Dredged Material Evaluation and Disposal Procedures

A Users Manual for the Puget Sound Dredged Disposal Analysis (PSDDA) Program

February 2000
(updated with 2003 COC table)

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U.S. Army Corps of Engineers, Seattle District
U.S. Environmental Protection Agency, Region 10
Washington Department of Natural Resources
Washington Department of Ecology

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AET	Apparent Effects Threshold
ANOVA	Analysis of Variance
ASTM	American Society for Testing and Materials
BT	Bioaccumulation Trigger
CAS	Chemical Abstract Service
CFR	Codified Federal Regulations
COC	Chemical of Concern
CSL	Cleanup Screening Level
CSO	Combined Sewer Overflow
CWA	Clean Water Act
CY	Cubic Yard
DAIS	Dredged Analysis Information System
WDFW	Washington Department of Fish and Wildlife
DMMO	Dredged Material Management Office
DMMU	Dredged Material Management Unit
DNR	Department of Natural Resources
DY	Dredging Year
EC50	Effective Concentration (affecting 50% of test organisms)
EPA	Environmental Protection Agency
EPTA	Evaluation Procedures Technical Appendix
ESA	Endangered Species Act
FC	Full Characterization
FDA	Food and Drug Administration
GIS	Geographic Information System
GPS	Global Positioning System
HPA	Hydraulic Project Approval
HPAH	High-molecular-weight PAH
JARPA	Joint Aquatic Resource Permits Application
Kow	Octanol-water partition coefficient
LC50	Lethal Concentration (affecting 50% of test organisms)
LPAH	Low-molecular-weight PAH
ML	Maximum Level
MLLW	Mean Lower Low Water
MPR	Management Plan Report
NAD	North American Datum
NPDES	National Pollution Discharge Elimination System
PAH	Polynuclear Aromatic Hydrocarbon
PC	Partial Characterization
PCBs	Polychlorinated Biphenyls
PCDDs	Polychlorinated Dibenzodioxins
PCDFs	Polychlorinated Dibenzofurans
PSDDA	Puget Sound Dredged Disposal Analysis
PSEP	Puget Sound Estuary Program
QA/QC	Quality Assurance/Quality Control
SAP	Sampling and Analysis Plan
SEDQUAL	Sediment Quality Database

SMS	Sediment Management Standards
SL	Screening Level
TBT	Tributyltin
TEC	Toxic Equivalent Concentration
TEF	Toxicity Equivalency Factor
TOC	Total Organic Carbon
TVS	Total Volatile Solids
USCG	United States Coast Guard
VTS	Vessel Traffic Service
WGS	World Geodetic System

INTRODUCTION

The Dredged Material Management Program (DMMP) represents an interagency approach to the management of dredged material in the State of Washington. The four cooperating agencies are: U.S. Army Corps of Engineers, Seattle District (Corps); U.S. Environmental Protection Agency, Region 10 (EPA); Washington Department of Ecology (Ecology); and Washington Department of Natural Resources (DNR).

Three separate, but closely related, dredged material programs exist under the DMMP: the Puget Sound Dredged Disposal Analysis (PSDDA), Grays Harbor and Willapa Bay, and the Lower Columbia River programs. This User's Manual includes dredged material evaluation and disposal procedures for the eight PSDDA open-water disposal sites in Puget Sound. The evaluation procedures address sediment sampling, chemical and biological testing and test interpretation (disposal guidelines) for determining the suitability of dredged material for unconfined, open-water disposal. The disposal procedures include such topics as barge positioning, debris management and restrictions on site use.

The procedures in this manual represent a condensed and updated version of the guidance found in *Evaluation Procedures Technical Appendix - Phase I* (PSDDA, 1988) and *Management Plan Report - Phase II* (PSDDA, 1989). Revisions and additions to the original PSDDA guidance have occurred via the sediment management annual review meeting (SMARM) process and public workshops. This edition of the manual includes program modifications up through the 1999 SMARM. The user should be aware that this manual will be revised periodically as needed to reflect changes made through the Annual Review Process.

CHAPTER 1
PROCESS OVERVIEW

This chapter describes the process of obtaining a Section 10/404 permit and getting the necessary sediment evaluation performed. It includes information on the overall regulatory process (Section 1.1), the dredged material evaluation process (Section 1.2), the development of the sampling and analysis plan (Section 1.3), the DNR site-use authorization (Section 1.4), the dredging quality control plan (Section 1.5), and the role of the Corps' Dredged Material Management Office (DMMO) (Section 1.6). Appropriate flow diagrams are included to illustrate the processes.

1.1. THE REGULATORY PROCESS

New dredging will always require new permits. For maintenance dredging, the dredging proponent needs to determine whether new permits will be required. To do this, check the expiration date on any existing permits. Unless all projected dredging can be completed before the expiration dates, new permits (or extensions on existing permits) will be required. For federal navigation project maintenance dredging, a determination is made whether a new Public Notice is required and whether an extension of the Water Quality Certification is needed.

