geology of the site must be stable enough to support the deposition of material there. No order of preference scenarios are presented for these factors.

Topography: Irregular and steep slopes increase the chance of material spread beyond the site boundaries. Slope requirements are presented in the function design requirements for CAD sites. Topography features that provide natural depressions and/or natural berms are desireable site characteristics. Various scenarios in order of preference are:

Sites with natural depressions or berms
Relatively level bed topography
Irregular and steep slopes

Groundwater: Groundwater has a limited applicability at CAD sites. It has the potential to serve as a transport mechanism for diffusion of contaminants through the cap. Because of its limited applicability, no order of preference scenarios are presented.

Biological - Fisheries: Siting considerations recognize the importance of fisheries resources. Sites should be evaluated for their potential effect on these resources. At CAD sites, both construction and long-term effects are a concern. The various scenarios, in order of preference are:

No significant effects anticipated on benthic and fisheries resources
Effects anticipated on resident benthic and fisheries resources
High effects anticipated on benthic and fisheries resources due critical life stage activities occurring at the site (i.e., reproduction or nursery)

Biological - Endangered Species: This factor is also directly applicable to CAD sites. The order of preference scenarios are the same as those described for the upland environment.

Zoning: This factor has limited applicability to CAD sites and therefore no order of preference scenarios are provided.

Cultural/Historical/Archaeological Resources: This factor is generally applicable to CAD sites. The order of preference scenarios are the same as those described for the upland environment.

Direct Routes: This factor must consider pipeline and barge transport routes in evaluating site locations. Routes should be through low density uses, but if transport methods are such that they mitigate a high density use (i.e., submerged pipeline), then density is not an important factor. The various route scenarios, in order of preference are:

Transport through low density waterway uses
Transport through medium waterway use
Transport through high density waterway use

3.5 SITING CRITERIA FOR FUNCTIONAL DESIGN

This section describes site criteria identified for each disposal environment. The criteria must be met for functional designs to be allowed. In other words, these criteria go hand-in-hand with the functional design.

Failure of a site to meet these criteria does not eliminate a site from permit approval. The effects-based design approach can always be implemented to correct any differences or variations a site may have as it relates to the functional design. Also, meeting the design criteria does not equate to final approval of any site through the functional design approach. Other factors such as the level of sediment contamination also play a role in final site approval through the functional design route.

In this section, for each disposal environment, we have also discussed biological conditions. Although no absolute criteria are presented, we believe biological conditions at the site are important enough that site considerations should be re-stated. If this section is used as a checklist, it is crucial that biological conditions are not overlooked even though defined criteria are not available.

Confined Aquatic Disposal

The criteria for confined aquatic disposal sites include:

1. Water Depth. Depth of water ranging from -80 ft to -200 ft, MLLW. Depths less than this must be evaluated for need cap armoring. Depths greater than this may need special controlled placement of materials.

2. Bed Slopes. Bed slopes shall be 3% on the average or less. Slopes greater than this must be evaluated for berms.

3. Water Column velocities. Currents in water column shall not exceed 1.0 ft/sec during contaminated sediment placement. Nearbottom currents shall not exceed 0.5 ft/sec.

4. Sediment Volume. One-time disposal of 10,000 yd^3 to 1,000,000 yd^3 of contaminated sediments.

5. Bed Stability. Bed stability site conditions shall be evaluated based on most recent and relevant existing information. Sites demonstrating unusual bed topography, history of sloughing, or significant bed elevation changes shall be considered speculative and require further analysis under effects-based design.

6. Biological Conditions. The biological conditions at a CAD site must be considered before site acceptance is granted. These standards do not define critical limits or cut-off values above which a site would be considered a fatal flaw (i.e. density limitations for geoduck populations are not identified). They do, however, identify types of habitat and biological conditions (siting considerations) that will make the approval of a site more difficult to obtain:

   - Spawning habitat
   - Critical life stage habitat (nursery areas)
   - Presence of abundant populations that provide recruitment to other areas
   - Presence of isolated populations not present elsewhere in nearby areas
   - Native American historical fishing areas.

Nearshore Disposal

The criteria for nearshore disposal sites include:

1. Groundwater/Tidal Elevations. All contaminated sediments must be placed below the annual groundwater elevation to assure sediments remain in anaerobic, saturated condition. Correction of impact on potable groundwater must be applied if applicable to site conditions.

2. Bed Materials. Foundation materials for dikes must be identified and found suitable for confinement dike construction support.

3. Bed Stability. Bed stability site conditions shall be evaluated based on most recent and relevant existing information. Sites demonstrating unusual bed topography, history of sloughing, or significant bed elevation changes shall be considered speculative and require further analysis under effects-based design.

4. Confinement Structures. Engineering design and construction of confinement structures, including dikes, overflow and dewatering outlets, and equipment access routes must be completed before dredging. Design of the confinement structure must incorporate adequate structural strength and capacity or temporary access using baffles or silt curtains to contain materials below groundwater elevation and assure structural integrity during catastrophic events.

5. Biological Conditions. Similar to the standards for CAD sites, the nearshore standards do not specify density/population limitations. Proponents must recognize that nearshore sites represent development in a limited and important habitat region of Puget Sound. Therefore, mitigation requirements may be extensive depending on site location and design.

   The following conditions are identified as those that will make the approval of a site more difficult to obtain:

- Juvenile salmon rearing and migration area
- Vegetated wetlands
- Eel grass beds
- Gently sloping mud flat habitat
- Native American historical fishing areas.

Upland Mixed Disposal

The criteria for upland mixed disposal sites include:

1. Dewatering Site. Dredged sediments must be delivered to the upland mixed disposal site at approximately in-situ water content or dryer.

2. Confinement. Temporary confined disposal site for dewatering will be necessary. Functional design criteria for the dewatering site is similar to nearshore disposal confinement structures.

3. Bed Stability. Bed stability site conditions shall be evaluated based on most recent and relevant existing information. Sites demonstrating unusual topography, history of sloughing, or significant elevation changes shall be considered speculative and require further analysis under effects-based design.

4. Biological Conditions. Biological conditions must be considered before site acceptance is granted. Upland sites that have already been seriously degraded as wildlife habitat can be considered a more preferred siting.

5. Groundwater. Long-term confinement must not degrade or be detrimental to groundwater quality.

6. Surface Water. Long-term confinement must not degrade or be detrimental to surface water quality.

7. Flood Plains. Sites located on floodplains should be avoided. Any facility placed in a flood plain must have an effects-based analysis of cover integrity under a range of predicted conditions.

Upland Mono Disposal

The criteria for upland mono disposal is:

1. Dewatering Site. Dredged sediments may be delivered to upland mono disposal site at approximate in-situ water content condition.

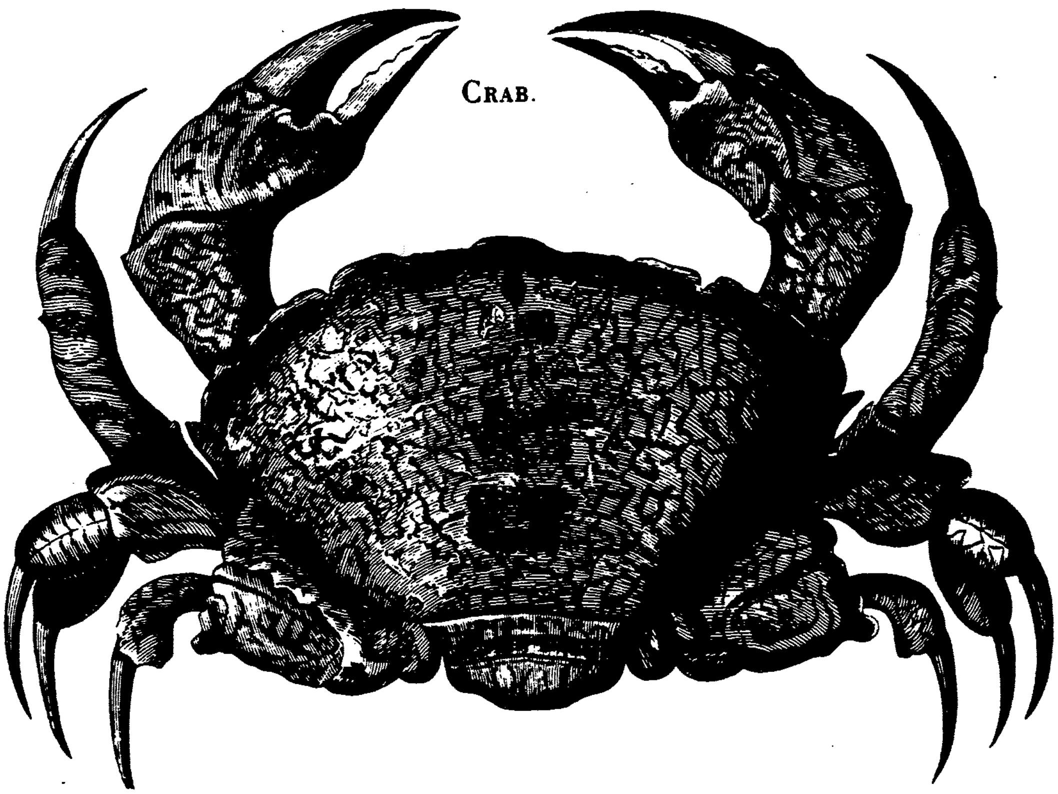
2. Bed Stability. Bed stability site conditions shall be evaluated based on most recent and relevant existing information. Sites demonstrating unusual topography, history of sloughing, or significant elevation changes shall be considered speculative and require further analysis under effects-based design.

3. Biological Conditions. Biological conditions must be considered before site acceptance is granted. Upland sites that have already been seriously degraded as wildlife habitat can be considered a more preferred siting.

4. Groundwater. Long-term confinement must not degrade or be detrimental to groundwater quality.

5. Surface Water. Long-term confinement must not degrade or be detrimental to surface water quality.

6. Flood Plains. Sites located on floodplains should be avoided. Any facility placed in a flood plain must have an effects-based analysis of cover integrity under a range of predicted conditions.



Testing

4. POTENTIAL SEDIMENT CHARACTERIZATION TESTS

4.1 INTRODUCTION

Sediment characterization is the second step in the decision model process for determining the most appropriate confined disposal for contaminated sediment (see Figure 1.5). This step provides information on the potential for sediments to release contaminants into the environment and allows determination of the suitability of the sediment for the various functional designs and disposal options.

A very broad array of tests can be used to characterize contaminated sediments. This chapter outlines the range of tests we considered and how we selected the recommended sediment characterization standards. Potential contaminant pathways for each disposal environment were evaluated, then we determined what tests were appropriate for addressing those pathways.

Section 4.2, **Summary of Potential Sediment Characterization Tests**, provides an overview of the physical, chemical, and biological tests that may be used to characterize contaminated sediments.

Section 4.3, **Test Interpretation Needs**, describes how the tests will be used to determine if sediment qualifies for the functional design options in the different disposal environments.

The recommended sediment characterization standards are presented in Chapter 9. These should provide reliable data on the sediment's potential to release contaminants into the environment. We also tried to allow proponents flexibility in determining the number and type of tests they perform.

4.2 SUMMARY OF POTENTIAL SEDIMENT CHARACTERIZATION TESTS

Initial characterization requirements may include physical, chemical, or biological tests to determine the dredged material's suitability for various disposal environments and design alternatives. The range of tests evaluated are presented in this section. Initial characterization addresses the sediment to be dredged and takes into account the disposal site environment. Detailed engineering for disposal site design may require disposal site characterization. Site characterization tests are not presented as part of these standards.

The results of the initial characterization tests will ultimately be used to determine the disposal site requirements and corresponding dredging and monitoring. The tests are not separated into distinct alternatives (i.e. Alternatives 1, 2, and 3) as are the disposal options. Separation into different alternatives does not provide a logical means of identifying/selecting required tests.

The key issues the potential characterization tests and eventual evaluation process need to address are these:

- What are the contaminant pathways and effects?
- What are the important pathways and effects?
- What tests have been used before?
- What other tests have been proposed, but are less established?
- How are sampling requirements determined?
- How are tests interpreted?
- How and when are decisions made regarding what tests go in initial characterization and which are left to the effects-based design?
- What do tests cost?
- How effective are tests given their costs?

4.2.1 Chemical Tests

Tests to determine chemical characteristics of the sediment will allow potential contaminant pathways to be assessed. The generalized pathways that release contaminants of concern into the environment from confined dredged material disposal sites are presented in Figures 2.1, 2.2, 2.3, 2.6, and 2.12. These pathways include the following:

- Release to the water column during dredging or disposal

- Release to surface waters via effluent from a disposal site

- Surface runoff after disposal

- Airborne emissions of volatile compounds or fugitive dust

- Release of leachate:

    - to surface water or groundwater in upland sites
    - to surface water by migration through cover materials by diffusion, bioturbation, or groundwater flow in CAD sites

- Direct contact

Some of these pathways may be part of one or more disposal alternatives. To simplify evaluating testing methods, the disposal alternatives and possible contaminant pathways are presented in Table 4.1.

Table 4.1. Disposal alternatives and potential contaminant transport pathways.

Pathway	Dredging/ Disposal	Capped Aquatic Disposal	Nearshore Disposal	Upland Disposal
	Disposal Alternatives			
Water Column (dredging & disposal)	X	X	X	X
Surface Water (effluent return)		X	X	X
Groundwater		X	X	X
Runoff			X	X
Airborne Emissions			X	X
Fugitive Dust			X	X
Direct Contact		X	X	X
Biological Uptake		X	X	X

Testing Methods

The testing methods for addressing the pathways of chemical contaminants may include bulk chemistry, leaching, rainfall simulator, or cap thickness tests. Sediment chemistry characterization methods for confined disposal are discussed by Peddicord et al. (1986). Table 4.2 summarizes these and other potential tests.

Chemistry Tests measure the concentration of contaminants of concern associated with the whole sediment (i.e. solid and liquid phases including all categories of bound contaminants). These tests typically involve aggressive digestion or extraction of whole sediments followed by instrumental analysis.

Leaching Tests generally can be divided into two types–batch and continuous. Batch leaching tests include elutriate, Extraction Procedure Toxicity test (EP Tox), Toxicity Characteristic Leaching Procedure (TCLP), and various modifications of these. Characteristically, these tests involve mixing specified volumes of sediment and leaching fluid for a short time (e.g. hours or days). Continuous leaching tests, on the other hand, involve passing unspecified volumes of leaching fluid through sediment for a longer time (weeks or months). Column leaching tests are continuous leaching tests done, usually, over one month.

In either batch or continuous leaching tests, the concentration of contaminants of concern is measured in the leaching fluid after the fluid contacts the sediment. In some cases, the concentration of contaminants of concern may be measured in residual solids.

Table 4.2. Summary of chemical tests for characterizing contaminated sediments for confined disposal.

Pathway	Test Methods	Reference
Water Column	Standard Elutriate Test Modified Elutriate Test	Palermo, 1986 Palermo, 1986
Surface Water	Batch Leaching Tests Column Leaching Tests Porewater Analysis	Hill et al. 1988
Groundwater	Column Leaching Tests Porewater Analysis Batch Leaching Tests	Hill et al. 1988
Runoff	Rainfall Simulator Tests Batch Leaching Tests	Skogerboe et al., 1987
Airborne Emissions	Bulk Chemistry Tests	EPA, 1986 or PSEP, 1986
Fugitive Dust	Bulk Chemistry Tests	EPA, 1986 or PSEP, 1986
Migration through Cap	Cap Thickness Evaluation Test	Brannon et al., 1985

An additional component of the leachate test is accelerated aging of the sediment to mimic the chemical changes which may take place under the conditions of upland disposal. After sediment aging, the leaching test is run and the concentration of contaminants of concern is measured in the leaching fluid.

The approach to assessment of contaminant release (leaching) from dredged material is in a developmental state. Communication with the Waterways Experimental Station indicates that new approaches may be recommended within the next two to three years. Because of this, it is important that the leaching tests recommended in this document be seen as evolutionary and transitional. As new tests become available and validated, their inclusion in the dredged material characterization will be appropriate.

An indirect method of evaluating leachate potential is the interstitial or porewater chemistry test. This test is valuable in establishing the in-situ steady-state porewater chemistry, but cannot specifically predict the nature of leachate in a changed environment, as would result from hydraulic dredging and disposal.

Rainfall Simulator Tests are highly specialized and involve equipment not widely available. In these tests, sediments are exposed to mimic field conditions such as cycles of wetting and drying, including simulated precipitation events. The concentrations of contaminants of concern may be measured in both liquid and solid phases.

Cap Thickness Tests are small-scale laboratory models used to measure diffusion or bioturbation of cap material placed over contaminated material. These tests, as yet experimental, typically last about 40 days.

Bulk Chemistry Testing is not listed as an alternative test for many issues of concern, it provides a basis for determining contaminants of concern. In addition, it is a useful screening tool for more complex tests. For this reason, bulk chemistry testing can be applied regardless of the confined disposal alternative.

Other Tests not limited to a specific pathway include the following:

- Extraction Procedure Toxicity Test (EP Tox) (EPA 1986)
- Toxicity Characteristic Leaching Procedure (TCLP) (Federal Register 1986)
- Persistence Testing Method Washington State Department of Ecology 83-13 (Ecology 1983).

The potential chemical characterization test methods and their disposal options are summarized in Table 4.3. The cost and duration of these tests is summarized in Table 4.4.

Disposal Environments

Capped Aquatic Disposal contaminant migration pathways include:

- Loss during disposal
- Bioturbation
- Migration through the cap
- Groundwater discharge.

Table 4.3. Potential chemical characterization test methods and their disposal environments.

Test Procedure	Capped Aquatic Disposal	Nearshore Disposal	Upland Disposal
Bulk Chemistry	X	X	X
Elutriate Tests	X[1]	X	X
TCLP/EP Tox			X[2]
Column Leaching	X[5]	X	X[3]
Rainfall Simulator			X[4]
Cap Thickness	X		

Notes:

[1]Special modifications of existing test protocol may be appropriate. Specifically, analysis of dissolved and total phases after one hour of settling has been used to indicate release characteristics for previously proposed CAD sites.
[2]These tests are grouped together because, while not directly useful to disposal of dredged material, one or both could be required for disposal in some operating landfills.
[3]If column leaching tests are performed on sediments proposed for upland disposal, the sediments should be allowed to dry before testing.
[4]Rainfall simulator tests are only applicable when site design does not include a cover.
[5]For capped aquatic disposal, column leaching tests may provide an indication of which contaminants of concern have sufficient mobility to migrate through a cap by diffusion or groundwater transport.

Table 4.4. Cost and duration of potentially applicable chemical characterization tests.

Test Procedure	Cost in Dollars[1]	Duration in Weeks[5]
Bulk Chemistry	$1,500	4
Elutriate Tests	$2,500	6
TCLP	$2,000	4
EP Tox	$1,800	4
Column Leaching	$8,000[2]	0[4]
Rainfall Simulator	$ 0[3]	0[4]
Cap Thickness	$ 0[3]	6
Sediment Aging/Oxidation	$ 0[3]	24

Notes:

[1]Costs assume testing may be required for all current PSDDA contaminants of concern.
[2]This cost is based on testing of four samples of leaching fluid.
[3]No established cost information.
[4]Duration flexible.
[5]Duration is only testing time requirements and does not include turnaround times.

At this time, no standardized methods have been developed to directly assess the physical conditions expected at the confined aquatic disposal functional design site after construction. The Waterways Experiment Station has used a laboratory simulation test (Palermo et al. 1989) to mimic short-term (six weeks) conditions, but tests for longer time periods are not yet available. Modifications of existing tests, such as column leaching, may provide a basis for estimating contaminant migration. Losses of contaminants during disposal can be addressed using standard elutriate testing.

Nearshore contaminant migration pathways include:

- Effluent during disposal
- Leachate migration primarily to surface water
- Direct contact, runoff, and atmospheric pathways (when cover is absent).

Modified elutriate and column leaching tests can be used to assess these first two pathways.

Upland Disposal contaminant migration pathways include:

- Effluent during disposal
- Runoff after disposal
- Airborne emissions
- Biological uptake
- Leachate migration.

Modified elutriate tests address effluent characteristics. Bulk chemistry tests can be used to evaluate airborne emissions. Runoff tests should be conducted only if runoff from the site is expected, a function of whether or not an upland site has a cover. Tests to establish biological uptake are listed elsewhere in this document. Modified column leaching tests can be used to estimate leachate concentrations.

4.2.2 Physical Tests

Physical characterization tests (e.g. soil index properties such as grain size, water content, or plasticity) may be necessary to verify that sediment to be dredged has physical characteristics compatible with engineering designs. Once the disposal environment and design are selected, the next step, detailed engineering of a functional design, may require further sediment characterization. A range of physical tests may be required for both the initial characterization and subsequent detailed engineering. The physical tests required for initial characterization are identified in Section 9.1.

Based on settling properties, volume changes, and disposal stability, physical characterization tests help determine dredge equipment selection and disposal site design. Among the questions physical characterization tests will answer are these:

- What equipment will be required to dredge the sediments?
  - Is there debris onsite?
  - What types of sediment are onsite?
  - What is the lateral and vertical extent of the major types of sediment onsite?

- How will the dredged sediment settle?
  - How will the disturbed sediment settle at the dredge site to limit turbidity at the dredge?
  - How will the sediment settle at the disposal site to limit turbidity in the overflow water?
  - What will be the rate of initial settling of the suspended sediment into a dense slurry/soft soil?
  - How much material will settle outside the disposal site?

- What is the volume of sediment?
  - What is the in-place volume?
  - What will be the initial volume at the disposal site (after initial settling)?
  - What will be the volume after self-weight consolidation settlement?

- How can the dredged material be placed in a stable mound at the disposal site?

Each of these questions applies to various disposal environments and the appropriate tests to answer the questions vary.

Testing Methods

The physical testing methods for sediment characterization tend to be well established by past practice and engineering standards. A summary of physical characterization tests and their usefulness for initial characterization and detailed engineering design is presented in Table 4.5. Tests that determine settling behavior, particle size, water content, and permeability are especially important in disposal site design.

Settling Column Tests were developed by the U.S. Army Corps of Engineers to quantify the suspended solids concentration in effluent and the rate of settling within confined disposal sites. The test is conducted in a large-diameter cylinder by mixing sediment with water, then letting the sediment settle. The rate of settling and turbidity of the water above the sediment is measured during the test.

Particle Size Tests are used to quantify the estimates made during visual classification. The particle size for gravel and sand is determined by passing sediment through a series of sieves with decreasing opening sizes. The particle size distribution for silt and clay is determined by settling behavior of the sediment in a cylinder filled with water. Two common methods for silt and clay particle size measurement are the hydrometer method and pipette method.

The sediment particle size, test is useful for assessing issues such as dredging methods, disposal methods, potential water quality effects, and benthic habitat potential.

Table 4.5. Summary of appropriate physical characterization tests for sediment.

Test Method	Applicable Initial Characterization Tests for Most Disposal Environments	Applicable Initial Characterization Tests For Some Disposal Environments	Might Be Applicable for Engineering Design
Site History	X		
Diver Survey			X
Side Scan Sonar			X
Surface Sample	X		
Test Dredge			X
Geophysical survey			X
Cores or Borings	X		X
Penetration test		X	
Cone or vane shear			X
Visual classification	X		
Water content	X		
Particle size distribution	X		
Lab. classification	X		
Specific gravity	X		
Organic content	X		
Settling column test		X	X
Test fills			X
Bathymetric survey	X		
In-place density	X		
Compression test		X	X
Consolidation		X	X
Shear strength			X
Permeability		X	X

Water Content of the sediment is determined by laboratory testing. Water content testing is recommended for initial characterization. In saturated samples (which is the case for sediments) the total and dry unit weights can be calculated from the water content and specific gravity of the soil particles. In addition, the water content of silt and clay give an indication of the strength of the sediment.

Permeability is established by one of three methods. The first method is correlation of soil index properties to typical permeability values. The second method is consolidation testing, which is also a measure of one-dimensional permeability. The third method is direct permeability measurement.

4.2.3 Biological Tests

Tests that determine the biological characteristics and toxicity of material to be dredged may be necessary. These tests will measure the toxicity of the sediments. The range of tests and their potential relevance to disposal environments is summarized in Table 4.6.

Table 4.6. Summary of biological tests and their relevance to disposal environments.

Test Type	CAD	Nearshore	Upland
Amphipod Bioassay	X	X[1]	
Echinoderm Larvae Bioassay	X	X[1]	
Oyster Larvae Bioassay	X	X[1]	
Juvenile Bivalve	X	X[1]	
Neanthes Chronic Test	X		
MicroTox	X	X	
Plant Uptake			X
Wetland Bioassay		X	
Earthworm Bioassay		X	X
Daphnia Bioassay		X	X
Minnow Bioassay		X	X
Trout/Salmon Bioassay		X	X

[1]Should be elutriate tests to be meaningful.

4.3 TEST INTERPRETATION NEEDS

Tests conducted during initial characterization need interpretation criteria. The criteria will be used to determine if the contaminated sediment qualifies for the functional designs of the various disposal environments or if an effects-based design will be necessary. The actual test interpretation criteria are identified in Chapter 9, Section 9.1.

4.3.1 Functional Design

As described in Chapter 1, the confined disposal standards afford two approaches: functional and effects-based. Functional design defines a prescribed design a proponent can use to meet regulatory requirements. Most Puget Sound sediments requiring confined disposal have relatively low-level contamination. They are closer to passing PSDDA than being classified as a dangerous waste. Accordingly, the functional designs were designed to be suitable for sediments with relatively low levels of contamination. Test interpretation criteria identify these limitations. The criteria we have proposed are presented in Chapter 9.

4.3.2 Effects-Based Design

Effects-based designs are customized elements within a Functional Design that will typically be used in one of four instances:

1. A proponent has a specific disposal site that does not fit the performance criteria associated with the functional designs.

2. A proponent has a very slightly contaminated sediment and wants to ease the requirements of a functional design.

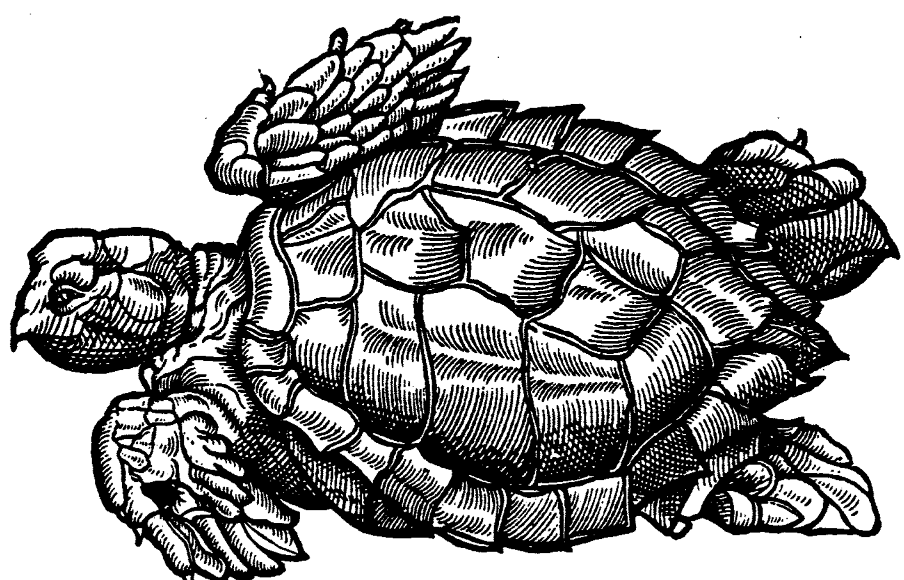
3. A proponent has sediment more contaminated than the functional design allows and must determine where and how the functional design needs to be strengthened.

4. A proponent has a new design feature they want to try.

In each of these scenarios, different characterization tests may be used to determine the effects-based solution. We cannot predict what tests will be required without knowing the details of the specific dredge project. Likewise, we cannot establish effects-based test interpretation criteria without knowing what specifically the effects-based design is attempting to accomplish. Therefore, the standards for effects-based design identify:

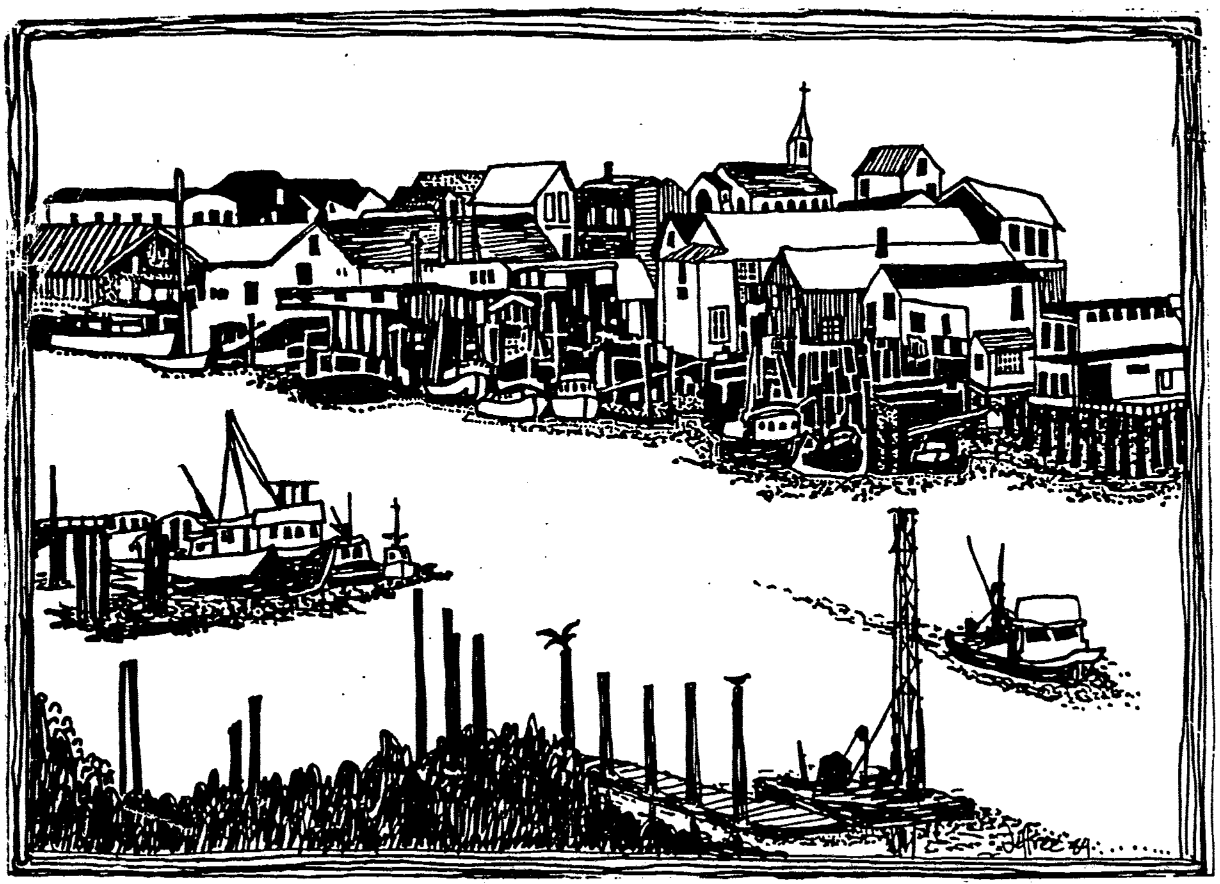
- test type
- pathway
- type of results
- use and interpretation of the test results.

This information is presented instead of specific test interpretation criteria. The effects-based testing recommendations are presented in Section 10.2 of Chapter 10.



MARINE TURTLE.

functional design



5. DREDGING, TRANSPORT, AND DISPOSAL SITE FUNCTIONAL DESIGN ALTERNATIVES DEVELOPMENT

5.1 INTRODUCTION

The development of design alternatives follows site review and sediment characterization in the decision model (see Figure 1.3). The alternatives include dredging and transport, site design, and monitoring components. This chapter describes the various site design elements for each of the four disposal environments (CAD, nearshore, upland mixed landfill, and upland monofill landfill). These elements are then used to identify functional design requirements and develop three alternative designs for each environment. The preferred alternative selected as the recommended standard is described in Chapter 9. Overviews of the disposal environments and the site design and alternatives comparison steps in the decision model are presented in Figures 1.6 and 1.7.

This chapter is organized by disposal environment. Each disposal environment is addressed in a section of the chapter:

- Section 5.2 - **Confined Aquatic Disposal**
- Section 5.3 - **Nearshore**
- Section 5.4 - **Upland Mixed Fill**
- Section 5.5 - **Upland Monofill**

Because dredging and transport are closely related to site design, the alternatives presented in this chapter include dredging and transport requirements (see Chapter 2 for additional information on dredging methods). Summary matrices comparing the alternatives and their respective features are also presented in this chapter.

Several alternative designs considered realistic and constructable with available equipment were identified. The alternatives provided different levels of environmental protection and cost-effectiveness. Three alternatives intended to provide low, medium, and high levels of environmental protection were subsequently selected, and are described in this chapter. The CAAP procedure (Chapter 8) was used to evaluate these alternatives and CAAP identifies a preferred alternative as the recommended standard.

We also considered a no-action alternative that was intended to reflect contaminated dredged material and disposal practices that occur today. This no-action alternative is presented as a reference for how much the alternatives vary from current practices. It will also be used as the no-action alternative in the EIS that will be written for these standards.

The primary site design requirement is to prevent long-term failure of contaminated sediment confinement. Disposal site failure presents the greatest potential for long-term contaminant release from sediments. In addition to environmental protection, the site design must be constructable and cost effective. Final design of any contaminated sediment disposal site will be a function of the confinement required, the level of contamination of the sediments, and the construction capabilities.

5.2 CONFINED AQUATIC DISPOSAL (CAD)

Confined aquatic disposal (CAD) design requires the controlled disposal of contaminated sediments at depth and adequate confinement of those sediments. Confinement always includes capping, and may or may not include underwater berms, natural depressions, excavation of a pit, or other features. The primary pathway for long-term contaminant loss is migration of contaminants through the confinement media (cap, berm, or bed). Another factor in contaminant loss is the integrity of the cap's cover against erosion, bioturbation, and geotechnical disturbances such as seismicity or slope failure. Secondary pathways are loss during the dredging and disposal activities.

5.2.1 CAD Design Elements

Considerations for developing final design elements for CAD disposal can be grouped into two broad categories: (1) location factors that directly affect the design, and (2) construction factors that must be undertaken for final design. Discussed here in terms of their importance to design, these factors are subdivided into the following specific items to consider for final functional design recommendations:

Location:	Biological conditions Water depths Bed slope Water column velocities Bed Stability (seismicity, slope sloughing, grain size)
Construction:	Cap (material type, thickness) Berms (natural, constructed) Area of site Distance from dredging.

Detailed technical information is provided in Appendix B for those items marked with an asterisk below.

Location

Site location has a major effect on the construction of a CAD site. Existing conditions at a site dictate its environmental acceptance, the boundaries of final design, and construction methods.

Biological Conditions. Biological use near the bottom and on the bed of the existing site must be identified to assess these problems:

- The potential for significant environmental effect on sediment disposal at the site
- The potential for bioturbation of the cap.

Water Depths*. Water depth is important because it can have a direct effect on cap integrity. Long-term cap integrity must consider the potential for capped sediments to be displaced or eroded. To protect the primary isolating cover layer from erosion by currents, a protective armor cap may be placed over this layer. For a CAD site placed in relatively shallow waters, currents from wave action or vessel passage may be a primary erosive force on the CAD protective cap. CAD sites placed in deep water are faced with the issue of whether or not sediment placement (both contaminated and clean cap material) can be done accurately enough to cap contaminants.

Bed Slope*. The slope of a site's bed creates design concerns for CAD disposal. Especially important is mounding. Two major processes determining mounding have been evaluated (Lukjanowicz et al. 1988):

- The tendency for sediments to flow because of the momentum generated during placement and slope impacts
- The tendency of the material to form a stable angle of repose.

Both processes are influenced by the method and the rate of dredged material placement and the condition or strength of the material being dumped.

Water Column Velocities*. Water column velocities influence CAD site design in two ways. First, the velocities can cause short-term contaminant loss by increasing areal spread of contaminated sediments. Second, current velocities can also cause long-term erosion of the cap and thereby compromise cap integrity.

A conservative CAD cap design would include primary cap material or secondary cap armor able to resist current-induced shear stress with little or no motion. For site water column velocities, the maximum yearly nearbed currents are a critical design factor. In addition, the bed shear stress produced by wave motion may suspend sediments, permitting transport by currents with velocities too low to initiate sediment motion.

Bed Stability. Stability of a long-term CAD site is of obvious concern. The potential for bed instability (slope sloughing and catastrophic failure) is a site design issue that needs to be considered to prevent site failure and contaminant release. Bed slope stability is directly associated with continuous delta building in some areas of Puget Sound as a result of major rivers discharging their bedload and suspended sediments.

Distance from Dredging. Distance from the dredging site is a transport and placement concern and is an example of how site design and dredge method are related. As a rule of thumb, distances greater than 2 to 3 miles would use haul barges and point dumping instead of hydraulic dredging and pipeline discharge.

Hydraulic pipeline dredges can pump distances greater than two miles, but require boosters in their lines. The CAD site will typically be located in open water, or in shallower water near the shoreline. The pipeline floats in exposed water and is subject to wave and wind conditions. Using long floating discharge lines of several miles in open or shallow water with booster pumps in line is not typical in the Northwest. Maintaining effective operation and avoiding pipeline separations is possible, but difficult in Northwest waters.

The equipment and labor costs for CAD would be significant. Additional boosters in line will decrease the daily effective time of a hydraulic dredge. Any pump breakdown stops the entire dredging operation until the booster unit problem is corrected. Long floating discharge pipelines require additional anchor barges to control pipeline position. These longer floating pipelines create a greater opportunity for navigation interference. However, shorter floating pipelines can be anchored, secured, and inspected to avoid most of these problems.

5.2.2 Construction*

CAD design depends on the location of the disposal site and the methods of dredging and transporting contaminated sediments. Final design plans for CAD sites must include geometric dimensions that meet all construction requirements.

Cap. Specifications for cap construction will include thickness of the cap and physical and chemical descriptions of the materials used. Cap thickness is based on the need to limit convection of chemical contaminants through the cap and to prevent biological contact with the contaminants. Physical characteristics of the cap are based on several requirements:

- Placing the cap over the contaminants at depth
- Preventing contaminant migration through the cap
- Acceptability of the cap materials to the benthos
- Preventing bioturbation or migration of contaminants through the cap
- Preventing direct benthos contact with contaminated material.

Berms. Berms, or underwater dikes, can be used in a CAD design. Their application in site engineering has been to define and limit the spread of contaminated sediments during placement (Corps 1986). They have also been used to limit the potential movement of mud waves from the site during cap placement (Hardin et al. 1988; Parametrix 1987).

Natural bed contours have been used in lieu of constructing dikes (Truitt 1986). This approach has advantages in that underwater dike construction on fine bed sediments is difficult. A natural depression provides confinement without cost. However, it has disadvantages since contour features acceptable for confinement use can also be indicative of localized bed sloughing or instability.

Area. The area of the bed available for material placement and cap material cover should be identified in the final design. Boundaries of an in-water disposal site have been determined, based on several criteria (Corps 1986, 1988). These boundaries were initially based on biological activity. No long-term significant effect on existing benthos and marine fisheries was allowed. Limiting the surface area of contaminated sediments exposed to the marine environment also limits the quantity of cap material. Depth of the bed and the method of placement likewise affect the construction limits of an acceptable site area.

5.2.3 Functional Design Alternatives

Introduction

Three alternatives for confined aquatic disposal were developed. The components of each alternative are summarized in Table 5.1. When possible within the matrix, quantifiable requirements for each component are stated. Otherwise, a "Yes" in the table denotes that the component is a part of an alternative, a "No" means a component is not required. "Not Specified" means that the component may be considered applicable, but is not specifically required. Many components were not applicable to every alternative (e.g. bucket size is not applicable to an alternative that uses a hydraulic dredge).

Each alternative presented in Table 5.1 will afford a specific level of protection. Alternative 1 is the most environmentally protective. Because Alternative 1 does not have cost restrictions (other than availability of equipment), it is the high-cost alternative. Alternative 3 is the least protective and least costly. We have not attempted to identify the levels of environmental protection associated with the no-action alternative. In some cases, it may provide more protection than Alternative 3, but in most cases, it does not.

Table 5.1. Summary of confined aquatic disposal dredging and design alternatives.

	ALTERNATIVES			
	1	2	3	N.A.[1]
DREDGE METHODS				
Mechanical Dredge				
- Clamshell	Yes	Yes	No	Yes
- Dipper	No	Yes	No	No
Hydraulic Dredge				
- Cutterhead	No	No	Yes	Yes
- Suction	No	No	Yes	No
Bucket Size (yd^3)	>5	>5	n.a.	No limit
Retrieval Rate Limitations	Yes	Yes	n.a.	None
Depth Tolerance Limitations	2 ft	2 ft	1 ft	2 ft
Dredge Depth (ft)	<200	<200	Equip Limited	Equip Limited
Anchor Placement Controlled	Yes	Yes	Yes	Yes
Overcutting Restrictions - Cutter Diameter	n.a.	n.a.	Yes	None
TRANSPORT METHODS				
Haul Barge	Yes	Yes	n.a.	Yes
Bottom Dump	Req'd	Req'd	n.a.	Not Req'd
Hopper Separation Units	4	Not Spec.	n.a.	Not Spec.
Hydraulic Check Requirements	Yes	Yes	n.a.	None
Overflow Allowed	No	No	n.a.	Not Spec.
Pipeline Restrictions	n.a.	n.a.	Subm. in channel	n.a.
Booster Pumps	n.a.	n.a.	<2	Not Spec.

Table 5.1. Summary of confined aquatic disposal dredging and design alternatives (continued).

	ALTERNATIVES			
	1	2	3	N.A.
MATERIAL PLACEMENT				
CONTAMINATED				
Release Rate	Inst.	Inst.	n.a.	Inst.
Positioning Accuracy Requirements (m)	3	3	3	None
- taut line buoy	Yes	Yes	n.a.	
- real time electronic positioning system	Yes	Yes	n.a.	
- positioning for each dump recorded	Yes	Yes	n.a.	
Submerged Diffuser	n.a.	n.a.	<2 ft/sec 10-40 ft from bed	n.a.
CAP MATERIAL				
Control Release Rate	Req'd	Req'd	Req'd	Not Spec.
Max Thickness of 1 Lift	<3 ft	<4 ft	<4 ft	Not Spec.
Slurry Discharge	n.a.	<2 fps	<2 fps	Not Spec.
Positioning Accuracy Restrictions (m)	3	3	3	None
DISPOSAL SITE DESIGN				
Depth Limitations				400 ft
• -80 to -200 ft	Yes			
• -05 to -200 ft		Yes		
• -200 to -400 ft			Yes	
Bed Slope				Vary
• Slopes	<4%	<2%		
• Unconsolidated Bed Sediment Thickness	≥30 ft	≤ 30 ft		
• Engineering Study to Confirm Acceptability	Yes	Yes	No	Not Req'd
Berm Requirements				Vary
• All Sites	Yes			
• Berm if Slope >4%		Yes		
• Berm only to Limit Total Bed Area			Yes	

Table 5.1. Summary of confined aquatic disposal dredging and design alternatives (continued).

	ALTERNATIVES			
	1	2	3	N.A.
Water Column Velocity Restrictions				Vary
• Water Column	≤1 fps	≤1 fps	≤1 fps	
• Near-Bottom	≤0.5 fps	≤0.5 fps	≤0.5 fps	
Bed Stability				
• Bed Stability Assessed by Professional	Yes	Yes	Yes	Vary
Cap Thickness	≥3 ft	≥3 ft	≥3 ft	Vary
Cap Physical Quality Restrictions				
• Uniform Grade, Clean Silty Sand	Yes			
• Sand Sediments (.2 - .4 mm)		Yes	Yes	
• Include Armor Layer		Yes		
Cap Chemical Quality Restrictions				Vary
• P-2	Yes			
• PSDDA		Yes		
• As Clean or Cleaner than Nearest Bed Reference Station			Yes	

[1]No-Action
n.a. = Not Applicable

The alternatives are organized into the following major components:

- Disposal site design
- Dredge type
- Transport method
- Material placement.

Disposal site design is selected first because site design includes location identification. Site location and design are the basis for selecting preferred dredging and transport methods for contaminated sediments.

Assumptions for Functional Design

In developing the functional design alternatives, we assumed the level of contamination in those sediments would be relatively low compared to the range of chemical constituents in dangerous waste (WAC 173-303, WAC 173-304). The actual level of contamination determined acceptable for the CAD functional design is presented in Section 9.1.

The functional design is appropriate for a sediment volume of approximately 10,000 yd^3 or more. Sediment volumes less than 10,000 yd^3 can be considered under the small projects standards (Chapter 11), as well as the functional design or the effects-based design approach.

Contaminated material physical characteristics can range from fine-grained sediments such as silts and clays to coarse-grained sediments such as sand. Typical contaminated sediments in Puget Sound are sandy silt (predominantly fine grain with some sand) or silty sand (predominantly sand with some fine grain).

5.3 NEARSHORE DISPOSAL

Nearshore disposal design requires a confined disposal site located within the area of sea level influence and groundwater interactions. This area typically includes intertidal fluctuation zones and subtidal inundated zones. The subtidal zone typically encompasses most of a nearshore site. Nearshore sites are typically used with direct placement of dredged sediments transported from the dredging site. Contaminated sediments will be deposited within the disposal site to an elevation that assures long-term anaerobic (oxygen-less), saturated conditions.

Leaching of contaminants through the confinement media (shoreline, bed, or dike materials) are the primary pathways for long-term contaminant loss with nearshore disposal. This loss can occur by groundwater movement through the site, seepage, tidal pumping, and surface runoff.

5.3.1 Nearshore Design Elements

Factors for developing final design elements for nearshore disposal are grouped into two general categories–location factors and construction factors. These are subdivided further into the following specific items of consideration for final functional design recommendations:

Location:
- Biological conditions
- Groundwater/tidal elevations
- Bed materials
- Equipment access
- Distance from dredging

Construction:
- Confinement structures
- Effluent control
- Site capacity
- Site closure.

Location

Location of the site has a direct effect on construction and design. Conditions onsite dictate environmental acceptance of the site, its boundaries of final design, and applicable methods of construction.

Biological Conditions. Existing nearshore sites are typically subtidal or intertidal areas with moderate to high habitat value. If nearshore areas are not productive because of manmade conditions, the potential for future habitat value by reclamation is still important. Therefore, mitigation will likely be a major component of nearshore sites. Although not actually a design element, mitigation issues will need to be addressed for nearshore site development.

Groundwater/Tidal Elevations. Groundwater and tidal elevations establish site disposal limits to keep contaminated sediments in a saturated, anaerobic condition. Many contaminants are sediment bound or have limited mobility when kept in the same chemical state by maintaining saturated, anaerobic conditions. Guideline recommendations for final disposal of contaminated sediments in Puget Sound have specifically identified the preference for anaerobic placement.

Existing groundwater and tidal elevations are also important in determining the potential for contaminant loss. This is especially true for soluble contaminants that are mobile in the saturated environment. Soluble contaminant loss occurs when water moves through sediments. Water movements can transport pore water from the sediment into and through confinement dike materials. Forces that move water within the sediments include tidal drawdown and groundwater flow.

Recent studies on leaching from nearshore sites have modified the concept of contaminant availability and movement through nearshore-sited sediments. Disposal of predominantly fine-grained sediments with some sands was done during 1982 in a nearshore site at Terminal 91 (Hotchkiss 1989). Conditions at that site were conducive to both tidal and groundwater forces causing movement of soluble organic contaminants through the dike confinements. Sediment characterization, modeling, and subsequent monitoring of the site determined that the fine-grained nature of the contaminated sediments prevents significant movement of waters. The combination of the low permeability of the disposed sediments and the dike materials has prevented any migration of contaminants to date (Hotchkiss 1989). The dredged sediments act as a "throttle" by limiting water movement and leaching of soluble contaminants through the disposal site.

Bed Materials. Conditions of bed materials at and adjacent to the nearshore site must be established for design. Confinement dikes must be constructed using bed sediments as a foundation. Final fill conditions behind the dikes demand that the structural integrity of the dikes be addressed in site engineering. Foundation conditions in nearshore locations are often fine-grained, deep layer sediments. These conditions will require large dike cross sections for dike stability, and will subsequently limit site capacity.

Bed materials at a site also affect the amount of foundation consolidation. In-situ bed sediments are typically loose, unconsolidated sediments. These materials will consolidate during sediment loading, thereby affecting the site volume available for anaerobic placement of contaminated sediments. Two types of consolidation must be factored into the final elevation: dredged material consolidation and foundation consolidation. Foundation, or bed consolidation, in nearshore sites can be several feet. Accounting for the elevation change from consolidation can result in an order of magnitude increase in site capacity availability (10,000-100,000 yd^3) (Ogden Beeman 1988; ABAM 1986).

Equipment Access. At nearshore confined disposal sites, dikes must be constructed before placing contaminated sediments. These dikes, which contain the contaminated sediments, limit access to the site and thereby limit the type of equipment used for dredging and disposal. Water access, including adequate water depths for haul barge and tug movement, allows either hydraulic or mechanical dredge operations without significant rehandling or equipment modification. If depths are great enough, contaminated sediments can be directly dumped on the bottom of the diked area. To do this, an opening in the dike is required for barge access. This opening can have silt curtains or some other mobile screen in place to limit and control the escape of turbidity.

Hydraulic pipelines can be used to gain access to most nearshore locations within economical pumping distance. This is done using floating pipeline, shore line, or submerged pipeline. Sediment with water slurry is discharged directly into the site.

Mechanical dredges can rehandle materials into trucks or other road haul equipment for final transport to the disposal site. It is neither feasible nor cost effective to use hydraulic pipeline dredges to directly load contaminated sediment into trucks or other road haul carriers. Dredging mechanics plus the volumes of water and sediment slurry generated by pipeline dredges (even the smaller 6- to 8-inch dredges) create too much contaminant loss to recommend slurry discharge directly into truck beds.

Distance from Dredging. Distance from the dredging site becomes a transport and placement concern. Mechanical dredges are not limited to distance operationally if there is direct water access. There is an incremental cost for each additional tug and haul barge required. An additional haul barge is necessary when the time to make a disposal run and return exceeds the time to fill a second barge at the dredge site.

Hydraulic pipeline dredges can pump distances greater than 2 miles, but require booster pumps in line. Because of their location, nearshore sites allow shoreline and shore-based booster equipment, which are preferred for their efficiency and environmental protection. The cost of equipment and labor would be significant, and additional boosters in line will decrease the daily effective time of a hydraulic dredge. Any pump breakdown results in the entire dredging operation standing by until the booster unit problem is corrected.

5.3.2 Construction

The construction features of a nearshore site include confinement structures, effluent return control for hydraulic dredging, site capacity, and site closure.

Confinement Structures. Dikes must be constructed before discharging contaminated sediments into a nearshore site. In general, the dike must be designed to provide the structural strength necessary to confine the sediment volume. The height of the dikes must be adequate, along with the area of the site, to retain sediments during disposal and after consolidation and dewatering. Detailed information on dike design and confinement structures is presented in Appendix C.

Effluent control. Release of the water that overlies the settled sediments in the disposal area is controlled by discharge facilities. These discharge facilities are sometimes called outlet structures, sluices, or spill boxes. This control is necessary to increase detention time. Increasing detention time helps to retain solid particles during hydraulic dredging disposal and creates an effluent with as few solids as possible (Hammer and Blackburn 1977). It can also be used to control surface water runoff. Details of effluent control devices are presented in Appendix C.

Site Capacity. Total volume capacity of a site must account for the potential bulking of dredged sediments from in situ to the disposal site quantity. In-situ measurements reflect consolidation before dredging. Those same sediments when disturbed by the dredging process will entrain additional water and bulk to a greater volume when finally placed into the disposal site.

Mechanical clamshell dredges will remove the material from the bed in a relatively undisturbed condition. Bulked volumes of the sediment in the disposal site have been estimated and give multiplier factors ranging from 0.96 to 1.1 times the in-situ volumes. Hydraulic dredges will create a slurry, and the bulking factor can be much greater, ranging from 1.1 to 1.5 times the in-situ volume.

These bulking values are for fine-grained sediments. They are not representative of sand or gravel sediments, which rapidly dewater and approach a 1.0 bulking factor. Since most contaminated sediments are fine-grained, a bulking factor must be considered. The procedures for designing dredged material containment areas included in EM 1110-2-5027 does incorporate sediment bulking when estimating site capacity requirements (Averett et al. 1988).

Site Closure. Following their discharge at the disposal site, materials must be dewatered and consolidated. For nearshore sites, dewatering and consolidating sediments before site closure would include two phases:

- Phase one is rapid sediment consolidation and dewatering during and immediately after material placement (primarily hydraulic discharge)

- Phase two is the-long term consolidation of the foundation and sediment as pore water is forced from the sediment (both hydraulic and mechanical).

During phase one, a temporary cover or cap can be given site-specific consideration. Any cap should be clean materials. A temporary or primary cap would be placed in the site to cover or confine the contaminated sediments until consolidation allows placement of a final cap. This primary cap would then be followed by the long-term cover that would permanently enclose contaminants.

The long-term cap could include a geotextile liner to prevent surface waters from percolating through the cap, creating hydraulic forces that would move contaminant leachate from the site. Requirements for a liner and analysis of the surface water forces through a specific cap sediment matrix must be done on a site-by-site and material-specific basis. If a cap liner is necessary, that liner must be located above any ponded water surface. Placement of a geotextile liner underwater while attempting to maintain liner cover integrity is difficult, if not impossible.

Final cap design will incorporate sloped conditions or the containment and removal of surface waters. Any hydraulic head from surface water ponding is not desirable. Thus, paving or a structural cover are preferred.

5.3.3 Functional Design Alternatives

Three alternatives for confined nearshore disposal were developed. The alternatives are summarized in Table 5.2. A narrative description of these alternatives is presented in Appendix C. A no-action alternative is also summarized in Table 5.6. The no-action alternative represents a broad interpretation of the current state of nearshore requirements, without adoption of confined sediment disposal standards.

Each alternative presented in Table 5.2 represents the same specific level of design considerations, components, and assumptions for functional design as those discussed in Section 5.2.3 for CAD design. An exception is that organic material will also be present in the sediment matrix for nearshore disposal.

Table 5.2. Summary of nearshore disposal dredging and design alternatives.

	ALTERNATIVES			
	1	2	3	N.A.[1]
DREDGE METHODS				
Mechanical Dredge - Clamshell	No	No	Yes	Yes

Table 5.2. Summary of nearshore disposal dredging and design alternatives (continued).

	ALTERNATIVES			
	1	2	3	N.A.[1]
Hydraulic Dredge				
- Cutterhead	Yes	Yes	No	No
- Suction	Yes	No	Yes	Yes
Bucket Size (yd^3)	n.a.	n.a.	>5	1
Retrieval Rate Limitations	n.a.	n.a.	Yes	None
Depth Tolerance Limitations	1 ft	1 ft & 2 ft	2 ft	2 ft
Dredge Depth (ft)	Equip Limit	Equip Limit	<100 ft	Equip Limit
Careful Anchor Placement	Yes	Yes	Yes	Yes
Overcutting Restrictions				
- Cutter Diameter	Yes	Yes	n.a.	None
TRANSPORT METHODS				
Haul Barge	n.a.	n.a.	Yes	Yes
Watertight Flat Deck	n.a.	n.a.	Req'd	Not Req'd
Hydraulic Check Requirements	n.a.	n.a.	Yes	Not
Rehandling:				
No Bucket Swings over Open Water	n.a.	n.a.	Yes	Not Spec.
Direct to Disposal Site or Equip.	n.a.	n.a.	Yes	Not Spec.
Rehandling Area Contained	n.a.	n.a.	Yes	Not Spec.
Booster Pumps	<2	<2	n.a.	n.a.
Pipeline Restrictions	Subm.	No Subm.	n.a.	n.a.
MATERIAL PLACEMENT				
CONTAMINATED				
Highest Contam. Placed First	Yes	No	No	No

Table 5.2. Summary of nearshore disposal dredging and design alternatives (continued).

	ALTERNATIVES 1	2	3	N.A.[1]
Contaminated Placed Anaerobic	Yes	Yes	Yes	Not Req'd
Access Prevented	Yes	Yes	Yes	Not Req'd
Overflow Allowed	n.a.	n.a.	No	Yes
No Displaced Material	n.a.	n.a.	Yes	Not Req'd
Final Fill Level	n.a.	n.a.	Yes	Site Rqmt
CAPPING SEDIMENTS				
Primary Cap Placed Immediately	Yes	Yes	None	None
Liner	Yes	None	None	None
Final Cap After Initial Consolid.	Yes	Yes	Yes	None
DISPOSAL SITE DESIGN				
Structural Dike Design Impervious Core	Yes	No	No	No
Engineering Designed	Yes	Yes	Yes	Yes
Retention Dike Design Effluent Quality	<100mg/L	WQ	n.a.	WQ
Bulk Factor Based Design	Site Spec.	Crit. 1.3	1.1	Crit. Site Spec.
Weir Overflow Height	2 - 4 inches	Not Spec.	n.a.	Not Spec.
Primary Cap			None	None
Uniform Clean Silty Sand	Yes	Yes		
Minimum 2 ft Thick	Yes	Yes		

Table 5.2. Summary of nearshore disposal dredging and design alternatives (continued).

	ALTERNATIVES			
	1	2	3	N.A.[1]
Final Cap				
Liner	Yes	No	No	No
Engineered to meet future use	Yes	Yes		Yes
Structural Requirements			Yes	
Minimum Thickness	6 ft	4 ft	4 ft	4 ft
Cap Quality				
P2	Yes			
PSDDA		Yes	Yes	
Other				Yes

[1] No Action
n.a. = Not Applicable

5.4 UPLAND MIXED DISPOSAL

Upland disposal design (for both monofill and mixed sites) requires a confined disposal site located above and outside the influence of normal tidal and groundwater fluctuations. Upland sites are typically used with rehandling of dredged sediments transported from the dredging site and overland haul by truck or rail to final upland disposal.

Primary pathways for short-term contaminant loss are from water column loss during dredging, material loss during transport and rehandling, and from dewatering. Primary pathways for long-term contaminant loss in upland sites are the leaching of contaminants through the confinement media (dike materials, existing site sediments, and ground cover) or by surface water runoff. The upland site allows sediments to dry, resulting in physicochemical conditions not observed in nearshore sites.

5.4.1 Upland Mixed Design Elements

Disposal Site

Existing state and federal regulations for upland disposal of solid waste apply to dredged sediments that will be mixed with other solid waste at upland mixed disposal sites. Sediments are identified as dredged materials until they are placed at a solid waste, upland mixed disposal site (i.e. sediments that are being rehandled, dewatered, and transported to an upland site are by definition dredged sediments). In Washington state, regulations for upland disposal of solid waste are set forth in the Minimum Functional Standards (MFS) for Solid Waste Handling WAC 173-304. We propose that these existing standards be used as upland mixed disposal standards for confined sediment disposal standards.

The important disposal site design elements to be considered for contaminated sediment disposal at a solid waste mixed landfill are these:

Bottom Liner. This may be a low-permeability geomembrane liner with a low-permeability barrier layer or a low-permeability barrier layer only. Bottom liners prevent vertical migration of leachate through the bottom of the landfill. Leachate is collected in pipes set in approximately 3 ft of sandy materials on top of the bottom liner, and the leachate is removed. The advantage of a bottom liner is the restriction of leachate flow out of the landfill toward the leachate collection system. The disadvantage is that a bottom liner may cause ponding of water before sediments are placed over it. The amount of ponding will depend upon the method and timing of dredged sediment disposal.

Leachate Collection System. This internal system is constructed on a gently sloping bottom liner. Leachate collection systems contain a network of converging perforated pipe in high-permeability materials. Leachate is collected in these drains by gravity flow and is directed towards the leachate treatment system. The advantage of this system is that the leachate is collected and controlled.

Leachate Treatment and Disposal System. This external system consists of tanks to hold leachate and, if necessary, physical and chemical processes to bring leachate to an acceptable level of quality for disposal in an environmentally safe manner. Pretreatment may be required in the case of discharge to a municipal wastewater treatment plant. The advantage of treatment is that the liquids may be released instead of stored.

Gas Management System. This system vents or collects gas as it is generated in the upland facility. This is generally not required at dredged material landfills because of the lower organic content of dredged sediments.

Runoff Control System. This control system is part of the surface water management system. It consists of a series of connected ditches and culverts on the surface of the disposal site that collect landfill surface runoff. The runoff is directed to the leachate treatment system during construction and to surface water after landfill closure. The advantage of this system is the removal of precipitation that would normally migrate into the refuse to form leachate. The disadvantage of this system is a possible change in the natural surface flow/infiltration balance in drainage basins.

Run-On Control System. This control system is also part of the surface water management system. It consists of a series of connected ditches and culverts around the perimeter of the landfill that collect and direct surface water from entering the landfill. This water is then directed around the landfill and to its original flow path. The advantages and disadvantages of the run-on control system are the same as for the runoff control system.

Top Barrier Layer. This is part of the final cover system. It may be a geomembrane liner with a low-permeability barrier layer or low-permeability barrier layer only. It impedes the vertical migration of surface water into the facility. Surface water that collects on top of this layer will drain from the landfill. The slope of this layer will be greater than 2% on the surface and less than 33% on the side slopes. The advantage and disadvantage of this layer are like those for the runoff control system.

Top Drainage Layer. This high-permeability layer is also part of the final cover system. It has the advantages of minimizing the accumulation of liquids on the barrier layer, providing slope stability, and supporting a vegetation layer. The disadvantage of a top drainage layer is the restriction of movement across the landfill while final cover is being placed.

Vegetation Layer. This layer of grasses is part of the final cover system, and usually consists of rye and other hardy grasses. It has the advantages of protecting the barrier layer from erosion, restoring the land for future uses, and increasing site aesthetics. A disadvantage of this design element is that it restricts movement across the landfill while the grasses are sprouting from seed.

Dewatering System. Dewatering may be done in the permanent disposal site. This system consists of a berm or dike to contain the dewatered sediments. The excess water is collected by the dewatering leachate collection system, and routed to the leachate treatment and disposal system. The berm has the advantage of protecting the surrounding environment from leachate contamination and direct contact. A disadvantage is the possible restriction of movement of machinery and materials into the landfill.

5.4.2 Dredging/Transport

Factors for development of final upland design elements for dredging and transport are similar to those for nearshore design. The contaminated sediments will be dredged and transported to a rehandling site located near a nearshore disposal environment. Nearshore and upland disposal differ, however, during the placement phase of disposal.

Upland disposal requires rehandling of dredged sediments for overland transport. A possible exception to this is when the upland disposal site is located within hydraulic pumping distance of the contaminated sediment dredge site. However, according to the functional design criteria, sediments pumped in a slurry must be dewatered to approximately in-situ condition for acceptance at an upland mixed disposal site. Therefore, in the functional design, all contaminated materials must be rehandled for final transport regardless of dredging method.

Rehandling Site Access. Access to the rehandling site can limit the type of equipment used for dredging and disposal. Water access, including adequate water depths for haul barge and tug movement, allows either hydraulic or mechanical dredge operations without significant equipment modification.

Rehandling Techniques. The rehandling techniques (including distance from dredging issues) for mechanical and hydraulic dredging are similar to those described for the nearshore environment.

Dewatering. Dewatering techniques for mechanical dredge operations using a clamshell dredge with haul barge will be similar to hydraulic dredging after the ponding water from hydraulic discharge is released and sediment initially consolidates. Because the mechanical dredging operation will deposit sediments at or near in-situ water content, the dewatering time should be substantially less than for hydraulic dredged sediments.

Dewatering methods have been evaluated by U.S Corps of Engineers at the Waterways Experiment Station (Corps 1978). The Corps identified continuous trenching as the most cost-effective dewatering method. Other methods proved moderately successful but were less time effective and cost substantially more for dewatering large volumes of dredged sediments in confined disposal sites.

Confinement Structures. Placement of wet dredged sediments into the dewatering site requires transport and site design similar to those for nearshore disposal. Confinement dikes must be constructed to retain the sediments and also have adequate structural strength. The dike materials, confinement area, and volume must be adequate to retain sediments with acceptable overflow release of effluent from the discharge slurry. The site must be designed or located so that it does not affect groundwater during temporary material confinement and dewatering.

5.4.3 Functional Design Alternatives

Disposal Site

The MFS for solid waste disposal provides two major options:

- Municipal design
- Demolition and inert waste design.

Alternative 1 is the municipal design and Alternative 2 is the demolition and inert waste design. Municipal design standards are set forth primarily in WAC 173-304-460 (MFS) and demolition and inert waste design standards are set forth primarily in WAC 173-304-461 (MFS). Alternative 1 is more costly and offers more environmental protection than Alternative 2. Generalized diagrams for these two designs are included in Figures 5.1 and 5.2. Descriptions of design features for these alternatives are listed in Table 5.3.

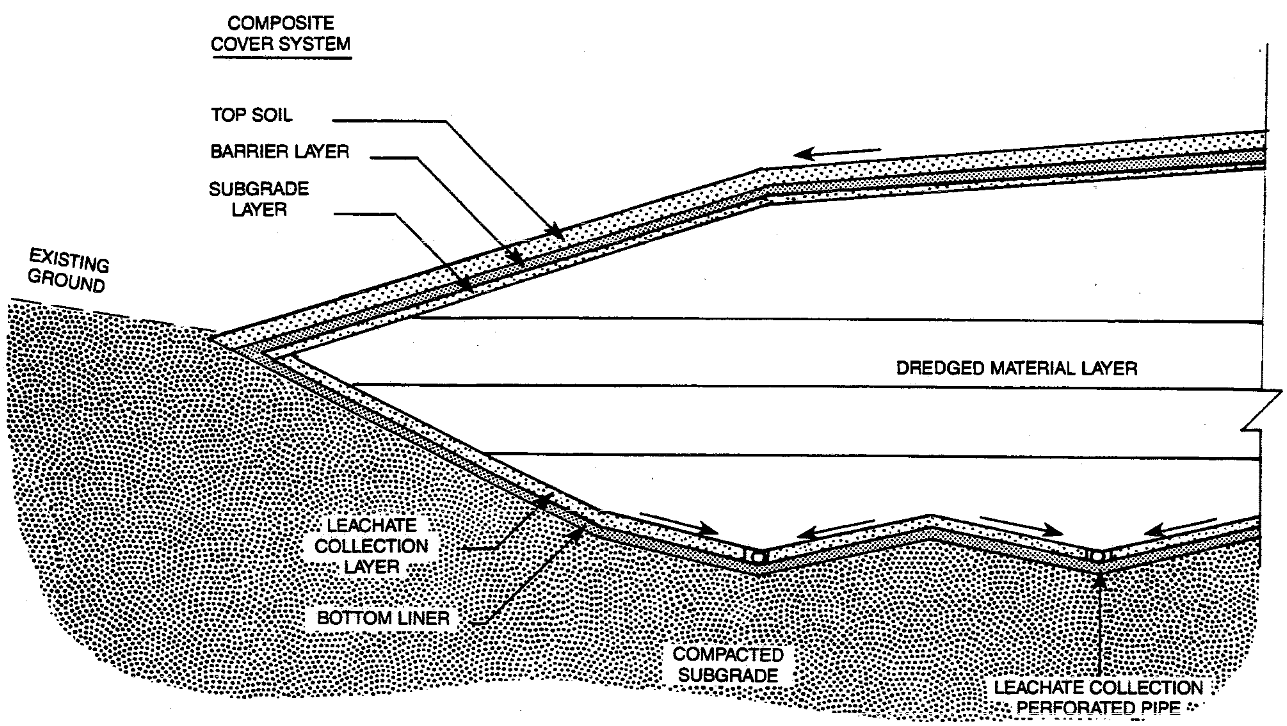


Figure 5.1 Upland mixed design, Alternative 1 (EH)

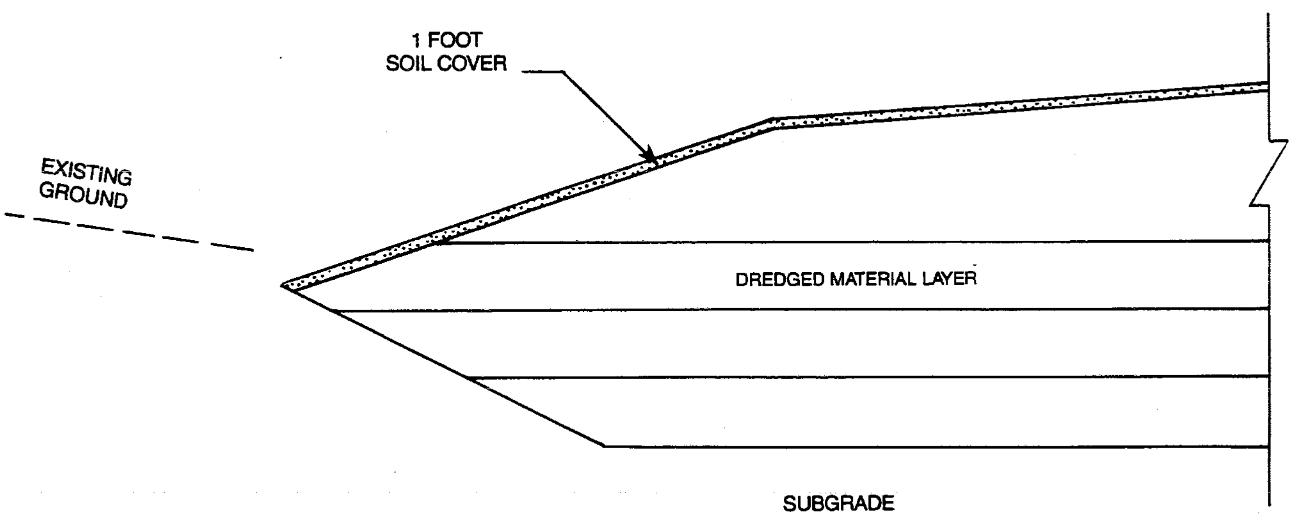


Figure 5.2 Upland mixed design, Alternative 2

Table 5.3. Summary of upland mixed design alternatives.

Disposal Site Design	ALTERNATIVES 1 Municipal	 2 Demolition
Bottom Liner (Option 1) Alternative Design		Liner not required
• Geomembrane thickness	50 mil	
• Barrier layer thickness	2 ft	
• Barrier layer hydraulic conductivity (cm/sec)	$1x10^{6}$	
Bottom Liner (Option 2) Standard Design		
• Barrier layer thickness	4 ft	
• Barrier layer hydraulic conductivity (cm/sec)	$1x10^{7}$	
Leachate Collection System		Not Required
• Head above liner	2 ft	
Leachate Treatment and Disposal System		Not Required
• Leachate within system must pass NPDES at point of discharge	X	
• Disposed leachate much meet municipal waste-water pre-treatment standards	X	
Gas Management System Required	Yes	Not Required
Surface Water Management		Not Required
• Must contain runoff from ___ yr storm	25 year	
• Must contain run-on from ___ yr storm	25 year	
Final Cover (Option 1) Alternative Design		Only One Option
• Geomembrane liner thickness	50 mill	
• Slope of low permeable layer	$\geq$ 2%	
• Side slope angle	$\leq$ 33%	
Final Cover (Option 2)		
• Material thickness	2 ft	1 ft soil
• Sediment hydraulic conductivity (cm/sec)	$1x10^{6}$	Not Specified
• Slope of low permeable layer	$\geq$ 2%	
• Side slope angle	$\leq$ 33%	
Topsoil		Not Required
• Thickness	6 inches	

Table 5.3. Summary of upland mixed design alternatives (continued).

Disposal Site Design	ALTERNATIVES 1 Municipal	2 Demolition
Dewatering		
• Permanent disposal site accepts wet sediments	No	Yes
Vector Control (as necessary)	Yes	Yes

Notes:

(1) This table is only an outline of the requirements set forth in the Minimum Functional Standards for Solid Waste Handling (WAC 173-304) and is not intended to reflect all of the requirements included in the WAC 173-304 standards. Arid design information is not included.

(2) Although some design elements for demolition sites are not specifically required in WAC 173-304, they are required by local agencies. For example, local jurisdictions often require surface water management as part of the grading permit.

Dredging/Transport

Three alternatives for dredging and transport to upland mixed disposal sites were developed. The alternatives are summarized in Table 5.4. A narrative description of the three alternatives is presented in Appendix D. Each of these alternatives follows the most-to-least environmentally protective pattern discussed under nearshore functional design alternatives in Section 5.2.3.

Each alternative for upland mixed disposal is organized into the following major components:

- Dredge type
- Transport method
- Dewatering.

Final alternatives for upland mixed design were developed. Dredging, transport and dewatering methods were developed based on site design requirements. For example, site design requirements may limit the water content of sediments for upland disposal. Dredging, transport, and dewatering methods will influence sediment water content.

Table 5.4. Summary of upland mixed dredging alternatives.

	ALTERNATIVES 1	2	3	N.A.
DREDGE METHODS				
Mechanical Dredge - Clamshell	Yes	Yes	No	Yes
Hydraulic Dredge - Cutterhead	No	No	Yes	No
Bucket Size (yd^3)	>5	>5	n.a.	No Limit
Retrieval Rate Limitations	Yes	None	n.a.	None
Depth Tolerance Limitations	2 ft	2 ft	1 ft	2 ft
Dredge Depth (ft)	<200 ft	<200 ft	Equip Limit	Equip Limit
Anchor Placement Controlled	Yes	Yes	Yes	Yes
Overcutting Restrictions - Cutter Diameter	n.a.	n.a.	Yes	None
TRANSPORT METHODS				
Haul Barge	Yes	Yes	n.a.	Yes
No Overflow	Yes	Yes	n.a.	Not Spec.
Watertight Flat Deck	Yes	Yes	n.a.	Not Spec.
Hydraulic Check Requirements	Yes	Yes	n.a.	Not Spec.
Off-Loading: No Bucket Swings over Open Water	Yes	Yes	n.a.	Not Spec.
Direct to Lined Equip.	Yes	No	n.a.	Not Spec.
Stockpile	No	Yes	n.a.	Yes
Rehandling Area Contained	Yes	Yes	n.a.	Not Spec.

Table 5.4. Summary of upland mixed dredging alternatives (continued).

	ALTERNATIVES			
	1	2	3	N.A.
Booster Pumps	n.a.	n.a.	<2	n.a.
Pipeline Restrictions	n.a.	n.a.	Subm in channel	n.a.
Final Haul Overland Approved Carrier Only	Yes	Yes	Yes	Not Req'd
No Material Misplaced	Yes	Yes	Yes	Not Req'd
Covers During Rainfall	Yes	None	None	None
Action Plan for Sediment Loss	Yes	Yes	Yes	None
DEWATERING SITE				
Structural Dike Design Engineering Designed	Yes	Yes	Yes	n.a.
Retention Dike Design Effluent Quality	n.a.	n.a.	100 mg/L	n.a.
Bulk Factor Based Design	1.1	1.0	n.a.	n.a.
Freeboard Minimum	2 ft	1 ft	n.a.	n.a.
Dewatering Outlets	Yes	Yes	2 - 4 inches	n.a.
Liner	Yes	No	Yes	n.a.
Dewatering Methods Engineering Design	Yes	Yes	Yes	n.a.
Runoff & Elutriant treated	Yes	Yes	Yes	n.a.
Final Transport at Paint Filter	Site Surface	Truck	Site Surface	n.a.

[1] No Action
n.a. = not applicable

Assumptions for Functional Design - Dredging Design

In developing the functional design alternatives, we assumed there would be a limitation on the level of contamination in the sediments eligible for upland mixed functional design. The level of contamination would be relatively low compared to the range of chemical constituents that could be present in the identified dangerous waste level (WAC 173-303, WAC 173-304).

The upland mixed alternatives require delivery of a dewatered sediment to the disposal site. This is a different requirement than that for upland monofill. Although design alternatives for dredging and transport to the dewatering site apply to both the upland mixed and upland monofill, dewatering design differs.

The functional design is appropriate for consideration with a volume of sediments in the range of from 10,000-1,000,000 yd^3. Sediment volumes less than 10,000 yd^3 should be considered under the small projects standards as well as the functional design and effects-based design approach. Projects with more than 1,000,000 yd^3 should be considered under the effects-based design approach.

Contaminated material physical description can range from fine-grained sediments such as silts and clays to sandy sediments such as fine-to-coarse sand. Contaminated sediments that will typically be found in Puget Sound will be a sandy silt (predominantly fine grain with some sand) or silty sand (predominantly sand with some fine grain) matrix of sediment grain sizes. Organic material will also be present in the sediment matrix.

5.5 UPLAND MONOFILL DISPOSAL

Upland monofill disposal sites require the same basic considerations as those discussed for upland mixed disposal in the introduction to Section 5.4.

5.5.1 Upland Monofill Design Elements

Lined Disposal Site

There are two types of upland monofill designs: lined and unlined. Figure 5.3 is a generalized schematic of a lined upland monofill facility. The design features are shown in this figure and described in Section 5.4.1 under Upland Mixed Disposal.

Unlined Disposal Site

Figure 5.4 is a generalized schematic of an unlined monofill facility. The relevant design features are shown on this figure.

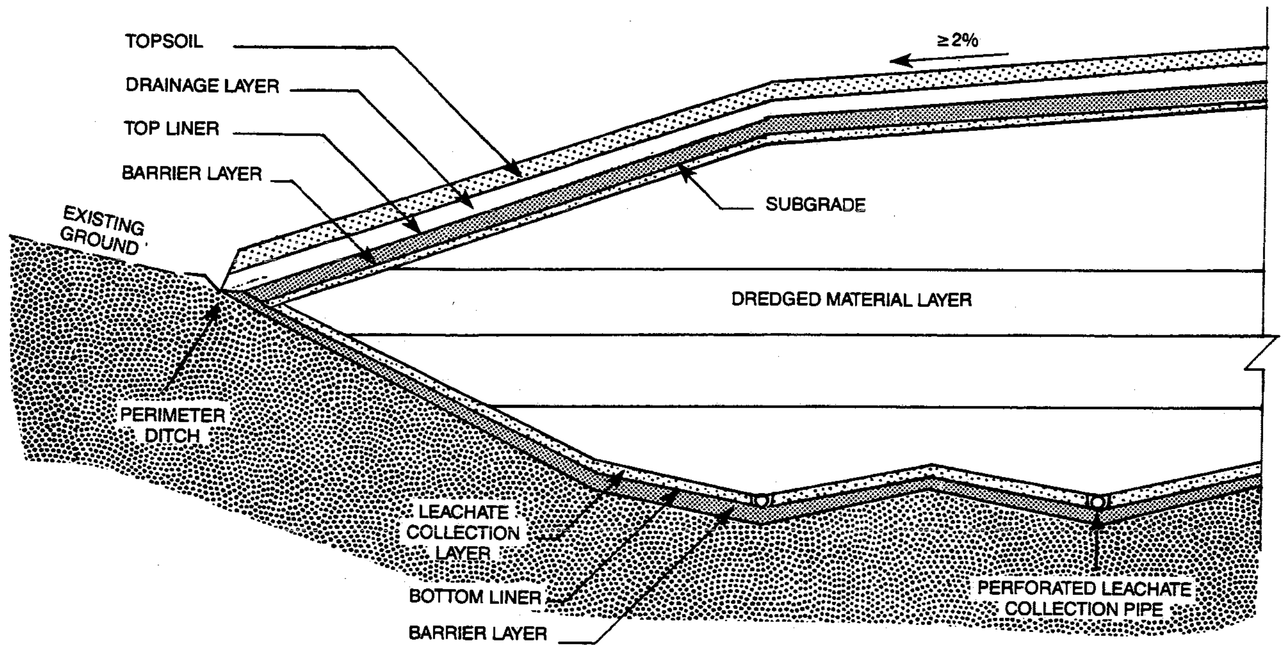


Figure 5.3 Upland mono-lined generic design

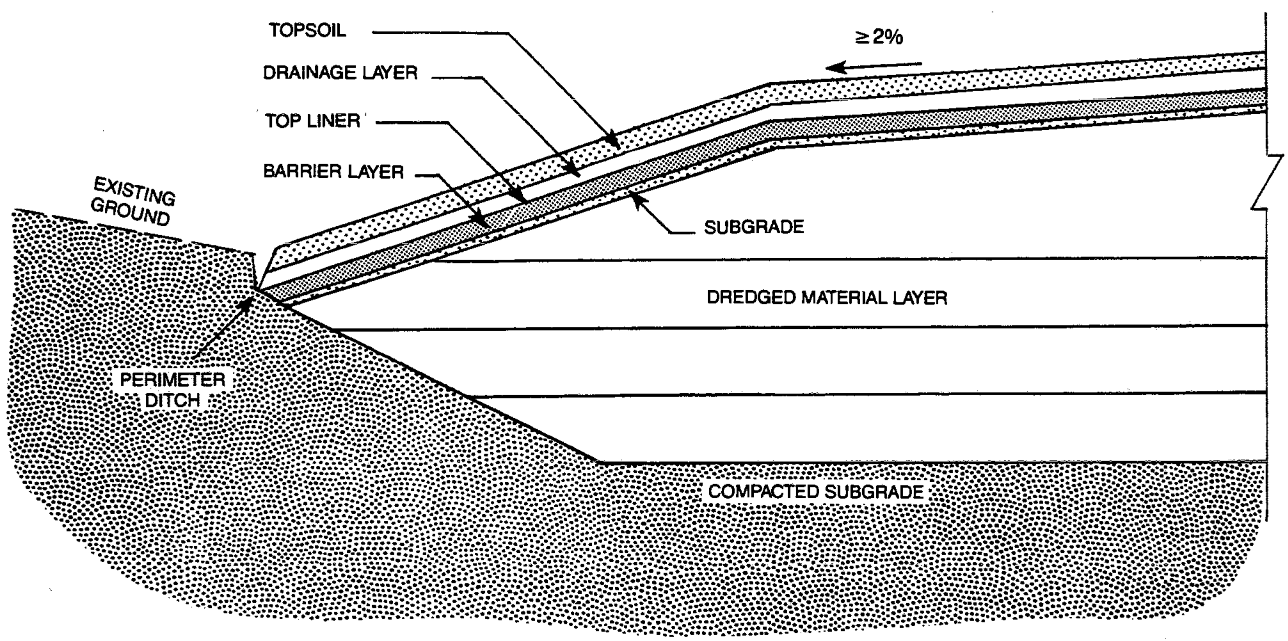


Figure 5.4 Upland mono-unlined generic design

5.5.2 Dredging and Transport

Dredging and transport factors for an unlined monofill facility final design are the same as those discussed in Section 5.4.2 for upland mixed disposal, with the exceptions discussed here.