Figure 1-1 illustrates the regulatory process when a new permit is required. In this case, two separate, but intertwined, processes occur. The first is the regulatory permitting process that consists of the following steps:

1. Submission of a complete Joint Aquatic Resource Permits Application (JARPA) to the appropriate agencies, including the Regulatory Branch of the Corps of Engineers.

2. Preparation and distribution of a Public Notice by the Corps with a 30-day comment period.

3. Review and incorporation of comments from other agencies by the Corps.

4. Issuance of a Water Quality Certification (or Modification) and Hydraulic Project Approval by the State of Washington.

5. Issuance of the Section 10/404 permit.

The second process consists of the evaluation of the sediments proposed for dredging. The dredged material evaluation process is required for every dredging cycle and is intertwined with the regulatory process as shown in Figure 1-1. The dredged material evaluation process contains the following steps:

1. Contact the Seattle District DMMO (see Section 1.6).

2. Test sediment if necessary (see Section 1.2).

3. DMMO prepares a suitability determination, which is signed by the agencies.

The two processes are connected via communication between the Corps' Regulatory Branch and the DMMO. When the Regulatory Branch receives a JARPA application, the project manager forwards a copy to the DMMO which then begins the dredged material evaluation process. **The dredging proponent can save some time at this step by both submitting a permit application to the Regulatory Branch AND directly contacting the Dredged Material Management Office.** Whether testing is required or not for the current dredging cycle, a suitability determination will be drafted by the DMMO and signed by the agencies. A copy of the suitability determination will be provided to the Regulatory Branch project manager who may then issue a public notice. A signed suitability determination is required before a public notice may be issued.

Figure 1-2 illustrates the regulatory process when a new permit is not required. In this case, the dredging proponent should contact the DMMO to determine the testing needs for the upcoming cycle of dredging. As in the preceding case, whether or not testing is required, a suitability determination will be drafted by the DMMO and signed by the agencies. Once the suitability determination is signed, the dredging proponent can proceed to obtain a DNR site-use authorization and then dredge.

For those dredging cycles in which sediment testing is not required, the suitability determination will include: (1) the volume to be dredged; (2) the disposal site to be used; (3) last sampling and testing dates; (4) an indication of how the recency and frequency guidelines apply to the current dredging cycle; (5) summary of previous testing data as necessary; and (6) any new pollution sources or known incidents (i.e., a spill) that have occurred which might impact the quality of sediment to be dredged.

Applicants considering beneficial use projects are encouraged to coordinate with the DMMO and with other resource agencies early in the dredged material evaluation process. A user’s manual for beneficial use projects is being developed.

1.2. THE DREDGED MATERIAL EVALUATION PROCESS

Figure 1-3 illustrates the dredged material evaluation process; it is an expansion of the simple hexagonal block from Figures 1-1 and 1-2. The following steps comprise this process:

1. Use chapter 3 of this manual to determine project-specific sampling and analysis requirements. The DMMO may be contacted for assistance.

2. Use chapters 2, 3, 4, 5 and 6 of this manual to develop a sampling and analysis plan (SAP) for sediment evaluation (see Section 1.3 for more detailed information).

3. Submit the SAP to the DMMO.

4. The DMMO coordinates review of the SAP by the other regulatory agencies.

5. The DMMO sends a SAP approval letter to the dredging proponent.

6. Field sampling and laboratory testing are conducted.

7. The dredging proponent submits a final report to the agencies. All required Dredged Analysis Information System (DAIS) data must be submitted in acceptable format to the DMMO with the final report (submittal of the DAIS data prior to the final report will speed the suitability determination process). All QA2 data must be submitted in acceptable format to Ecology. Cost data are optional but it is highly recommended that these data be submitted to the DMMO at the same time as the final report. See Chapter 8 for a more detailed description of the data required.

8. The DMMO coordinates review of the testing data with the regulatory agencies.

9. The DMMO drafts and the agencies sign a suitability determination for disposal.

Figure 1-4 presents the tiered testing decision diagram that will be followed for dredged material evaluations in Puget Sound. Time can be saved by compressing tiers II and III; that is, by conducting concurrent chemical and biological testing. If Tier IV testing is needed, it will need to be specially designed with or by the regulatory agencies.

1.3. DEVELOPMENT OF THE SAMPLING AND ANALYSIS PLAN

A well-designed sampling and analysis plan (SAP) is essential when evaluating the potential impact of dredged material discharge upon the aquatic environment. The SAP is submitted to the DMMO for coordinated review and approval by regulatory agencies before any sampling is initiated, as shown on Figure 1-3. This coordination, including full and open disclosure of information, can reduce the chance of having to repeat costly procedures and can assist in keeping projects on schedule. The SAP should contain the following information in enough detail to allow the regulatory agencies to determine the adequacy of the SAP:

1. Tier I (see Chapter 2) information, including site history, existing data, current site use, identification of sources of contamination, and past permitting (including NPDES permits as well as dredging).

2. Project description, including a plan view of the site, recent bathymetric survey data, one or more cross-sections of the dredging prism, type and volume of sediment.

3. The personnel involved with the project and their respective responsibilities, including project planning and coordination, field sampling, chemical and biological testing labs, QA management and final report preparation.

4. Computation of sampling and analysis requirements, formulation of a conceptual dredging plan, identification and rationale for dredged material management units, allocation of field samples and development of a compositing plan.

5. Sampling procedures, including field sampling schedule, sampling technology, positioning methodology, decontamination of equipment, sample collection and handling protocols, core logging, sample extrusion, sample compositing and subsampling, sample transport and chain of custody.

6. Physical and chemical laboratory testing, including grain-size analysis, sediment conventionals, chemicals-of-concern, extraction/digestion methods, analysis methods, holding time requirements and quality assurance requirements.

7. Biological testing, including holding time requirements, proposed testing sequence, bioassay protocols and quality assurance requirements.

8. Reporting requirements, including the sediment characterization report, DAIS data, QA2 data for Ecology and cost data.

Examples of sampling and analysis plans for both small and large projects are available from the DMMO's homepage at http://www.nws.usace.army.mil/dmmo/homepage.htm. These documents can be modified to meet the needs of specific dredging projects. The DMMO can provide any additional assistance needed in the development of a SAP.

1.4. THE DNR DISPOSAL SITE USE AUTHORIZATION

A disposal site use authorization must be obtained from Washington State Department of Natural Resources (DNR) prior to disposal of dredged material at a PSDDA open-water site. Processing of the application for a site use authorization can be accomplished by DNR in as little as 2-3 weeks. This relatively quick processing time is possible, however, only if the applicant has all necessary permits and documents in hand when application is made to DNR for site use authorization. It is permissible to apply for the DNR authorization at any time during the process described in Figures 1-1 and 1-2. The DNR application can be processed up to the point of receiving the final DNR signature on the authorization. This signature can be obtained only after all other permits have been issued (or, if no permit is required, a suitability determination has been signed) and takes a week or less if all the other DNR paperwork has been completed. Dredging proponents are encouraged to contact DNR early in the process to avoid delays after other permits and/or a suitability determination have been obtained. A copy of the use authorization is on the DMMO homepage.

1.5. THE DREDGING QUALITY CONTROL PLAN AND PREDISPOSAL CONFERENCE

Prior to dredging, a dredging quality control plan must be submitted to the Enforcement Section of the Seattle District Regulatory Branch, which will coordinate review of this document with DNR and Ecology. Timing of submittal is as shown on Figures 1-1 and 1-2. The dredging quality control plan provides the following information (see Section 9.1 for details):

1. Project schedule.
2. Dredging and disposal procedures.
3. Water quality monitoring plan.
4. Coordination procedures.

For PSDDA projects, a predisposal conference is scheduled to develop consensus among the agencies, permittee and contractors regarding details in the dredging quality control plan and to modify the plan as needed. This conference is usually not required for Grays Harbor and Columbia River projects.

1.6. THE ROLE OF THE DREDGED MATERIAL MANAGEMENT OFFICE

The Corps' Dredged Material Management Office (DMMO) provides a "one-stop" location for dredged material evaluations. The staff is available to answer questions, assist in the development of sampling and analysis plans, and help trouble-shoot during sediment sampling and testing (see DMMO on Figures 1-1, 1-2, and 1-3). The DMMO coordinates SAP and data reviews with the other regulatory agencies which jointly administer the PSDDA program (EPA Region 10, Ecology and DNR), prepares the SAP approval letter and drafts suitability determinations. The DMMO also interfaces with the Corps' Regulatory Branch and provides them assistance on dredged material management issues. **Any questions, problems or issues related to dredged material management should be directed to the DMMO:**

	Department of Army
	Seattle District, CENWS-OP-TS
Mailing Address:	P.O. Box 3755
	Seattle, WA 98124-3755
Street Address:	4735 East Marginal Way South
	Seattle, WA 98134-2385
Fax:	206-764-6602
DMMO Staff Members:	David Kendall (206) 764-3768 david.r.kendall@usace.army.mil
	Stephanie Stirling (206) 764-6945 stephanie.k.stirling@usace.army.mil
	Lauran Cole Warner (206) 764-6550 lauran.c.warner@usace.army.mil

or visit DMMO's homepage at:

http://www.nws.usace.army.mil/dmmo/homepage.htm

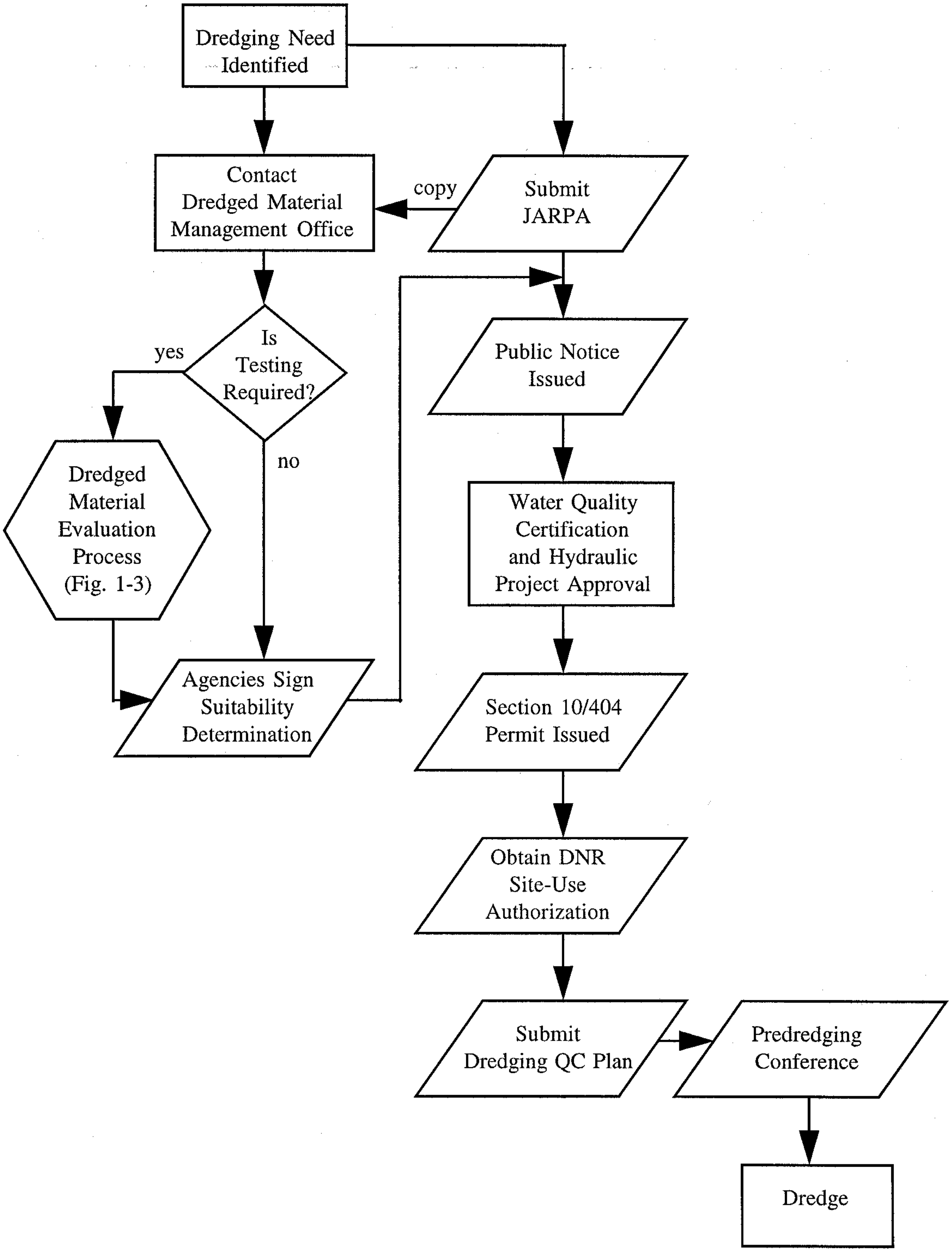

Figure 1-1. Section 10/404 Regulatory Process (New Permit Required).