Sediments for upland mono landfills must reach the site in a condition approaching the in-situ wetted condition. This design criteria is based on existing upland practices for acceptance of dredged sediment from Port of Everett dredging done in 1987 and from U.S. Navy dredging at Bremerton in 1986. Sediments that have been hydraulically dredged must be dewatered for acceptance at the upland site. Therefore, all contaminated materials going to existing solid waste landfills must be rehandled for final transport regardless of dredge method. However, the exception is contaminated sediments placed at an upland site specifically approved for dredged material disposal under the confined disposal standards. These sediments may not need to be dewatered and rehandled. This disposal condition would be approved through the effects-based design process.

Design elements of monofill upland sites have been separated into two categories–dredging and site disposal . Dredging design includes dredging, transport with rehandling, and dewatering elements. Upland disposal site design includes disposal site design. Final design elements for dredging and transport have been presented in nearshore functional design development (Section 5.3). However, upland monofill dredging design must also consider the rehandling site design with dewatering method and final overland transport to disposal.

The rehandling site design for hydraulic dredging must include methods of dewatering. Hydraulic dredging introduces too much water into the slurry for direct haul and material acceptance at the upland monofill site without dewatering. Dewatering methods discussed in the upland mixed dredging section are appropriate.

5.5.3 Functional Design Alternatives

Unlined Disposal Sites

There are three alternatives for upland monofill unlined sites. The alternatives are summarized in Table 5.5. A narrative description of the three alternatives is presented in Appendix E.

Lined Disposal Sites

There are three alternatives for upland monofill lined facilities. The alternatives are summarized in Table 5.6. A narrative description of the three alternatives is presented in Appendix E.

Table 5.5. Summary of upland mono-lined design alternatives.

	ALTERNATIVES		
	1	2	3
Bottom Liner (Option 1)			
• Geomembrane thickness	50 mil	30 mil	20 mil
• Barrier layer thickness	2 ft	2 ft	1 ft
• Barrier layer hydraulic conductivity (cm/sec)	10^{7}	10^{6}	10^{6}
Bottom Liner (Option 2)			
• Barrier layer thickness	4 ft	4 ft	2 ft
• Barrier layer hydraulic conductivity (cm/sec)	10^{7}	10^{6}	10^{6}
Leachate Collection System			
• Head above liner	1 ft	2 ft	2 ft
Leachate Treatment and Disposal System			
• Safety factor	1.5	1.25	1.0
• Leachate within system must pass NPDES at point of discharge	Yes	Yes	Yes
• Disposed leachate must meet municipal wastewater pre-treatment standards	Yes	Yes	Yes
Gas Management System Required	No	No	No
Surface Water Management			
• Must contain runoff from ___ yr to ___ yr storms	2-100	2-50	2-25
• Must contain run-on from ___ yr storm	100	50	25
Final Cover (Option 1)			
• Geomembrane liner thickness	30 mil	30 mil	20 mil
• Barrier layer thickness	1 ft	1 ft	1 ft
• Barrier layer hydraulic conductivity (cm/sec)	10^{7}	10^{6}	10^{6}
• Slope of low permeable layer	>2%	>2%	>2%
• Side slope angle	<33%	<33%	<33%
Final Cover (Option 2)			
• Material thickness	2 ft	2 ft	1 ft
• Sediment hydraulic conductivity (cm/sec)	10^{7}	10^{6}	10^{6}
• Slope of low permeable layer	>2%	>2%	>2%
• Side slope angle	<33%	<33%	<33%
Drainage Layer			
• Maximum allowable head	1 ft	2 ft	2 ft

Table 5.5. Summary of upland mono-lined design alternatives (continued).

	ALTERNATIVES 1	2	3
Topsoil			
• Thickness	24 inches	12 inches	6 inches
Dewatering			
• Permanent disposal site accepts wet sediments	Yes	Yes	Yes
• Berms designed by engineer	Yes	Yes	Yes
• Vector control as necessary	Yes	Yes	Yes

Table 5.6. Summary of upland mono-unlined design alternatives.

	ALTERNATIVES 1	2	3
Bottom Liner		Not Required	
Leachate Collection System		Not Required	
Leachate Treatment and Disposal System		Not Required	
Gas Management System		Not Required	
Surface Water Management			
• Must contain runoff from ___ yr to ___ yr storms	2-100	2-50	2-25
• Must contain run-on from ___ yr storm	100	50	25
Final Cover (Option 1)			
• Geomembrane thickness	30 mil	30 mil	20 mil
• Barrier layer thickness	1 ft	1 ft	1 ft
• Barrier layer hydraulic conductivity	10^{7}	10^{6}	10^{6}
• Slope of low permeable layer	>2%	>2%	>2%
• Side slope angle	<33%	<33%	<33%
Final Cover (Option 2)			
• Barrier layer thickness	2 ft	2 ft	1 ft
• Barrier layer hydraulic conductivity	10^{7}	10^{6}	10^{6}
• Slope of low permeable layer	>2%	>2%	>2%
• Side slope angle	<33%	<33%	<33%
Drainage Layer			
• Maximum allowable head	1 ft	2 ft	2 ft
Topsoil			
• Thickness	24 inches	12 inches	6 inches

Table 5.6. Summary of upland mono-unlined design alternatives (continued).

	ALTERNATIVES 1	2	3
Dewatering			
• Permanent disposal site accepts wet sediments	Yes	Yes	Yes
• Berms designed by engineer	Yes	Yes	Yes
• Vector control as necessary	Yes	Yes	Yes

Dredging and Transport

Three alternatives for dredging and transport to upland monofill disposal sites were developed. The alternatives are summarized in Table 5.7. A narrative description of these alternatives is presented in Appendix E. A no-action alternative is also summarized in Table 5.7. No action represents the current state of upland monofill requirements. Each of these alternatives follows the most-to-least environmentally protective pattern discussed under nearshore functional design alternatives in Section 5.2.3.

Table 5.7. Summary of Upland monofill dredging alternatives.

	ALTERNATIVES 1	2	3	N.A.[1]
DREDGE METHODS				
Mechanical Dredge - Clamshell	Yes	Yes	No	Yes
Hydraulic Dredge - Cutterhead	No	No	Yes	
Bucket size (yd^3)	>5	>5		No Limit
Retrieval Rate Limitations	Yes	None	n.a.	None
Depth Tolerance Limitations	2 ft	2 ft	1 ft	2 ft
Dredge Depth (ft)	<200 ft	<200 ft	Equip Limit	Equip Limit
Anchor Placement Controlled	Yes	Yes	Yes	Yes

Table 5.7. Summary of Upland monofill dredging alternatives (continued).

	ALTERNATIVES 1	2	3	N.A.[1]
Overcutting Restrictions				
- Cutter Diameter	n.a.	n.a.	Yes	None
TRANSPORT METHODS				
Haul Barge	Yes	Yes	n.a.	Yes
Overflow Allowed	No	No	n.a.	Not Spec.
Watertight Flat Deck	Yes	Yes	n.a.	Not Spec.
Hydraulic Check Requirements	Yes	Yes	n.a.	Not Spec.
Off-Loading:				
No Bucket Swings over Open Water	Yes	Yes	n.a.	Not Spec.
Direct to Lined Equip.	Yes	No	n.a.	Not Spec.
Stockpile	No	Yes	n.a.	Yes
Off-Loading Area Contained	Yes	Yes	n.a.	Not Spec.
Booster Pumps	n.a.	n.a.	<2	n.a.
Pipeline Restrictions	n.a.	n.a.	Subm in channel	n.a.
Final Haul Overland				
Approved Carrier Only	Yes	Yes	Yes	Not Req'd
No Material Misplaced	Req'd	Req'd	Req'd	Not Req'd
Covers During Rainfall	Yes	None	None	None
Action Plan for Sediment Loss	Req'd	Req'd	Req'd	None

Table 5.7. Summary of Upland monofill dredging alternatives (continued).

	ALTERNATIVES			
	1	2	3	N.A.[1]
DEWATERING SITE				
Structural Dike Design Engineering Designed	n.a.	n.a.	Yes	n.a.
Retention Dike Design Effluent Quality	n.a.	n.a.	100 mg/L	
Weir Overflow	n.a.	n.a.	2 - 4 inches	n.a.
Liner	n.a.	n.a.	Yes	n.a.
Dewatering Methods Engineering Design	n.a.	n.a.	Yes	n.a.
Runoff & Elutriant Treated	n.a.	n.a.	Yes	n.a.
Final Transport	in-situ	in-situ	in-situ	n.a.

[1] No-Action
n.a. = not applicable

Each alternative for upland monofill disposal is organized into the following major components:

- Dredge type
- Transport method
- Dewatering (Hydraulic Only).

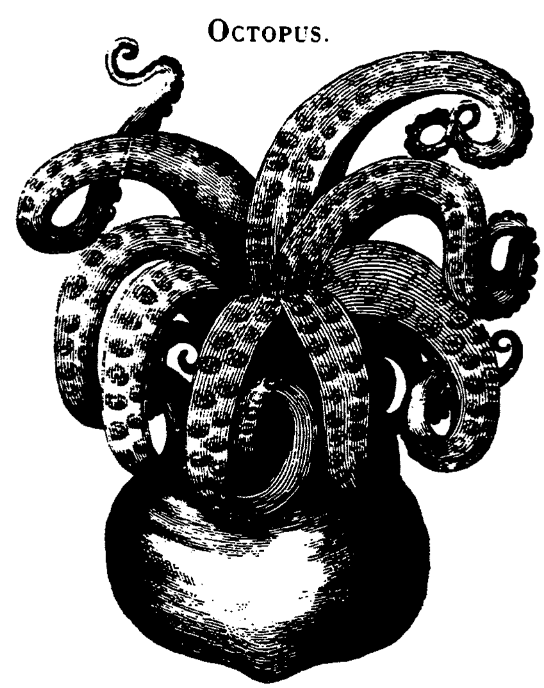
Final alternatives for upland mono lined design and unlined design were developed. Dredging, transport and dewatering requirements were derived considering site design alternatives.

Assumptions for Functional Design - Dredging Design

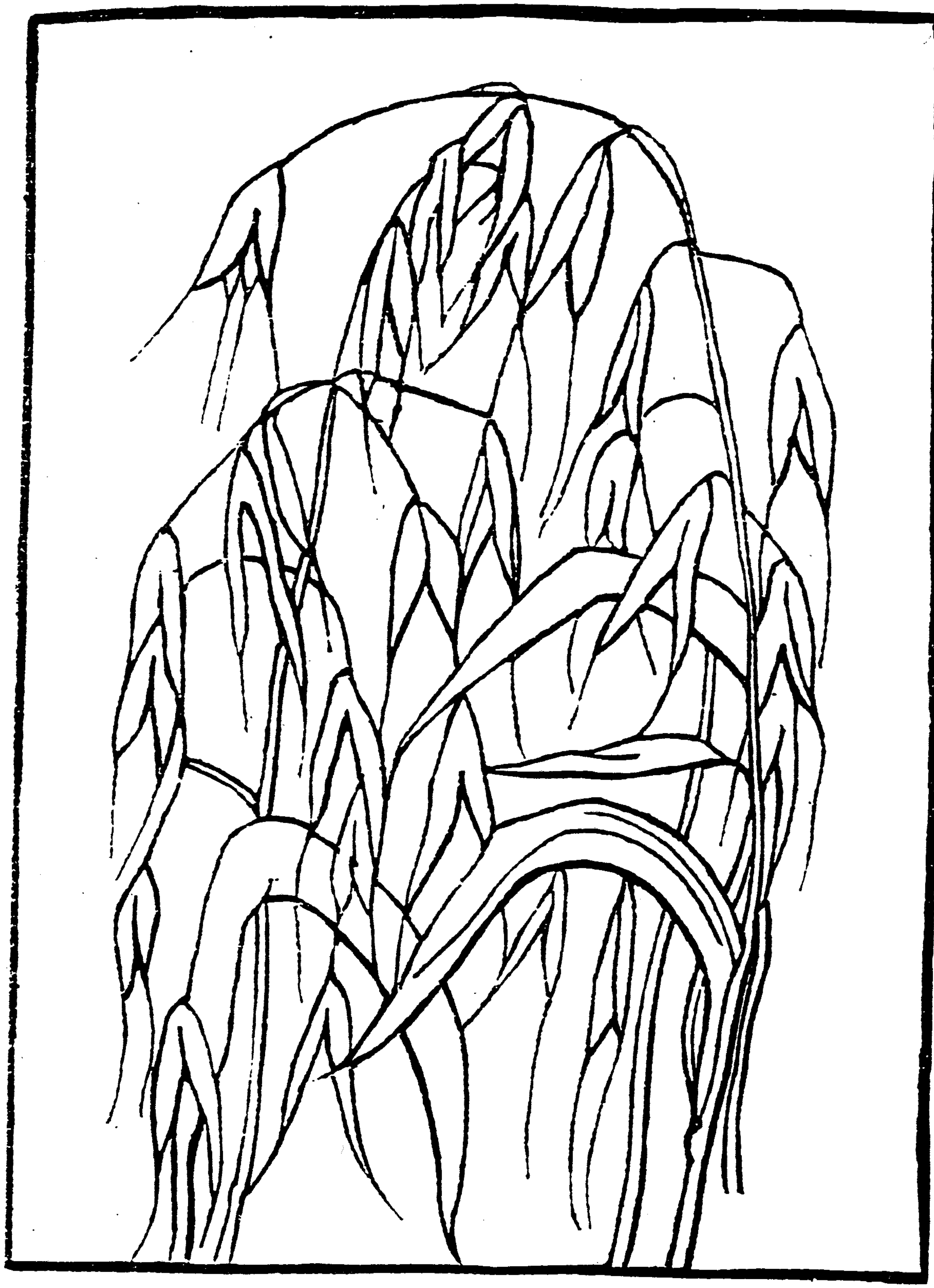
In developing the functional design alternatives, we assumed there would be a limitation on the level of contamination in the sediments eligible for upland monofill functional design. The level of contamination would be relatively low as compared to the range of chemical constituents that could be present in the identified dangerous waste level (WAC 173-303, WAC 173-304).

Both the lined and unlined design alternatives allow delivery of in-situ wet sediments to the disposal site. Design alternatives for dredging apply to both the lined and unlined design.

For the functional design of monofill disposal, the volume of sediments and their physical description are the same as those discussed for mixed disposal in Section 5.4.3.



Monitoring Alternatives



6. MONITORING ALTERNATIVES DEVELOPMENT

6.1 INTRODUCTION

The process for confined disposal of contaminated sediments includes monitoring to assess contaminant loss through the pathways of concern. Monitoring is performed during dredging and disposal operations and at the disposal site. This chapter describes available monitoring methods, sampling devices, and types of measurements to be obtained. Monitoring alternatives for the different disposal environments are also described.

Section 6.2, **Summary of Monitoring Methods**, summarizes the various types of monitoring available to measure the loss of contaminants from dredged sediments.

Section 6.3, **Alternatives Summary**, uses the monitoring methods discussed in Section 6.2 to develop alternatives for monitoring CAD, nearshore, and upland environments.

6.2 SUMMARY OF MONITORING METHODS

6.2.1 Physical Monitoring

There are several types of physical methods for monitoring dredging operations and disposal sites. These methods are dilution zone boundary monitoring, positioning, bathymetry, sub-bottom profiling, sidescan surveys, and sediment profiling.

Dilution Zone Boundary Monitoring

Monitoring water quality in the dilution zone around a dredge area assesses how much and what effect dredge site material has on the surrounding water column. To ensure compliance with the State of Washington Water Quality Standards (WQS), water is monitored outside of the exempted area immediately adjacent to dredging activities in an area specified by the Washington State Department of Ecology (Ecology). This area is known as the dilution zone.

Measurements of dissolved oxygen (DO) and turbidity are required to ensure WQS compliance. Other Ecology-prescribed monitoring may be required under the terms of the water quality certification issued for a specific project. DO may be measured by deploying a probe in the water column in-situ or by Winkler titration (determining oxygen concentrations in solution) on collected water column samples. Turbidity can be measured in situ by a calibrated, submersible transmissometer. Or turbidity can be measured by collecting water column samples and determining light transmission (transmissivity) or light attenuation (turbidity). These samples can also be used to measure the concentrations of total suspended solids (TSS).

Positioning

Accuracy in positioning the barge and dredge is important in both dredge site and disposal site activities. The choice of a system is based on the requirements for a specific task and the cost effectiveness of a particular system for that task. Common positioning methods include optical range azimuth systems (theodolite and laser), microwave systems, and GPS (Global Positioning System). These positioning systems operate by triangulating the observed ranges from two or more known locations or by determining the range and azimuth from a known location. For nearshore projects, positioning by survey-established markers may be suitable and cost effective. For monitoring the removal and placement of dredged materials, the optional range azimuth, microwave, and GPS absolute positional accuracies of the required systems are typically ± 3 m. The positioning systems all can meet or exceed the ± 3 m accuracy requirement. Optical range azimuth systems are limited by weather conditions, and their accuracy deteriorates at large distances (greater than 3.5 km). This limitation can be mediated by using an infrared tracking system with the range azimuth device to effectively increase the operating distance 50%. Microwave systems can operate during inclement weather and darkness and have a range of up to 80 km. However, microwave-based systems are generally more expensive than the optical range azimuth systems. GPS systems work over a wide variety of ranges and conditions, but their effectiveness is limited by the incomplete coverage of the navigation satellite system.

Bathymetry

Precision bathymetry (water depth measurement) documents the progress of dredging activities. By measuring changes in bottom depth, bathymetry monitors the deposition of material and the effective capping of contaminated material. The accuracy of each bathymetric survey is an important aspect of this monitoring technique since data must be comparable. Therefore, positioning and sounding accuracy are critical to precise survey control.

To achieve such control, a computerized data logger integrated to both a positional system and a depth sounder is required. Overall positioning errors no greater than ± 3 m are essential. This accuracy can be achieved using one of the systems described in the previous section.

Several depth sounder systems are available depending on the application required. These bathymetric instruments have an accuracy on the order of 0.05% of the measured depth. Typically, depth sounder systems use a narrow beam 200 kHz transducer capable of sounding in water depths over 150 m. Additional considerations for accurate water depth measurement are lane spacing to provide adequate resolution, and the speed of sound must be accurately measured using either a bar check or a conductivity, temperature and depth (CTD) profiler.

Data analysis is equally important to survey control. Tide measurements corrected for barometric pressure, ship's draft, and speed of sound corrections must be consistently applied during successive surveys. Bottom depths should be displayed to .10 ft at a scale that clearly plots the contours or spot elevations of the seafloor.

Sub-bottom Profiling

For dredging or disposal operations where information on seafloor stratigraphy is required, dual frequency systems are used to accurately profile these sub-bottom layers. To achieve greater penetration, a lower frequency must be used, while to attain better resolution, a higher frequency is required. The most advanced systems permit simultaneous dual frequency operation typically over a frequency range from 3 to 300 kHz. These systems allow adjustable frequency selections in 10 Hz steps for the low frequency channel and 250 Hz steps for the high frequency channel. The need for adjustable frequencies stems from the variable materials encountered in the seafloor and is especially applicable to profiling capped disposal mounds where differences in the cap thickness might be expected. The final sub-bottom profiles can be analyzed and the geotechnical properties of each layer estimated.

Sidescan Surveys

Sidescan sonar allows an immediate post-disposal and post-capping monitoring survey of seafloor characteristics. Typical sidescan frequencies associated with these systems are 100 and 500 kHz with a sub-bottom profiler operating at a frequency of 3.5 kHz. To obtain the resolution necessary to adequately detect important features (dredged material mounds, bedforms, rock outcrops, capping material), the survey tracklines and sonar sweep must be spaced so that each transect overlaps 50%. The best record can be achieved by using a consistent survey configuration, by tuning the instrument, and by keeping the sonar fish at a constant level above the bottom. This technique is often used with other monitoring techniques, such as sediment profile surveys and bathymetry, because the margins of the disposed material usually lose the sidescan signature within a few months after disposal due to bioturbation and physical processes.

Sediment Profiling Samples

A sediment-profile camera profiles in-situ sediment. The camera photographs a vertical section of the seafloor at the sediment and water interface. An additional camera can be mounted on the camera's external frame to obtain a plan view of the sampling site. Variables measured from the sediment-profile images include a variety of subsurface sediment characteristics. These characteristics include thickness of dredged material (cap deposits up to 22 cm), sediment grain size, surface boundary roughness, apparent redox potential discontinuity (RPD) and infaunal successional stage.

Sediment-profile images should be obtained before and after contaminated material disposal and after capping of the contaminated dredged material. Such profiling determines the characteristics of each phase of disposal, as well as the thickness and extent of the deposits. These data are then used to supplement the bathymetry. Sediment profile monitoring may be done periodically over a long term to assess the stability (or mobility) of disposed material and the extent of bioturbation and infaunal recolonization on the cap.

6.2.2 Chemical Monitoring

Water Quality

Disposal site water quality monitoring includes measuring dissolved oxygen (DO) content at a variety of depths within the water column and tracking the sediment plume from dredged material disposal. Dissolved oxygen content can be measured by either a probe or by collecting water column samples then testing those samples by standard methods such as the Winkler titration. Although it is most commonly used to quantify the relationship between acoustic backscattering levels and turbidity, water column sampling may also be used for plume tracking.

In disposal operations where residence time of the plume is very short, tracking by acoustic methods is recommended. A sediment plume can be tracked through remote sensing using a high frequency acoustic depth sounder. The plume position is measured spatially by observing the interference of the plume with the high frequency signal.

Shallow Borings

Shallow borings at the CAD and nearshore disposal sites should be taken before disposal of contaminated material and after the disposal site is capped. Depending on several factors–the cap thickness, water depth, sediment properties and depth sampled–a variety of demonstrated sediment sampling devices can be employed. For collecting surface sediments when there is no need for stratigraphic information, Van Veen-type samplers are commonly used at CAD sites. For shallow undisturbed coring, a boxcore can be used. When sampling a CAD or nearshore site's cap and underlying material, a device must be chosen that will achieve the required penetration and retention. Such sampling devices include hydraulic impact corers, diver-operated hammer corers, piston corers, vibracorers, gravity corers, and auger corers. Typical sediment sampling depths from these corers vary from 4 ft to more than 50 ft for an auger corer. The choice of the boring device depends on the desired volume of sample, cost, equipment availability, and water depth.

The samples collected from borings can be analyzed for conventional physical and chemical parameters or for contaminants present before, during, or after dredged material disposal. Conventional tests include grain size distribution, total volatile solids, total organic carbon, ammonia and total sulfides. Contaminant analysis of the collected samples can be conducted for a suite of compounds (i.e. chemicals of concern) or for specific target chemicals during the initial characterization of the contaminated sediments.

Soil Testing

Surface soils are collected from nearshore and upland disposal sites and offsite at a benchmark location following disposal. Soils are tested for contaminant chemicals of concern, pH, and salinity.

6.2.3 Biological Monitoring

Biological monitoring indicates the effects of dredged material disposal on the biological communities. This may be done through a variety of techniques:

Acute Bioassays

Bioassays involve exposing aquatic test organisms to sediment samples for specified periods of time. The response of these aquatic organisms to the sediment is a relative measure of sediment toxicity. The acute toxicity bioassays prescribed by PSDDA (1988) are recommended for the S-4 program. They are described below.

Amphipod Bioassay. This test involves exposing the amphipod *Rhepoxynius abronius* to test sediment for 10 days and counting the surviving animals at the end of the exposure period. Daily emergence of amphipods is also recorded. Clean reference sediments are selected based on their similar grain size compared with test sediment. The reference sediments are collected from appropriate reference sites.

Bivalve Larvae or Echinoderm Embryo Sediment Bioassay. These bioassays monitor the first 48 to 96 hours of embryonic development of fertilized eggs of the Pacific oyster (*Crassostrea gigas*), the blue mussel (*Mytilus edulis*), or a echinoderm species in the presence of test sediment. Egg mortality or the development of abnormal larvae are used as toxicity indicators. PSDDA-specified modifications to the PSEP (Tetra Tech 1986) procedures should be followed during these tests.

Microtox Bioassay. The Microtox bioassay measures the luminescence of the bacterium *Photobacterium phosphoreum* following a 15-minute exposure to a saline extract of test sediment. Decreased luminescence following the exposure period provides a quantitative measure of toxicity.

***Neanthes* Bioassay.** Although not currently prescribed by PSDDA, a 10-day acute toxicity test using the polychaete, *Neanthes arenaceodentata*, may be adopted. Test protocol is currently being developed. At the end of the 10-day experiment, the survivors are counted in control, reference, and test sediments, and the statistical significance of each test mean is measured against the reference mean.

Bioaccumulation

Bioaccumulation studies provide another indication of the effects of contaminated sediments on the biota. The basis for bioaccumulation studies is the potential for contaminant uptake by infaunal deposit or suspension feeders and the subsequent availability and transfer of this contamination to higher trophic levels. Done according to a specified sampling plan, bioaccumulation studies collect benthic organisms with surface grabs, box cores or dredges in sufficient amounts for chemical tissue analysis. Bioaccumulation data are collected before disposal and at various long-term intervals following cap placement.

Benthic Resources Assessment Technique (BRAT)

The Benthic Resources Assessment Technique (BRAT) indicates changes in the biological community due to changes in the seafloor characteristics (Lunz and Kendall 1982). Included in long-term dredged material disposal monitoring, BRAT addresses the potential resource value of the disturbed seafloor regions. Soft bottom disturbances can affect benthic communities which in turn result in positive or negative changes in fish foraging habitat. The quality of the habitat change is measured by the change in foraging conditions for the various fish species in a given area. The BRAT uses information about the size and depth distributions of benthic macroinvertebrate infauna in an area. BRAT then compares this information to the feeding habits of fishes from the same area to determine the area's forage value to fishes. The BRAT can be conducted with or without Traditional Taxonomic Analysis (TTA).

Traditional Taxonomic Analysis (TTA)

Traditional Taxonomic Analysis (TTA) complements the BRAT by identifying the benthic macroinvertebrate community in an area. The technique allows changes in benthic macroinvertebrate population and community conditions to be assessed over time; sampling occurs before and following dredged material disposal.

Plant Bioassays

Plant bioassay tests evaluate plant uptake of contaminants from dredged material placed in an intertidal, wetland or upland environment. Two tests have been applied with good results. The first takes a sediment sample from a waterway and places it in either a wetland-simulated environment or an upland environment. An index plant suited to estuarine (e.g. *Spartina alterniflora)* or freshwater (e.g. *Cyprus esculentus*) sediments is introduced to the environment. The plant is monitored for growth, phytotoxicity and bioaccumulation during growth. At the end of the growth phase, the plant is removed and tested for contaminants of concern. The second test measures the capacity of a plant root to extract metals from dredged material. The results of these tests indicate different ways plant growth can be managed in and around upland sites.

Earthworm Bioassay

Using an earthworm as an index species, the bioassay tests the uptake of contaminants by animal species from dredged material placed upland. The earthworm is placed in test sediment maintained in moist and semi-moist air-dried environments. Both mortality and tissue analysis results are evaluated.

6.2.4 Groundwater Monitoring

Groundwater is monitored to assess whether a containment facility is performing as designed and to evaluate the extent and degree to which various contaminants may enter the subsurface environment. Groundwater near an area containing contaminated dredged material can also become contaminated as chemical constituents move from the dredge material to the groundwater. The contaminants are typically mobilized and transported by water entering and flowing through dredged material. Water can enter as infiltrated rainfall when the dredged material is placed above the water table in an upland site, or as groundwater when the dredged material is placed below the water table (or in a body of water) in a nearshore site.

Groundwater monitoring is applicable in upland and nearshore monitoring. Most upland areas are underlain at some depth by aquifers that may supply drinking water to wells or springs, or discharge groundwater to streams or other surface water bodies. Groundwater monitoring can indicate when these aquifers are in jeopardy or when a facility is not working as planned. Groundwater monitoring is also applicable for nearshore dredge disposal. Typically, water leaving a nearshore facility passes through an artificial (or in some cases natural) berm in the form of groundwater. This groundwater usually discharges directly into the body of surface water in which the nearshore facility has been placed. Monitoring groundwater in the berm can indicate the amounts of contamination that will reach the adjacent surface water and whether the facility is performing as designed. In some cases, excessive groundwater contamination levels in the berms can trigger a corrective action before the contaminants reach the environment.

Groundwater monitoring is not applicable to confined aquatic disposal sites. The path of groundwater in these sites is always into the bottom of the site through the sea floor, through the CAD facility, and out through the cap. Groundwater is always upgradient from the contamination and is therefore unaffected by the concentration of various contaminants within the dredged material. Monitoring this water indicates only the condition of the groundwater before it reaches the contaminated dredged material. Water exiting the facility could contain contaminants but is not considered groundwater since it flows out of the cap and becomes part of the aquatic environment, where other methods of monitoring are more appropriate. Thus, monitoring groundwater in the cap is technically feasible but not practical.

Groundwater is usually monitored using small diameter wells (2-4 inches) made from a variety of materials, but typically plastic or steel. Typically, the wells open to water-bearing strata through a slotted section of the well casing known as a "well screen." The area above the well screen is usually sealed from the top of the screen to the ground surface with a grout containing clay, a clay-cement mixture, or cement. Water samples are collected from the well using a dedicated pump or bailer after standing water has been removed from the well to ensure samples come from the monitoring zone. The water sample is transported to a chemical analysis laboratory following chain-of-custody procedures to help ensure the sample is not lost, mixed up, or otherwise invalidated. The sample is then analyzed for the parameters designated for that well.

6.3 ALTERNATIVES SUMMARY

Drawing upon elements of the monitoring (physical, chemical, biological) types discussed in Section 6.2, we developed three alternatives for monitoring the disposal of contaminated sediments. These alternatives were designed for CAD, nearshore, and upland environments.

For each of the three alternatives, monitoring consists of short-term (construction monitoring) and long-term (post-construction) monitoring. Short-term monitoring, conducted at both the dredge site and the disposal site, documents that dredging and disposal follow the project design. Long-term monitoring, conducted only at the disposal site, provides data on the continued effectiveness and impact limitations of each alternative. Depending on long-term monitoring results, corrective action may be required.

6.3.1 CAD Monitoring Alternatives Summary

Three confined aquatic disposal monitoring alternatives were developed. These CAD alternatives are summarized in Table 6.1 and described below. The alternatives range from least environmentally sensitive, thorough, and costly (Alternative 1) to most sensitive, thorough, and costly (Alternative 3). This structure is intentionally opposite that in Chapter 5. In Chapter 5, the Alternative 1 design is always the most conservative and rigorous. Therefore, it makes sense that the corresponding monitoring alternative would not have to be too rigorous or thorough.

Alternative 1

Short-Term Monitoring. Short-term monitoring will consist of dredge site water quality measurements, dredge positioning control, dredge and disposal site bathymetric surveys, disposal site sediment profile surveys, and shallow borings.

Table 6.1. CAD monitoring alternatives.

	ALTERNATIVES 1	2	3	N.A.
SHORT-TERM MONITORING				
Dredge Site				
Dilution Zone Boundary, Water Quality				
• Dissolved Oxygen	Yes	Yes	Yes	
• Turbidity	Yes	Yes	Yes	
• Other Water Quality Certification Requirements	Yes	Yes	Yes	
Dredge Positioning				
• Hydraulic - hourly	Yes	Yes	Yes	
• Mechanical - after each barge relocation	Yes	Yes	Yes	
Bathymetry				
• Survey Frequency	Biwkly	Wkly	Dly	
• 25-ft intervals, or start, mid-point, and end of dredging progress	Yes	Yes	Yes	
Disposal Site				
Monitoring Positioning Accuracy (m)	3	3	3	
Water Quality (Column)				
• Plume Tracking (acoustic and bottle casts)			Yes	
- Frequency, 5 of first 10 barge dumps			Yes	
• Dissolved Oxygen				
- Frequency, before & after 5 of first 10 dumps			Yes	
- Distribution, surface, mid-depth, near-bottom			Yes	
Bathymetry				
• Frequency - Contaminated Sediment Disposal				
- Onè Pre-Disposal Survey	Yes	Yes	Yes	
- During disposal	One/ Mnth	One/ Mnth	One/ 2 wks	
- One Post Disposal Survey within 2 weeks after placement	Yes	Yes	Yes	
• Frequency - Cap Material				
- One survey, completed 1 month after capping	Yes	Yes	Yes	
Side Scan Surveys				
- One survey, pre-contaminated material disposal		Yes	Yes	
- One survey, post-contaminated material disposal		Yes	Yes	
- One survey, post-cap material disposal		Yes	Yes	

Table 6.1. CAD monitoring alternatives (continued).

	ALTERNATIVES 1	2	3	N.A.
Sediment Profile Samples				
- One round, pre-contaminated material disposal	Yes	Yes	Yes	
- One round, post-contaminated material disposal	Yes	Yes	Yes	
- One round, post-cap material disposal	Yes	Yes	Yes	
Shallow Borings (Physical/Visual Measurements)				
- One round, pre-contaminated disposal	Yes	Yes	Yes	
- One round, post-cap material disposal	Yes	Yes	Yes	
LONG-TERM MONITORING				
INTENSIVE FIRST-YEAR				
• Conduct following sampling at 3-mo. & 6-mo. milestones				
- Bathymetry		Yes	Yes	
- Sediment Profile Samples		Yes	Yes	
- Shallow Borings (visual & chemical)			Yes	
SUBSEQUENT YEARS' MONITORING				
• Shallow Borings (visual and chemical)				
- Years 2, 4, 7, & 10	Yes	Yes	Yes	
• Biological				
- BRAT @ years 1, 2, 4, & 7			Yes	
- BRAT @ years 2, 4, & 7		Yes		
- Bioaccumulation @ years 1, 2, 4, 7			Yes	
• Sediment Profile Camera				
- Years 2, 3, & 4		Yes	Yes	

Water quality measurements will be conducted at the dredge site based on the dimensions of the Water Quality Dilution Zone. This zone will be established on a case-by-case basis by Ecology, in the state water quality modification and Section 401 Water Quality Certification (WAC/71-201-035). A Water Quality Dilution Zone assures protection of the ecosystem and other beneficial uses identified in the current state dilution zone guidelines. Applicable WQS criteria for dissolved oxygen (DO) and turbidity will be met at the dilution zone boundary. Within the dilution zone boundary, WQS are modified for DO and turbidity; however, DO will not be allowed to fall below 5 mg/L. Measurements will be taken at the mid-point between the dredging activity and the dilution zone boundary. Ecology's Water Quality Modification and Certification may establish other project-specific requirements within the dilution zone boundary, depending on sediment characteristics, the nature of the ecosystem, and other beneficial uses in the dredging area. However, at no time will these modifications allow acute toxic effects to occur.

The dredge will be positioned by established land control locations. Position will be determined by two angle sextant plot, laser and theodolite triangulation, electronic positioning, or other approved method. Dredge position will be updated hourly for a hydraulic dredge, and after each relocation of a mechanical bucket dredge.

Bathymetric surveys will be completed at the dredging site as biweekly progress surveys. These bathymetric surveys provide volume estimates of the amount of dredged material removed, the amount placed at the disposal site, and the amount of material placed in the cap. Surveys will be cross lines placed over dredged track line at 25-foot intervals, or at start, midpoint, and end of each day's dredging progress as a minimum. At the disposal site, pre-disposal, disposal, and post-disposal bathymetric surveys will be done during contaminated sediment placement. These bathymetric surveys will use an acoustic depth sounder with an electronic horizontal positioning system. Real time on board plots and electronic xzy data disks will be produced. Data output will include depths in feet to the nearest 0.1 ft, and x-y horizontal positioning in Washington state plane coordinates (± 3 m positional accuracy). During disposal, or progress surveys during contaminated sediment placement will be completed once every month, at a minimum. Post-disposal surveys will be completed within two weeks of contaminated sediment placement and before capping a site. Post-capping surveys will be completed within one month of capping.

Pre-disposal and post-disposal sediment profiling camera surveys will be conducted. The major objective of these surveys is to verify the limits of contaminant deposition and capping thickness. This method will supplement bathymetric surveys for thin deposits of contaminated and capping materials. Sediment-profile images will also provide information on the extent of sediment reworking by benthic organisms. Sampling will be done for pre- and post-deposition of contaminated sediments and post-disposal of capping materials. Post-sampling will be completed one month after capping is completed.

Shallow borings will be obtained for pre-disposal conditions at a subset of the sediment profiling camera stations. Post capping borings will also be obtained at the same coordinates to establish compliance with required capping thickness. Physical and visual measurements will be conducted on each boring to verify cap integrity.

Long-Term Monitoring. Long-term monitoring is required only at the disposal area. For Alternative 1, long-term monitoring consists solely of shallow borings, which will be obtained on years 2, 4, 7, and 10 after disposal. Target compound chemistry, grain size and visual inspection of sediments will be conducted for each foot of core retrieved through the contaminant sediment level. The objective of this sampling is to verify the physical and chemical integrity of the cap. Target chemical compounds to be analyzed will be determined by the results of initial sediment characterization on a project-by-project basis.

Alternative 2

Short-Term Monitoring. Short-term monitoring for Alternative 2 consists of dredge site water quality measurements, dredge positioning control, dredge and disposal site bathymetric surveys, disposal site sidescan and sediment profile surveys, and shallow borings.

At the dredge site, water quality measurements and dredge positioning will be conducted as described for Alternate 1. Bathymetric surveys will be conducted weekly, rather than biweekly.

At the disposal site, bathymetric and sediment-profile surveys, and sediment sampling (shallow borings) will be completed as described for Alternative 1. In addition, sidescan surveys will be conducted before disposal of contaminated sediments, following disposal of contaminated sediments, and following capping. Sidescan surveys will be conducted immediately following the disposal site bathymetric surveys. The objective of the sidescan surveys is to map the areal distribution of disposed dredge material and capping material. Survey tracklines will overlap each track sonograph by 50%.

Long-Term Monitoring. Alternate 2 long-term monitoring consists of intensive first-year sampling as well as long-term trend monitoring. First-year sampling will be required at 3 and 6 months, and will include repeat post-disposal bathymetric and sediment-profile surveys.

The following year, long-term monitoring will include shallow borings at the interval described for Alternative 1 (2, 4, 7, and 10 years after disposal). Additional sediment-profile surveys will be conducted 2, 3, and 4 years after disposal and BRAT (Benthic Resource Assessment Technique) surveys will be conducted on years 2, 4, and 7. The BRAT surveys will assess the vertical and horizontal distribution of infaunal taxa at the site and their utilization by bottom feeding fish. In addition, the BRAT data will provide information on the extent of biogenic sediment reworking of the cap material (supplemental to the sediment-profile data).

Alternative 3

Short-Term Monitoring. Short-term monitoring for Alternative 3 includes the same elements described for Alternative 2, as well as disposal area water quality sampling during contaminated sediment disposal.

At the dredge site, water quality measurements and dredge positioning will be conducted as described for Alternatives 1 and 2. However, bathymetric progress surveys will be conducted on a *daily*, rather than weekly basis.

At the disposal area, sediment dispersion during disposal will be monitored by acoustic plume tracking from identified disposal coordinates. The plume tracking will allow estimation of the amount of dredged material lost during disposal. The acoustically imaged plume will be measured by deploying bottle casts to determine actual suspended load concentrations. Monitoring will be done on five of the first ten barge dumps. Dissolved oxygen measurements will also be made within the state-identified dilution zone boundaries. Sampling will take place before and immediately after barge disposal. These samples will be collected at the surface, mid-depth, and near bottom for five of the first ten barge dumps.

Disposal-area, pre-disposal, disposal, and post-disposal bathymetric surveys will be conducted as described for Alternatives 1 and 2. An exception under Alternative 3 is that the surveys done during disposal will be conducted at *two-week* rather than one-month intervals.

Pre- and post-disposal sediment profile and sidescan surveys will be conducted as described for Alternative 2. An exception under Alternative 3 is that progress sediment-profile surveys will be done after every 200,000 yd^3 of contaminated sediment deposition. The surveys ensure that material is placed within the target disposal area. To monitor cap integrity, shallow borings will be collected (pre-disposal and post-cap placement) and visually and chemically analyzed at all sediment-profile survey stations.

Long-Term Monitoring. Alternative 3 long-term monitoring consists of intensive first-year sampling as well as long-term trend monitoring. Intensive first-year sampling, required at 3 to 6 months, will include repeat post-disposal bathymetric and sediment-profile surveys, as well as shallow borings.

Long-term monitoring will include shallow borings at the intervals described for Alternatives 1 and 2 (2, 4, 7, and 10 years after disposal). Target compound chemistry, grain size, and visual inspection of sediments will be conducted for each foot of core retrieved through the contaminant sediment level. Sediment-profile surveys will be conducted as described for Alternative 2. BRAT surveys will be done on years 1, 2, 4, and 7. Bioaccumulation sampling, (chemical tissue analysis of an infaunal, deposit-feeding organism) will also be conducted on years 1, 2, 3, and 4 after disposal.

6.3.2 Nearshore Monitoring Alternatives Summary

Dredging and Disposal Monitoring

Monitoring during dredging and disposal operations primarily addresses water quality. The monitoring during dredging is identical to that discussed in Section 6.3.1 for CAD alternatives. The monitoring during disposal needs to address effluent quality at the weir outlet boxes to measure suspended sediment loads. Disposal monitoring also includes water column samples in the effluent receiving waters at the dilution zone boundaries to verify compliance with Ecology's Water Quality Standards. These monitoring alternatives are summarized in Table 6.2.

Disposal Site - Long Term

Monitoring at the disposal site examines contaminant migration from the site to the receiving waters. This monitoring will be done through water column samples collected at various distances offshore, groundwater monitoring, runoff monitoring, and cap borings. Analysis of these samples will target contaminants of concern based on the characteristics of the dredged material placed in the site. The long-term monitoring alternatives are also summarized in Table 6.2.

Groundwater

Three alternatives for groundwater monitoring at nearshore disposal sites are summarized in Table 6.2 and described in detail in this section.

Table 6.2. Summary of nearshore monitoring alternatives.

	ALTERNATIVES		
	1	2	3
Dredging			
Dilution Zone Boundary, Water Quality			
• Dissolved Oxygen	Yes	Yes	Yes
• Turbidity	Yes	Yes	Yes
• Other Water Quality Certification Requirements	Yes	Yes	Yes
Dredge Positioning			
• Hydraulic - hourly	Yes	Yes	Yes
• Mechanical - after each barge relocation	Yes	Yes	Yes
Bathymetry			
• Survey Frequency	Wkly	Wkly	Dly
• 25-ft intervals, or start, mid-point, and end of daily dredging progress	Yes	Yes	Yes
Disposal			
Effluent Overflow			
• Suspended Sediments	Wkly	Dly	2/day
Water Quality @ Return			
• D.O.	5 days	5 day/ wk	Dly
- mid-point of dilution zone, boundary			
- surface, mid, bottom			
• Suspended Sediments			
- mid-point, boundary			
- surface, mid, bottom			

Table 6.2. Summary of nearshore monitoring alternatives (continued).

	ALTERNATIVES 1	2	3
• Boring (cap)			
- depth of contaminants	2	4	8
Groundwater			
• Number of Wells*	4	6	8
• Number of Sampling Rounds** - through the first year	5	5	7
• Number of Sampling Rounds - subsequent years	2	2	2
• Contaminants of Concern			
Priority Pollutants - predisposal round	Yes	Yes	Yes
Priority Pollutants - 6-month round		Yes	Yes
Indicator parameters + degradation product	Yes	Yes	Yes
Nitrate, nitrite, nitrogen, ammonia	Yes	Yes	Yes
COD	Yes	Yes	Yes
Dissolved PP metals, iron, manganese	Yes	Yes	Yes
TOC	Yes	Yes	Yes
Adjacent Surface Water Samples			
• Sampling events/yr	1	2	4
• Number of samples	6 (3 on 2)	12 (4 on 3)	20 (5 on 4)
• Years	5	10	20
Runoff Surface Waters			
• Sampling events/yr	---	.5 yrs	1
• Number of samples	---	6	9
• Number of years	---	7	15
Cap Borings			
• Sampling events/yr	---	.5 yrs	1/yr
• Number of borings	---	2	4
• Number of years	---	9	15

*The number of wells listed here are estimated, the actual number will depend on site-specific conditions.
**Includes pre-disposal background sampling.

Alternative 1. Whenever possible, monitoring wells will be installed at least one month before the site is prepared for disposal. To establish existing site conditions and background concentrations, samples will be collected and analyzed for priority pollutants. Sampling will be timed so that wells are sampled during the outgoing tide at the latest time a sample can be collected from a well. Water levels will be measured in all wells during a tide cycle. The data will be used to predict high and low concentrations for typical annual cycles.

Groundwater sampling will be more frequent immediately following placement of dredged material to evaluate the initial impact of the contaminated sediments and the dewatering surge that follows. After disposal operations are completed and clean caps are in place, sampling frequency may be reduced unless contamination is evident. The sampling frequency will be 1 month, 2 months, then 6 months thereafter.

Monitoring Well Design. All monitoring wells will be cased to maintain the integrity of the monitoring well bore hole. This casing will allow collection of representative groundwater samples. Wells will be constructed to prevent contamination of the samples, the sampled strata, and to prevent contamination between aquifers and water-bearing strata. Such well construction is in accordance with chapter 173-160 WAC, Minimum Standards for Construction and Maintenance of Water Wells. And wells will be drilled following accepted procedures for decontamination of drilling and sampling equipment.

Each well will be constructed in accordance with the requirements outlined in WAC 173-160-500. The minimum requirements specific to Alternative 1 are as follows:

- Casing will consist of Schedule 40 PVC, with non-glued, flush-joint connections.

- Well screens will consist of Schedule 40 PVC, with machined slots of 0.02 inch over a 10-foot length. A suitable silica sand pack will be placed by tremie pipe from 1 ft below the lowest screen opening to 3 ft above the uppermost screen opening.

Well Placement and Number of Wells. Wells will be placed at a minimum of three locations downgradient from the nearshore containment site and at a minimum of one location upgradient of the containment site. One well will be placed in the contained dredge fill at the location most likely to have maximum concentrations of contaminant release. This location will be selected based on:

- The location of maximum contamination concentrations based on the pre-dredging chemical and physical characterization of the dredged material

- The location of hydraulically active areas (e.g. near the berm or in upper levels of fill)

- The location of relevant high permeability zones

- The types of contaminants that are likely to be released (e.g. metals).

For a nearshore containment having a granular fill berm with permeability greater than the non-fill material in the remainder of the berm, a minimum of two wells will be placed in the berm. Each well will be placed halfway between the containment side and the seawater side of the berm. The middle of the well screen will be placed at MLLW, where the berm is known to be generally homogeneous. Where the berm's composition is believed to vary, the well will be centered in the zone of highest permeability that remains saturated during the normal tidal cycle. If the fill is contained in part by non-bermed, existing materials with permeabilities comparable to those of the berm (one half to greater than the permeability of the berm materials), then at least one monitoring well will be placed in the non-bermed, existing materials. Specifically, the well will be placed in the most permeable zone of the non-berm containment materials that remains saturated during the normal tidal cycle.

For a nearshore containment created out of existing nearshore materials (i.e. excavated in a nearshore, land-based environment with dredge fill placed in a pit that remains saturated) three wells will be placed at downgradient locations as indicated by either:

- A hydrogeologic characterization of the site, or
- Placement of three of the four wells, collection of valid water level data, and assessment of groundwater flow direction. Three of the wells will be located to indicate flow from the contained dredged material. The fourth well will be located to indicate flow upgradient from the contained dredged material. If necessary, additional wells will be placed so that at least three wells lie downgradient from the containment site.

The middle of each well screen will be placed at MLLW, where the existing material is known to be generally homogeneous. Where the existing material's composition varies, the well will be centered in the zone of highest permeability that remains saturated during the normal tidal cycle.

Sampling Techniques. All sampling will be done with state-of-the-art sampling equipment and procedures. At the beginning of each sampling round, water levels will be measured in all wells. At least three casing volumes from each well will be purged, or the well will be purged until dry. Groundwater will be sampled by stainless steel bailer, dedicated bladder pump constructed of materials similar to the well and well screen or other method as approved by Ecology. The pH will be measured in the field with the electrode calibrated before each measurement. The conductivity meter will be calibrated once before the sampling round.

Sampling quality assurance and quality control (QA/QC) includes field blank samples and field replicate samples. One bailer rinsate blank or field blank may be collected each sampling round to determine the existence and magnitude of contamination problems. One field replicate sample may be collected and analyzed each round to provide an indication of overall precision. Sampling frequencies for field blanks and field replicates are typically one per twenty samples. If samples are filtered for metal analyses, the filters will be tested before their use for addition or subtraction of dissolved metals in solution.

Monitoring Parameters. The chemistry of the dredged sediments will determine what monitoring parameters are used. An indicator parameter list will be developed based on the initial sediment and elutriate chemistry. The list will include likely toxic degradation products of compounds in the original sediment chemistry. At a minimum, the following parameters will be analyzed:

- pH, conductivity (field measurements)
- Nitrate, nitrite, nitrogen, ammonium
- Chemical oxygen demand
- Dissolved priority pollutant metals, iron, manganese
- Total organic carbon.

Analytical laboratory QA/QC will follow the Contract Laboratory Program (EPA 1987, 1988) for inorganic and organic priority pollutants on the indicator parameter list. Analytical laboratories generally provide data for QA/QC sample analyses (i.e. method blanks, spike recoveries, duplicate analyses) associated with nutrients, COD, and TOC at no additional charge to their client. If organic priority pollutants are analyzed, the laboratory may charge for matrix spike/matrix spike duplicate samples and method blank samples (required at a minimum frequency of one per twenty samples) as additional samples.

Alternative 2. Alternative 2 is similar to Alternative 1. The alterations for greater environmental protection are as follows:

Well Installation. Alternative 1 requires, that whenever possible, monitoring wells be installed at least one month before the site is prepared for disposal. Alternative 2 allows wells to be installed anytime before the site is prepared for disposal. We recognize that in some situations, it is not possible or desirable to install wells before sediment placement, so this requirement should remain flexible.

Groundwater Sampling. Alternative 1 allows for reduction in sampling frequency unless contamination is evident. Alternative 2 requires decisions on reduction in sampling frequency to be statistically based.

Well Placement. Alternative 1 requires that wells will be placed at a minimum of three locations downgradient from the nearshore containment site. Alternative 2 requires that wells will be placed 300 ft apart at locations downgradient from the containment site or at three locations downgradient from the containment site (whichever is greater).

Alternative 1 requires a minimum of 2 monitoring wells in granular fill berms which have permeability greater than non-fill material in the remainder of the berm. Alternative 2 requires a minimum of 2 monitoring wells in granular fill berms, regardless of non-fill material permeability.

Monitoring Parameters. Unlike Alternative 1, Alternative 2 requires that priority pollutant organic compounds be analyzed in samples after six months of disposal, if priority pollutant organic compounds were not included earlier as indicator parameters.

Alternative 3. Under Alternative 3, monitoring wells will be designed, placed, sampled, and monitored for the same parameters discussed for Alternative 1 with the following alterations for greater environmental protection:

Well Installation. Monitoring wells will be installed, whenever possible, sometime before the site is prepared for disposal. Two rounds of samples will be collected and analyzed for priority pollutants to establish existing site conditions and background concentrations during tidal and seasonal fluctuations. Sampling will be timed for wet season high high tide and dry season low low tide sampling. The low low tide sampling may need to be adjusted if wells go dry. In that event, samples will be collected during the outgoing tide at the latest time that a sample can be collected from a well.

Groundwater Sampling. Decisions on reducing the frequency of groundwater sampling will be statistically based in Alternative 3, and an additional sampling event is required at 2 weeks.

Well Placement. The unique feature of Alternative 3 well design is the use of clustered wells completed at multiple depths. Use of these well groups changes several aspects of the monitoring plan. Like Alternative 2, wells will be placed in locations 300 ft apart or at three locations downgradient from the nearshore containment site (whichever is greater). However, under Alternative 3, groups of wells will be installed at each location. The groups will consist of two to three wells, depending on the thickness of the zone of groundwater discharge. Zones less than 30 ft thick will require at least two wells while zones greater than 30 ft thick will require a minimum of three wells. And two wells (unlike only one for Alternatives 1 and 2) will be placed in the contained dredge fill at locations most likely to release maximum concentrations of contaminants. The area of probable contaminant release will be determined by considering:

- The location of dredged materials with relatively high contaminant concentrations
- The location of hydraulically active areas (e.g. near the berm or in upper levels of fill)
- The location of relevant high permeability zones
- Types of contaminants that are likely to be released.

Well Placement and Number of Wells. Wells will be placed in groups 300 ft apart at locations downgradient from the contained dredged materials or at three locations downgradient from the nearshore containment site (whichever is greater). The groups will consist of two to three wells depending on the thickness of the zone of groundwater discharge. Zones less than 30 ft thick will require at least two wells while zones greater than 30 ft thick will require a minimum of three wells. At least one well will be located upgradient of the containment site. Two wells will be placed in the contained dredge fill at locations most likely to have the maximum concentrations of contamination. The maximum contamination concentrations are based on the pre-dredging chemical and physical characterization of the dredge material.

For a nearshore containment with a granular fill berm, a minimum of two wells groups will be placed in the berm. Each group will be located halfway between the containment side and the seawater side of the berm. The middle of the well screen of the upper well in the group will be placed at MLLW. The additional deeper wells will be placed at depths most likely to yield representative results.

The second well screen will be placed with the top 10-20 ft below the bottom of the upper well screen in a location where the berm's composition is known to be generally homogeneous. Where the zone of groundwater discharge is greater than 30 ft thick, the third well will be located 10-20 ft deeper than the second well. Where the berm's composition varies, the deeper wells will be centered in the zones of highest permeability. If the fill is contained in part by non-bermed, existing materials with permeabilities comparable to the berm materials (one half to greater than the permeability of the berm materials), then at least one monitoring well will be placed in the highest permeability zone of the non-berm containment materials that remains saturated during a normal tidal cycle.

For a nearshore containment created out of existing nearshore materials (i.e. excavated in a nearshore, on-land environmental with dredge fill placed in a pit that remains saturated) three well groups will be placed at locations downgradient from the containment as indicated by either:

- A hydrogeologic characterization of the site, or
- Placement of a minimum of three wells for each depth interval, collection of valid water level data and assessment of groundwater flow direction. Additional wells for each depth interval will then be located so that at least three wells indicate flow from the contained dredge material while at least one well indicates flow upgradient from the contained dredge material. If necessary, additional wells will be placed so that at least three wells lie downgradient from the containment site.

The middle of the well screen of the upper well in the group will be placed at MLLW. The additional deeper wells will be placed at depths most likely to yield representative results.

Where the existing material is known to be generally homogeneous, the top of the second well screen will be placed at 10-20 ft below the bottom of the upper well screen. Where the zone of groundwater discharge is greater than 30 ft thick, the third well will be located 10-20 ft deeper than the second well. Where the berm's composition varies, one to two deeper wells will be centered in the zones of highest permeability.

Monitoring Parameters. An indicator parameter list will be developed for subsequent sampling rounds based on the initial sediment and elutriate chemistry, the two pre-disposal groundwater sampling rounds, and the six-month post-disposal sampling round for priority pollutant organic compounds.

Biological Monitoring

Biological monitoring has the potential to be used as an indicator of contaminant migration from the site into the receiving waters. If contaminant migration was significant, it would be expected to be reflected in the benthic population adjacent to the disposal site. In the absence of confounding factors, biological monitoring would serve as a reliable indicator. In reality, though, most of the nearshore sites are in urban settings. As a result, effects on biological populations adjacent to the site may be totally unrelated to site failure. Nearby outfalls, past practices, chemical spills, natural disturbance patterns, and a variety of other causes associated with a nearshore urban setting could be the cause of adverse biological effects.

Since it is realistic to assume that biological monitoring will not provide cause-and-effect type evidence for disposal site performance, we have not identified biological monitoring alternatives. However, if a site location is rural, or for some other reason allows that type of evaluation, Ecology would likely make it a part of the permit condition.

6.3.3 Upland Mixed Monitoring Alternatives Summary

Dredging and Disposal Monitoring

Monitoring during dredging and disposal operations primarily addresses water quality. The monitoring during dredging is identical to the CAD alternatives. The monitoring during disposal needs to address effluent quality at the weir outlet boxes to measure suspended sediment loads. Disposal monitoring also includes water column samples in the effluent receiving waters at dilution zone boundaries to verify compliance with Ecology's Water Quality Criteria. Monitoring alternatives are summarized in Table 6.3.

Groundwater

Two alternatives for groundwater monitoring at upland mixed fill sites are summarized in Table 6.3 and described in detail in this section.

Table 6.3. Summary of upland mixed monitoring alternatives.

	ALTERNATIVES 1	2	3
Dredging			
Dilution Zone Boundary, Water Quality			
• Dissolved Oxygen	Yes	Yes	Yes
• Turbidity	Yes	Yes	Yes
• Other Water Quality Certification Requirements	Yes	Yes	Yes
Dredge Positioning			
• Hydraulic - hourly	Yes	Yes	Yes
• Mechanical - after each barge relocation	Yes	Yes	Yes
Bathymetry			
• Survey Frequency	Wkly	Wkly	Dly
• 25-ft intervals, or start, mid-point, and end of daily dredging progress	Yes	Yes	Yes
Disposal			
Effluent Overflow			
• Suspended Sediments	Wkly	Dly	2/day
Water Quality @ Return			
• D.O.	5 days	5 day/ wkly	Dly
- mid-point of dilution zone, boundary			
- surface, mid, bottom			
• Suspended Sediments			
- mid-point, boundary			
- surface, mid, bottom			
Groundwater			
• Number of Wells*	4	4	
• Number of Sampling Rounds** - through the first year	5	6	
• Number of Sampling Rounds - subsequent year	2	2	
• Analytes			
Priority Pollutants - predisposal round		Yes	
Priority Pollutants - 6-month round		Yes	
Indicator parameters + degradation product	Yes	Yes	
Nitrate, nitrite, nitrogen, ammonia	Yes	Yes	
Chloride, potassium, sodium, calcium	Yes	Yes	
COD	Yes	Yes	
Alkalinity	Yes	Yes	
Dissolved PP metals, iron, manganese	Yes	Yes	
TOC	Yes	Yes	

*The number of wells listed here are estimated, the actual number will depend on site-specific conditions.
**Includes pre-disposal background sampling.

Alternative 1. Timelines and siting requirements will follow WAC 173-304, Minimum Functional Standards for Solid Waste Handling. Whenever possible, monitoring wells will be installed at least one month before the site is prepared for disposal. Water levels will be measured and samples collected to establish existing site conditions and background concentrations. From this data, predicted high and low concentrations for typical annual cycles will be extrapolated.

Groundwater sampling will be more frequent immediately following the placement of dredged material to evaluate the initial effect of the contaminated sediments and the dewatering surge that follows. After disposal operations are completed and clean caps are in place, sampling frequency may be reduced unless contamination is evident. The sampling frequency will be 1 month, 2 months, then 6 months thereafter.

Well Design. Mixed fills contain solid waste as defined in WAC 173-304 and therefore must follow the requirements of WAC 173-304. Well design will be in accordance with WAC 173-160. There are no alternatives for this monitoring program.

Well Placement and Number of Wells. Mixed fills contain solid waste as defined in WAC 173-304 and therefore must follow the requirements of WAC 173-304. Well placement and the number of wells will be in accordance with WAC 173-304-490. There are no alternatives for this monitoring program.

Sampling Techniques. Mixed fills contain solid waste as defined in WAC 173-304 and therefore must follow the requirements of WAC 173-304. Detailed sampling is not outlined in WAC 173-304-490. Only one alternative sampling technique is recommended for this monitoring program.

All sampling will be done with state-of-the-art sampling equipment and procedures. At the beginning of each sampling round, water levels will be measured in all wells. At least three casing volumes from each well will be purged, or the well will be purged until dry. Groundwater will be sampled by stainless steel bailer, dedicated bladder pump constructed of materials similar to the well and well screen, or other method approved by Ecology. The pH will be measured in the field with the electrode calibrated before each measurement. The conductivity meter will be calibrated once before the sampling round.

Sampling quality assurance and quality control (QA/QC) includes field blank samples and field replicate samples. One bailer rinsate blank or field blank may be collected each sampling round to determine the existence and magnitude of contamination problems. One field replicate sample may be collected and analyzed each round to provide an indication of overall precision. Sampling frequencies for field blanks and field replicates are typically one per twenty samples. If samples are filtered for metal analyses, filters will be tested before their use for addition or subtraction of dissolved metals in solution.

Monitoring Parameters. Monitoring parameters must follow WAC 173-304, Minimum Functional Standards for Solid Waste Handling. WAC 173-304 also empowers the local Health Department to add or delete parameters.

Monitoring parameters will be chosen based on the chemistry of the dredged sediments and elutriates. An indicator parameter list will be developed based on the initial sediment and elutriate chemistry tests. The list will include likely toxic biodegradation products of initial contaminants. At a minimum, the following parameters will be analyzed:

- pH, conductivity (field measurements)
- Nitrate, nitrite, nitrogen, ammonium
- Chloride, potassium, sodium, calcium
- Alkalinity
- Chemical oxygen demand
- Dissolved priority pollutant metals, iron, manganese
- Total organic carbon.

Analytical laboratory QA/QC will follow the Contract Laboratory Program (EPA 1987, 1988) for inorganic and organic priority pollutants on the indicator parameter list. Analytical laboratories generally provide data for QA/QC sample analyses (i.e. method blanks, spike recoveries, duplicate analyses) associated with nutrients, COD, and TOC at no additional charge to their client. If organic priority pollutants are analyzed, the laboratory may charge for matrix spike/matrix spike duplicate samples and method blank samples (required at a minimum frequency of one per twenty samples) as additional samples.

Alternative 2. Under Alternative 2, monitoring wells will be designed, placed, sampled, and monitored for the same parameters discussed for Alternative 1. These alterations for greater environmental protection are as follows:

Timelines and siting requirements will follow WAC 173-304, Minimum Functional Standards for Solid Waste Handling. Whenever possible, monitoring wells will be installed at least six months before preparing the site for disposal. One round of sampling will be performed to measure water levels to establish existing site conditions and background concentrations. The samples will be analyzed for priority pollutants. From this data, the range of site conditions during wet and dry seasons will be extrapolated.

Groundwater Sampling. Decisions for reduction in frequency will be statistically based. The sampling frequency will be 2 weeks, 1 month, 2 months, 4 months, and 6 months thereafter.

Monitoring Parameters. All groundwater samples from the pre-disposal sampling round and the six-month post-disposal sampling round will be analyzed for priority pollutant organic compounds. The results of these sampling rounds along with initial sediment and elutriate chemistry will be used to develop an indicator parameter list for subsequent sampling.

6.3.4 Upland Lined Monofill Monitoring Alternatives Summary

Dredging and Disposal Site Monitoring

Monitoring during dredging and disposal operations primarily addresses water quality. These are the same as the nearshore dredging and disposal alternatives (see Table 6.3).

Groundwater

Two alternatives for groundwater monitoring at lined, upland monofill sites are summarized in Table 6.4 and described in detail in this section.

Table 6.4. Summary of upland mono-lined groundwater monitoring alternatives.

	ALTERNATIVES	
	1	2
Number of Wells*	4	4
Number of Sampling Rounds** - through the first year	5	6
Number of Sampling Rounds - subsequent year	2	2
Analytes		
Priority Pollutants - predisposal round	Yes	
Priority Pollutants - 6-month round		Yes
Indicator parameters + degradation product	Yes	Yes
Nitrate, nitrite, nitrogen, ammonia	Yes	Yes
Chloride, potassium, sodium, calcium	Yes	Yes
COD	Yes	Yes
Alkalinity	Yes	Yes
Dissolved PP metals, iron, manganese	Yes	Yes
TOC	Yes	Yes

*The number of wells listed here are estimated, the actual number will depend on the site-specific conditions.
**Includes pre-disposal background sampling.

Alternative 1. Whenever possible, monitoring wells will be installed before preparing the site for disposal. Water levels will be measured and samples collected and analyzed for priority pollutants to establish existing site conditions and background concentrations. From this data, high and low concentrations for typical annual cycles will be predicted.

Groundwater sampling will be more frequent immediately following the placement of dredged material to evaluate the initial impact of the contaminated sediments and the dewatering surge that follows. After disposal operations are completed and clean caps are in place, sampling frequency may be reduced unless contamination is evident. The frequency will be 1 month, 2 months, then 6 months thereafter.

Monitoring Well Design. All monitoring wells will be cased to maintain the integrity of the monitoring well bore hole. This casing will allow collection of representative groundwater samples. Wells will be constructed to prevent contamination of the samples, the sampled strata, and to prevent contamination between aquifers and water-bearing strata, in accordance with chapter 173-160 WAC, Minimum Standards for Construction and Maintenance of Water Wells. Wells will be drilled following accepted procedures for decontamination of drilling and sampling equipment.

Each well will be constructed following the requirements outlined in WAC 173-160-500. The minimum requirements specific to Alternative 1 are as follows:

- Casing will consist of Schedule 40 PVC, with non-glued, flush-joint connections.
- Well screens will consist of Schedule 40 PVC, with machined slots of 0.02 inch over a 10-ft length. A suitable silica sand pack will be placed by tremie pipe from 1 ft below the lowest screen opening to 3 ft above the uppermost screen opening.

Well Placement and Number of Wells. Wells will be placed at a minimum of three locations downgradient from the upland monofill site and at a minimum of one location upgradient of the upland monofill site. The wells will be placed at the edge of the expected boundary of the final fill property ("compliance point"). The upgradient and downgradient locations will be determined by either:

- A hydrogeologic characterization of the site that indicates groundwater flow direction, or
- Placement of three of the four wells, collection of valid water level data, and an assessment of groundwater flow direction. The fourth well will then be located so that three of the four wells indicate flow from the area containing the fill while one of the wells indicates flow toward (upgradient from) the area containing the dredged material. If necessary, additional wells will be placed so that at least three wells lie downgradient from the containment site.

The top of each well screen will be placed at the top of the first water-bearing zone beneath the site that can deliver a reasonable amount of water to a monitoring well over a reasonable time. The intent is to locate wells in zones with horizontal flow that has passed beneath the fill site. In the case of a fine-grained soil overlying a coarser-grained soil, it may be possible to extract water from the fine-grained soil, but the fine-over-coarse arrangement is likely to produce mostly vertical flow in the overlying fine-grained soil. Wells placed adjacent to the fill are unlikely to indicate conditions beneath the adjacent fill.

Sampling Techniques. All sampling will be done with state-of-the-art sampling equipment and procedures. At the beginning of each sampling round, water levels will be measured in all wells. At least three casing volumes from each well will be purged, or the well will be purged until dry. Groundwater will be sampled by stainless steel bailer, dedicated bladder pump constructed of materials similar to the well and well screen, or other method approved by Ecology. The pH will be measured in the field with the electrode calibrated before each measurement. The conductivity meter will be calibrated once before the sampling round.

Sampling quality assurance and quality control (QA/QC) includes field blank samples and field replicate samples. One bailer rinsate blank or field blank may be collected each sampling round to determine the existence and magnitude of contamination problems. One field replicate sample may be collected and analyzed each round to provide an indication of overall precision. Sampling frequencies for field blanks and field replicates are typically one per twenty samples. If samples are filtered for metal analyses, filters will be tested before their use for addition or subtraction of dissolved metals in solution.

Monitoring Parameters. The chemistry of the dredged sediments and elutriates will determine what monitoring parameters are used. An indicator parameter list will be developed based on the initial sediment and elutriate chemistry. The list will include likely toxic biodegradation products of contaminants in the initial sediment chemistry. At a minimum, the following parameters will be analyzed:

- pH, conductivity (field measurements)
- Nitrate, nitrite, nitrogen, ammonium
- Chloride, potassium, sodium, calcium
- Alkalinity
- Chemical oxygen demand
- Dissolved priority pollutant metals, iron, manganese
- Total organic carbon.

Analytical laboratory QA/QC will follow the Contract Laboratory Program (EPA 1987, 1988) for inorganic and organic priority pollutants on the indicator parameter list. Analytical laboratories generally provide data for QA/QC sample analyses (i.e. method blanks, spike recoveries, duplicate analyses) associated with nutrients, COD, and TOC at no additional charge to their client. If organic priority pollutants are analyzed, the laboratory may charge for matrix spike/matrix spike duplicate samples and method blank samples (required at a minimum frequency of one per twenty samples) as additional samples.

Alternative 2. Under Alternative 2, monitoring well design, well placement, sampling techniques, and monitoring parameters are the same as those discussed for Alternative 1, with these alterations:

Whenever possible, monitoring wells will be installed at least six months before preparing the site for disposal. Water levels will be measured and samples collected and analyzed to establish existing site conditions and background concentrations; full priority pollutant analysis is not required. From this data, the range of site conditions during wet and dry seasons will be predicted.

Groundwater Sampling. Decisions for reduction in frequency will be statistically based. The sampling frequency is 2 weeks, 1 month, 2 months, then 6 months thereafter.

Well Placement and Number of Wells. If the site is wider than 600 ft, then sufficient wells will be placed at locations 300 ft apart to monitor the downgradient discharge area from the upland monofill site.

Monitoring Parameters. Alternative 2 will *not* test for chloride, potassium, sodium, calcium, or alkalinity. All the other parameters under Alternative 1 will be analyzed. Those chemical parameters are the following:

- pH, conductivity (field measurements)
- Nitrate, nitrite, nitrogen, ammonium
- Chemical oxygen demand
- Dissolved priority pollutant metals, iron, manganese.
- Total organic carbon.

6.3.5 Upland Unlined Monofill Monitoring Alternatives Summary

Water Quality

Short-Term. The short-term water quality monitoring alternatives primarily address water quality during dredging and transport. This is same as nearshore short-term dredging site alternatives (see Table 6.2).

Groundwater

Monitoring alternatives for the unlined functional design are nearly identical to the alternatives for the lined functional design described above (see Table 6.5). Monitoring well design, sampling techniques and monitoring parameters are the same for both lined and unlined designs. The only differences in monitoring requirements for the two designs are in well placement and the number of wells required. The lined functional design requires wells placed at a minimum of three locations downgradient from the upland monofill site and at a minimum of one location upgradient of the upland monofill site. For the unlined functional design, an additional monitoring well will be placed within the portion of the dredge fill expected to release the highest concentrations of contaminants. This location will be selected with consideration to:

- The pre-dredging chemical and physical characterization of the dredged material
- The location of areas that are likely to have high permeability and that are likely to be hydraulically active
- The types of contaminants that are likely to be released (e.g. metals)

Table 6.5. Summary of upland mono-unlined groundwater monitoring alternatives.

	ALTERNATIVES 1	2
Number of Wells*	5	5
Number of Sampling Rounds** - through the first year	5	6
Number of Sampling Rounds - subsequent year	2	2
Analytes		
Priority Pollutants - predisposal round		Yes
Priority Pollutants - 6-month round		Yes
Indicator parameters + degradation product	Yes	Yes
Nitrate, nitrite, nitrogen, ammonia	Yes	Yes
Chloride, potassium, sodium, calcium	Yes	Yes
COD	Yes	Yes
Alkalinity	Yes	Yes
Dissolved PP metals, iron, manganese	Yes	Yes
TOC	Yes	Yes

*The number of wells listed here are estimated, the actual number will depend on site-specific conditions.
**Includes pre-disposal background sampling.

Alternatives by disposal Environment

7. SUMMARY OF ALTERNATIVES BY DISPOSAL OPTION

The alternatives for each disposal environment are summarized in this chapter, thereby allowing all the alternatives for a specific environment to be more easily reviewed and synthesized. The chapter is organized by disposal environment:

- Section 7.1 - **Confined Aquatic Disposal**
- Section 7.2 - **Nearshore**
- Section 7.3 - **Upland Mixed**
- Section 7.4 - **Upland Monofill**

In each section, the dredging and transport, site design, and monitoring alternatives for that environment are summarized. New information is not presented in this chapter. Although various parts of Chapters 5 and 6 are repeated, we felt it was important to summarize concisely in one chapter all of the dredging, transport, and monitoring components for each alternative in each disposal environment. Detailed descriptions of dredging and transport, disposal site design, and monitoring components and alternatives is provided in Chapters 5 and 6, respectively.

7.1 CONFINED AQUATIC DISPOSAL

The alternatives for dredging, transport and disposal site design in nearshore environments are presented in Table 7.1. Both Alternatives 1 and 2 require use of a mechanical dredge. Therefore, dredging limits and tolerances are similar in these two alternatives. Use of a hydraulic dredge is specified in Alternative 3 and other dredging specifications vary accordingly. Transport methods are also similar in Alternatives 1 and 2, although additional hopper separation units are required in Alternative 1. Pipeline and pump requirements are only applicable to Alternative 3 (because of hydraulic dredge use). There are also differences in material placement requirements. Each disposal site design alternative has a different depth limitation. Bed slope and berm requirements are specified for sites at depths less than -200 ft (Alternatives 1 and 2). Cap restrictions also vary among the three alternatives. Water column velocity limits and bed stability assessment are required in all alternatives.

The alternatives for short-term and long-term monitoring at CAD sites are summarized in Table 7.2. The alternatives generally present identical or similar types of monitoring activities but represent increasing levels of effort (i.e., sampling frequency, sample numbers). Alternative 1 is the least conservative; Alternative 3 is the most conservative.

Table 7.1. Summary of confined aquatic disposal design alternatives.

	ALTERNATIVES			
	1	2	3	N.A.[1]
DREDGE METHODS				
Mechanical Dredge				
- Clamshell	Yes	Yes	No	Yes
- Dipper	No	Yes	No	No
Hydraulic Dredge				
- Cutterhead	No	No	Yes	Yes
- Suction	No	No	Yes	No
Bucket Size (yd^3)	>5	>5	n.a.	No limit
Retrieval Rate Limitations	Yes	Yes	n.a.	None
Depth Tolerance Limitations	2 ft	2 ft	1 ft	2 ft
Dredge Depth (ft)	<200	<200	Equip Limited	Equip Limited
Anchor Placement Controlled	Yes	Yes	Yes	Yes
Overcutting Restrictions - Cutter Diameter	n.a.	n.a.	Yes	None
TRANSPORT METHODS				
Haul Barge	Yes	Yes	n.a.	Yes
Bottom Dump	Req'd	Req'd	n.a.	Not Req'd
Hopper Separation Units	4	Not Spec.	n.a.	Not Spec.
Hydraulic Check Requirements	Yes	Yes	n.a.	None
Overflow Allowed	No	No	n.a.	Not Spec.
Pipeline Restrictions	n.a.	n.a.	Subm. in channel	n.a.
Booster Pumps	n.a.	n.a.	<2	Not Spec.
MATERIAL PLACEMENT				
CONTAMINATED				
Release Rate	Inst.	Inst.	n.a.	Inst.

Table 7.1. Summary of confined aquatic disposal design alternatives (continued).

	ALTERNATIVES			
	1	2	3	N.A.
Positioning Accuracy Requirements (m)	3	3	3	None
- taut line buoy	Yes	Yes	n.a.	
- real time electronic positioning system	Yes	Yes	n.a.	
- positioning for each dump recorded	Yes	Yes	n.a.	
Submerged Diffuser	n.a.	n.a.	<2 ft/sec 10-40 ft from bed	n.a.
CAP MATERIAL				
Control Release Rate	Req'd	Req'd	Req'd	Not Spec.
Max Thickness of 1 Lift	<3 ft	<4 ft	<4 ft	Not Spec.
Slurry Discharge	n.a.	<2 fps	<2 fps	Not Spec.
Positioning Accuracy Restrictions (m)	3	3	3	None
DISPOSAL SITE DESIGN				
Depth Limitations				400 ft
• -80 to -200 ft	Yes			
• -05 to -200 ft		Yes		
• -200 to -400 ft			Yes	
Bed Slope				Vary
• Slopes	<4%	<2%		
• Unconsolidated Bed Sediment Thickness	≥30 ft	≤ 30 ft		
• Engineering Study to Confirm Acceptability	Yes	Yes	No	Not Req'd
Berm Requirements				Vary
• All Sites	Yes			
• Berm if Slope >4%		Yes		
• Berm only to Limit Total Bed Area			Yes	
Water Column Velocity Restrictions				Vary
• Water Column	≤1 fps	≤1 fps	≤1 fps	
• Near-Bottom	≤0.5 fps	≤0.5 fps	≤0.5 fps	
Bed Stability				
• Bed Stability Assessed by Professional	Yes	Yes	Yes	Vary
Cap Thickness	≥3 ft	≥3 ft	≥3 ft	Vary

Table 7.1. Summary of confined aquatic disposal design alternatives (continued).

	ALTERNATIVES 1	2	3	N.A.
Cap Physical Quality Restrictions				
• Match Grain Size Characteristics	Yes			Vary
• Uniform Grade, Clean Silty Sand	Yes			
• Sand Sediments (.2 - .4 mm)		Yes	Yes	
• Include Armor Layer		Yes		
Cap Chemical Quality Restrictions				Vary
• P-2	Yes			
• PSDDA		Yes		
• As Clean or Cleaner than Nearest Bed Reference Station			Yes	

[1] No-Action
n.a. = Not Applicable

Table 7.2. Summary of CAD monitoring alternatives.

	ALTERNATIVES 1	2	3	N.A.
SHORT-TERM MONITORING				
Dredge Site				
Dilution Zone Boundary, Water Quality				
• Dissolved Oxygen	Yes	Yes	Yes	
• Turbidity	Yes	Yes	Yes	
• Other Water Quality Certification Requirements	Yes	Yes	Yes	
Dredge Positioning				
• Hydraulic - hourly	Yes	Yes	Yes	
• Mechanical - after each barge relocation	Yes	Yes	Yes	
Bathymetry				
• Survey Frequency	Biwkly	Wkly	Dly	
• 25-ft intervals, or start, mid-point, and end of dredging progress	Yes	Yes	Yes	
Disposal Site				
Monitoring Positioning Accuracy (m)	3	3	3	
Water Quality (Column)				
• Plume Tracking (acoustic and bottle casts)			Yes	
- Frequency, 5 of first 10 barge dumps			Yes	
• Dissolved Oxygen				
- Frequency, before & after 5 of first 10 dumps			Yes	
- Distribution, surface, mid-depth, near-bottom			Yes	
Bathymetry				
• Frequency - Contaminated Sediment Disposal				
- One Pre-Disposal Survey	Yes	Yes	Yes	
- During disposal	One/ Mnth	One/ Mnth	One/ 2 wks	
- One Post Disposal Survey within 2 weeks after placement	Yes	Yes	Yes	
• Frequency - Cap Material				
- One survey, completed 1 month after capping	Yes	Yes	Yes	
Side Scan Surveys				
- One survey, pre-contaminated material disposal		Yes	Yes	
- One survey, post-contaminated material disposal		Yes	Yes	
- One survey, post-cap material disposal		Yes	Yes	

Table 7.2. Summary of CAD monitoring alternatives (continued).

	ALTERNATIVES 1	2	3	N.A.
Sediment Profile Samples				
- One round, pre-contaminated material disposal	Yes	Yes	Yes	
- One round, post-contaminated material disposal	Yes	Yes	Yes	
- One round, post-cap material disposal	Yes	Yes	Yes	
Shallow Borings (Physical/Visual Measurements)				
- One round, pre-contaminated disposal	Yes	Yes	Yes	
- One round, post-cap material disposal	Yes	Yes	Yes	
LONG-TERM MONITORING				
INTENSIVE FIRST-YEAR				
• Conduct following sampling at 3-mo. & 6-mo. milestones				
- Bathymetry		Yes	Yes	
- Sediment Profile Samples		Yes	Yes	
- Shallow Borings (visual & chemical)			Yes	
SUBSEQUENT YEARS' MONITORING				
• Shallow Borings (visual and chemical)				
- Years 2, 4, 7, & 10	Yes	Yes	Yes	
• Biological				
- BRAT @ years 1, 2, 4, & 7			Yes	
- BRAT @ years 2, 4, & 7		Yes		
- Bioaccumulation @ years 1, 2, 4, 7			Yes	
• Sediment Profile Camera				
- Years 2, 3, & 4		Yes	Yes	

Requirements for short-term monitoring at the dredge site are similar in all alternatives, except that bathymetric surveys are required daily in the more conservative alternatives (2 and 3) but only weekly in Alternative 1. Short-term disposal site monitoring is also similar for the three alternatives. Monitoring positioning accuracy, bathymetry, and

shallow borings are specified in all Alternatives. Alternatives 2 and 3 also require sediment profile samples. Water quality monitoring and sidescan surveys are required only in Alternative 3.

Long-term monitoring requirements also vary according to the level of effort of each alternative. Only periodic shallow borings are required in Alternative 1. Alternatives 2 and 3 require intensive first-year monitoring, followed by periodic shallow borings, biological sampling (most frequently in Alternative 3), and sediment profile camera surveys.

7.2 NEARSHORE DISPOSAL

The alternatives for dredging, transport, and disposal site design in nearshore environments are presented in Table 7.3. Use of a hydraulic dredge is specified in both Alternatives 1 and 2. A mechanical dredge is required in Alternative 3. Other dredging method specifications in the alternatives are related to characteristics of the dredging method. Transport methods also depend on the dredging method. Pipeline and pump requirements are provided for Alternatives 1 and 2. Barge disposal specifications are listed for Alternative 3.

Alternatives 1 and 2 differ primarily in material placement and site design requirements. Alternative 1 requires that the highest contaminated sediments be placed first. A final cap liner and a structural dike with an impervious core are required only in this alternative. However, capping characteristics and retention dike design vary among the three alternatives.

Monitoring alternatives for groundwater, surface runoff and adjacent surface waters are summarized in Table 7.4. Similar monitoring activities are required in each, but there are different levels of effort (e.g., number of stations, frequency of sampling, and number of analytes). Alternative 3 requires the greatest level of effort, as indicated by the most frequent sampling, greatest number of samples and fewer requirements for priority pollutant analyses. Alternative 1 requires the lowest level of effort, specifying fewer samples and fewer priority pollutant analyses. Alternative 2 is an intermediate option.

7.3 UPLAND MIXED

The alternatives for dredging and transport in upland mixed environments are presented in Table 7.5. Both Alternatives 1 and 2 specify use of a mechanical dredge. Therefore, dredging limits and tolerances are similar in these two alternatives. Alternative 3 specifies use of a hydraulic dredge, and other dredging specifications vary accordingly. Transport methods are also similar in Alternatives 1 and 2, although direct off loading to lined equipment is required only in Alternative 1. Alternative 1 also requires a liner at the dewatering site. Pipeline and pump requirements apply only to Alternative 3 (because of hydraulic dredge use). A liner and effluent quality analysis are also required in this alternative.