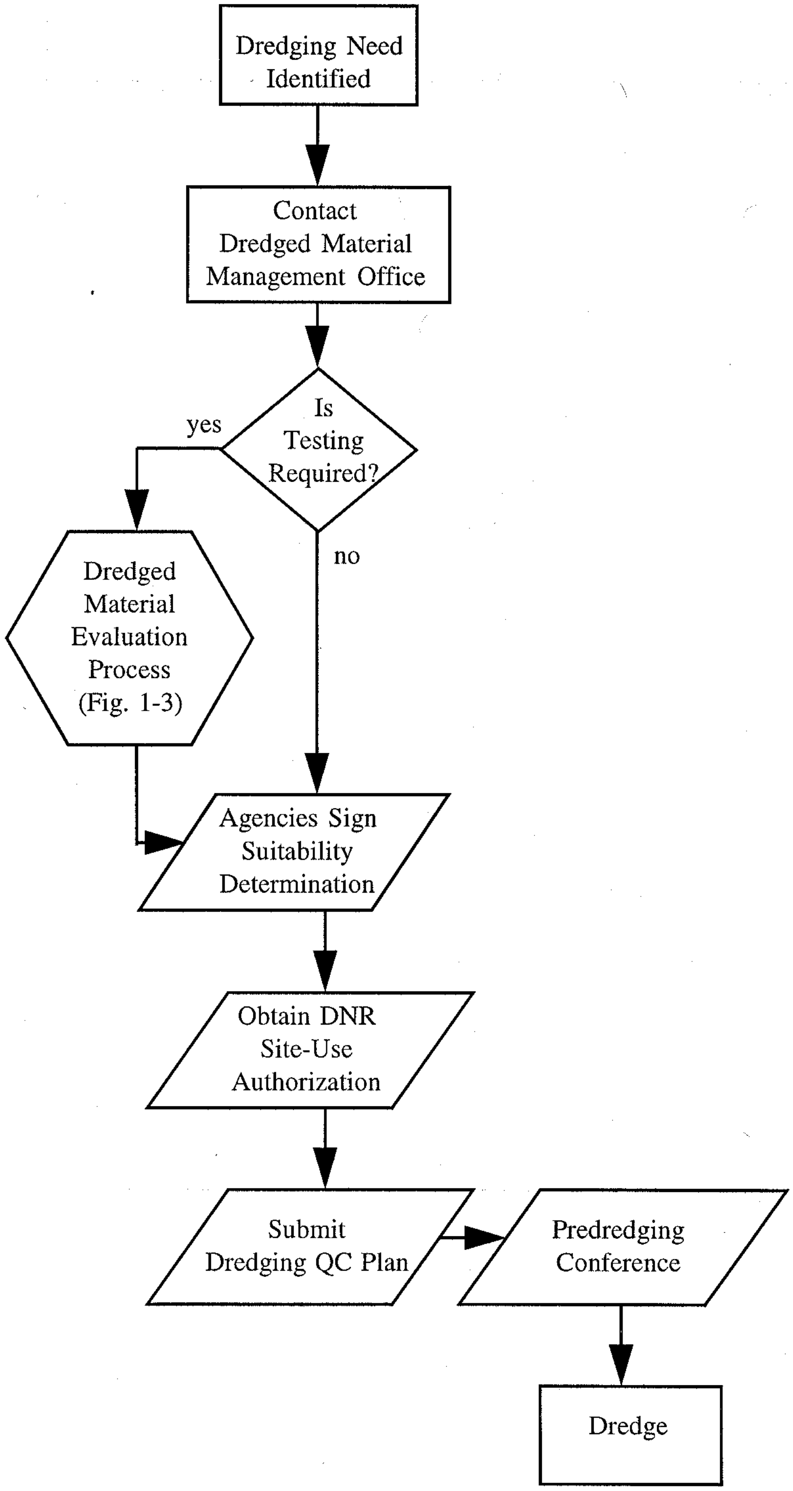

Figure 1-2. Section 10/404 Regulatory Process (New Permit NOT Required).

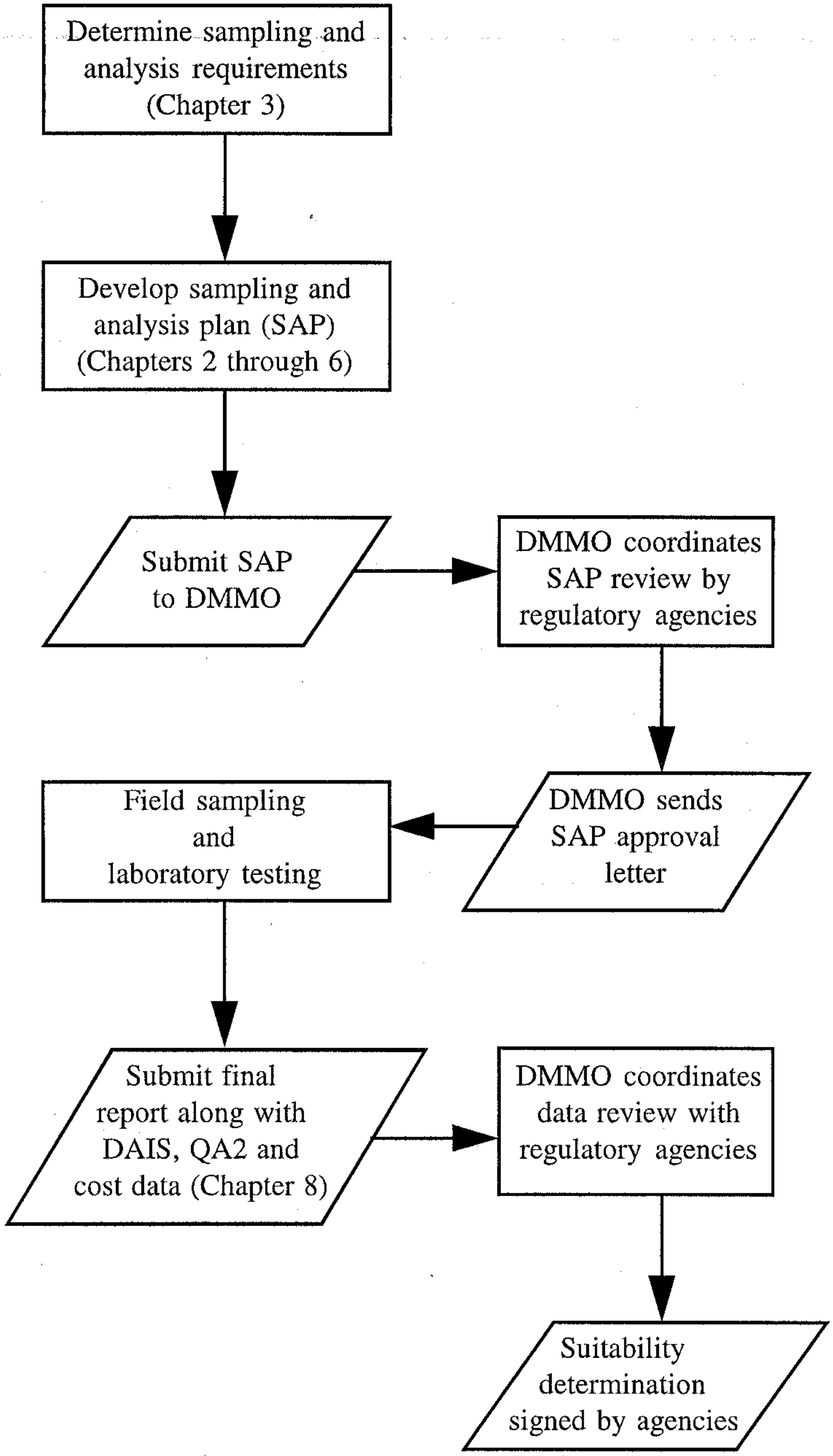

Figure 1-3. Dredged Material Evaluation Process.