Table 7.3. Summary of nearshore disposal design alternatives.

	ALTERNATIVES			
	1	2	3	N.A.[1]
DREDGE METHODS				
Mechanical Dredge - Clamshell	No	No	Yes	Yes
Hydraulic Dredge - Cutterhead	Yes	Yes	No	No
- Suction	Yes	No	Yes	Yes
Bucket Size (yd^3)	n.a.	n.a.	>5	1
Retrieval Rate Limitations	n.a.	n.a.	Yes	None
Depth Tolerance Limitations	1 ft	1 ft & 2 ft	2 ft	2 ft
Dredge Depth (ft)	Equip Limit	Equip Limit	<100 ft	Equip Limit
Careful Anchor Placement	Yes	Yes	Yes	Yes
Overcutting Restrictions - Cutter Diameter	Yes	Yes	n.a.	None
TRANSPORT METHODS				
Haul Barge	n.a.	n.a.	Yes	Yes
Watertight Flat Deck	n.a.	n.a.	Req'd	Not Req'd
Hydraulic Check Requirements	n.a.	n.a.	Yes	Not
Rehandling: No Bucket Swings over Open Water	n.a.	n.a.	Yes	Not Spec.
Direct to Disposal Site or Equip.	n.a.	n.a.	Yes	Not Spec.
Rehandling Area Contained	n.a.	n.a.	Yes	Not Spec.
Booster Pumps	<2	<2	n.a.	n.a.
Pipeline Restrictions	Subm.	No Subm.	n.a.	n.a.

Table 7.3. Summary of nearshore disposal design alternatives (continued).

	ALTERNATIVES 1	2	3	N.A.[1]
				Spec.
MATERIAL PLACEMENT				
CONTAMINATED				
Highest Contam. Placed First	Yes	No	No	No
Contaminated Placed Anaerobic	Yes	Yes	Yes	Not Req'd
Access Prevented	Yes	Yes	Yes	Not Req'd
Overflow Allowed	n.a.	n.a.	No	Yes
No Displaced Material	n.a.	n.a.	Yes	Not Req'd
Final Fill Level	n.a.	n.a.	Yes	Site Rqmt
CAPPING SEDIMENTS				
Primary Cap Placed Immediately	Yes	Yes	None	None
Liner	Yes	None	None	None
Final Cap After Initial Consolid.	Yes	Yes	Yes	None
DISPOSAL SITE DESIGN				
Structural Dike Design Impervious Core	Yes	No	No	No
Engineering Designed	Yes	Yes	Yes	Yes
Retention Dike Design Effluent Quality	<100mg/L	WQ	n.a.	WQ
Bulk Factor Based Design	Site Spec.	1.3	1.1	Site Spec.
Weir Overflow Height	2 - 4 inches	Not Spec.	n.a.	Not Spec.
Primary Cap			None	None
Uniform Clean Silty Sand	Yes	Yes		
Minimum 2 ft Thick	Yes	Yes		

Table 7.3. Summary of nearshore disposal design alternatives (continued).

	ALTERNATIVES			
	1	2	3	N.A.[1]
		Crit.		Crit.
Final Cap				
Liner	Yes	No	No	No
Engineered to meet future use	Yes	Yes		Yes
Structural Requirements			Yes	
Minimum Thickness	6 ft	4 ft	4 ft	4 ft
Cap Quality				
P2	Yes			
PSDDA		Yes	Yes	
Other				Yes

[1] No Action
n.a. = Not Applicable

Table 7.4. Summary of nearshore monitoring alternatives.

	ALTERNATIVES 1	2	3
Dredging			
Dilution Zone Boundary, Water Quality			
• Dissolved Oxygen	Yes	Yes	Yes
• Turbidity	Yes	Yes	Yes
• Other Water Quality Certification Requirements	Yes	Yes	Yes
Dredge Positioning			
• Hydraulic - hourly	Yes	Yes	Yes
• Mechanical - after each barge relocation	Yes	Yes	Yes
Bathymetry			
• Survey Frequency	Wkly	Wkly	Dly
• 25-ft intervals, or start, mid-point, and end of daily dredging progress	Yes	Yes	Yes
Disposal			
Effluent Overflow			
• Suspended Sediments	Wkly	Dly	2/day
Water Quality @ Return			
• D.O.	5 days	5 day/ wk	Dly
- mid-point of dilution zone, boundary			
- surface, mid, bottom			
• Suspended Sediments			
- mid-point, boundary			
- surface, mid, bottom			
• Boring (cap)			
- depth of contaminants	2	4	8
Groundwater			
• Number of Wells*	4	6	8
• Number of Sampling Rounds** - through the first year	5	5	7
• Number of Sampling Rounds - subsequent years	2	2	2
• Contaminants of Concern			
Priority Pollutants - predisposal round	Yes	Yes	Yes
Priority Pollutants - 6-month round		Yes	Yes
Indicator parameters + degradation product	Yes	Yes	Yes
Nitrate, nitrite, nitrogen, ammonia	Yes	Yes	Yes
COD	Yes	Yes	Yes
Dissolved PP metals, iron, manganese	Yes	Yes	Yes
TOC	Yes	Yes	Yes

Table 7.4. Summary of nearshore monitoring alternatives (continued).

	ALTERNATIVES		
	1	2	3
Adjacent Surface Water Samples			
• Sampling events/yr	1	2	4
• Number of samples	6 (3 on 2)	12 (4 on 3)	20 (5 on 4)
• Years	5	10	20
Runoff Surface Waters			
• Sampling events/yr	---	.5 yrs	1
• Number of samples	---	6	9
• Number of years	---	7	15
Cap Borings			
• Sampling events/yr	---	.5 yrs	1/yr
• Number of borings	---	2	4
• Number of years	---	9	15

*The number of wells listed here are estimated, the actual number will depend on site-specific conditions.
**Includes pre-disposal background sampling.

Table 7.5. Summary of upland mixed dredging alternatives.

	ALTERNATIVES 1	2	3	N.A.
DREDGE METHODS				
Mechanical Dredge - Clamshell	Yes	Yes	No	Yes
Hydraulic Dredge - Cutterhead	No	No	Yes	No
Bucket Size (yd^3)	>5	>5	n.a.	No Limit
Retrieval Rate Limitations	Yes	None	n.a.	None
Depth Tolerance Limitations	2 ft	2 ft	1 ft	2 ft
Dredge Depth (ft)	<200 ft	<200 ft	Equip Limit	Equip Limit
Anchor Placement Controlled	Yes	Yes	Yes	Yes
Overcutting Restrictions - Cutter Diameter	n.a.	n.a.	Yes	None
TRANSPORT METHODS				
Haul Barge	Yes	Yes	n.a.	Yes
No Overflow	Yes	Yes	n.a.	Not Spec.
Watertight Flat Deck	Yes	Yes	n.a.	Not Spec.
Hydraulic Check Requirements	Yes	Yes	n.a.	Not Spec.
Off-Loading: No Bucket Swings over Open Water	Yes	Yes	n.a.	Not Spec.
Direct to Lined Equip.	Yes	No	n.a.	Not Spec.
Stockpile	No	Yes	n.a.	Yes
Rehandling Area Contained	Yes	Yes	n.a.	Not Spec.
Booster Pumps	n.a.	n.a.	<2	n.a.

Table 7.5. Summary of upland mixed dredging alternatives (continued).

	ALTERNATIVES 1	2	3	N.A.[1]
Pipeline Restrictions	n.a.	n.a.	Subm in channel	n.a.
Final Haul Overland				
Approved Carrier Only	Yes	Yes	Yes	Not Req'd
No Material Misplaced	Yes	Yes	Yes	Not Req'd
Covers During Rainfall	Yes	None	None	None
Action Plan for Sediment Loss	Yes	Yes	Yes	None
DEWATERING SITE				
Structural Dike Design				
Engineering Designed	Yes	Yes	Yes	n.a.
Retention Dike Design				
Effluent Quality	n.a.	n.a.	100 mg/L	n.a.
Bulk Factor Based Design	1.1	1.0	n.a.	n.a.
Freeboard Minimum	2 ft	1 ft	n.a.	n.a.
Dewatering Outlets	Yes	Yes	2 - 4 inches	n.a.
Liner	Yes	No	Yes	n.a.
Dewatering Methods				
Engineering Design	Yes	Yes	Yes	n.a.
Runoff & Elutriant treated	Yes	Yes	Yes	n.a.
Final Transport at Paint Filter	Site Surface	Truck	Site Surface	n.a.

[1] No Action
n.a. = not applicable

Table 7.6. Summary of upland mixed design alternatives.

Disposal Site Design	ALTERNATIVES 1 Municipal	 2 Demolition
Bottom Liner (Option 1) Alternative Design		Liner not required
• Geomembrane thickness	50 mil	
• Barrier layer thickness	2 ft	
• Barrier layer hydraulic conductivity (cm/sec)	$1x10^{6}$	
Bottom Liner (Option 2) Standard Design		
• Barrier layer thickness	4 ft	
• Barrier layer hydraulic conductivity (cm/sec)	$1x10^{7}$	
Leachate Collection System		Not Required
• Head above liner	2 ft	
Leachate Treatment and Disposal System		Not Required
• Leachate within system must pass NPDES at point of discharge	X	
• Disposed leachate much meet municipal waste-water pre-treatment standards	X	
Gas Management System Required	Yes	Not Required
Surface Water Management		Not Required
• Must contain runoff from ___ yr storm	25 year	
• Must contain run-on from ___ yr storm	25 year	
Final Cover (Option 1) Alternative Design		Only One Option
• Geomembrane liner thickness	50 mill	
• Slope of low permeable layer	$\geq$ 2%	
• Side slope angle	$\leq$ 33%	
Final Cover (Option 2)		
• Material thickness	2 ft	1 ft soil
• Sediment hydraulic conductivity (cm/sec)	$1x10^{6}$	Not Specified
• Slope of low permeable layer	$\geq$ 2%	
• Side slope angle	$\leq$ 33%	
Topsoil		Not Required
• Thickness	6 inches	

Table 7.6. Summary of upland mixed design alternatives (continued).

Disposal Site Design	ALTERNATIVES 1 Municipal	 2 Demolition
Dewatering		
• Permanent disposal site accepts wet sediments	No	Yes
Vector Control (as necessary)	Yes	Yes

Notes:

(1) This table is only an outline of the requirements set forth in the Minimum Functional Standards for Solid Waste Handling (WAC 173-304) and is not intended to reflect all of the requirements included in the WAC 173-304 standards. Arid design information is not included.

(2) Although some design elements for demolition sites are not specifically required in WAC 173-304, they are required by local agencies. For example, local jurisdictions often require surface water management as part of the grading permit.

Alternatives for disposal site design are based on existing regulations for upland disposal of solid waste (see Section 5.4). The requirements for the two types of landfill (municipal and demolition waste) are summarized in Table 7.6. Existing regulations for municipal site design require a liner, leachate collection and treatment systems, a gas management system, and surface water management. These elements are not required at demolition landfills. Wet sediments may be placed at demolition landfills but not at municipal landfills.

Two groundwater monitoring alternatives are summarized in Table 7.7. Similar groundwater monitoring activities are required in each, but there are different levels of effort. Alternative 2 requires a greater level of effort than Alternative 1, as indicated by more frequent sampling during the first year and requirements for priority pollutant analyses. Alternatives for water quality monitoring during dredging and at the dewatering site are also presented. These alternatives generally have the same elements, but varying levels of intensity.

Table 7.7. Summary of upland mixed monitoring alternatives.

	ALTERNATIVES 1	2	3
Dredging			
Dilution Zone Boundary, Water Quality			
• Dissolved Oxygen	Yes	Yes	Yes
• Turbidity	Yes	Yes	Yes
• Other Water Quality Certification Requirements	Yes	Yes	Yes
Dredge Positioning			
• Hydraulic - hourly	Yes	Yes	Yes
• Mechanical - after each barge relocation	Yes	Yes	Yes
Bathymetry			
• Survey Frequency	Wkly	Wkly	Dly
• 25-ft intervals, or start, mid-point, and end of daily dredging progress	Yes	Yes	Yes
Disposal			
Effluent Overflow			
• Suspended Sediments	Wkly	Dly	2/day
Water Quality @ Return			
• D.O.	5 days	5 day/ wkly	Dly
- mid-point of dilution zone, boundary			
- surface, mid, bottom			
• Suspended Sediments			
- mid-point, boundary			
- surface, mid, bottom			
Groundwater			
• Number of Wells*	4	4	
• Number of Sampling Rounds** - through the first year	5	6	
• Number of Sampling Rounds - subsequent year	2	2	
• Analytes			
Priority Pollutants - predisposal round		Yes	
Priority Pollutants - 6-month round		Yes	
Indicator parameters + degradation product	Yes	Yes	
Nitrate, nitrite, nitrogen, ammonia	Yes	Yes	
Chloride, potassium, sodium, calcium	Yes	Yes	
COD	Yes	Yes	
Alkalinity	Yes	Yes	
Dissolved PP metals, iron, manganese	Yes	Yes	
TOC	Yes	Yes	

*The number of wells listed here are estimated, the actual number will depend on site-specific conditions.
**Includes pre-disposal background sampling.

7.4 UPLAND MONOFILL

The alternatives for dredging methods, transport methods, and dewatering site characteristics in upland monofill environments are summarized in Table 7.8. Use of a mechanical dredge is required in both Alternatives 1 and 2. Therefore, dredging limits and tolerances are similar in these two alternatives. Alternative 3 specifies use of a hydraulic dredge, and other dredging specifications vary accordingly. Transport methods are also similar in Alternatives 1 and 2. Pipeline and pump requirements are only applicable to Alternative 3. Dewatering site requirements are not applicable in Alternatives 1 and 2, but are provided for Alternative 3.

There are two types of upland monofill site designs: lined and unlined. Three alternatives were presented for each type and these are summarized in Tables 7.9 (lined) and 7.10 (unlined).

Table 7.8. Summary of upland monofill dredging alternatives.

	ALTERNATIVES			
	1	2	3	N.A.[1]
DREDGE METHODS				
Mechanical Dredge - Clamshell	Yes	Yes	No	Yes
Hydraulic Dredge - Cutterhead	No	No	Yes	
Bucket size (yd^3)	>5	>5		No Limit
Retrieval Rate Limitations	Yes	None	n.a.	None
Depth Tolerance Limitations	2 ft	2 ft	1 ft	2 ft
Dredge Depth (ft)	<200 ft	<200 ft	Equip Limit	Equip Limit
Anchor Placement Controlled	Yes	Yes	Yes	Yes
Overcutting Restrictions - Cutter Diameter	n.a.	n.a.	Yes	None
TRANSPORT METHODS				
Haul Barge	Yes	Yes	n.a.	Yes
Overflow Allowed	No	No	n.a.	Not Spec.

Table 7.8. Summary of upland monofill dredging alternatives (continued).

	ALTERNATIVES 1	2	3	N.A.
Watertight Flat Deck	Yes	Yes	n.a.	Not Spec.
Hydraulic Check Requirements	Yes	Yes	n.a.	Not Spec.
Off-Loading:				
No Bucket Swings over Open Water	Yes	Yes	n.a.	Not Spec.
Direct to Lined Equip.	Yes	No	n.a.	Not Spec.
Stockpile	No	Yes	n.a.	Yes
Off-Loading Area Contained	Yes	Yes	n.a.	Not Spec.
Booster Pumps	n.a.	n.a.	<2	n.a.
Pipeline Restrictions	n.a.	n.a.	Subm in channel	n.a.
Final Haul Overland				
Approved Carrier Only	Yes	Yes	Yes	Not Req'd
No Material Misplaced	Req'd	Req'd	Req'd	Not Req'd
Covers During Rainfall	Yes	None	None	None
Action Plan for Sediment Loss	Req'd	Req'd	Req'd	None
DEWATERING SITE				
Structural Dike Design				
Engineering Designed	n.a.	n.a.	Yes	n.a.
Retention Dike Design				
Effluent Quality	n.a.	n.a.	100 mg/L	
Weir Overflow	n.a.	n.a.	2 - 4 inches	n.a.
Liner	n.a.	n.a.	Yes	n.a.
Dewatering Methods				
Engineering Design	n.a.	n.a.	Yes	n.a.

Table 7.8. Summary of upland monofill dredging alternatives (continued).

	ALTERNATIVES 1	2	3	N.A.
Runoff & Elutriant Treated	n.a.	n.a.	Yes	n.a.
Final Transport	in-situ	in-situ	in-situ	n.a.

[1] No-Action
n.a. = not applicable

Table 7.9. Summary of upland mono-lined design alternatives.

	ALTERNATIVES 1	2	3
Bottom Liner (Option 1)			
• Geomembrane thickness	50 mil	30 mil	20 mil
• Barrier layer thickness	2 ft	2 ft	1 ft
• Barrier layer hydraulic conductivity (cm/sec)	10^{7}	10^{6}	10^{6}
Bottom Liner (Option 2)			
• Barrier layer thickness	4 ft	4 ft	2 ft
• Barrier layer hydraulic conductivity (cm/sec)	10^{7}	10^{6}	10^{6}
Leachate Collection System			
• Head above liner	1 ft	2 ft	2 ft
Leachate Treatment and Disposal System			
• Safety factor	1.5	1.25	1.0
• Leachate within system must pass NPDES at point of discharge	Yes	Yes	Yes
• Disposed leachate must meet municipal wastewater pre-treatment standards	Yes	Yes	Yes
Gas Management System Required	No	No	No
Surface Water Management			
• Must contain runoff from ___ yr to ___ yr storms	2-100	2-50	2-25
• Must contain run-on from ___ yr storm	100	50	25
Final Cover (Option 1)			
• Geomembrane liner thickness	30 mil	30 mil	20 mil
• Barrier layer thickness	1 ft	1 ft	1 ft
• Barrier layer hydraulic conductivity (cm/sec)	10^{7}	10^{6}	10^{6}
• Slope of low permeable layer	>2%	>2%	>2%
• Side slope angle	<33%	<33%	<33%

Table 7.9. Summary of upland mono-lined design alternatives.

	ALTERNATIVES 1	2	3
Final Cover (Option 2)			
• Material thickness	2 ft	2 ft	1 ft
• Sediment hydraulic conductivity (cm/sec)	10^{7}	10^{6}	10^{6}
• Slope of low permeable layer	>2%	>2%	>2%
• Side slope angle	<33%	<33%	<33%
Drainage Layer			
• Maximum allowable head	1 ft	2 ft	2 ft
Topsoil			
• Thickness	24 inches	12 inches	6 inches
Dewatering			
• Permanent disposal site accepts wet sediments	Yes	Yes	Yes
• Berms designed by engineer	Yes	Yes	Yes
• Vector control as necessary	Yes	Yes	Yes

Table 7.10. Summary of upland mono-unlined design alternatives.

	ALTERNATIVES 1	2	3
Bottom Liner		Not Required	
Leachate Collection System		Not Required	
Leachate Treatment and Disposal System		Not Required	
Gas Management System		Not Required	
Surface Water Management			
• Must contain runoff from ___ yr to ___ yr storms	2-100	2-50	2-25
• Must contain run-on from ___ yr storm	100	50	25
Final Cover (Option 1)			
• Geomembrane thickness	30 mil	30 mil	20 mil
• Barrier layer thickness	1 ft	1 ft	1 ft
• Barrier layer hydraulic conductivity	10^{7}	10^{6}	10^{6}
• Slope of low permeable layer	>2%	>2%	>2%
• Side slope angle	<33%	<33%	<33%

Table 7.10. Summary of upland mono-unlined design alternatives.

	ALTERNATIVES 1	2	3
Final Cover (Option 2)			
• Barrier layer thickness	2 ft	2 ft	1 ft
• Barrier layer hydraulic conductivity	10^7	10^6	10^6
• Slope of low permeable layer	>2%	>2%	>2%
• Side slope angle	<33%	<33%	<33%
Drainage Layer			
• Maximum allowable head	1 ft	2 ft	2 ft
Topsoil			
• Thickness	24 inches	12 inches	6 inches
Dewatering			
• Permanent disposal site accepts wet sediments	Yes	Yes	Yes
• Berms designed by engineer	Yes	Yes	Yes
• Vector control as necessary	Yes	Yes	Yes

The three lined monofill alternatives present different levels of environmental protection. Alternative 1 provides the highest level of protection. The different levels of protection are provided by differing liner and leachate collection system requirements, as well as final cover specifications. Surface water management requirements also vary, with the most conservative specifications required for the least protective alternative (Alternative 3). No gas management systems or separate dewatering facilities are required for any of the three alternatives.

The three unlined monofill alternatives also present different levels of environmental protection. Alternative 1 provides the highest level of protection. However, leachate collection or disposal systems, gas management systems, and dewatering areas separate from the permanent disposal site are not required in any of the three alternatives. The different levels of environmental protection are provided by differences in the final cover characteristics and surface water management requirements.

Two groundwater monitoring alternatives for both lined and unlined monofill sites are summarized in Tables 7.11 and 7.12, respectively. Alternatives for lined and unlined sites differ only in that one additional well is required at unlined sites. The two alternatives presented for each disposal type require slightly differing levels of effort. For both lined and unlined disposal sites, the second alternative requires a greater level of effort than the first, as indicated by more frequent sampling during the first year and requirements for priority pollutant analyses.

The water quality monitoring alternatives for upland monofill dredging activities are the same as the nearshore short-term dredge site monitoring alternatives (Table 7.4).

Table 7.11. Summary of upland mono-lined groundwater monitoring alternatives.

	ALTERNATIVES 1	2
Number of Wells*	4	4
Number of Sampling Rounds** - through the first year	5	6
Number of Sampling Rounds - subsequent year	2	2
Analytes		
Priority Pollutants - predisposal round	Yes	
Priority Pollutants - 6-month round		Yes
Indicator parameters + degradation product	Yes	Yes
Nitrate, nitrite, nitrogen, ammonia	Yes	Yes
Chloride, potassium, sodium, calcium	Yes	Yes
COD	Yes	Yes
Alkalinity	Yes	Yes
Dissolved PP metals, iron, manganese	Yes	Yes
TOC	Yes	Yes

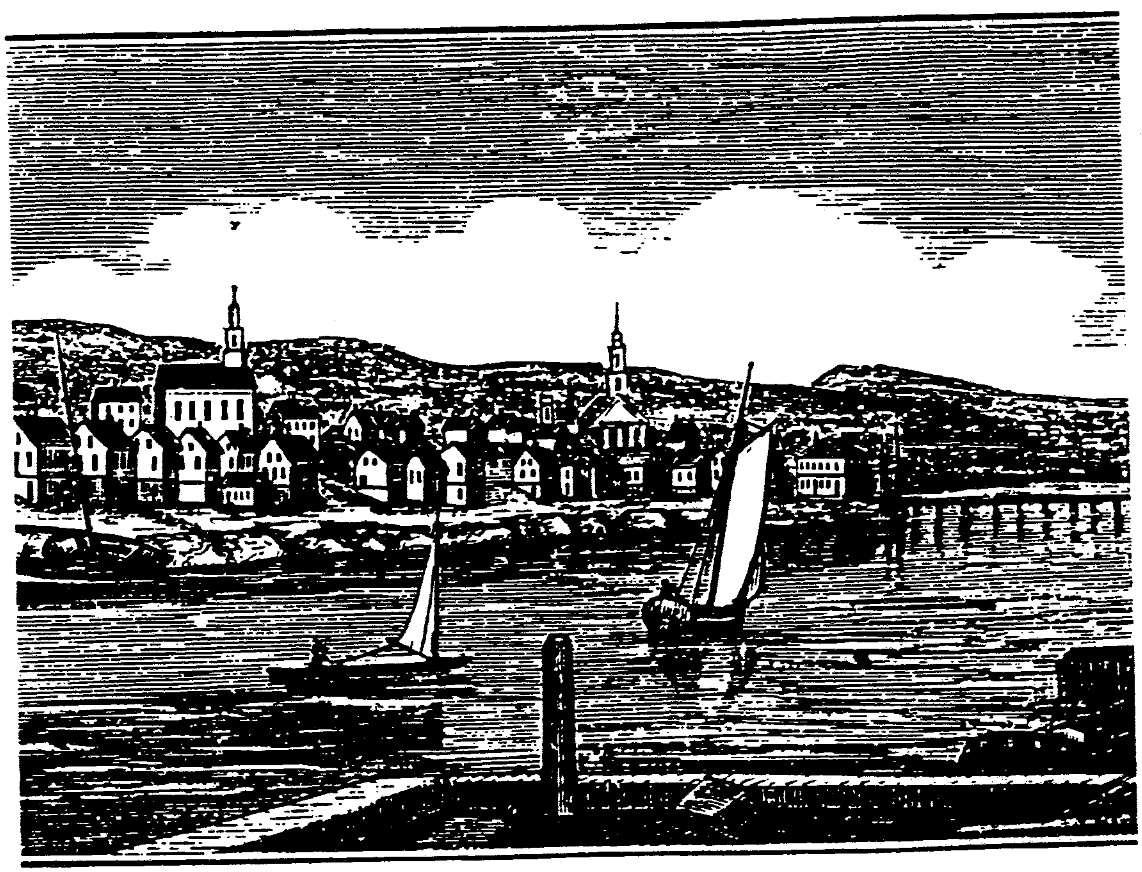
*The number of wells listed here are estimated, the actual number will depend on the site-specific conditions.
**Includes pre-disposal background sampling.

Table 7.12. Summary of upland mono-unlined groundwater monitoring alternatives.

	ALTERNATIVES 1	2
Number of Wells*	5	5
Number of Sampling Rounds** - through the first year	5	6
Number of Sampling Rounds - subsequent year	2	2
Analytes		
Priority Pollutants - predisposal round		Yes
Priority Pollutants - 6-month round		Yes
Indicator parameters + degradation product	Yes	Yes
Nitrate, nitrite, nitrogen, ammonia	Yes	Yes
Chloride, potassium, sodium, calcium	Yes	Yes
COD	Yes	Yes
Alkalinity	Yes	Yes
Dissolved PP metals, iron, manganese	Yes	Yes
TOC	Yes	Yes

*The number of wells listed here are estimated, the actual number will depend on site-specific conditions.
**Includes pre-disposal background sampling.

Assessment Procedure



8. CONFINEMENT ALTERNATIVES ASSESSMENT PROCEDURE (CAAP)

The Confinement Alternatives Assessment Procedure (CAAP) was developed to allow each alternative to be evaluated and a recommended standard to be identified. This chapter describes the development of CAAP as part of the Confined Disposal Standards Program, and the application of CAAP to various program components. The chapter includes descriptions of how CAAP works as well as the underlying rationale associated with its applications. Section 8.2, **Application to Dredging and Disposal**, describes the steps involved in applying CAAP to evaluate dredging and dredged material transport and disposal technologies. This is the primary and original function of CAAP.

Section 8.3, **Application to Characterization**, describes how CAAP was used to evaluate certain elements within the development of the sediment characterization guidelines.

Section 8.4, **Application to Monitoring**, describes how a modified CAAP procedure was used to assess alternative monitoring standards. The actual implementation of CAAP in this program and the results derived from its use follow in Chapter 9.

8.1 THE DEVELOPMENT OF CAAP

Faced with alternative standards for characterizing dredged material, for dredging, for dredged material transport and disposal, and for disposal site monitoring, the development of standards required a procedure allowing each alternative to be evaluated. When each alternative standard can be evaluated, the preferred standards are identifiable. CAAP was developed in response to this requirement.

CAAP is based on a report published through the PSDDA Program entitled "Guidelines for Selecting Control and Treatment Options for Contaminated Dredged Material" (Cullinane et al. 1986). The evaluation procedure described in that report, the "Strategy for Selection of Dredging/Control/Treatment Alternatives" has been adapted for use in the development of standards for confined disposal. The original procedure addressed many of the same issues faced within disposal standards development. Therefore, its use as a basis is most appropriate. Adaptations were made in three principal areas.

1. Ambiguous or overlapping evaluation criteria were eliminated.

2. Weighting factors were assigned to those criteria viewed as most important.

3. Evaluation criteria that rely on knowledge of site-specific conditions were eliminated and viewed as inappropriate since S-4 does not deal with specific disposal sites.

8.2 APPLICATION TO DREDGING, TRANSPORT AND DISPOSAL

The basic CAAP procedure, and that used in assessing dredging, dredged material transport and disposal standards, consisted of six steps:

Step 1. Presume Contaminant Pathways associated with Dredging, Transport and Disposal Technologies. The transport pathways considered are listed below:

- water column
- surface water
- groundwater
- atmospheric
- direct contact

Step 2. Develop dredging, dredged material transport and dredged material disposal alternatives. Alternatives associated with CAD, Nearshore and Upland Disposal were developed. The alternatives combined the design features identified in the S-4, Element 9 report with control/treatment designs identified in PSDDA and the knowledge and experience of dredging and disposal features of the TAG members.

Step 3. Alternative Evaluation and Ranking. This is a multi-step process that scores or otherwise considers each pathway individually and then combines the results of individual pathway analysis to produce a composite score.

CAAP employs five different evaluation factors in assessing an alternative. They are the following:

- Cost
- Technical Effectiveness
- Compliance with Regulatory Requirements
- Safety
- Public Acceptance

The alternatives associated with each evaluation factor must be ranked to allow the selection of the preferred alternatives by comparison. Ideally, ranking criteria would be expressed in absolute quantitative terms; however, for criteria other than costs, it is not possible to quantify the factors in absolute terms. Therefore, relative numeric ranking of alternatives have been devised. The relative numeric rankings and their definitions are shown in Table 8-1. During CAAP implementation, the evaluation factor scoring for different alternative standards has been based on the best professional judgement and experience of the team members in conjunction with the guidelines and considerations described below.

Table 8.1. Evaluate factor scoring.

Weight		
None	Costs	Capital Costs O&M Costs
3	Technical Effectiveness	1 low probability that standards will be met 2 moderate probability that standards will be met 3 high probability that standards will be met
2	Regulatory Requirements	1 probably meets requirements 2 fully compliant with applicable laws, ordinances, and regulations on the implementation of proposed control/treatment alternatives
1	Safety	1 no apparent safety risks
1	Public Acceptance	1 some public concern is probable 2 no public concern is anticipated

Cost. The cost factor addresses the overall cost of implementing a control/treatment alternative. Overall cost (including capital and operation and maintenance costs) was quantified as the present worth or equivalent annual cost of the alternative. Alternative selection decisions were not based solely on cost since other important factors may have been overlooked. The criteria by which the cost factor was measured is cost effectiveness. The cost effective alternative was considered to be the least cost alternative that acceptably met the criteria established for the other evaluation factors.

Technical effectiveness. The technical effectiveness/efficiency factor addresses the ability of an alternative to meet control/treatment requirements. The technical effectiveness/efficiency alternatives under consideration were evaluated in terms of the testing protocols performed in accordance with prescribed characterization standards. The ability of an alternative to meet these requirements was assessed by comparison of the allowable contaminant release at a specific site with the estimated contaminant release after implementation of the control/treatment option. The criterion for the technical effectiveness/efficiency factor was the ability of the alternative to meet contaminant release requirements. The evaluation process was conducted by estimating the contaminant containment efficiency (for all pathways) of each alternative.

Regulatory Requirements. The regulatory requirements evaluation factor addresses the impact of compliance with applicable laws, ordinances, and regulations on the implementation of the proposed control/treatment alternative. Regulatory requirements are extremely important in that they may determine the overall acceptability of an alternative, and at the very least, impact the cost and time required for implementation. Because it is assumed that all alternatives must comply with appropriate regulations, it may be argued that these requirements would have an equal impact on all alternatives. However, not all regulations will apply equally, if at all, to all alternatives. For example, only those alternatives resulting in discharges to surface waters would have to comply with state water quality standards under Section 404 of the Clean Water Act. It was difficult to quantify the impact of regulatory requirements on the implementation of control/treatment alternatives. In many cases, the interpretation of regulations by regulatory agencies is subjective and carried out on a case-by-case basis. This can lead to uncertainty in the evaluation of the regulatory requirements factor. In quantitative terms, both a time and cost criteria are included in the regulatory requirements factor. In terms of cost, the criterion is that the cost of regulatory compliance associated with the implementation of a control/treatment alternative does not constitute a significant increase in costs beyond those required to meet contaminant containment requirements. In terms of time, satisfying regulatory requirements should not result in extension of the project time frame beyond acceptable time limits.

For those alternatives meeting the above minimum criteria, a subjective ranking of the regulatory difficulty associated with each can be prepared.

Safety. The safety evaluation factor addresses the issue of whether the proposed control/treatment alternative can be safely implemented. The safety of both on-site personnel and the general public should be addressed. Whereas the technical effectiveness/efficiency evaluation factor addresses the consequences of the migration of contaminants from the dredged material, the safety evaluation factor considers those direct hazards associated with implementation of the control/treatment alternatives. Examples of concerns addressed by this evaluation factor include:

a. Can the proposed control/treatment alternative be safely constructed or operated?
b. Will special personnel protection be required during the construction process?
c. Will transportation of material endanger the general public during active project performance?

Alternatives were selected that minimize safety hazards to both on-site personnel and the general public.

Public Acceptance. The public acceptance evaluation factor addresses the concerns of the public about implementation of control/treatment alternatives, including all of those factors perceived by the public as being important. Addressing public concerns has proven to be a vital consideration in a number of cases, particularly those involving siting. A major difficulty in dealing with public concerns is that they are often problems of perception, not based solely on technical considerations; nonetheless, they cannot be dismissed solely on a technical basis. Alternatives that are acceptable to the public were selected whenever possible. The measurement of public acceptance and comparison with a criteria is difficult since public acceptance often involves intangibles and cannot be easily quantified. The evaluation of public acceptance may best be expressed in terms of cost criterion. The cost of achieving public acceptance of a control/treatment alternative should not result in a significant increase in cost beyond that required to meet the primary contaminant containment requirements.

Step 3.1. Estimate Costs using experience and Best Professional Judgment. All costs were estimated based on certain assumptions regarding project size and site conditions.

Step 3.2. Determine Technical Effectiveness of the Control/Treatment Technology for affecting contaminant transport along individual pathways (performed concurrently with step 3.1). Score according to Table 8-1.

The character of the Effectiveness Test on the Procedure influenced the score in such a way that a crude or unproven test or procedure added uncertainty to the probability of meeting standards.

Step 3.3. Evaluate for Regulatory Requirements, Safety and Public Acceptance. Score according to Table 8-1.

Step 4. Calculate composite scores for the specific alternative/pathway combination. Using the CAAP scoring form shown in Table 8-2, determine the composite score for each alternative/pathway combination. Note that weighting factors have been added to technical effectiveness (3X) and the regulatory requirement (2X) evaluation factors.

Step 4.1. Calculate weighted scores.

Step 4.2. Apply weighted scores to calculate composite scores relating to the formula

$$T_w * R_w * (S + P)$$

where T_w = weighted score for Technical Effectiveness
R_w = weighted score for Regulatory Requirements
S = Safety
P = Public Acceptance

Step 5. Calculate composite scores for the entire alternative according to the formula

$$(P_1 + P_2 + P_3 + P_n) * P_L$$

where P_1 through P_n represent the composite scores for each pathway associated with a particular alternative, and

P_L = the lowest composite score calculated for a particular alternative.

Step 6. Select the alternative considering the Cost and the Composite score.

8.3 APPLICATION TO SEDIMENT CHARACTERIZATION

The S-4 sediment characterization process/guidelines are detailed in chapter 3.0 of this report. The phased approach to characterization which has been developed is built upon existing programs (e.g. PSDDA) and the experience of the S-4 team. While the development of this approach did not extensively utilize the CAAP process, whenever alternative tests were available for a given component of the characterization, CAAP was used to select the preferred procedure. For example, a modified elutriate test

Table 8.2. S-4 assessment procedure scoring form.

DISPOSAL ACTION: CAD, Nearshore, Upland Mixed, Upland Mono Lined, Upland Mono Unlined (Circle One)

COMPONENT: Dredging, Transport, Site Design (Circle One)

ALTERNATIVE: 1, 2, 3, Other (Circle One)

PATHWAY: Water Column, Surface Water, Groundwater, Atmospheric, Direct Contact (Circle One)

Control/ Treatment Technology	Effectiveness Test or Procedure	Level of Protection	Technical Effectiveness (Score 1-3)	Mult. Factor (3)	Tech. Effect. Total	Regulatory Requirements (Score 1-2)	Mult. Factor (2)	Regulat. Require. Total	Safety (Score 1-1)	Public Acceptance (Score 1-2)	TOTAL SCORE

(Palermo, 1986) is specified as part of the sediment characterization for nearshore and upland-lined disposal (functional designs). This test was selected as the preferred standard following consideration of candidate elutriate tests using CAAP.

8.4 APPLICATION TO MONITORING

A modified version of CAAP was used to evaluate the monitoring alternatives. These modifications are reflected in the CAAP scoring form, which was revised for use in monitoring alternative assessment (Table 8-3).

The modifications are evident if one compares Table 8-3 with Table 8-2. The original category "Control/Treatment Technology" was replaced with "Monitoring Procedure/ Package." This more accurately describes what CAAP is evaluating. The word "package" is important as monitoring schemes are assessed as a package because the number of samples, location of samples, and frequency of sampling are all important to evaluating the monitoring. Without evaluating the entire package, the procedure would only consider the type of monitoring and would not adequately assess some of the differences between alternatives.

In addition, "Technical Effectiveness" has been replaced with "Data Reliability," but the scoring and weighting remain the same. In considering this criteria, we asked the question: How reliable are the data generated by this monitoring scheme in providing an indication of the site's performance (particularly failure)?

Table 8.3. S-4 assessment procedure scoring form for monitoring alternatives.

DISPOSAL ACTION: CAD, Nearshore, Upland Mixed, Upland Mono Lined, Upland Mono Unlined (Circle One)

ALTERNATIVE: These may be presented below

PATHWAY: Water Column, Surface Water, Groundwater, Atmospheric, Direct Contact (Circle One)

Monitoring Procedure Package	Data Reliability (Score 1-3)	Mult. Factor (3)	Tech. Effect. Total	Regulatory Requirements (Score 1-2)	Mult. Factors (2)	Regulat. Require. Total	TOTAL SCORE	COST
<u>Alternative 1</u>								
Groundwater								
Water Column								
Surface Water								
<u>Alternative 2</u>								
Groundwater								
Water Column								
Surface Water								
<u>Alternative 3</u>								
Groundwater								
Water Column								
Surface Water								

The Regulatory Requirements factor stays the same and this was evaluated based on whether or not the proposed monitoring was consistent with present regulatory requirements. Finally, Safety and Public Acceptability have been deleted because they are not very relevant to monitoring.

With these modifications incorporated, the CAAP procedure was applied to the S-4 monitoring alternatives in the same way it was applied to dredging, transport and disposal as described in Section 8.2.

9. IMPLEMENTING CAAP/RECOMMENDED STANDARDS

Developing the confined disposal standards has been an iterative process that started with developing a knowledge base on the subject and culminates with the recommended standards. Some of the steps in between have included:

- Developing and refining alternatives
- Developing and refining assessment procedures for evaluating the alternatives
- Developing cost estimate procedures
- Estimating the costs of each alternative
- Studying existing confined disposal sites
- Working with a Technical Advisory group to receive input on standards development.

Although the process has been iterative and the recommended standards have evolved over the course of the project, the process can be summarized into evaluating alternative standards and selecting recommended standards. This chapter summarizes the recommended standards for sediment characterization, dredging, site design, and monitoring in each disposal environment. The recommended standards are the result of applying CAAP to the dredging, design, and monitoring alternatives described in Chapters 5 and 6. Details of the actual CAAP evaluation are provided in the CAAP scoring forms in Appendix F.

This chapter also presents the sediment characterization requirements identified as one of the early steps in the Decision Model (Figure 1.5). The tests that were selected were based on an evaluation of the tests described in Chapter 4. The selection of tests were done using a modification of the CAAP procedure.

Section 9.1, **Sediment Characterization,** presents the sediment characterization methodology for confined disposal of sediments and then describes the recommended functional design standards for sediment characterization.

The next four sections present the recommended dredging, design and monitoring standards for each disposal option. A narrative description of the key deciding factors from CAAP is presented first, followed by an environmental impacts analysis. As each disposal environment is reviewed, some of the impact analysis becomes redundant, especially for dredging. Rather than reference an earlier section, we have opted for redundancy. This decision is based on the importance of this chapter and the need for a clear understanding of the impacts in each environment. Cross-referencing earlier sections may create confusion or misunderstanding where a clear understanding is essential. Following the impacts analysis, the resulting recommended standard is summarized. Each section includes the recommended standards for a different disposal environment.

- Section 9.2 - **Confined Aquatic Disposal**
- Section 9.3 - **Nearshore**
- Section 9.4 - **Upland Mixed Fill**
- Section 9.5 - **Upland Monofill**

9.1 SEDIMENT CHARACTERIZATION

Sediment characterization provides information on the potential for sediments to release contaminants into the environment. It also allows determination of the suitability of the sediment for the various disposal options. This section presents a sediment characterization methodology for confined disposal of sediments. The methodology incorporates the following:

- A phased approach to sediment characterization which includes:
  - Consideration of existing data
  - Initial characterization based on bulk chemistry and soil index properties
  - Disposal environment specific testing for functional designs (bioassays and effluent testing), and testing for effects-based design
- Integration of the PSDDA unconfined open-water disposal with the confined disposal aquatic methodology
- A methodology that builds on PSDDA interpretation criteria for aquatic and nearshore disposal and on State of Washington Dangerous Waste (D.W.) interpretation criteria from WAC 173-303 for nearshore and upland disposal
- Sediment sampling protocol and quantities based on PSDDA.

9.1.1 Phased Methodology for Sediment Characterization

The phased approach to sediment characterization is intended to build on existing data and to streamline the testing process (Figure 9.1). The four phases are these:

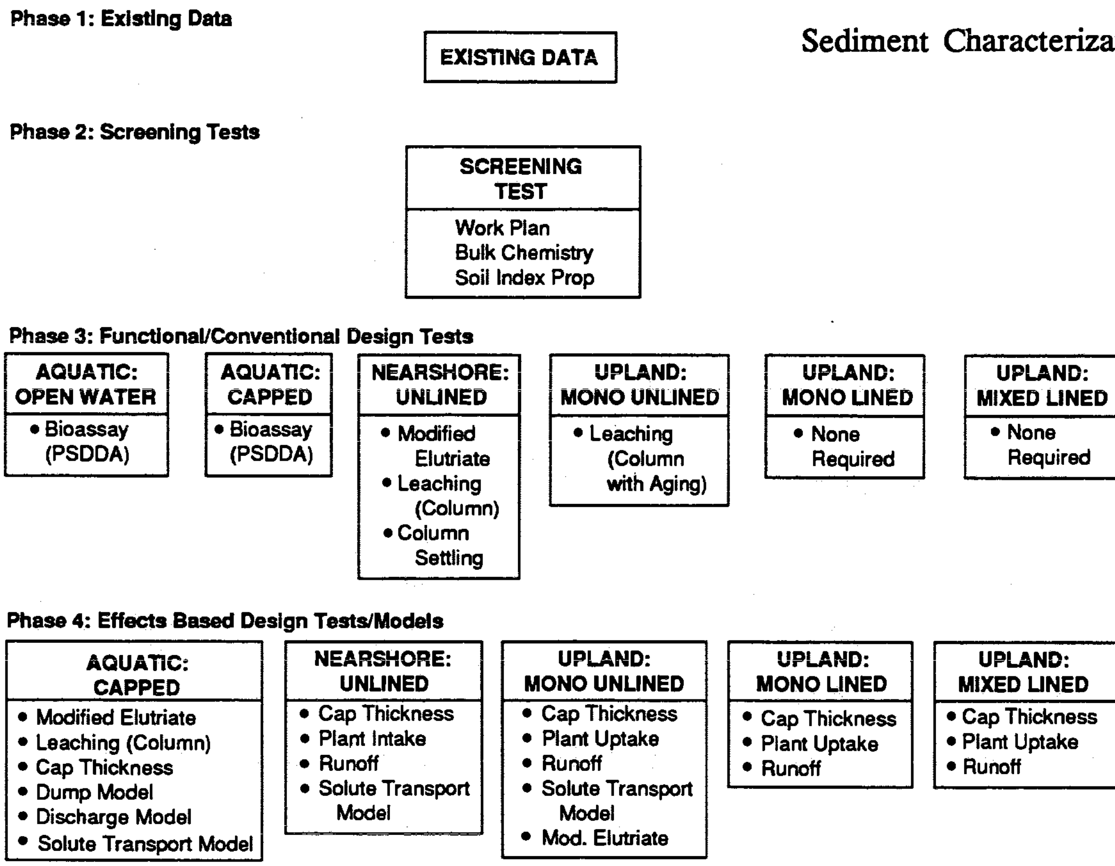


Figure 9.1 Phased approach to sediment characterization

- Phase 1 - Existing Data Review
- Phase 2 - Screening Tests
- Phase 3 - Functional/Conventional Design Test
- Phase 4 - Sediment Characterization for Effects-Based Design.

This four-phased method of characterizing sediment is as follows:

Phase 1 - Existing Data Review. The first step a project proponent takes in designing the sediment characterization work plan is to collect existing data on a proposed project. Existing data from the proposed site, nearby sites, and from potential disposal sites may help determine the best disposal option for contaminated sediment. Such data may include the following:

- Sediment
  - Bulk chemistry
  - Water chemistry
  - Physical soil properties
  - Bioassay
  - Volume to be dredged

- Disposal options
  - Possible dredging methods
  - Possible disposal sites
  - Possible disposal technologies.

Phase 2 - Screening Tests. The first step of Phase 2 is to develop the sediment characterization work plan. To focus on the likely disposal options so that testing and sampling are streamlined, the work plan builds upon the existing data. For example, if a nearshore site is the likely disposal option, and upland unlikely, then the work plan might specifically encompass screening tests, as well as the nearshore functional design testing. The work plan should address both confined disposal and PSDDA unconfined open-water disposal, if both are being considered.

Before initiating screening tests, Ecology encourages the proponent to submit a workplan for review, comment, and approval. The Ecology review is intended to prevent unnecessary testing, or the need for repeat sampling because insufficient testing was done the first time.

The two categories of screening tests are bulk chemistry and physical soil index properties. The general screening program is as follows:

- **Sediment Sampling.** The sampling protocols and quantity/volume criteria are those specified by PSDDA. The intent is to have both the PSDDA and the confined disposal programs covered by one protocol.

- **Bulk Chemistry.** Aquatic and nearshore disposal options will follow the PSDDA protocol for bulk chemistry testing. Upland disposal will follow the chemistry testing requirements of WAC 173-303, Sections 090 and 102, Dangerous Waste.

- **Physical Soil Index Properties.** The physical soil index properties will be measured in accordance with U.S. Corps of Engineers manuals EM 1110-2-1906 and EM 1110-2-5027. The properties measured are visual classification and water content of all samples, and grain size and Atterberg limits of representative samples.

Bulk chemistry testing will indicate if it is appropriate to consider functional design disposal options for sediment disposal, or if effects-based design is required. That determination will be made by comparing the screening test results to the state dangerous waste standards. Functional designs will be limited to sediments with less than 0.1 of the D.W. standards. Since the aquatic and nearshore disposal options do not require direct D.W. testing, the process will happen as follows:

- Complete the PSDDA bulk chemistry on the sediments during screening for aquatic and nearshore options. Then calculate a "total" Polycyclic Aromatic Hydrocarbons (PAH) and "total" Halogenated Hydrocarbons (HH) and compare to the standards in WAC 173-303. If the "total" PAH or "total" HH is greater than 0.1 D.W., then perform the actual D.W. testing on the sediments.

- If the PSDDA "total" PAH and HH is less than 0.1 D.W., or if the results of actual D.W. testing show the sediment to be less than 0.1 D.W., then proceed toward functional design.

If the results are greater than 0.1 D.W., then effects-based design is required. If the results indicate the sediments are a dangerous waste, then these confined disposal standards are not applicable.

Phase 3 - Functional Design Tests. Further testing will typically be required for approval of a functional design disposal method. The primary tests are these:

- The PSDDA bioassay tests for aquatic functional design
- Effluent tests consisting of column leaching and modified elutriate for nearshore functional design and column leaching upland-unlined functional disposal
- No additional testing for upland-lined functional disposal.

These testing requirements are summarized in Table 9.1. In general, sediments that qualify for functional design will have the characteristics presented in Table 9.2.

Phase 4 - Sediment Characterization for Effects-Based Design. The purpose of Phase 4 is to customize (project-specific) testing to address issues outside the constraints of functional design. The testing for effects-based design will specifically address the contamination pathways in question, and incorporate testing/modeling to demonstrate that the exposure does not exceed acceptable levels. As mentioned previously, these EBD tests can be for sediments that are either greater than 0.1 D.W., or are clean enough that a proponent believes conventional disposal is acceptable. Sediment characteristics allowing for conventional disposal are well defined for unconfined aquatic (PSDDA) disposal. However, sediment characteristics allowing for conventional nearshore and upland disposal are not well defined. Effects-based testing will be required to achieve conventional disposal in these two environments.

The generalized pathways through which contaminants of concern could be released into the environment from confined dredged material disposal sites are presented on Figures 2.1, 2.2, and 2.3. The pathways include these routes of contaminant migration:

Table 9.1. Testing methods for screening tests and for functional design.

	Method	Quantity
Physical Tests		
Visual Classification	EM 1110-2-5027	All samples
Water Content	EM 1110-2-1906, Appen. I	All samples
Grain Size	EM 1110-2-1906, Appen. V	Under PSDDA
Atterberg Limits	EM 1110-2-1906, Appen. III	Same as Grain Size
Chemical Tests		
Bulk Chemistry	PSEP 1986, or WAC 173-303	Under PSDDA Under PSDDA
Modified Elutriate Column Leaching Test Sediment Aging	Palermo 1986 Hill et al. 1988	Set of three tests for each class of contaminated sediment with similar chemical characteristics
Biological Tests		
Bioassays	PSEP 1986	Under PSDDA

Table 9.2. Sediment pass/fail characteristics for functional design.

Functional Disposal Method	Bulk Chemistry	Bioassay	Effluent
Aquatic Unconfined	<ML (PSDDA) <0.1 D.W.	< Site Condition 2 (PSDDA)	N.A.
Aquatic Confined	<ML (PSDDA) <0.1 D.W.	< Site Condition 3 (PSDDA)	N.A.
Nearshore	<0.1 D.W.	N.A.	Applicable water quality criteria, with attenuation/dilution factor
Upland Mono-Unlined	<0.1 D.W.	N.A.	Applicable water quality criteria, with attenuation/dilution factor

- Release to the water column during dredging or disposal
- Release to surface waters through effluent from a disposal site
- Surface runoff after disposal
- Airborne emissions of volatile compounds or fugitive dust
- Release of leachate to surface water or groundwater
- Migration through cover materials from diffusion, bioturbation, or groundwater flow.

Some of these pathways may relate to one or more disposal alternatives. To simplify selecting testing methods, the disposal alternatives and applicable pathways are presented in Table 9.3.

Table 9.3. Disposal alternatives and applicable contaminant transport pathways.

	Disposal Alternatives		
Pathway	Capped Aquatic Disposal	Nearshore Disposal	Upland Disposal
Water Column	X	X	X
Surface Water	X	X	X
Groundwater	X	X	X
Runoff		X	X
Airborne Emissions		X	X
Fugitive Dust		X	X
Biological Uptake	X	X	X

Before starting work on an effects-based design, a project proponent should submit a Phase 4 workplan to Ecology for review, comment, and approval. This work plan should address what pathways are affected by the modification in the effects-based design, and how these pathways will be addressed through sediment testing.

9.1.2 Sediment Characterization for Functional Design

The phased approach to sediment characterization lays out the tests required for screening tests functional design (see Table 9.1), and the sediment pass/fail characteristics for functional design (see Table 9.2). This section of the report presents flow charts showing the characterization tests and interpretation for each functional disposal method. The flow charts and their corresponding figure numbers are found in the following:

Figure 9.2 - Aquatic Disposal
Figure 9.3 - Nearshore Disposal
Figure 9.4 - Upland Unlined Disposal
Figure 9.5 - Upland Lined Disposal.

The philosophy behind functional designs is that they protect the environment for most sediments requiring confined disposal. Those sediments that are highly contaminated and do not fit with this philosophy would require a more rigorous design determined by an effects-based approach. The sediment characterization approach outlined on the flow chart reflects the need for both functional and effects-based designs.

Functional designs will be allowed only for sediments that meet a fairly narrow band of criteria. Those criteria start at the upper limit of existing criteria for unconfined aquatic disposal (PSDDA), and consider existing standards for unconfined upland disposal (county health regulations for 0.1 dangerous waste). The upper limit for functional design criteria is set for aquatic disposal at site condition III (PSDDA bioassays), and on effluent tests that meet appropriate water quality criteria for nearshore and upland-confined disposal. Sediment outside that band of criteria is then considered under effects-based disposal design. Final selection of the preferred disposal method can always be elevated to more complex methods, as indicated by the "option" (dashed line) at the bottom of each flow chart.

Once a functional design is chosen, the project sponsor will need to complete the detailed engineering design for the disposal system. Plans and specifications will be developed to address the details of construction as well as specifically adapting the functional design concept to the dredging and disposal site. Professional engineering will be necessary to address dredging technologies, disposal technologies, and geotechnical issues.

The philosophy behind effects-based designs is that they will likely require additional testing, but will also provide additional information about the level of protection provided by the design. Effects-based design can be used for sediments more contaminated than the 0.1 D.W. limit established for functional designs, or for sediments clean enough for conventional disposal in the nearshore and upland environments. Therefore, the flow charts presented later in this chapter depict an effects-based design process that can lead to conventional disposal. This process is explained in more detail in Chapter 10.

In reviewing the following characterization requirements, the reader should keep in mind that there is a Phase 1 process where existing information is reviewed. If the existing data are adequate, they can substitute for these characterization requirements.

Sediment Characterization for Functional Aquatic Disposal. The sediment characterization process for confined aquatic disposal incorporates both confined aquatic disposal (CAD) and the PSDDA unconfined open-water disposal method (Figure 9.2). The methodology generally follows the PSDDA approach, with initial bulk chemistry testing, followed by bioassay testing, if appropriate.

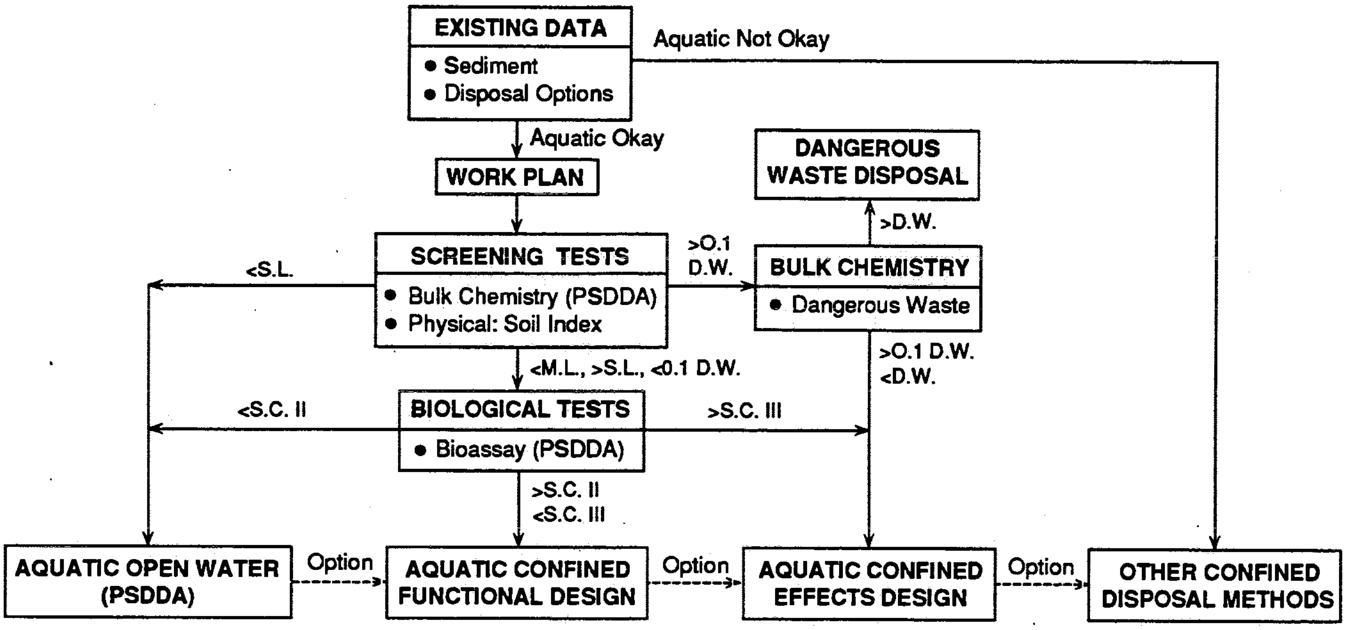


Figure 9.2 Sediment characterization for aquatic disposal

If the bioassay tests indicate sediments are less toxic than Site Condition II (S.C. II) (as defined by PSDDA), then PSDDA unconfined open water disposal is acceptable. If the tests indicate a toxicity between S.C. II and S.C. III (as defined by PSDDA), then the aquatic confined functional design is acceptable. If the toxicity is greater than S.C. III, then an effects-based design, or another disposal option, will be required.

Sediment Characterization for Functional Nearshore Disposal. The flow chart for nearshore disposal is presented in Figure 9.3. It incorporates a path for functional nearshore design, and for effects-based nearshore design. The methodology generally follows the PSDDA approach for bulk chemistry testing, and also requires effluent testing. The effluent tests are the modified elutriate (Palermo 1986) and the column leaching test (Hill et al. 1988). The column leaching test shall be run for at least 30 days.

The approach to assessing contaminant release (leaching) from dredged material is in a developmental state. The Waterways Experiment Station indicates that new approaches may be recommended within the next two to three years. Because of this, it is important that the leaching tests recommended in this document be seen as evolutionary and transitional. As new tests become available and validated, their inclusion in the dredged material characterization process will be appropriate.

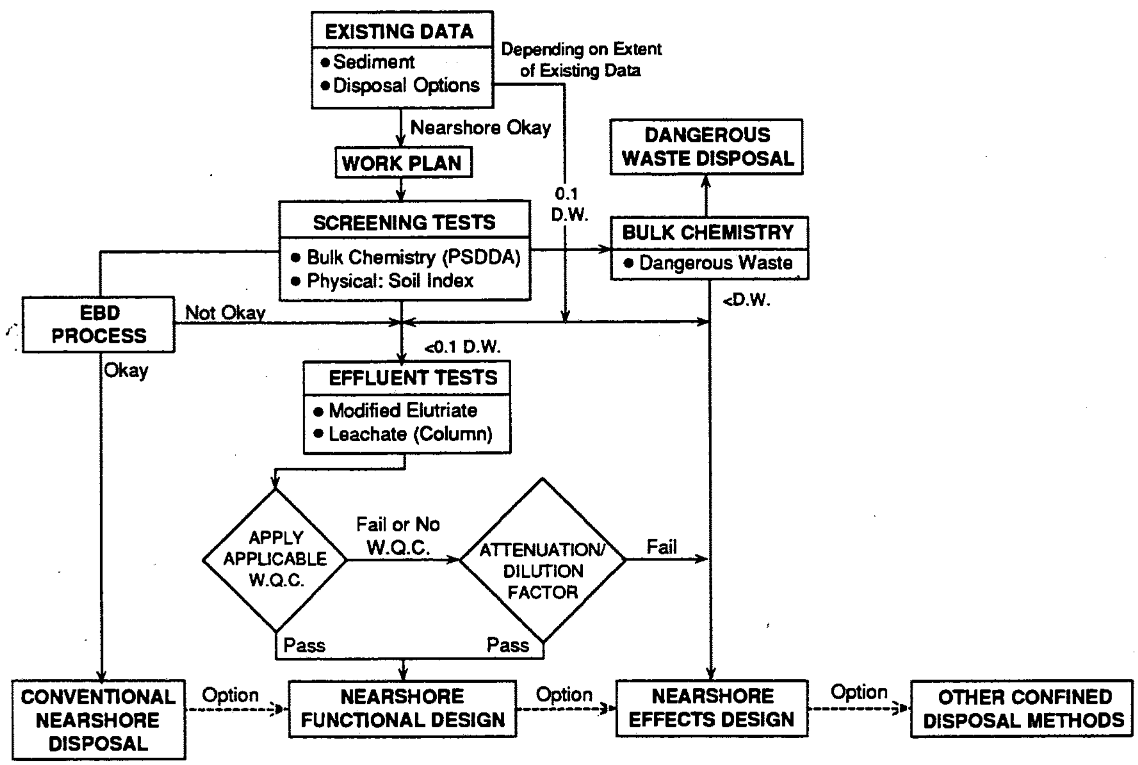


Figure 9.3 Sediment characterization for nearshore disposal

The effluent test results are compared to the applicable State of Washington Water Quality Criteria (W.Q.C.). The functional nearshore design will typically be applied to brackish coastal sites, and Class 3 groundwater (non-drinking water) and the adjacent water body would establish the applicable W.Q.C.

If the results of the effluent tests pass the applicable W.Q.C., then functional design is acceptable. If they do not pass, or if a W.Q.C. does not exist for a contaminant of concern, then the project sponsor and Ecology would negotiate appropriate attenuation or dilution factors on a case-by-case basis. The effluent test results will then be checked against the W.Q.C. with attenuation/dilution factors and if they pass, then functional design is acceptable. If not, then effects-based design is required.

Sediment Characterization for Functional Upland Unlined Disposal. The flow chart for addressing upland disposal in an unlined facility is presented in Figure 9.4. The initial bulk chemistry screening is based on WAC 173-303, Dangerous Waste. Only sediments less than 0.1 D.W. are acceptable for functional design. Effluent testing is required for final approval of the functional approach.

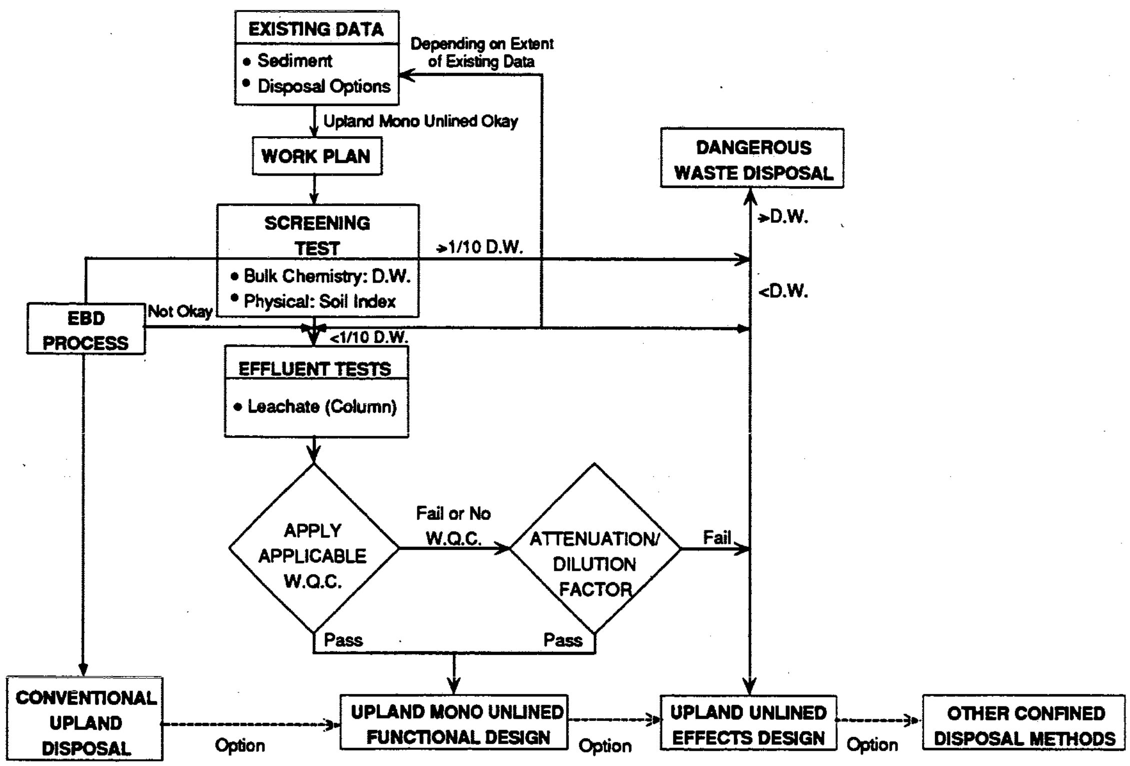


Figure 9.4 Sediment characterization for upland mono-unlined disposal

Column leaching (Hill 1988) is the currently recommended effluent test for functional upland unlined disposal. The leaching test for upland disposal requires aging sediments to simulate the aerobic environment of disposal. Currently, there are no standardized procedures for aging. However, two procedures have been used by the Waterways Experiment Station (WES). One procedure involves placing the sediment in a shallow, open pan where it can be oxidized at ambient temperature. The sediment is thoroughly and regularly stirred and is kept moist through the sparing addition of distilled, deionized water (Palermo et al. 1989). Another procedure presented by WES (1987) involves adding hydrogen peroxide to oxidize the sediment. WES indicates that new approaches may be recommended within the next two to three years. However, until specific procedures are developed, the aging process will have to be developed on a case-by-case basis.

The effluent test results are compared to applicable water quality criteria, with appropriate dilution/attenuation factors, as presented for sediment characterization for functional nearshore disposal (Figure 9.3). The upland unlined functional disposal design is for sites located over Class 3 brackish groundwater conditions.

Sediment Characterization for Functional Upland Lined Disposal. The flow chart for disposal of sediments in a lined upland facility, receiving either mixed wastes (mixed landfill), or sediments only (mono landfill) is presented in Figure 9.5. The only testing required is bulk chemistry based on WAC 173-303, Dangerous Waste. Sediments less than dangerous waste can go to a functional designed landfill. The project sponsor can choose between upland-monofill functional design, upland-mixed functional design, or an upland effects-based design.

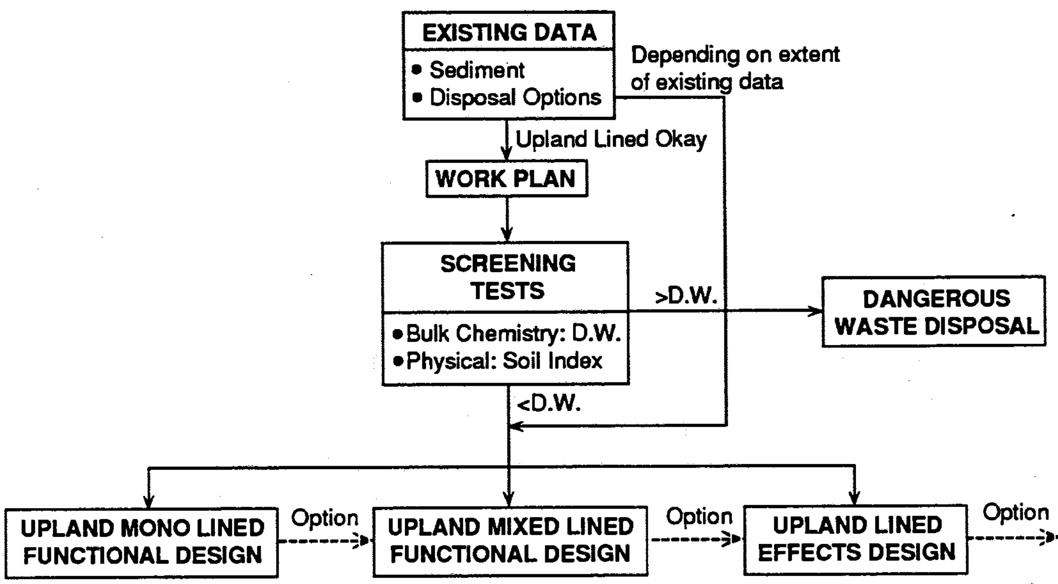


Figure 9.5 Sediment characterization for upland lined disposal

9.2 CONFINED AQUATIC DISPOSAL (CAD)

Final selection of a recommended CAD alternative was done using the Confinement Alternative Assessment Procedure (CAAP). That procedure has built into it an environmental effects analysis. The analysis is an objective quantitative system that ultimately leads to a cumulative score for the alternative being analyzed. In this section of the report we summarize the quantitative aspect of the CAAP evaluation, and provide a narrative environmental effects analysis of each alternative. These two summaries are presented for each of the major elements associated with dredging and disposal (that is, dredging, transport, site design, and monitoring).

9.2.1 Summary of CAAP

Dredging

The primary difference between the three CAD alternatives was the use of a mechanical dredge in Alternatives 1 and 2, and a hydraulic dredge in Alternative 3. Both of these dredge types were rated as having the same technical effectiveness in controlling sediment loss to the environment. On a scale of 1-3 (with three being the most effective - see Chapter 8, section 8.2) all of the alternatives were rated a 2.5 (see Appendix F for CAAP detailed information). The mechanical dredge has more potential for sediment loss to increase as depth increases (greater retrieval distance). This consideration was accounted for by limiting the dredging depth to a maximum of 200 ft in the alternatives where a mechanical dredge was considered.

Transport and Material Placement

Differences in transport and material placement technologies between the three alternatives are primarily based on dredge type. For example, hydraulic dredging and mechanical dredging use significally different technologies. For the transport component of disposal, the two technologies were rated similarly for technical effectiveness. The transport method for mechanical dredge alternatives was haul barge. Overflow controls and hydraulic checks (to ensure that the barge does not accidentally open and release its load) make barge transport rate equally with hydraulic pipeline transport. Without these controls, barge transport would potentially lose more sediment and be less effective than hydraulic pipeline transport.

Material placement was the component where differences between alternatives became most evident. For the alternatives based on mechanical dredging, the contaminated material placement was specified as bottom-dump barge with instantaneous release. For the hydraulic dredge alternative, the contaminated material placement was specified as a submerged diffuser with a control that the discharge point be within 10-40 ft of the bottom. Even though a control was placed on the submerged diffuser, the bottom-dump barge alternatives were rated more effective (2.5 versus 2.0).

The submerged diffuser received a lower rating for two reasons:

- The material is entrained with water (slurry state) and will have more opportunity for being transported offsite before settling to the bottom.
- Entrainment with water will create more opportunity for soluble contaminants to be released from the sediments into the environment.

In addition, hydraulic dredging has two other drawbacks related to cost and logistics. First, hydraulic pipeline dredging limits the distance between the dredge and disposal site. Second, it is significantly more expensive than mechanical dredging due to added mobilization costs.

Site Design

Differences in site design alternatives were based primarily on the disposal depth, bed slope at the site, and berm requirements. Of these factors, site depth was the most important in rating technical effectiveness.

Alternative 1 had higher effectiveness ratings (surface water pathway = 2.5 and direct contact pathway = 2.4) than Alternatives 2 and 3 (surface water 2.0 and 1.7, respectively; direct contact 2.2 and 2.4, respectively). The site depth in Alternative 1 was limited to between 80 and 200 ft. The maximum depth (200 ft) was established because that is the upper limit for effective dredging. If site monitoring indicates the site is not performing as intended (that is, contaminants are being released to the environment), the CAD site would be difficult to cleanup by material removal at depths greater than 200 ft. If the site is less than 200 ft deep, material removal remediation can occur more effectively. Alternative 3 included disposal site depths up to 400 ft and therefore received a low effectiveness rating. Alternatives 1 and 2 were limited to depths less than 200 ft and therefore had equal ratings for maximum depths.

A minimum depth (80 ft for Alternative 1) is also important to prevent wave erosion and accidental dredging/disruption from violating the cap's integrity. Alternative 2 included disposal site depths as shallow as 5 ft deep and therefore received a low overall effectiveness rating.

Alternative 1 has a substantially more expensive site design cost estimate than Alternatives 2 and 3. The difference in cost is attributed to a berm requirement in Alternative 1, regardless of the slope at the site. Alternatives 2 and 3 require berms only if the bottom slope is greater than 4% or 2%, respectively. Although a berm was given a high technical effectiveness rating, the relative weight given to that design feature was minor compared to other more important design features. The ultimate conclusion from the evaluation was that berms do not provide a significant enough measure of effectiveness for the additional cost they represent, and they are not a requirement in the functional CAD design.

Cap quality was also considered in the site design evaluation. PSDDA quality criteria were determined to be more appropriate than P2 criteria. The rationale for selecting PSDDA is due in part to the uncertainty of what the P2 criteria will be since they have not yet been promulgated. Resolution of the most appropriate cap quality criteria may be necessary following the completion of the P2 criteria.

Monitoring

CAD Monitoring

Using CAAP to evaluate the three CAD monitoring alternatives was relatively straightforward (the CAAP scoring form is in Appendix F). The CAAP scoring progressively ranked the three increasingly conservative monitoring alternatives from low to high. Similarly, the cost estimates for Alternatives 1 through 3 were $225,000, $500,000, and $1,000,000, respectively. Given the complexities and uncertainties associated with oceanographic monitoring, these are planning level cost estimates. In actuality, the absolute costs may vary substantially, but the relative costs among the three alternatives should be consistent.

The straightforward progression observed in both the CAAP scores and the cost estimates is not unexpected. This is because monitoring Alternative 1 through 3 generally represent increased levels of effort (that is, sampling frequency and sample numbers) that use identical or similar types of monitoring activities.

Based on the CAAP assessment, monitoring Alternative 2 is recommended as the preferred CAD monitoring alternative. Alternative 2's suite of monitoring activities will provide reliable information to establish a site's short- and long-term performance, without being extraordinarily costly.

9.2.2 Environmental Impacts Analysis

Dredging

Environmental concerns at the dredge site are associated with two types of contaminant release to the environment. First, soluble contaminants can be released into the water column when sediments are disturbed and sediment-bound particles can be transported into non-contaminated areas. These dredging impacts typically remain localized to the area of dredging, especially the transport of sediment particles out of the area. The two types of dredging methods we evaluated both indicated less than 1% loss of sediment loss during dredging. The significance of the impacts associated with such loss are obviously related to the extent of contamination associated with the sediment. Furthermore, the alternatives we evaluated are functional designs targeted at sediments with contamination that is less than 0.1 of dangerous waste. A one-percent loss (or less) of soluble contaminants to the water column when dredging sediments with the target 0.1 D.W. contamination level should be negligible.

A comparison of environmental impacts between the alternatives indicates similar low-level impacts. Because both hydraulic and mechanical dredging have relatively low levels of sediment loss, there are no discernible differences in dredging impacts among the three alternatives.

Transport and Placement

Like those environmental impacts associated with dredging, material transport could cause contaminants to be released into the water column. Thus, all three alternatives have similarly negligible impacts. Barge transport controls are required that prohibit overflow of dredged material in the barge. Sediment loss over the sides of barges is a potentially significant loss if such prohibitions are not in place. Hydraulic pipeline transport is a closed system that typically confines contaminants.

Dredged material placement has the potential for two types of environmental impacts. First, and most significant, is the unavoidable impact of smothering the marine biota present on the bottom. The impacts range from direct loss of benthic communities to indirect impacts to fish and shellfish that rely on these communities as a food base. Depending on the size of the area covered and the populations of fish/shellfish in the area, these indirect impacts of material placement may be negligible or significant. However, they will occur regardless of whether the dredged material is clean or contaminated, and do not vary significantly between the alternatives considered.

Second, is contaminant loss to the environment during disposal. This impact is related to the level of contamination present in the dredged material. Most contaminated sediments requiring dredging in Puget Sound are fine-grained cohesive sediments. For this type of material, Alternatives 1 and 2, which specify open barge dump and instantaneous release, will have less impact environmental effect than that caused by submerged diffuser placement in Alternative 3.

The entrainment of water associated with the hydraulic dredge and submerged diffuser will cause more soluble contaminants to release into the water column faster and in greater concentrations than the bottom-dump barge release. Because bottom-dump barge disposal tends to keep cohesive dredged materials clumped together, it releases less contaminants.

Site Design

Environmental impacts associated with site design are based primarily on site location, cap thickness, and cap quality. The magnitude of unavoidable impacts of direct loss of biota by smothering is the same for two of the three alternatives (Alternatives 1 and 2). More biota will be directly lost under Alternative 1 since it requires berms, and they increase the footprint of the site. Since it depends entirely on site-specific populations, it is not possible to quantify this magnitude.

Site Location. Site location will influence the extent of indirect environmental impacts from contaminant loss. Alternative 3 has the potential for more impacts than either 1 or 2 because of its greater release potential during disposal in depths up to 400 ft. Alternative 3 also has the potential for irreversible impacts if site design fails because dredging is effective only at depths up to 200 ft and this alternative allows disposal up to 400 ft. Deferred remediation of environmental impacts caused by site failure would be limited to placing additional cap material on top of the contaminated material.

Another potential site location impact associated with CAD sites is disturbance of the cap and re-exposure of contaminated sediments to the environment. Cap disturbance can potentially occur through wave erosion, physical disturbance (such as anchors unintentionally dragged through the area), and bioturbation. Wave erosion impacts and physical disturbance impacts are minimized in Alternatives 2 and 3 because site depth must be greater than 80 ft. Wave erosion impacts have the potential to be significant in Alternative 1 because site depths can be as shallow as 5 ft.

Cap Thickness. Cap thickness is the primary means for preventing the bioturbation of caps (that is, burrowing of benthic biota through the clean cap into the contaminated sediments). All three alternatives require a 3 ft cap. The bioturbation impacts associated with this cap thickness should be negligible. Three types of organisms creating the greatest concern for burrowing to depths greater than 3 ft are geoducks, ghost shrimp, and burrowing cucumbers. There is considerable information on geoduck burrowing abilities compared to that for the other two organisms. That information suggests that a 3-foot cap will adequately protect against geoduck penetration.

Two genera of ghost shrimp, *Callianasa* and *Axiopis*, pose the greatest concern about bioturbation. Unfortunately little information is available on their burrowing depth, especially in deep water (greater than 80 ft). One species (*Axius serratus*) has been documented to burrow (7.5 ft) 250 cm, but it is an East Coast species (Suchanek 1985). The burrowing depth of its West Coast counterpart (*Axiopis spinulicauda*) is unknown. A cap thickness of (7.5 ft) 250 cm was not selected, but a cap thicker than 3 ft (100 cm) may need to be considered at sites where *A. spinulicauda* are prevalent because of the greater potential for environmental impacts. Burrowing sea cucumbers (*Molpadia intermedia*) do not burrow in open channels. Their behavior is to plow through sediments. Therefore, their ability to re-expose contaminated sediments buried under 3 ft of clean cap is limited. Little information is available on the depths they plow, but they have been routinely collected in depths in excess of (1.5 ft) 50 cm. Their tendency is to burrow in soft fine-grained sediments. Cap characteristics could be designed to incorporate sediment characteristics that are not desireable for sea cucumber burrowing.

Two Puget Sound CAD sites are available for study to determine the effectiveness of cap thickness. One of these sites, the Duwamish CAD site has been in place for five years and has a 3-foot-thick cap. Recent studies of this site (see chapter 14) indicate that chemicals have not migrated through the cap. If bioturbation were a prevalent problem, some chemicals would have migrated. The lack of chemical migration at this site supports the conclusion that a 3-foot-thick cap will pose negligible environmental impacts.

Cap Quality. Cap quality is another aspect of site design where impacts to the environment could occur. Three different types of cap quality were considered. These included P-2 sediment standards, PSDDA standards, and adjacent reference sediments. The impacts to the environment for these three cap quality types depend somewhat on the chemical quality of the existing bed sediments at the disposal site. For the alternative that considered adjacent reference sediment quality, the impacts should be negligible because that alternative would cap the site with material equivalent in quality to what is present onsite. Depending on the existing quality of sediments at the site, the P-2 and PSDDA quality standards may either improve the existing quality or have a negative impact. P-2 standards are less likely to degrade existing cap quality than the PSDDA standards (especially the PSDDA ML standards). In either case, if the quality of existing bed sediments is degraded the extent of the impacts would be marginal.

Monitoring

The monitoring options do not create environmental impacts. Their purpose in the standards is to monitor site performance and verify that adverse impacts are not occurring. Alternative 2 monitoring will do an acceptable job of detecting adverse impacts, should they occur, given the design features associated with the preferred functional design standards.

9.2.3 Recommended CAD Functional Design Standard

The recommended standard includes elements from more than one alternative. Some elements were excluded because they did not additionally control contaminant release. Certain other elements were revised to best reflect the intent of their use in improving contaminant confinement. Site design is presented first because it often controls the dredging, transport, and monitoring standards.

Recommended CAD Site Design Standards

Functional design standards require that site design be completed by competent professional engineers. Total CAD site design will incorporate the following components:

Water Depth. CAD functional design will be based on a depth of water ranging from -80 ft to -200 ft MLLW. Elevations outside the identified range require approval through the effects-based design procedures.

Bed Slope. Bed slopes will be based on relatively flat gradients that are at 3% grade or less with loose, unconsolidated sediments of 10 ft thickness or greater. Sea beds with loose, unconsolidated deposits less than 10 ft (regardless of slope) or sea beds with slopes greater than 3% will require approval through the effects-based design procedures.

Bed Stability. Bed stability must be assessed by competent professional engineers using the most relevant information collected at the proposed site. Assessment will incorporate concern for local area sloughing, seismicity, or unusual sediment conditions. Speculative site conditions that are based on available information will be further considered under the effects-based design procedures.

Berms. Berm construction for CAD functional design will not be required provided bed slope, site stability, biological conditions, and other pertinent standard requirements are satisfied. Berm construction would be addressed under effects-based design procedures.

Water Column Velocities. Current velocities will be identified by available records or by onsite measurements of nearbed, mid-depth and near-surface velocities. CAD sites must be located such that currents present in the water will not exceed 1 ft/sec during contaminated sediment placement. Near-bed velocities will not exceed 0.5 ft/sec.

Design Volume. Functional design for CAD is assumed to be a one-time disposal of 10,000 yd^3 or more of contaminated sediments. Contaminated sediment volumes less than 10,000 yd^3 should be considered under the small projects standards as well as the effects-based design standards.

Cap Sediment Type. Primary cap materials are to be placed by hydraulic slurry release from a specified elevation above the bed. Those materials must be released from the discharge pipe in an un-clumped condition. Non-cemented, fine-to-medium grain size sand would meet this standard. Materials to be used will be a non-cemented sand matrix (with some fine grain and fine-to-medium size (gravel) sediment acceptable) capable of releasing in a homogenous, uniform sediment slurry.

Cap Sediment Quality. Sediments will be chemically as clean as or cleaner than maximum level criteria identified in PSDDA.

Cap Thickness. Primary cap thickness must be a minimum of 3 ft after placement and consolidation.

Recommended CAD Dredging Standards

Dredge Type. Contaminated sediments will be dredged by a clamshell bucket dredge with haul barge. Bucket size will be 5 yd^3 or larger.

Operational Control. The following operational limits are required for functional design:

- Limit dredging to water depths of 200 ft or less

- Remove contaminants by including as a minimum a 1-foot overdepth of clean sediments beyond the contaminated and clean sediment interface.

Operational controls that should be considered for inclusion in a permit, but not codified within the standard, are the following:

- Minimize turbidity from sediment resuspension at the dredging site by avoiding underwater stockpiling, site leveling by bucket drag, and increasing the retrieval rates of buckets

- Demonstrate control of dredging depths to within a 2-foot tolerance.

Recommended CAD Material Transport Standards

CAD functional design will be based on the following transport method:

Transport Type. Contaminated sediment will be transported from the dredge site to the disposal site by bottom-dump haul barge.

Operational Control. The following operational limits are required for functional design:

- Sediment excavated by clamshell from the haul barge will not be allowed to overflow during dredging or transportation operations.

- Full haul barges will not be allowed to standby for more than 24 hours before dumping.

- The hydraulic systems operating on the haul barge will be checked for correct operation.

The following operational controls should be considered for inclusion in a permit, but not codified within the standard.

- Contractor should have mechanical or hydraulic lock device on the haul barge before allowing a full barge to standby.

Recommended CAD Material Placement Standards

Contaminated Sediment Placement. Contaminated sediments will be transported and released from a bottom-dump haul barge over the identified disposal site based on the following standards:

- Release of the barge load volume will be instantaneous below the water surface within the designated target area. "Instantaneous" is defined as a single continuous discharge of sediments from the barge within a period of a few minutes.

- Dump position will be established by electronic positioning system capable of ± 3 m accuracy.

- Target area for barge release of contaminated sediments will be a circle with radius of 500 ft or less.

Operational controls that should be considered for inclusion in a permit, but not codified within the standard, are the following:

- Records for dump position on each barge release will identify the start of the bottom door opening and the end of release of sediments from the barge.
- Whenever feasible, taut line buoys will be deployed at the site to represent the center of the 500-foot radius target circle for disposal.

Capping Sediment Placement. Sediments of suitable quality will be transported and released as a hydraulic slurry from a pipeline discharge or from pumpout of a haul barge over the identified disposal site, based on the following standards:

- A minimum of one week will elapse between completion of contaminated sediment placement and capping.
- Capping sediment release will be released slowly to avoid displacing of contaminated sediments.
- A single lift will not be greater than 4 ft thick. The contaminated sediment deposit will be uniformly capped before a second lift is positioned.
- Slurry discharge position will be established by electronic positioning system capable of ± 3 m accuracy.

Operational controls that should be considered for inclusion in a permit, but not codified within the standard, are the following:

- Rate of sediment slurry discharge will be less than 2 ft^3/sec, and may require a diffuser.
- Discharge position at each release point will be recorded at the start of slurry discharge, during discharge, and at the end of release of sediments.
- Whenever feasible, taut line buoys will be deployed at the dredge site to represent the position of the slurry discharge capping disposal.

Recommended CAD Monitoring Standards

Dredging Site Monitoring. In addition to dredge positioning control, monitoring at the dredge site and immediate area will consist of water quality and bathymetric monitoring.

Water Quality. Two parameters required as measurements for water quality standards at the dilution zone are dissolved oxygen (DO) and turbidity. Other parameters may be added based on site specific features of the dredge area and further recommendations from Ecology. Within the dilution zone, the DO content should not fall below the recommended limit of 5 mg/L and measurements should be taken midway between the dredge and the dilution zone boundary. The measurement of turbidity should occur at the dilution zone boundary and meet applicable water quality standards. Standards for turbidity are waived within the dilution zone. The definition of the dilution zone and monitoring above the minimum requirements will be prescribed by Ecology on a site-specific basis. Sampling intensities will also be determined on a site- and project-specific basis.

Bathymetry. Bathymetric surveys at the dredging area will be performed weekly, using acoustic depth sensing techniques. Surveys should consist of 25-foot lane spacing run across the dredge track. The surveys will occur at the start, midpoint, or end of a day's dredging.

Dredge Positioning. Dredge position will be determined by establishing land-based horizontal control points and one of the following: two angle sextant plot, laser and theodolite triangulation or range azimuth, microwave (electronic) positioning or other approved positioning method capable of ± 3 m accuracy. The position of the dredge should be updated at one-hour intervals for a hydraulic dredge and at each relocation for a mechanical dredge.

Disposal Site Monitoring. Monitoring at the disposal site will consist of positional accuracy, bathymetry, sidescan sonar, sediment profiling, and shallow boring monitoring. Long-term monitoring at the disposal site consists of two phases: (1) intensive first-year monitoring and (2) subsequent yearly monitoring. Intensive first-year monitoring consists of bathymetric and sediment profile surveys. The subsequent years' monitoring will consist of shallow borings for visual and chemical analysis, the BRAT, and sediment profiling surveys.

Short-Term (Compliance) Monitoring

Positioning. All disposal site monitoring activities will use an electronic positioning system capable of ± 3 m absolute accuracy. Positions should be determined in Washington State Plane coordinates.

Bathymetry. Bathymetric surveys will be done before, at monthly intervals during, and two weeks after the completion of contaminated sediment disposal. In addition, a survey will be done after each lift of cap placement and one month after the site is capped. The surveys will use an acoustic fathometer interfaced with an electronic positioning system. The interfaced systems will provide the following data and formats:

- real-time plots of positions

- real-time depth trace
- continuous logging of X,Y,Z coordinates on magnetic media
- positions in Washington State Plane coordinates
- depth measurements to the nearest 0.1 ft.

Sidescan Sonar. Sidescan sonar surveys will be conducted before and within two weeks after the completion of contaminated sediment disposal. Another sidescan survey will be performed within one month after the site is capped, immediately following the post-capping bathymetry survey. The sidescan sonar will be interfaced with an electronic positioning system to facilitate comparison with bathymetry results. The survey should be done so that a 50% overlap of each track sonograph will occur.

Sediment Profile Sampling. Surveys using a sediment profiling camera will be conducted before and within two weeks after the completion of the disposal of contaminated sediments and within one month after the site is capped. Sediment profile surveys will be used to verify the limits of deposition of both contaminated dredged materials and capping materials. Sediment-profile images will also provide information on the rate and extent of infaunal recolonization of the capping materials by providing estimates of the biogenic mixing depths across the site. Although sampling sites are targeted to be the same for each survey, they may be modified pending the results of each survey.

Shallow Borings for Visual and Physical Measurements. Shallow borings will be obtained before contaminant disposal and after cap placement. Although the sampling sites will be the same at each survey, they may be modified pending the results of the sediment profiling surveys. Surface sampling (e.g. box core or grab) adequately characterizes the pre-disposal sediment. However, a deeper penetrating sampling device such as an impact or piston corer must be used for establishing unconsolidated bed sediment layer thicknesses before disposal and for post-capping sampling in order to determine the cap thickness.

Long-Term Monitoring - First Year

Bathymetry. Bathymetric surveys will be conducted at three- and six-month milestones. These surveys will duplicate the post-capping survey.

Sediment Profile Samples. Sediment profiling camera surveys will be conducted at the three- and six-month milestones and will duplicate the post-capping survey.

Long-Term Monitoring - Subsequent Years

Shallow Borings for Visual and Chemical Analysis. Borings will be obtained during years two, four, seven and ten after cap placement. The shallow boring survey will use the same stations as the post-capping survey in short-term monitoring. Each core will be analyzed visually to describe contaminant chemistry at one-foot intervals.

BRAT. BRAT surveys will be conducted during years two, four and seven after the completion of cap placement. The location of a few BRAT sampling stations will be directed by the results of the sediment profile camera survey. BRAT sampling will help determine the lateral and vertical distributions of the major infaunal organism recolonizing the site.

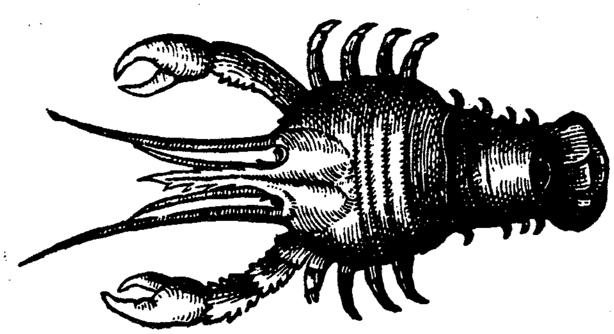
9.3 NEARSHORE

Final selection of a recommended nearshore alternative was done using the Confinement Alternative Assessment Procedure (CAAP). In this section of the report we summarize the quantitative results of the CAAP evaluation and provide a narrative environmental effects analysis of each alternative. These two summaries are presented for each of the major elements associated with dredging and disposal (that is, dredging, transport, site design, and monitoring).

9.3.1 Summary of CAAP

Dredging

The primary difference in dredging methods in the three Alternatives was the type of dredge used. A hydraulic dredge was used in Alternatives 1 and 2 and a mechanical (clamshell) dredge was used in Alternative 3. Alternative 1 allows use of either cutterhead or suction hydraulic dredges, while Alternative 2 uses only a cutterhead dredge. These alternatives were rated based on their technical effectiveness in controlling sediment loss to the environment. On a scale of 1-3 (with 3 being the most effective), Alternative 1 was scored highest in technical effectiveness (2.5 versus 2.0). Both dredge types effectively control sediment loss during dredging. However, hydraulic dredging with a cutterhead dredge was judged most environmental protective in reducing sediment loss. This conclusion is based on the premise that filling a nearshore site to capacity would require rehandling clamshell dredged material. If site design is such that bottom-dump barge can reach the site and thereby eliminate rehandling, then clamshell dredging would be as protective as hydraulic dredging.



MARINE CRUSTACEAN.

Transport and Material Placement

Differences in transport and material placement technologies between the three alternatives were based on dredge type. Pipeline transport was used in Alternatives 1 and 2, and barge haul was used in Alternative 3. Because hydraulic dredging was selected as the preferred alternative, only the CAAP evaluation of pipeline transport (Alternatives 1 and 2) is discussed below.

Because pipeline transport is enclosed, it reduces the contaminant loss to the water column and was highly rated for technical effectiveness. However, Alternative 1, which requires that the pipeline be submerged, ranked higher in technical effectiveness than Alternative 2 (3.0 versus 2.0). Without submerged pipe in channel areas, the navigation requirements may result in a need to occasionally separate pipe for vessel passage. Residual sediment slurry in the pipeline is lost under these conditions. For nearshore disposal, the recommended transport and material placement alternative was therefore pipeline transport, with submerged pipeline required in navigation areas.

Differences between nearshore alternatives were also evident in the material placement component. Alternative 1 has a higher technical effectiveness ranking than Alternative 2 (2.8 versus 2.3). Although both alternatives require that sediments remain anaerobic and that site access be prevented, Alternative 1 also places the highest contaminated sediments in the disposal site first. This placement method minimizes the possibility of contaminated sediment becoming aerobic or moving through the cover material. Logistical considerations, however, make this requirement infeasible and it was not included in the recommended standards.

There were also differences among the nearshore alternatives in sediment capping methods. Alternative 1 includes placement of a liner over the contaminated material to provide additional protection against contaminant migration through the final cap.

Site Design

Differences in site design alternatives were based primarily on capping requirements. The presence or absence of a primary cap was the most important factor in determining technical effectiveness ratings. Alternatives 1 and 2 (with a primary cap) had substantially higher technical effectiveness ratings than Alternative 3 (no cap). For surface water, direct contact and atmospheric pathways, Alternative 1 rankings ranged from 2.7 to 3, Alternative 2 from 2.5 to 2.6. But Alternative 3 ratings ranged from 1.5 to 1.9. Alternative 1 ranks slightly higher in technical effectiveness than Alternative 2, primarily because it includes a liner, thicker cap, and cleaner capping sediment.

Because it uses a liner, Alternative 1 is substantially more expensive than either Alternative 2 or 3. Even though the liner provides slightly higher technical effectiveness, the small amount of increased protection does not justify the cost. Therefore, Alternative 2 was the recommended alternative and functional design will require a primary cap but will not include a liner.

Monitoring

Differences in the monitoring alternatives were based primarily on the intensity of sampling. The groundwater monitoring alternatives use similar methods, but varied in the number of wells and sampling frequency. Alternative 3, which required the greatest number of wells and samplings, ranked highest (1296). Alternative 1, with the least intensive sampling, ranked lowest (324). Alternative 3 was also the most expensive alternative while Alternative 1 was the least expensive. Given the degree of certainty necessary to evaluate site performance and the relative cost, Alternative 2 was recommended as the preferred nearshore monitoring alternative. This alternative will provide reliable information without being extraordinarily costly.

9.3.2 Environmental Impacts Analysis

Dredging

Environmental concerns at the dredge site are associated with two types of contaminant release to the environment. First, soluble contaminants can be released into the water column when sediments are disturbed. Second, sediment-bound particles can be transported into non-contaminated areas. These dredging impacts typically remain localized to the dredging area, especially the transport of sediment particles out of the area. The two types of dredging methods we evaluated both indicated less than 1% sediment loss during dredging. The significance of the impact associated with such a loss is obviously related to the extent of contamination associated with the sediment. Furthermore, the alternatives we evaluated are for functional designs targeted at sediments with contamination that is less than 0.1 D.W. A one-percent loss (or less) of soluble contaminants to the water column when dredging sediments with this target contamination level should be negligible.

For nearshore disposal sites, dredging methods will also influence sediment loss during disposal. Clamshell dredged material, which must be transported by haul barge, will require rehandling to fill a nearshore site to capacity. This rehandling increases the probability of contaminant release. Because hydraulic dredging and pipeline transport do not require rehandling, they reduce contaminant loss. Therefore, hydraulic dredging was selected as the recommended method. If a nearshore project is designed such that rehandling of mechanically dredged material can be minimized, then its impacts will be similar to those of hydraulic dredging.

Transport and Placement

Environmental impacts associated with transport of the material are similar to those described for dredging. Basically contaminant loss, either soluble phase or sediment-bound are potential impacts. Contaminant loss may occur during transport or material placement. For nearshore sites, selection of hydraulic dredging necessitates pipeline transport. Contaminant loss to the water column during pipeline transport is minimal. When the pipeline is submerged in navigation areas (as in Alternative 1) sediment loss impacts are negligible.

Contaminant loss to the environment may also occur during placement of the dredged material. All alternatives include placement of sediments below the low water line or groundwater level to keep the contaminated material wet and aerobic, thereby reducing contaminant loss and minimizing potential impacts. Alternative 1 also places the highest contaminated sediments in the disposal site first, further reducing the possibility of contaminant loss. Since logistical considerations are major drawbacks, this requirement was not included in the functional design. However, adequate protection is provided by other placement and site design requirements.

Site Design

The primary site design impact is loss of intertidal habitat. This is an avoidable adverse impact not affected by the level of contamination in the dredged material. The main factors controlling the magnitude of the impact are existing habitat quality and site design. Depending on site location, the existing habitat may be of marginal quality or may be high quality, thus varying the strength of the impact. At some sites (that is, superfund sites), it is possible that the existing habitat is of extremely low value due to the presence of contaminated sediments. Although uncommon, this condition will make habitat loss negligible.

Site design affects habitat loss impacts for two reasons. First, it dictates how much habitat is lost. Second, it has the potential to mitigate losses. If berms can be built with gentle slopes that provide potential habitat, then design mitigation can minimize impacts. Future use of the site typically dictates such berm slope characteristics.

Site design features also address the long-term pathways of contaminant migration through the dikes or cap and prevent the water from direct contact with the capped contaminated sediment. For nearshore sites, important design features that determine impacts at nearshore sites include dike design, physical characteristics of the contaminated material, depth of contaminated material placement, effluent, and primary and final cap characteristics.

All three alternatives include dikes strong enough to confine sediments and retain them during disposal and subsequent consolidation. To provide additional protection against contaminant migration through the dike, Alternative 1 includes an impermeable liner or core. The other alternatives, and the recommended functional design, do not include this liner.

However, under Alternative 2 and 3, contaminant loss should still be minimal even without an impermeable liner in the dike for two reasons. First, contaminated material will be less permeable than the dike material and will act as a controlling "throttle" on contaminant release at the site. Second, the contaminated material is confined to the anaerobic zone of the site, where leaching potential of contaminants is minimized.

In addition, a primary cap limits contaminant migration until the sediment consolidates and the final cap is placed. Because Alternative 3 does not include a primary cap, its potential for contaminant release is substantially greater than in the other two alternatives. The primary cap for Alternatives 1 and 2 is composed of fine-grained sediment with some sand materials, preventing both contaminant loss and cap erosion. Alternatives 1 and 2 also have a primary cap thickness of 2 ft or greater, further limiting potential contaminant migration.

The final cap needs to consist of sediment type and quality and be of sufficient thickness to protect the primary cap, prevent contaminant migration, and allow use of the site following disposal. All alternatives require a final cap thickness of greater than or equal to 4-6 ft. A liner was included in Alternative 1 to provide additional protection against contaminant migration, but was not included in the recommended standard. The cap thickness requirement will provide enough protection that a liner will not provide enough additional environmental protection to justify its additional cost.

Monitoring

The monitoring options create no environmental impacts. Their purpose in the standards is to monitor site performance and verify that adverse impacts are not occurring. Given the design features associated with the preferred functional design standards, Alternative 2 monitoring will do an acceptable job of detecting adverse impacts.

9.3.3 Recommended Nearshore Functional Standards

The recommended standard includes elements from more than one alternative. Other elements in the alternatives were not included because they did not provide additional control of contaminant release. Certain elements were revised to best reflect the intent of the element use in improving contaminant confinement.

Recommended Nearshore Site Design Standards

Groundwater/Tidal Elevations. To establish contaminant placement within the zone of saturation, groundwater/tidal elevations must be identified. Groundwater elevation within a site must be determined and all contaminated sediments placed below that elevation. Site settlement and sediment consolidation will be considered, and the final long-term elevation of material placement will result in anaerobic, wetted sediment conditions.

Bed Materials. Bed materials and the depth of material layers must be investigated for geotechnical design of the dike structures and for foundation consolidation calculations.

Equipment Access. Transport equipment access to the disposal site must be available and identified. The project proponent will identify the preferred equipment specifications and address the access necessary for acceptable equipment operation.

Distance from Dredging. Distance will be within a pumping distance that does not need more than two booster pumps in line.

Confinement Dikes. Dike construction has two requirements. First, the individual site design must be strong enough to confine sediment and avoid dike failure. Second, dike height and disposal area (dike confined volume) must retain sediments during dredging disposal and during subsequent consolidation and dewatering of sediments.

Structural Design. Confinement dikes will be designed using accepted geotechnical and earthwork engineering methods. Structural strength and erosion protection will be incorporated in the design

Contaminant Migration. The confinement dikes in the functional design standard do not require an impermeable liner or core designed to prevent contaminant migration through the dikes. The functional design is based on the premise that the contaminated material will be less permeable than the dike material. If this premise is true, the contaminated material will be the controlling "throttle" on contaminant release from the site. This is a reasonable assumption since most contaminated sediments come from sink areas where fine-grained material (low permeability) settles out. If the contaminated material is more permeable than the dikes and will not act as a throttle, an effects-based design will be necessary. Monitoring and lab analysis at the dike/marine water interface will confirm these assumptions.

Sediment Retention Design. Adequate retention in the site is based on area and volume capacity and must allow for sediment settling out of slurry (hydraulic dredging). The acceptance of a design is based on effluent quality release of less than 100 mg/L. Design methods should follow the U.S. Corps of Engineers Engineering and Design Manual for Confined Disposal of Dredged Material (Corps 1987).

Effluent Control. Confined disposal sites will have outlet structures for release of ponded water. These outlets (or dewatering structures) will be a drop inlet sluice-style outlets with fixed length and variable height overflow. Hydraulic dredging and disposal operations will incorporate an entrance drop box to the outlet structure. The drop box will be constructed with a weir length that limits overflow depths to 2-4 inches.

Effluent discharge during dredging will be measured within the dilution zone. When permit requirements for water quality are exceeded, dredging operations will be revised to provide the necessary retention time (e.g. a partial-day dredging cycle). If water quality criteria cannot be met based on dredge cycles, other corrective actions will be considered. These measures include use of flocculants, construction of interior dikes, secondary ponding, or some other action to be identified by the applicant and approved by the regulatory authority. If no revision is identified, the project will be terminated.

Cap Design. Contaminated sediments will be capped following placement into a nearshore site. Cap design will include a primary cap and a final cap. The primary cap will be placed over contaminated sediments following contaminated sediment placement. The primary cap isolates contaminated sediments while the site settles and the sediment consolidates. The final cap will be placed over the primary cap.

Sediment Type. Material used for final cap must be an engineered design appropriate for future site use. Consideration for long-term cap stability must be included in material selection. Such stability considerations include preventing erosion due to runoff, loss of cap materials due to human activities, or other protective actions reasonable to site location. Examples of stability design are site vegetation, armoring with larger grain size sediments, or paving the site.

Recommended Nearshore Disposal Dredge Standards

Dredge Type. Contaminated sediments will be dredged by a hydraulic pipeline dredge.

Operational Control. The following operational limits are required for functional design:

- Spuds or anchors will be carefully placed to reduce the potential for sediment resuspension and loss from the area.

- Depth of cut during any one swing advance of dredge will be controlled to a value between 1 and 1.5 the diameter of the cutterhead. Cut depth can be less than the diameter of the cutterhead if the contaminated layer plus overdepth tolerance for dredge is less than the cutter diameter. The cut can never be greater than 1.5 the diameter, regardless of contaminated layer thickness.

- Removal of contaminants to include, as a minimum, a 1-foot overdepth of clean sediments beyond the contaminated and clean sediment interface.

Operational controls that should be considered for inclusion in a permit, but not codified within the standard, are the following:

- Demonstrate control of dredging overdepth for each lift of sediment removed to within a 1-foot tolerance for cutterhead dredge

- Dredging depth limited by ladder design and position of submerged pump.

Recommended Nearshore Disposal Transport Standards

Transport Type. Contaminated sediment will be transported from the dredging site to the disposal site by discharge pipeline.

Operational Control. The following operation limits are required for functional design:

- Discharge pipeline route and type of discharge line must be identified incorporating the following discharge line types:

Submerged Pipeline. Submerged pipeline is discharge line that is submerged below the water surface when dredging. Submerged line is often placed across navigation channels and submerged to an adequate depth so that vessel traffic can pass over without disrupting dredge operations.

Floating Pipeline. Floating discharge line is supported by floats on the water surface. Connections of pipe are typically ball joint connections, flexible rubber connections, or glue welded connections (plastic pipe). These connections allow some flexibility needed for movement of surface waves and dredging operations.

Shore Pipeline. Shore line is placed on the shore or upland. Connection of steel pipe is by ball joint, rubber sleeve, or tapering one end of pipe to fit into the downstream end of the next pipe. Plastic pipe is glue welded.

Booster Pumps. Booster pumps are additional pumps with an individual power plant placed in the discharge line. Added pumps allow greater discharge pumping distance from the dredge to disposal site.

- Submerged pipeline 600-1,000-foot long will be required in navigation areas.

- The discharge pipeline may or may not incorporate a booster pump in line, depending on distance to the disposal site from the dredging area, size of dredge, and the sediment type being transported.

- Limit booster pumps in line to two or less.

Recommended Nearshore Disposal Material Placement Standards

Nearshore disposal functional design will be based on the following material placement conditions:

Contaminated Sediment Placement. Contaminated sediments will be transported and discharged into the site by pipeline following these conditions:

- Contaminated sediments will be placed in the site so that they will remain anaerobic and wet for the long term. To determine the acceptable fill elevation during dredging, consideration will be given for site settlement, foundation, and dredged material consolidation.

- Discharge will be managed to provide maximum hydraulic efficiency of site and maximize sediment retention.

- The site will be controlled to prevent access to it during disposal and following disposal until the site is safe and contaminated sediments have been isolated.

Capping Sediment Placement. Contaminated disposal site will be closed by placing capping sediments of acceptable quality over the contaminated sediments. The following conditions govern placement:

- Primary cap must be placed over sediments while the sediments are still wet.
- Primary cap will be placed on contaminated fill in thin lifts to prevent creating a mud wave and/or unnecessary mixing of clean primary cap and contaminated sediments.
- Final capping will occur after the dredged material and dike have initially consolidated and settled.

Recommended Nearshore Monitoring Standards

Dredging Site Monitoring. In addition to dredge positioning control, monitoring at the dredge site and immediate area will consist of water quality and bathymetric monitoring.

Water Quality. These are identical to the dredge site water quality standards identified previously for the CAD environment.

Sediment Quality. Monitoring of sediment quality within the limits of the water quality dilution zone adjacent to the effluent return will include shallow surface borings before disposal and immediately following contaminant placement. Samples collected at the 1-foot depth in nearshore and median locations and at the dilution zone boundary will be analyzed for pollutants of concern. Post-dredge sediment conditions exceed PSDDA criteria and pre-dredge sample levels will be treated as contaminated sediments, removed, and disposed with previously placed sediments at nearshore sites.

Bathymetry. These are identical to the dredge site bathymetric survey standards identified previously for the CAD environment.

Dredge Positioning. These are identical to the dredge positioning standards identified previously for the CAD environment.

Disposal Area Monitoring. Compliance monitoring at the disposal area will consist of effluent overflow monitoring at the weir, water quality monitoring at the effluent return to waters of the state, water quality monitoring at the periphery of the confinement dike, and groundwater monitoring at test wells. Long-term monitoring at the disposal site will include water chemistry monitoring around the disposal periphery at the dike/marine water interface, groundwater monitoring at test wells, and cap borings for contaminant migration.

Short-Term Compliance Monitoring.

Effluent Overflow. Water samples will be obtained from dredged slurry effluent during dredging operations immediately downstream of the overflow weir(s). Samples will be analyzed for suspended sediments and target pollutant analyses based on contaminated sediment characteristics. In addition, areas of potential resettlement of suspended sediments outside the site will be sampled and analyzed.

Water Quality Monitoring. Effluent monitoring directly to waters of the state will be monitored to establish compliance with water quality certification. Monitoring of water quality at the dilution zone boundaries from the effluent point of return will include, as a minimum, two parameters – DO, and turbidity.

Groundwater Monitoring. A minimum of one sample round will be obtained from six sampling wells after five days of disposal into the site, or before completion of dredging operations, whichever comes first. Samples will be analyzed for pollutant analytes as identified by sediment characterization.

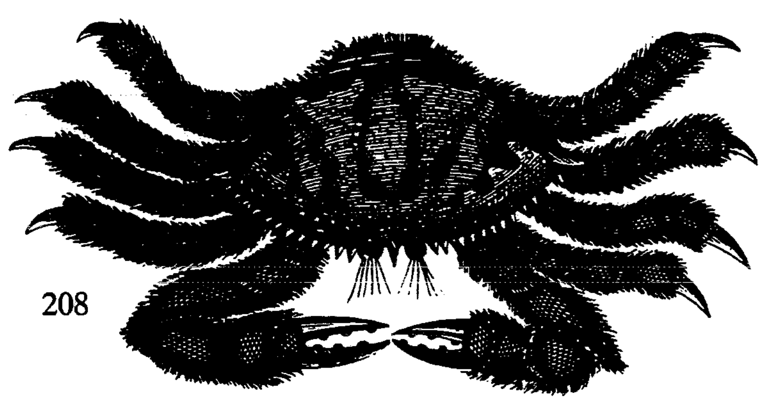
Periphery Water Chemistry. Waterways adjacent to nearshore confinement structures will be sampled weekly. Samples will be collected 2 ft below the water surface during the last three hours of ebb tide conditions. The samples will be analyzed for chemicals of concern.

Long-Term Monitoring.

Periphery Water Chemistry. Waterways adjacent to nearshore confinement structures will be sampled annually. Samples will be collected 2 ft below the water surface during the last three hours of ebb tide conditions. These samples will be analyzed for chemicals of concern.

Groundwater Monitoring. Recommended groundwater monitoring calls for six wells sampled five times a year initially, decreasing to two samplings per year. Analyses for priority pollutants will be required.

Cap Borings. Four borings of cap sediments will be obtained to establish any migration of contaminants through the cap sediments. The borings on the cap surface will be positioned for site coverage.



9.4 UPLAND MIXED LANDFILL

Final selection of a recommended upland mixed disposal alternative was done using the Confinement Alternative Assessment Procedure (CAAP). This procedure has built into it an environmental effects analysis. The analysis is an objective quantitative system that ultimately leads to a cumulative score for the alternative that is analyzed. In this section of the report, we summarize the quantitative aspect of the CAAP evaluation, and provide a narrative environmental effects analysis of each alternative. These two summaries are presented for each of the major elements associated with dredging and disposal (that is, dredging, transport, site design, and monitoring).

9.4.1 Summary of CAAP

Dredging

The alternatives for upland dredging are the same as those for CAD, including both clamshell and hydraulic dredge. Both dredge types were rated as having the same technical effectiveness in controlling sediment loss to the environment. All of the alternatives were rated a 2.5 However, clamshell dredging was selected as the recommended alternative because the clamshell dredged sediments contain less moisture than hydraulically dredged sediments. Sediments dredged hydraulically will require dewatering, an expensive and potentially environmentally degrading procedure.

Transport and Material Placement

As in CAD, the alternatives for transporting material to the upland site included both barge haul and pipeline transport. For the initial transport component of disposal, the technologies were rated similarly for technical effectiveness. Operational controls and hydraulic checks make barge transport equal to hydraulic pipeline transport in technical effectiveness. Without these controls, barge transport would have more potential for sediment loss and would be rated lower.

Sediment handling was the component where differences between alternatives became most evident. Sediment transfer and handling are required in all three alternatives and are major sources of contaminant release to surface water. Both Alternatives 1 and 2, which transport material by haul barge, include similar operational requirements (e.g. no barge overflow, hydraulic checking procedures, watertight sideboard) to reduce sediment loss. However, Alternative 1 offloads material directly into the transport equipment, while Alternative 2 allowed stockpiling sediment. Stockpiling increases the potential area and time for contaminants to be misplaced. Alternative 1 therefore ranked higher in technical effectiveness than Alternative 2 (ratings of 2 and 1, respectively). Alternative 3, using pipeline transport, would directly deposit contaminated sediments into the rehandling area. Because pipeline transport produces only slight contaminant loss to the water column and rehandling requirements are reduced, this alternative received a technical effectiveness rating of 2, equal to that of haul barge without stockpiling.

Because sediments accepted at the upland site must have a low sediment moisture content, they may require rehandling to a temporary confinement site for dewatering. Dewatering site features vary among the alternatives. However, dike construction requirements are similar in all alternatives. Alternatives 1 and 3 also include a liner to collect leachate, and capture of surface water at the site. The collected waters are then treated for release. These two elements substantially reduce contaminant release effects and contribute to the high technical effectiveness rating for these two alternatives. Alternative 2, using no liner, would have a much greater impact and ranked much lower for technical effectiveness in preventing contaminant loss to groundwater.

All three alternatives were similar in final overland haul methods. Transport is by lined, watertight, approved equipment. With operational controls, the technical effectiveness rating was 2 for all the alternatives.

Site Design

There are existing regulations for disposal of mixed waste at upland sites. The federal regulations for disposal of solid waste are set forth in the Federal Register, 40 CFR, Parts 257 and 258, Solid Waste Disposal Facility Criteria, Subpart B, Subpart C, Subpart D, and Subpart E. The Washington state regulations are the Minimum Functional Standards (MFS) for Solid Waste Handling (WAC 173-304). Under WAC 173-304, two primary types of upland disposal sites are permitted: (1) municipal landfills and (2) demolition and inert waste landfills. Details of the municipal design are set forth primarily in WAC 173-304-460, and details of the demolition design are set forth primarily in WAC 173-304-461.

Characteristically, municipal landfills are lined, have leachate collection systems, and are located on sites that meet specific siting criteria. Demolition sites, however, characteristically are not lined, have no leachate collection system, and meet only the siting criteria of a stable slope.

Current landfilling practice includes placing dredged sediments in municipal and demolition landfills. Since upland mixed sites are currently regulated, it was not appropriate to run CAAP for upland mixed alternatives. However, we did run CAAP on the upland monofill lined and upland monofill unlined alternatives. We concluded that groundwater quality could be significantly degraded if an unlined site was placed above a shallow drinking water aquifer. For example, if wet dredged sediments were placed in an unlined site directly above a gravel drinking water aquifer, the water quality in that aquifer would likely be compromised. This additional siting criteria is necessary at unlined demolition sites.

Therefore, we recommend continuing to permit dredged sediments to be placed in all lined municipal sites. But, we recommend that the current practice of allowing dredged sediments to be placed in unlined demolition landfills, without requiring an effects-based analysis, be discontinued. Placing dredged sediments in demolition sites should only be approved if a site-specific effects-based analysis has been conducted, and that analysis demonstrates no acceptable environmental risk.

Monitoring

Two alternatives were evaluated for groundwater monitoring. Monitoring methods were similar in both alternatives, but Alternative 1 included less frequent sampling and fewer wells than Alternative 2. Therefore, Alternative 1 ranked only half as high in data reliability as Alternative 2. Since the upland mixed disposal site design follows MFS for municipal landfills, a high degree of environmental protection is built in. Based on this, we determined that Alternative 1, the least intensive monitoring, was sufficient and should be the recommended standard.

9.4.2 Environmental Impact Analysis

Dredging

Environmental concerns at the dredge site are associated with two types contaminant release to the environment. First, soluble contaminants can be released into the water column when sediments are disturbed. Second, sediment-bound particles can be transported into non-contaminated areas. These dredging impacts typically remain localized to the dredging area, especially sediment transport out of the area. The two types of dredging methods we evaluated both indicated less than 1% sediment loss during dredging. The significance of the impact associated with such loss are obviously related to the extent of contamination associated with the sediment. Furthermore, the alternatives we evaluated are functional designs targeted at sediments with contamination that is less than 1/10 of Dangerous Waste classifications. A one-percent (or less) loss of soluble contaminants to the water column while dredging sediments with this target contamination level should be negligible.

A comparison of environmental impacts between the alternatives indicates similar low-level impacts. Clamshell dredging was selected as the preferred alternative because sediments dredged using this method contain less moisture, reducing or eliminating dewatering requirements.

Transport and Placement

Environmental impacts from transporting and rehandling dredged material to upland sites include possible contaminant release to surface waters. Initial transport alternatives are associated with the dredging method used and include haul barge and pipeline transport. All three alternatives have negligible impacts.

The major differences in dredging and transport alternatives relate to dewatering and rehandling requirements due to high water content of the sediments. Increased dewatering is required when sediments are transported by pipeline instead of barge haul. Pipeline transport (Alternative 3) must be to a temporary holding facility to dewater the sediments, and not directly to the site. This additional step increases the probability for contaminant loss. Barge haul is therefore the preferred method. For similar reasons, stockpiling material after barge transport was not included in the recommended alternative. Stockpiling increases the potential for contaminant release because of the increased area and time for contaminants to be misplaced, in addition to the additional transfer step that is required. Clamshell with barge haul will require significantly less dewatering time and may effectively eliminate need for dewatering. Material should be directly placed into lined transport equipment or the dewatering site.

The dewatering site also provides potential short-term pathways for contaminant loss through migration to groundwater and surface runoff from the site. Temporary confinement requires dikes, ponding and runoff outlet structures and dewatering methods. Alternatives 1 and 3 use a liner and impacts to groundwater are significantly reduced.

Site Design

Primary pathways for long term contaminant loss in upland sites are the leaching of contaminants through the confinement media (dikes, existing site sediments or ground cover) or by surface runoff. Current practice includes placement of dredged sediments in municipal and demolition landfills. Municipal landfills have several features that substantially reduce the potential for impacts due to contaminant release. These sites are lined, thereby preventing the vertical migration of leachate through the bottom of the landfill. Leachate collection systems control and treat the leachate before release. The potential for impacts on groundwater from demolition landfills is much greater. Because these sites are not lined, groundwater quality could be significantly degraded. This is the major reason that disposal at demolition landfills was not included in the recommended functional design.

Another design feature reducing impacts at municipal landfills is the cover requirement. Use of a liner or cover of sufficient thickness impedes the vertical migration of surface water into the facility and further reduces the likelihood of contaminant loss. Topsoil placement protects the cover from erosion and encourages revegetation. Cover requirements at demolition landfills are minimal and the potential for contaminant migration much greater.

Municipal landfills must also have surface water management systems capable of containing runoff and run-on from 25-year storm events. This will remove surface water that would migrate into the landfill to form leachate.

Monitoring

The monitoring options do not create environmental impacts. Their purpose in the standards is to monitor site performance and verify that adverse impacts are not occurring. Monitoring Alternative 1 will do an acceptable job of detecting adverse impacts given the design features associated with the preferred functional design standards.

9.4.3 Recommended Upland Mixed Functional Design Standard

Recommended Upland Mixed Disposal Dredging Standards

Upland mixed disposal functional design will be based on the following dredge operation conditions:

Dredge Type. Contaminated sediments will be dredged by a clamshell bucket dredge.

Operational Control. The following operational limits are required for functional design:

- Limit dredging to water depths of 200 ft or less.
- Include as a minimum a 1-foot overdepth of clean sediments beyond the contaminated and clean sediment interface.

The following operational control should be considered for inclusion in a permit, but not codified within the standard:

- Minimize turbidity from sediment resuspension at the dredging site by avoiding underwater stockpiling, site leveling by bucket drag, and increasing the bucket retrieval rates.

Recommended Upland Mixed Transport Standards

The upland mixed waste site functional design will be based on the following transport methods:

Transport Type. Contaminated sediment will be transported from the dredging site to the dewatering site by haul barge.

Operational Control. The following operation limits are required for functional design:

- No overflow of the clamshell excavated sediment from the haul barge will be allowed during dredging or transport operations.

- Flat deck barges with side boards will be watertight along their side board deck interface.

- Shallow hull barges, if split-hull or bottom-hopper door type, will have a hydraulic system checking procedure.

Rehandling. Contaminated sediments will be rehandled for dewatering and final transport to the disposal site. The following conditions control rehandling contaminated sediments:

- Sediments will be off-loaded at the approved site by clamshell, backhoe or front end loader. Off-loading will be done over the barge and contained rehandling area. No bucket swings over open water will be allowed.

- Contaminated sediment placement will be directly into the dewatering site or into lined transport equipment such as a haul truck or railroad car. No materials may be stockpiled for rehandling to a dewatering site.

- Rehandling area will be contained to catch and control incidental contaminated sediments misplaced during off-loading.

Dewatering Site. Contaminated sediments accepted at the upland site must have a low moisture content. Before overland haul to disposal site, sediments must be rehandled to a temporary confinement site for dewatering. That temporary confinement will require confinements dikes, ponding, and runoff outlet structures, and dewatering method.

Confinement Dikes. Dike construction has two requirements. First, the dike design must be strong enough to confine sediments and avoid dike failure. Second, dike height and disposal area (dike confined volume) must retain sediments during dredging disposal and during subsequent dewatering.

- *Structural Design.* Confinement dikes will be designed using accepted geotechnical and earthwork engineering design methods.

- *Sediment Volume Design.* Adequate site volume to receive dredged materials must be allowed (mechanical dredging). The total volume capacity will allow for bulking of sediments plus a 1-foot minimum freeboard to the top of the dike from contaminated sediment placement.

Dewatering Outlets. Confined disposal sites will have outlet structures for release of ponded and runoff water. These outlet or dewatering structures will be a drop-inlet sluice-style outlet with a fixed length and variable height overflow.

Liner. The dewatering area will be constructed with a geotextile liner or compatible clay liner to provide leachate containment.

Local Requirements. Slurried materials may require several months to dewater. These standards will not supersede local government authority under the Shorelines Management Act, County public health, or other applicable statutory requirements.

Dewatering Methods. Contaminated sediments will be dewatered by accepted methods that include, but are not limited to, progressive trenching, vacuum well point, capillary wick, or under drainage. Functional design requirements include these:

- Dewatering approach will be engineering design.
- Runoff and leachate from dewatering site will be captured and tested to identify treatment. Consideration for dilution zone or treatment as required will be based on standard wastewater treatment methods and dredging water quality criteria for release of runoff and elutriate to Washington state waters.
- Contaminated sediments will be accepted for transport to upland disposal when the reduced moisture content passes the paint filter test.
- Gradual removal of dewatered surface sediments only is an acceptable procedure. Depth of surface removal will be based on sediment core samples taken at 1 ft subsurface depth intervals.

Upland Haul. Final haul overland to the disposal site will be required.

- Method of contaminated sediment haul to upland disposal site will be by approved carrier only. Contaminated sediment will be transported from dewatering site to the disposal site using lined, watertight and covered haul equipment. No contaminated sediments will be dropped or misplaced during the transit. Any materials accidentally misplaced will be recovered immediately and disposed of at the approved disposal site.

Action Plan. An action plan to control and avoid sediment loss during rehandling, dewatering, and haul to final disposal will be developed and submitted for approval. The plan will identify the following:

- Plant proposed for rehandling, off-loading, and hauling
- Location of rehandling area and dewatering area
- Method of dewatering and clean up.

Recommended Upland Mixed Site Design Standards

All lined upland municipal landfills that meet the MFS for Solid Waste Handling WAC 173-304 should be permitted to receive dredged sediments contaminated at levels below dangerous waste criteria. Unlined demolition sites should not be permitted to receive dredged sediments unless it can be demonstrated, by a site-specific effects-based analysis, that the dredged sediments will not adversely affect groundwater and surface water quality.

Recommended Upland Mixed Monitoring Standards

Dredging monitoring requirements are the same as those identified for the CAD environment.

The recommended groundwater monitoring calls for four wells sampled five times a year initially, subsequently decreasing to two samplings a year. Priority pollutants will not be sampled before disposal, but will be required in the post-disposal rounds. This monitoring scheme assumes a typical mixed waste landfill and an average size dredge project. Should a proponent's project vary from this, the monitoring approach can be modified through the effects-based design.

No biological monitoring is required since the recommended design includes an impermeable liner and 6 inches of topsoil.

9.5 UPLAND MONOFILL DISPOSAL

Final selection of a recommended upland monofill disposal alternative was done using the Confinement Alternative Assessment Procedure (CAAP). This procedure has built into it an environmental effects analysis. The analysis is an objective quantitative system that ultimately leads to a cumulative score for the alternative that is analyzed. In this section of the report we summarize the quantitative aspect of the CAAP evaluation, and provide a narrative environmental effects analysis of each alternative. These two summaries are presented for each of the major elements associated with dredging and disposal (that is, dredging, transport, site design, and monitoring).

9.5.1 Summary of CAAP

Dredging

The alternatives for upland dredging are the same as those for CAD, including both clamshell and hydraulic dredge. Both of these dredge types were rated as having the same technical effectiveness in controlling sediment loss to the environment. All of the alternatives were rated a 2.5 However, clamshell dredging was selected as the recommended alternative because the dredged sediments contain less moisture than hydraulically dredged sediments. Sediments dredged hydraulically will require dewatering, an expensive and potentially environmentally degrading procedure.

Transport and Material Placement

As in CAD, the alternatives for transporting material to the upland site included both barge haul and pipeline transport. For the initial transport component of disposal, the technologies were rated similarly for technical effectiveness. Operational controls and hydraulic checks make barge transport equal to hydraulic pipeline transport in technical effectiveness. Without these controls, barge transport would have more potential for sediment loss and would be rated lower.

Sediment handling was the component where differences between alternatives became most evident. Sediment transfer and handling is required in all three alternatives and are major sources of contaminant release to surface water. Both Alternatives 1 and 2 which transport material by haul barge, include operational requirements (e.g. no barge overflow, hydraulic checking procedures, watertight sideboard) to reduce sediment loss were similar in both alternatives. However, Alternative 1 off-loads material directly into the transport equipment, while Alternative 2 allowed stockpiling sediment. Stockpiling increases the potential area and time for contaminants to be misplaced. Alternative 1 therefore ranked higher in technical effectiveness than Alternative 2 (ratings of 2 and 1, respectively). Alternative 3, using pipeline transport, would directly deposit contaminated sediment into the rehandling area. Because pipeline transport produces minimum contaminant loss to the water column and rehandling requirements are reduced, this alternative received a technical effectiveness rating of 2, equal to haul barge without stockpiling.

Because sediments accepted at upland sites must have a low sediment moisture content, they may require rehandling to a temporary confinement site for dewatering. Dewatering site features vary among the alternatives. However, dike construction requirements are similar in all alternatives. Alternatives 1 and 3 also include a liner to collect leachate and capture surface water at the site. The collected waters are then treated for release. These two elements substantially reduce contaminant release impacts and contribute to the high technical effectiveness rating for these two alternatives. Alternative 2, using no liner, would have much greater impact and ranked much lower for technical effectiveness in preventing contaminant loss to groundwater.

All alternatives were similar in final overland haul methods. Transport is by lined, watertight, approved equipment. With operational controls, the technical effectiveness rating was 2 for all alternatives.

Site Design

Lined Site Design. Differences in important features of the site design alternatives are summarized below:

Bottom Liner. For each alternative there are two options for the bottom liner. Option 1 includes a geomembrane liner and low permeability natural material. Option 2 includes a thicker layer of low permeability material without a geomembrane liner. Alternatives differ in geomembrane thickness and in hydraulic conductivity and thickness of the natural barrier. As part of CAAP we ran the Hydrologic Evaluation of Landfill Performance (HELP) model for each design alternative to see how the designs performed over a range of environmental conditions. (The HELP model is a quantitative water balance tool that we used to examine surface and subsurface fluid flow in the various landfill design scenarios.) We examined both options for each alternative. Based on the performance of the geomembrane materials and their relative costs, we decided to recommended a 30 mil geomembrane liner in Option 1 of the recommended functional design. If, however, a particular site poses construction problems that require a heaver liner, then a thicker geomembrane should be selected by the design engineer. The bottom liner assists in controlling contaminant migration along the groundwater and surface water pathways.

Leachate Collection System. The leachate collection system assists in controlling contaminant migration along the surface water and groundwater pathways. All three alternatives include a leachate collection system. The alternatives differ in the amount of head remaining in the high permeability material directly above the bottom liner.

The HELP model was used to confirm that the proposed liners would preform with the maximum allowable heads. All alternatives were technically effective. Based on cost, Alternative 2 was selected over Alternative 1.

Leachate Treatment and Disposal System. The leachate treatment and disposal system assists in controlling contaminant migration along the surface water, groundwater, atmospheric and direct contact pathways. All three alternatives include a leachate treatment and disposal system. The alternatives differ in the required safety factor applied to collection ponds. Alternative 2 was preferred based on case-specific experience of individual team members.

Surface Water Management. The surface water management system assists in controlling contaminant migration along the surface water and groundwater pathways. All three alternatives include surface water runoff and run-on controls. The alternatives differ in required design storms. Alternative 2 is recommended because it represents a balance between the end-points used in current practice. Also, based on case experience, Alternative 2 provides adequate protection at a reasonable cost.

Final Cover. The final cover assists in controlling contaminant migration along all pathways. There are two options for the final cover in each alternative. Again, the first option includes a geomembrane liner and low permeability natural material. The second includes a thicker layer of low permeability material without a geomembrane liner. Alternatives differ in geomembrane thickness and in hydraulic conductivity and thickness of the natural barrier. As part of CAAP we ran the HELP model with a set of reasonable assumptions held constant over all alternatives. We examined both options for each alternative. Based on the performance of the geomembrane materials and their relative costs we decided to recommend a 30 mil geomembrane liner in Option 1 of the recommended functional design. If, however, a particular site poses construction problems that require a heavier liner, a thicker geomembrane should be selected by the design engineer.

Drainage Layer. The drainage layer assists in stabilizing the cover and therefore assists in controlling contaminant migration along all pathways. All three alternatives include a drainage layer. The alternatives vary in the maximum allowable head permitted in the drainage layer immediately above the barrier layers of the final cover. Results of the HELP model and cost were used to select Alternative 2.

Topsoil. Topsoil is required for all alternatives, but the alternatives vary in the thickness of topsoil each requires. Alternative 2 is most effective from a technical and cost perspective.

Dewatering. It was assumed that dewatering would not occur before placement in the upland facilities. It was also assumed that dredging and transport methods for upland bound sediments would retain their in-situ water content.

Unlined Site Design.

The most significant finding in the CAAP process for unlined facilities is the need for strict siting criteria for all unlined landfill alternatives. This conclusion affects the recommended functional design for monofill unlined facilities and upland mixed facilities.

We began by running CAAP on unlined monofill alternatives with no specific siting requirements. Because these alternatives do not include a liner, the dredged sediments will be in direct contact with the underlying ground. We found that CAAP scores for groundwater and surface water would vary greatly depending on the assumed site conditions. For example, if we assumed that the site was placed directly on a highly permeable, very shallow aquifer then the groundwater pathway score was extremely low for technical effectiveness. The groundwater score was also very low in other major categories.

In addition to the information we gained with CAAP, we are aware of the trend at the federal, state, and local level to tighten environmental requirements for all facilities that receive non-municipal waste. We have also reviewed the recently proposed State of Washington regulations for groundwater quality. Based on all of this information and the insight we gained in the public workshop, it seemed unlikely that an unlined alternative without strict siting guidelines would be feasible.

Therefore, in an effort to develop a feasible upland unlined monofill functional design for contaminated sediment disposal we worked at developing adequate siting criteria for the design. The primary requirement set forth in the performance siting criteria for upland unlined monofill facilities receiving marine sediments is that those facilities be placed only above brackish water aquifers. Placement of an unlined facility above a fresh water aquifer would require an effects-based analysis. This siting restriction is due to a concern of salt leaching into the groundwater and degrading the aquifer. Depending on the leachability of contaminants, this siting restriction may not apply to freshwater sediments.

The unlined design alternatives were run through CAAP with the assumption that each site was placed above a brackish aquifer and that only sediments that fell at or below 10% of the dangerous waste criteria would be placed in the facility. With these assumptions the groundwater pathway is adequately protected. The CAAP scores for unlined monofill upland alternatives, shown in Appendix F, would have been much lower if the brackish water aquifer and the 10% dangerous waste assumptions were not imposed.

The selection of specific design elements was very similar to the selection of design elements for upland monofill lined facilities. The previous section on lined sites provides the description design elements.

Monitoring

Lined Site. Two alternatives were developed for groundwater monitoring. They were the same in type of sampling, but differed in frequency of sampling and number of analytes. Alternative 1 is the least intensive and therefore ranked lower in data reliability than Alternative 2 (144 vs 900). Given the degree of certainty necessary to evaluate site performance and the relative cost of the two alternatives, Alternative 1 was recommended as the preferred upland monitoring alternative. The less rigorous alternative was selected because of the protective nature of the design features incorporated in its design.

Unlined Site. Two alternatives were developed for groundwater monitoring. They were the same type of sampling, but differed in frequency of sampling and number of analytes. Alternative 1 is the least intensive and therefore ranked lower in data reliability than Alternative 2 (144 vs 729). Given the degree of certainty necessary to evaluate site performance and the relative cost of the two alternatives, Alternative 2 was recommended as the preferred upland monitoring alternative. The more rigorous monitoring alternative was selected because the site does not have a liner and the major pathway for contaminant transport is not blocked.

9.5.2 Environmental Impacts Analysis

Dredging

Environmental concerns at the dredge site are associated with contaminant release to the environment. Two types of release can occur. Soluble contaminants can be released into the water column when sediments are disturbed and sediment-bound particles can be transported into non-contaminated areas. These dredging impacts typically remain localized to the area of dredging, especially the transport of sediment particles out of the area. The two types of dredging methods we evaluated both indicated less than 1% loss of sediment loss during dredging. The significance of the impact associated with such loss are obviously related to the extent of contamination associated with the sediment. The alternatives we evaluated are functional designs targeted at sediments with contamination that is less than 0.1 dangerous waste. A one-percent (or less) loss of soluble contaminants to the water column during dredging of sediments with this target 0.1 contamination level should be negligible.

A comparison of environmental impacts between the alternatives indicates similar low-level impacts. Clamshell dredging was selected as the preferred alternative because sediments dredged using this method contain less moisture and dewatering requirements are reduced or eliminated.

Transport and Placement

Environmental impacts associated with transport and rehandling of dredged material to upland sites include possible contaminant release to surface waters. Initial transport alternatives are associated with the dredging method used and include haul barge and pipeline transport. All three alternatives have negligible impacts.

The major differences in dredging and transport alternatives relate to dewatering and rehandling requirements due to the high water content of the sediments. Increased dewatering is required when sediments are transported by pipeline instead of barge haul. Pipeline transport (Alternative 3) must be to a temporary holding facility to dewater the sediments, and not directly to the site. This additional step increases the probability for contaminant loss. Barge haul is therefore the preferred method. For similar reasons, stockpiling material after barge transport was not included in the recommended alternative. Stockpiling increases the potential for contaminant release because of the increased area and time for contaminants to be misplaced, in addition to the additional transfer step that is required. Clamshell with barge haul will require significantly less dewatering time and may effectively eliminate dewatering. Material should be directly placed into lined transport equipment or the dewatering site.

The dewatering site also provides potential short-term pathways for contaminant loss through migration to groundwater and surface runoff from the site. Temporary confinement requires dikes, ponding and runoff outlet structures and dewatering methods. Alternatives 1 and 3 use a liner and impacts to groundwater are significantly reduced.

Site Design

Lined Site Design. Environmental impacts associated with lined upland site design are controlled primarily through the liner, leachate collection system, surface water management, and final cover.

The bottom liner prevents migration of leachate through the bottom of the landfill and helps direct the flow of leachate toward the leachate collection system. The alternatives differed in geomembrane thickness, barrier layer thickness, and barrier layer hydraulic conductivity. All the alternatives provided protection against contaminant migration, with greater thickness providing greater certainty against contaminant release. Quantitative modeling, however, showed that the intermediate geomembrane thickness provides adequate protection.

The leachate collection and treatment system controls leachate flow and treats leachate prior to release. Although the collection alternatives differed in the maximum allowable head, all were effective in controlling contaminant migration along the surface water and groundwater pathways. The treatment systems differed in the required safety factor applied to collection ponds. Alternative 3, with the lowest safety factor, had the potential for more impacts. Alternative 1, with the highest safety factor, provided the greatest assurance against contaminant loss.

Surface water management includes runoff and run-on control systems. The alternatives differ in required design storms. Failure of the surface water system to control stormwater flow could result in contaminant release to surface water and groundwater pathways. Alternative 1, designed for a 2-100 year storm provides greater protection than Alternative 3, designed for only a 2-25 year storm. The intermediate alternative (2-50 year storm), however, provides adequate protection and failure is unlikely.

Final cover is important in controlling contaminant release through groundwater, surface water, direct contact, and atmospheric pathways. The final cover includes a top barrier layer, a drainage layer, and a vegetation layer. The top barrier layer or liner performs much like the bottom liner discussed above. The drainage layer minimized the accumulation of water on the barrier layer and provides stability. The alternatives differed in maximum allowable head permitted. Both Alternatives 1 and 2 provided adequate protection against contaminant migration along all pathways. The thinner geomembrane liner thickness in Alternative 3 increases the potential for contaminant loss. The alternatives also differed in topsoil thickness. The 6 inches of topsoil required in Alternative 3 may not be adequate for protecting the barrier layer against erosion and allowing revegetation. Alternatives 1 and 2, with topsoil thickness greater than 12 inches, provide adequate protection.

Unlined Site Design. Environmental impacts of specific design elements are like those described for the same elements for upland monofill lined facilities described above. The most important additional feature for unlined facilities are the site conditions. If a site is located on a permeable, very shallow aquifer, then the impact on groundwater contamination may be substantial. The requirement that unlined facilities receiving marine sediments be placed only above brackish water aquifers substantially reduces the potential for groundwater impacts.

Monitoring

The monitoring options do not create environmental impacts. Their purpose in the standards is to monitor site performance and verify that adverse impacts are not occurring. The recommended monitoring alternatives will do an acceptable job of detecting adverse impacts given the design features associated with the preferred functional design standards.

9.5.3 Recommended Upland Monofill (Lined and Unlined) Standard

The recommended standard for site design, monitoring, and dredging includes features from more than one alternative. Certain features in the alternatives were not included since they did not provide additional control of contaminant release through the pathways. However, other features were revised to best reflect the intent of each feature's use in improving contaminant confinement.

Recommended Upland Monofill (Lined and Unlined) Dredging Standards

Upland Monofill for both lined and unlined functional design will be based on the following dredge operation conditions:

Dredge Type. Contaminated sediments will be dredged by a clamshell bucket dredge.

Operational Control. The following operational limits are required for functional design:

- Limit dredging to water depths of 200 ft or less.
- Include as a minimum a 1-foot overdepth of clean sediments beyond the contaminated and clean sediment interface.

Operational controls that should be considered for inclusion in a permit, but not codified within the standard are the following:

- Minimize turbidity from sediment resuspension at dredging site by avoiding underwater stockpiling, site leveling by bucket drag, and increased bucket retrieval rates.
- Demonstrate control of dredging depths to within a 2-foot tolerance.

Recommended Upland Monofill Transport Standards

The upland monofill site functional design will be based on the following transport methods:

Transport Type. Contaminated sediment will be transported from the dredging site to the rehandling site by haul barge.

Operational Control. The following transport operation limits are required for functional design:

- No overflow of the clamshell excavated sediment from the haul barge will be allowed during dredging or transport operations.
- Flat deck barges with side boards will be watertight along side board deck interface.
- Shallow hull barges, if split-hull or bottom-hopper door type, shall have a hydraulic checking procedure.

Rehandling. Rehandling of contaminated sediments will be required for final transport to disposal site. Functional design requirements include:

- Sediments will be off-loaded at the approved site by clamshell, backhoe, or front-end loader. The sediments will be off-loaded over the barge and the contained rehandling area. No bucket swing over open water will be allowed.
- Contaminated sediment placement will be directly into lined transport equipment such as haul truck, railroad car, or other vehicle. No stockpiling of materials for rehandling will be allowed.
- The rehandling area will be contained to allow catchment and control of incidental contaminated sediments misplaced during the off-loading operation.

Upland Haul. Final haul overland to the disposal site will be required. The method of contaminated sediment haul to an upland disposal site will be by approved carrier only. Transport from the dewatering site to the disposal site will use only lined, watertight and covered haul equipment. No contaminated sediments will be dropped or misplaced during transit. Any materials accidentally misplaced will be recovered immediately and disposed at the approved disposal site.

Action Plan. An action plan to control and avoid sediment loss during rehandling, dewatering and haul to final disposal will be developed and submitted to Ecology for approval. This plan will identify the plant proposed for rehandling, off-loading, and hauling. The location of the rehandling area will be identified. The method of clean up will also be specified.

Recommended Upland Monofill Lined Site Design Standards

The recommended functional design is Alternative 2. Nothing was deleted from this alternative as a result of completing CAAP. Therefore, the description of Alternative 2, presented in the Disposal Site Design Alternatives Development section of this report, is still valid. However, since completing CAAP, we have identified the need to clarify some issues and to include some operating requirements for the recommended functional design.

There are two issues that need clarification in the functional design. First is the definition of maximum allowable head above the bottom liner. This maximum head refers to the depth of water in the high permeability layer immediately above the liner. Second is the issue of chemical compatibility between the dredged sediment leachate and the natural low permeability materials used for liners and covers. We resolved the chemical compatability issue by requiring all natural materials used at upland monofill sites to be chemically compatible with brackish leachate.

The recommended operating requirements for the functional disposal site design include these protections:

- To prevent direct contact with sediments, after placement and before covering, control access to the site. Fence the site if necessary.

- To prevent direct contact with collected leachate, fence leachate collection system.

- To prevent topping the lined berms, dredged sediments should be placed in controllable, measured quantities.

- To prevent atmospheric degradation, monitor gases at leachate treatment facility and treat gas if necessary.

As a result of the upland technical studies completed as part of this work, we recommend routine sampling of collected leachate at all upland lined monofill facilities.

Recommended Upland Monofill Unlined Site Design Standards

The recommended functional design is Alternative 2. No design elements were deleted from this alternative as a result of completing CAAP. Therefore the description of Alternative 2, which is presented in the Disposal Site Design Alternatives Development section of this report, is still valid. However, as a result of completing CAAP we have identified the need to require strict performance siting criteria for this unlined design. Specifically the unlined monofill facilities, which use the functional design and receive marine sediments, can only be constructed above brackish aquifers.

The recommended operating requirements for the functional design include these:

- To prevent direct contact with sediments, after placement and before covering, control access to the site. Fence the site if necessary.
- To prevent topping the berms, dredged sediments should be placed in controllable, measured quantities.

Recommended Upland Monofill Lined Monitoring Standards

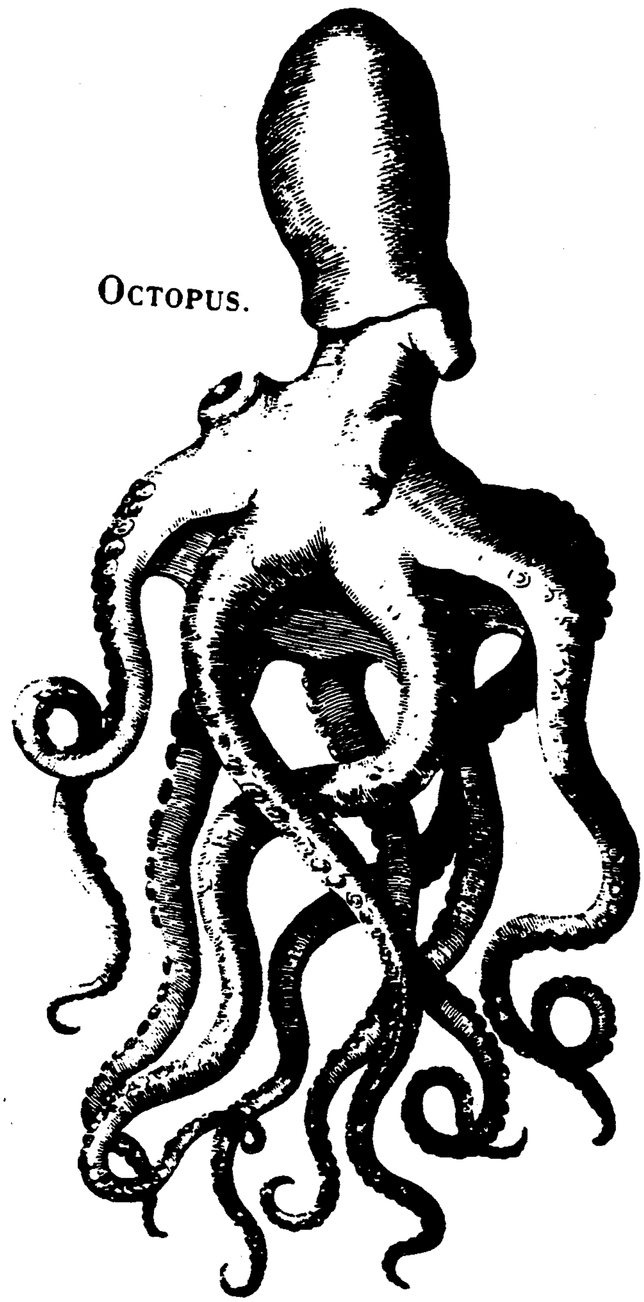
Dredging monitoring is identical to that presented for the CAD environment.

Groundwater monitoring includes four wells sampled five times a year for the first year, and twice a year in subsequent years.

Recommended Upland Monofill Unlined Monitoring Standards

Groundwater monitoring includes five wells sampled six times a year for the first year, and twice a year in subsequent years.

Effects Based Design



10. EFFECTS-BASED DESIGN

10.1 EFFECTS-BASED DESIGN APPROACH

The standards for confined disposal of contaminated sediments need to address two types of designs. The majority of documentation in this report has been devoted to the functional design. The purpose of this chapter is to describe the effects-based approach, and define some sediment characterization testing that addresses effects-based design.

When do you use an Effects-Based Approach?

The effects-based approach will derive a customized design that allows for modifications to the functional design. These modifications are likely to occur due to one of four circumstances:

- A proponent wants to modify one or more components of a functional design to better match the proposed development.
- A proponent wants to use a specific site that does not meet the functional design criteria.
- A proponent wants to use a conventional disposal design (i.e. reduce the design requirements of the functional design) because their dredged material is relatively uncontaminated or has physical characteristics that reduce the likelihood of contaminant migration.
- A proponent needs to create an effects-based design because their material is more contaminated than the functional design allows.

These scenarios are obviously wide-ranging. The variability in when an effects-based design is needed is representative of the fact that it is not possible to predict what an effects-based design will look like. Each one will be customized to its own particular situation. Therefore, it is not possible to identify specific dredging, transport, design, or monitoring elements of an effects-based design as part of these standards.

What is the value of Effects-Based Design?

Ecology recognizes that each disposal project has its own nuances. These nuances will often mean that a functional design is not feasible. The effects-based design's value is that it becomes the mechanism by which nuances and variations from the functional design are accounted for.

A logical question is why have a functional design if most projects will have a nuance that prevents its use. The functional design will provide the standard requirements for site design, dredging and monitoring. For example, the standards for a disposal environment may include 30 major components, 10 in each of the three categories (site design, dredging, and monitoring). If a proponent's project has no modifications to 27 of the 30 components, then it becomes more straightforward to deal with the three components that are different. A proponent can determine how they are different, and what can be done to provide the same level of protection as the functional design. The functional design then becomes both a tool for focusing on areas where there are differences, and a yardstick for comparing the modifications that were developed through the effects-based approach.

<u>How is an Effects-Based Design determined?</u>

In determining an effects-based design, a proponent needs to define what modifications of the functional design are necessary for their project. Modification of a functional design could require only limited technical analysis, or extensive testing and modeling depending on the nature of the change. Examples of modifications considered to be relatively straight forward are:

- Use of clamshell dredging and bottom dump barge for near-shore disposal, instead of the functional method of hydraulic dredge and pipeline transport. The proponent should show a case history where similar sediments were disposed of in the same manner, with monitoring indicating no adverse effects. Modification of the functional design would then require little additional testing or modeling.

- Use of asphalt or concrete paving as the cap for an upland mono-unlined design, instead of the functional multi-layer cover system. The proponent should show evidence that the paved cap has the necessary surface drainage collection and control to restrict introduction of surface water into the fill, based on case histories and/or technical analysis. Modification of the functional design would then require little additional testing or modeling.

A process will be developed that establishes how EBDs are determined and accepted. The details of this process will be determined in the next phase of developing the standards, but a general outline of how the process will work is presented in the following paragraphs.

A checklist approach will be established that inventories all of the features in a functional design and compares them against the potential effects-based design. Completion of such a checklist serves to highlight the design features/components that are different between the FD and EBD.

The next step in the process outline is determination of what pathways of contaminant transport are affected by the change in design. Following identification of pathways will be a determination of what tests/models are applicable to determine capability of the change in design feature to adequately block the transport pathway.

The planning and acceptance of an EBD will be a two-step process. The first step will be a completion of:

- A checklist that identifies differences, and
- A work plan that addresses how the differences will be evaluated.

The second step of the process presents the data generated by the workplan and evaluating the effectiveness of the design modifications. This second step is outlined below.

In determining modifications it is necessary to consider what pathway will be most affected. A number of tests are available that serve as surrogates to determine how the dredge sediment will behave in releasing contaminants along a pathway. These tests need to be evaluated and a workplan developed that specifies which tests will be conducted and how they will be interpreted. The following section describes those tests that will most likely be used in establishing effects-based designs.

For those modifications to the functional design that remove caps and allow human exposure to contaminated sediments, a risk assessment approach for evaluation may be necessary. Initiative 97 cleanup standards may also need to be evaluated for acceptability as criteria for allowing cap removal.

Acceptance of Effects-Based Design

General acceptance of any design that differs from the functional design will be based on engineering of the site design. Concerns for pathways of contaminant loss as identified in the functional design will be addressed in effects-based design. For sediment contamination less than or near functional design levels, the acceptance of an engineered design will be predominantly based on technical analysis. For sediment contamination significantly greater than functional design levels, and for qualified site design concerns that have limited technical solutions, the acceptance of an effects-based design must also consider remediation and increased monitoring. Any effects-based design that has high levels of contamination, poor technical basis for design, and lack of a feasible, practicable remediation action would not likely achieve acceptance.

The process by which the EBD is evaluated and ultimately accepted will include comparison to the FD. Functional designs were determined using the CAAP described in Chapter 8. The CAAP will be modified so it can be used as a tool to compare EBDs against FD standards. This modification will occur in the next phase of the standards development and incorporated into the EBD process developed at that time.

The CAAP comparison needs to address the level of protection to the environment that the EBD and FD provide. The level of protection provided by the FD will likely be higher than the level of protection provided by the EBD. This is due to the inherent nature of the two design types, and is illustrated graphically in Figure 10.1.

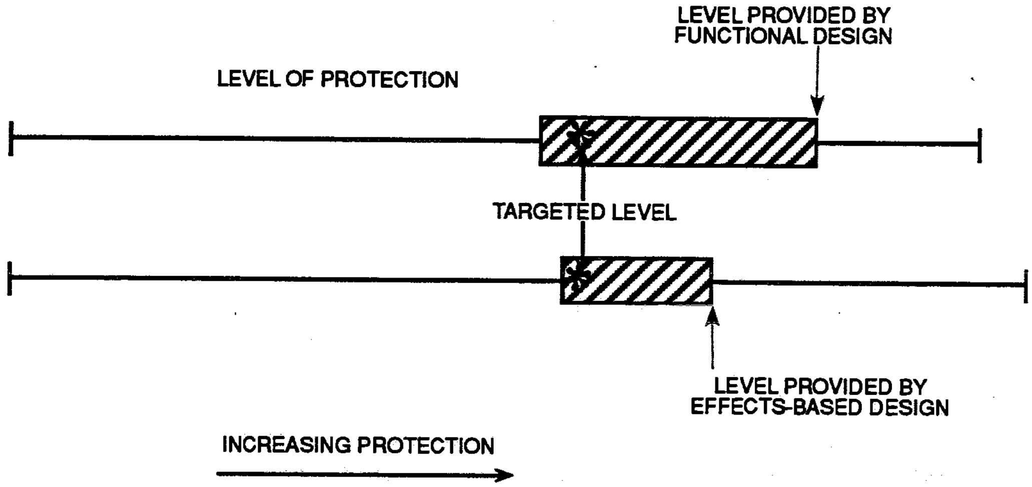


Figure 10.1 Conceptual representation of the level of protection provided by the FD and EBD

In each design there is a targeted or desired level of protection that is the same. In the functional design, conservative design features have been included that result in over-protection beyond the targeted level. This was done to insure that the target level of protection is met. Since a minimal amount of testing is required in the functional design scenario, this over-protection insurance is necessary.

In the EBD, more site-specific and/or sediment-specific data will be available. This additional data will allow a proponent to tailor the design such that it provides a level of protection within a range closer to the targeted level. Although the EBD level of protection may be less than the FD level of protection, it still must be equal to or greater than the targeted. This important concept will be incorporated into the CAAP procedure that is revised for EBD evaluation.

The product of the second step in the EBD process will be the data generated by the step one work plan, and the results of the CAAP. The details of the regulatory review of this product need to be determined in the next phase of standards development.

10.2 SEDIMENT CHARACTERIZATION FOR EFFECTS-BASED DESIGN

The Phased Methodology for Sediment Characterization, Phase 4, explains the approach to sediment characterization for effects- based design: specifically address exposure pathways (Figures 2.1, 2.2, 2.3, and 2.11) and incorporate testing/modeling to demonstrate that the environmental exposure does not exceed acceptable levels. The seven primary pathways and the basic techniques used to address these pathways in functional design are highlighted in Table 10.1.

Table 10.1. Functional Design Pathway Controls

Pathway	Functional Design Control Method
Water Column	Limiting modified elutriate test concentrations to applicable water quality criteria.
Surface Water	Limiting chemical concentrations and runoff.
Groundwater	A landfill liner (upland-lined) or limiting leachate concentrations to applicable water quality criteria.
Runoff	Cap, limiting chemical concentrations, and construction controls.
Airborne Emissions	Cap, limiting chemical concentrations, and construction controls.
Fugitive Dust	Cap, limiting chemical concentrations, and construction controls.
Biological Uptake	Cap and limiting chemical concentrations.

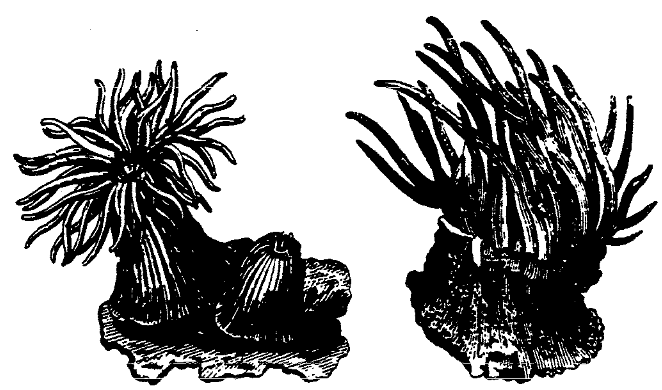
Modification or elimination of any of the central factors would require further analysis under effects-based design.

The tests which are currently considered appropriate for evaluating these pathways are presented in Chapter 4, and on Figure 9.1. In general, the tests required for initial characterization (Phase 2) and functional design (Phase 3) will be required for effects-based design. In addition, tests which address cap effectiveness, solute transport, runoff, and biological uptake may be required to address the specific characteristics of each individual project. The testing is summarized in Tables 10.2, 10.3, 10.4, and 10.5 by disposal method.

The effects-based design will also address projects where all but one component of a functional design is appropriate. In such a case, the project sponsor may only have to address modifications of the functional design which alter exposure pathways.

Table 10.2. Capped aquatic disposal effects-based design testing.

Test	Pathway	Results	Use/Interpretation
Chemical			
Bulk chemistry	All pathways	Numerical concentrations	Design accordingly
Standard elutriate	Surface water	Numerical concentrations	Design for appropriate dilution based on whether appropriate WQC are exceeded
Modified column leaching	Groundwater transport	Numerical concentrations	Design for attenuation/ dilution
Solute transport modeling (groundwater discharge zone)	Groundwater transport	Numerical concentrations	Design for attenuation/ dilution
Cap thickness	Diffusion to surface water Bioturbation	Thickness of cap	Design cap according to results
Biological			
PSDDA Biological Testing	Diffusion to surface water	Toxicity to marine organism	Modify cap or other design features according to results
Physical			
Dump Model	Surface water	Sediment loss	Sizing of disposal site
Discharge Model	Surface water	Sediment loss	Sizing of disposal site



SEA ANEMONES.

Table 10.3. Nearshore disposal effects-based design testing.

Test	Pathway	Results	Use/Interpretation
Chemical			
Modified elutriate	Surface water	Numerical concentrations (model of effluent)	Design for appropriate dilution based on whether appropriate WQC are exceeded (treatment for effluent)
Column leaching	Groundwater transport	Numerical concentrations	Design for attenuation/ dilution based on whether appropriate WQC are exceeded
Runoff	Surface water transport	Numerical concentrations	Design for cover as needed
Solute transport modeling (groundwater discharge zone)	Groundwater transport	Numerical concentrations	Design for attenuation/ dilution based on whether appropriate WQC are exceeded
Biological			
PSDDA Biological Testing	Diffusion to surface water	Toxicity to marine organisms	Modify cover/berm or other design features according to results
Terrestrial/wetlands plant uptake	Terrestrial uptake of contaminants	Uptake by plants	Modify cover/berm or other design features according to results

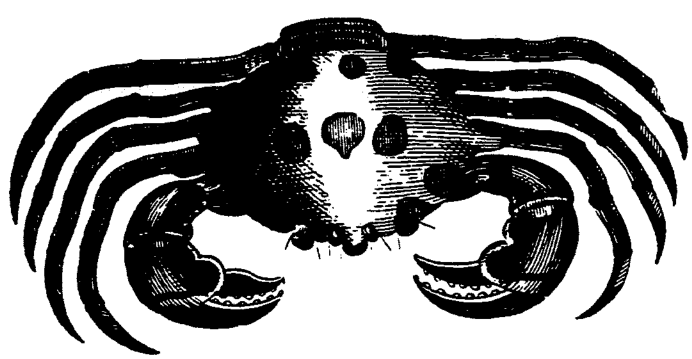


Table 10.4. Upland unlined disposal effects-based design testing.

Test	Pathway	Results	Use/Interpretation
Chemical			
Modified elutriate	Surface water	Numerical concentrations	Design for appropriate attenuation/dilution based on whether appropriate WQC are exceeded
Column leaching	Groundwater transport	Numerical concentrations	Design for attenuation/ dilution appropriate WQC are exceeded
Solute transport modeling	Groundwater transport	Numerical concentrations	Design for attenuation/ dilution appropriate WQC are exceeded
Runoff test	Surface water transport	Numerical concentrations	Determine appropriateness of cover
Biological			
Cyperus uptake bioassay	Biological uptake	Numerical concentrations	Determine appropriateness of cover based on evidence of biological waste

Table 10.5. Upland lined disposal effects-based design testing.

Test	Pathway	Results	Use/Interpretation
Chemical			
Runoff test	Surface water transport	Numerical concentrations	Determine appropriateness of cover
Biological			
Cyperus uptake bioassay	Biological uptake	Numerical concentrations	Determine appropriateness of cover based on evidence of biological uptake

Small Projects

11. SMALL PROJECT STANDARDS

The Technical Advisory Group pointed out that small projects, such as those conducted by marinas or smaller ports, should not require the same level of testing and design scrutiny as projects involving millions of cubic yards of sediment. Ecology agreed to develop separate standards for smaller projects. This chapter describes our proposal for these standards.

For small projects, the cost of testing, dredging, and disposal must be balanced against the environmental risks posed when a very small quantity of dredged material fails the open-water unconfined disposal criteria. Any framework for small project standards must assure environmentally acceptable long-term disposal without excessive delays in sampling, evaluation, and regulatory processes.

Dredged materials not suitable for open-water disposal under PSDDA guidelines will require confined disposal elsewhere. Section 10/404 requires extensive and time-consuming case-by-case evaluation of alternatives prior to disposal of non-hazardous dredged materials to a pre-approved upland site. Disposal may be directly authorized under state and local solid waste management regulations. Consequently, upland disposal to approved local lined and unlined landfills provides opportunity for small project exceptions meeting selected guidelines.

A minimum of sediment characterization will be required to assure that the materials are not hazardous waste under state regulations and are acceptable at the landfill, and that potential contaminant losses during dredging and transportation are acceptable. Where testing is required, data collected in accordance with PSDDA guidelines for open-water unconfined disposal is considered adequate for the necessary regulatory determinations; therefore, available PSDDA data should be submitted for regulatory reference. In cases where PSDDA tests are not conducted sediment will be characterized by testing for EP-toxicity (EP Tox), total halogenated hydrocarbons (HH) and Total Petroleum Hydrocarbons (TPH).

A number of qualifiers were developed to clarify what constitutes a small project:

Size. Intentional partitioning of a single large dredging project in order to avoid testing and/or the Standards is not acceptable. This requires defining the project in as large a context as possible. For example, portions of a single project dredged at different times or by different contractors would be described as the aggregate of volumes, and recurring maintenance dredging would be summed over the life of the permit.

Two categories of small projects are allowable:

- Less than 4,000 yd^3, and
- Greater than 4,000 yd^3, but less than 10,000 yd^3.

The 4,000 yd^3 limit is equivalent to the maximum dredged material sampling unit allowable under PSDDA guidelines for dredging projects located in areas where concern for occurrence of contaminants is ranked moderate to high. The 10,000 yd^3 volume is indicative of the size (order of magnitude) of smaller, isolated projects that will be dredged only one time.

Contaminant Sources. The dredged material must not be part of a directed or voluntary cleanup action involving designated dangerous (hazardous) wastes. A review of potential contaminant sources to the dredging area must show that dangerous wastes are not likely to be present.

Disposal. Disposal will be to approved upland sites authorized under WAC 173-304 (MFS). Each disposal project will require prior approval of the local Health jurisdiction and the landfill operator. Projects less than 4,000 yd^3 may be disposed to the lined landfills (WAC-173-304-460) without testing provided that the above qualifiers are met. Projects between 4,000 yd^3 and 10,000 yd^3 will require minimum testing to demonstrate compliance with state dangerous waste designation levels and specific landfill requirements for Total Petroleum Hydrocarbons (TPH). Disposal to unlined landfills may be permitted if testing shows that sediment chemical characteristics are less than 10% of state hazardous waste designation levels and 200 ppm TPH. It should be noted that organics may interfere with the standard TPH test; EPA Method 8015 is an alternative TPH analysis to be considered.

Dredging and transport. Main pathways for contaminant loss during dredging and transportation are suspended sediment losses to the water column during dredging, and dewatering drainage to the waterway during rehandling for truck haul. A clamshell dredge and barge will be used to minimize both sediment resuspension during dredging, and water content of the dredged mass to be disposed. Offloading will also be by clamshell either directly to sealed bed trucks or to an impervious temporary dockside rehandling area prior to truck haul. For rehandling within the same harbor area where the dredging occurs, dockside runoff may be permitted without additional chemical analysis. For rehandling with runoff at a different harbor, testing for PSDDA chemicals of concern will be required for agency determination of acceptability for drainage return to the harbor.

Testing requirements for small projects are summarized in Table 11.1.

Table 11.1. Small project testing requirements.

Volume	Upland Disposal Lined	Upland Disposal Unlined	Testing Required
Rehandling with drainage to dredge harbor			
<4,000 yd^3	X		None[1]
		X	TPH; PSDDA or EP-tox and HH
>4,000 yd^3 and <10,000 yd^3	X	X	TPH; PSDDA or EP-tox and HH
Rehandling with drainage to different harbor			
<4,000 yd^3	X		PSDDA
<4,000 yd^3		X	TPH and PSDDA
>4,000 yd^3 and <10,000 yd^3	X	X	TPH and PSDDA

[1] Although no tests have been identified, approval of local health jurisdiction and landfill operators is still required. These entities may require testing before allowing disposal.

12. COST COMPARISONS

Cost comparisons are a necessary component of the confined disposal standards. Cost comparisons are one of the criteria that may be used to rank alternatives. Thus, in this chapter we present a standardized framework for examining disposal costs. Then we use that framework to present preliminary cost estimates for each of the five functional designs (CAD, nearshore, upland mixed, upland monofill lined, and upland monofill unlined).

This chapter is separated into two main parts:

Section 12.1, **Cost Determination Framework**, presents a framework for determining the cost of confined disposal. This framework can be used by dredge proponents and regulators. It can also be used to compare costs between disposal environments, or costs for different designs within a disposal environment.

Section 12.2, **Functional Design**, presents cost estimates for the five functional designs (CAD, nearshore, upland mixed, upland monofill lined, and upland monofill unlined). The line items the costs are based on and the assumptions behind the costs are also included.