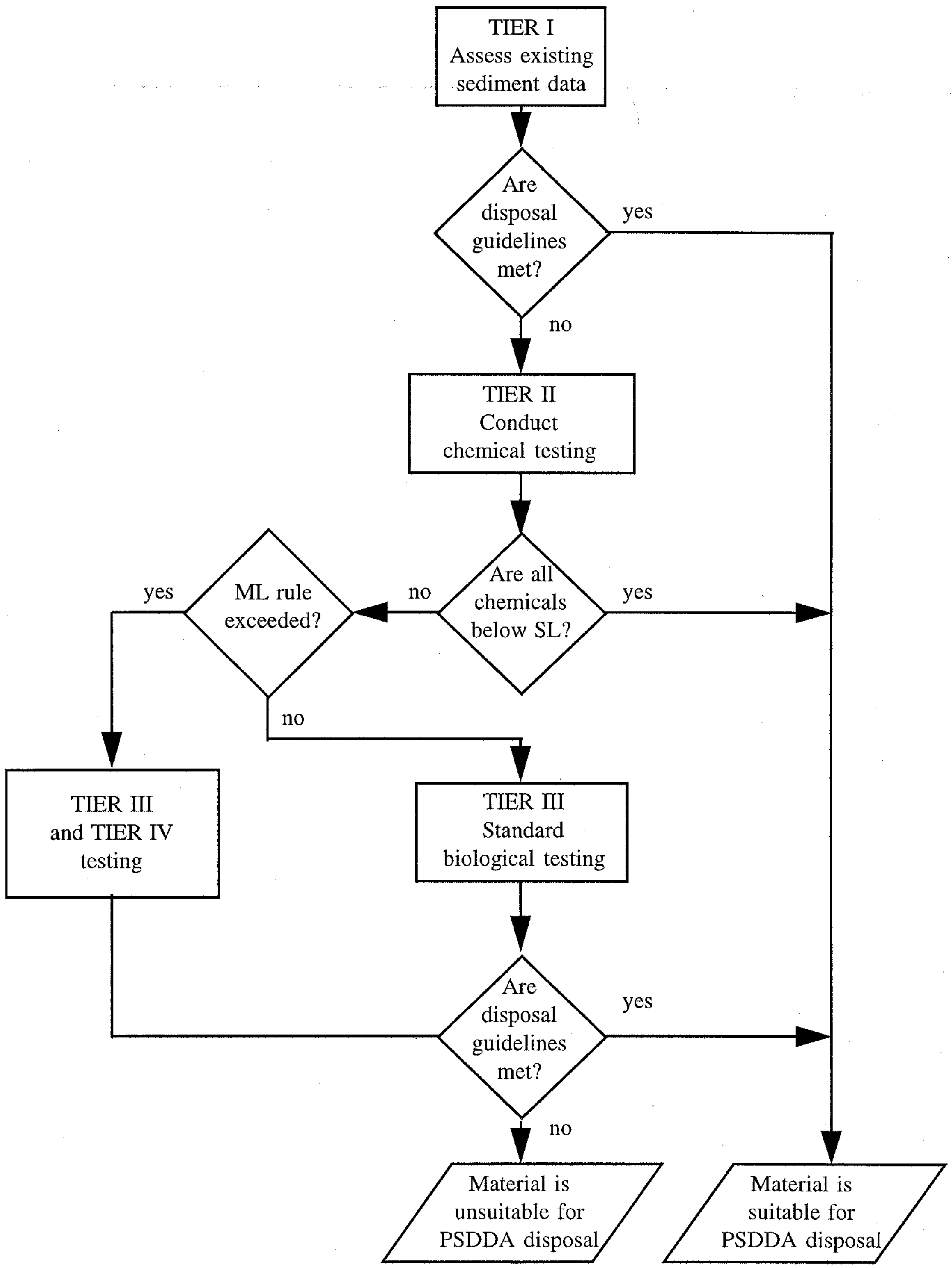

Figure 1-4. Tiered Testing Decision Diagram.

CHAPTER 2
TIER I EVALUATION/SITE HISTORY

A Tier I evaluation of existing information should be included in the sampling and analysis plan (SAP). Tier I is a comprehensive analysis of all existing and readily available, assembled, and interpreted information on the proposed dredging project, including a site history and all previously collected physical, chemical and biological data. The type and amount of information required for a Tier I evaluation will vary according to the size and complexity of the project and the history of the dredging site.

2.1. SITE HISTORIES

The history of a project area plays a pivotal role in project evaluation and sampling plan development. The purpose of the site history is to document past and present sources of potential contamination to dredged material proposed for open-water disposal. A site history characterizes known activity at the dredging site, in near-shore areas, and on adjacent properties. It identifies past activities, and describes the type of contamination that may have resulted from those activities.

The following outline identifies the type of information that may be necessary in a site history for a large, complicated site. Smaller projects in areas of lower concern will require less information. For most projects, site histories do not need to extend beyond two to three pages. A reasonable effort should be made to obtain data. It is recognized that certain types of data may not be readily available but the effort to obtain it should be documented. Information available in agency files does not need to be regathered, but should be referenced and summarized.

Emphasis should be placed on those activities that took place since the last dredging cycle, and any previous sampling data is crucial to the site history and should be summarized in the sampling and analysis plan. It is important to identify whether the proposed dredging project is within, or adjacent to, an EPA or Ecology-listed MTCA, CERCLA or SMS site, and who the appropriate site manager is (if known). This will facilitate the coordination process among agencies.

The site history should include all the following information that is applicable to the specific project:

1. A map showing the site's location, layout, storm drainage, outfalls, and special aquatic sites such as eelgrass or wetlands.

2. Current site use.

3. Industrial processes at or near the site (and hazardous substances used/generated).

4. Outfall information, such as type, volume, NPDES data.

5. MTCA-, CERCLA- or SMS-listed site information (including site manager if known).

6. Spill events.

7. History of site ownership and land uses.

8. Adjacent property use, especially those up-gradient or up-current/upstream.

9. Site characteristics that could affect movement of contaminants (e.g. prop wash, ferry traffic).

10. Results of any previous sampling and testing.

11. Any dredging activity and data/information from that activity.

2.2. SOURCES OF INFORMATION.

There are a wide variety of information sources for site histories. Potential sources include:

- Current and previous property owners.
- Aerial photographs (past and present).
- Real estate and Sanborn fire insurance maps.
- Zoning, topographic, water resource, and soil maps.
- Agency records, such as NPDES permit files, contaminated site lists (state and federal), aquatic leases, previous permits, databases, etc.
- Land use records.
- Knowledgeable persons at or near the site (managers, employees, adjacent property owners).
- City atlases (Kroll and Metsker).

Not all sources are needed for all projects, and the type and extent of sources consulted will vary. Smaller projects and those with less complicated source histories will generally require less documentation but should always include enough information to enable the agencies to adequately address sampling and testing issues. Dredging proponents can contact the Dredged Material Management Office to determine the level of effort required for their specific project. The DMMO will coordinate with the other agencies as necessary to determine project-specific requirements.

CHAPTER 3
DEVELOPING THE SAMPLING AND ANALYSIS PLAN

The following steps are followed in the development of a sampling plan for the full characterization of project sediments:

1. determine the rank for the project
2. determine the volume of material to be dredged
3. determine the required number of dredged material management units (DMMUs) and field samples based on the volume and rank
4. develop a conceptual dredging plan
5. develop a sampling plan which distributes the DMMUs to reflect the conceptual dredging plan, allocates the required number of field samples, and presents a compositing plan.