12.1 COST DETERMINATION FRAMEWORK

12.1.1 Confined Aquatic Disposal (CAD)

The cost framework for CAD alternatives contains six major categories. Those categories are:

- Site Design and Permitting
- Dredge Site Construction
- Dredge Operation
- Transport
- Material Placement
- Monitoring.

These six major categories contain the subcategories, elements, and the line items for the cost report. (See Table 12.1)

Site Design and Permitting

Engineering Design. The category, Site Design, contains four sub-categories:

- Engineering Design
- Permit

Confined Aquatic Disposal

Table 12.1 Confined Aquatic Disposal Cost Framework

CONFINED AQUATIC DISPOSAL	year 0	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	year 11	year 12	year 13	year 14	year 15	PRESENT VALUES
Site Design and Permitting																	
A. Engineering Design																	
B. Site Selection																	
1. Surveys																	
2. Other Site Characterization																	
C. Permitting																	
D. Environmental Documentation																	
Disposal Facility Construction																	
A. Site Preparation																	
1. Positioning Control																	
2. Equipment Mobilization																	
3. Survey(s)																	
B. Berm Construction																	
1. Construction Equipment																	
2. Construction Materials																	
3. Construction Labor																	
4. Energy (fuel)																	
Dredge Operation																	
A. Contaminated																	
1. Labor																	
2. Equipment																	
3. Other																	
a. Surveys																	
b. Water Quality																	
B. Cap																	
1. Labor																	
2. Equipment																	
3. Other Equipment																	
a. Surveys																	
b. Water Quality																	
Transport																	
A. Equipment																	
1. Tug (lease)																	
2. Barge																	
3. Other Equipment																	
Material Placement (Acquisition)																	
A. Contaminated																	
1. Downpipe/diffuser																	
2. Additional Labor																	
B. Cap																	
1. Material Acquisition																	
2. Barge to Release Site																	
Monitoring																	
A. Baseline																	
B. Short Term (During Dredging)																	
1. Equipment																	
2. Labor																	
C. Long Term (Post Disposal)																	
1. Equipment																	
2. Labor																	
ANNUAL WORTH																	

- Site Selection
- Environmental Documentation.

The first category, Engineering Design, has no further sub-divisions on the cost summary sheet.

Site Selection. The sub-category, Site Selection, should include all costs incurred in the choice of site for the disposal activity. Typical costs would include:

- Land and Hydrographic Surveys
- Hydro-Geologic Investigations
- Current Monitoring
- Geotechnical Investigations.

The cost of surveys and investigations in this section should relate directly to collection of information to categorize and compare sites.

Permits. The sub-category, Permits, should contain the estimated costs for all necessary permits.

Environmental Documentation. The subcategory, Environmental Documentation, includes the cost of any environmental evaluations that may be required (may include Environmental Impact Assessment or Environmental Impact Statements).

Disposal Facility Construction

Site Preparation. The Site Preparation component of Disposal Facility Construction contains three major elements:

- Equipment Mobilization
- Positioning Control
- Survey(s).

Equipment Mobilization. The Equipment Mobilization element should include costs of acquisition or plant ownership rental rates of all equipment used for preparing the dredge site. These costs should include purchase prices or leases. If equipment is purchased, the purchase price should be entered in year one, even if the equipment is financed over a longer period of time. If the equipment is to be resold, the expected salvage value of that equipment should be entered in the year the sale is expected. (If resale is expected in the same year as the purchase, the cost entered should be the purchase price minus the anticipated salvage value.) If equipment is leased, the lease cost should appear in the column, year 1. (For any multi-year operations the yearly lease price should be entered in the appropriate column.) The Equipment Mobilization cost should also include any cost incurred in delivery of dredging equipment to the site such as towing cost, trip insurance, taxes.

Positioning Control. The Positioning Control element should include the costs of setting up survey layout control, including offsite shore stations for the electronic positioning of disposal operations. It should include all costs associated with site control and procurement of shore station locations.

Survey. The Survey element should include all work necessary to complete land and hydrographic surveys for predredge and predisposal baseline conditions at the dredge and disposal sites.

Berm Construction. The sub-category, Berm Construction, includes the cost of building the berm which would contain the lateral movement of the contaminated dredged material. The elements of the sub-category are:

- Construction equipment
- Acquisition cost to purchase construction materials
- Construction costs to erect confinement dikes.
- Fuel (delivery costs)

Cost will include consideration for engineering and long term protection from erosion.

Dredge Operation

Contaminated. The sub-category, Contaminated, includes the dredge operations that are directly associated with the onsite excavation of contaminated material. The cost elements are as follows:

- Labor
- Equipment
- Other O&M.

The labor and equipment elements are straightforward. They include all labor costs and equipment operations costs directly associated with removing contaminated material. For hydraulic dredging operations, the costs would reflect excavation and transport by pipeline to the disposal site or to a booster pump facility. For mechanical dredging operations, the costs would reflect excavation and placement of materials into a haul barge. The equipment element would include costs such as equipment maintenance and fuel.

The element, Other O&M, may be used to include any other costs incurred in operation and management of the dredged material removal activity. In this element, there are two items that are specified that should be covered. Those two items are surveys and water quality. These two items are the progress and post-dredge surveys for documenting material removal and water quality monitoring. They must be conducted while dredged material is being removed from the dredge site.

Cap. The sub-category, Cap, should include all elements associated with dredging clean cover materials for placement over the contaminated dredge material after its placement at the disposal site. The elements in this sub-category are:

- Labor
- Equipment
- Other O&M.

For hydraulic dredging operations, the costs would reflect excavation and transport by pipeline to the disposal site or to a booster pump facility. For mechanical dredging operations, the costs would reflect excavation and placement of materials into a haul barge. The equipment element would include costs such as equipment maintenance and fuel.

The element, Other O&M, may be used to include any other costs incurred in operation and management of the cap material excavation activity. In this element, there are two items that should be covered: surveys, and water quality. These two items are the progress and post-dredge surveys for documenting material removal and water quality monitoring. They must be conducted while cap material is being removed from the dredge site and into the disposal site.

Transport

Equipment. The category, Transport, has two sub-categories: Equipment and Labor. The sub-category, Equipment, has three options:

- Mechanical Dredge, which would include tug lease and barge lease
- Hydraulic Dredge, which would include booster pump or pumpout facility costs
- Other.

If the equipment is leased, the yearly lease value will be entered in the year-one column (this assumes a project of one year). If the equipment is purchased, the purchase value less the expected salvage value should be entered in the year-one column (again assuming a project of one year's duration). If the equipment cost is based on an ownership plant rental rate, consideration for date of purchase, equipment life, and salvage value will be incorporated in the yearly rate.

The element, Labor, should reflect all costs of labor for the transport of the dredged material.

Material Placement

This category is closely related to the transport of the dredged material. It is separate from transport costs, however, in that it covers the identifiable costs of actual placement of both the dredged material and the cap material.

Contaminated. Identifiable costs applicable to certain projects, but not previously included in the cost estimates are down pipe (TREMI) and/or use of a diffuser that is specific to controlling contaminated sediment.

Cap. In confined aquatic alternatives, one identifiable cost not yet included in the estimate is the offsite acquisition of material for use in the final cover. Two elements in this sub-category are material acquisition or purchase price and the transport cost to haul the cap material to the disposal site. Construction cost will include equipment and labor cost to place and spread cover, and will include consideration for engineering and long-term cap protection from erosion.

Monitoring

Baseline. This sub-category includes elements for Equipment and Labor. The other sub-categories, Short-Term and Long-Term, will have the same elements, Equipment and Labor.

The three sub-categories (Baseline, Short-Term, and Long-Term) differ from each other in the following ways. Baseline monitoring will include those costs associated with establishing the conditions at both the dredge and the disposal sites before dredging or dredge deposition begin. Short-Term Monitoring will include the monitoring activities that take place during dredging and deposition of the dredged materials. Long-Term Monitoring will include the costs associated with monitoring the site after the dredging has been completed and the cap placed on the deposited dredge material at the disposal site.

12.1.2 Nearshore

The cost framework for nearshore alternatives also contains six major categories. Those categories are:

- Site Design and Permitting
- Dredge Facility Construction
- Dredge Operation
- Transport
- Material Placement
- Monitoring.

These six major categories contain the subcategories, elements and the line items for the cost report (see Table 12.2).

Site Design and Permitting

Engineering Design. The category, site design, contains four sub-categories; Engineering Design, Permitting, Site Selection, and EIS. The first category, Engineering Design has no further sub-divisions on the cost summary sheet.

Nearshore Disposal

Table 12.2 Nearshore Cost Framework

NEARSHORE EXAMPLE	year 0	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	year 11	year 12	year 13	year 14	year 15	PRESENT VALUES
Site Design and Permitting																	
A. Engineering Design																	
B. Site Selection																	
1. Surveys																	
2. Other Site Characterization																	
C. Permitting																	
D. EIS																	
Disposal Site Construction																	
A. Site Preparation																	
1. Equipment Mobilization																	
2. Survey(s)																	
B. Dike Construction																	
1. Construction Equipment																	
2. Construction Materials																	
3. Construction Labor																	
4. Other																	
Dredge Operation																	
A. Contaminated																	
1. Labor																	
2. Equipment																	
3. Other O&M																	
a. Surveys																	
b. Water Quality																	
B. Cap																	
1. Labor																	
2. Equipment																	
3. Other																	
a. Surveys																	
b. Water Quality																	
Transport																	
A. Equipment																	
1. Mechanical Dredge																	
2. Hydraulic Dredge																	
3. Other Equipment																	
B. Labor																	
Material Placement (Acquisition)																	
A. Contaminated																	
1. Equipment																	
2. Labor																	
B. Cap																	
1. Material Acquisition																	
2. Barge to Release Site																	
Monitoring																	
A. Baseline																	

Table 12.2 Nearshore Cost Framework

NEARSHORE EXAMPLE	year 0	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	year 11	year 12	year 13	year 14	year 15	PRESENT VALUES
1. Equipment																	
2. Labor																	
B. Short Term (During Dredging)																	
1. Equipment																	
2. Labor																	
C. Long Term (Post Disposal)																	
1. Equipment																	
2. Labor																	
ANNUAL WORTH																	

The cost framework for nearshore disposal alternatives uses the same Site Design, Permitting, and Site Selection as that for CAD disposal. See Section 12.1.1.

EIS. The sub-category, EIS, includes the cost of Environmental Impact Assessments or Environmental Impact Statements. The cost of surveys and investigations in this section should relate directly to collection of information to categorize and compare sites.

Disposal Site Construction

Site Preparation. Unlike CAD disposal, nearshore disposal costs do not include a Positioning Control element. Instead, the Site Preparation component of Disposal Site Construction contains two major elements:

- Equipment Mobilization
- Survey(s).

However, nearshore Equipment Mobilization and Survey cost elements are the same as those presented for CAD in Section 12.1.1.

Dredge Operation and Transport elements for nearshore disposal are also the same as those presented for CAD in Section 12.1.1.

Material Placement

Contaminated. For nearshore material placement, the sub-category, Contaminated, should cover the cost of the actual placement of the contaminated dredged materials at the disposal site. The cost elements are as follows:

- Labor
- Equipment
- Other O&M.

Cap. In nearshore alternatives, one identifiable cost not previously included is the offsite acquisition of material for use in the final cover. Two elements in this sub-category are material acquisition or purchase price and the transport cost to haul the cap material to the disposal site. Construction cost will include equipment and labor cost to place and spread cover, and will include consideration for engineering and long-term cap protection from erosion.

Monitoring

Baseline. The sub-category, Baseline Monitoring, includes elements for equipment and labor. The other sub-categories, Short-Term, and Long-Term, will have the same elements, equipment and labor.

The three sub-categories (Baseline, Short-Term, and Long-Term) differ from each other in the following ways. Baseline monitoring will include those costs associated with establishing the conditions at both the dredge and the disposal sites before dredging or dredge deposition begin. Short-Term Monitoring will include the monitoring activities that take place during dredging and deposition of the dredged material. Long-Term Monitoring will include the costs associated with monitoring the site after the dredging and cap placement at the disposal site have been completed.

12.1.3 Upland Disposal

The cost framework for upland alternatives contains seven major categories, those categories are:

- Site Design and Permitting
- Dredge Facility Construction
- Disposal Site Construction
- Dredge Operation
- Transport
- Material Placement
- Monitoring.

These seven major categories contain the subcategories and the line items for the cost report (see Table 12.3).

Site Design and Permitting

The cost framework for upland disposal uses the same Site Design, Permitting, and Site Selection elements as presented for CAD in Section 12.1.1.

Facility Construction

Dredge Facility - Site Preparation. The Site Preparation component of Dredge Facility Construction contains two major elements:

- Equipment Mobilization
- Survey(s).

Like nearshore disposal, the Equipment Mobilization and Survey elements are the same as those presented for CAD in Section 12.1.1.

Dredge Facility - Site Construction. The Site Construction component of Dredge Facility Construction contains all costs of construction associated with the dredge facility and any transfer facility required to load the dredge material for overland transport.

Upland Disposal

Table 12.3 Upland Cost Framework

UPLAND EXAMPLE	year 0	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	year 11	year 12	year 13	year 14	year 15	PRESENT VALUES
Site Design and Permitting																	
A. Dredge Site																	
1. Engineering Design																	
2. Site Selection																	
a. Surveys																	
b. Other Site Characterization																	
3. Permits																	
4. EIS																	
B. Disposal Site																	
1. Engineering Design																	
2. Permit																	
C. Site Selection																	
1. Surveys																	
2. Other Site Characterization																	
D. EIS																	
Facility Construction																	
A. Dredge Facility																	
1. Site Preparation																	
2. Equipment Mobilization/Demobilization																	
B. Site Construction																	
1. Construction Equipment																	
2. Construction Materials																	
3. Construction Labor																	
4. Other																	
Disposal Site Construction																	
A. Bottom Liner																	
1. Labor																	
2. Equipment																	
3. Materials																	
4. Other																	
B. Leachate Control System																	
1. Labor																	
2. Equipment																	
3. Materials																	
4. Other																	
C. Gas Management System																	
1. Labor																	
2. Equipment																	
3. Materials																	
4. Other																	
D. Surface Management System																	
1. Labor																	
2. Equipment																	
3. Materials																	
4. Other																	

Table 12.3 Upland Cost Framework

UPLAND EXAMPLE	year 0	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	year 11	year 12	year 13	year 14	year 15	PRESENT VALUES
E. Final Cover System																	
1. Labor																	
2. Equipment																	
3. Materials																	
4. Other																	
F. Top Soil																	
1. Labor																	
2. Equipment																	
3. Materials																	
4. Other																	
G. Drainage Layer																	
1. Labor																	
2. Equipment																	
3. Materials																	
4. Other																	
H. De-watering System																	
1. Labor																	
2. Equipment																	
3. Materials																	
4. Other																	
I. Berms and Dikes																	
1. Labor																	
2. Equipment																	
3. Materials																	
4. Other																	
Operations																	
A. Dredge: Material Removal																	
1. Testing																	
2. Labor																	
3. Equipment																	
4. Other																	
B. Disposal Site: Leachate Disposal																	
1. Tanker Haul																	
2. Disposal Costs																	
3. Other O&M																	
C. Material Handling																	
1. Equipment																	
2. Labor																	
3. Other O&M																	

Table 12.3 Upland Cost Framework

UPLAND EXAMPLE	year 0	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	year 11	year 12	year 13	year 14	year 15	PRESENT VALUES
Transport																	
A. Tug & Barge (lease)																	
B. Pipeline																	
C. Overland Equipment																	
1. Vehicles (truck or rail)																	
2. Liners (truck or rail)																	
Material Placement (Acquisition)																	
A. Dredged Material																	
B. Final Cover																	
Monitoring																	
A. Baseline																	
B. Short Term (During Dredging)																	
1. Equipment																	
2. Labor																	
C. Long Term (Post Disposal)																	
1. Equipment																	
2. Labor																	
ANNUAL WORTH																	
												Present Value Total					

Disposal Site Construction. The sub-category, Disposal Site Construction, should contain all of the costs associated with construction of the upland disposal facility. There are nine elements in this sub-category:

- Bottom Liner
- Leachate Control System
- Gas Management System
- Surface Management System
- Final Cover System
- Top Soil
- Drainage Layer
- De-watering System
- Berms and Dikes.

The cost components of these elements are Labor, Equipment, Materials, and Other. Each of these elements will be accounted for separately.

Operation

Dredge Material Removal. The sub-category, Dredge Material Removal, should cover the costs of operations directly associated with the removal of dredge material at the dredge site. The cost elements in this sub-category are:

- Testing
- Labor
- Equipment
- Other.

The elements Labor, Equipment, and Other, should include dredge removal operations other than testing. Testing operations are accounted for in its own element in this sub-category. The element, other, should include surveys and water quality.

Disposal Site: Leachate Disposal. This sub-category should reflect the cost of the disposal of leachate collected at the disposal site. The elements of this sub-category are:

- Tanker Haul
- Disposal Costs
- Other O&M.

Disposal Site: Material Handling. The sub-category, Material Handling, should represent the costs of handling the dredged material at the upland disposal site. The cost elements in this sub-category are equipment, labor, and other O&M.

Transport

The transport category has three major sub-categories: Mechanical, Hydraulic, and Other. The first two, Mechanical and Hydraulic, cover the cost of the transport of dredged material from the dredging site to the shore by tug and haul barge (Mechanical) or pipeline (Hydraulic).

The third sub-category, Other, includes land transportation to the disposal site and should be used to present truck or rail costs. The sub-element, Liners, should deal with the cost of lining either truck beds or rail cars to prevent seepage of the dredged material during transport.

Material Placement

This category is closely related to the transport of the dredged material. It is separate from transport costs, however, in that it covers any identifiable costs of material conditioning before disposal placement. This could include dewatering, temporary site berming, or other activity not specified above.

Monitoring

Baseline. The sub-category, Baseline Monitoring, includes elements for equipment and labor. The other sub-categories, Short-Term, and Long-Term, will have the same elements, equipment and labor.

The three sub-categories (Baseline, Short-Term, and Long-Term) differ from each other in the following ways. Baseline monitoring will include those costs associated with establishing the conditions at both the dredge and the disposal sites before dredging or dredge deposition begin. Short Term Monitoring will include the monitoring activities that take place during dredging and deposition of the dredge materials. Long Term Monitoring will include the costs associated with monitoring the site after the dredging has been completed and the cap placed on the dredge material deposited at the disposal site.

Annual Worth and Present Value

For purposes of comparing project alternatives Annual Worth and Present Values will be calculated. The present value of each line of the spread sheet will be calculated and a total present value will be summed. In addition, the annual worth of the costs will be calculated and reported as dollars per cubic yard of dredge material.

Projects with an anticipated active life of one year have actual lives of several years. These projects have costs in year 0, resulting from planning and preparation activities. There are also several years of post-operation monitoring activities.

Multi-year projects will have greater active lives and cost entries on the spread sheet will be reported for operational activities over the active years.

12.2 COSTS FOR RECOMMENDED STANDARDS FOR DISPOSAL OPTIONS

This section compares the cost of disposing of dredged sediments in the three disposal environments: CAD, nearshore, and upland. These costs are estimated at a more general level than costs for specific projects. Project-specific costs would be estimated at the level of detail presented in Section 12.1. Without a specific dredge site and disposal site, a number of assumptions are necessary to complete the spreadsheet forms in Section 12.1. The following assumptions were made for the general cost estimates presented in this section:

- Contaminated material including overdepth to be dredged equals 200,000 yd^3
- Contaminated material is a sandy silt sediment matrix with some organics
- All projects are independent, one-year, one-user scenarios
- The total distance between the contaminated dredging site and the disposal site is approximately 2 miles, except for all upland sites where 30 additional miles of overland transport are required.

Recent case history information from the Pacific Northwest was used to develop the cost estimates. All costs for dredging, transport, disposal site design and construction, and monitoring were estimated. The total cost of all alternatives and the recommended functional design for each disposal environment is summarized in this chapter. Detailed cost information is presented in Appendix G.

12.2.1 Confined Aquatic Disposal (CAD)

The cost estimates for CAD are summarized in Table 12.4. The following assumptions were made about the CAD area for the cost estimates. The area of disposal was estimated as a flat circular area with a 4% slope (greater than 3%). A 2-foot depth of dredged sediments deposition would cover approximately 62 acres. Berm development to contain contamination during disposal and subsequent capping would result in approximately a 70-acre limit. Without a berm, the material would tend to elongate, creating an elliptical footprint (surface space) in the down slope direction. The estimated area without a berm was established at 78 acres.

Table 12.4. Estimated cost for confined aquatic disposal alternatives.

		Alternative			
		1	2	3	Recommended
Site Design and Permitting (for dredging and disposal)		$ 850,000	$ 850,000	$ 850,000	$ 850,000
Dredge Site Construction					
Equipment Mobilization		150,000	150,000	400,000	150,000
Positioning		100,000	100,000	100,000	100,000
Predredge Survey		30,000	35,000	35,000	30,000
Berm Construction (assuming berms are needed)		450,000			450,000
	Subtotal	$ 730,000	$ 285,000	$ 535,000	$ 730,000
Dredge Operations					
Contaminated		$ 600,000	$ 600,000	$ 550,000	$ 600,000
Cap		837,000	1,263,000	863,000	837,000
	Subtotal	$1,437,000	$1,863,000	$1,413,000	$1,437,000
Transport					
Contaminated		$ 140,000	$ 140,000	$ 250,000	$ 140,000
Cap		325,000	719,000	719,000	325,000
	Subtotal	$ 465,000	$ 859,000	$ 969,000	$ 465,000
Material Placement					
Slow Release	Subtotal	$ 20,000	$ 10,000	$ 15,000	$ 20,000
Monitoring	Subtotal	$ 225,000	$ 500,000	$1,000,000	$ 500,000
TOTAL COST OF RECOMMENDED ALTERNATIVE					$4,002,000

12.2.2 Nearshore

Nearshore cost estimates assumed 200,000 yd^3 of dredged material. Nearshore costs are summarized in Table 12.5. Details of the cost estimates are presented in Appendix G. The recommended standard includes features from more than one alternative; therefore, the subtotal and total cost estimates for the recommended standards will vary from the individual alternatives.

Table 12.5. Estimated cost for nearshore alternatives.

		Alternative			
		1	2	3	Recommended
Site Design and Permitting (for dredging and disposal)		$ 810,000	$ 810,000	$ 810,000	$ 810,000
Dredging					
Equipment mobilization		400,000	400,000	150,000	400,000
Dredge positioning		100,000	100,000	100,000	50,000
Dredging contaminated		605,000	550,000	600,000	550,000
Dredging cap		375,000	305,000	393,000	375,000
	Subtotal	$1,480,000	$1,355,000	$1,243,000	$1,375,000
Transport					
Contaminated transport		$ 200,000	$ 200,000	$ 140,000	$ 200,000
Cap transport		250,000	203,000	153,000	250,000
Rehandling				1,331,000	
	Subtotal	$ 450,000	$ 403,000	$1,624,000	$ 450,000
Disposal Facility					
Site survey		$ 35,000	$ 35,000	$ 35,000	$ 20,000
Dike Construction		1,166,000	556,000	433,000	546,000
Liner		1,307,000			
	Subtotal	$2,507,000	$ 591,000	$ 468,000	$ 566,000
Monitoring (Groundwater/15 years)		$ 161,300	$ 245,100	$ 347,600	$ 245,100
TOTAL COST OF RECOMMENDED ALTERNATIVE					$3,446,100

12.2.3 Upland Mixed

Estimated costs for upland mixed disposal are summarized in Table 12.6. To estimate the disposal facility cost for the upland mixed site, we used the tipping fee for 200,000 yd^3 at a typical municipal landfill. Costs associated with dewatering are significantly higher for the upland mixed site than for the upland mono sites because sediments must be dewatered at a separate facility before they go to the upland mixed site. The disposal facility cost estimates are based on tipping fees.

Table 12.6. Estimated cost of upland mixed disposal alternatives.

	Alternative			
	1	2	3	Recommended
Site Design and Permitting for Dredging	$ 200,000	$ 200,000	$ 200,000	$ 200,000
Site Design and Permitting for Upland Site	1,500,000	1,500,000	1,500,000	1,500,000
Site Design and Permitting for Temp. Dewater Site	200,000	200,000	200,000	200,000
Subtotal	$ 1,900,000	$ 1,900,000	$ 1,900,000	$ 1,900,000
Dredging				
Equipment Mobilization	$ 150,000	$ 150,000	$ 400,000	$ 150,000
Predredge Survey	35,000	35,000	35,000	35,000
Contaminated Dredging	600,000	600,000	550,000	600,000
Subtotal	$ 785,000	$ 785,000	$ 985,000	$ 785,000
Transport				
Rehandling/Dewatering Site Survey	$ 45,000	$ 45,000	$ 45,000	$ 45,000
Dewatering Site Construction				
Dike Construction	155,000	152,000	591,000	145,000
Liner	1,815,000		1,815,000	1,815,000
Contaminated	140,000	140,000	200,000	140,000
Offloading	520,000	520,000		520,000
Haul to Dewatering Site	134,000	232,000		134,000
Dewatering Operations	42,000	42,000	42,000	42,000
Transport from Dewatering to Upland Site	1,300,000	1,300,000	1,300,000	1,300,000
Subtotal	$ 4,151,000	$ 2,431,000	$ 3,993,000	$ 4,141,000
Disposal Facility	$ 11,422	$ 1,300		$11,422,000
Monitoring (Groundwater/15 years)	$ 177,000	$ 185,400		$ 177,000
TOTAL COST OF RECOMMENDED ALTERNATIVE				$18,425,000

12.2.4 Upland Mono - Lined

Cost estimates for upland lined, monofill disposal are summarized in Table 12.7. The recommended standard includes features from more than one alternative; therefore, the subtotal and total cost estimates for the recommended standards will vary from the individual alternatives.

The primary overall cost assumptions for upland monofill disposal facility design were these:

- The cost is for a one-acre site
- Natural, high-permeability and chemically compatible low-permeability materials are available near the site
- The geomembrane is smooth high-density polyethylene (HDPE)
- Quantities are measured based on a horizontally projected area
- The cost of a FAILED DESIGN was not considered.

A few details of the cost analysis are listed below:

- The same price per cubic yard was used for all low-permeability natural material. However, there is an underlying assumption that chemically compatible materials with these permeabilities are available near the site. In practice, stricter limits on hydraulic conductivity will make acceptable natural materials more difficult to find.
- Two different qualities of gravel was used in the designs. Higher quality more expensive gravel was used when maximum allowable heads in the gravel were low.
- Cost of geomembrane varies with thickness.

To compare recommended functional designs across disposal environments, we applied the underlying assumption that all sites would receive 200,000 yd^3 of material. Therefore, the detailed, one-acre site design costs in Appendix G were converted to a 10.3-acre site for this section. The conversion is based on 12-foot sediment depth in the disposal site.

Table 12.7. Estimated cost for upland monofill lined disposal alternatives.

	Alternative 1	2	3	Recommended
Site Design and Permitting for Dredging	$ 200,000	$ 200,000	$ 200,000	$ 200,000
Site Design and Permitting for Upland Site	1,500,000	1,500,000	1,500,000	1,500,000
Site Design and Permitting for Temp. Dewatering Site			200,000	
Subtotal	$1,700,000	$1,700,000	$1,900,000	$1,700,000
Dredging				
Equipment Mobilization	$ 150,000	$ 150,000	$ 400,000	$ 150,000
Predredge Survey	70,000	100,000	35,000	70,000
Contaminated Dredging	600,000	600,000	550,000	600,000
Subtotal	$ 820,000	$ 850,000	$ 985,000	$ 820,000
Transport				
Rehandling Area Survey	$ 10,000	$ 10,000	$ 45,000	$ 10,000
Dewatering Site Construction				
Dike Construction			591,000	
Liner			1,815,000	
Contaminated	140,000	140,000	200,000	140,000
Offloading to Land Haul Equipment	520,000	434,000		500,000
Truck Haul	1,300,000	1,300,000		1,300,000
Dewatering Operations			42,000	
Transport from Dewatering to Upland Site			1,300,000	
Subtotal	$1,970,000	$1,884,000	$3,993,000	$1,940,000
Disposal Facility				
Option 1	$ 762,700	$ 611,500	$ 501,800	$ 611,500
Option 2	959,600	818,400	560,800	
Monitoring (Groundwater/15 years)	$ 215,500	$ 221,000		$ 215,500
TOTAL COST OF RECOMMENDED ALTERNATIVE				$5,297,000

12.2.5 Upland Mono - Unlined

Cost estimates for upland monofill unlined disposal are summarized in Table 12.8. The recommended standard includes features from more than one alternative; therefore, the subtotal and total cost estimates for the recommended standards will vary from the individual alternatives.

The primary cost assumptions and details of the cost analysis listed for upland lined monofill sites (Section 12.2.4) were used for upland unlined sites. In order to compare recommended functional designs across disposal environments, we applied the underlying assumption that all sites would receive 200,000 yd^3 of material. Therefore, the detailed, one-acre site design costs in Appendix G were converted to a 10.3-acre site for this section. The conversion is based on 12-foot sediment depth in the disposal site.

Table 12.8. Estimated cost for upland monofill unlined disposal alternatives.

	Alternative			
	1	2	3	Recommended
Site Design and Permitting for Dredging	$ 200,000	$ 200,000	$ 200,000	$ 200,000
Site Design and Permitting for Upland Site	1,500,000	1,500,000	1,500,000	1,500,000
Site Design and Permitting for Temp. Dewatering Site			200,000	
Subtotal	$1,700,000	$1,700,000	$1,900,000	$1,700,000
Dredging				
Equipment Mobilization	$ 150,000	$ 150,000	$ 400,000	$ 150,000
Predredge Survey	70,000	100,000	35,000	70,000
Contaminated Dredging	600,000	600,000	550,000	600,000
Subtotal	$ 820,000	$ 850,000	$ 985,000	$ 820,000
Transport				
Rehandling Area Survey	$ 10,000	$ 10,000	$ 45,000	$ 10,000
Dewatering Site Construction				
Dike Construction			591,000	
Liner			1,815,000	
Contaminated	140,000	140,000	200,000	140,000
Offloading to Land Haul Equipment	520,000	434,000		500,000
Truck Haul	1,300,000	1,300,000		1,300,000
Dewatering Operations			42,000	
Transport from Dewatering to Upland Site			1,300,000	
Subtotal	$1,970,000	$1,884,000	$3,993,000	$1,940,000
Disposal Facility				
Option 1	$ 396,800	$ 305,500	$ 279,600	$ 305,500
Option 2	460,800	369,500	269,600	
Monitoring (Groundwater/15 years)	$ 171,000	$ 179,100		$ 179,100
TOTAL COST OF RECOMMENDED ALTERNATIVE				$4,954,600

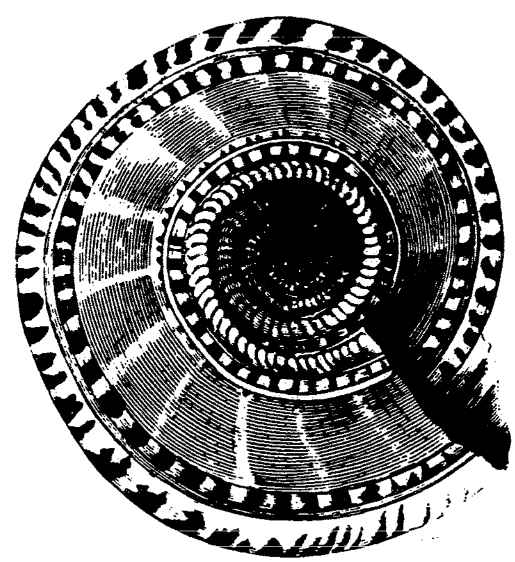
CONCLUSION

The costs presented in Section 12.2 are useful as general comparisons of the generic functional designs in each disposal environment: CAD, nearshore, and upland. However, there are limitations to these comparisons that need to be recognized. One limitation is that these costs are based on many assumptions. Site-specific projects may vary in several of those assumptions. To the extent possible, all of the alternatives were based on the same set of assumptions, but assuming exactly the same conditions for each disposal environment was impossible.

Another source of limitation is the format of the cost totals themselves. These costs were estimated and compiled for single-user, one-year projects. Even though the projects have a life of one year, the costs cover a planning period before the active disposal period. Costs also continue after the active life during a post-disposal monitoring period. For accurate comparisons the cost should be attenuated over the appropriate number of years. Since these cost estimates were generated by different sources and in a very general manner, such attenuation was impossible.

This last limitation is adjusted somewhat because Design, Permitting, and Monitoring costs (costs spread over a number of years) are similar in each disposal environment. These costs also occur over the same period for all disposal environments.

The costs presented in this section, although they have limits, permit rough comparisons among the alternatives considered within each disposal environment. These costs also allow comparisons among the recommended functional designs for the three disposal environments.



Technical Studies Review of

Puget Sound Confined Disposal Sites

13. TECHNICAL STUDIES

13.1 INTRODUCTION

Studies of existing disposal sites in the Puget Sound region were reviewed to provide information on several aspects of standards development:

- Project design elements that are or are not working properly were indicated.
- Design features to be adopted as standards were identified.
- Existing methods and site designs were compared to the recommended standards.

Information from five disposal sites located in the different disposal environments was analyzed. Investigations included field studies and reviews of existing data. Information on sediment characterization, site design, monitoring data, and possible environmental impacts are reported for each disposal site. The results are then compared to the recommended standards for confined disposal of contaminated sediments.

In Section 13.2, **CAD**, disposal sites located at One Tree Island Marina and the Duwamish Waterway are examined. Results of recent field sampling are reported and analyzed.

In Section 13.3, **Nearshore**, existing data collected at the Terminal 91 short fill site are summarized.

In Section 13.4, **Upland**, monitoring data from two mixed upland sites, the Olympic View Sanitary Landfill and Coal Creek (Newcastle) Demolition Landfill are reviewed. Currently monitoring programs at the landfills are designed to assess impacts of the landfill, not the specific effects of dredged material disposal. Therefore, available data pertaining to upland sediment disposal are limited and the review primarily identified data needs and requirements for future monitoring.

13.2 CAD

13.2.1 Duwamish CAD Site

The U.S. Army Corps of Engineers started the Duwamish River CAD site in March 1984 as a demonstration project on the feasibility of CAD technology. The Corps dredged a shoaling area of the Duwamish River that was contaminated with metals and PCB's and disposed of the material in a depression in the West Waterway and covered the contaminated sediment with clean sand from an upstream settling basin. The cap material varied from 1 to more than 3 ft thick. The location of the Duwamish River CAD site is shown in Figure 13.1.

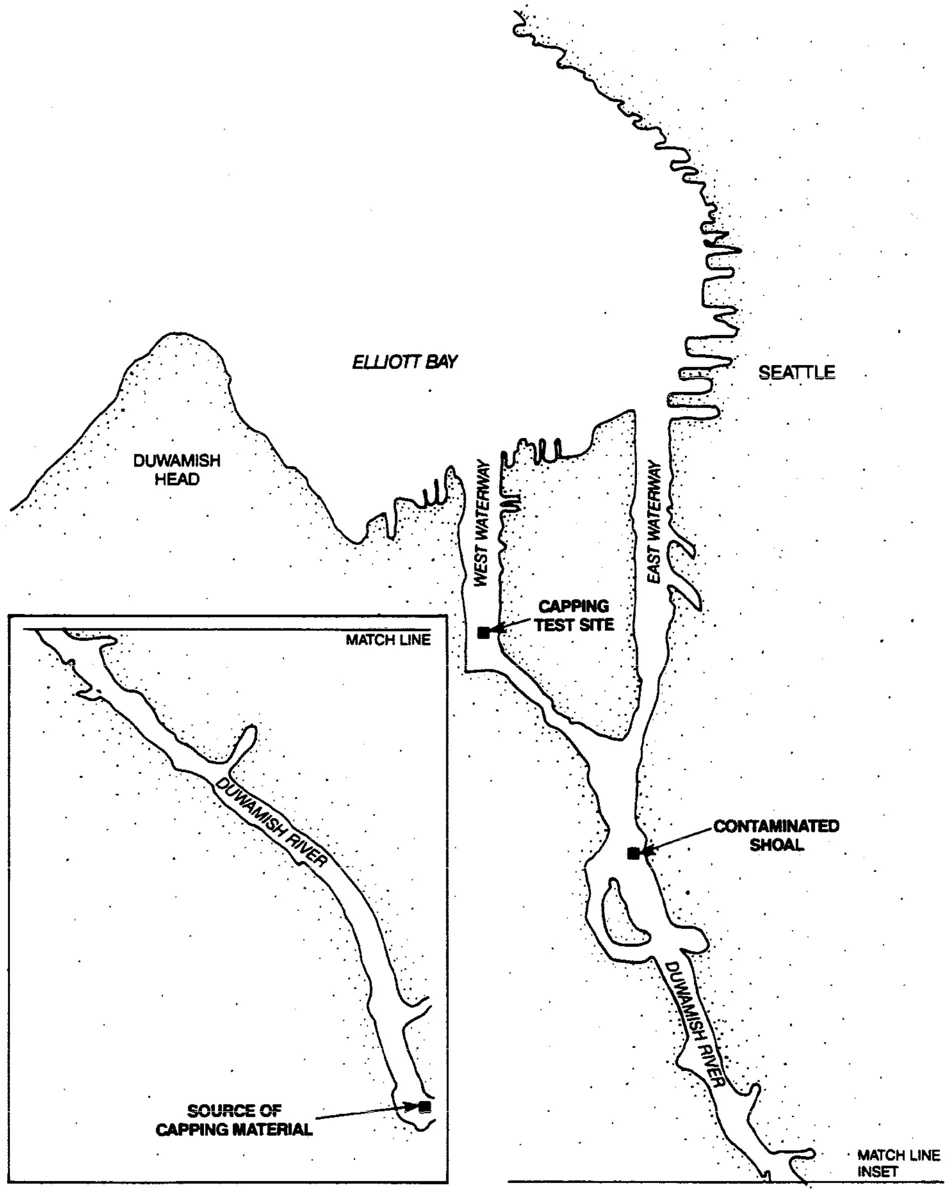


Figure 13.1 Location and site map for the Duwamish CAD site.

Following capping, the site was monitored by extracting cores from the cap site and testing for metals and PCB's at 4 cm intervals. The monitoring was repeated at 6 and 18 months following the capping. From the post-disposal monitoring, there was no indication of cap degradation through 18 months following disposal.

Duwamish River CAD Sampling

The Duwamish River CAD was sampled again approximately five years after capping to see if contaminants had migrated through the cap or if the cap material had degraded over time. Surface grab samples were examined to characterize the benthic community of the cap and to check for any benthic organisms that could burrow into the cap (bioturbation) and physically degrade the integrity of the cap.

Sediment cores were extracted from the cap at approximately the same locations monitored during the 18 month post-disposal monitoring. Due to cost constraints, the number of cores was limited to three or four cores collected in one day. The cores were sub-sampled at 0.5 foot intervals above the cap/contaminated sediment interface. A single sample from 0.5 to 1.0 ft below the interface was used as a reference sample for the contaminated sediment. Van Veen grab samples were taken at two of the coring sites.

The Duwamish River CAD site was sampled April 17, 1989, using the Corps vibracore sediment sampler. Three samples were collected at approximately the same locations as three sites monitored in the 18-month sampling (Figure 13.2). The site locations were located longitudinally on the disposal area with one site in the center and the others approximately 75 ft east and west of the center. Based on post-disposal analysis by the Corps, contaminated sediment was estimated at greater than 3 ft thick at the center and west sites and 1 to 2 ft thick at the east site. Cap thickness was estimated at greater than 3 ft thick at all sites.

The core casings were sliced open lengthwise. In all cores, the interface between the cap and the contaminated sediment was easily identified by differences in grain size. Four sub-samples were taken from 0.5, 1.0, and 1.5 ft above the interface and one sample from below the interface.

Surface grab samples were taken approximately 100 ft north of the center and east core sampling sites. Due to problems with water pressure, only one grab sample was screened and examined for characteristics of the benthic population.

The samples from the sediment cores were analyzed for copper, lead, zinc, and PCB's (1242, 1254, 1260). The chemical analysis was limited to the same contaminants identified in the 18-month monitoring

Results and Conclusions

Results from the chemical analysis of the Duwamish River core samples are presented in Table 13.1. The profiles indicate a sharp break between the concentration of contaminants in the cap and the underlying sediments. The cap concentrations match almost exactly the concentrations found in the cap during the 18-month monitoring. These results do not indicate diffusion of contaminated material into the cap.

Examination of the grab samples indicate a low-to-moderately-diverse abundance of bivalves and annelids. A cursory evaluation of the data suggests that the population is not indicative of contaminated sediments, but typical of environments physically disturbed by estuarine and sedimentary processes.

Overall, the Duwamish CAD has succeeded in confining the contaminated sediments for a five year period. The rate of contaminant diffusion into the cap is negligible. There is no indication that the cap is degrading from either chemical transport or biological activity.

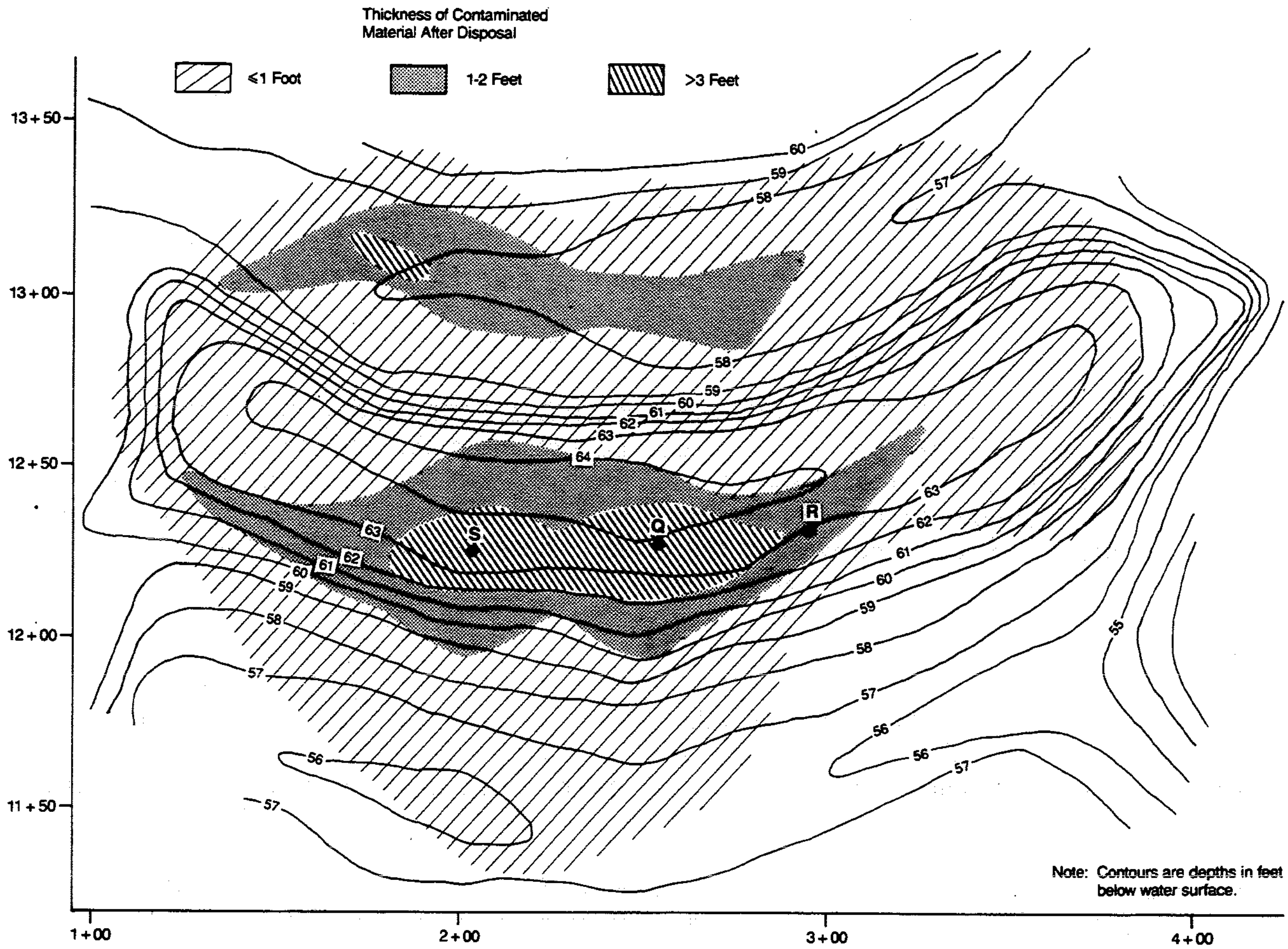


Figure 13.2 Core sample locations at the Duwamish CAD site.

Table 13.1. Results of chemical analysis of Duwamish River CAD cores.

Station	Feet from Cap/Sediment Interface	Metals (ppm)			PCBs (ppb)		
		Copper	Lead	Zinc	1242	1254	1260
Q	1.5	16.1	7.8	56.3	<20	155	420
	1.0	12.3	3.6	49.8	<20	<20	<20
	0.5	12.8	4.4	52.5	<20	125	<20
	-1.0	133	165	338	6200	6300	2300
R	1.5	13.5	4.5	48.8	<20	<20	<20
	1.0	13.4	3.8	51.3	<20	<20	<20
	0.5	12.1	4.6	50.4	<20	<20	<20
	-1.0	138	195	430	650	1500	600
S	1.5	15.2	7.5	54.6	<20	50	<20
	1.0	12.7	5.6	51.6	<20	<20	<20
	0.5	12	3.5	47.5	<20	<20	<20
	-1.0	102	172	264	140	220	170

Further monitoring is recommended. However, the slow rate of transport and the lack of bioturbation of the cap, indicates that frequent monitoring is not appropriate. Future sampling at approximately 10-years post-capping would provide valuable information on the long term integrity of the cap.

13.2.2 One Tree Island Marina

The CAD site at One Tree Island Marina in Olympia was established to dispose of contaminated sediment dredged to deepen the marina. The location of One Tree Island Marina and a site map are presented in Figure 13.3. The disposal plan called for on-site, confined disposal of contaminated sediments and deep water, unconfined disposal of uncontaminated sediments. A conical shaped depression was dredged in uncontaminated sediments to a depth of -46 ft MLLW and back filled with contaminated sediment from the site. The uncontaminated dredge material was used to cap the contaminated sediments. The cap was designed to be at least 4 ft thick. The actual material used to cap the site was not analyzed for chemical composition.

In contrast to the Duwamish site, the One Tree Island Marina was not monitored after capping. There is little information on the type of operation or the sediment type used in the capping operation. Consequently, selection of One Tree Island Marina as a technical study area for Element 10 is most useful to establish a post-capping baseline.

One Tree Island CAD Sampling

The objective at One Tree Island was similar to that described for the Duwamish CAD site. One Tree Island Marina is a small site measuring only 160 by 300 ft. The cap site is a 160-ft diameter area on the site. Two piers have been constructed on the site. One pier transects the cap site and provides ease in positioning by moving along the pier. The sampling plan called for extracting three cores from the CAD site. Cores were to be at least 5 ft deep to extend into the contaminated sediment for at least one foot. Due to the similarity in grain size of the material used in the cap and the contaminated sediments, a well-defined interface between the cap and underlying sediments was not expected. Therefore, sub-samples were be taken by compositing material from 0 to 1 ft, 1 to 2.5 ft, 2.5 to 4 ft, and 4 to 5 ft. Sub-samples were analyzed for arsenic, copper, cadmium, lead, zinc, and PAHs. These contaminants were found to be in high concentrations in the contaminated sediment during post-dredging monitoring.

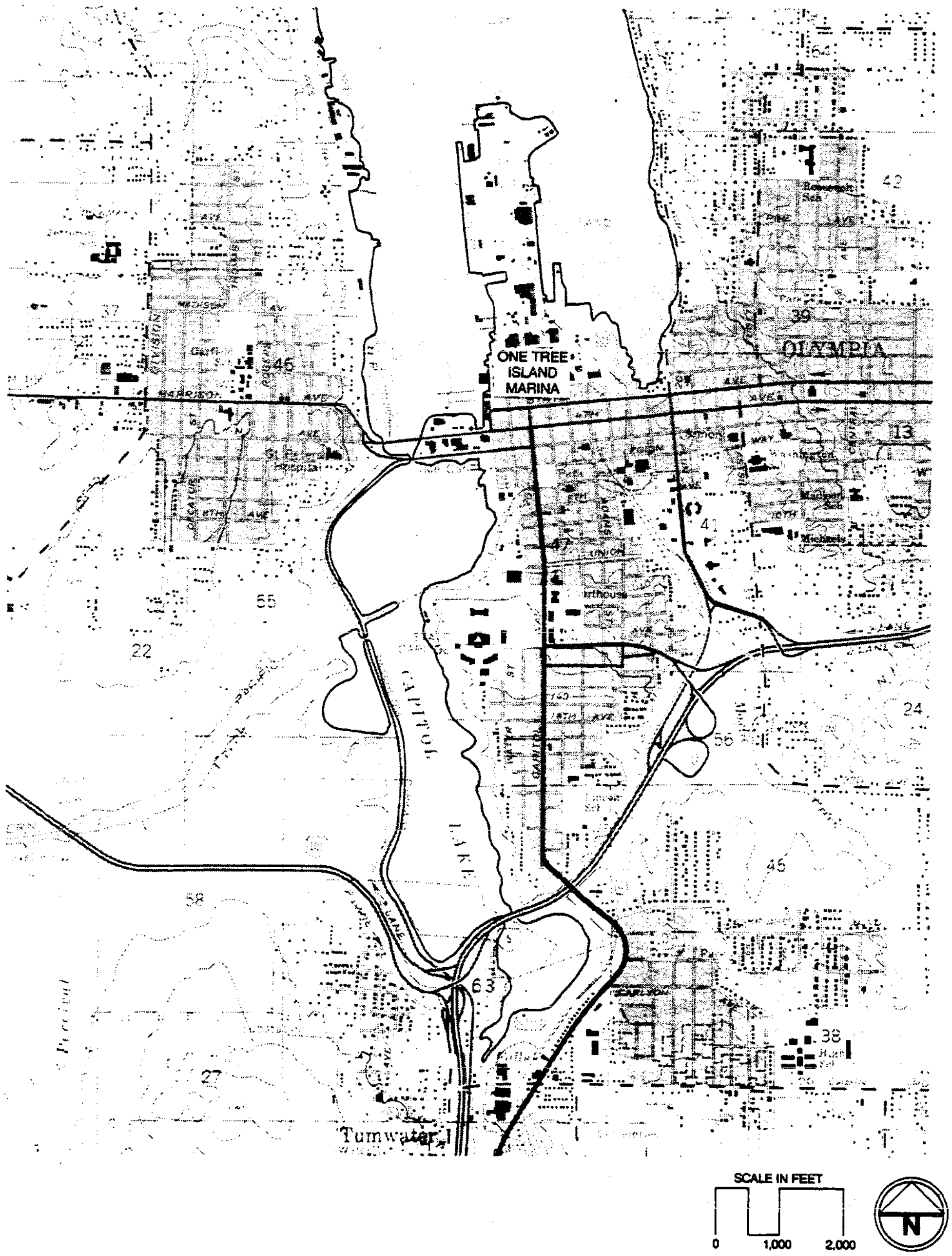


Figure 13.3 Location and site map for the One Tree Island Marina.

The One Tree Island Marina sampling took place on May 4, 1989, using an impact corer. The locations of the core sampling are given in Figure 13.4. Cores were taken approximately 10 ft and 30 ft east, and 30 ft west of the center of the cap. The depth of material cored was monitored using depth soundings inside and outside the core tube. Each core extracted at least 8 ft of sediment depth. Surface grab samples were taken at the coring sites 10 ft east and 30 ft west of the cap center, and a third grab was taken outside the cap site for reference.

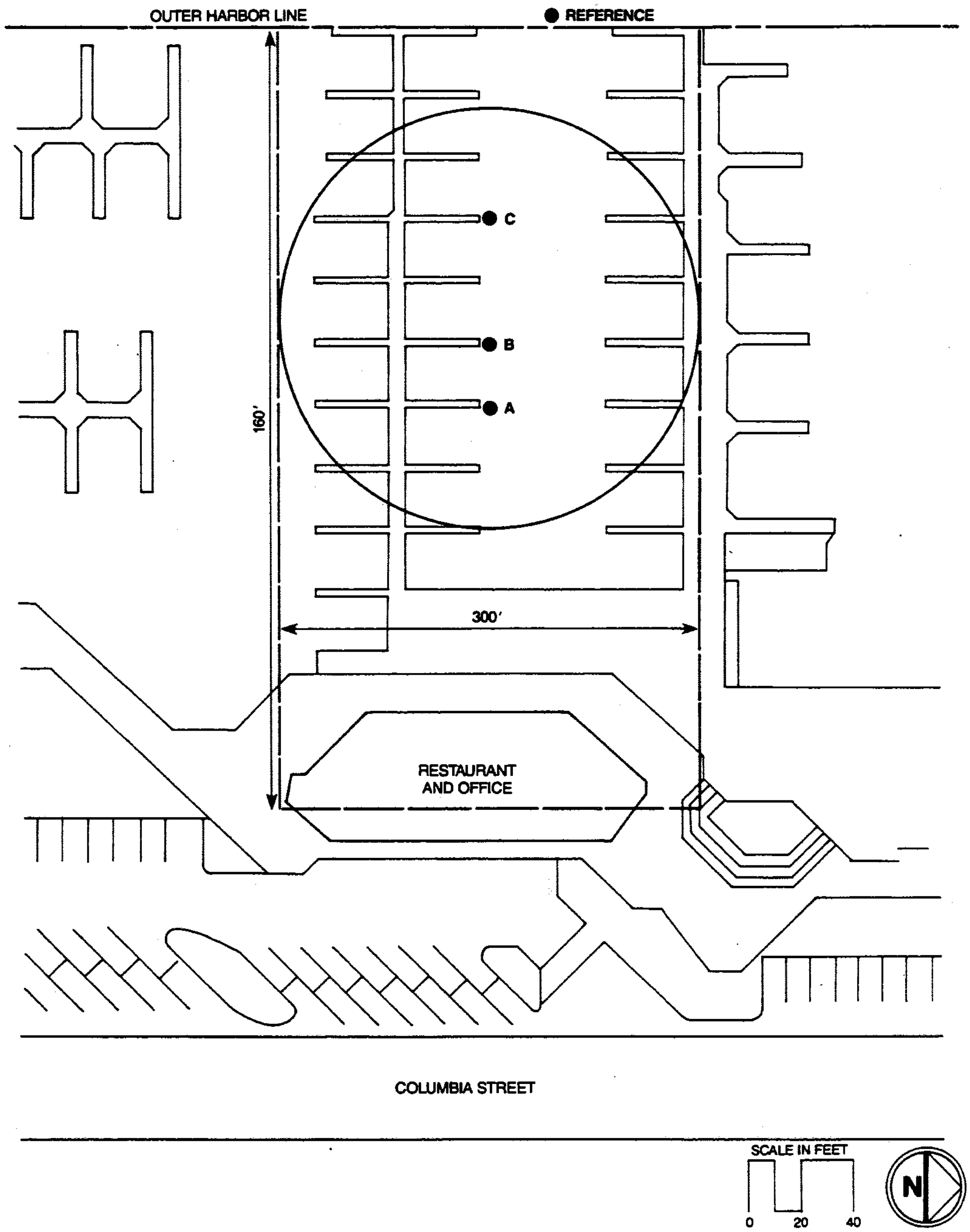


Figure 13.4 Core and grap sample locations at the One Tree Island Marina CAD site.

The cores were stored on ice and returned to Parametrix for processing. The core tubes were cut lengthwise and the cores examined for indications of cap and contaminated materials. The cores were sub-sampled according to the sampling plan.

Surface grab samples were collected at the same sites as cores B and C. A third sample was collected off the CAD site to serve as a reference. Surface grab samples were sieved on site and retained material was stored in 10% formalin. The samples were returned to Parametrix for sorting.

Results and Conclusions

Results from the metals analysis for the One Tree Island Marina core samples are presented in Table 13.2. From these results, it appear that contaminated material was not present in the sub-samples. Although there were variations in the physical composition along the length of the cores, there was no definite interface between the cap and contaminated sediment. Consequently, it was not possible to insure that the 4 to 5 ft sub-sample was actually in the contaminated section of the core material.

Table 13.2. Results of the chemical analysis of One Tree Island Marina CAD cores compared to contaminated and uncontaminated sediments previously found on the site.

Station	Average Feet from Sediment Surface	Cadmium (ppm)	Copper (ppm)	Lead (ppm)	Zinc (ppm)
A	0.5	0.79	98.5	3.7	81.5
	1.8	0.36	24.6	2.4	27.3
	3.3	0.25	9.33	2.8	26.0
	4.5	0.2	7.74	2.5	25.6
B	0.5	0.78	37.0	15.9	46.5
	1.8	0.49	67.9	34.2	61.3
	3.3	0.45	50.1	16.5	43.0
	4.5	0.38	26.2	2.7	42.5
C	0.5	0.43	35.0	37.0	42.3
	1.8	0.56	21.8	8.7	39.5
	3.3	1.33	38.4	10.5	54.5
	4.5	0.63	21.5	4.8	37.1
Pre-Dredging Onsite Sediment Data					
Contaminated		250	2990	1015	1525
Uncontaminated		9.4	270	129	275

Due to the lack of previous core sampling, it was not possible to determine if the chemical concentrations in the cap indicate diffusion of contaminants into the cap material, or if contaminants were initially present in the capping material However, concentrations in the cap are roughly 100 times lower than concentrations found in the contaminated sediments before dredging, and 10 times lower than the concentrations in the surface sediments that were to be used as cap material. This suggests that the cap material came from relatively clean sediment excavated below the surface sediments.

The relatively low concentrations of metals in the cap and the lack of increasing concentrations with depth suggest that the cap material is not being contaminated by the underlying sediment. In fact, most depth profiles show a decreasing concentration with depth which may indicate more impact from recent sedimentation than from vertical diffusion of contaminants.

Results of the PAH analysis are presented in Table 13.3. The results are similar to the results from the metals analysis. There are no clear, consistent patterns in the distribution of PAHs in the sediment profiles. However, concentrations of the various PAHs are approximately 100 to 1000 times less then concentrations found in the contaminated surface sediments and generally less than concentrations in uncontaminated sediments previously found on the site. The PAH results support the conclusion that the cap material consists of material excavated below the surface of the CAD site and that there is no indication of transport of contaminants into the cap material.

The three surface grab samples were screened and the organisms found were identified to family. A list of the organisms is given in Table 13.4. The sample from the reference area contained 122 individuals representing 12 families distributed in 3 phyla. Excluding brachyuran larvae which may have entered in the initial screening water, the samples from the cap were relatively similar. Sample B had 275 individuals belonging to 15 families of 5 phyla. Sample C had 282 individuals of 17 families in 4 phyla. Although the numerical abundances from the two cap samples are quite similar the distributions of organisms are substantially different.

Station B has substantially more barnacles and predatory hesionid polychaete annelids than does station C. Conversely, station C is dominated by cirratulid polychaetes which were not found in the sample from site B. Polychaete worms dominate all three sites, although the assemblage from the reference site indicated the benthic assemblage from that area was much less diverse and abundant.

The domination of the polychaete community by Capitellids at station C is typical of an organically enriched area. However, the high abundances of Nereids and Hesionids indicates the assemblage still has large populations of herbivores and predators, respectively.

Burrowing infaunal organisms were collected from each station and were particularly abundant in the cap material. None of these organisms (particularly polychaetes in the families Nephtyidae, Goniadidae, Cirratulidae, and Spionidae) are very large. Although, Phoronid worms, common in sample B, can build tubes up to 15 cm long, few of the other animals sampled are likely to go deeper than that.

Table 13.3. **Results of the analysis for PAHs at the One Tree Island CAD site. Results are compared to contaminated and uncontaminated sediments previously found on the site.**

COMPOUND	DEPTH (ft)	CONCENTRATION (ppb)* A	B	C	UNCONTAMINATED (ppb)	CONTAMINATED (ppb)
Naphthalene	0 - 1	18 U	28 U	21 U	300	7000
	1 - 2.5	28 U	17 J	20 U		
	2.5 - 4	25 U	25 U	24 J		
	4 - 5	24 U	23 U	18 U		
2-Methylnaphthalene	0 - 1	18 U	28 U	21 U	--	--
	1 - 2.5	28 U	6 M	20 U		
	2.5 - 4	25 U	25 U	14 J		
	4 - 5	24 U	23 U	18 U		
Acenaphthylene	0 - 1	18 U	28 U	21 U	0	1000
	1 - 2.5	28 U	36 M	20 U		
	2.5 - 4	25 U	25 U	29 M		
	4 - 5	24 U	23 U	18 U		
Acenaphthene	0 - 1	18 U	28 U	21 U	0	600
	1 - 2.5	28 U	19 J	20 U		
	2.5 - 4	25 U	25 U	66		
	4 - 5	24 U	23 U	18 U		
Dibenzofuran	0 - 1	18 U	28 U	21 U	--	--
	1 - 2.5	28 U	10 J	20 U		
	2.5 - 4	25 U	25 U	26 J		
	4 - 5	24 U	23 U	18 U		
Fluorene	0 - 1	18 U	28 U	21 U	0	1000
	1 - 2.5	28 U	12 J	20 U		
	2.5 - 4	25 U	25 U	100		
	4 - 5	24 U	23 U	11 J		
Phenanthrene	0 - 1	41	100	21 U	500	30000
	1 - 2.5	41	90	59		
	2.5 - 4	25 U	77	240		
	4 - 5	24 U	23 U	81		
Anthracene	0 - 1	21	86	21 U	300	3000
	1 - 2.5	28 U	45	25		
	2.5 - 4	25 U	35	160		
	4 - 5	24 U	23 U	37		
Fluoranthene	0 - 1	120	730	12 J	800	44000
	1 - 2.5	47	340	180		
	2.5 - 4	25 U	230	520		
	4 - 5	24 U	23 U	94		
Pyrene	0 - 1	140	680	22	1100	39000
	1 - 2.5	58	450	160		
	2.5 - 4	25 U	260	490		
	4 - 5	24 U	23 U	100		
Benzo(a)anthracene	0 - 1	65	290	21 U	200	5000
	1 - 2.5	20 J	150	58		
	2.5 - 4	25 U	120	240		
	4 - 5	24 U	23 U	36		
Chrysene	0 - 1	89	470	21 U	600	11000
	1 - 2.5	24 J	210	95		
	2.5 - 4	25 U	160	300		
	4 - 5	24 U	23 U	47		

Table 13.3. Results of the analysis for PAHs at the One Tree Island CAD site. Results are compared to contaminated and uncontaminated sediments previously found on the site.

COMPOUND	DEPTH (ft)	CONCENTRATION (ppb)* A	B	C	UNCONTAMINATED (ppb)	CONTAMINATED (ppb)
Benzo fluoranthenes	0 - 1	100	540	21 U	1300	20000
	1 - 2.5	32	290	94		
	2.5 - 4	25 U	260	300		
	4 - 5	24 U	23 U	52		
Benzo(a)pyrene	0 - 1	62	230	21 U	400	15000
	1 - 2.5	19 J	180	45		
	2.5 - 4	25 U	150	210		
	4 - 5	24 U	23 U	42		
Ideno(1,2,3-cd)Pyrene	0 - 1	28	120	21 U	500	10000
	1 - 2.5	28 U	110	21		
	2.5 - 4	25 U	110	94		
	4 - 5	24 U	23 U	18		
Dibenz(a,h)anthracene	0 - 1	18 U	40	21 U	--	--
	1 - 2.5	28 U	32	20 U		
	2.5 - 4	25 U	37	31 M		
	4 - 5	24 U	23 U	18 U		
Benzo(ghi)perylene	0 - 1	29	110	21 U	500	12000
	1 - 2.5	28 U	130	22		
	2.5 - 4	25 U	130	110		
	4 - 5	24 U	23 U	21		

U indicates compound was not detected at the detection limit shown. J indicates estimated value below detection limit. M indicates an estimated value with low spectral match parameters.

Table 13.4 Organisms found in benthic samples at One Tree Island Marina.

STATION	PHYLUM	CLASS	FAMILY	NO./SAMPLE
B	Annelida	Polychaeta	Cirratulidae	3
			Goniadidae	4
			Hesionidae	45
			Nephtyidae	56
			Nereidae	1
			Opheliidae	1
			Phyllodocidae	1
			Spionidae	65
	Arthropoda	Crustacea	Balanidae	29
			Brachyuran zoea	1
	Echinodermata	Ophiuroidea	Ophiuridae	1
	Phoronida		Phoronida	29
	Egg cases			6
	Mollusca	Bivalvia	Lucinidae	10
			Montacutidae	18
			Tellinidae	15
		Gastropoda	Nassariidae	2
C	Annelida	Polychaeta	Capitellidae	144
			Dorvilleidae	2
			Glyceridae	3
			Hesionidae	38
			Nephtyidae	20
			Nereidae	4
			Opheliidae	7
			Phyllodocidae	6
			Spionidae	14
	Arthropoda	Crustacea	Balanidae	8
			Brachyruan zoea	12
			Brachyuran megalops	1
			Nebaliidae	2
	Cnidaria	Anthozoa	Metridiidae	1
	Mollusca	Bivalvia	Montacutidae	9
			Tellinidae	1
		Cephalopoda	Octopodidae	1
	Egg cases			22
Reference	Annelida	Polychaeta	Capitellidae	1
			Glyceridae	1
			Goniadidae	2
			Hesionidae	31
			Pectinariidae	1
			Phyllodocidae	3
			Pilargiidae	40
			Polynoidae	2
			Spionidae	18
	Arthropoda	Crustacea	Pinnotheridae	7
	Mollusca	Bivalvia	Montacutidae	4
			Tellinidae	5
	Egg cases			7

In summary, the One Tree Island CAD has been effective in isolating contaminated sediments. Due to the lack of previous monitoring and the unexpectedly thick cap, it is not possible to estimate rates of diffusion of chemicals into the cap. However, the lack of highly contaminated material in the cap and the inconsistency of chemical concentrations with depth, indicate that the cap is effective and not in danger of failing.

13.2.3 Comparison with recommended standards

The siting conditions at One Tree Island and Duwamish River CAD sites are similar in some ways to the recommended functional design standards for CAD site design. A comparison of the recommended design against each of the two CAD sites is presented in Table 13.5.

Table 13.5. Comparison of the recommended CAD site design standards and site conditions at One Tree Island and Duwamish River CAD sites.

CAD site design	Recommended	Duwamish	One Tree
Depths	-80 to -200	-60	-8
Bed slope	3% max	< 1%	< 1%
Berm	none	in existing berm	none
Cap thickness	> 3'	< 1' to > 3'	> 4'
Cap material	fines/sand mix	uniform sand	fine silt with shells
Water column currents	< 1 fps	1.4 fps max	unknown
Bottom currents	< 0.5 fps	0.2 fps	unknown

Generally, the Duwamish and One Tree Island sites do not exactly match the recommended functional design standards. Both sites are in shallower water than recommended. Bed slopes are less than the maximum recommended bed slope. Cap thickness was variable especially at the Duwamish site. Cap material at the Duwamish site was a medium, uniformly graded sand with few fines. Currents at the Duwamish site are generally within the recommended range. Currents at the One Tree Island site are highly variable because of the shallow water and wakes caused by boats in the marina.

The recommended functional design standards are much more conservative than the design criteria at either of the two CAD sites. Yet, both CAD sites have been highly successful in confining contaminated material and preventing the migration of contaminants back to the water column. The performance of both CAD sites indicate that the more conservative recommended functional design standards will be more than adequate to insure proper and effective containment of contaminated material.

13.3 NEARSHORE

13.3.1 Terminal 91 Short Fill Project

In early 1987, the Port of Seattle disposed of approximately 127,000 yd^3 of dredged material in the nearshore area between Piers 90 and 91 (Figure 13.5). Filling of the site increased the working area at Pier 91 and provided for disposal of dredged materials unsuitable for open water disposal. The Port of Seattle is extensively monitoring the site, and data collected to date have been analyzed and discussed by Hotchkiss (1988, 1989). This review of the data confirmed Hotchkiss' conclusions, and the results are briefly summarized in the following discussion.

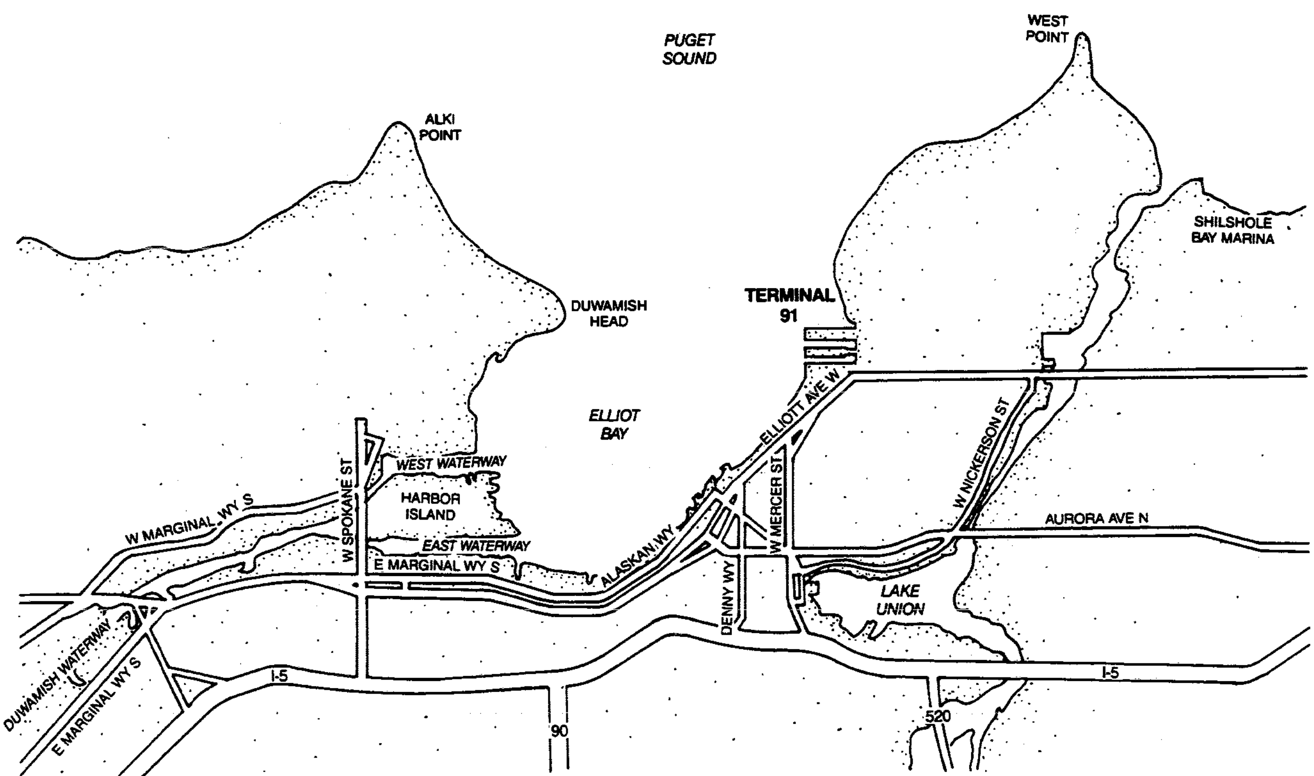


Figure 13.5 Location of Terminal 91.

Sediment Characteristics

The dredged material deposited at the Terminal 91 short fill site came from several locations. 87,000 yd^3 came from the Port of Seattle Terminal 30 expansion project. An additional 25,000 yd^3 of material from Corps maintenance dredging in the Duwamish Waterway. Finally, 15,000 yd^3 resulted from small maintenance projects conducted by the Port of Seattle at other terminals were deposited at the site. Although the sediments were determined to be unsuitable for open water disposal based on the 4-Mile Rock interim criteria, they qualified for disposal at an inert construction landfill (King County solid waste criteria). Contaminants in these sediments included PCBs, metals and PAH.

Disposal Site Design

The general design of the nearshore disposal site is presented in Figure 13.6. Two clean-fill structural berms were constructed between Pier 90 and Pier 91. The northern berm separates the fill from the head of the slip and prevents deformation of the adjacent bridge. The dredged sediments were hauled to the disposal site in bottom dump barges. The barges passed through a gap in the berm, a silt curtain and oil berm, and were positioned and dumped. Upon completion of filling, the berm was completed and monitoring wells installed. Surface water over the fill was analyzed for priority pollutants and found clean enough to be pumped back to the waterway. Clean fill was next placed over the dredged material and leveled using small loaders. The material was consolidated, and the site was paved. All of the contaminated fill material was placed below groundwater level and kept saturated. No special liners or leachate control systems were included in the disposal site design.

The project was modeled to predict the rate of contaminant leaching and transport into the surrounding waters (Hart-Crowser and URS 1985). Both physical (e.g., groundwater hydraulics, permeability of the various components, tidal pumping) and chemical (e.g., worst-case sediment chemistry data, absorption constants, equilibrium partitioning coefficients) variables were incorporated. The model indicated that the route of water flow (and contaminant loss) was through the south berm. The estimated total release of metals was 1 - 2%. The estimated loss of PCBs and PAHs was much less than 1% in 100 years, but the release of volatile organics was estimated to be 20% in 100 years. Mixing at the berm face was more than a 100 to 1 average dilution in comparison with concentrations in the middle of the berm. The sensitivity analysis demonstrated that interstitial concentrations and fill permeability were the major factors determining the concentration and quantity of released contaminants (Hotchkiss, 1988). Monitoring data have been collected to evaluate the model predictions.

Monitoring Data

The Port of Seattle has conducted extensive studies focusing on:

- Assessment of water quality impacts
- Estimation of contaminant flux
- Evaluation of site design and implications for the design of future disposal sites.

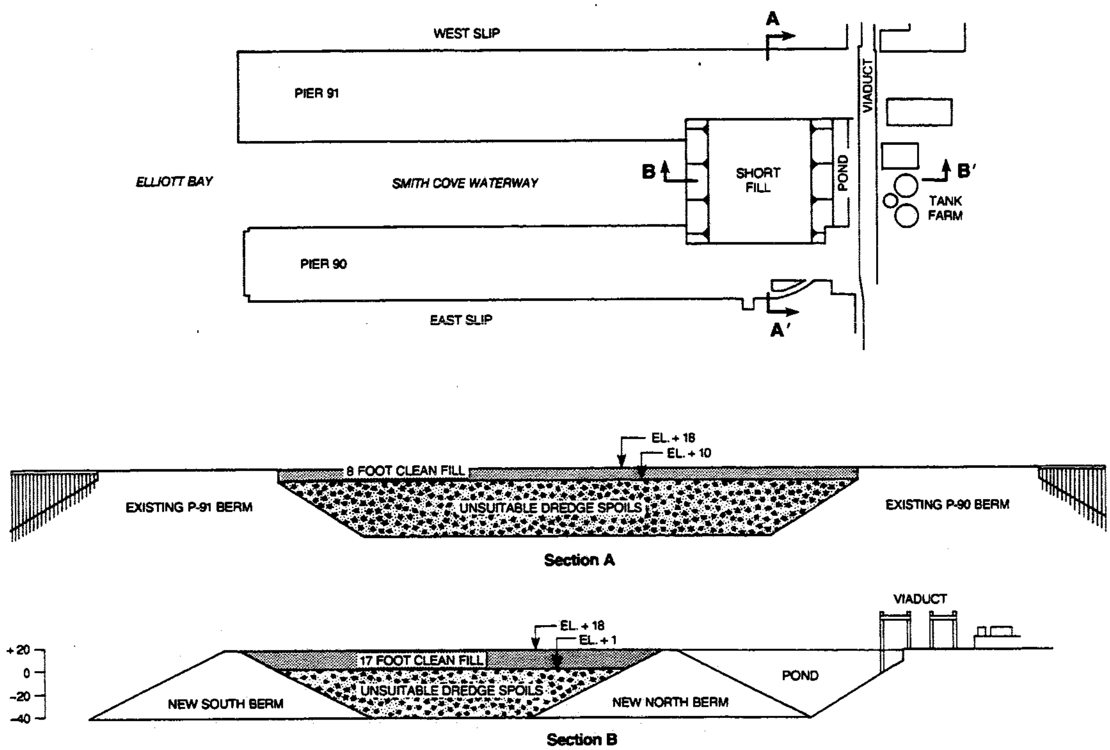


Figure 13.6 Terminal 91 short fill project.

Sampling stations are shown in Figure 13.7. Monitoring wells were installed in the north and south berms, the fill area, upstream of the pond and at Pier 91. Water samples were collected in the pond, at locations in the slip, and at the mouth of the slip in Elliott Bay. Stations 4 and 7, (south berm) and Station 5 (in the fill area) consisted of three wells at various depths. The sample depth is designated by a letter following the stations number:

- a - the hydraulically active upper layer
- b - the shallowest layer of the dredged material fill
- c - approximately the middle layer of the fill

Before completion of the fill, water samples were collected at the berm and upslope wells in November and December 1986 and January 1987. Samples were collected at all stations approximately every quarter from January 1987 to May 1988. All samples were analyzed for metals, and organics were analyzed in samples collected on May 1987 and January 1988. In August and December 1988, the sampling program was modified to address specific questions and assumptions of the model, including the impact of tidal fluctuations on leachate production and movement.

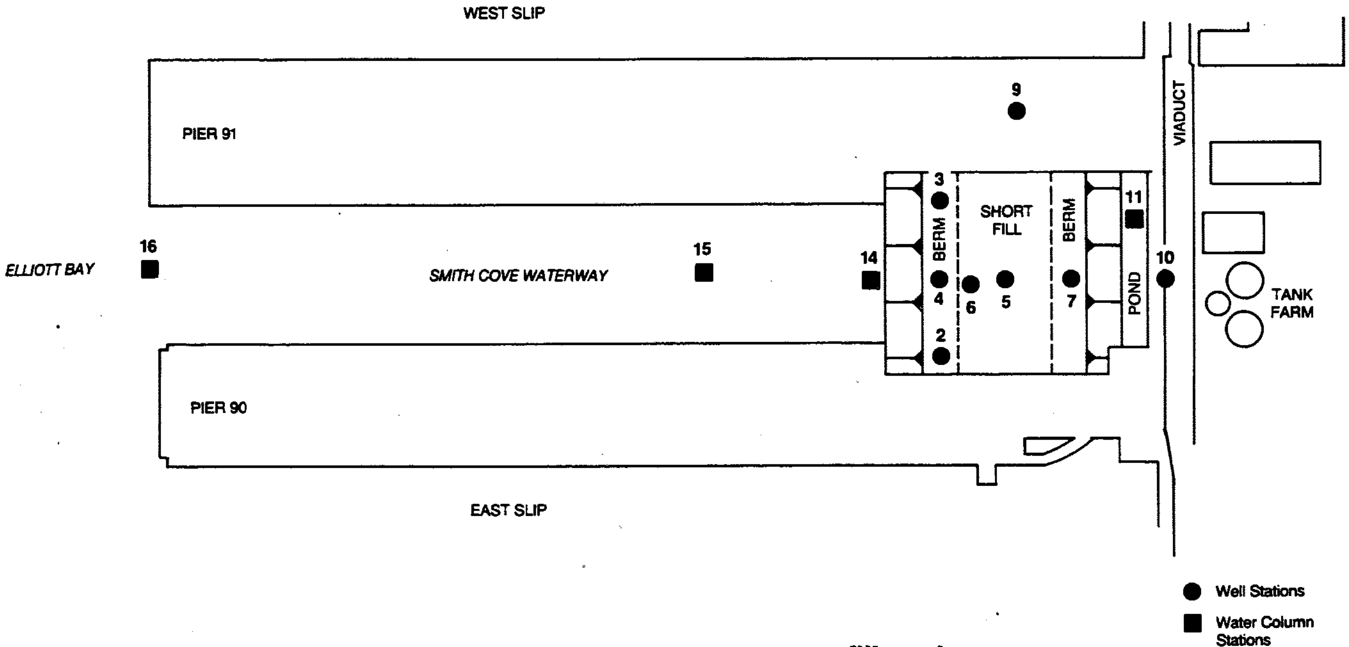
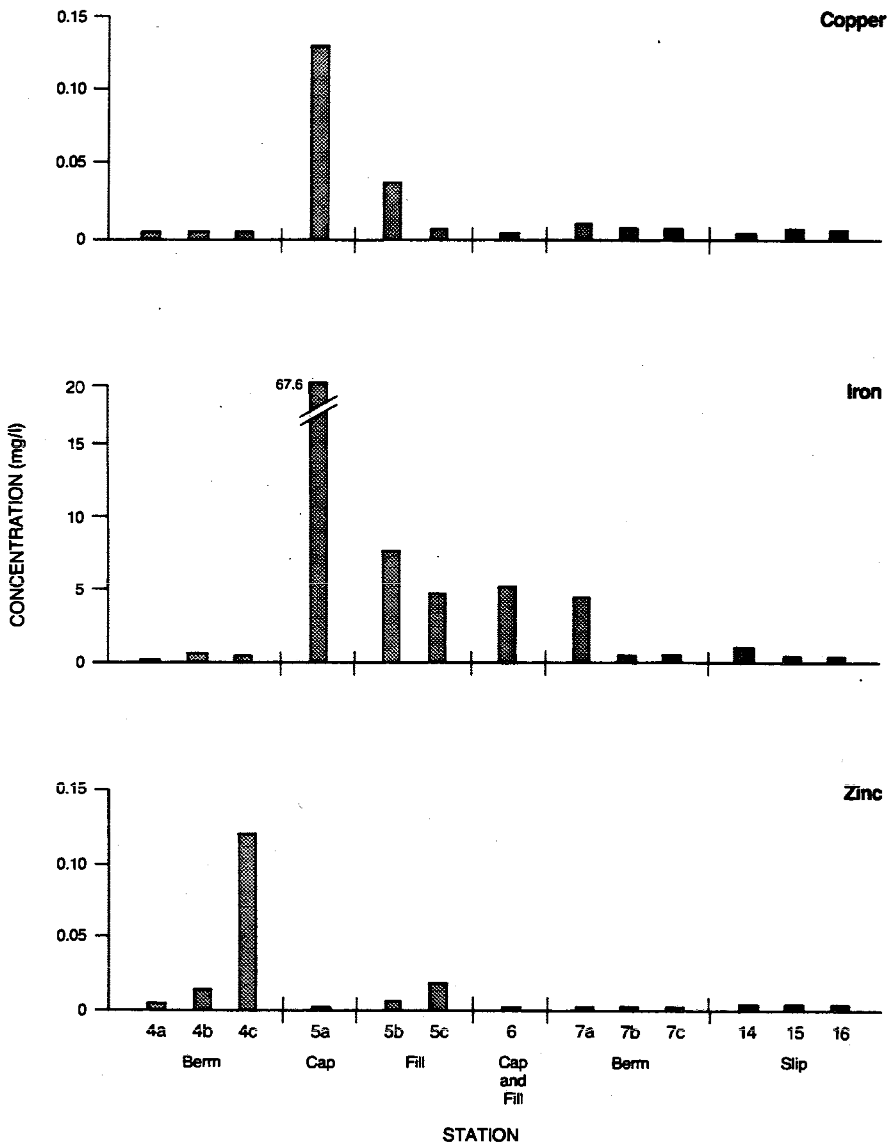


Figure 13.7 Station locations at the Terminal 91 short fill project.

Results and Discussion

Currently there is no evidence that contaminants are transported from the dredged material either through the berms or into adjacent waters by other pathways. The highest interstitial metal concentrations were consistently observed in the "clean" berm and cap material. Concentrations of copper, iron, and zinc were consistently higher in the cap (Station 5a) than in the dredged material fill (Stations 5b and 5c). Although nickel was also observed at relatively high levels in both berms and the cap, but was generally undetectable in the fill material. Figure 13.8, based on data collected in May 1988, provides an example of the characteristic distributions of metals that are observed along a transect from the upstream stations to the slip. The highest concentrations of manganese were measured in the south berm, but may have resulted from damage to the well and contamination from gravel in the berm material (Hotchkiss 1988).

Organic chemicals were analyzed in samples collected at the berm before placement of the dredged material, and at all stations in May 1987 and January 1988. Organic contaminants consisting primarily of LPAHs were observed in the interstitial water of the fill material (Station 5). The same contaminants were also present in samples from the pond (Station 10) before and after placement of the fill material, and in the upstream



Note: Letters denote samples from different depths at a station.

Figure 13.8 Metal concentrations in water samples from wells and water column stations located along a north-south gradient, May 1988.

groundwater (Station 11) (Table 13.6). However, these chemicals were undetected in all samples collected in the north and south berms. These results suggest the dredged material is not the source of organic contamination but that upstream sources exist. PCBs have not been detected in samples from the fill material (Hotchkiss 1989).

Table 13.6. Organic chemical concentrations at Terminal 91 short fill monitoring stations.

May 1987 — Station

Chemical	S.Berm 4a-4c	Fill 5b	Fill 5c	N.Berm 7a-7c	Upstream 10	Pond 11d	Slip 14
Naphthalene	---	2.8	4.8	---	27	18	---
2-methylnaphthalene	---	---	0.3J	---	18	2.8	---
Acenaphthene	---	0.45MJ	1.85	---	2.4	6.2	---
Dibenzofuran	---	---	0.65M	---	3.9	2.6	---
Fluorene	---	---	0.5J	---	4.6	2.5	---
Phenanthrene	---	---	0.75J	---	3.1	2.5	---

January 1988

Chemical	S.Berm 4a-4c	Fill 5b	Fill 5c	N.Berm 7a-7c	Upstream 10	Pond 11d	Slip 14
Naphthalene	---	2.2	---	---	26	---	---
2-methylnaphthalene	---	0.2J	---	---	25	---	---
Acenaphthene	---	1.1	---	---	3.2	---	---
Dibenzofuran	---	0.3J	---	---	4.8	---	---
Fluorene	---	0.3J	---	---	5.9	---	---
Phenanthrene	---	---	---	---	4.3	---	---

--- = Below detection limits
M = Estimated value, poor spectral match
J = Estimated value, less than detection limit

The absence of contamination attributable to the dredged material (as predicted by the low release rates of metals and PAHs estimated by the model) has made it difficult to determine the rate of leachate production and transfer and to confirm the dilution predictions of the model. Only TOC and phosphorus are consistently observed at relatively high concentrations in the interstitial water of the fill material. Because TOC and phosphorus are not conservative, it is difficult to use these variables as tracers. Hotchkiss (1988) reported that a detailed TOC analysis detected no priority pollutants but the chromatograms showed different compounds present in the berm, berm face and fill samples. Quantitative measurement of individual TOC compounds does not appear to be feasible at these low concentrations (Hotchkiss 1989, personal communication). Other chemicals are being considered as potential tracers and the Port of Seattle is continuing to pursue this question.

There is currently no evidence that dredged material disposal at this nearshore location is adversely affecting water quality in Elliott Bay. Only iron and manganese concentrations measured at the face of the south berm (Station 14) were higher in 1988 than in early 1987. However, these elements derive from the berm material, not the dredged fill. Concentrations of all metals in the water column are well within the marine chronic toxicity criteria and are comparable to background measurements (Table 13.7).

Table 13.7. Range of concentrations (mg/L) measured at stations located in the Terminal 91 slip and Elliott Bay, May 1987-May 1988.

Chemical	Station 14	Station 15	Station 16	U.S. EPA Marine Chromic Criteria
Arsenic	<0.001-0.002	<0.001-0.002	0.001-0.002	0.036
Cadmium	<0.001	<0.001	<0.001	0.009
Chromium	<0.001	<0.001	<0.001	0.05
Copper	<0.001-0.004	0.002-0.006	<0.001-0.004	0.0029
Lead	<0.001	<0.001	<0.001	0.0056
Nickel	<0.001	<0.001	<0.001	0.075
Zinc	0.003-0.023	0.0032-0.019	0.001-0.007	0.086

Conclusions

The Terminal 91 disposal site design is working effectively and as predicted. In addition, the project has provided valuable information for the design of future projects, site specific characteristics, and the observation that low permeability dredged material may regulate hydraulic flow. The basic design assumption, that contaminants are contained by controlling particulates and maintaining the wet anaerobic state, appears to be substantiated. However, site specific characteristics must still be considered (Hotchkiss 1989).

The monitoring program conducted by the Port of Seattle also demonstrates factors that should be considered in the design of monitoring programs at other projects:

- Stations should be located to permit evaluation of all potential sources (including the surrounding material). Fewer sampling locations at Terminal 91 would have led to incorrect conclusions about the source of contamination.
- Control stations are required, particularly in areas with relatively high levels of background contamination.
- The time-frame over which dredged material effects can be observed may be relatively long (as predicted by the model). Impacts may not be immediately apparent, and less frequent sampling over a longer time period may be appropriate.

- The information obtained per level of effort may be broadened by selectively analyzing specific chemicals (e.g. contaminants identified in the dredged material).

The extensive monitoring at the Terminal 91 short fill project has clearly demonstrated the effectiveness of this nearshore disposal site. Comparisons of the monitoring data and the model predictions and assumptions showed the model to be an accurate and useful tool for predicting impacts of a nearshore-fill project on the environment (Hotchkiss 1988). Both the field results and model provide useful information for future project designs and monitoring programs.

13.3.2 Comparison with Recommended Standards

Three major components of the Terminal 91 short fill project were compared to the recommended nearshore functional design standards presented in Section 9.3.6. These components includes dredging, transport, and site design.

Dredging

The recommended standards require use of a hydraulic pipeline dredge, and specific operational controls are specified (see Section 9.3.6). The contaminated sediments placed at the Terminal 91 nearshore site were from several different dredging projects. All used mechanical dredged.

Transport

Transport method was the major difference between the recommended nearshore functional design standard and the Terminal 91 short fill project. The recommended standard designates transport of contaminated sediment from the dredging site to the disposal site by discharge pipeline. At the Terminal 91 short fill project, the dredged sediments were transported and dumped by haul barge.

Site design

The primary nearshore site design standards are met by the Terminal 91 project. The volume of sediment deposited at Terminal 91 (127,000 yd^3) is within the functional design volume (10,000 - 1,000,000 yd^3). As in the recommended standards, sediments were placed in anaerobic, wet conditions. The confinement berm was an engineered structure designed to provide the necessary strength and sediment retention requirements. The site was capped with 18 ft of clean fill material (much greater than the required 6 ft thickness). The recommended functional design standards require primary cap placement while sediments are still wet and final capping after initial consolidation and settlement. At Terminal 91, there was a six-month construction delay between filling and cap placement that allowed additional consolidation and compaction of the sediment.

13.4 UPLAND

Two upland mixed fill sites, the Coal Creek (Newcastle) Demolition Landfill and the Olympia View Sanitary Landfill, have been used for sediment disposal. Both locations are monitored, and existing data were reviewed to obtain information on dredged material effects. Because current monitoring programs are designed to assess landfill impacts, information pertaining specifically to upland disposal of contaminated sediments is limited.

13.4.1 Coal Creek Landfill

The Coal Creek Landfill is located in east King County and overlies the old Newcastle coal mine (Figure 13.9). The landfill is currently used for disposal of demolition material. The landfill area is 269 ac, of which 70 ac are permitted for demolition fill and an additional 67 ac are permitted for earth fill. Between late 1987 and early 1988, with approval by the Seattle King County Department of Public Health, approximately 60,000 yd^3 of dredged sediments were placed in a bermed area at the landfill. This report reviews the existing landfill monitoring data in an attempt to identify possible impacts of dredged material disposal at an upland mixed disposal site.

Sediment Characteristics

The sediments derived from two different sources but were placed at the landfill during the same time period. Approximately half of the material (30,000 yd^3) was dredged from Fisherman's Terminal (Port of Seattle). Analysis of multiple sediment cores indicates that chemical concentrations were relatively low (Port of Seattle 1987). Representative data from three composite samples collected on December 1987 are presented in Table 13.8. The samples were analyzed for EP toxicity metals and pesticides. All measurements were below maximum contaminant levels (MCL). One composite sample collected in early 1987 was analyzed for all priority pollutants. Concentrations of chemicals measured above detection limits are listed in Table 13.9. Although this sample represents a small portion of the total dredged material, comparison of these data with PSDDA screening levels (SL) and maximum levels (ML) indicates the low level of contamination. All concentrations are below current PSDDA screening levels. Open-water disposal was not an option at this time because a site was not available and the consistency of the dredged material made it unsuitable for use as fill (Wells 1989, personal communication).

The second source of dredged material (approximately 27,000 yd^3) was Hewitt Terminal, north of Pier 3 (Port of Everett). This project was conducted before completion of PSDDA criteria, and sediment samples were evaluated based on the interim decision criteria for unconfined disposal of dredged material at the Port Gardner open-water disposal site (EPA 1986; Dames and Moore 1988). Sediment characterization included collection of core and grab samples.

Table 13.8. EP toxicity analysis (mg/L) of sediment at Fisherman's Terminal prior to dredging.*

Chemical	Sample 1	Sample 2	Sample 3	MCL
Arsenic	<0.2	<0.2	<0.2	5.0
Barium	0.2	0.2	0.3	100.0
Cadmium	<0.01	<0.01	<0.01	1.0
Chromium	<0.1	<0.1	<0.1	5.0
Lead	<0.1	<0.1	<0.1	5.0
Mercury	<0.005	<0.005	<0.005	0.2
Selenium	<0.2	<0.2	<0.2	1.0
Silver	<0.1	<0.1	<0.01	5.0
Copper	<0.1	<0.1	<0.01	--
Nickel	<0.1	<0.1	<0.1	--
Zinc	0.2	0.1	1.1	--
Endrin	<0.0002	<0.0002	<0.0002	0.02
Methoxychlor	<0.001	<0.001	<0.001	10.0
Toxaphene	<0.010	<0.010	<0.010	0.5
2,4-D	<0.002	<0.002	<0.002	10.0
2,4,5-TP	<0.001	<0.001	<0.001	1.0
Lindane	<0.0002	<0.0002	<0.0002	0.4

*Reference: Wells, B. 1989.

Table 13.9. Priority pollutant analysis of a composite sample from three cores collected at Fisherman's Terminal. Only chemicals measured above detection limits are reported.

Chemical	Concentration
METALS (mg/kg)	
Arsenic	4.1
Copper	16
Nickel	39
Zinc	59
Aluminum	53,000
Iron	25,000
Manganese	450
ORGANICS (ug/kg)	
Naphthalene	17
Acenapthylene	13
Phenanthrene	36
Anthracene	10
Fluoranthene	61
Pyrene	84
Benzo(a)anthracene	29
Chrysene	34
Bis(2-ethylhexyl)phthalate	65
Benzo(b)fluoranthene	69
Benzo(a)pyrene	43
Ideno(1,2,3-cd)pyrene	21
Benzo(ghi)perylene	25
PESTICIDES (ug/L)	
Lindane	1.3

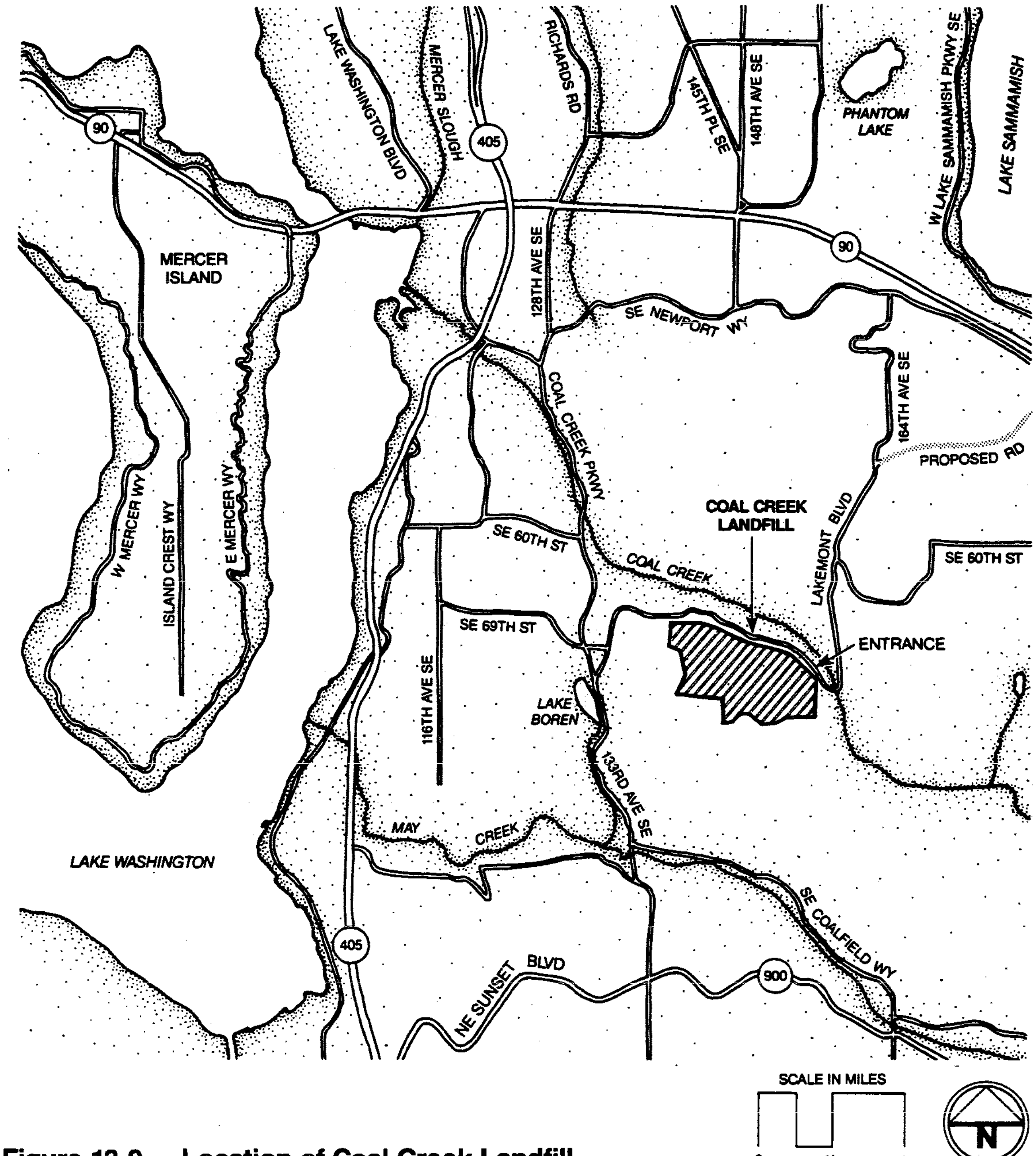


Figure 13.9 Location of Coal Creek Landfill.

Results of the chemical analyses of samples from the area designated unsuitable for open-water disposal are shown in Table 13.10 (Dames and Moore 1987). Sediment core stations are denoted by the prefix "HA" and were obtained by integrating the top 4 ft of the sediment core. The prefix "GW" indicates grab sample stations. These samples were from the top 6 inches of sediment. Chemical concentrations in the grab samples are expectedly higher than in the cores where recent contamination is combined with the underlying, less-contaminated layers of sediment. One composite core sample and one composite grab sample failed to meet the interim criteria for metals, total LPAH, and total HPAH. A second sample failed to meet the interim criteria for total LPAH and total HPAH. It

Table 13.10. Chemical analysis of sediments at Hewitt Terminal.

Chemical	PSDDA SL	PSDDA ML	Port Gardner Interim Criteria	Station HA-7* HA-8	Station HA-3* HA-4	Station GR-1** GR-2
Metals (ppm)						
Arsenic	70	700	12.5	8.2	5.9	7.5
Cadmium	0.96	9.6	0.7	0.7	0.1	---
Copper	81	810	68	65	12	47
Lead	66	660	33	32	4	42
Zinc	160	1600	105	110	35	290
Mercury	0.21	2.1	0.15	0.32	0.08	0.2
Organics (ppb)						
HPAH	1800	51,000	2690	11,705	3206	15,350
LPAH	610	6100	680	8051	3026	3735

*Core samples (surface, integrated over top 4 ft)
**Grab samples (surface, approximately top 6 inches of sediment)

should be noted, however, that the interim criteria for metals are more restrictive than the PSDDA screening levels. SL exceedances were observed for HPAH and LPAH. Concentrations of metals in the grab sample also exceeded SL. There were no ML exceedances in any of the samples. No pesticides or PCBs were detected.

Disposal Site Description

A berm was constructed at the landfill to contain the wet dredged sediments. The 5-7 acre cell for sediments is located on the west side of the landfill (Figure 13.10). As is currently typical of demolition landfills, there is no liner or leachate collection system in this area. However, low hydraulic conductivity of clay material previously deposited at the site may act to slow leachate transport to the groundwater. The dredged material consisted primarily of clays and silts and had a high water content at the time of disposal. Some runoff was directed to temporary holding ponds. The sediments have been reworked and have gradually dried, and portions have been used as cover in other parts of the landfill. The disposal site is not capped.

Monitoring Program

The extensive monitoring program at the Coal Creek landfill is designed to assess impacts of the landfill on water quality and is not intended to specifically distinguish effects of dredged material disposal. Therefore, station locations, sampling frequency, and analyses are not optimal for evaluating dredged disposal effects, and useful data pertaining to this issue are limited. However, some of the monitoring data provide preliminary information

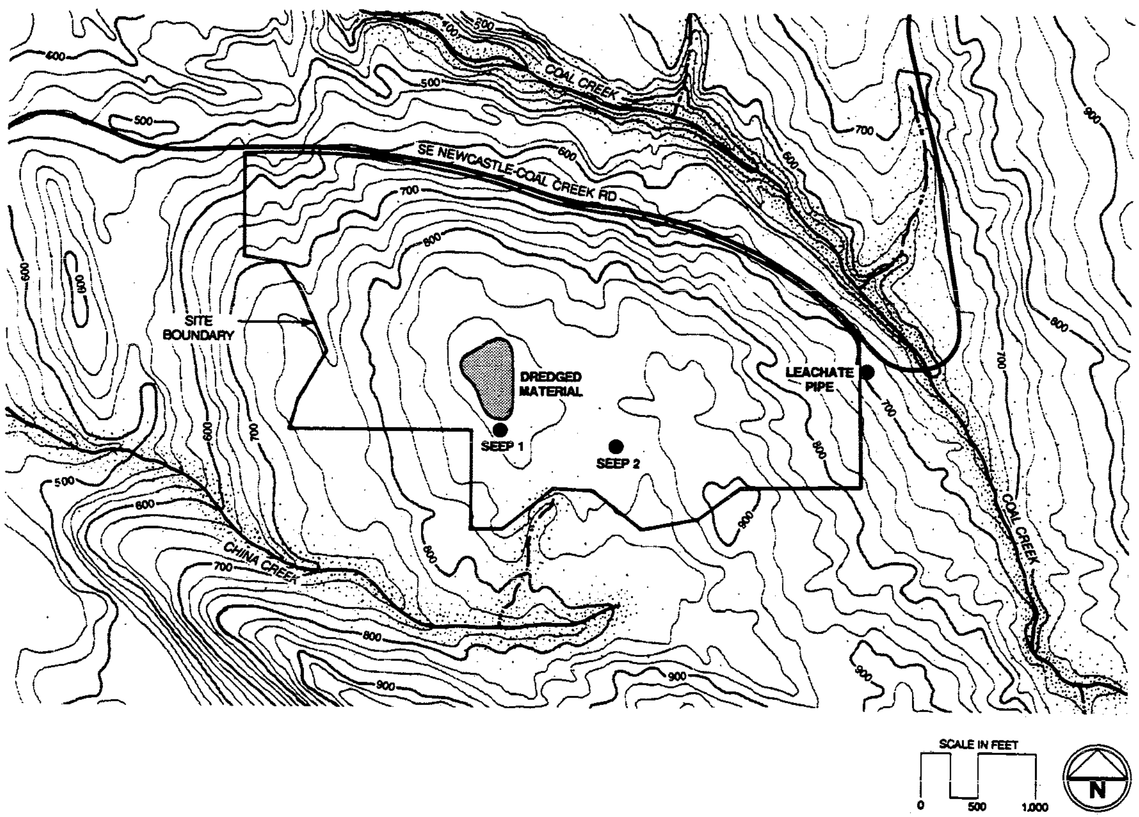


Figure 13.10 Location of temporary seeps and leachate pipe at Coal Creek Landfill.

and serve to highlight the problems inherent in distinguishing dredged material impacts from those of other material deposited in a mixed waste landfill. Landfill monitoring data were reported by Preston, Thorgrimson, Ellis and Holman and Parametrix (1988, 1989).

Water quality monitoring at the Coal Creek Landfill during 1987-1989 included collection of surface water and groundwater samples. Surface water samples were collected in Coal Creek (upstream and downstream of the landfill), near the Coal Creek Parkway overpass, and at various locations near the landfill. Two temporary seeps that could potentially provide information on dredged material impacts were also sampled (Figure 13.10). Seep 1 was located at the toe of the berm surrounding the dredged material. Seep 2 was located east of Seep 1, at the base of the south slope of the landfill. Water samples were collected at both seeps on December 2, 1988 and January 13, 1989, and analyzed for selected metals and conventional variables.

Four groundwater monitoring wells are located within the landfill boundaries (Figure 13.11). Three wells (MW-2, MW-3, MW-4) are located downgradient of the landfill and were installed in April, 1988. One well (MW-1) is upgradient of the landfill and is used to monitor background groundwater quality. It was installed in August, 1988.

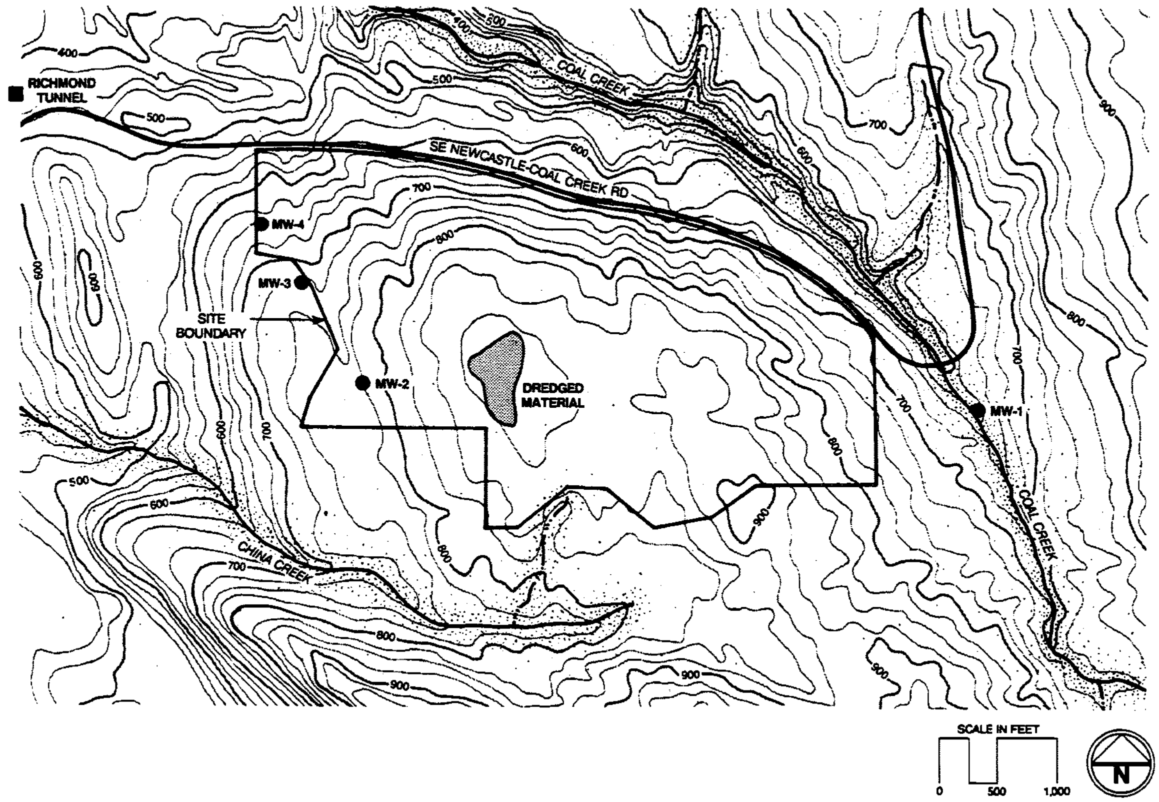


Figure 13.11 Location of groundwater monitoring wells at Coal Creek Landfill.

Additional water samples were collected at the Richmond Tunnel and from the leachate drainage system. Some water draining through the mine workings underlying the landfill exits through the Richmond Tunnel (Figure 13.11). Water samples for measurement of conventional variables have been collected at the tunnel outlet for several years. Some samples have also been analyzed for priority pollutants. The drainage system underlying the east side of the landfill drains through a leachate pipe (Figure 13.10). Water samples are collected at the pipe and analyzed for selected metals and conventionals.

Results

Surface Water. Analysis of surface water samples collected in Coal Creek and at other locations in the vicinity of the landfill currently provide no evidence of landfill impacts on surface water quality. Sampling stations were generally not well-positioned for assessing impacts from the dredged material (Figure 13.10). However, the two temporary seeps were located in areas that would possibly allow dredged material impacts to be identified. Seep 1, near the berm surrounding the dredged material, may be affected by leachate from the sediments. However, this assumption is based solely on the position of the seep, and no direct sampling of dredged material leachate was conducted. Seep 2, because of its position on the south slope of the central landfill, is not affected by the dredged material. Water quality at these two locations was compared to determine if dredged material impacts could be distinguished from those of other waste material in the landfill.

Water quality measurements at the two seeps and at the leachate pipe are presented in Table 13.11. Concentrations of most metals were below detection limits in all the seep samples. Copper was measurable, but concentrations are less than those measured at the leachate pipe before disposal of the dredged material. Most conventional variables are lower at Seep 1 than Seep 2, indicating no additional contamination attributable to the dredged material. Chloride was the one variable that was substantially higher at Seep 1 than Seep 2. In December 1988, the chloride concentration at Seep 1 (331 mg/L) was twice as high as at Seep 2 (115 mg/L). In January 1989, chloride was nearly 10 times greater at Seep 1 (705 mg/L) than at Seep 2 (71 mg/L). However, chloride concentrations in leachate samples from the leachate pipe (draining the east side of the landfill) ranged from 1,252 to 12,509 mg/L. These data indicate that high chloride concentrations are observed in leachate throughout the landfill, and increased chloride at Seep 1 cannot be unequivocally attributed to the dredged material.

In addition to chloride, water samples collected at the leachate pipe exhibit somewhat elevated concentrations of the conventional parameters associated with dredged material (e.g., sulfate, total dissolved solids). Although other dredged material has been deposited at the landfill and sediments used as cover throughout the landfill, water quality at the leachate pipe primarily reflects impacts of demolition waste material. The similar chemicals associated with dredged material and mixed waste demonstrate the difficulties in distinguishing dredged material impacts from more general landfill effects. The available data do not permit conclusions on dredged material impacts on leachate water quality at the Coal Creek Landfill. Collection of leachate samples directly from the dredged material would allow clearer identification of impacts attributable to the sediments.

Groundwater. So far, data collected to date at the Richmond Tunnel and from nearby groundwater monitoring wells indicate no changes in water quality attributable to the landfill. No violations of Safe Drinking Water Standards have been observed. The only organics detected in the groundwater samples were attributable to laboratory contamination.

Although the groundwater monitoring program at the Coal Creek landfill was not designed to evaluate dredged material impacts, there are two ways the existing data would allow sediment effects to be identified. First, differences in water quality at stations upgradient and downgradient of the dredged material may be observed. Second, water quality at the Richmond Tunnel before and after sediment disposal can be compared.

Before conducting the comparisons, transport directions, speeds and associated travel times were estimated to determine if leachate from the dredged material could have reached the Richmond Tunnel and the monitoring wells in the time elapsed since the sediments were deposited. Arrival time estimates were based on the following conservative assumptions: fully saturated porous media and total absence of the clay and glacial till layers below the dredged sediments. In addition to these assumptions, existing field data and published

TABLE 13.11. Chemical analysis of seep and leachate samples collected at the Coal Creek Landfill (mg/L unless noted).

	DECEMBER 1988		JANUARY 1989	
VARIABLE	SEEP 1	SEEP 2	SEEP 1	SEEP 2
pH	6.93	7.09	6.61	6.63
Temperature (oC)	NT	NT	13.5	17.4
Conductivity (umho/cm)	3026	2110	2320	2560
Chloride	331	115.1	705.83	71.05
Ammonia-N	0.659	4.606	0.01	6.741
Sulfate	558.7	812	675.5	566.6
COD	NT	NT	43.3	241.2
TOC	32.8	75.7	4.2	67
Iron	0.014	0.131	0.019	3.67
Manganese	1	10.8	0.081	5.11
Zinc	<0.004	0.0008	0.019	0.033
Hardness	NT	NT	522.64	1552.33
Cadmium	<0.002	<0.002	<0.002	<0.002
Chromium	<0.005	<0.005	<0.005	<0.005
Mercury	<0.0002	<0.0002	<0.0002	<0.0002
Arsenic	<0.005	0.0065	<0.05	<0.05
Lead	<0.03	<0.03	<0.03	<0.03
Copper	0.006	0.004	0.003	<0.002

		LEACHATE	
	OCT 1987	SEPT 1988	JAN 1989
pH	NT	8.34	6.24
Temperature (oC)	NT	20.5	21.9
Conductivity (umho/cm)	NT	63000	8040
Chloride	NT	12509	1252.73
Ammonia-N	NT	24.096	34.598
Sulfate	NT	461.7	1177.4
COD	NT	1635	2292.2
TOC	NT	472.4	665
Iron	NT	23	0.194
Manganese	NT	3.65	2.4
Zinc	0.091	0.033	0.045
Hardness	NT	3320	3272.37
Cadmium	0.004	NT	<0.002
Chromium	0.024	NT	0.082
Mercury	<0.002	NT	<0.0004
Arsenic	0.005	NT	0.128
Lead	0.017	NT	<0.03
Copper	0.22	NT	<0.002

*NT = Not tested

information (Freeze and Cherry 1979) were used to estimate flow paths, hydraulic gradients, and porous media properties including stratigraphic thickness, hydraulic conductivity, and porosity of subsurface layers.

Based on estimated travel time calculations, it seems extremely unlikely that any leachate from the dredged sediments could have reached MW-3 in the time elapsed since sediment placement. In fact, unless considerable flow occurs through fractures, it may take over 100 years for any dredged sediment leachate to reach MW-3. Since effects of the dredged sediments cannot be observed at MW-3, we did not continue this part of the analysis.

However, some dredged sediment leachate may have traveled through 40 ft of underlying refuse and into old mineworkings that intersect the now buried natural ground surface. Travel time through the mine workings to the Richmond Tunnel is difficult to predict but may occur in a number of days. Although it is not possible to predict with certainty an arrival time for dredged sediment leachate at the Richmond Tunnel, it does seem possible that it may be within the time elapsed since sediment disposal. Therefore, the water quality data collected at the Richmond Tunnel was reviewed.

Several conventional variables were measured to the Richmond Tunnel before and after dredged material disposal. The concentration ranges are compared in Table 13.12. Measurements of pH following sediment disposal are somewhat lower, but concentrations of all other variables are within the ranges previously observed. To date, changes in water quality possibly attributable to the disposal of dredged material have not been identified, but data are limited and do not permit a thorough evaluation.

Table 13.12. Range of conventional variable measurements at the Richmond Tunnel before and after dredged material disposal.

Chemical (mg/L)	Aug. 85 - Dec. 87 (n = 7)	April 88 - Jan. 89 (n = 4)
pH (units)	7.11 - 7.8	6.55 - 7.11
Specific conductivity (μmhos/cm)	870 - 1130	760 - 1080
Chloride	<1 - 22	<1 - 14.12
TOC	1.2 - 30	1.04 - 1.57
Hardness	370 - 445	357.64 - 384
TDS	602 - 677	104 - 696

Conclusions

Surface and groundwater monitoring to date have identified <u>no adverse water quality impacts attributable to the Coal Creek Landfill</u>. The data pertaining specifically to the dredged material are limited and do not allow a thorough investigation of dredged material impacts or evaluation of disposal site design. Comparison of water quality at a seep located adjacent to the dredged material was similar to that of leachate from other parts of the landfill. Slow estimated travel times indicated that leachate from the sediments would not yet have reached the groundwater monitoring well, but may have reached the Richmond Tunnel. To date, no adverse water quality impacts attributable to the dredged sediments have been observed at the Richmond Tunnel. However, identification of dredged material impacts on surface and groundwater quality is complicated by the presence of similar chemical constituents throughout the landfill and in the dredged sediments.

13.4.2 Olympic View Landfill

The Olympic View Sanitary landfill is a mixed solid waste disposal site located in Kitsap County, Washington (Figure 13.12). Dredged material was deposited at Olympic View during January–April 1987. The landfill is extensively monitored, and data were reviewed to determine if there were detectable differences in water quality following dredged material disposal. The following discussion briefly describes the sediment and disposal site characteristics. An evaluation of the relevant data for potential effects of dredged material disposal follows.

Sediment Characteristics

Approximately 59,000 yd^3 of sediment from the Puget Sound Naval Shipyard were disposed of at the Olympic View Landfill. Sediment chemistry data are limited, but analyses conducted before dredging indicate that the sediments contained metals, PCBs and PAHs (Puget Sound Naval Shipyard 1983). Results are reported in Table 13.13, and although the project was conducted prior to PSDDA, SL and ML values are also provided for comparison purposes. The PCB concentration in one sample exceeds the ML, but this sample represents a relatively small portion of the total dredged material deposited at Olympic View. Open-water disposal at 4-Mile Rock was not permitted because chemical concentrations in some samples exceeded 125% of the existing background levels.

Table 13.13. Chemical analysis of sediments from the Puget Sound Naval Shipyard (concentrations in ppm unless noted).

Chemical	PSDDA* SL	PSDDA* ML	Pier B Berthing Basin 1	Pier B Berthing Basin 2	Pier B Berthing Basin 3	Pier B Berthing Basin 4	Pier 3 Berthing Basin 9	Pier 3 Berthing Basin 10
Arsenic	70	700	17.6	18.6	17.9	23.8	21.8	22.7
Cadmium	0.96	9.6	1.3	1.33	0.73	0.43	0.5	1.24
Copper	80	810	37.2	34.6	47.6	83	235	35.5
Lead	70	660	26.3	10.3	49.5	62.5	140	179
Mercury	0.21	2.1	0.23	0.12	0.4	0.78	0.96	0.084
Zinc	160	1600	65.2	63.2	83.2	132	163	94.8
HPAH (ppb)	1800	51000	673	241	1397	9690	3350	660
LPAH (ppb)	610	6100	110	68	102	935	656	520
DDT (ppb)	6.9	69	ND**	ND	ND	ND	ND	ND
PCB (ppb)	130	2500	53	ND	29	16300	140	ND

*Puget Sound Dredge Disposal Analysis (PSDDA 1989). Underlined numbers exceed Screening Levels (SL). Double-underlined values exceed Maximum Levels (ML).
**ND - not detected.

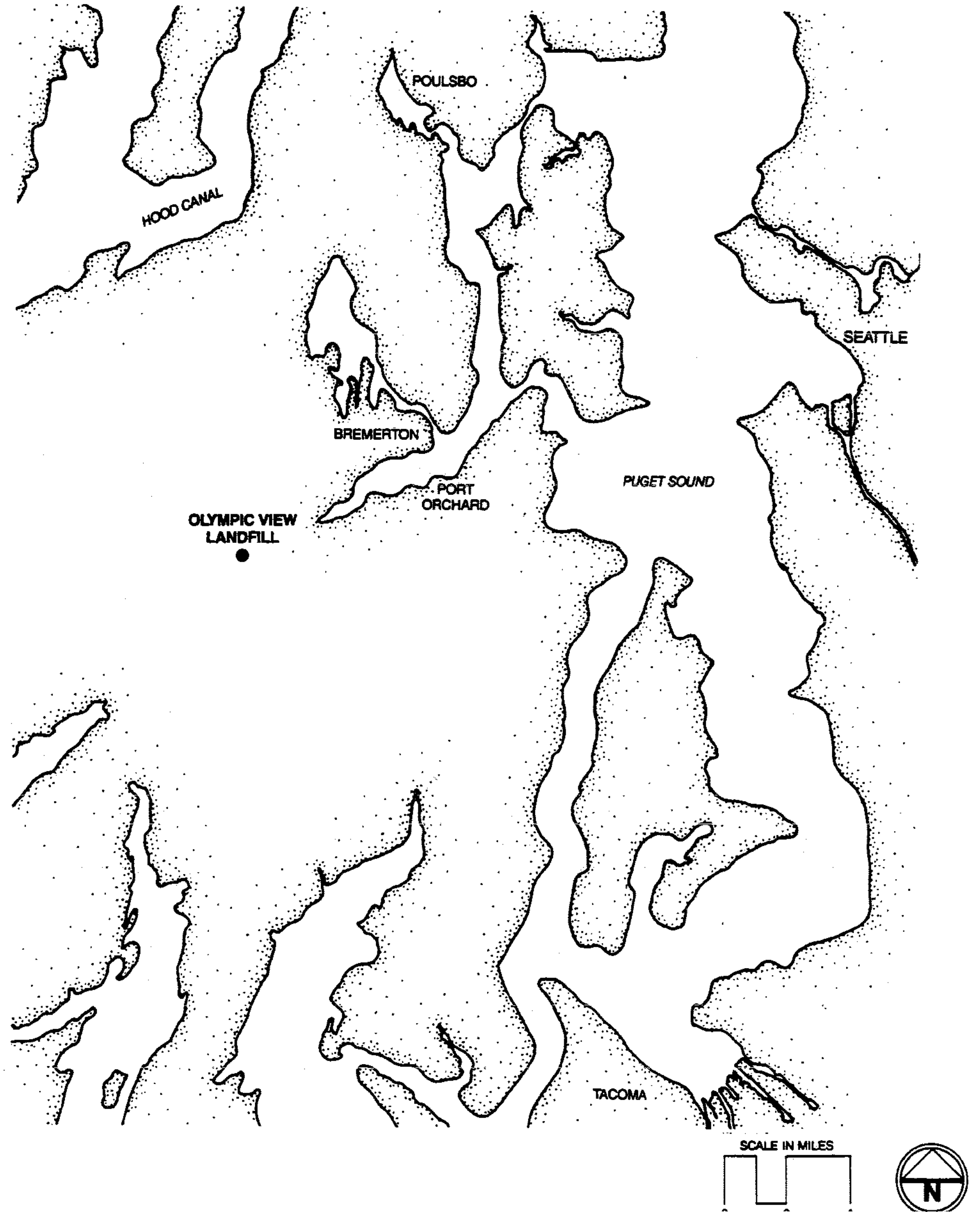


Figure 13.12 Location of Olympic View Landfill

The sediments were removed using a clamshell dredge, placed on a barge, and transported to shore. The material was offloaded to a bermed area and runoff was directed back to Sinclair Inlet. The water content of the sediments remained high, however, due to the consistency of the material (primarily clays and silts) and the rainy period during which the project was conducted. The material was trucked to the landfill for disposal.

Disposal Site Description

The dredged material was placed over waste at the existing landfill (Figure 13.13). The sediments were dumped at the top of the slope and contained by a berm at the bottom. Waste material and garbage were placed on top of the sediments. Three temporary ponds resulted from dewatering of the sediment at the disposal site.

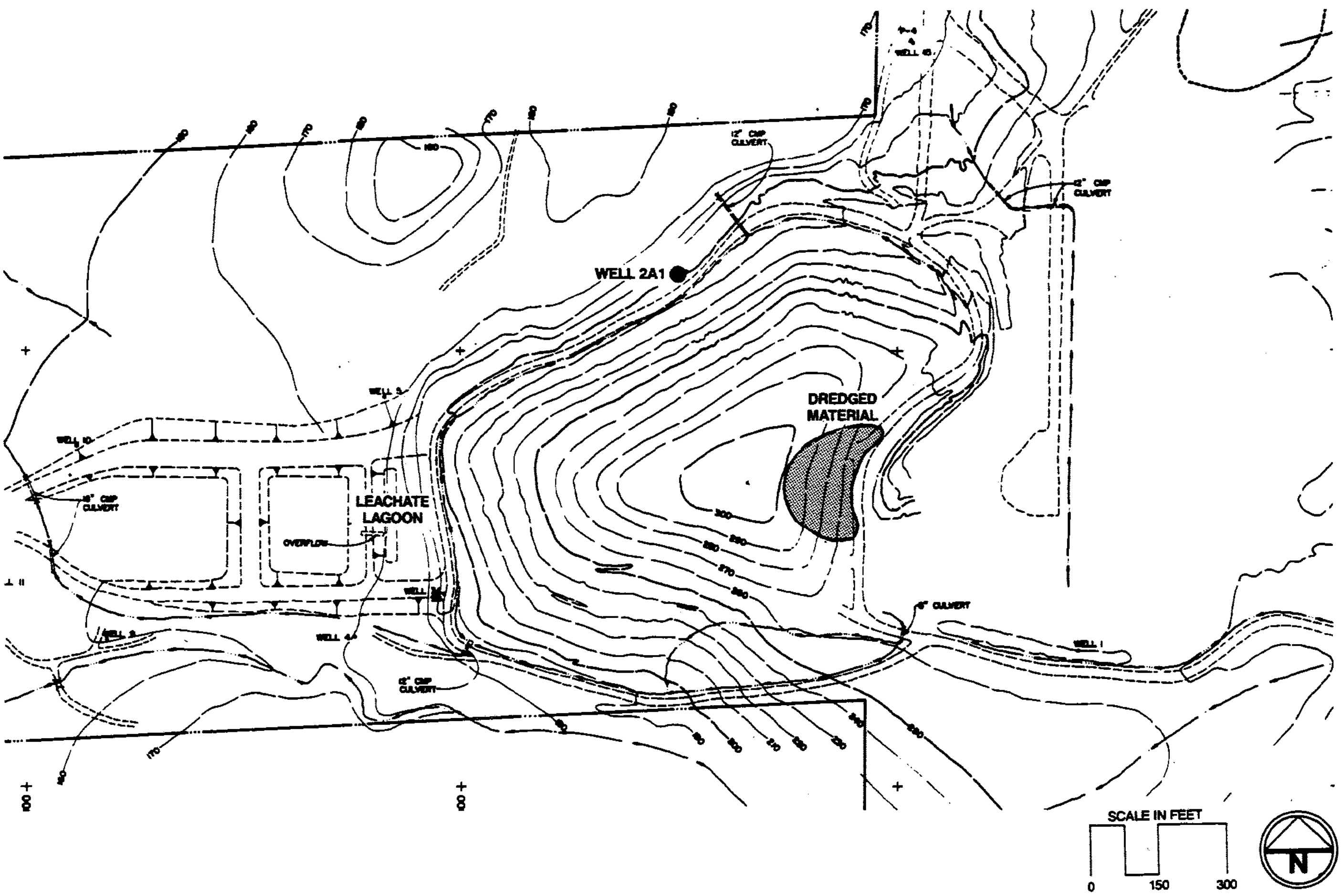


Figure 13.13 Approximate location of dredged material at Olympic View Landfill.

Approximately half of the dredged material lies over an unlined portion of the old landfill. However, the remaining sediments are positioned over a liner, and leachate drains to a collection system on the east side of the landfill. This leachate is then pumped to lagoons (west of the landfill) for settling and treatment before being discharged to the Bremerton Wastewater Treatment Plant or an on-site spray irrigation area.

Results

The Olympic View Landfill monitoring program is designed to assess landfill impacts on water quality and is not intended to permit evaluation of dredged material disposal. The combination of dredged material and other mixed waste also prohibits direct sampling of the sediments and increases the difficulty in distinguishing impacts attributable solely to dredged material disposal. Two components of the existing monitoring program were identified as potentially useful in identifying the effects of dredged material disposal. These components included measurements of water quality in the groundwater and in the influent to the leachate lagoons. Comparison of water quality at these two locations before and after sediment disposal may permit identification of changes attributable to the dredged material. For example, possible increases in those parameters associated with dredged material (e.g., chloride) may be observed following sediment disposal.

Transport rates and travel times of water in the leachate collection system are rapid. Once leachate from the sediments reaches the collection system, it is quickly transported to the lagoon. Construction of the leachate collection system and lagoons was completed by late 1986-early 1987 but sampling did not begin until August 1987, several months after disposal of the dredged material. Therefore, these data do not permit before and after comparisons to detect changes in water quality following sediment disposal.

There are several groundwater monitoring wells located at the landfill. One of these (Well 2A1) is positioned in the groundwater plume downgradient from the sediment disposal site (Figure 13.13). This well has been monitored for conventionals and metals since 1984. Analysis of organic chemicals or pesticides is not required. Estimates of transport rates and travel times indicate that leachate from the sediments would have arrived at Well 2A1 anywhere from several months after disposal of the dredged material until just recently. Therefore, changes in water quality attributable to sediment disposal should be reflected in existing monitoring data.

The range of concentrations of selected variables measured at Well 2A1 before (1984-1985) and after (1987-1989) dredged material disposal are presented in Table 13.14. Measurements after sediment disposal are within the range previously observed. Metals contained in the sediments before dredging (cadmium, copper, lead, and mercury) are undetected in the groundwater at Well 2A1. No increase in chloride or sodium was observed following sediment disposal. These data provide some indication that metal concentrations and conventional measurements of the groundwater at a mixed solid waste landfill were not substantially affected by the disposal of dredged material.

Table 13.14. Concentration ranges of selected chemicals at groundwater monitoring well 2A1 before and after sediment disposal.

Variable (mg/L)	Before (5/9/84 - 7/17/85[a])	After (8/13/87 - 3/1/89[b])
pH	5.3 - 6.51	6.39 - 6.97
Chloride	1 - 170	1.8 - 120
Sodium	34 - 50	28.7 - 36.5
Cadmium	<0.002	<0.002
Copper	NT	<0.002
Lead	<0.01	<0.001
Mercury	NT	<0.0001
Zinc	0.012 - 0.038	0.01 - 0.049

[a]Includes three sampling dates
[b]Includes seven sampling dates
[c]Not tested

Conclusions

Although extensive monitoring data have been collected at the Olympic View Landfill, only a very small portion was useful in evaluating impacts of dredged material disposal. One of the groundwater monitoring wells is located in the flow path from the dredged material disposal site. Data collected at this well indicate that there have been no changes in groundwater quality (metals and conventionals) since sediment disposal. Collection of leachate monitoring data at the landfill began after the disposal of dredged material; therefore, changes in leachate quality due to sediment disposal could not be evaluated.

Recommendations for future upland monitoring

Monitoring programs designed to assess water quality in the vicinity of a landfill. Stations are generally not sufficient for addressing impacts of dredged material disposal. The existing database will be expanded as confined disposal standards are implemented and findings of ongoing research and monitoring programs are incorporated.

The review of existing data served to highlight future needs and monitoring requirements. Recommendations for future study of dredged material impacts at upland disposal sites include:

- Direct sampling of leachate from the dredged material
- Monitoring wells positioned downgradient of the sediment disposal site with consideration given to estimated groundwater transport rates and travel times
- Travel time also considered in determining sampling frequency
- Water quality monitoring should include testing for the chemicals of concern identified in the dredged sediments.
- Consideration given to the difficulties in distinguishing the effects of dredged material (even when compartmentalized) from that of other waste material deposited at the landfill. Many chemicals are common to both sources. Comparison of before and after measurements is a possible alternative, but provides circumstantial evidence at best and may be affected by many other factors (e.g. other waste deposited at the landfill, travel times).

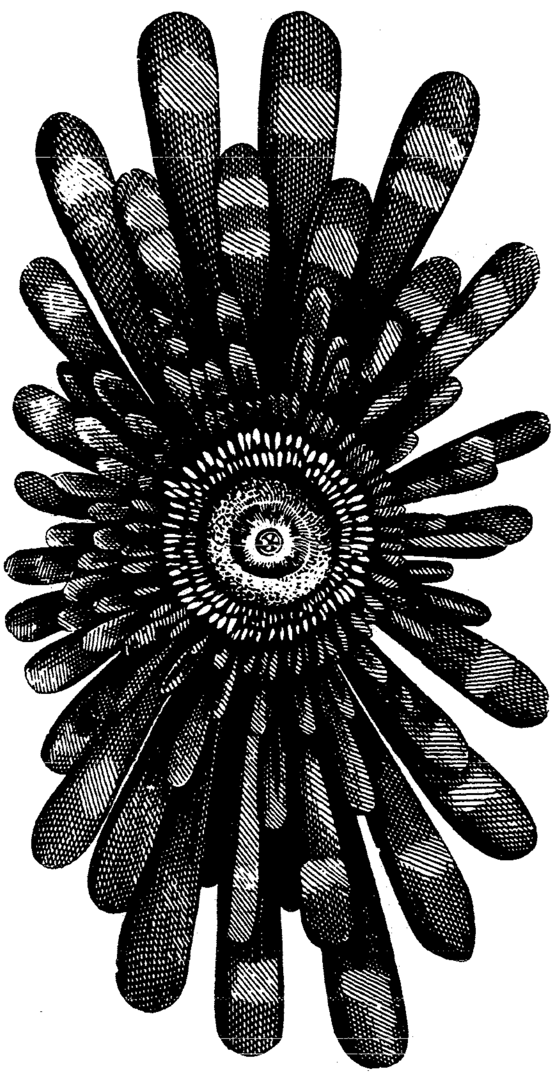
Additional data collection incorporating some of the above recommendations will permit more complete assessment of the effects of dredged material disposal at upland sites.

13.4.3 Comparison with recommended standards

Dredged sediments were placed at both the Coal Creek and Olympic View landfills in compliance with current regulations and regulatory agency approval. However, similar disposal methods would not be permitted under the recommended functional design standards for upland mixed disposal of contaminated sediments (see Section 9.4.6).

One of the recommendations presented in Section 9.4.6 is that the current practice of allowing dredged sediments to be placed in unlined demolition landfills, without an effects based analysis, be discontinued. Therefore, sediment disposal at an unlined area of the Coal Creek demolition landfill (as was done in 1987-1988) would no longer be approved unless a site specific effects based analysis demonstrated an acceptable environmental risk.

Municipal sites are generally lined and meet specific siting criteria. The recommended standard is to continue to permit placement of dredged sediments in all lined municipal sites. The sediments placed at the Olympic View landfill during 1987. were only partially over a lined area. The recommended standards would require that all of the dredged sediments be placed in a lined site.



Beneficial Uses of

MAILLOL WOODCUT

Dredged Material

14. ANALYSIS OF BENEFICIAL USES OF CONTAMINATED DREDGED MATERIAL

14.1 INTRODUCTION

The concept of beneficial uses of dredged material is founded on the belief that dredged material can be disposed of in a manner that is economically and environmentally acceptable and that it creates benefits to society by becoming a natural resource. Like conventional disposal alternatives, the concept of beneficial uses includes a long-term management plan which addresses site selection, potential use designation, dredged material handling, coordination, site management and costs. Currently, the main obstacle for beneficial uses is public and regulatory agency acceptance.

The 9 broad categories of beneficial uses of dredged materials are described in Section 14.2 of this chapter:

Section 14.2.1 - **Habitat Development**

Section 14.2.2 - **Beach Nourishment**

Section 14.2.3 - **Aquaculture**

Section 14.2.4 - **Parks and Recreation**

Section 14.2.5 - **Agriculture, Forestry, and Horticulture**

Section 14.2.6 - **Strip Mine Reclamation and Solid Waste Management**

Section 14.2.7 - **Shoreline Stabilization and Erosion Control**

Section 14.2.8 - **Construction and Industrial Use**

Section 14.2.9 - **Multiple Purposes Use**

The potential beneficial use of contaminated dredged material or of a dredged material containment area will be primarily influenced by concerns that the beneficial use has influenced the contaminant hazard. In general, beneficial uses of sediments not suitable for open water disposal will require some form of containment or cap. Of the nine categories, two (beach nourishment and shoreline stabilization) are inappropriate for use of contaminated dredged material because of the potential for remobilization of contaminants. However, with proper management, most beneficial uses may be applied to slightly or moderately contaminated dredged materials.

In this chapter, the compatibility between contaminated dredged material and potential beneficial uses is assessed. The cornerstone of this review is "Beneficial Uses of Dredged Material" (Corps 1986). First, some considerations for using contaminated dredged material are discussed. This is followed by individual briefings on eight categories of beneficial uses evaluated in terms of their applicability, concerns and limitations. The final section applies a modification of CAAP to each beneficial use alternative. Environmental safety, engineering feasibility, historical precedences, public acceptance and site availability are assessed. From this evaluation, a preferred beneficial use is defined.

Special Considerations for Using Contaminated Sediments for Beneficial Use

The use of contaminated sediments creates potential environmental hazards, depending on the presence of available chemical constituents in the dredged material. These problem areas are:

- plant toxicity
- animal toxicity
- surface water contamination
- ground water contamination (Lee et al. 1976; Mang et al. 1978)

Sublethal plant or animal uptake of chemicals may also present problems if growth or reproductive potential of the organism is altered, or if harmful chemicals are passed upwardly through the food web.

Reports from the Waterways Experiment Station of the Army Corps of Engineers (WES) (Burks and Engler 1978; Gambrell et al. 1978) indicate that dredging operations have the potential to temporarily mobilize or release some contaminants from sediments. During disposal operations, anaerobic (oxygen-less) sediments are mixed with aerated surface seawater and a complex redox chemical interaction occurs. Heavy metals (such as cadmium, copper, chromium, lead, and zinc) or sulfides, which have been stabilized in oxygen-free sediments, form precipitates or oxides in the presence of oxygen. Phosphorus and nitrogen can be temporarily released into the water column. Pesticides and oil and grease are usually not very water soluble and will remain in the sediments. However, all of these contaminants have the potential to affect a proposed beneficial use.

Metals

Lee et al. (1978) and other studies have shown that plants grown in wetlands constructed of dredged material absorb heavy metals in varying degrees depending on the plant species. In most cases, these contaminants are retained primarily in the root systems and not the top shoots (meristems). Most potential adverse impacts are limited to waterfowl that feed on plant tubers. However, research also indicates a tendency for plants grown in upland sediment disposal areas to accumulate heavy metals in all plant parts, including stems and seeds.

Organics

Many organics have unknown adverse affects on aquatic and terrestrial wildlife. Some pesticides affect reproductive abilities of birds by causing egg shell thinning and behavioral modifications. High nutrient levels may affect plant growth patterns and species composition and reduce dissolved oxygen levels in water. Highly acidic dredged material can severely limit beneficial use options unless the pH is corrected by lime addition.

Management Procedures

Contaminant problems can be minimized on most beneficial use sites through a variety of management procedures:

- Stabilizing the areas with plant species that do not transport contaminants into their top shoots.
- Avoiding exposure and reducing the danger of biomagnification by restricting wildlife grazing, fish nursery use, or intense human use at the site.
- Avoiding attracting animals that will potentially feed at the site (for example, fish-eating birds that may use the site for nesting or roosting).
- In cases where levels of contamination are too great to permit direct exposure to the environment, contaminated sites can be capped with clean soil or dredged material.
- Treating the contaminants so that they are broken down or otherwise immobilized (e.g. thermal fusion, solidification and stabilization, incineration, immobilization, degradation, extraction).

Logistical Considerations

Beneficial uses are not feasible if the material cannot be transported to the site economically. Costs associated with the transport of dredged material can amount up to 90% of the total cost of a beneficial use plan budget (Corps 1986). Two primary logistical considerations are pre-treatment of the contaminated dredged material and its subsequent handling and transport to other beneficial use site(s). Pre-treatment includes dewatering of the dredge slurry and the use of treatment technologies such as thermal fusion, solidification and stabilization, etc. on contaminated dredged material. Handling and transport involves the loading, transporting and unloading of the dredged material.

14.2 POTENTIAL BENEFICIAL USES FOR CONTAMINATED SEDIMENT

14.2.1 Habitat Development

Applications

Dredged material has seen wide use in developing wildlife and fisheries habitats in a variety of environments (including upland, wetland, and aquatic sites). Examples include the development of confined disposal facilities into artificial islands that serve as bird nesting habitats and the construction of subsurface mounds or berms to enhance invertebrate and fish habitat.

Currently, the primary use of dredged material for habitat development construction of disposal mounds or islands at confined aquatic disposal sites. One example is the DAMOS site in New England. This site provides an example of both the physical and biological alterations resulting from offshore habitat development and possible beneficial uses. These effects and associated concerns are described in detail below and provide an indication of potential impacts and issues at similar sites in Puget Sound. Other examples of habitat development using dredged material are also described below.

Concerns

There are potential problems with exposing the resident or transient biota to the contained contaminants. The major concern is food chain transfer of contaminants. The degree to which this is a problem is unclear and requires further long-term biological studies. These studies would address questions related to bioaccumulation of contaminants by both resident and transient populations (i.e. migratory water fowl) and potential public health impacts. A possible solution to these problems is to isolate contaminated sediments (e.g. site capping).

Example: Disposal Mounds

Confined aquatic disposal can potentially create habitat by building offshore topographic features. As part of a recent compilation of information on fishery use of open-water disposal sites, SAIC (1989) presented data suggesting that fish having commercial or recreational potential were attracted to disposal mounds. The attraction of fish to alterations in the seafloor topography is evidenced by the extensive use of artificial reefs to attract fish. Disposal mounds have many characteristics similar to artificial reefs, and whether capped or not, offer physical and biological factors attractive to some species of fish and shellfish.

The data presented below are generic in that the principles apply whether the sediment is clean and uncapped, or contaminated and capped with an appropriate thickness of clean cover material.

SAIC (1989) reviewed the biology of shellfish and finfish at the New England DAMOS disposal sites. Commercial species of finfish and lobster were observed at most of the disposal sites. In assessing the effects of the disposal mounds on populations, the effects of several physical and biological parameters that might alter fish and shellfish populations were considered.

Effects of Physical Alterations. Dredged material disposal alters the topography, grain-size, and near-bottom current patterns of the ambient environment. Topographic changes can provide additional habitat, especially with small-scale relief. For example, lobsters and crabs seek rocks and small depressions for refuge. Specific types of physical alternations include:

- Increased large-scale topography established by the presence of a disposal mound.
- Increased small-scale topography (boulders, cobble, mud clumps).
- Changes in sediment grain size.

Large-Scale Topography. Large-scale topographical changes include (1) the establishment of distinct mounds on normally level sand or (2) mud bottoms or the filling of troughs and valleys at hard bottom sites.

Oceanographic conditions are different in the two situations. On the mounds established in level areas, the benthic boundary flow patterns will be altered as currents rise over the deposits, depending upon the slope of the deposit. Benthic boundary layer flow dynamics is an active area of ecological research. Changes in flow patterns have been demonstrated to have a profound influence on the recruitment, stability, and structure of benthic communities (Nowell and Jumars 1984; Nowell et al. 1989). Changes in benthic communities may also result in behavioral changes in bottom fish. In hard bottom areas, the disposed material is contained within the outcrops, but flow patterns may be altered as well.

At the DAMOS site, the effect of large-scale topographic changes from dredged material disposal were variable depending on fish species, but in no case were negative impacts observed. The physical habitat alterations benefit some species, but may not benefit all fish species in the same fashion.

Small-Scale Topography. Small-scale topographic features include rocks, debris, ripple marks, mud clasts, and biogenic structures such as mounds and depressions caused by the activities of burrowing organisms. In addition to creating attachment sites for epifaunal organisms, these small-scale features also provide refuge for fish and crustaceans.

As with large-scale topographic changes, small-scale topographic changes at the DAMOS site had variable impacts on fish populations, depending on the species. Those species that exhibit a positive response to the addition of small-scale topography or relief habitat presumably use these features as a form of refuge. Grain-size alterations also result in variable impacts depending on the fish species and the direction of change (fine-to-coarse-grained or coarse-to-fine-grained). Variable responses would also be expected at similar sites located in the Puget Sound area.

Effects of Biological Alterations. While physical alterations of habitat may influence the presence or absence of fish, any change in fish biology is a major concern. Biological alterations involve changes in the structure of the benthic community in response to physical or chemical alterations. In particular, the recolonization of a site following disposal invariably results in the establishment of a community dominated by numerous, small polychaetes of the families Capitellidae and Spionidae. The production ratio of disturbed/undisturbed bottoms following such an event is at least 6 (with 1.0 mm mesh sieves) and probably much higher when finer mesh screens (0.3 or 0.5 mm) are employed (Rhoads et al. 1978).

In the recolonization model proposed by Rhoads and Germano (1982, 1986) these initial colonizers represent the initial state in a successional series that ultimately ends with a community of larger, deep-burrowing invertebrates. Because this biological change results in an increase in potential prey for bottom fish, changes in the concentrations of fish following disposal should be detectable. Likewise, the recovery of a disturbed site should also result in observable changes. Unfortunately, the use of trawls and standard fishing methods has proven inadequate in accurately determining such responses. The DAMOS site results summarized by SAIC (1989) are incomplete and, in many cases, represent anecdotal observations rather than hard data. Lunz (1986) determined that fish captured at the Foul Area Disposal Site were feeding more efficiently than fish captured in the reference area. This result suggests a strong positive response to disposal mounds by this fish.

Concerns. A primary concern at the DAMOS site, as at all CAD sites, is contaminant bioaccumulation. Additional information on fish diet and behavior in disturbed habitats is required to predict which fish species are most susceptible to contaminant bioaccumulation. A cap of sufficient thickness to isolate prey from the underlying contaminated sediment will reduce the potential for bioaccumulation.

Conclusions. The use of the CAD for habitat creation and fisheries enhancement is an attractive use for disposed materials. However, site-specific studies are required to determine the degree to which specific predator species are attracted to the site and benefit from the enhanced secondary production. This use could enhance sport or commercial fisheries.

An important design requirement is that the enhanced production must be insulated from contaminants within the dredged material deposit. Capping will address this problem. Yearly monitoring of cap integrity and invertebrate body burden is required to ensure that the cap is functioning efficiently.

Other Examples

Other examples of habitat development include the Great Lakes and a number of ports along the eastern and gulf coasts where Corps of Engineers Districts have constructed large (up to 1,000 acres), permanent, diked islands from maintenance dredging material. These islands are often well-armored, and in most cases designed to permanently contain contaminated sediments. Since their construction, island use by nesting and resting seabirds has increased. Management of these areas generally consists of continued protective isolation, wildlife monitoring, and posting. However, vegetation management has not yet become a problem on any of these relatively new islands.

A confined disposal site in Saginaw Bay provides nesting habitat for waterfowl. A monitoring program that began in 1988 is determining potential bioaccumulation on this site.

A demonstration of upland and wetland island development was successfully performed in the lower Columbia River at Miller Sands during the Dredged Material Research Program. The program developed upland nesting meadows, vegetated marshlands and protected shallow water aquatic habitat adjacent to the high energy Columbia River channel.

Conclusion

Confined disposal facilities such as man-made islands offer an option for beneficial uses of dredged material within the shallow waters of Puget Sound.

14.2.2 Beach Nourishment

This is essentially an open-water disposal option and is not appropriate in the context of contaminated dredged material disposal.

14.2.3 Aquaculture

Applications

Dredged material containment areas have been used between dredged material disposal cycles for raising shrimp, clams, and other commercial species. These programs have not identified beneficial uses of dredged material, but have been designed to show that containment areas are productive between disposal cycles.

Concerns

The main concern has been the accumulation of contaminants in the tissues of organisms raised in the containment areas and the impact of that accumulation on public health or upon the marketability of the organisms.

Response

Contaminants within the sediments are relatively unavailable to aquatic animals. Available contaminants are generally not concentrated by aquatic animals to concentrations in excess of those found in the sediments.

Laboratory experiments exposing aquatic animals to sediments contaminated with various metals and organic contaminants have shown organics are more likely to be transferred from sediments to animals. Animals, such as certain marine worms that live and feed below the surface of the sediment, are more likely to accumulate organic compounds than most shrimp or clams, which live or feed at or above the surface of the sediment.

Higher levels of organic material in the sediment appear to reduce the biological availability of PCBs and other organic chemicals in sediments. Some data indicate animals can accumulate lead and petroleum hydrocarbons from contaminated sediments. However, the levels of these contaminants found in the animals are low in comparison to sediment levels, and no evidence suggests that the organisms are harmed by these low levels of contamination.

The level of contamination should be considered. The only basis upon which to judge the potential biological availability of contaminants in dredged material is through plant or animal bioassays designed to document the growth effects on the toxicity of contaminants associated with those materials.

Examples

Shrimp farming in the Gulf of Mexico is well documented, but few examples are available for the use of contaminated dredged material.

Conclusion

The use of mildly contaminated sediments for aquaculture in Puget Sound would need to be pursued cautiously. Before any such activities are initiated, laboratory scale demonstrations using carefully selected target species would be required. A general lack of aquaculture activities in the Puget Sound area limits the use of dredged materials, no matter how clean. Public acceptance is also an obstacle.

14.2.4 Parks and Recreation (commercial and noncommercial)

This category is similar to multiple purpose use, construction and industrial or commercial options which are addressed in Sections 14.2.8 and 14.2.9.

Dredged material is used for fill and is suitable for contaminated sediments if capped with clean material. A common use of dredged material is park development adjacent to the water. The sediment is often stabilized with vegetation, such as grass, or pavement to reduce migration of contaminants offsite.

Conclusions

Appropriate conclusions regarding the beneficial use of contaminated dredged material for parks development can be found in Section 14.2.8.

14.2.5 Agriculture, Forestry, and Horticulture

Applications

Dredged material frequently contains high concentrations of plant nutrients (nitrogen, phosphorus, silicon), and may be used to improve physical characteristics of soil. Two examples are livestock pasture and soil conditioners to enrich marginal soils. However, salts and sulfides contained in the dredged material compromise this application. The U.S. Department of Agriculture (USDA) and other regulatory agencies have investigated the application of sewage sludge to agricultural lands.

Concerns

Concerns about using contaminated sediments for agriculture, forestry, or horticulture center on three basic problems:

- Salinity of water. Most crops and upland vegetation will not grow on brackish or highly saline soils. Salt-tolerant plant species are available and research on salt-tolerant agriculture crops is underway, but to date, none have been found to be economically productive. Techniques for treating dredged material for salinity problems are available and should be applied before the material is transported to the agricultural site.

- Oxidation of sulfides which depresses pH and makes metals soluble

- Heavy metals, rather than organics, are most likely to be mobilized by plants. Heavy metal uptake by plants depends on many factors, including the form and concentration of metals in the rooting media and the type of plant. Research has shown that heavy metal uptake by plants is normally much less than the heavy metal content of the rooting media (Lee et al. 1978; Gupta et al. 1978). The suitability of dredged material for producing food crops as opposed to non-food crops depends upon the chemical contaminants in the dredged material.

Conclusions

Non-food crop applications would have the best chance for public acceptance. These include primarily forestry applications, such as growing Christmas trees or pulp wood. Agricultural use should be considered for at least some categories of "contaminated" sediments that are low in salts and sulfides.

14.2.6 Strip Mine Reclamation and Solid Waste Management

Applications

Strip Mine Reclamation. The application of dredged material for strip mine reclamation has limited value in the Puget Sound region because strip mining is not a local form of mining. This beneficial use is discussed in an attempt to be thorough and as an example of the broad array of national alternatives. A major environmental problem associated with abandoned strip mines is erosion and acid surface runoff. This problem may be controlled by capping the site to reduce air and water contact with the acid-generating mine spoils. Once the cap is in place, the area is revegetated to control erosion, and returned to productive use. Dredge material is well suited to this application; however, as in agriculture applications, the sediment should be treated to reduce salt and sulfides concentrations.

Solid Waste Management. The location of a sanitary landfill is often constrained by cover material requirements and availability, and by site characteristics related to potential adverse environmental impact. Bartos (1977) reports that dredged material can satisfactorily perform the functions of a cover material, thereby making it possible to locate sanitary landfills at sites previously considered unsuitable due to a lack of native cover soil. Dredged material treated to reduce salt and sulfides concentrations may be used for covers, liners, leachate drains, and gas barriers.

Concerns

Transport of contaminants from dredged material into the ecosystem by plants or burrowing animals is the main concern. Of additional concern are problems associated with salt and sulfides contained in the dredged material.

Examples

Strip Mine Reclamation. A demonstration project was conducted by the Chicago District Corps of Engineers (Perrier et al. 1980; Simmers and Rhett 1986). The mining site was leveled, capped with dewatered material, mixed, lime added, and planted with a grass mixture. The site rapidly established vegetative cover and maintained good vegetative cover eight years after planting.

Because the dredged material contained toxic metal contaminants, a contaminant mobility monitoring program was implemented. Plant uptake of metals was minimal. Earthworms exhibited cadmium levels similar to those in the dredged materials. The monitoring program concluded there was significant movement of heavy metal contamination into the ecosystem through leaf litter and duff material.

Although some heavy metals, PCBs, and PAHs are present, there does not appear to be any contaminant uptake other than the movement of cadmium from leaf litter as indicated by the bioassay earthworms. The presence of low levels of contaminants in dredged material need not eliminate it from consideration for productive use. However, appropriate bioassay monitoring procedures must be conducted and appropriate management strategies implemented.

Sanitary Landfills. St. Paul and Mobile Corps of Engineers Districts have both used clean dredged material as caps for urban landfills. The solid waste at landfills is covered daily with at least 6 inches of clean dredged material to control vectors at the site, prevent internal fires, and control surface water infiltration.

Engineering Considerations

Strip mine reclamation requires that slopes be reduced to facilitate revegetation and limit runoff and erosion (Spaine et al. 1978). Dredged material must generally be dewatered. However, the use of slurry in areas close to the source of dredge material appears promising. However, this approach has not been tested. Potential requirements must be established for desalination, pH adjustment, and organic content of the top layer to promote plant growth. Area mining results in a series of parallel ridges, which merely need to be leveled. Contour mine sites are more difficult because they require terracing.

Solid waste landfill applications require dewatered material, but this may be easily hauled, spread, and compacted using conventional earth moving equipment. Truck haul is the recommended transport method.

Limitations/Management Strategy

Strip Mine Reclamation. The design of the reclaimed site must limit transport of contaminants to the environment by plants or animals. The reclamation site must also be nearby, but since truck haul could be used, immediate proximity is not critical. Again, low concentrations of salts and sulfides are required.

Solid Waste Management. The primary limitation applies to the use of salty marine sediments.

Conclusions

The use of dredged material in strip mine reclamation and as clean cover for sanitary landfills are very attractive beneficial uses. Engineering feasibility is high, and contaminant mobility pathways are relatively easy to control. The applicability of the concept of strip mine reclamation with dredged material, however, is limited in Puget Sound. However, sanitary landfills are available and near some dredge sites.

14.2.7 Shoreline Stabilization and Erosion Control

This beneficial use is not suitable for contaminated material.

14.2.8 Construction and Industrial Use

Construction and industrial uses of contaminated sediments include development of ports, airports, urban and residential areas, fill dikes, levees, parking lots and roads.

Applications

Fill. The dredged material in this beneficial use is used primarily for fill. In port developments, dredged material is used to create new dry areas for industrial development. In other construction uses, areas may be filled and leveled using dredged material. This option is very attractive environmentally because the sediments are generally capped by the development itself. Shoreline developments are also attractive because of ease of transport, and reduced water quality (groundwater and surface water) concerns.

Construction Aggregate. As an example of current beneficial uses in the research and development stage, dredged materials, particularly silts and clays high in silicate minerals and low in carbonates, can be used to produce light-weight construction aggregate. This light-weight fused product has a superior strength-to-weight ratio and can be used as an aggregate to produce light weight blocks, similar to cinder blocks. It may be used in the same way that sintered (heat welded) clay or pumice are currently used to produce construction block (Rhoads, Gordon, and Vaisnys 1975).

Concerns

Fill. There are minimal concerns about contaminant transport because material is capped by parking lots, buildings, etc.. However, wetlands development is limited to creating wetlands as habitat replacement mitigation, not destroying existing ones.

Construction Aggregate. Rhoads, Gordon, and Vaisnys (1975) showed that at the firing temperature (1050°C) organics (including contaminants) were thermally degraded. Most of the heavy metals are expected to be immobilized in the glass phases of the sintered mud. However, mercury, cadmium, and lead are expected to be released into the stack effluent during fusion. One concern is the potential air pollution problem with sediments containing high concentrations in these three metals.

The fusion option has not produced a usable commercial product. Production of light weight aggregate from marine muds was done in a commercial brick kiln but in small quantity. Initial evaluation of the resulting product by the brick-making industry acknowledged its potential use as a building product.

Examples

Harbor/Port Development. This is one of the most common uses of dredged material. Dikes are built and fill is used to create industrial sites. The Presidents Island-Memphis Harbor Project is a good example of dredged material used to create thousands of acres of industrial area. Another example is creating a foundation above floodplains (Portland, Oregon and Vicksburg, Mississippi).

Residential and Urban Use. Some examples include:

- the City of Galveston, constructed almost entirely on dredged material,
- residential areas in the Bronx, New York and shopping centers in Portland, OR, and
- airports in New York City; Grays Harbor, Washington, and Portland, Oregon.

Engineering Considerations

Fill. In-situ dewatering of sediments for fill would almost always be required. At upland locations, measures to protect groundwater supplies are generally used.

Construction Aggregate. For production of construction aggregate, dewatering is necessary to reduce the mud water content to 10-30%. This produces a plastic material that can be shaped or extruded into pellets. Desalination is not necessary since only 3% of the initial salts are retained after firing.

The engineering aspects of a portable on site incineration plant has been explored and demonstrated in the EPA Superfund Innovative Technology Program (EPA 1989).

Limitations/Management Strategies

Fill. Shoreline development is relatively free of ground water/surface water problems. Capping is included in most project designs.

Construction Aggregate. The use of dredged material for construction aggregate is limited by the structure and mineral composition of the starting material for production of a high quality product. However, there appears to be many coastal sites that contain appropriate material for this option. The most serious limitation is that no commercial process currently exists to make this option attractive.

Conclusions

Industrial site development is one of the best uses of dredged material due to the sediment capping included in most projects. Possible ground water problems in areas with shallow groundwater supplies are major concerns.

The major appeal of fusion is that it can render polluted dredged materials inert. Therefore, thermal fusion is a treatment technology and provides a beneficial use for contaminated dredged material. Some cost recovery may be possible if the fused material can be used in a commercial product. Potential users of this product would have to be convinced that the treated material was inert when exposed to weathering and that no health hazards exist for long-term human exposure.

14.2.9 Multipurpose Use

Applications

Building a park and recreational development over an existing solid waste landfill using dredge material as a cap is an example of how several of the beneficial uses can be combined in a multipurpose project. Shoreline development projects hold the most promise in Puget Sound. Projects could combine the use of contaminated materials for industrial/real estate development with the use of clean materials for fish and wildlife habitat development.

Concerns

The greatest concern would be contaminant mobility by plants and burrowing organisms. The concerns tend to be dependent on the types of beneficial uses that are combined and where they are used.

Examples

Pointe Mouillee in western Lake Erie, Michigan is a confined disposal facility for contaminated sediment, and has been under development for over 10 years (Landin 1984). The project included construction of freshwater marshes, marinas, visitors center, public walks and areas, and fishing facilities. Islands for nesting birds were built of dredged material.

Another multipurpose disposal site is being constructed in Coos Bay, Oregon, where a large containment site with eight compartments and extensive cross dikes are being filled and dewatered incrementally. The site will ultimately be developed for port, industrial, residential urban uses, and parts of the site are scheduled for agricultural crops.

Engineering Considerations

The engineering considerations applied to multipurpose beneficial uses are the combination of those that apply to other beneficial uses.

Limitations/Management Strategies

A well-planned, well-integrated project, which may include use of both contaminated and uncontaminated dredged materials, is critical to shoreline development. Dewatering may be accomplished on-site.

Conclusions

Multipurpose uses are best suited to shoreline development with access to both contaminated and uncontaminated sediments.

14.3 CONCLUSIONS

The beneficial use of contaminated material is generally restricted by concerns about the transfer of contaminants into resource and human populations coming in contact with the disposal site. Restrictions on the use of contaminated material generally apply to most biologically active disposal site substrates in which contaminated materials remain exposed to the environment. Empirical tests of contaminant uptake by plants and animals are recommended to assess the potential for contaminant transfer. Beneficial uses involving no exposure of resources or human populations to the substrate are most suited for contaminated dredged material; these include strip mine reclamation and solid waste management, construction and industrial use and multiple purpose uses. An evaluation of the compatibility of various beneficial uses options of contaminated materials is offered in the next section.

14.4 BENEFICIAL USES EVALUATION PROCEDURE

The Confinement Alternative Assessment Procedure (CAAP) presents a means of evaluating alternative standards for confined disposal of contaminated dredged material in upland, nearshore and aquatic environments. It also suggests that beneficial uses assessment could be the final step in the alternatives strategy selection.

CAAP evaluates the contaminant pathways associated with dredging, transport and disposal techniques and identifies the dredging, dredged material transport and dredged material disposal alternatives. It then considers each pathway individually and combines the results (scores) to produce a composite score.

A modification to the CAAP procedure was developed based on the information given in this chapter. The following questions were asked to build a score sheet:

1. Assuming a confined disposal site (CAD, nearshore, upland) is required, what does the design look like?, i.e., what controls/treatment technologies does it incorporate?

2. Given #1., what effect is the beneficial use likely to have on costs and contaminant problems?

Each disposal option and beneficial use was scored by considering five evaluation factors: environmental safety (the opposite of contaminant hazard), engineering feasibility, historical precedences, public acceptance and available sites. A score of 0 (Low) to 3 (High) was given to each evaluation factor and weighted using a scale from 1 (Low) to 3 (High). Each score and weight were multiplied and the sum of the products tallied to produce a composite score.

The score sheets were filled out and the results summarized. The summarized score sheet reveals the optimal beneficial uses of contaminated dredged material: strip mine reclamation, construction and industrial use and solid waste management (Table 14.1). Habitat development and applications in forestry also provide promising contaminated dredged material disposal options. Except for strip mine reclamation, the other four categories of beneficial uses can be applied in Puget Sound.

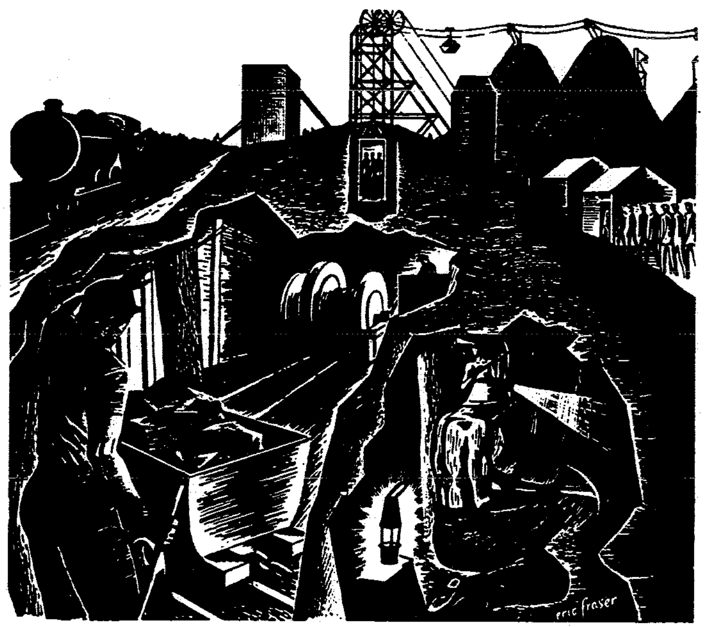


Table 14.1. Summarized S-4 beneficial use assessment procedure form.

DISPOSAL OPTION: CAD, Nearshore, Upland (Circle One)

DESIGN TYPE: Chemical Treatment, Control(s) - Cap, Liner, Cover, Other (Circle One)

BENEFICIAL USES: Habitat Development, Aquaculture, Foresty, Solid Waste Management, Strip Mine Reclamation, Construction and Industrial Use (Circle One)

PATHWAY: Water Column, Surface Water, Groundwater, Atmosphere, Direct Contact, Plant Uptake, Animal Uptake, Benthic (Circle One)

COMPOSITE SCORE:

Evaluation Factors	Score (S) (0-3)*	Weight (W) (1-3)*	S x W
Environmental Safety			
Engineering Feasibility			
Historic Precedences			
Public Acceptance			
Available Sites			

Total: ___________

Beneficial Use	CAD	Nearshore	Upland
Habitat Development	19	25	18
Aquaculture	--	19	17
Agriculture	--	15	20
Forestry	--	--	25
Strip Mine Reclamation	--	--	31
Construction/Industrial Uses	--	27	31
Solid Waste Management	--	--	31

*0 = none, 1 = low, 2 = intermediate, 3 = high

3 sites proposed for dredge spoils

Human And Environmental Risk From Toxic Marine Sediments

Furor on Burial of Dredged Sediment

Sleuthing scientist stalks Puget Sound's polluted fish

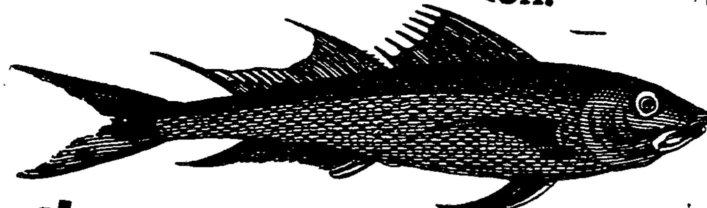
A PROJECT IN LIMBO

THE EVERETT HOME PORT

While Everett's Navy base faces judicial and legislative problems, proponents and opponents continue efforts despite uncertainty

Plans for underwater pits are drawing opposition.

Fishermen fear effect of dumping sludge near prime fishing grounds



dredge plan helps clean Sound

Public Involvement

Data gaps muddy the water over sediments

"We have to set reasonable standards that truly are to the best interest of the public."

— John Terpstra, Port of Tacoma executive director

15. PUBLIC INVOLVEMENT

15.1 BACKGROUND

Disposal of dredged sediments in Puget Sound became an issue in the early 1980s with the convergence of several events questioning the Sound's water quality. In 1984 two major dredged material disposal sites, in Elliott Bay and Port Gardner, were closed due to public concerns about contaminants and possible effects on marine organisms. At about the same time, research revealed contaminants in marine sediments and biological abnormalities such as liver tumors in bottom fish. It became apparent that toxics entering the Sound are not flushed out as previously believed, but remain in bottom sediments.

Extensive media and political coverage led to several corrective measures, including giving broad water quality management power to the Puget Sound Water Quality Authority. The U.S. Environmental Protection Agency established the Puget Sound Estuary Program to identify water and sediment quality problems and to promote cleanup actions.

Historically, sediment disposal decisions have been made on a case-by-case basis with little consistency or certainty. In 1984 the Puget Sound Dredged Disposal Analysis (PSDDA), a multiagency effort headed by the U.S. Army Corps of Engineers, began to address this lack of standards. It set out to identify acceptable locations for unconfined disposal of sediments, to develop adequate site management plans, and to define consistent and objective evaluation procedures for dredged material. This four-and-one-half year study included extensive public involvement.

PSDDA established standards for sediment contamination and identified disposal sites for sediments meeting its definition of uncontaminated. However, no disposal sites or standards were available for the large volume of sediments not clean enough for open water disposal but not requiring disposal as dangerous waste. As described in Chapter 1, the Puget Sound Water Quality Plan addressed this need by requesting Ecology to develop standards for confined disposal of these sediments.

15.2 AFFECTED AUDIENCES

The proposed standards for confined disposal of contaminated sediments will potentially affect numerous agencies and organizations. The affected groups fall into five major categories:

- dredgers, agencies or businesses who use disposal facilities either regularly or occasionally
- businesses or agencies which provide dredging or transportation services
- current or potential operators of confined disposal facilities

- regulators and tribal governments charged with some aspect of oversight of dredging activities or dredged sediment disposal facilities

- environmental organizations and the general public

In some cases these categories overlap. For example, a government agency with regulatory responsibilities may also undertake dredging projects and share the concerns of other dredgers.

Ecology developed a mailing list early in 1988 when standards development began in earnest. Outreach began to all identified constituent groups at that time, including consistent mailings of technical documents and executive summaries as they were developed. All the groups were invited and encouraged to participate in the Standards Development process.

Following is a brief overview of some of the groups identified and some of their primary interests in the standards development process.

15.2.1 Dredgers

Potential users of disposal facilities are perhaps most interested in the proposed standards. They face the need for predictable, safe disposal and have the most to gain, or to lose, from changes in dredging and disposal guidelines. This category includes port districts, the Washington Public Ports Association (WPPA), the Corps of Engineers, the U.S. Navy, marinas, boat repair facilities, local and state governments, industrial/ commercial transportation, waterfront industrial facilities, private citizens and developers, and companies responsible for cleanup of contaminated sediments. WPPA and the ports of Seattle and Tacoma have been especially active in the standards development process. Other groups such as the Northwest Pulp and Paper Association or marina owners may become more involved as they become more aware of the draft standards.

Dredgers are concerned that disposal options be practical, cost-effective, and available when needed. They often use dredged sediments for their own development purposes and want to retain this option. Other concerns are liability and the reasonableness and consistency of the regulatory process.

15.2.2 Dredging Businesses

Companies that supply and operate dredges, tugs, barges, pipelines and trucks will also be affected because the standards specify certain methods for dredging and transportation as well as for disposal sites. Their primary concerns are likely to be that the standards be based on available and proven equipment, and procedures and that costs be reasonable enough that the number of dredging projects will not decrease.

15.2.3 <u>Regulators</u>

Indian tribes and agencies with direct or indirect regulatory authority also have an interest in standards development. These agencies include:

- Environmental Protection Agency
- National Oceanic and Atmospheric Administration
- National Marine Fisheries Service
- National Fish and Wildlife Service
- Department of Ecology
- Department of Fisheries
- Department of Wildlife
- Department of Natural Resources
- Puget Sound Water Quality Authority
- Shoreline Hearing Board
- Municipality of Metropolitan Seattle (Metro)
- County governments
- City governments
- Health departments and districts

<u>Tribal governments have authority over their lands and are interested in environmental and land use issues</u>. They are also concerned with safeguarding the fishery resource and maintaining their ability to fish unhampered in their usual places. The Northwest Indian Fisheries Commission represents many tribal interests relative to fisheries, but there is no single entity to speak for all the tribes.

<u>The primary interest of regulators is environmental protection, in accordance with their individual mandates</u>. <u>City and county governments</u> are concerned about land use, transportation, potential public health impacts, solid waste disposal, and landfill operations. They <u>have been less actively involved in sediment issues than have other agencies, but this may change</u> if possible impacts on landfills or public health become apparent. The Department of Natural Resources (DNR), the major owner of aquatic lands, also has land use concerns. A DNR representative has been an active participant throughout the process.

Public agencies with regulatory responsibilities may sometimes have their own dredging projects and share the concerns of other dredgers. Agencies may also own and/or operate confined disposal sites (particularly landfills), facing the same issues as other owners and operators. DNR has particular concerns about liability for others' chemical substances because they manage state-owned lands where aquatic, nearshore, and upland disposal sites may be located.

15.2.4 Environmental Organizations/General Public

The third major interest group is environmental organizations and the general public. several individuals from the Washington Environmental Council and the Sierra Club, with specific expertise, have occasionally been involved in sediment and dredging issues. Groups with particular interest in water quality, fisheries, or waste disposal may become involved when more information on the draft standards is distributed. This may include organizations such as the Puget Sound Alliance, county solid waste advisory committees, or the Commencement Bay Advisory Group.

The general public has shown relatively little interest in sediment, dredging and disposal issues. Dredging and dumping activities have low visibility, and the environmental issues are complex. Water quality, which includes sediment management, has been the public's primary concern, but the importance of sediment contamination is not widely understood. Education in this area, reaching out to potentially concerned groups, is needed. Organizations with a general interest in environmental issues, water quality, fisheries or toxics are a logical starting point. Outreach techniques are discussed in Section 15.4.

Community groups and individuals near potential disposal sites become more active when specific issues arise. Examples include potential damage to crabs in Port Gardner, possible interference with fishing activities or resources, or perceived beach contamination from the Four-mile Rock disposal site. Community interest will probably increase when specific locations for disposal sites are being identified.

15.2.5 Owners and Operators

Most CAD and nearshore confined disposal sites are owned by DNR, which controls most of the aquatic lands in the state. These sites are often operated by individual ports or other waterfront property owners who use them primarily for their own dredging projects. Smaller quantities of sediments often go to existing landfills owned by private companies or county governments. Primary concerns of facility owners and operators are liability for chemical substances, monitoring requirements, costs, regulatory clarity and consistency, and operational feasibility.

15.3 ISSUES IDENTIFICATION

Issues differ from one disposal medium to another. Three disposal options are being considered for confined disposal: confined aquatic disposal, nearshore, and upland. Upland sites may be designed to contain contaminated sediments only or to mix sediments with either demolition debris or municipal solid waste. The dredging, transporting and dumping activities themselves raise additional issues.

One general issue worthy of attention is the public's perception of "contaminated" sediments as hazardous waste. Much publicity has focused on sediments from contaminated areas such as Port Gardner, the Duwamish River, Commencement Bay and

Eagle Harbor. The public appears to perceive sediments in general as harmful, with the expectation that they should be disposed of as hazardous waste. The possible impact of this belief is that only the most stringent disposal requirements would be found acceptable. Public education is needed to explain the relative degree of contamination found in sediments slated for confined disposal, showing that the level of contaminants is much lower than materials sent to hazardous waste disposal sites.

Other major issues that may arise are listed below. Each of these general areas has many specifics, such as questions about particular tests or types of environmental impacts.

- Generalized degradation of water quality, such as turbidity and increased contaminants in the water column
- Contaminant damage to marine resources including fin and shellfish, marine plants and benthic communities
- Physical damage to marine resources, such as burying or destruction during dredging and dumping activities
- Human health impacts, primarily through ingestion of contaminated fish and shellfish
- Interference with fishing activities by dredging or disposal close to fishing grounds
- Interference with shipping lanes by dredging or disposal activities
- Costs of testing, planning, permitting, site construction, dredging, transportation and monitoring
- Achieving a balance between costs and environmental and social impacts
- Practicality and efficiency of the permitting, siting, testing, dredging and disposal procedures
- Extent and type of testing required, including number, frequency and timing
- Extent and type of monitoring required
- Lack of scientific data to support criteria and the validity of specific tests
- Extent of additional environmental documentation required for dredging projects
- Length of decision-making and permitting processes
- Groundwater contamination from upland or nearshore sites

- Truck traffic and noise from upland sites

- Establishing standards without a regular review procedure to update them as new data and technology become available

- Use of scarce landfill space for contaminated sediments

- Risk of assuming liability for others' chemical substances

- Long-term costs of operation and associated economic risk

- Continued regulatory uncertainty

- Possible decrease in opportunities to use contaminated sediments for specific purposes such as port development

When specific sites are selected, additional issues may arise, especially appropriateness of land use, harm to local marine resources, or operational concerns such as noise, traffic and dust.

15.4 PUBLIC EDUCATION/INVOLVEMENT PLAN

The public involvement and education activities have so far been focused on bringing all affected groups into the process of developing the standards. The objectives are:

- Educating the public about sediment issues and increasing awareness of their importance in the ecology of Puget Sound.

- Educating interested and potentially affected parties so that they are to be knowledgeable about the proposed rules and thus prepared to comment on them.

The most interested parties, such as the ports, have participated actively in the process. Their continued involvement is built into the process. However, others who are potentially affected apparently have not had the interest or time to participate. Technical discussion of the standards is not likely to attract the general public or those only slightly interested to public meetings or workshops.

Ecology needs to define the appropriate extent to which the general public can be made aware of sediment management issues. The appropriate level of effort can then be discerned. An aggressive mailing program and active pursuit of opportunities to make presentations to key organizations that should be considered. Outreach efforts using written materials, displays and media contacts will be needed to educate the public as a whole about sediments.

15.4.1 Site Specific Issues

The process of developing standards for confined disposal of contaminated sediments will not identify specific disposal sites. Significant public concerns and possible strong opposition may arise when disposal sites are actually selected. This public information and education program is not designed to address site specific concerns. In such a broad planning effort it is impossible to reach all communities that may host disposal sites in the future. However, having clear procedures and standards, developed in consultation with local governments, environmental groups and interested citizens, will serve as a solid basis for selecting specific sites and explaining needs and environmental protection measures to affected communities.

15.4.2 Rule-making Process and Schedule

Because of requirements in the Puget Sound Water Quality Management Plan, a process is being used for enacting the proposed standards into final rules. The first stage focused on scientific studies to develop a technical basis for the proposed standards. The second stage is resolution of policy issues through a multiagency confined disposal workgroup.

A draft report summarizing the standards for confined disposal sites, with draft recommendations, became available for public review in August 1989. Scoping for the draft environmental impact statement also began in August, with the draft document to be completed in December and finalized by May 1990. Additional detail on the process and schedule is contained in the next section.

15.4.3 Previous and Current Activities

Several educational activities have already been undertaken:

- Ecology hosted a workshop in June 1989, to provide basic background on the development of confined disposal standards. Approximately forty people from the most interested groups participated, including the Corps of Engineers, the ports, Ecology, and several other regulatory agencies. Some groups were under-represented, including local governments and environmental organizations.

- The Puget Sound Water Quality Authority presented a day-long seminar on sediments in early June; many of the interested groups attended.

- Ecology has compiled a mailing list of approximately 3,200 people and organizations interested in sediments or Puget Sound-related concerns.

- Ecology has mailed a general fact sheet on its sediment projects to 400 people. Another update is being prepared for distribution.

- General fact sheets on sediments and the confined disposal standards and a glossary have been prepared and distributed.

- Two advisory groups, the Technical Advisory Group (TAG) and the Sediment Advisory Group (SAG), representing a variety of agencies and industry and environmental groups, are kept informed of the project and will review draft reports. The TAG worked on issues with considerable technical detail. Increased involvement by these groups when the draft report and interim rules come out will be important comment opportunities because these groups represent the most affected and informed parties.

15.4.4 Recommended Activities

The following additional educational and involvement activities are recommended, listed in approximate chronological order:

- Present the draft report to the Technical Advisory Group for their review and comment.

  Timing: July-August 1989

- Update Ecology's sediment mailing list and add people and organizations that are missing. Make a project sub-list of those who may have particular interests in sediments other than water quality in general. Some examples of groups that may be included are previous applicants for Corps of Engineers dredging permits, citizen advisory groups for solid waste issues and for relevant projects such as the cleanup activities at Commencement Bay and Eagle Harbor, and community groups that have shown previous interest.

  Timing: January 1990

- Prepare the draft report and an executive summary for public review in a format and style suitable for non-technical readers. Highlight issues, advantages and disadvantages, and include questions to encourage comment on specific aspects. Distribute to key organizations and individuals and to those who request it. Publicize the report's availability in news releases.

  Timing: Autumn 1989

- Hold a scoping meeting for the draft environmental impact statement. Publicize through a news release and a clear, informative scoping notice sent to a broad range of potentially interested groups and agencies.

  Timing: August 1989

- Prepare a brief FOCUS sheet describing the purpose and scope of the standards. Send to the project mailing list, with an invitation to request more detailed information.

  Timing: August-September 1989

- Write brief articles about the standards, their purpose and the review process; send to newsletters of relevant environmental and trade associations. This will be to encourage interest, review of further materials, and comment on the standards.

  Timing: Through promulgation

- Hold a technical workshop to familiarize interested participants with the provisions of the proposed standards.

  Timing: January 1989

- Prepare a slide show presenting an overview on sediments, their role in Puget Sound, contamination levels and as much information as possible on the purpose, substance and impacts of the proposed decision model and standards.

  Timing: September 1989

- Solicit opportunities to speak at meetings of potentially interested organizations rather than relying on their coming to public meetings. Target presentations to groups that have not been very involved in the process: small and intermediate dredgers such as marinas; local government decision-makers who are not accustomed to considering sediments but are responsible for issuing permits; and environmental organizations. These may include organizations such as the Washington Association of Counties, American Public Works Association, Association of Washington Cities, Washington Environmental Council, the Puget Sound Alliance and other groups concerned with waste disposal or water quality.

  Timing: October 1989-February 1990

- Present the interim rule, the documentation report and the draft EIS to the Sediment Advisory Group and the Ecological Commission for their review.

  Timing: December 1989

- Hold an informal public meeting to explain the proposed standards and seek public comments. Publicize through the fact sheet and news releases. Inclusion in organization newsletters is especially important, so follow-up telephone calls should be made to key groups.

Timing: January 1989

- Solicit written comments through a feedback and comment form distributed at the meetings. Include an address for comments in all mailings.

  Timing: August 1989-March 1990

- Distribute draft EIS for public review. Request comments through a mailing and through public hearing notices.

  Timing: January-February 1990

- Hold a public hearing on the proposed standards and the draft EIS at a convenient time and location for public comment. Seek written comments as well.

  Timing: March 1990

- Prepare a responsiveness summary containing all written and verbal comments and Ecology's response to them.

  Timing: May 1990

The preceding actions will allow ample opportunity for comment by those who have been involved and will meet the requirements for final rule-making. At the same time, they will draw in other potentially interested parties and educate them about the importance of sediments, the issues faced in this project, and the solutions developed.

15.4.6 Long-Term Education Activities

The previous section described activities needed to inform interested parties about the confined disposal standards and obtain comment on the draft standards. However, a broader effort to educate the general public about sediments, their role in Puget Sound, contamination levels, and disposal is also needed. This is a long-term education effort not directly related to the short time frame of standards development; many of these activities will take several months or longer to plan and implement effectively.

Sediments should not be viewed as an isolated issue, but explained in terms of Puget Sound as a whole, a major public concern. The most effective approach is to coordinate with other water quality education activities, especially those sponsored by Ecology and PSWQA. Because of the importance of dredging to economic development and industry, sediment issues also present a good opportunity for cooperating with ports and private entities on educational ventures.

Several education and information ideas are being proposed:

- Develop a full range of educational materials on sediments, as described in the 1989 Puget Sound Water Quality Management Plan. This should include information on physical characteristics of sediment particles, contamination levels and distribution, effects on organisms, dredged material management, and the ecology of bottom-dwelling organisms. Materials should be attractive and easily understood by the general public. Examples and illustrations should be used to explain problems and solutions vividly. A full-color 8-1/2 by 11-inch brochure explaining sediment issues and ecology could be the primary piece, supplemented by more detailed Focus sheets or brochures.

- Write a brochure focusing on personal actions that can improve sediment quality and include this information in displays and other materials whenever appropriate.

- Identify and prioritize other educational activities throughout the region which should be coordinated with; PSWQA and Ecology have extensive information on water quality programs.

- Approach television stations and major newspapers to produce feature stories and documentaries on Puget Sound today. Previous stories were instrumental in getting government action to study and clean up the Sound. Now it is time for an update, telling people what has been done, what has been discovered, what regulations have been passed, and what remains to be done. Sediment studies and disposal would be one aspect. This is a feasible objective that would tie in well with other events such as the Alaska oil spill and Environment 2010.

- Produce a video in addition to the slide show. The topic lends itself to video since dredging, dumping, marine life and sediments themselves can be shown to good effect. This could include topics such as why dredging is done, how and where it is done, what sediments are like, and what is done with them, what levels of contamination are present and how these compare to other contaminated substances. The video could be used at presentations and displays.

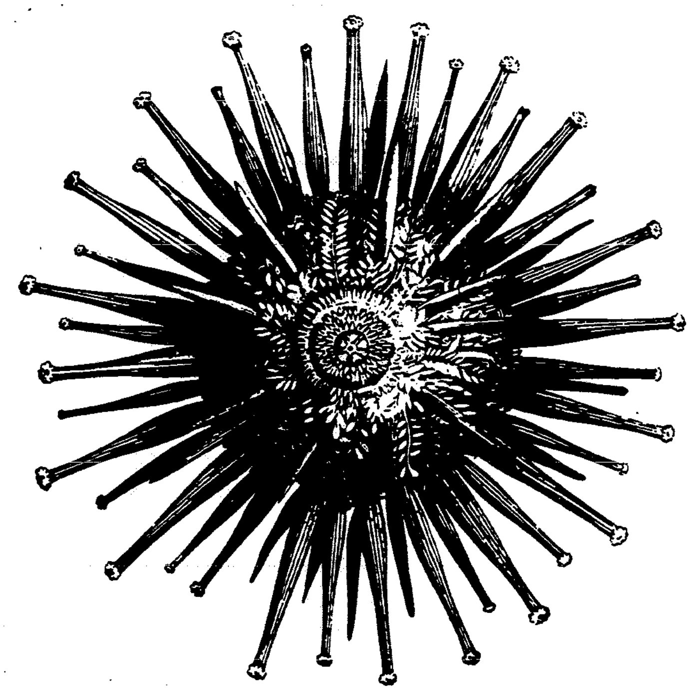
- Construct a first class educational display explaining sediments, contamination and disposal. Arrange to show at the Seattle or Fort Defiance aquariums or at one or more of the ten other existing interpretive centers. Such a display could include samples of sediments, maps of their locations, pictures of dredging projects, and an explanation of their role in the Sound. Provide printed materials and simpler displays to the other interpretive centers as well.

- Prepare one or more portable displays for use at trade and environmental fairs and similar events. These could be supplemented with brochures, maps and fact sheets to provide additional information. This display could also be integrated into educational programs presented on the Washington State ferries.

- Distribute a small tabletop display and informational materials to interested groups staffing their own displays at fairs. This would reduce Ecology's staffing needs and broaden exposure to sediment information.

- Review existing environmental curricula for schools and prepare appropriate materials on sediments to be included. Distribute materials to science teachers at all levels including college.

The activities suggested above will meet the three objectives of the program by providing education and comment opportunities for interested parties while developing a long-term sediment education effort for the general public.



CHAPTER 16

RESPONSE TO COMMENTS

AUGUST 28, 1989

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Mr. Tom Schadt
Parametrix, Inc.
13020 Northup Way
Bellevue, Washington

Dear Mr. Schadt:

This letter documents changes and additions to Ecology's coordinated comments on the Phase 2 reports, which we discussed in our meeting last week. We gave you our original, marked-up documents from the Corps' and other reviewers, which you should refer to as an additional source of comments. I will need these comments returned when the final report is complete.

As we agreed, please address the major comments first. This letter summarizes our priorities. If you have any questions regarding these major comments or some of the comments from other agencies, please call me so we can discuss.

We also agreed that you would include in the final document a "comments/ response summary" that indicates the manner in which significant comments were addressed.

<u>Overall comments</u>

The documentation report needs to be edited:

* to remove unnecessary redundancy.

* to remove information not directly applicable to the focus of a chapter or section.

* to integrate all chapters, clearly indicating to the reader. what stage of the decision model is being illuminated.

* to provide smooth transitions between chapters & sections.

* to provide white space at the end of subsections to clearly define beginnings and endings of sections.

* to highlight key phrases (recommendations, key points)

* to include straight sequential numbering of the pages.

* to tighten sentence/ paragraph structure in favor of short, clear statements minus "clutter words" (per Zinnser.)

* to make explicit reference, where possible, to Technical Advisory Group input.

* to make reference citations consistent throughout report.

Consider adding a few paragraphs to the beginning of each chapter which introduces new and key terms used in that chapter, putting them in context to further illuminate their meaning.

Chapter specific comments

Chapter 1:
Include Ecology version of introduction as provided in Coordinated Comments Document, 24 August 1989. Describe where we are in the overall process of standards development by reference to past and future milestones.

The Decision Model should either be in the introduction chapter or in a separate chapter, early in the document. Likewise, consider adding a summary on Technical Studies chapter, to provide context with the current text by describing "what's out there."

Functional and effects based design need to be clearly explained here and context provided so there is no confusion as to the pros and cons of each, and their intended applications are easily understood. Reference to Chapter 3 should be made regarding what materials require confined disposal.

Chapter 2
The information in this chapter needs clearer focus on siting. Much of the current presentation either goes too much in detail, almost becoming more "standard" related, or not far enough to be a "siting guideline." Please clarify, throughout this chapter.

After acknowledging the Corps' "Dredged Material Alternative Selection Strategy" (DMASS), go on to describe how and why PASS was developed and how it augments the limitations we saw in DMASS.

Siting guidelines should be organized by environment, especially the "considerations" and "performance criteria." Please reorganize accordingly.

The report should contain thorough analysis of the environmental effects and costs of each alternative for each environment. This analysis should be in text form, to support development of the EIS. The effects/costs of the "No Action" alternative, though more difficult to define, should also be discussed.

Monitoring: The report needs to address the purpose of monitoring, i.e., the hypotheses underlying the proposed techniques/frequencies. Also, the interpretation of monitoring, the management response triggers/actions, should be addressed.

Chapter 3 & 4

A clear description is needed for how the requirements for testing address the early part of the decision model... how a proponent knows they have "clean" or "dangerous" sediment, and so whether it is subject to the remaining part of the model.

Please consider combining portions of these chapters together to integrate the related elements of pathways, dredging and transport requirements, serving as a chapter on an overview of the dredging/disposal process.

In text on testing, address comments regarding accuracy and clarification of terminology. Purposes of chosen tests need further illumination.

Emphasis on environmental effects of dredging and transport technologies needs to be clearer in text on these topics.

The relation of "upland/mono/unlined" to "functional design" needs needs to be addressed in this chapter and in the decision model discussions. Per our meeting, the UP/MD/UL should probably be moved to the "OK for conventional/clean" box coming off the initial characterization process/

Chapter 13
The cost comparison work needs to be expanded. Comparison of costs between alternatives within an environment was specifically called for and needs to be added.

As we agreed, please prepare a cost estimate for funding needed to address the comments, and get it to me no later than September 1, 1989. Again, please call if you need clarification on any of this. Thanks, Tom!

Sincerely,

Jeffree R. Stewart

Jeffree R. Stewart
Sediment Management Unit

LETTER NO. 1

WASHINGTON STATE DEPARTMENT OF
Natural Resources

BRIAN BOYLE
Commissioner of Public Lands

OLYMPIA, WA 98504

Jeff Stewart
Sediment Management Unit
Central Operations
Department of Ecology
PV-11
Olympia, WA 98504

August 11, 1989

Dear Jeff:

Here are my comments on the draft report on Recommended Standards:

(1) 1. p 14. I don't agree that a bottom dump barge is the best method for placing the cap. I would prefer to see a distance element inserted in the proposal. If the site is within X feet of a source of capping material then a hydraulic dredge would be used. Otherwise the material would be pumped out of a barge. The last resort would be as is currently recommended. My concern is with "bombing" of the site if the doors on the barge are not properly cracked open.

(2) 2. p 15. You have argued previously that you can't dredge in water depths greater than 100 feet because of loss on removal. How can you dispose of the material at 200 ft and expect to retrieve it should the cap fail in a satisfactory manner? The depths should also be no deeper than 100ft for a CAD site.

(3) 3. p 16. The capping material must meet P-2 standards not PSDDA. Interim capping material could meet PSDDA but the final should meet P-2.

(4) 4. p 17. Water depth: See earlier comment.

Bed Stability: Stability must be assessed using the most current and relevant information collected from the site in question. Historical data would not normally be adequate.

Design Volume: The lower volume limit should be restricted to that volume which would be cost effective to place and monitor. I don't believe that 10,000 yds is enough.

Cap Sediment Quality: See # 3 above.

(5) 5. p 18. A hydraulic check valve should be a must.

(6) 6. p 19. The target area should not be like PSDDA but rather a series of cells so as to contain the material as much as possible.

How is cap placement going to be checked prior to the second lift?

Operational controls should be part of the standard.

(7) 7. p 20. Dredging monitoring should be so as to prevent a certain % of the material from leaving the site or it must also be traced and capped. High accuracy positioning should be used in all phases of the dredging process.

(8) 8. p 22. Borings should evaluate more in detail the one foot interface between the contaminated sediment and the cap.

Need more detail on the biological sampling and analysis.
(9) Surface recolonization and chemical creep within the cap must be addressed.

9. p 26. Need to specify tests to be sure dike is filtering out all of
(10) the contaminants.

There should be a standard to define how much and of what quality can come over the weir. To much material would have to be cleaned up.

(11) 10. p 29. Should add loss of material standards to dredging site monitoring section.

(12) 11. p 50. Any work plan that involves state owned aquatic land must be submitted to DNR for approval and issuance of a use document.

(13) 12. p 51. What is the bioturbation test? Why isn't this part of functional design? It must be.

(14) 13. p 52. Should have a test that predicts the amount and quality of sediment that would be lost over the weir.

Sincerely yours,

David W Jamison, Ph.D.
Senior Marine Scientist
Division of Aquatic Lands

RESPONSE TO LETTER NO. 1: WASHINGTON DEPARTMENT OF NATURAL RESOURCES

1. Comment noted. See text revision in Section 9.2.2, **Cap Placement**.

2. Comment noted. See text revision in Section 9.2.2, **Dredging Depth** and **Operational Control.** Also, reference Letter #3, Comment #57.

   Sediment loss caused by depth of dredging is relatively minor compared to other factors. Loss associated with depth is also a function of rate of retrieval and currents in the water column. Controlled operation of dredging at depths of 100 or 200 feet can limit material loss to less than 1%. The depth factor was given a low to moderate rating in the CSDAP analysis, and has a minor impact on environmental score.

   A depth of 200 feet for contaminated sediment removal and for CAD siting is recommended. A depth of 200 feet is based primarily on dredger ability and secondarily on loss from the bucket during retrieval. This appears environmentally acceptable while providing consistent standards for both initial dredging and future need to remove materials from a failed CAD site.

3. Text was not modified. Use of P-2 or PSDDA criteria for cap materials was given long discussion during the completion of the draft confined disposal standards. The draft standards document was completed with the intent to avoid conflict with existing State and Federal standards. At present the standard for in-water disposal is PSDDA. P-2 standards are being developed. It is not known if the final P-2 will be the same, greater or less stringent than PSDDA, and therefore will or will not provide the same level of protection as PSDDA requirements. Resolution of this may be necessary following the completion of the P-2 standards. At this time the PSDDA standards are considered most appropriate, both environmentally and politically.

4. Water Depth -- see Comment 2 above.

   Bed Stability -- Comment noted. See text revision in Section 9.2.2.

   Design Volume -- Text was not modified. Comment is noted, and your concern about 10,000 cubic yards as being cost effective for CAD site is reasonable. The volume was established to provide a lower range for functional design, and an upper limit for small project standards. It was derived from the aspect of dredging project size as well as apparent cost. Cost for each CAD application will be site specific, and can vary significantly with each application. The applicant must evaluate use of a proposed site and the CAD option against other disposal options to determine whether CAD is cost effective for them.

   Cap Sediment Quality -- See Comment 3 above.

5. Comment noted. See text revision in Section 9.2.2.

6. Target Area -- Text was not modified. Target area for release of sediments refers to positioning control of barge during release. It is a circle with radius of 500 feet or less. Dump position during the release must be within this circle. PSDDA target area is 600 foot radius. Your concept of a series of dump cells can be accommodated by specifying several locations for the release position. This would come from the site design and be related to water depths, bed conditions, material type. The PSDDA terminology was applied to provide consistent terminology from one standard to another.

   Second Lift Cap Check -- Comment noted. See text revision in Section 9.2.2, **Bathymetry**.

   Operational Controls -- Text was not modified. Operational controls as provided in the draft document were not codified because they are not always applicable. As an example the use of a taut line buoy may not be desirable if the disposal sites do have several release locations. Pick up and placement of the buoy could disturb the deposited contaminated sediments, or depth of the site would not be conducive to use of a buoy.

7. Dredge monitoring -- Text was not modified. Intent of functional standard is to limit or prevent contaminant loss through associated pathways, and limit or avoid biological impacts. This was accomplished for several reasons, one of which is the inability to assign a % loss impact relative to varied sediment contamination. Implementation of the confined sediment standards will provide for continued monitoring and better data in the future. Correlation with a per cent loss and corrective action is one of the goals to be derived from that monitoring. Specific monitoring to establish basis for corrective operator actions should be considered further in the context of the effects based design.

   High Accuracy Positioning -- Comment noted. See text revision in Section 9.2.2.

8. Text was not modified. Intent of core sampling and analysis is to establish cap success and contaminant creep based on one foot sampling increments. This was derived from sampling analysis to date of Duwamish, Simpson (Commencement Bay) and One Tree Island (Budd Inlet) CAD projects. Additional sampling at selected projects for prototype research purposes and confirmation of one foot increment monitoring is a consideration.

9. See text revision in Section 9.2.1.

10. Dike Contaminant Filtering -- Comment noted. See text revision in Section 9.3.2.

    Quality Over Weir -- Comment noted. See text revision in Section 9.3.2.

11. Comment noted. See text revision in Section 9.3.2.

12. Comment noted. See text revision in Section 9.2.

13. Bioturbation is a pathway, not a test. The only test we are aware of that directly assesses bioturbation is cap thickness. This is an innovative test WES is working on, it takes a relatively long time to run (6 weeks), and is costly. For these reasons, we have not incorporated it as a functional design requirement.

14. Comment noted. This is already required under sediment retention design. The design methods under EM 1110-2-5027 requires column settling testing used to design site suspended sediment loss of less than 100 milligrams per liter. This is also included in the initial characterization testing.

LETTER NO. 2

WASHINGTON
PUBLIC
PORTS
ASSOCIATION

August 14, 1989

Mr. Jeffrey Stewart
Department of Ecology
Sediment Management Unit
Mail Stop PV-11
Olympia, WA 98504

Dear Mr. Stewart,

This is a comment letter on the draft report titled Confined Disposal of Contaminated Sediments: Documentation of Standards Report. The Washington Public Ports Association appreciates this opportunity to review and comment on the development of these standards.

General Comments

The Department and its consultants are to be commended for the large improvements this report contains over the earlier versions of the document. There is much more evidence of technical consistency throughout the document, and the general policy direction has been improved.

(1) However, there is still little explicit recognition of the lack of current problems with existing confined disposal sites. As I mentioned in my letter of March 2, 1989; we need to be more clear about what is wrong with the current method of operation. It is not in the public interest to have increased bureaucratic procedures and sediment testing without clear environmental benefits.

It is in the combined interests of the port districts and the Department of Ecology to facilitate the disposal process as much as possible. True improvement in the process will help the ports by allowing easier maintenance of navigation channels and terminals, and will help the Department of Ecology by minimizing the contaminated material's exposure to the environment.

Siting Guidelines

(2) The primary concern with siting guidelines is the possibility that they will unnecessarily restrict viable disposal options. Have you applied these guidelines yet to known potential disposal sites in Puget Sound in order to assess their impact? This would be a very important exercise for the Department to perform.

3 In addition, the sentence on page 2-2 of the draft report which reads "The permit review will use the siting restrictions as a means of permit denial" is of some concern. Which permit review is the report referencing? The next sentence adds confusion: "This evaluation is preliminary in the decision making process and will be followed by a more detailed analysis as provided for in these standards, NEPA and SEPA."

4 The Department of Ecology does not have the authority to deny proposals prior to the environmental review process. Is a new and additional permit process envisioned for this program? If not, what is meant by the phrase "as provided for in these standards?"

Testing Procedures

5 Page 9-3 of the draft report states "Upland disposal will follow the chemistry testing protocols for WAC 173-303." This is a potentially confusing requirement, as a variety of tests could be considered appropriate. Will this testing be done at the discretion of the local health department, or the project applicant, or another entity?

6 Also, it seems odd to require the comparatively crude screening tests (such as gravimetric PNA, and Parr bomb test for Halogenated Hydrocarbons) as a follow-up to the more refined gc/ms analysis required under PSDDA. In the past, Ecology has accepted addition of individual PAH's from the gc/ms analysis as a substitute for the PNA/HH screening tests. In this way, the "totals" calculated under the PSDDA tests should suffice. It is possible, though unlikely, that a project proponent may attempt to pass by doing just the 173-303 tests. In any case, there is no clear rationale for requiring gc/ms testing prior to dangerous waste screening.

A further testing concern is that effects-based design testing should only be done for the pathways available at the site. I stressed this point when presenting the matrix at the last S-4 TAG meeting. Figures 10-1 through 10-4 appear to be lists of testing for all sites; but there should be an explicit emphasis on only performing tests that are appropriate to the pathways in question.

7 For example, there is an apparent requirement in the draft report for plant uptake studies for nearshore and upland sites. Most nearshore and upland disposal sites will be built with a cap, limiting the percolation of stormwater. In addition, many of these sites will end up being paved and used for marine terminals. No project proponent should be made to do plant uptake studies for a site that will be capped, as there is no plant pathway for contaminant release.

<u>Disposal Options</u>

There is come concern from the ports that hydraulic dredging has
been selected as the "preferred alternative" for nearshore
disposal. Does this mean that there will not be a proposed
functional design standard for mechanical dredging at a nearshore
site? Physical limitations (such as distance between dredging and
8 disposal sites) often limit the use of hydraulic dredging in Puget
Sound.

The Department should perform an analysis of the number of dredging actions in the past that have used hydraulic dredging equipment. If most projects use mechanical dredging, then will the functional designs only rarely be used?

<u>Functional versus Effects-based Design</u>

There is a continuing concern about restricting functional designs
to sediments with less that one-tenth dangerous waste contamination
levels. In many urban projects, it is likely that the proponent
9 will have one sample that exceeds this standard. Does this mean
that the entire project goes to effects-based design, or just that
"management unit"? This should be made clear in the final
document.

It is also important to analyze the proportion of past projects
10 where sediments have exceeded one-tenth of the dangerous waste
levels. This history would indicate how many confined disposal
projects would have been required to use effects-based designs.
The document should also be very clear about whether a project
11 proponent always has the option to choose an effects-based design,
even if all of the material is below the one-tenth dangerous waste
threshold.

I hope these comments are useful as you revise the draft document. I look forward to continued work with you and the consultants as we resolve these important issues. Do not hesitate to contact me if you have any questions.

Yours Truly,

WASHINGTON PUBLIC PORTS ASSOCIATION

Eric Johnson

Eric Johnson
Environmental Specialist

RESPONSE TO LETTER NO. 2: WASHINGTON PUBLIC PORTS ASSOCIATION

1. Comment noted. See text revision in Section 1.1.

2. Comment noted. See text revisions throughout Section 3. Intent of siting guidelines is to not eliminate any site. It is intended to provide a structure for the preliminary assessment of a site.

3. Comment noted. See text revision in Section 3.1.3.

4. A new permitting process is not envisioned. See text revision in Section 3.1.3.

5. Comment noted. See text revision in Section 9.1.1.

6. We understand and agree with the logic of the comment. It has been our experience, however, that compliance with WAC 173-303 requires performance of the specified tests. There is nothing to prevent a proponent from petitioning Ecology to accept alternative test results for waste designation.

7. The text of Section 10.2 states that tests may be required to address specific characteristics of each project. We believe this maintains sufficient flexibility for a proponent to establish which pathways and tests are applicable to their project.

8. Comment noted See text revision in Section 9.3.

9. Separation of a project into management units is acceptable; in reality it may occur frequently. The sediment characterization process is designed to identify management units that meet either the functional design or effects-based design. Following this determination, a proponent has the option to separate their project, or have the entire project go to an effects-based design. This has been clarified in Section 1.4.

10. A review of past projects suggested that the 0.1 Dangerous Waste levels was an appropriate level at which to limit functional design implementation and require effects-based design.

11. We concur with the comment. See text revision in Section 1.3.

LETTER NO. 3

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 SIXTH AVENUE
SEATTLE, WASHINGTON 98101

AUG 1 4 1989

REPLY TO ATTN OF:

WD-138

MEMORANDUM

SUBJECT: Technical Advisory Group Review of Phase 2 Report, Confined Disposal Standards (S-4)

FROM: John Malek *John Malek*

TO: Jeffree Stewart, Ecology

I've completed my review of the draft report, "Confined Disposal of Contaminated Sediments Documentation of Standards Development." My comments are provided by attachment. They reflect my review as a member of the Technical Advisory Group (TAG) and should not be construed as the comments of the Environmental Protection Agency. Owing to the time schedule, I am furnishing these comments as *draft* for your use. I also have provided these comments to others at EPA (i.e., Mike Stoner and Catherine Krueger) as draft. We may provide consolidated comments at a later time.

You will see immediately that my comments are not happy ones. The report is not well organized. The writing is confused and obviously different chapters were written by different persons with apparently no reworking. I am most disappointed with the paucity of new technical information and the failure of the document to synthesize existing information and to help us to move on from what we have learned. The problems have been handled as discrete, compartmentalized units with conventional, predictible results. There does not appear to have been much integration of the individual components into comprehensive approaches. While it is useful and necessary to address confined disposal issues under a microscope, at some point it becomes necessary to step back and put the several pieces together. And be able to explain *why* the pieces were strung together in that particular order.

I recommend that the draft report be refocussed, re-evaluated, and rewritten. There are policy issues that will eventually have to be referred to the Sediment Advisory Group but I do not believe that is necessary at this time. The revision of this document should receive another TAG-level review prior to being finalized.

I would be please to discuss my comments with you at your convenience.

Attachment

11<<<

bcc: Mike Stoner
Catherine Krueger
Bill Riley

DRAFT

WD-138

August 15, 1989

SUBJECT: Confined Disposal Standards (S-4) for State of Washington: Technical Advisory Group Review Comments

General Comments

(1) 1. In general, the document does not add significant information or technical justification for a number of recommendations (e.g., 3 foot cap) over what was presented in Phillips *et al* 1985, the Navy Homeport work by the Corps, or PSDDA 1988 and 1989. Document is extremely uneven. While there is a great deal of information presented, it is not always logical or straight-forward in its presentation. Also, there is little evidence of the information having been integrated, i.e., individual problems or objectives are addressed microscopicly, but not in terms of how those implications then effect the whole dredging and disposal problem. Much of the document is redundant and could use strong editing for brevity. Most of the concepts presented are fairly straight-forward, although their presentation is not.

(2) 2. Citations are haphazard and do not correlate well to the references. Also, it is not clear that citations are consistent throughout.

(3) 3. The document's tone and focus is misdirected. There is too much emphasis on "dredging and disposal as normally practiced." Either these sediments are sufficiently contaminated to be of concern or they are not. If not, then we are wasting our time and resources in attention to a non-problem. If so, then we have entered a new "business as usual" arena. Production, for instance, is a very critical factor for maintenance dredging of clean material because production translates to cost. Production is less a primary concern for contaminated sediment. Efficient production (getting the most contamination out without having to return for minor dressing) is of more concern. Safety and minimizing risk/impact to the environment and human health take on greater priorities. The objective of the activity is not merely removal of sediment from an inconvenient location, but includes effective confinement of that *recognized* potentially harmful material. A lowered production rate that achieves better containment or lower risk (e.g., dredging and placing the most contaminated material first) may well be appropriate. Accordingly, the entire operation should be considered comprehensively rather than as fragmented problems with cost implications.

Specific Comments

Page Comment

1. Introduction

1-5 Para. 1.3 Functional and Effects-Based Designs: The explanations of these concepts are critical to understanding use of the guidelines. A number of assumptions are embodied here and the explanations given overly sparse. "Most dredged material requiring confined disposal *is expected to be* only slightly (4) contaminated relative to the range of material eligible for S-4 (failing PSDDA to dangerous waste)." At this point, we have little hard data that this is true. The definition of *material* (5) *that would require confinement* has not been previously given; it should be provided prior to this.

The explanations for functional designs walks into the trap of "overdesign." Most persons familiar with disposal site or waste site terminology already carry a mindset towards overdesign. If a material has to be confined, the containment vessel is made a little stronger, less porous, etc. as a safety feature. This preconception is contrary to what is being defined by the functional design. "Overdesign" should be specifically called out, defined, and clearly stated is different from the functional (6) design as well as an explanation provided as to why overdesign is not the focus of these standards. This would be the appropriate location for such explanation.

2. Siting Guidelines

2-3 2.2.1 Key Federally-Mandated Regulations: A number of items discussed in this section are state rather than federal (7) regulations. Either the title should be expanded or the state authorities removed to the state section. (I.e., SEPA, Washington Solid Waste Management Act.)

The Clean Water Act (CWA) does not address "navigable waters"; its jurisdiction is described as "waters of the United States." In (8) the past, the Corps of Engineers attempted to *interpret* the jurisdiction of the CWA as navigable waters. This was corrected by court interpretation. All navigable waters are waters of the U.S., however, not all waters of the U.S. are navigable waters.

2-4 The paragraphs on the Fish and Wildlife Coordination Act and Endangered Species Act are out of place on this page. They should (9) be removed to later (following the discussions of the Clean Water Act) or explanation provided as to how they interact and relate to section 10 and 404 actions.

Specific Comments

Page		Comment
	(10)	Last paragraph: Compliance with the 404(b)(1) guidelines is mandatory in order to secure a 404 permit. The Corps does not "consider" the guidelines, but must find compliance with them. Thereafter, the *public interest* review is conducted and a finding made whether the proposed activity is in the public interest. With regard to section 10 permitting, it should be noted that the public interest review also includes compliance with the numerous federal environmental laws, etc.
2-5	(11)	401 Certification: Section 401 certification is a precondition to compliance with the Section 404(b)(1) guidelines. Compliance with the guidelines is required to receive a 404 permit.
2-9	(12)	Washington Shoreline Management Act: It should be noted that this is the formal mechanism for determining compliance with the federal Coastal Zone Management Act. (I do not feel that it is necessary to add the CZMA to the key federal regulations section.)
2-10	(13)	Acronym for the Puget Sound Water Quality Authority should be changed. It duplicates the one for the Act.
	(14)	PSDDA is a federal-state consensus program that derives its basic authority from the CWA. It should be appropriately relocated. A better explanation of its purpose and elements could be easily obtained from existing documents. Those document should be referenced. It is appropriate to note that PSDDA forms an important base to the implementation of the Authority's Plan and to the development of these confined disposal standards.
2-11	(15)	Last paragraph: An excellent, concise summary. It makes a much better topic paragraph and should have been stated up-front as lead-in to all the descriptions of various laws, regulations, etc.
2-12	(16)	Clean Water Act Section 401: It should be noted that the bolded sentence is not recognized as gospel by some federal agencies.
	(17)	Various cultural resource laws and regulations should be added to this section as the criteria are "most likely to provide <u>concerns</u> or "fatal flaws" during the siting process." Cultural resources or Native American religious use considerations may not constitute "fatal flaws" but can prove to be major siting impediments.

Specific Comments

Page		Comment
2-17	(18)	Flood Hazard: Use of the 100-year flood plain designation is a convenient but short-sighted convention. The greater danger of breaching will occur is associated with the larger floods (200-, 500-year events) which can result in movement of the channel. This should be expressed. The various scenerios do suggest the preference for locating such facilities outside of the flood plain completely. This concern is more associated with riverine than estuarine situations.
2-22	(19)	Considerations of the Native American Religious Freedom Act should also be included with the cultural/historic/archaeological resources.
	(20)	Direct Routes: The scenerios do not seem to logically fit the concerns. One of the considerations should be whether the existing transportation infrastructure is adequate (i.e., do now roads, railways, etc. need to be built)? Transportation and access should be addressed in the abstract. The second scenerio for "Truck"-only access appears inappropriate. The issue is with all transportation impacts and conflicts; accordingly, there is direct application to all the disposal environments. Believe this element should be rethought.
2-23	(21)	Aesthetics: I believe that this element is redundant with Potential Visual Impacts (page 2-19). These could be consolidated and clarified.
	(22)	Airport Safety: This ought to be consolidated with Direct Routes and converted into a comprehensive Transportation Effects element. It is difficult to believe that airport safety is directly applicable to CAD.
2-24	(23)	Functional Design Criteria: In general, the section does not specify performance *criteria* but identify design *restrictions* that are of optimum desireability. Within these parameters, *it is expected that the proponent will be able to perform without unacceptable risk to the environment* and *to human health.*
	(24)	Confined Aquatic Disposal: Water Depth: Depths greater than 200 feet **may** need *special* controlled placement. CAD, by its nature, does require controlled placement of materials (both the contaminated and cap materials).

Specific Comments

Page		Comment
2-25	25	Nearshore Disposal: Groundwater/Tidal Elevations: The presence of potable groundwater would be a constraint rather than an advantage. While this is not normally the case in nearshore areas (near marine or estuarine areas anyway) it should not be ignored.
	26	Bed Stability: This should be a factor similar to what is described for CAD.
	27	Confinement Structures: Design of these structures should be such as to withstand the (200-/500-year) flood event. Confinement structures should incorporate X monitoring wells per (acres of fill/linear feet of confinement structure/etc.)
2-26	28	Upland Mixed and Mono: Bed Stability should be added (see similar comment for Nearshore). Flood Plain considerations should be added, though this may be able to be construed as part of bed stability. Biological conditions should also be added. Perhaps an emphasis could be added toward use of existing sites that have already been seriously degraded as wildlife habitat. The impression left otherwise is that upland disposal has no environmental problems. That perception is not true.
		3. Potential Sediment Characterization Tests
3-2	29	Table 3-1: "Dredging/Disposal" should be changed to "Dredging". Biological Uptake pathway should be "X" for Dredging. Uptake would typically occur through the water column and through resuspension of dredged material (see figure 3-1). In most cases (for functional designs) this concern should be minor.
3-9	30	Table 3-3: Note 2: For upland destined sediments, drying **must** occur.
	31	Table 3-4: Rainfall Simulator and Cap Thickness tests: Preliminary (and very conservative) costs are provided by the Navy Homeport experience with WES.
3-10	32	CAD: Last sentence: In the Navy Homeport work, we found that neither the usual Standard or Modified Elutriate tests by themselves provided sufficient information. The standard elutruate test looks at dissolved constitutents only after an hour of settling. The modified elutriate test looks at both dissolved and totals after 24 hours of settling and is more appropriate to evaluation of effluent from nearshore sites. What was done was to look at both dissolved and totals after an hour of settling. This is different from either protocol as presently written.

Specific Comments

Page — **Comment**

(33) Nearshore: The *modified* elutriate test would address the effluent pathway.

Upland: The *modified* elutriate test would address the effluent pathway. It is doubtful that standard bulk chemistry testing would be terribly useful in evaluation of airborne emissions without further thought and adjustment. Airborne emissions should be a concern only when the site is not covered. Perhaps if the (34) sediments contain high levels of volitile chemicals there would be immediate human health and environmental risk. In such a case, effects-based testing and design would be needed. Otherwise, the major risk is through wind-borne loss of fines. While we presume that this sediment fraction loss would result in equivalent loss of contaminants, standard bulk chemistry is not going to provide us with any useful answer.

3-12 (35) Table 3-5: Add "X" to "Might be applicable for engineering design" column for Cores or Borings and Bathymetric survey.

3-13 Initial Characterization: Biological: Most of the tests identified are pertinent to the marine or estuarine system. There are a few freshwater biological tests that would be more appropriate to many nearshore situations and most upland (36) situations where effluent or leachate return to surface waters is anticipated. These include *Daphnia*, fXathead minnow, rainbow trout or salmon species, etc. Their use would not be expected for every disposal, but they should be noted as potential tests needed for design of a site.

(37) Test Interpretation Needs: Since everything is referenced to Chapter 9, I see no need for this section. Recommend its deletion.

3-14 Functional Design: Fourth sentence: This is the expectation. If the fifth sentence proves to be true, then the sixth sentence does not logically follow. It would seem more appropriate to attempt to identify whether that level of sediment that does not qualify for PSDDA disposal actually requires more than minimal containment (38) behind conventional containment structures. The intent of the functional design is to provide a readily acceptable design that would be acceptable for safe containment of a certain range of material volumes with a certain range of sediment contamination. In this regard, it is an "overdesign" option for the less obviously contaminated sediments. This point should be made elsewhere in the document and this section deleted.

Specific Comments

Page	Comment
(39)	Effects-Based Design: Redundant with previous discussions. Delete.

4. Dredging and Material Transport Alternatives Development

Page	Comment
4-1/-24 (40)	The majority of description of dredging equipment is simply restatement of previous documents. The drawings of dredges are much nicer than in most other documents. Still, most of this could be referenced and severely condensed. Actually, the information contained in Appendix A is more pertinent to the main report than the existing text is. Consider exchanging the two. Another option is to place chapter 7 in front of this one.
4-7 (41)	Sediment Fate: The difference between "mass release" and "mass loss", given our inability to precisely measure either, is academic. I disagree that "[m]ass loss can be thought of as far field turbidity of suspended sediments where the materials are not removed from the bed by the dredging operation." Mass loss is not restricted to *sediment particle* loss. However, loss of sediment particles during dredging or disposal is *one* mechanism of mass loss. Dredging and disposal activities will *release* sediment particles as well as liberate chemicals partitioned to interstital water. Some of the chemicals (maybe most) associated with the aqueous phase will be scavanged by suspended sediments. Some (apparently a minor amount) can partition to the water column from the sediments. The real thrust is that most of the small percentage of sediment that is suspended by the dredge will resettle in the near field based on the material characteristics, currents, etc. Mass loss or release should have been defined elsewhere as a pathway issue (and what tests are appropriate to get a handle on how much of an issue it is) for both dredging and disposal. Recommend doing so and deleting sentences 2 - 6 of this first paragraph.
4-15 (42)	Mechanical Dredges: Fourth paragraph: "Watertight" buckets aren't entirely. Also, their "mass release" of sediment resuspended is typically about the same as a conventional bucket. The difference is that the 1-2 percent resuspended is more concentrated near the bottom with the enclosed bucket. The open bucket tends to distribute the turbidity and resuspended sediment throughout the water column. Depending upon the site conditions, there may be an advantage of one type over the other. The implication is that use of the watertight clamshell *is* an "effective" means to *reduce* resuspension. Its effectiveness is probably marginal under most circumstances--slowing the bucket retrieval is probably more effective.

Specific Comments

Page | Comment

4-20 With the possible exception of the Pneuma dredge, all the special dredges are basically hydraulic dredges. It no longer seems useful to differentiate dredges based on operation type. What may

(43) be more appropriate is to differentiate between "Conventional Dredges" mechanical and hydraulic which have been used for normal, sloppy navigation dredging, and the Special Dredges which have been designed for specific jobs or are still under development for contaminated sediment removal. Far too much of the dredge

(44) description discusses limitations of control options on "productivity." Productivity is very important for typical maintenance dredging of uncontaminated sands and silts. In the case of removal of contaminated sediments, productivity as a key factor is reduced in importance and replaced with safety or adverse environmental effects as the primary dredge consideration--or should be.

4-27 Hydraulic Dredging: Third paragraph: For the narrow objective of minimizing contact of contaminated sediments with surrounding waters, submerged pipeline discharge is a good alternative. It is not appropriate to think of discharge in this way, however.The

(45) objective of discharge is to place the dredged material at a set location. With contaminated sediments that are to be capped, it is generally a good idea to place the sediments on the bottom in as near in situ condition as possible [so that it will support the cap when placed]. Additionally, it is desireable to place these sediments in a definable area (small or large) that can be capped. Deeper waters may justify use of submerged discharge pipe. In almost all cases, discharge velocities will be more important.

-- **5. Disposal Site Functional Design Alternatives Development**

5-5 Assumptions for Functional Design: It may be that some limitation on the level of contamination in the sediments is appropriate. However, it seems to me that the stability of the contaminant-binding to the sediments is more critical. Chemicals that bind tightly to the sediment (i.e., that do not readily partition back

(46) to the water column) should be candidates for CAD. Physcial considerations (i.e., does the sediment remain together or does it break apart in the water column and tend to scatter all over and hence be "lost") are also important. These may be related to chemical concentration, but the existing tests (i.e., elutriate tests and "plop" test) can more objectively address the physical manifestations.

<u>Specific Comments</u>

Page | **Comment**

Additionally, the level of contamination assumed to be in the majority of Puget Sound sediments has already been considered to be low. It would be expected that most S-4 level sediments would be considered CAD-able.

5-6/-24 (47) Tables 5-1, 5-2, 5-3, 5-4: The matrices are relatively worthless without explanation. Suggest that a brief narrative be included in the main report for each option. [Also, the text cites table 5-2 for CAD.]

The sections dealing with Upland Mixed and Mono Disposal are much cleaner and clearer than those for CAD and Nearshore.

6. Monitoring Alternatives Development

6-1/-31 (48) The purpose of alternatives for monitoring is not apparent. Neither is the basis for decision-making that one is more effective, less costly, etc. than another. For the functional design, the trade-off of overdesign should obviate the need for extensive monitoring. If this is seriously in question, then the proponent should be doing an effects-based design. The other philosophy is that the overdesign concept must include a greater than minimum level of monitoring. It is unclear what is the intent in this chapter.

(49) I am unsure that Short-term monitoring is an alternative to Long-term monitoring. Both ought to be components of any generic monitoring program. For the unlined v. the lined disposal site option, the intensity and type of monitoring would differ. The use or not of a liner is an alternative and the type of monitoring (short- and long-term) associated with each alternative might be different.

7. Summary of Alternatives by Disposal Option

7-1/-23 (50) An acceptable summary. It should have been presented earlier to clarify what is going on, what the alternatives are, etc.

8. Prototype Alternative Selection Strategy (PASS)

8-1/-6 (51) A throw-away chapter. Keep sections 8.1, combine 8.2-4 into single section, reference a separate PASS document (if one exists), and combine with chapter 9.

Specific Comments

Page Comment

9. Implementing PASS/Recommended Standards

9-2 (52) Figure 9-1: Elutriate testing (the Palermo/Malek modified Standard Elutriate test) should be performed for the functional design where sediments are near the upper end of the "functional design level of contamination." Under the Phase 4: Modified elutriate testing is a different test and is not appropriate for CAD.

9-3/-4 (53) Phase 1 - Existing Data Review: In a number (maybe majority) of cases, this would occur in context of obtaining dredging and disposal permits or as result of cleanup orders. Suggest here that reference be made to the tier 1 evaluation required under the CWA/404 process and outlined in the PSDDA documents.

(54) Phase 2 - Initial Chemical Characterization: The PSDDA program allows flexibility to require analysis for other chemicals than the standard PSDDA chemical of concern. This should be noted and allowed for in these standards.

(55) Phase 3 - Sediment Characterization for Functional Design: See comment for figure 9-1. Elutriate testing should be required for CAD under conditions noted. Additionally, material cohesiveness should be assessed to insure that material will not go to pieces during water column descent.

9-10 (56) Are effluent returns being judged based on chronic or acute water quality criteria?

9-13 (57) Dredging depth: The 100-feet dredging depth allowance seems unrealistic. Especially as most contaminated sediments occupy the upper layers of most sediment prisms. However, I see no need for any functional design limits on dredging depth on the basis of potential environmental effect (other than the physical dredging itself).

(58) Why is there no discussion/requirement for overdepth dredging as is included in Nearshore? What other operational controls may be appropriate? Several were identified for the Navy Homeport project.

(59) Spud and Anchor Placement: Suggest that disturbance phenomena are not dissimilar to pile driving for which data do exist. Pile driving has relatively benign effects on disturbance of contaminated sediments.

Specific Comments

Page Comment

(68) How intensive is this monitoring? While intensity should vary according to size, difficulty, and potentially at-risk resources, some guidance should be provided. The recommended monitoring could be considered inadequate or excessive depending on how one interprets.

9-23 (69) Pipeline Transport: I have yet to see a completely tight pipeline, especially where flexible pipe or submerged pipes are used. Losses are still minimal, however, some requirement for checking seals, secondary catch basins, etc. may be prudent depending on what environment is being traversed.

(70) Sediment placement: Depending on the specific conditions at the dredge site, the "logistical problems" alluded to are frequently imaginary. The general policy should be to place the most contaminated sediments in the site first. Where there are valid reasons for proceeding in another sequence are presented, flexibility should be provided to allow a reasonable change. The dredging is removing contaminated sediments after all. While ther is no need to exaggerate the potential problems or risks, neither is there justification for a no-concern attitude. If the sediments truly merit "no concern" then perhaps the need for confined disposal standards with additional monitoring should be reassessed.

9-24 (71) Final Cap: Paving or drainage intercepts to channel away precipitation rather than allow infiltration through the cap are also feasible options. In certain instances, these techniques could reduce the need for a thick cap.

9-30 (72) Short-term Monitoring: Area of potential resettlement of suspended sediments ou\tside of the weir should be sampled and analyzed. If need be, it too should be removed and placed into the site. Possibly a secondary settling area should be included as part of the functional design.

9-31 (73) Rehandling Techniques: Temporary stockpiling should be avoided. However, when it is necessary, what are the standards or recommendations to minimize contaminant loss? Possibly creation of a lined or otherwise enclosed area would address the problem. Temporarily covering the stockpile with visqueen to prevent erosion runoff would also help.

9-32 (74) Final Overland Haul: Once the material has dried, particles can be stripped form the truck (or railcar, other open transport carriers, etc.) by winds, vehicle-movement induced vectors, and perhaps other forces. It would seem that provision of some sort of cover would be appropriate in any event.

Specific Comments

Page	Comment
9-33	Third paragraph: This observation seems a little too obvious for effusive prose. While a contractor's technical considerations may not *change* existing standards set by WAC, it would be appropriate to offer insights and considerations for the edification of the ultimate decisionmaker. (75)
	Fourth paragraph: Given the variety of material that typically goes to demolition sites, it is difficult to believe that dredged material, with the exception of salt leaching, would *necessarily* pose unacceptable adverse risks. Given our existing experience, it seems that once placed, monitoring can't even find leachate from the material. While I agree that further investigation into the matter is prudent, nothing in the *gee whiz!* evaluation above suggests that alarm is warranted. Each demolition site should be evaluated specificly for proxity to groundwater and other resources in any case. (76)

10. Effects-Based Design

10-1/-6	Another throw-away chapter. It can and should be combined with earlier material. Most of it deals with "Why an effects-based design?" This should have been addressed in the introduction. (77)
	The tables are nice however.

11. Decision Model

11-1/-11	A brief, fairly well-written chapter.

12. Small Project Standards

12-1/-3	Another brief, fairly well-written chapter. It hardly deserves to stand as a separate chapter, however.

13. Cost Comparison

13-1/-18	The document appears to merely repeat the same words for each disposal environment (with minor exceptions). If the purpose is to instruct an applicant how to do a cost comparison, then this information is useful. Otherwise it could be condensed. Or omitted. (78)

14. Technical Studies

14-1/-41	Interesting information. Should be removed to appendix.

Specific Comments

Page	Comment
14-40	(79) Comparison with recommended standards: If no adverse effect is identified, what is the basis for the recommended prohibition for use of demolition landfills? It appears that there may soon be no more approved demolition landfills operating, but that does not provide justification of the recommendation.

15. Analysis of Beneficial Uses of Contaminated Dredged Material

15-1/-18	(80) The objective of this chapter is puzzling. It can be shown that dredged material, even contaminated dredged material, can be used in a beneficial manner. Even contaminated sediments in Boston Harbor provide habitat. Landfills also provide habitat for a variety of avian and mammalian species. The bottom line seems to be that *if* the contaminants are not bioavailable (they will probably pass PSDDA and be considered "clean") or can be worked with to *make* them non-bioavailable (capping, stablized, etc.) then the material can be used productively. The central question remains: What are the incentives v. liabilities of attempting to use contaminated sediments beneficially? Typically, liabilities far outweigh incentives.

RESPONSE TO LETTER NO. 3: ENVIRONMENTAL PROTECTION AGENCY

1. Comment noted. The final report has been revised and edited.

2. Comment noted. Text citations and reference list have been revised.

3. We feel that the report is intended for the general public, not just technical specialists. Therefore, basic background information necessary to understand the basic issues addressed by the document is included in the final report.

4. Comment noted. The introductory text has been revised to provide additional background information clarifying these issues.

5. Comment noted. See text revision in Section 1.1.

6. We have developed two types of standards: functional design and effects-based design. The functional design standards are technology-driven and therefore, inherently have some overdesign elements. Effects-based design standards are effects driven and therefore are not overdesigned. We do not believe it is appropriate to define at this point in the document the terms and jargon used in the dredging/disposal design industry.

7. Comment noted. See text revision in Section 3.2.1, **Key Federal Regulations** and Section 3.2.2, **Key State Regulations**.

8. Comment noted. See text revision in Section 3.2.1.

9. Comment noted. See text revisions in Section 3.2.1.

10. Comment noted. See text revisions in Section 3.2.1.

11. Comment noted See text revisions in Section 3.2.1.

12. Comment noted. See text revisions in Section 3.2.2.

13. Comment noted. See text revision in Section 3.2.2.

14. Comment noted. See text revision in Section 3.2.2.

15. Comment noted. Paragraph was moved to Section 3.1.

16. Text was not modified. Purpose of this section is an overview to identify regulations most likely to provide concerns or "fatal flaws" during the siting process. There may be specific applications whereby the Department of Ecology can not use state law requirements to protect aquatic habitat and beneficial uses in condition the Section 404 permit under Section 401. The authority given to

Department of Ecology still remains of major significance relative to purpose of section.

17. Comment noted. Cultural resources are considered in Section 3.4. Also, see text revisions in Section 3.2.2.

18. Text was not modified. Purpose of this siting consideration is to assure consideration of the Federal Emergency Management Authority procedure and avoid unacceptable floodway alterations. The decrease of the floodway cross section can result in unacceptable increase in flood backwater elevations. Danger of exposure of contaminants because of flood conditions greater than 100 year would be addressed in the final site engineering design. Concur with comment that this condition is more associated with riverine than estuarine situations.

19. Comment noted. See text revisions in Section 3.4.

20. Comment noted. See text revisions in Section 3.4.

21. Comment noted. See text revisions in Section 3.4.

22. Comment noted. See text revisions in Section 3.4.

23. Comment noted. See text revisions in Section 3.5.

24. Comment noted. See text revisions in Section 3.5.

25. Comment noted. See text revisions in Section 3.5.

26. Comment noted. See text revisions in Section 3.5.

27. Design of Structures -- Comment noted. Text revised to reflect design adequate for catastrophic events.

    Monitoring Wells -- Text was not modified. Number of monitoring wells is not a direct function of site size.

28. Comments noted. See text revisions in Section 3.5.

29. Comment noted. Table 4.1 has been revised accordingly.

30. At this time, there is considerable disagreement over what constitutes appropriate sample preparation prior to column leaching tests. Until specific standard testing protocol is available, it is appropriate to maintain this flexibility.

31. Comment noted.

32. Modifications to established testing procedures, such as the one described in the comment, are acceptable as long as they are technically justifiable within the framework of a specific project. To address the comment, a note has been added to Table 4.3.

33. Comment noted. The test of Section 4.2.1 has been modified accordingly.

34. Comment noted. The text of Section 4.2.1 has been modified to reflect the comment about elutriate testing. We understand the logic of the remaining part of the comments, however, we believe that bulk chemistry testing provides reasonable indications of whether airborne emissions will be a problem.

35. Comment noted. See revised Table 4.5.

36. See revision to text in Section 4.2.3, Table 4.6.

37. Comment noted.

38. Comment noted. See text revision in Section 4.3.1.

39. We understand the comment. We have left the section in place as we believe it provides additional clarification of functional vs. effects-based design.

40. Text was modified. The description of dredge equipment has been moved to a separate background chapter (see Chapter 2). This is a review of existing documentation. Its purpose is illuminating the logic of standards derivation to reviewers. The reviewing audience will include individuals not as familiar with dredging as those providing initial comments. This is particularly true with that portion of the reviewing audience that has been involved in solid waste disposal only. Chapter 5 now primarily describes the dredging and transport alternatives. Material contained in Appendix A allows Chapters 2 and 5 to focus on available equipment and fundamental concepts of that equipment use and alternatives development. Appendix A does relate most recent data collection and technical evaluation of the existing dredging and disposal methods. We shortened and clarified, sending much to Appendix A.

41. Comment noted and text revised.

42. Comment noted and text revised. We concur with the conclusions, see Appendix A.

43. Comment noted and text revised.

44. Text was not modified. You are correct in stating that the dredge description focuses on production as one of the impacts created by control options. This was to establish basis for cost impacts resulting from instituting control options. Reduced productivity results in increased cost for dredging. Another impact

focused on is the increased or decreased amount of contaminant loss created by control options. The amount of contaminant loss is indicative of the level of protection afforded by dredging with and without control options. Both of these impacts were provided to allow some economic measure of the increased or decreased level of protection a control option provides. It is believed that productivity is important in any dredging activity. Safety and avoidance of adverse environmental effects is a very important consideration. Text is not intended to present any other concept.

45. Comment noted and text revised.

46. The design features and chemical concentration limtis (1/10 DW) for functional designs are conservative enough that the factors raised in the comment (stability of the contaminants and sediment cohesiveness) are not critical. If a proponent's sediment is more contaminated than 1/10 DW, or if they had a CAD site that was depper than 200 ft, then these other factors would take on more importance. Plop tests and elutriate tests could then be implemented as part of an effects-based design to determine if a CAD design is feasible.

47. Comment noted. See table and text revisions in Chapter 5. Also note Comment 50, and Chapter 8 that summarizes alternative disposal options.

48. Three different design alternatives are presented, each providing a different level of environmental protection. The monitoring associated with each alternative will vary with the level of protection. In general, as the site design provides a greater level of protection, the need for extensive site monitoring will decrease. The intent of this chapter is to describe the various types of monitoring that would be most appropriate for each alternative.

    One important clarification is needed. The functional design does not necessarily constitute overdesign as it is traditionally used in land-based disposal. Minimum functional standards typically incorporate overdesign. For the upland disposal standards, we have incorporated this concept of overdesign. For the nearshore and CAD standards, our functional design was developed from effects-based technology.

49. Comment noted. We agree with all points made. Short-term monitoring is not presented as an alternative to long-term monitoring. Each alternative has both short- and long-term components.

50. Comment noted.

51. Comment noted.

52. See response to Comment 32, this letter.

53. Comment noted.

54. Comment noted.

55. Comment noted.

56. The appropriate water quality criteria for effluent return will be project specific. For example, the acute criteria are more appropriate for short-term flow during disposal. For effluent discharge over longer time periods, the chronic criteria are applicable.

57. Text was not modified. See Letter 1, Comment 2. Project sites do exist where contaminated sediments are deeper than 100 feet. Purpose of limitation is to identify depths beyond functional design limit that require further analysis because of equipment limitations. Depths beyond 200 feet will be determined under effects based design approach.

58. Text was not modified. Over depth dredging referenced in nearshore relates specifically to pipeline cutterhead dredging, while over depth dredging in CAD relates to clamshell dredging. Both options include requirement for one foot minimum over depth of clean material to be dredged below the contaminated sediments. CAD recommends that permit include control of dredging to two foot over depth. Nearshore recommends that permit include control of dredging to one foot. Please note that nearshore also limits hydraulic cutter head dredge from over cutting a sediment bank because it also significantly increases turbidity. Reference Appendix A regarding effects of overcutting by cutter head relative to water column turbidity. This is not a consideration with mechanical clamshell.

59. Text was not modified. Concur with suggestion that disturbance phenomena is not dissimilar to pile driving. Level of turbidity created by anchor movement is function of how carefully crew members lift, handle and relocate them. Piling impacts are also function of how they are handled. Typically the piling operations are more standardized than are anchor and spud placement, and piling is not generally removed from bed after placement. In both cases, the anticipated sediment disturbance should be localized and relatively minor.

60. Comment noted. Text was not modified.

61. Comment noted. Reference Letter 1, Comment 1 and Letter 3, Comment 64. Hydraulic capping is option selected for functional design. Placement of cap is a major consideration in the CAD disposal option and a preferred method is identified in the functional design. Hydraulic is preferred over barge dump because the depth of water for hydraulic release is not a factor. Hydraulic discharge can be positioned at a submerged depth while barge dump is at near surface. Hydraulic discharge is in slurry and potential for contaminated displacement during capping is less than barge dump. Another cap placement option could be considered in the effects based design. That option would be approved if appropriate control of material placement is identified for existing technical factors at the proposed site. Capping by barge dump is most probable

to be accepted in effects based design if applicant demonstrates controlled placement by rate of release and barge positioning.

62. Comment noted. Text was not modified. Geotextile filter cloth has been used as a filter in other dredging projects. Unless the filter area is quite large, the cloth mesh will quickly become clogged and impermeable. Use of a filter at the top of a barge is not justified when dredging sediments with relatively low levels of contamination. A project with high levels of contamination would not comply with a functional design and would require effects based design approval. Consideration for a barge outfitted with a filter to reduce loss of overflow waters could be justified for higher levels of contamination. Another approach is to limit loss of the over flow waters from the dredging area by use of baffles or silt curtains around the dredging operations. Refer to initial characterization methods for discussion of sediment contamination acceptable for functional design.

63. Comment noted. Text was not modified. Cap sediment type is identified under Section 9.2.2, **Section Design Standards.**

64. Comment noted. See text revisions in Section 9.2.2, **Capping Sediment Placement.** Purpose of recommending bottom dump barge for contaminated material placement is based on consideration of settling time to provide sediment strength to support cap. Hydraulic placement in slurry requires significant consolidation time to regain cap support. Bottom dump allows placement with greater sediment strength, thereby avoiding significant consolidation time. Capping by hydraulic slurry further assures that materials will not be displaced by capping.

65. Comment noted. Reference Letter 3, Comments 48 and 49.

66. Text was not modified.

67. Comment noted. To maintain consistency with the rest of the document, especially Section 6, we prefer to define short-term and long-term as indicated. Short-term monitoring can be considered synonymous with compliance monitoring, see header revisions in Section 9.2.2.

68. Comment noted. See text revision in Section 9.2.2.

69. Comment noted. Text was not modified. Concur with comment that there are no completely tight pipelines. Note Section 9.3.2, **Operational Control** requirement to identify discharge pipeline route and type of discharge pipeline. Purpose of the requirement is to assure applicant consideration of discharge route and allow regulator review and permit conditioning specific to inspection and control of discharge line. Concur with comment that pipeline losses are still minimal.

70. Comment noted. See text revision in Section 9.3.1, **Sediment Placement**, and 9.3.2, **Contaminated Sediment Placement.** Difficulty in requiring a "most contaminated sediment first" approach is when the most contaminated sediments are below a

layer of lesser contaminated sediments. The concern becomes what to do with the less contaminated sediments that must be dredged first but placed into the disposal site second. Focus of first draft of standards was to assure that all materials were placed in anaerobic, wetted conditions. Based on technical information available, that action assured limited or no long term contaminant loss from the disposal site, regardless of where the most or least contaminated sediment was placed in the nearshore environment.

As a general policy, we concur with placement of the most contaminated sediments first. Establishing a functional design using this policy relegates to the effects based design process for approval any situation where "valid reasons" for another disposal sequence exists. Regarding the situation where most contaminated sediments underlay less contaminated sediments. Dredging both layers of contaminated sediments so that the most contaminated materials are placed into the site first, but in a mixture with lesser contaminated, should be interpreted as acceptable under the functional design and general policy criteria.

71. Text was not modified. Concur with comment. If applicant wants to reduce the thickness of the cap as identified in functional design, it could be justified based on site design including paving, drainage or other action to limit cap infiltration. That would be proposed by applicant in an effects based design approach.

72. Comment noted. See Letter 1, Comment 10 regarding quality over weir, and Section 9.3.2.

73. Text was not modified. As part of PASS, we considered methods to minimize contaminant loss from temporary stockpiles and we concur that lining a temporary site and covering stored materials with visqueen would help to minimize contaminant loss. However, since the pathways and transport mechanisms at a temporary upland facility are very similar to a permanent upland facility, we could not justify a functional design for a temporary facility that provided significantly lower environmental protection than the level of protection provided by the permanent upland facility. In addition, the recommendation to avoid stockpiling (and the increased potential for loss of contaminants) was based on the use of a mechanical dredge with haul barge transport. Sediments dredged by mechanical clamshell dredge do not need to be dewatered and can be off loaded directly into upland carrier for transport to the disposal site. If an applicant desires to temporarily stockpile material before transport, that can be approved through the effects-based design process. Applicant must present approach to control and limit contaminant loss during off loading, stockpiling and rehandling. The approach for an acceptable stockpiling operation is suggested in the dewatering site presentation in Section 9.4.1, **Dewatering Site**.

74. Comment noted. See text revisions in Sections 9.4 and 9.5.

75. We worked closely with Ecology throughout the course of the project and together agreed to mesh our work with existing regulations rather than develop new recommendations in a vacuum. And the focus of our work was to develop technical input for new regulations, not to evaluate the effectiveness of existing regulations. We did look for weaknesses in the current practice of upland disposal, we considered carefully existing regulations, and we did make recommendations on how to improve current practice. In short, it was not within our scope and budget to provide a critical review of WAC 173-304.

76. Although it is true that a wide variety of materials are currently going to demolition landfills, it is also true that the trend at federal, state, and local levels is to critically review the acceptance of such a broad based waste stream at unlined demolition sites. Additionally, it is our opinion that introducing salt to drinking water aquifers is not an acceptable part of any functional design. We concur that all demolition sites should be evaluated specifically for proximity to groundwater and other resources; however, WAC 173-304 does not specifically require demolition sites to be placed in any particular hydrogeologic setting.

77. Comment noted.

78. Comment noted. See text revision in Chapter 12.

79. The recommendation that disposal at unlined demolition landfills be discontinued is based on the potential for groundwater contamination and the inability (as part of this work) to modify existing siting standards (WAC 173-304) to address this concern (see Section 9.4). Existing data from the Coal Creek demolition landfill did not permit thorough evaluation of the effects of dredged material disposal on groundwater quality and definite conclusions could not be made.

80. Comment noted. We do not disagree with any of the points raised. The major objective of Section 15 is simply to present an overview of the beneficial uses of dredged material. Provided with this introduction, a dredging proponent may further investigate a beneficial use application for a given project. It was <u>not</u> the purpose of this document to resolve complex liability issues. Obviously, liability is a real issue that a proponent needs to factor in when considering a benefical use.

LETTER NO. 4

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT. CORPS OF ENGINEERS
P.O. BOX C-3755
SEATTLE, WASHINGTON 98124-2255

REPLY TO
ATTENTION OF

Planning Branch

15 AUG 1989

Mr. Greg Sorlie
Washington Department of Ecology
MS PV-11
Olympia, Washington 98504

Dear Mr. Sorlie:

Reference the draft report "Confined Disposal of Contaminated Sediments, Documentation of Standards Development" dated July 20, 1989.

The report was reviewed by a number of Seattle District and Waterways Experiment Station (WES) personnel. Mike Palermo, Jim Brannon, and Dick Lee of the WES prepared comment memoranda (see enclosures 1 and 2). Their hand-written comments (including those of Norm Francingues) are also furnished on enclosed copies of report pages.

Seattle District's specific comments are included on enclosed memoranda and copied pages (see enclosures 3, 4, and 5). Some general comments are outlined below:

(1) 1. We appreciate the restrictive time schedule that has been imposed on the state's development of the S-4 program and which prevented editing prior to the release of this report. However, this report needs a thorough editing prior to finalization. As noted in several of the comment memos, sections were repetitive or unnecessary and should be deleted. All of the sections should be tied coherently into the overall S-4 program.

(2) 2. The Corps of Engineers does not oppose the concept of a functional design option as long as the effects based design option is available. The concept of an effects based design is presented in this report; however, a number of specific technical questions were raised during the review. The WES hand-written technical comments provided should be carefully reviewed and considered.

(3) 3. The chapter 6 discussion of proposed monitoring should explicitly include the objective of each monitoring task.

(4) 4. We are not providing technical comments on the sections where solid waste provisions are applied to dredged material as we do not consider these provisions applicable to dredged material.

Seattle District plans to remain involved in the S-4 process and appreciates the opportunity to comment on the products as they are completed. If you have questions about the comments received, please contact Justine Smith at (206) 764-3654.

Sincerely,

Frank Urabeck
Acting Chief, Planning Branch

Enclosures

RESPONSE TO LETTER NO. 4: U.S. ARMY CORPS OF ENGINEERS (FRANK URABECK)

1. Comment noted. Report has been revised and edited.

2. Comment noted.

3. See revisions to text in Section 6.3.1.

4. Comment noted.

CEWESEE-P

9 Aug 89

Memorandum for: Justine Smith, CENPS

From: M. Palermo, EED

Subject: DOTS Request 89-122, Review of Report "Confined Disposal of Contaminated Sediments, Documentation of Standards Development" July 20, 1989 Draft

1. As requested, the subject report has been reviewed by myself, Mr. Norman Francingues, Dr. Dick Lee, and Dr. Jim Brannon.

2. As described in my previous memo concerning the S-4 Standards dated 30 Jun 89, we have no fundamental technical problem with the concept of a functional design option as long as the effects based design option is available. However, the subject report which describes the details of the functional design standards is technically deficient in a number of areas. I will separately send a copy of the report with specific comments noted by myself and Mr. Francingues. Dr. Lee has transmitted a copy of his memo with general comments. I have attached another memo with comments prepared by Dr. Brannon (encl 1). (1)

3. My major comments are as follows:

a. The report is poorly organized and reflects the fact that a number of authors prepared various chapters. The linking together of the various parts does not provide a clear and concise picture of what the standards are and how projects must be evaluated under the standards. Although several individuals who contributed to the report are well experienced in dredging and disposal, the finished draft does not reflect a sound understanding of the technology.

(2)

b. The text of the report is repetitious and needs a good edit.

c. There are numerous technical inconsistencies between the several chapters. Also, there are numerous instances of terms with no definitions, incomplete descriptions of terms or processes, and generalities which can be misleading.

d. There is either a basic problem with terminology for some of the contaminant pathway testing or a poor understanding of the applicability of the various tests to various pathways. The column leachate test is not the recommended approach at this time for the groundwater pathway (see Dr. Brannon's memo). (3) Also, the column leachate test is not applicable to the effluent pathway (which we define as that water discharged over a weir during hydraulic filling). Even more puzzling is the apparent confusion of which elutriate test is which. The standard elutriate is the

(4)

appropriate test to simulate contaminant release during open water placement. The modified elutriate test is the appropriate way to simulate release of contaminants in effluents from diked disposal areas. The authors should look again at the DMF/DMASS reports.

e. There is a basic problem with the assumptions made for upland disposal. In several places in the report, the implication is made that upland disposal will only involve the placement of dewatered material with no discharge to waters of the US. A common case for upland disposal would be direct placement by pipeline from hydraulic dredging operations. There may be some confusion here with the possible use of a separate site for rehandling and dewatering, but such a site would involve effluent discharge and possible release to groundwater during the dewatering process. In short, the rehandling basin used for dewatering is an upland confined site if the material is placed above the MLW elevation. Would such a site fall under the S-4 standards? If so, which category does it fall under? As we have stated previously, it is the Corps technical position that dredged material should not be regulated as a solid waste. (5)

f. The information on siting in chapter 2 seems a relatively useless description of generalities. I did not see how this information entered into the evaluation process. (6)

g. The use of Alternatives 1, 2, and 3, is confusing and inconsistent. Why not have one level of environmental protection for a functional design, and leave all else to the effects based design? (7) The rationale for the various entries in the tables in Chapter 5 should be presented along with the tables. There are many inconsistencies and questions raised by the entries in these tables. (8)

h. The monitoring in Chapter 6 will be very expensive. The reason for each monitoring task and the utility of the data in the context of regulatory decision-making should be clearly stated. Since this should not be monitoring for the sake of gaining information, how the monitoring data would be used in enforcement of the standards is a major question. (9)

i. The use of PASS, patterned after the DMASS ranking approach, for ranking standards is of questionable value. DMASS scorings are applied to alternatives, not standards. Further, the scores under DMASS would be assigned only after consideration of site specific factors. In contrast, PASS gives numerical rankings to generic control measures without any consideration of site specifics. Since the functional design standards in the tables in Chapter 5 are either arbitrary or are based on literature values, I fail to see how the PASS scores were used in setting the standards. In fact, I recall only one instance in the entire text where specific PASS scores were even mentioned. (10)

4. A major rewrite is necessary for this report to have technical (11) credibility. I suggest that the state consider publishing a shorter document, stressing the information on the functional design contained in the tables along with appropriate descriptive text. The effects based design could be handled by simply referencing existing Corps documents.

5. If the state does a rewrite on this, I would suggest that WES be asked to review it (additional reviewers were suggested by Mr. Francingues). Also, as mentioned in my 30 Jun 89 memo, consultation with NPD and HQUSACE would be advisable.

CF:
Engler, EEDP/EL
Francingues, EED/EL
Saunders, ERSD/EL
Hart, ERSD/EL

Michael R. Palermo, PhD, PE
Research Civil Engineer

Routing:
C/EED, Palermo/EED

RESPONSE TO LETTER NO. 5: U.S. ARMY CORPS OF ENGINERS, WATERWAYS EXPERIMENT STATION (MIKE PALERMO)

1. Specific comments noted in report are addressed in the Addendum to Letters 4, 5, and 6.

2. Comment noted. Report has been revised and edited.

3. Comment noted. Various sections of the text have been modified accordingly.

4. Comment noted. Various sections of the text have been modified accordingly.

5. Text was not modified. Contaminated materials disposed at the final upland sites are sediments that have been dredged by clamshell with haul barge and rehandled, or by pipeline dredge and then placed in a temporary confined site for dewatering and rehandled. The functional design does not include direct placement of hydraulically dredged sediment into a final upland site. Direct placement of contaminated sediments into an upland site would be processed through the effects-based design approach.

   We concur with the comment that a rehandling basin (labeled a dewatering site in functional design standards) used for dewatering is an upland confined site. Construction and operation of this site is expressly for the dewatering of sediments before they are transported to the approved solid waste landfill site. If they are transported to a new site that is not an approved landfill, but is rather a dredged material disposal site, the disposal site design and approval would be processed through the effects-based design. It would not be considered a functional design and has not been included in the draft standards.

   We are in concurrence with the Corps' technical position that dredged material should not be regulated as solid waste except when it is disposed at an approved solid waste landfill. The functional design standards approach is to define all contaminated sediments removed from the aquatic and sub-aquatic environment as dredged sediments until they are released into an approved solid waste landfill site.

   A solid waste landfill approved through existing standards requires material acceptance based on minimum functional standards for solid waste disposal in the State of Washington. Our functional design standards have attempted to develop an approach that will satisfy existing solid waste criteria. Note that prior to actual release in an approved landfill, all of the activity covered in our draft functional design standards considers the contaminants as dredged sediments regulated under the functional design standards for materials requiring confined disposal.

In the case of a future upland site that will receive only contaminated dredged sediments, and not other solid waste, the design and approval will be through effects-based design standards. The dredged materials will not be regulated as a conventional solid waste.

6. Text was not modified. Section 3 (Siting Guidelines) describes generalities to be considered at the early stages of site review. Significant changes in the section have been made based on other reviewer comments.

7. Text was not modified. Three alternatives were selected to reflect a perceived high, moderate and low level of environmental protection, indiscriminate of cost. Descriptions of the alternatives were based on methods considered technically available from the dredging industry. Initial ranking (high,moderate,low) of environmental protection was based on experience and available technical literature. Subsequent prototype data collection and CSDAP analysis allowed relative comparison of protection to demonstrate acceptability of one alternative over another. It also enabled us to establish a cost impact for increased or decrease protection. Evaluation of different alternatives also meets SEPA and NEPA requirements that must be satisfied during the EIS process to be completed by the State in assumption of a final standard. We concur with comment recommendation for establishing one level of environmental protection to the functional design and leaving all else to the effects based design. Evaluation of three alternatives allowed us to establish that level of protection environmentally acceptable from a human risk, environmental harm and economic standpoint for each disposal environment.

8. Comment noted. See Letter 3, Comment 47, and revisions to text.

9. See response to Comment 3 in Letter 4.

10. CSDAP was used for ranking alternatives in the same fashion as the use of DMASS. The alternatives were selected based on the scores they received. Those achieving the highest scores became standards. The view that site-specifics were not considered is accurate and is the consequence of the need for a procedure that would be generically applicable for selecting functional design standards. Among the largest differences between DMASS and CSDAP is the conscientious attempt by the developers of CSDAP to devise a procedure that could be applied without knowing site-specific conditions.

11. Comment noted. A separate report presenting only the recommended standards is also being prepared.

LETTER NO. 6

Memorandum For Record

Subject: Review of S-4 Standards

4 August 1989

1. The terminology used throughout the document requires clarification and more consistancy. Examples are shown below:

Word(s)	change to
"Spoil"	"Material"
"dredge material"	"dredged material"
"dredged materials"	"dredged material"
"surface water"	"effluent"

(1)

2. The Part 1. Introduction section needs editorial work. The use of "we" should be omitted and the entire section written with subject being emphasized. (See notes on manuscript.) (2)

3. Part 2. Siting Guidelines needs some additional qualifying statements to indicate that dredged material is not regulated under RCRA or NPDES, that the Corps does have a Dredged Material Management Strategy that can evaluate impacts to nearshore and upland disposal sites in an appropriate environmental sound manner. The Corps needs to be very careful how this document addresses application of State Regulations to Dredged Material. (Suggest that Joe Wilson and Dave Mathis, OCE review this section). (3)

4. Part 3. Potential Sediment Characterization Tests needs considerable revision and clarification. Comments are written on the specific attached pages. The use of solid phase sediment bioassay tests for nearshore disposal is inappropriate. It is unclear as to what these test results will be used for. Water column bioassay tests could be conducted on the modified elutriate (effluent) for nearshore disposal. But it is unclear what the purpose of the present testing scheme is for. (4)

5. Part 5. A topsoil thickness of 6 inches may not be sufficient if the final cover material is a compacted poor soil medium for plant growth. A foot of topsoil on top of the final cover would be better and will insure a good grass cover to control soil erosion. (5)

6. Part 6. Similar comments are made for this part as given in Part 3 above. (6)

7. There are some typos in the References. (See attached pages). (7)

8. As I glaced over other parts of the document I noticed other items that need clarification. It will take a bit more time to review these parts.

Charles R. Lee

Charles R. Lee, PhD, CPSS

Attachments: 29 pages

RESPONSE TO LETTER NO. 6: U.S. ARMY CORPS OF ENGINEERS (CHARLES R. LEE)

1. Comment noted. Terminology has been revised throughout report.

2. Comment noted. Text has been edited.

3. Comment noted. See text revisions in Section 3.2.1. We concur that Corps does have a Dredged Material Management Strategy that can evaluate impacts to nearshore and upland disposal sites.

4. Comments noted in text are addressed in Addendum to Letters 4, 5, and 6.

5. We concur with this comment. Topsoil thickness of 6 inches is required for mixed municipal landfills under WAC 173-304. We have recommended 12 inches of topsoil for both the lined and unlined upland monofill functional designs.

6. Comments noted in text are addressed in Addendum to Letters, 4, 5, and 6.

7. Comment noted. Text revised.

Additional comments noted in text by Mike Palermo, Jim Brannon, Norm Francingues, U.S. Army Corps of Engineers.

(1) p. 1-6 Point out idea that functional design is an attractive alternative for small-volume projects where effects-based design testing would cost nearly as much as implementing the functional design.

(2) p. 2-3 Section 10. "Upland" must be defined early in the report. Here, upland has a very specific meaning, i.e. no 404 discharge. However, is important to consider that dredged material can be placed in the upland environment with a 404 discharge. This fact confuses the content/intent of Chapter 5 and others.

(3) p. 2-5 Last paragraph. Explain "Corp's nationwide permit for upland sites".

p. 2-9 Section 2.2.2. Some discussion is necessary to explain which regulations apply to permittees and which to COE.

(4) p. 2-15 Geology and Soils are closely linked, yet the listings are not compatible. Suggest combining these into a single category.

p. 2-16 Second sentence. Contrary to statement in text, a rough and irregular bottom may help reduce spread of contaminated material on the bottom.

(5) The listings for Groundwater and Geology and Soils on the preceding page are inconsistent. Also, there is no wording on water table depth. What about soils?

p. 2-18 What is the limited application of floodplain location on CAD?

(6) Noise and Visual Impacts have nothing to do with contaminant issues.

p. 2-26 What is the paint filter test? State where this is defined in report.

(7) p. 3-1 Much of this chapter is contaminant pathway testing. I think of sediment characterization as the physical and chemical characterization of sediment.

(8) p. 3-7 Table 3-2. A better reference for the Standard Elutriate Test is the 404 or 103 manual. Brannon et al. would be a better reference for the Cap Thickness test.

(9) I question the listing of batch leaching and column leaching tests for surface water.

(10) p. 3-8 Table 3-3. I couldn't use column leaching test for CAD. Interstitial water chemistry is a better indicator.

(11) p. 3-10 Confined Aquatic Disposal, last sentence in section. Standard elutriate test, not modified, is used for contaminant release to water column during placement for CAD. Use this terminology carefully. The elutriate tests addressing effluent

characteristics at upland disposal sites (last paragraph on page) are <u>modified</u> elutriate.

(12) p. 3-12 Why give additional information on just 4 tests, when over 20 are listed in Table 3-5?

(13) p. 4-27 Fifth paragraph. I disagree. Some materials may be a concern for the benthic pathway, yet would not be a concern with the water column pathway. If water column release is a problem, it would be a problem for shallow as well as deep sites.

(14) p. 5-1 The concept of describing functional design alternatives 1, 2, and 3 needs clarification.

(15) p. 5-6 Inclusion of a no-action alternative is confusing. The entries in this table imply plenty of action for the no-action.

(16) p. 5-27 Section 5.5.2, second paragraph. Does this mean that direct pipeline disposal too upland sites will be prohibited? If so, I object.

(17) Chapter 6. Is there no distinction for monitoring with functional design vis a vis effects-based design?!

(18) p. 6-12 Weekly bathymetry monitoring in CAD, Alternative 1, is excessive.

(19) p. 6-23 The Disposal Site monitoring really confuses me. On p. 5-15 it is implied that only dewatered material will be allowed at upland sites.

(20) p. 8-3 Table 8-1. Need a weighting factor for cost (1?) or is cost not considered equally or in the same light as other factors. Should so state if this is the case.

(21) p. 8-5 Step 5. Why are P_N and P_L multiplied? Also, why is each pathway equally weighted?

(22) p. 8-7 Table 8-2. There are basic inconsistencies between this scoring sheet and Table 8-1. For example, there are no "0" scores in Table 8-1.

(23) p. 9-3 Initial characterization requirements should be the same regardless of which disposal alternatives are later considered.

(24) p. 9-5 Table 9-1. Palermo is referenced for Accelerated Aging tests but he's never heard of this test.

(25) p. 9-6 Either define or delete "Phase 4"
p. 10-2 Section 10.2. Need explanation of Sediment Characterization, Phase 4.

(26) p. 9-8 Figure 9-2. The logic here makes sense, but I don't have a good feel for what is involved in S.C.II versus S.C.III. You must define S.C.II and S.C.III either is a table etc. or by reference.

27 p. 9-9 Figure 9-3. Effluent tests - modified elutriate and column leaching. Must straighten out this terminology and the applicability of each pathway test. Also used in Figure 9-4 and top of p. 9-10.

28 p.9-10 Section 9.2. Suggest that this text go along with Chapter 5 tables, and made to be consistent.

29 p. 9-13 Third paragraph. "2% loss" - This is a WES figure and I fail to see how "PASS" could generate it. Same comment for depths presented in fourth paragraph of p. 9-15.

30 p. 9-17 I'm confused. What happened to Alternatives 1, 2, and 3 in Table 5-1? The selected Water Depths correspond to Alternative 1 only. Same with Bed Slope and Cap Sediment Type.

31 p. 10-4 Modified elutriate test for surface water diffusion should be standard elutriate for surface water release.

p. 11-1 This chapter is so general it should logically belong up front somewhere.

32 Third paragraph. The four steps listed for the decision model are not consistent with Figure 11-1 (three steps).

33 p. B-1 Last paragraph. The Brannon et al. (1985) reference is incorrect.

RESPONSE TO ADDENDUM TO LETTERS 4, 5, AND 6: U.S. ARMY CORPS OF ENGINEERS

1. Comment noted. See text revision in Section 1.4.

2. Comment noted. See text revisions in Section 3.2.1. Please refer to Section 2.2.1, **Key Federal Regulations, Section 404.**

3. Corp's nationwide permit -- Comment noted. See text revision in Section 3.2.1. Federal and state regulating agencies disagree on the application of 401 certification for confined disposal permitted by nationwide upland permit. Specifically the applicability of 401 certification required for upland disposal with dredging by mechanical clamshell and no effluent return to waters of the U.S.

4. Comment noted. See text revisions in Section 3.4. Geological siting considerations reflect site foundation failure, while soils siting consideration focus on groundwater and leachate movement through the site.

   Comment noted. See text revision in Section 3.4.

5. Groundwater, Geology and Soils -- Comment noted. See text revision in Section 3.4.

   Text was not modified. Limited application of floodplain impacts from CAD occurs when capping results in a restriction near the mouth of flat gradient river and increased backwater flood elevations upstream. Application is very limited but does exist.

6. Text was not modified. Noise and visual impacts can have a significant impact on siting issues.

7. Comment noted.

8. Comment noted. The reference to Brannon et al. 1985 has been included.

9. Batch and column leaching tests measure release of contaminants from dredged material. Depending on the way the data are evaluated, these tests can provide insight into surface water impacts.

10. At many potential CAD sites in Puget Sound, groundwater discharge is an important factor to consider in contaminant migration assessment. Column leaching is considered a better indicator of contaminant release in this situation.

11. Comment noted. Various sections of the text have been revised accordingly.

12. As noted in the first paragraph of Testing Methods: "Tests that determine settling behavior, particle size, water content, and permeability are especially important in disposal site design." For that reason, additional information was presented on those four tests, although over 20 tests are listed in Table 4.5.

13. Comment noted. See text revisions. Basis of text is sediment and contaminant loss, outside limits of confined disposal area. Sediment lost outside disposal limits can become a concern for the benthic pathway. Deeper waters result in longer time to settle out, greater displacement of contaminants over the bed area. This is also dependent on the water column or current velocities that transport sediments.

14. Comment noted. See text revisions in Section 5.1.

15. Comment noted. See text revision in Sections 5.2.3 and 5.3.3. No action refers to no adoption of standards, not to discontinuance of dredging and disposal.

16. Comment noted. See text revision in Section 5.5.2.

17. The document as written addresses standards for the functional design only. There may be a distinction between monitoring for the functional vs. the effects-based designs. Monitoring the effects-based design would be tailored to individual project conditions following the decision not to follow the functional design approach.

18. See revisions to text in Section 6.3.

19. Comment noted.

20. Comment noted. The CSDAP composite score is calculated based on the weighted, non-cost factors listed in Table 8.1. The preferred alternative is then selected by comparing the composite score of each alternative with its estimated cost. As stated in Section 9.2, Step 3, "The cost effective alternative was considered to be the least cost alternative that acceptably met the criteria established for the other evaluation factors."

21. Comments noted. The sum of P_1 to P_n is multiplied by P_L to exaggerate the differences in the CSDAP composite scores among different alternatives. This calculation also ensures that any single low scoring pathway will significantly influence the total score.

    The pathways are equally weighted because contaminant transfer to the environment through any medium was deemed equally undesirable.

22. See revisions in Tables 8.2 and 8.3. Table 8.1 is correct, the lowest score for any category should be "1", not "0".

23. Comment noted. Based on discussion with many dredging proponents in Puget Sound, standardized initial characterization regardless of disposal alternative is not desirable.

24. Comment noted. See Table 9.1.

25. Comment noted. See Phase 4 discussion in Section 9.1.

26. Comment noted. See Section 9.1.2, where S.C. II and S.C. III are defined as Site Condition II and III by PSDDA.

27. Comment noted. Various sections of the text have been revised accordingly.

28. Comment noted. See text revision. All components of alternative standards are not discussed in Section 9 text. Discussion was limited to those component issues requiring major consideration. Components that are discussed in Section 9 text have been moved to same order as Section 5 tables as, recommended in comment.

29. Comment noted. See text revision in Section 9.2.1.

30. The site design alternatives presented in Table 5.1 were evaluated using CSDAP, and a preferred alternative selected as the recommended standard. Alternative 1 was selected as the recommended standard for water depth, bed slope, and cap sediment type at CAD sites, and described in Section 9.2.2.

31. The text has been revised accordingly.

32. Comment noted. The discussion in Section 11 has been integrated into the Section 1, Introduction. The Decision Model is one of the three steps in the confined disposal process illustrated in Figure 1.2. There are four steps within the Decision Model.

33. Comment noted. See text revision in Appendix B.

LETTER NO. 7

CENPS-EN-PL-ER

11 August 1989

Memorandum for: Comment

From: Justine Smith

Subject: Review of Report "Confined Disposal of Contaminated Sediments, Documentation of Standards Development", July 20, 1989.

1. I am including comment pages from the report with additional editing and comments.

2. p. 1-2 "The decision model illustrates the process by which proponents and regulators determine the most appropriate disposal environment and disposal site design for their dredged material". Eric Johnson (WPPA) has made the point that disposal sites are very scarce and that project proponents usually have restricted siting options very early in the process. This is also the case with Corps projects, where frequently there may be only one or two disposal options available in the vicinity of a particular dredging project. (1)

3. p. 1-5 The report begins to discuss "slightly contaminated" sediments here. Does contaminated begin with PSDDA and sediments that have failed PSDDA? This definition should be spelled out in the text up front. (2)

4. Throughout the report we should be discussing "dredged material", not dredge material or dredge spoils. (3)

5. p. 2-7. Under the Washington Solid Waste Management Act, it is unclear whether being subject to a 404 permit means that one is not required to obtain a permit from the jurisdictional health department. Also this may be different in the short term and long term. (4)

6. p. 2-13. For ownership/acquisition potential there is no explanation for why ~~the~~ various scenarios are in the order shown. Also see written comments on p. 2-18 and p. 2-21. (5)

7. The entire report needs a thorough editing. It is difficult to follow how the early chapters fit into the whole S-4 picture. Unnecessary and repetitive paragraphs and chapters should be deleted. In chapters where the same paragraph is repeated for a number of the alternatives, why not do a combined paragraph at the beginning that generally covers the overlapping alternatives? (6)

8. The appendices that support the tables in chapter 5 should include discussion on sediment quality guidelines (including that used for capping) and explain the relationships (chemical and political/programmatic) between the alternatives and the preferred alternative. (7)

Additional comments noted in text by Justine Smith, U.S. Army Corps of Engineers.

(8)	p. 2-13	Section 2.3.1. Explain why the bulleted regulations are considered "most likely" to produce a fatal flaw.
(9)	p. 2-17	Why are groundwater, surface water and precipitation considerations only of general application in nearshore environments? Direct application seems more correct.
(10)	p. 2-21	Compatibility with nearby land uses: Direct application to Nearshore (instead of General).
(11)	p. 3-12	Provide descriptions (in text) of the test methods listed in the table.
(12)	p. 5-6	Need additional explanation of how the alternative tables were developed.
(13)	p. 5-11	Last sentence. Explain or reference ADDAMS program.

RESPONSE TO LETTER NO. 7: U.S. ARMY CORPS OF ENGINEERS (JUSTINE SMITH)

1. The sediment characterization step in the decision process is designed to allow a proponent to target a selected disposal site, and testing for all possible options is not required.

2. Comment noted. See text revision in Section 1.1.

3. Comment noted. Text revised.

4. Comment noted. Text revised. At this time the interpreted application of Federal 404 and local permit authority for confined sediment standards document is as follows. All dredged materials that are placed in an upland site will require a local jurisdictional permit for one or both of the following reasons. The material is a problem waste that does not require 404 permit, and the disposal site creates a stockpile of material for a time period that exceeds regulations. Not all dredged materials will require a 404 permit. Specifically those materials that will not create effluent return to waters of the state during disposal operations would be excluded from federal 404 permitting.

5. Comment noted. See text revision in Section 3.4.

6. Comment noted. Report has been revised and edited.

7. Text was not modified. See Letter 1, Comment 3. Sediment quality guidelines are being developed under element P-2 of the PSWQA Management Plan. PSDDA sediment quality requirements are undergoing continued reevaluation in this early implementation period. Sediment quality guidelines in these standards have been primarily selected on the basis of existing standards (Minimum Functional Standards, PSDDA) rather than additional technical or effects-based research. Future review and revision as demonstrated by prototype experience would be a most appropriate action following standards implementation, continued monitoring, and completion of impact analysis.

8. Text was not modified. Bulleted regulations have been interpreted as absolute requirements for which loss of wetlands or impact on endangered species will not be acceptable and cannot be mitigated. Other regulations have been structured and administered to allow alternative approaches or mitigation to be conducted so that project can be completed.

9. Comment noted. See text revisions in Section 3.4.

10. Comment noted. See text revisions in Section 3.4.

11. Text was not modified. Test procedures are provided in separate literature, and with the exception of the few that are described in greater detail in the text, all are relatively standard within technical area of expertise.

12. Comment noted. See response to Addendum to Letters 4, 5, and 6, Comment 14 and text revision in Section 5.1.1.

13. Comment noted. See text revision in Section 5.3.2.

LETTER NO. 8

Alex Sumeri

SEATTLE DISTRICT, CORPS OF ENGINEERS
COMMENTS ON

CONFINED DISPOSAL OF CONTAMINATED SEDIMENTS

DOCUMENTATION OF STANDARDS DEVELOPMENT
DRAFT REPORT

- pg 1-2, 1.2.1 Phase 1 of S-4 Standards Development, paragraph 3: Basis of Estimate not Given - Is volume likely to require confined disposal "contaminated" or is reason to dispose other than open-water involve cost or beneficial use of material such as fill. (1)

- pg 1-4, 1.2.2 Phase 2 of S-4 Standards Development, paragraph 1: WAC 90.48 - What is this? Can your expand? (2)

- pg 2-11, Puget Sound Dredged Disposal Analysis (PSDDA): "The sediment characterization siting and monitoring guidelines developed under PSDDA provide precedents for developing similar criteria for disposal of dredged material unsuitable for unconfined disposal." - Don't entirely agree with this broad of a statement as precedent, especially monitoring requirements. Besides, are "similar" criteria being proposed?? Would seem that this can be turned around i.e., adopted as part of PSWQ plan, and still explained as offering starting period for S-4. (3)

- pg 2-12, 2.3 SITING RESTRICTIONS: This section remains unclear and without descriptions as intended. (4)

- pg 2-13, top of page: "The violation of federal or state effluent limits could be considered fatal to a project while the broad powers under Section 401 may be used to stop a project" - Please explain difference between "fatal" and "stop." (5)

- pg 2-13, Summary: "...particularly as applied to wetland areas" Is this all of fatal flows noted on previous page 2-12 or just summary? (6)

- pg 2-25, 2.5 FUNCTIONAL DESIGN CRITERIA, Biological Conditions: Native American historical areas are sociological/political conditions not biological. (7)

- pg 2-26, Upland Mixed Disposal, Dewatering Site "...pass paint filter test" - What is this test and why made condition under functional criteria instead of "effects" based criteria? (8)

- pg 2-26, Upland Mono Disposal, Dewatering Site "...may..." "...approximate in situ water content condition" - If this is a "MAY" then why placed under functional design criteria. If it is a "MUST" then explain basis as rules out hydraulic dredging which is cost factor. (9)

(10) - pg 5-7, <u>CAP MATERIAL</u> <3 ft <4 ft <4 ft - Should be greater than >?

(11) - pg 5-7, <u>CAP MATERIAL</u>: 0.2 ft 3/min/ft 2 is too low. On Duwamish CAD - 25 cy/min was used in releasing from a 128' long hopper. Assuming opening was between 6" and 1 ft, the release note was 5 to 10 ft 3/min/ft 2 for uniformly graded sand with mean dia (d50 = 0.4 mm).

$$\frac{25\ \text{cy} \times 27\ \text{ft3}}{128' \times (0.5' \text{to } 1')} = \frac{675\ \text{ft3/min}}{64 \text{ to } 128} = \underline{5.2 \text{ to } 10.5\ \text{ft } 3/\text{min}/\text{ft } 2}$$

(12) - pg 5-14, Table 5-2 Summary of nearshore disposal design alternatives. Weir Overflow, "None" - Why no overflow weir with hydraulic dredging?

(13) - pg 5-17, <u>5.4.2 Dredging/Transport</u>, paragraph 2: "However, delivery of sediments in an in situ (mechanical dredge) or sediment and water slurry (hydraulic dredge) would not be in conformance with the Upland Mixed Disposal criteria." - Cannot find rational for criteria in Functional Design Criteria Section 2.5. Need to support.

(14) - pg 5-17, <u>5.4.2 Dredging/Transport, Mechanical Dredge Rehandling Techniques</u>, paragraph 4: "A more efficient process for equipment time is the placement of sediments into a temporary stockpile and rehandling by wheel mounted front end loaders to trucks for haul to dewatering site." - Thought this isn't allowed as some dewatering will occur.

(15) - pg 6-2, paragraph 3: Not possible with present equipment to have accuracy of depths to nearest 1/10th ft, even though soundings are shown to 1/10th ft. Based on ability to repeat soundings to that depth.

(16) - pg 6-3, Side Scan Surveys: Why are these being generally asked for? They are useful in only specific instances (i.e. when different materials are involved such as sand or silt or to determine the extent of log clearing required by a contractor in a logs storage dredging area). What good would a pre-disposal side scan survey provide, besides costing a lot.

(17) - pg 6-10, Bathymetry: 25-foot survey cross-section intervals are too restrictive for dredging area as is a requirement for daily progress surveys. They could not bee processed timely nor would enough surveyors be available, not to mention the prohibitive cost.

(18) - pg 9-16, Top paragraph: Why limit mean grain diameter to 0.2 to 0.4 mm? Finer grain material is more effective cap material as it allows absorption of contaminants in the underlying layers of clean cap material. With a fine-grained material cap a suitable placement method is necessary as this type of material will tend to towards a corrective descent - bombing the bottom.

(19) - pg 9-37, 9.5.1 Summary of PASS, Upland Dredging: "Hydraulic dredging will require dewatering, an expensive step that is potentially environmentally degrading unless controls are applied." - If decision/recommendation is based on economics rather than environmental the option should be kept for hydraulic dredging with some sort of dewatering if necessary.

(20) - pg 9-37, 9.5.1 Summary of PASS, Rehandling Techniques: "...direct off-loading to transport vehicle." - This requirement can offset hydraulic dredging with dewater cost - another reason to retain option.

Additional comments noted in text by Alex Sumeri and Bob Parker, U.S. Army Corps of Engineers.

(21) p. 1-1 Section 1.1, last sentence. Define "database" and state who will develop/maintain.

(22) p. 2-24 Water depth for confined aquatic disposal: what is the basis for the cap armoring requirement at depths less than -80 ft? "We have no hurricanes in Puget Sound. Wave tidal velocity influences to much larger depth. Needs local evaluation/design."

(23) p. 3-8 Need definitions of all characterization test methods listed in Table 3-3 should be included in glossary.

p. 3-11 Second bullet, last question. By "initial settling", do you mean consolidation? This is unclear.

(24) p. 3-14 Last paragraph. "It is not possible to predict what tests will be required without knowing the details of the specific dredging project". Isn't this true for functional design (above) as well?

p. 4-3 Last paragraph. Cutterhead pipeline dredge production rate of 25 cu yd/hr seems very low.

p. 4-10 $1.50 cost of pipeline dredging in Commencement Bay: for what distance and volume? Same question for costs reported on p. 4-14, 4-19.

p. 4-11 First paragraph. Suction without rotating the cutter would reduce suspension but production would suffer and costs increase. In addition, this is not practical for some material.

(25) p. 4-28 Third paragraph, discussion of relation between dump volume and water entrainment. What is source of this information? Is this documented or hypothetical?

(26) p. 9-15 Requirements for cap armoring depths are too conservative and bed slope requirements are too site-specific to regulate.

(27) Chapter 15. Capping of contaminated sediments in place should be discussed - could be a mitigation measure (i.e., similar to Simpson Tacoma Kraft).

RESPONSE TO LETTER NO. 8: U.S. ARMY CORPS OF ENGINEERS, SEATTLE DISTRICT (ALEX SUMERI, BOB PARKER)

1. Comment noted. See text revision in Section 1.2.1.

2. Comment noted. See text revision in Section 1.2.2.

3. Comment noted. See text revisions in Section 3.2.2.

4. Comment noted. See text revision in Section 3.3.

5. Comment noted. See text revision in Section 3.3.

6. Text was not modified. See Letter 7, Comment 8.

7. Text was not modified. Native American historical fishing areas are considered to have habitat and biological conditions that support the fishery location. Historical use of site indicates the biological value and probability that site approval will be difficult to obtain.

8. Comment noted. See text revision in Section 3.5. Paint filter test is an existing method used by local jurisdictions and landfill operators to establish acceptable sediment water content for landfill disposal.

9. Comment noted. See text revision in Section 3.5. Considerations listed are for initial site review and indicate high or low potential for a proposed dredging and disposal to meet the functional design standard. It does not rule out the acceptance of a hydraulic pipeline disposal. It does indicate that dewatering action is necessary for hydraulic dredged sediments before final disposal at a functional design site. The alternative to dewatering is approval of direct hydraulic disposal through the effects-based design process.

10. Comment noted. See text revision. The component referenced is the maximum thickness a single lift of cap should be when placed over all contaminated sediment area. Limiting the single lift thickness prevents inadvertent displacement of contaminated sediment by concentrating the weight of the cap over a small area. See Appendix B.1.2, **Narrative Descriptions**, regarding placement of capping sediment.

11. Comment noted. See text revisions in Section 5.2.3. Also reference Appendix B.1.2, **Narrative Descriptions**, regarding placement of capping sediment.

12. Comment noted. See text revision in Section 5.3.3. "None" as used in the draft document was to indicate no specified requirements for overflow **height**. Also reference Appendix C, Section C.1.2, **Narrative Description**, paragraph item titled **Effluent Control**.

13. Comment noted. See text revision in Section 5.4.2.

14. Text was not modified. Refer to additional discussion of stockpiling in Sections 5.4.2 and Appendix D, Section D.1.1, **Narrative Descriptions**. Also reference Comment 6 in Addendum to Letters 4, 5, and 6.

15. Comment noted. With proper survey conditions and controls (e.g. relatively calm sea state, accurate tidal corrections) and state-of-the-art equipment, survey accuracy of 0.1 ft is possible and should be the survey objective.

16. This issue is addressed above as part of response to Letter 4, Comment 3.

17. Comment noted. We feel the 25-foot lane spacing is needed to obtain highly accurate dredged volume estimates. This should not prove restrictive in terms of adding significant survey time due to the relatively small areas dredged on a daily basis. The real test of what is reasonable must account for the geometry of the dredging area. A closer spacing is reasonable in the dredging of a large, irregular area associated with a new project; the maintenance dredging of a symmetrical channel would not justify 25-foot lane spacing. The daily survey requirement was included as part of the most rigorous monitoring alternative (3). Although it would certainly be costly and labor intensive, it could be done. We feel it is appropriate as part of Alternative 3.

18. Text was not modified. The paragraph referred to in the comment is a review discussion of alternatives for cap materials. This text concurs with the comment that fine-grained material tends to be more environmentally acceptable. See Section 9.2.1. We also concur with the concern for "bombing" the site. That is the intent of controlling the release rate of capping materials. See Section 9.2.2, **Capping Sediment Placement**. Also see Appendix B, **Capping Sediment Placement**.

19. Text was not modified. Decision and recommendation are based on several factors, of which cost and environmental impacts are included. See Section 9. Hydraulic dredging with dewatering is available to a project proponent through the effects based design process.

20. Text was not modified. We concur that direct offloading to the transport vehicle can result in greater expense than offloading with stockpiling. The potential for environmental impact is deemed greater with stockpiling methods. The project proponent can use stockpiling through the effects-based design process. This will also allow the proponent to determine if control procedures necessary for stockpiling operations are cost-effective compared to direct offloading.

21. Comment noted. Text has been revised to omit reference to database development. This issue will not be discussed within the scope of this report.

22. Text was not modified. The basis for cap armoring at depths less than -80 feet is the potential for deep draft vessel contact or propeller scour, wave energy and tidal current energy to disturb bottom sediments. Refer to Sections 5.2.1 and 9.2.1, and Appendix B. We concur with comment on the need for local evaluation and design.

23. Comment noted. For the purpose of this document, we believe the tests listed in Table 4.3 are adequately described in Section 4.2.1.

23(b). Initial settling is the period from initial introduction of the sediment until it changes from a dense slurry to soft soil.

24. The functional design specifies the equipment and procedures for dredging, while the effects-based design does not. Text was not modified. We concur with the conclusion that 25 cubic yards per hour is very low. This reflects small dredging operations on a long pipeline without boosters. Production rates at that level are typically not economical except when involved in operations such as material reclamation or contaminated sediment clean up.

Comment noted and text revised.

Text was not modified. We concur with comment conclusions. These are two of the reasons that suction without rotating cutter equipment was not selected as the recommended functional design method.

25. Comment noted and text revised. Water entrainment as presented is a combination of theoretical and logical application of data available from prototype dredging operations.

26. Text was not modified. Cap armoring is intended to be conservative for functional design. Exceptions to the cap armoring requirement on a site-specific basis may be demonstrated by the applicant and permitted through the effects-based design process. This is also true for slope conditions. Functional design is not intended and does not cover all disposal site conditions.

27. In-place capping is another means of dealing with contaminated sediments. If designed properly, a capped-in-place site may enhance intertidal habitat. The reality of capping in place is that it has an extremely limited use.

Comments received from Doug Hotchkiss, Port of Seattle.

(1) p. 5-16 All the design elements need to be put in context, with applicability clearly stated. This has been included for some categories but not others. For example, gas management is standard landfill practice, but how is it applicable to dredged material?

(2) p.5-19 First paragraph. Dewatering is not similar for clamshell and hydraulic dredging. See the bulking figures reported in the document to compare these methods. The best hydraulic may equal the worst clamshell, but the two methods are not really comparable.

(3) p. 5-35 Bottom of table. Clarify (in text) what is meant by an "Approved Carrier".

(4) p. 6-1 Clearly state assumptions in the introduction to this section. For example, site size should be clearly stated, as this will influence the number of monitoring wells required.

(5) p. 6-1 Positioning by markers should be included. This method is suitable for many nearshore projects and accuracy can be as good as $\pm$3m.

(6) p. 6-2 The bathymetry discussion is oriented toward CAD sites and does not address shallow and nearshore sites where there is good positioning information.

(7) p. 6-4 The biological monitoring section presents a list of potential tests but needs additional information on when and where these tests are applicable. State why each test was considered and relate it to rest of document.

(8) p. 6-7 The numbering of the monitoring alternatives is the reverse of the other components, i.e., Alternative 1 is the least protective and costly, Alternative 3 is the most protective and costly. This is potentially confusing and should be switched for consistency among all components.

(9) p. 6-12 Nearshore Long-term Monitoring. Runoff monitoring is generally not necessary. Need to clearly state when this might be applicable and relevant. An additional Section (6.2.5) on Runoff Monitoring should be added to address this question and provide additional information.

(10) p. 6-13 Again, assumptions concerned site size should be clearly stated in table and text.

Disposal site monitoring prior to placement of dredged material should include collection of background sediment chemistry information.

(11) p. 6-14 A short section discussing Sediment Chemistry should precede the Groundwater discussion.

(12) Alternative 1. The one-month requirement for well installation should be omitted and timing remain flexible. Upgradient wells may be installed one

month (or sooner) prior to disposal, other wells (e.g., fill or cap) may be installed after fill consolidation.

(13) Sampling at low low tide will not be possible at all wells due to positioning and timing and this requirement should be deleted or qualified. The critical requirement is that downstream wells be sampled on the lower half of the outgoing tide. (ck. against Tom's notes).

(14) p. 6-15 Well Placement and Number of Wells. The requirement for "one well placed in the contained dredge fill at the location most likely to have maximum concentrations of contaminants" is too simplistic. Well position requirements are very site specific and more general requirements should be discussed. For example, the intent should be to target locations of probable contaminant release:

1. Areas with high levels of contamination
2. Contaminants that are likely to be released from sediments (e.g. metals)
3. Areas that are hydraulically active (e.g., near the berm or in upper levels of fill)
4. Consider the permeability of highly contaminated areas.

(15) p. 6-16 Sampling Techniques. The requirement that three casing volumes be purged seems excessive. Two volumes are generally adequate, many wells will be dry after one.

(16) The percentage of QA/QC samples that are required is very high and will substantially increase monitoring costs. These QA/QC requirements should be justified and referenced.

(17) p. 6-17 to 6-19, Alternative 2 and Alternative 3. Comments the same as for Alternative 1 (above).

(18) p. 6-21 Biological monitoring. Clarify: "..biological monitoring would serve as a reliable indicator" of effects if substantial contaminant migration has occurred at a site.

(19) p. 9-4 Phase 3 characterization. The PSDDA bioassay requirement doesn't match the monitoring requirements. If the bioassay characterization test is intended to leave open the possibility of open-water (PSDDA) disposal, this should be stated, and the bioassay requirement included for all disposal environments.

(20) The application of PSDDA bulk chemistry measurements to dangerous waste standards is discussed for PAH and HH, how should metals be handled?

(21) p. 9-22, bottom of page. Suggest adding numbers to back up statement "hydraulic dredging more environmentally protective than clamshell because there would be less sediment loss.."

(22) p. 9-23, second bullet. Does loss from placement of contaminated sediments mean loss over the weir? Clarify.

23 p. 12-2 TPH requirement. Mention should be made of the problems with the standard TPH test in the presence of organics. The 8000 method series is an alternative analysis.

24 p. 13-21 Costs for Site Design and Permitting in Tables 13-5 to 13-8 are too low. This estimate is not broken down, but the time for the permitting process and design may have been underestimated. A better estimate is at least $200,00 (??for disposal alone? ck Tom's notes).

25 Costs for Dike Construction (nearshore) are also too low (Table 13-5). The assumptions need to be clearly stated, e.g., is this for construction of three new dike walls or just one dike across an existing slip. Costs are site specific, but an estimate of $1-2 million is more realistic for most possible sites. Recent work at Slip 27 (approximately a 200,000 yd^3 site) was $3.24 million. This included some demolition work, however.

26 p. 14-24 All sediments placed at Terminal 91 were dredged using mechanical dredges.

27 p. 14-25 The six month delay between filling and cap placement at Terminal 91 was due to construction operations and was not planned to allow fill consolidation (although additional consolidation did result).

RESPONSE TO LETTER NO. 9: PORT OF SEATTLE (DOUG HOTCHKISS)

1. Comment noted. See text revision in Section 5.4. Also see Letter 5, Comment 5; Letter 7, Comment 4.

2. Comment noted. See text revision in Section 5.4.3. Dewatering techniques for drying sediments are similar, after the hydraulically slurried sediments have been dewatered to approximately in-situ water content.

3. Comment noted. See text revision in Section 5.5.3.

4. The number of monitoring wells required will depend on the shape of the disposal area and the hydrogeologic conditions. The recommended number of wells presented in Section 7 represents what we think is likely to be adequate for the functional designs discussed in Section 6.

5. See text revision in Section 6.2.1.

6. Comment noted. The CAD orientation of the bathymetry discussion is due to the critical nature of accurate bathymetric measurements in CAD monitoring. In shallow, nearshore sites, the same survey requirements would be applicable; these requirements would be technically simpler and more economical to achieve.

7. Comment noted. Additional information on the applicability of biological tests is presented in Chapter 4.

8. Comment noted. The least protective site design will require the most protective monitoring. Therefore, the monitoring alternatives are numbered such that the most protective monitoring alternative number is the same as the least protective dredging and site design alternative number.

9. Comment noted. Text has been revised to clarify when runoff monitoring is required. We do not feel that this is a substantive enough issue to warrant a separate section.

10. Site size is addressed in Section 9.1. Comment regarding background chemistry data noted. Pre-disposal chemical characterization of any disposal site would be conducted as part of the site characterization/selection process.

11. Sediment chemistry is addressed in Section 7.2.2, **Chemical Monitoring**.

12. Comment noted. See revisions in text.

13. Comment noted. See revisions in text.

14. Comment noted. See revisions in text.

15. The requirement is for three casing volumes OR until the well goes dry.

16. Comment noted. See revisions in text.

17. Response to comments for Alternative 2 and Alternative 3 are the same as Alternative 1.

18. Comment noted. See text revision in Section 6.3.2.

19. Comment noted. The PSDDA bioassay requirement, at this stage in the decision process, is intended to leave open the possibility of open-water disposal. Note that at this point, the proponent has shown that the dredged material is less than 1/10 D.W. In addition, this testing would provide an indication of the degree of toxicity of the material should an inadvertent release of material into the marine environment occur. These bioassays are not relevant to the upland disposal alternative.

20. Comment noted. See Section 9.1.1 of document.

21. Comment noted. See text revision in Section 9.3.1. Also refer to Appendix A regarding operational control of cutterhead dredge and mechanical clamshell dredge; and Appendix C regarding calculations for sediment loss comparison.

22. Comment noted. See text revision in Section 9.3.1. and Appendix C.

23. Comment noted. See text revision in Section 11.

24. Cost estimates have been changed to reflect comment. See Tables 1.5 through 1.8.

25. Comment noted. No modification to text at this time. Estimate is as commentor suggests very dependent on the site conditions.

26. Comment noted. See text revision in Section 13.3.

27. Comment noted. See sext revision in Section 13.3.

17. REFERENCES

ABAM Engineers. 1989. Naval Station Puget Sound, upland disposal site investigation. Lead Agency, Department of the Navy, San Bruno, California.

Averett, D.E. et al. 1988. Verification of procedures for designing dredged material containment areas for solids retention. Technical Report D-88-2, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Massachusetts.

Bartos, M.J., Jr. 1977. Use of dredged material in solid waste management. Technical Report D77-11, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Becker, D.S. and K.K. Chew. 1987. Predation on Capitella spp. by small-mouthed pleuronectids in Puget Sound, Washington. Fishery Bulletin 85:471-479.

Bokuniewicz, H.J. and R.B. Gordon. 1980. Deposition of dredged sediment at open water sites. Estuarine and Coastal Marine Science, Vol. 10.

Brannon, J.M. et al. 1985. Effectiveness of capping in isolating contaminated dredged material from biota and overlying water. Technical Report D-85-10, U.S. Army Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Burks, S.L. and R.M. Engler. 1978. Water quality impacts of aquatic dredged material disposal: laboratory investigations. Technical Report DS-78-04, U.S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi.

Clausner, J. E., and C.L. Truitt. 1987. Propeller wash effects on protective armor layer design for container aquatic disposal sites. PIANC Bulletin No. 58, Brussels, Belgium.

Collie, J.S. 1985. Feeding habits of the Yellowtail Flounder and production of its invertebrate prey on Georges Bank. Ph.D. Dissertation, Woods Hole Oceanographic Institution, Massachusetts Institute of Technology. WHOI Publ. 85-32, 165p.

Cullinane, M. John, Jr. et al. 1988. Technologies for the control/treatment of contaminated dredged material. 1988 National Research Council, Washington D.C. Symposium and Workshop on Contaminated Marine Sediments, Tampa, Florida.

Dames and Moore. 1987. Sediment sampling and analysis program for Hewitt Avenue and South Terminal projects. Report prepared for Port of Everett, Everett, Washington.

Dillon, Tom M. 1988. Environmentally acceptable methods of dredging and handling harbour and channel sediments. Proceedings of Central Dredging Association, Hamburg, Germany.

Engler, R.M. 1988. Management of bottom sediments containing toxic substances. Proceedings of the 11th U.S./Japan Experts Meeting. U.S. Army Corps of Engineers Water Resources Support Center, Seattle, Washington.

EPA. 1986. Interim decision criteria for disposal of dredged material at the Port Gardner open-water disposal site. U.S. Environmental Protection Agency. Region 10. Seattle, Washington.

EPA. 1989. Progress and accomplishments fiscal year 1988: SITE superfund innovative technology evaluation. Office of Solid Waste and Emergency Response, Washington, D.C.

Federal Register. 1986. Volume 51, No. 216, p 40642.

Folsom, B.L., Jr. Lee, C.R., and D.J. Bates. 1981. Influence of disposal environment of availability and plant uptake of heavy metals in dredged material. Technical Report EL-81-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Fredette, T.J. 1987. Dredged material behavior at a deep water, open ocean disposal site. Proceedings of the Twentieth Dredging Seminar at Toronto, Canada. Texas A&M University, College Station, Texas.

Fujimori, K. 1985. Management of bottom sediments containing toxic substances. Proceedings of the 11th U.S./Japan Experts Meeting. U.S. Army Corps of Engineers Water Resources Support Center, Seattle, Washington.

Gambrell, R.P. et al. 1978. Disposal alternatives for contaminated dredged material as a management tool to minimize adverse environmental effects. Technical Report DS-78-08, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Glindemann, H. et al. 1988. Research into dredged material disposal in the Port of Hamburg. Environmentally acceptable methods of dredging and handling harbour and channel sediments. Proceedings of Central Dredging Association, Hamburg, Germany.

Gomyoh, M. et al. 1986. The movement of sediment under a progressive wave. Management of bottom sediments containing toxic substances. Proceedings of the 11th U.S./Japan Experts Meeting. U.S. Army Corps of Engineers Water Resources Support Center, Seattle, Washington.

Graf, W.H. 1971. Hydraulics of sediment transport. McGraw-Hill Book Company, New York, New York.

Gupta, S.C. 1978. The agricultural value of dredged material. Technical Report D-78-36, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Haider, G. 1988. Disposal of dredged materials. Environmentally acceptable methods of dredging and handling harbour and channel sediments. Proceedings of Central Dredging Association, Hamburg, Germany.

Haliburton, T. Allan. 1978. Guidelines for dewatering/densifying confined dredged material. Technical Report DS-78-11. Synthesis of research results: dredged material research program, U.S. Army Engineer Waterways Experiment Station, Final Report, September, 1978.

Hammer, D.P. and Blackburn, E.D., Design and construction of retaining dikes for containment of dredged material. Dredged Material Research Program, Technical Report D-77-9. U.S. Army Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Hands, E.B. 1985. Techniques for monitoring stability of offshore submerged disposal mounds. Management of bottom sediments containing toxic substances. Proceedings of the 11th U.S./Japan Experts Meeting. U.S. Army Corps of Engineers Water Resources Support Center, Seattle, Washington.

Harrison, W., and A. van Luik. 1980. Suitability of dredged material for reclamation of surface-mined land. Technical Report EL-80-7, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Hart-Crowser and Associates, Inc. and URS Corporation. 1985. Hydraulic and contaminant modeling, Terminal 91, Seattle, Washington. Lead Agency, Port of Seattle.

Hartman. 1976. Evaluation of estuarine channel conditions in Coos Bay, Oregon using side-scan sonar. Masters Thesis submitted to Oregon State University. Corvallis, Oregon.

Hatano, R. and Y. Abe. 1985. Use of anti-turbidity curtains at a sand compaction piling area in Yokohama Harbour. Management of bottom sediments containing toxic substances. Proceedings of the 11th U.S./Japan Experts Meeting. U.S. Army Corps of Engineers Water Resources Support Center, Seattle, Washington.

Hayes, D.F. 1985. Guide to selecting a dredge for removal of contaminated bottom sediments. Environmental effects of dredging, Technical Notes. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

Hayes, D.F., T.N. McLellan, and C.G. Truitt. 1988. Demonstration of innovative and conventional dredging equipment at Lakemet Harbor, Illinois. MP EL-88-1, U.S. Army Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

Hayes, D.F., G. Raymond, T.N. McLellan. 1984. Sediment resuspension from dredging activities. Dredging and dredged material disposal. Proceedings of the ASCE Specialty Conference Dredging. 84, Clearwater Beach, Florida.

Herbich, J.B. 1988. Overview of available technologies: developments in equipment designed for handling of contaminated sediments. National Research Council, Washington, D.C. Symposium and workshop on contaminated marine sediments, Tampa, Florida.

Hill, D.O., T.E. Myers, and J.M. Brannon. 1988. Development and application of techniques for predicting leachate quality in confined disposal facilities. Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi.

Hotchkiss, D. 1988. Terminal 91 short fill: monitoring a dredged material disposal site. Proceedings of the First Annual Meeting on Puget Sound Research. Vol. 2. Puget Sound Water Quality Authority, Seattle, Washington.

Hotchkiss, D. 1989. Personal communication of May 3, 1989. Port of Seattle, Seattle, Washington.

Hotchkiss, D. 1989. Terminal 91 short fill monitoring results: insights for the future of contaminated dredge material disposal. Proceedings of ASCE Specialty Conference, Ports 89, Boston, Massachusetts.

Hotchkiss, D.A. 1989. Site monitoring data from Port of Seattle, Pier 91 fill project Port of Seattle, Washington.

Hotchkiss, D.A., and W.W. Watson. Contaminant mobility and engineering design at a nearshore confined disposal site -- Port of Seattle Terminal 91 short fill. Management of bottom sediments containing toxic substances. Proceedings of the 11th U.S./Japan Experts Meeting. U.S. Army Corps of Engineers Water Resources Support Center, Seattle, Washington.

Huston, J. 1970. Hydraulic dredging. Cornell Maritime Press, Cambridge, Maryland.

Kimura, S. et al. 1985. Analytical survey of accumulations of sediments in canals of Tokyo Port. Management of bottom sediments containing toxic substances. Proceedings of the 11th U.S./Japan Experts Meeting. U.S. Army Corps of Engineers Water Resources Support Center, Seattle, Washington.

Landin, M.C. 1984. Habitat development using dredged material. Proceedings of the ASCE on dredging and dredged material disposal. Tampa, Florida.

Landin, M.C., Editor. 1988. Inland Waterways. Proceedings of a national workshop on the beneficial uses of dredged material. Technical Report D-88-8, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Larson, R.S. 1989. Capping of contaminated sediments - A case study. Dredging: technology, environmental, mining. Proceedings of the XII World Dredging Congress, World Dredging, Mining and Construction, Irvine, California.

Lee, C.R. et al. 1978. Prediction of heavy metal uptake by marsh plants based on chemical extraction of heavy metals from dredged material. Technical Report D-78-06, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Lee, C.R. et al. Decisionmaking framework for management of dredged material: application to Commencement Bay, Washington. Miscellaneous Paper D-85, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Lee, C.R., R.N. Engler and J.L. Mahloch. 1976. Land application of waste materials from dredging, construction, and demolition processes. Miscellaneous Paper D-76-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Lejuste, F. et al. 1988. New concept of density measurement in dredgers. Environmentally acceptable methods of dredging and handling harbour and channel sediments. Proceedings of Central Dredging Association, Hamburg, Germany.

Loxham, M. et al. 1988. Comparison of four strategies for the disposal of contaminated dredged material. Environmentally acceptable methods of dredging and handling harbour and channel sediments. Proceedings of Central Dredging Association, Hamburg, Germany.

Lukjanowicz, E. et al. 1988. Strategies and technologies for dredging and dipsosal of contaminated marine sediment. A case study U.S. Navy Carrier Battlegroup Homeport Project Everett, Washington. Symposium and Workshop on Contaminated Marine Sediment, Tampa, Florida, National Research Council, Washington, D.C.

Lunz, J.D. and D.R. Kendall. 1982. Benthic Resources Assessment Technique (BRAT), a method for quantifying the effects of benthic community changes on fish resources. In: Proceedings of Oceans '82, Washington, D.C.

MacGinite, G.E. 1934. The natural history of Callianassa californiensis Dana. The American Midland Naturalist 15.

Mang, J.L. 1978. A study of leachate from dredged material in upland areas and/or in productive uses. Technical Report D-78-20, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Meyers, T.E. et al. 1985. Development of leachate testing protocols for disposal of contaminated sediments. Management of bottom sediments containing toxic substances. Proceedings of the 11th U.S./Japan Experts Meeting. U.S. Army Corps of Engineers Water Resources Support Center, Seattle, Washington.

Mohr, A.W. 1974. Development and future of dredging. Journal of the Waterways, Harbors and Coastal Engineering Division. 100. 69-83.

Mohr, A.W. 1975. Energy and pollution concerns in dredging. Journal of the Waterways, Harbors and Coastal Engineering Division, ASCE, 101:405-417.

Mohr, A.W. 1980. A practical method for estimating pipeline dredge production. Third International Symposium on Dredging Technology, Texas A&M, College Station, Texas.

Mohr, A.W. 1984. Economic advantages: cost comparison of dredged material transport. World Dredging and Marine Construction.

Morton, R.W. 1980. Capping procedures as an alternative technique to isolate contaminated dredged material in the marine environment. U.S. Army Engineers, New England Division, Newport Rhode Island.

Nakano, T. et al. 1985. Test results of sediment removal in Ise Bay. Management of bottom sediments containing toxic substances. Proceedings of the 11th U.S./Japan Experts Meeting. U.S. Army Corps of Engineers Water Resources Support Center, Seattle, Washington.

Neal, R.W. et al. 1978. Evaluation of the submerged discharge of dredged material slurry during pipeline dredge operations. Dredged Material Research Program, Technical Report D-78-44, U.S. Army Engineer Waterways Experiment Station.

Nowell, A.R.M. and P.A. Jumars. 1984. Flow environments of aquatic benthos. Annual Review of Ecology and Systematics 15:303-328.

Nowell, A.R.M. et al. 1989. The effects of sediment transport and deposition on infauna: results obtained in a specially designed flume. Ecology of Marine Deposit Feeders. Lecture Notes on Coastal and Estaurine Studies 31:247-268. Springer-Verlag, New York, N.Y.

O'Conner, J.M. and S.G. 1983. Evaluation of the 1980 capping operatiions at the experimental mud dump site, New York Bight Apex. Technical Report D-83-3, U.S. Army Corps of Engineers Waterways Experiment Station.

Ogden Beeman & Associates. 1988. Milwaukee Waterway fill project. Lead Agency, Port of Tacoma, Washington.

Palermo et al. 1989. Evaluation of dredged material disposal alternatives for U.S. Navy Homeport at Everett, Washington. Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi.

Palermo, M. R. et al. 1978. Guidelines for designing, operating, and managing dredged material containment areas. Synthesis of Research Results: Dredged Material REsearch Program, Technical Report DS-78-10, U.S. Army Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

Palermo, M.R. 1986. Long-term effects of dredging operations program. Development of a modified elutriate test for estimating the quality of effluent from confined dredged material disposal areas, Technical Report D-86-4, U.S. Army Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

Parametrix, Inc. 1987. St. Paul Waterway Area Remedial Action and Habitat Restoration Project. Overview of the project SEPA environmental checklist technical appendices. Unpublished report to Simpson Tacoma Kraft Company.

Parametrix, Inc. et al. 1988. Newcastle demolition landfill compliance audit checklist. Report to Coal Creek Development Corporation, Seattle, Washington.

Payonk, P.M. et al. 1989. Clamshell dredging and overflow monitoring. Dredging: technology, environmental, mining. Proceedings of World Dredging Congress XII, Orlando, Florida. Western Dredging Association, Fairfax, Virginia.

Peddicord, R.K. et al. 1986. Interim Draft Report. General decision-making framework for management of dredged material - example application to Commencement Bay, Washington, Miscellaneous Paper DS-86-___, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Perrier, E.R. et al. 1980. Area strip mine reclamation using dredged material: A field demonstration. Technical Report EL-80-4, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Peterson, S.A. 1985. Lake restoration methods: some work, some don't. Management of bottom sediments containing toxic substances. Proceedings of the 11th U.S./Japan Experts Meeting. U.S. Army Corps of Engineers Water Resources Support Center, Seattle, Washington.

Phillips, K.E. and J.F. Malek. "Evaluation of Dredging as a Remedial Technology for the Commencement Bay Superfund Site" In: Management of Bottom Sediments Containing Toxic Substances, Proceedings of the 11th U.S./Japan Experts Meeting, November 4-6, 1985, Seattle, Washington, Thomas R. Patin, Editor. U.S. Army Corps of Engineers Water Resources Support Center.

Phillips, K.E. et al. 1985. Commencement Bay Nearshore/Tide Flats Superfund Site, Tacoma, Washington, remedial investigations. Evaluation of alternative dredging methods and equipment disposal methods and sites and treatment practices for contaminated sediments. U.S. Army Corps of Engineers Seattle District, Seattle, Washington.

Port of Seattle. 1987. Unpublished data on Fisherman's Terminal sediment analyses. Port of Seattle, Seattle, Washington.

Preston, Thorgrimson, Ellis and Holman; and Parametrix, Inc. 1989. Newcastle demolition landfill compliance audit checklist. Report to Coal Creek Development Corporation, Seattle, Washington.

Puget Sound Dredged Disposal Analysis. 1988. Evaluation Procedures Technical Appendix - Phase I (Central Puget Sound). Puget Sound dredged disposal analysis reports series. Cooperatively published by (in alphabetical order) U.S. Army Corps of Engineers, Seattle District; U.S. Environmental Protection Agency, Region 10; Washington State Department of Ecology; and Washington State Department of Natural Resources.

Puget Sound Dredged Disposal Analysis. 1989. Management Plan Report - Unconfined Open Water Disposal of Dredged Material, Phase II (North and South Puget Sound) Draft, Cooperatively published by (in alphabetical order) U.S. Army Corps of Engineers, Seattle District; U.S. Environmental Protection Agency, Region 10; Washington State Department of Ecology; and Washington State Department of Natural Resources.

Puget Sound Naval Shipyard (PSNS). 1983. Environmental Assessment for Pier B dredging, Pier 3 dredging and Pier B Mooring cluster additions. Puget Sound Naval Shipyard, Public Works Department, Bremerton, Washington.

Puget Sound Water Quality Authority. 1988. Draft 1989 Puget Sound Water Quality Management Plan. Seattle, Washington. 270pp.

Rhoads, D.C. et al. 1975. Conversion of marine muds to lightweight construction aggregate. Environmental Science and Technology 9:360-362.

Rhoads, D.C. et al. 1978. Disturbance and production on the estuarine seafloor. American Scientist 66:577-586.

Riddell, J.F. et al. 1988. Experience on the river Clyde in the use of dredged material as a top soil. Environmentally acceptable methods of dredging and handling harbour and channel sediments. Proceedings of Central Dredging Association, Hamburg, Germany.

Sato, T. et al. 1985. Effects of sediment removal in Tokyo Bay. Management of bottom sediments containing toxic substances. Proceedings of the 11th U.S./Japan Experts Meeting. U.S. Army Corps of Engineers Water Resources Support Center, Seattle, Washington.

Science Applications International Corporation (SAIC). 1989. Fishery Utilization of open-water disposal sites. Interim Report. U.S. Army Corps of Engineers, New England Division, Waltham, Massachusetts. 142 pp. + tables and figures.

Semonian, R.C. 1981. Studies on capping of contaminated dredged material in New England division. Proc. Management of bottom sediments containing toxic substances. Proceedings of 7th Annual U.S. - Japan Experts Meeting. New York New York.

Shields, F.D. et al. 1987. Design and management of dredged material containment areas to improve hydraulic performance. Technical Report D-87-2, U. S. Army Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Simmers, J.W. 1980. Field survey of heavy metal uptake by naturally occurring saltwater and freshwater marsh plants," Technical Report 80-5, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Simmers, J.W. and R.G. Rhett. 1986. Strip-mine reclamation using dredged material. Technical Report D-86-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Simmers, J.W. et al. 1985. Bioavailability of heavy metals in relation to potential use of dredged material for large scale acid mine spoil restoration. Proceedings of Heavy Metals in the Environmental Conference. Edinburgh, United Kingdom. 3p.

Simons, D.B., and F. Senturk. 1976. Sediment transport technology, Water Resources Publications, Ann Arbor, Michigan.

Skogerboe, J.G. et al. 1987. Field verification program (upland disposal). Prediction of surface runoff water quality from Black Rock Harbor dredged material placed in an upland disposal site, Miscellaneous Paper D-87-1, U.S. Army Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

Spaine, P.A. et al. 1978. Guidance for land improvement using dredged material. Technical Report DS-78-21, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Sternberg, R.W. 1975. Predicting initial motion and bedload transport of sediment particles in the shallow marine environment. Shelf Sediment Transport, Dowden, Hutchinson and Ross, Inc., Stroudsburg Pennsylvania.

Stevens, B.A. 1928. Callianassidae From the west coast of North America. Publications of Puget Sound Biological Station, University of Washington Press, Seattle, Washington.

Sumeri, A. 1984. Capped in-water disposal of contaminated dredged material. Proceedings of the Conference on Dredging '84, American Society of Civil Engineers, Vol. 2.

Tavolaro, J.F. 1984. A sediment budget study of clamshell dredging and ocean disposal activities in the New York Bight. Environmental Geology and Water Science 6:3.

Tetra Tech, Inc. 1986. Recommended protocols for measuring selected environmental variables in Puget Sound. Prepared for the Puget Sound Estuary Program (PSEP). Tetra Tech, Inc., Bellevue, Washington.

Thomas, R.F. 1989. Effluent water quality at Hart Miller Island, Baltimore, Maryland. Dredging: technology, environmental, mining. Proceedings of WODCON XII, Orlando, Florida.

Truitt, C.L. 1986. The Duwamish Waterway Capping Demonstration Project: Engineering analysis and results of physical modeling. Technical Report D-86-2, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

Turner, T.M. 1984. Fundamentals of hydraulic dredging. Cornell Maritime Press, Centerville, Maryland.

U.S. Army Corps of Engineers. 1978. Guidelines for dewatering/densifying confined dredged material. Technical Report DS-78-11, U.S. Army Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

U.S. Army Corps of Engineers. 1978. PCB cleanup operations, Duwamish Waterway, Seattle Harbor, Washington. U.S. Army Corps of Engineers, Seattle, District, Seattle, Washington.

U.S. Army Corps of Engineers. 1983. Dredging and dredged material disposal. Engineer Manual 1110-2-5025, U.S. Army Corps of Engineers.

U.S. Army Corps of Engineers. 1984. Shore protection manual. Coastal Engineering Research Center, Waterways Experiment Station, Vicksburg, Mississippi.

U.S. Army Corps of Engineers. 1985. Engineering and design, government estimates and hired labor estimates for dredging. Regulation No. 1110-2-1300, U.S. Army Corps of Engineers, Washington, D.C.

U.S. Army Corps of Engineers. 1986. Beneficial Uses of Dredged Material. Engineer Manual 1110-2-5026. Office of Engineers, Washington, DC. 297pp + app.

U.S. Army Corps of Engineers. 1986. Evaluation of dredged material disposal alternatives for U.S. Navy Homeport at Everett, Washington. Lead Agency, U.S. Army Engineer District, Seattle, Washington.

U.S. Army Corps of Engineers. 1986. Guidelines for selecting control and treatment options for contaminated dredged material requiring restrictions. PSDDA Reports, Waterways Experiment Station.

U.S. Army Corps of Engineers. 1987. Confined disposal of dredged material. Engineer Manual 1110-2-5027, U.S. Army Corps of Engineers, Washington, D.C.

U.S. Army Corps of Engineers. 1988. Dredging fundamentals. Corps Engineers Training Management Division, Huntsville, Alabama.

U.S. Army Corps of Engineers. 1988. Final environmental impact atatement - unconfined open-water disposal sites for dredged material. PSDDA Reports, Lead Agency: U.S. Corps of Engineers, Seattle District, Seattle, Washington.

U.S. Environmental Protection Agency (EPA). 1985. Update Number II to test methods for evaluating solid waste, physical/chemical methods, SW-846.

U.S. Navy Western Division. 1987. Permit Application for proposed dredge, fill, shoreline improvements, pier, wharf, disposal & breakwater, Revised March 10, 1987. U.S. Corps of Engineers, Regulatory Function Branch, Seattle, Washington.

URS Consultants. 1989. Standards development of confined disposal of contaminated sediments. Draft final report. Lead Agency, Washington Department of Ecology, Olympia, Washington.

van Doorn, T. 1988. Dredging polluted soil with a trailing suction hopper dredger. Environmentally acceptable methods of dredging and handling harbour and channel sediments. Proceedings of Central Dredging Association, Hamburg, Germany.

van Drimmelen, N.J. 1988. Modern dredging methods and their environmental aspects. Environmentally acceptable methods of dredging and handling harbour and channel sediments. Proceedings of Central Dredging Association, Hamburg, Germany.

van Raalte, G.H. et al. Determination of dredging induced turbidity. Environmentally acceptable methods of dredging and handling harbour and channel sediments. Proceedings of Central Dredging Association, Hamburg, Germany.

Veltman, M. 1988. Management of contaminated sediments by insulation and recycling. Environmentally acceptable methods of dredging and handling harbour and channel sediments. Proceedings of Central Dredging Association, Hamburg, Germany.

Walsh, M.R., and Malkasian, M.D. 1978. "Productive Land Use of Dredged Material Containment Areas: Planning and Implementation Considerations". TR DS-78-20, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Washington State Department of Ecology (Geology). 1982. Chemical testing methods for complying with the State of Washington dangerous waste regulation, Ecology document 83-13, Revised July 1983.

Washington State Department of Ecology. 1989. Workshop on Workable Standards for Confined Sediment Disposal Standards - A Review of the Decision Process, Battelle Northwest, Seattle, Washington.

Watari, Y. et al. 1985. Sedimentation and effluent concentration of soft clay on reclamation works. Management of bottom sediments containing toxic substances. Proceedings of the 11th U.S./Japan Experts Meeting. U.S. Army Corps of Engineers Water Resources Support Center, Seattle, Washington.

Wells, B. 1989. Personal communication of May 25. Port of Seattle, Seattle, Washington.

Yagi, T. et al. 1975. Effect of operating conditions of hydraulic dredges on dredging capacity and turbidity. Technical Note 228, Port and Harbor Research Institute, Ministry of Transport, Yokosuka, Japan.

18. GLOSSARY

Absorption. A process in which one material takes up and retains another. The result is a homogeneous mixture which has the characteristics of a solution.

Adsorption. The adhesion of molecules to the surfaces of solids or liquids with which they are in contact. Many chemicals adsorb to sediment particles and are transported by these particles.

Aerobic. Living, active, or occurring only in the presence of oxygen. For example, soil microorganisms which degrade sewage effluent from septic systems need oxygen in order to function.

Alternatives. Alternative sets of requirements that will be assessed to determine a preferred standard for each of the options for disposal of contaminated dredged sediments.

Amphipods. Small shrimp-like crustaceans (for example, sand fleas). Many live on the bottom, feed on algae and detritus, and serve as food for many marine species. Amphipods are used in laboratory bioassays to test the toxicity of sediments.

Anaerobic. Living, active or occurring only in the absence of oxygen, or the condition of being without oxygen.

Apparent Effects Threshold (AET). The sediment concentration of a contaminant above which statistically significant biological effects would always be expected.

Area Ranking. The designation of a dredging area relative to its potential for having chemicals of concern in the sediment. Rankings range from "low" potential to "high" potential, and are used to determine the intensity of dredged material evaluation and testing that might be required.

Assessment Procedure. Procedure that will be used to assess alternative disposal standards and select a preferred standard. Preliminary and final assessment procedures will be developed.

Baseline Study. A study designed to document existing environmental conditions at a given site. The results of a baseline study may be used to document temporal changes at a site or to document background conditions for comparison with another site.

Benthic Organisms. Organisms that live in or on the bottom of a body of water.

Best Management Practice (BMP). Refers to methods for preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals. The term originated with the rules and regulations developed pursuant to Section 208 of the Federal Clean Water Act (40 CFR, Part 130).

Bioaccumulation. The accumulation of chemical compounds in the tissues of an organism. For example, certain chemicals in food eaten by a fish tend to accumulate in its liver and other tissues.

Bioassay. A laboratory test used to evaluate the toxicity of a material (commonly sediments or wastewater) by measuring behavioral, physiological, or lethal responses of organisms.

Biodegradation. The conversion of organic compounds into simpler compounds through biochemical activity. Toxic compounds can sometimes be converted into nontoxic compounds through biodegradation. Unfortunately, in some cases complex compounds are first converted into intermediate substances that can be more toxic than the original substance.

Biological Treatment. A wastewater treatment process that utilizes heavy growth of microorganisms for the purpose of oxidizing, absorbing, and adsorbing wastewater impurities, both organic and inorganic. Secondary treatment plants usually provide biological treatment.

Biomagnification. The process by which concentrations of contaminants increase (magnify) as they pass up the food chain so that each animal in the chain has higher tissue concentrations than did its food. For example, concentrations of certain contaminants can increase as they are passed from herring to salmon to seals.

Biota. The animals and plants that live in a particular area or habitat.

Categorical Standards. To deal with the tremendous number of individual industrial and commercial operations that may require water pollution standards, EPA has established 34 industrial categories based on a standard industrial classification developed for tax purposes. Some examples are adhesives and sealants, explosives manufacturing, ore mining, pulp and paperboard mills, and textile mills. As part of the settlement of a lawsuit, EPA identified 22 of these industrial categories for which federal pretreatment standards would be developed. As of February 1986, 21 such sets of standards have been adopted. An industry in an industrial category for which pretreatment standards have been set is referred to as a categorical industry and the federal pretreatment standards are referred to as categorical standards.

Characterization. The process of identifying a particular sediment's attributes, especially the types and levels of contaminants.

Chronic Toxicity. Any toxic effect on an organism that results after exposure of long duration (often 1/10th of the life span or more). The end result of a chronic effect can be death although the usual effects are sublethal (e.g., inhibited reproduction or growth). These sublethal effects may be reflected by changes in the productivity and population structure of the community.

Confined Disposal. A disposal method that contains contaminants in sediments by isolating the dredged material from the environment. Confined disposal may be in aquatic, nearshore, or upland environments.

Confined Aquatic Disposal (CAD). Confined disposal in a water environment. Usually accomplished by placing a layer of clean sediment over material that has been placed on the bottom of a water body (i.e., capping).

Contaminant. A chemical or biological substance that, when present in a form or in sufficient quantity, can harm aquatic organisms or users of the aquatic environment.

Contaminated Sediment. Technically, a sediment that contains measurable levels of contaminants or sufficient concentrations of chemicals to produce unacceptable adverse environmental effects and thus require restrictions. In a regulatory sense, sediment is considered contaminated if it contains levels of contaminants above PSDDA and P-2 levels, but below Dangerous Waste levels.

Conventional Pollutants. Sediment parameters and characteristics that have been measured routinely in assessing sediment quality. These include sulfides, organic carbon, etc.

Decision Model. A flow chart describing necessary steps for deciding where and how a given volume of sediment will be disposed.

Disposal. Methods by which unwanted materials are relocated, contained, treated, or processed. Unless contaminants are converted to less harmful forms or removed from the material before disposal, they may be released again into the environment.

Disposal Options. The four disposal environments that standards are being developed for: upland mixed, upland monofill, nearshore, and confined aquatic.

Disposal Site. The bottom area that receives discharged dredged material, encompassing, and larger than, the target area and the disposal zone.

Dredger. Private developer or public entity (e.g., federal or state agency, port or local government) responsible for funding and undertaking dredging projects. This is not necessarily the dredging contractor who physically removes and disposes of dredged material (see below).

Dredging. Any physical digging into the bottom of a water body. Dredging can be done with mechanical or hydraulic machines and is performed in many parts of Puget Sound for the maintenance of navigation channels that would otherwise fill with sediment and block ship passage. Dredging is also done to clean up contaminated sediments.

Dredging Contractor. Private or public (e.g., Corps of Engineers) contractor or operator who physically removes and disposes of dredged material for the dredger (see above).

Effects Based. Basing decisions on tests that indicate the degree of harmful effect to biological resources and human health.

Effects Based Design. A customized disposal site design that can be proposed at a dredger's discretion if they believe their material is so clean it does not need certain features of a functional design, or if their material does not meet test interpretation levels (see below).

Effluent. The liquid that flows out of a facility or household into a water body or sewer system. For example, the treated liquid discharged by a wastewater treatment plant is the plant's effluent.

Erosion. Wearing away of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical and chemical forces.

Flocculation. Aggregation of small suspended particles into a loose mass caused by ionic changes due to contact with seawater. Many contaminants carried into Puget Sound in fresh water change form through this process when the fresh water enters the Sound.

Functional Standards. Standards using designs considered to be certain to provide adequate protection; same as technology-based standards.

Groundwater. Underground water body, also called an aquifer. Aquifers are created by rain which soaks into the ground and flows down until it collects at a point where the ground is not permeable.

Habitat. The specific area or environment to which a particular type of plant or animal lives. An organism's habitat provides all of the basic requirements for life.

Hazardous Waste. Any solid, liquid, or gaseous substance which, because of its source or measurable characteristics, is classified under state or federal law as hazardous, and is subject to special handling, shipping, storage, and disposal requirements. Washington State law identifies two categories of hazardous waste: dangerous and extremely hazardous. The latter category is more hazardous and requires greater precautions.

Intertidal Area. The area between high and low tide levels. The alternate wetting and drying of this area makes it a transition between land and water and creates special environmental conditions and habitats.

Leachate. Water or other liquid that may have dissolved (leached) soluble materials, such as organic salts and mineral salts, derived from a solid material. Rainwater that percolates through a landfill and picks up contaminants is called the leachate from the landfill.

Medium, Media. In pollution control programs, media are the components of the environment that may be contaminated with a substance. Thus lead can be discharged to the air, to the water, or on the land. A program that handles lead contamination in all media is a cross-media program. A disposal practice that allows contaminants to go from water to air allows cross-media transfers.

Metals. Metals are naturally occurring elements. Certain metals, such as mercury, lead, nickel, zinc, and cadmium, can be of environmental concern when they are released to the environment in unusually high amounts.

Microlayer, Sea Surface Microlayer. The extremely thin top layer of water that can contain high concentrations of natural and other organic substances. Contaminants such as oil and grease, many lipophylic (fat or oil associated) toxicants, and pathogens may be present at much higher concentrations in the microlayer than they are in the water column. Also the microlayer is biologically important as a rearing area for marine organisms.

Microtox. A laboratory test using luminescent bacteria and measuring light production, used to assess toxicity of sediment extracts.

Monitor. To systematically and repeatedly measure something in order to detect changes or trends.

National Pollutant Discharge Elimination System (NPDES). A part of the federal Clean Water Act, which requires point source dischargers to obtain discharge permits. These permits are referred to as NPDES permits and are administered by the Washington Department of Ecology.

Nephloid Layer. A cloudy or turbid water layer in which light is scattered and absorbed by suspended particles. In the main basin of Puget Sound, the cloudiness of water increases near the bottom because fine particles are repeatedly suspended from the bottom.

Overdepth Material. Dredged material removed from below the dredging depth needed for safe navigation. Though this material is removed incidentally due to limited precision of dredging equipment, its excavation is usually planned as part of the dredging project to ensure proper final water depths. Common overdepth is 2 feet below the needed dredging depth.

P-2 Standards. Sediment quality standards established by Ecology under Element P-2 of the Puget Sound Water Quality Plan. These standards identify and designate sediments that have acute or chronic adverse effects on biological resources or that pose a significant health risk to humans.

Parameter. A quantifiable or measurable characteristic. For example, height, weight, sex, and hair color are all parameters that can be determined for humans. Water quality parameters include temperature, pH, salinity, dissolved oxygen concentration, and many others.

Persistent. Not readily degraded by natural physical, chemical, or biological processes. Persistent compounds such as PCBs remain in the environment for a long period of time.

Pesticide. A general term used to describe any substance, usually chemical, used to destroy or control organisms (pests). Pesticides include herbicides, insecticides, algicides, and fungicides. Many of these substances are manufactured and are not naturally found in the environment. Others, such as pyrethrum, are natural toxins extracted from plants or animals.

pH. The degree of alkalinity or acidity of a solution. Water has a pH of 7.0. A pH of less than 7.0 indicates an acidic solution, and a pH greater than 7.0 indicates a basic solution. The pH of water influences many of the types of chemical reactions that occur in it. Puget Sound waters, like most marine waters, are typically pH neutral.

Pollutant. A contaminant that adversely alters the physical, chemical, or biological properties of the environment. The term includes pathogens, toxic metals, carcinogens, oxygen-demanding materials, and all other harmful substances. With reference to nonpoint sources, the term is sometimes used to apply to contaminants released in low concentrations from many activities which collectively degrade water quality. As defined in the federal Clean Water Act, pollutant means dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water.

Polychlorinated Biphenyls (PCBs). A group of manmade organic chemicals with about 70 different but closely related compounds made up of carbon, hydrogen, and chlorine. If released to the environment, they persist for long periods of time and can concentrate in food chains. PCBs are not water soluble and are suspected to cause cancer in humans. PCBs are an example of an organic toxicant.

Polycyclic (Polynuclear) Aromatic Hydrocarbon (PAHs). A class of complex organic compounds, some of which are persistent and cancer-causing. These compounds are formed from the combustion of organic material and are ubiquitous in the environment. PAHs are commonly formed by forest fires.

Priority Pollutants. Substances listed by EPA under the Clean Water Act as toxic and having priority for regulatory controls. The list includes toxic metals, inorganic contaminants such as cyanide and arsenic, and a broad range of both natural and artificial organic compounds. The list of priority pollutants includes substances that are not of concern in Puget Sound, and also does not include all known harmful compounds.

Puget Sound Dredged Disposal Analysis (PSDDA). A multi-agency effort (led by the Army Corps of Engineers) to establish a program for the unconfined open-water disposal of dredged material. The project has selected sites for disposal of dredged materials, specified material evaluation procedures, and established site monitoring and management requirements. PSDDA also refers to the testing procedure and maximum contamination level required for sediment to be suitable for in-water unconfined disposal.

Puget Sound Water Quality Authority. An agency created by the Washington State legislature in 1985 and tasked with developing a comprehensive plan to protect and enhance the water quality of Puget Sound. Two Puget Sound Water Quality Management Plans have been adopted, in 1987 and 1989. These plans contain the framework and direction for Ecology's sediment efforts.

Regional Administrative Decisions. A term used to describe decisions that are a mixture of scientific knowledge and administrative judgment. These regionwide policies are made collectively by all regulatory agencies with authority over dredged materials disposal to obtain Sound-wide consistency.

Regulatory Agencies. Federal and state agencies that regulate dredging and dredged material disposal in Puget Sound, along with pertinent laws/permits.

Runoff. Runoff is the liquid fraction of dredged materials or the flow/seepage caused by precipitation landing on and filtering through upland or nearshore dredged materials disposal sites.

S-4. Element S-4 of the Puget Sound Water Quality Management Plan is to establish standards for the safe disposal of dredged material that is not eligible for disposal at an unconfined open water disposal site and for placing dredged material in upland and nearshore sites.

S-6. Element S-6 of the Plan is to determine the utility and viability of establishing public multiuser confined disposal sites for dredged materials.

S-7. Element S-7 is to develop guidelines for decisions on when sediments having adverse effects should be capped, removed, or otherwise treated.

Sediment. Material suspended in or settling to the bottom of a liquid, such as the sand and mud that make up much of the shorelines and bottom of Puget Sound. Sediment input to Puget Sound comes from natural sources, such as erosion of soils and weathering of rock, or from human activities such as forestry, agriculture, and construction. Certain contaminants tend to collect on and adhere to sediment particles. The sediments of some areas around Puget Sound contain elevated levels of contaminants.

Shoreline Development. As regulated by the Shoreline Management Act (Chapter 90.58 RCW) the construction over water or within a shoreline zone (generally 200 feet landward of the water) of structures such as buildings, piers, bulkheads, and breakwaters, including environmental alterations such as dredging and filling, or any project which interferes with public navigational rights on the surface waters.

Siltation. The process by which a river, lake, or other water body becomes clogged with sediment. Silt can clog gravel beds and prevent successful salmon spawning.

Siting Guidelines. Environmental, social and engineering constraints for developing public disposal sites.

Sludge. Precipitated or settled solid matter produced by sewage treatment processes.

Standards. Regulations that provide a predictable yet flexible course for decisions on sediment disposal. They include an established set of testing, monitoring, or design requirements for each of the basic steps in completing a dredge project: characterization, dredging, disposal facility design, and monitoring. Both functional or technology-based designs and effects-based alternatives are included.

Statistically Significant. A quantitative determination of the statistical degree to which two measurements of the same parameter can be shown to be different, given the variability of the measurements.

State Environmental Policy Act. A state law intended to minimize environmental damage. SEPA requires that state agencies and local governments consider environmental factors when making decisions on activities, such as development proposals over a certain size. As part of this process, environmental documents such as environmental impact statements are prepared and opportunities for public comment are provided.

Subtidal. The marine environment below low tide.

Suspended Solids. Organic or inorganic particles that are suspended in water. The term includes sand, mud, and clay particles as well as other solids suspended in the water column.

Target Area. The specified area on the surface of Puget Sound for the disposal of dredged material. The target area is within the disposal zone and within the disposal site.

Technology Based. Basing decisions or standards on designs considered to be certain to provide adequate environmental protection.

Test Interpretation Levels. As part of the characterization standards, a set of criteria will be established to determine whether or not material is suitable for a functional design. These criteria are being established so that functional designs do not have to be suitable for all contamination levels from minimal contamination (just above being suitable for unconfined disposal) to heavy contamination (Dangerous Waste).

The Resource Conservation and Recovery Act. The Federal law that regulates solid and hazardous waste.

Total Suspended Solids (TSS). The weight of particles suspended in water. Suspended solids reduce light penetration in the water column, can clog the gills of fish and invertebrates, and are often associated with toxic contaminants because organics and metals tend to bind to particles.

Toxic. Poisonous, carcinogenic, or otherwise directly harmful to life.

Toxic Substances and Toxicants. Chemical substances, such as pesticides, plastics, detergents, chlorine, and industrial wastes that are poisonous, carcinogenic, or otherwise harmful to life if found in sufficient concentrations.

Treatment. Chemical, biological, or mechanical procedures applied to an industrial or municipal discharge or to other sources of contamination to remove, reduce, or neutralize contaminants.

Turbidity. A measure of the amount of material suspended in the water. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. Very high levels of turbidity can be harmful to aquatic life.

Unconfined Open-Water Disposal. Discharge of dredged material into an aquatic environment, usually by discharge at the surface, without restrictions or confinement of the material once it is released.

Upland Disposal. Disposal of dredged material on land. In upland mixed sites the sediments are disposed of with other materials such as municipal waste or demolition debris. Upland monofill sites are designed for sediments alone.

Volatile. Can be readily vaporized at a relatively low temperature.

Washington Administrative Code. Contains all regulations adopted by state agencies through a rulemaking process. For example, Chapter 173-201 WAC contains water quality standards.

Water Column. The water in a lake, estuary, or ocean which extends from the bottom sediments to the water surface. The water column contains dissolved and particulate matter and is the habitat for plankton, fish, and marine mammals.

Waterways Experiment Station (WES). U. S. Army Corps of Engineers research facility located in Vicksburg, Mississippi, that performs research and support projects for the various Corps districts.