These steps must be documented in the sampling and analysis plan developed for review by the agencies. Details are provided in the following sections.

3.1. DETERMINING THE RANK FOR THE PROJECT

A dredging area, or a specific project, may be assigned to one of four possible ranks: *high*, *moderate*, *low-moderate*, and *low*. In that order, these ranks represent a best professional judgement of concern or potential risk *by the agencies*, typically reflective of a scale of decreasing potential for adverse biological effects or decreasing concentration of chemicals of concern. Therefore, the lower the rank, the less intense the sampling and testing requirements needed to adequately characterize the dredged material. The ranking system is based on two factors:

1. The available information on chemical and biological-response characteristics of the sediments.

2. The number, kinds, and proximity of chemical sources (existing and historical).

For those dredging projects with sufficient historical data, the assigned ranking is based on the available chemical and biological data for project sediments. For those projects lacking sufficient historical data, the number, kinds and proximity of chemical sources are the major factors driving the assigned rank. Table 3-1 defines the ranking guidelines.

3.1.1. General Rankings

Certain areas or use activities are assigned a general rank, based upon the nature and extent of possible sources of chemicals of concern that could impact sediments needing to be dredged. In the absence of sediment quality data to the contrary, urban and industrialized areas are initially ranked *high*. Marinas, fueling and ship berthing facilities, construction facilities, and sediments located close to moderate-sized sewer outfalls are initially ranked *moderate*. High energy areas that are characterized by coarse-grained material (sand and gravel) and are distant from potential sources of chemicals of concern are initially ranked *low-moderate* or *low*. Initial rankings are shown on Table 3-2.

3.1.2. Project-Specific Rankings

To facilitate the determination of sampling requirements, initial rankings for dredging projects in specific geographic areas of Puget Sound or associated with certain activities were determined by comparing project-specific data against the ranking guidelines in Table 3-1. Initial rankings are shown on Table 3-2.

3.1.3. Re-ranking of Areas/Projects/Project Reaches

Modifications of the initial rankings can occur as the result of additional testing. A project area can be ranked higher (e.g., from low-moderate to moderate) based on the results of a single testing period. However, consistent results from two testing periods are required before a ranking can be lowered (e.g., from high to moderate). Projects may be ranked lower for a one-time dredging event based on the results of a partial characterization (see Section 3.6). However, two testing cycles will be required to lower the rank on a longer-term basis.

Table 3-1. Ranking Guidelines

RANK	GUIDELINES
Low	Few or no sources of chemicals of concern, data are available to verify low chemical concentrations (below PSDDA screening levels) and no significant response in biological tests.
Low-Moderate	Available information indicates a "low" rank, but there are insufficient data to confirm the ranking.
Moderate	Sources exist in the vicinity of the project, or there are present or historical uses of the project site, with the potential for producing chemical concentrations within a range associated historically with some potential for causing adverse biological impacts.
High	Many known chemical sources, high concentrations of chemicals of concern, and/or biological testing failures in one or both of the two most recent cycles of testing.

Table 3-2. Initial Rankings for Puget Sound. Rankings based on potential for presence of chemicals of concern.

HIGH RANKINGS:
♦ Bellingham Harbor from the cement plant to the old disposal site and from the I&J Waterway to Post Point
♦ East Waterway, Everett Harbor
♦ Intertidal areas of Snohomish River up to upper turning basin
♦ Mukilteo
♦ Edmonds
♦ Salmon Bay
♦ Lake Washington Ship Canal
♦ Lake Union
♦ Kenmore
♦ Elliott Bay
♦ Duwamish River downstream of station 257+35
♦ Outer Eagle Harbor (south of the former creosote plant)
♦ Sinclair Inlet
♦ Commencement Bay (except Blair Waterway)
♦ Olympia Harbor (except parts of navigation improvement project)
♦ Lower Budd Inlet (including East Bay Marina)
♦ Shelton
♦ Port Townsend south side of point and south of marina
♦ Port Angeles inside the Harbor
MODERATE RANKINGS:
♦ Squalicum Boat Harbor
♦ Capsante Waterway
♦ Anacortes waterways, marinas and Guemes Channel
♦ Subtidal areas of the Snohomish River (through the upper settling basin)
♦ West Port Susan (near Cavelero Beach)

Table 3-2 (continued). Initial Rankings for Puget Sound.

MODERATE RANKINGS, CONT.:
♦ Port Madison
♦ Lake Washington (except Kenmore)
♦ Dyes Inlet
♦ Upper portion of Quartermaster Harbor
♦ Gig Harbor
♦ Port Townsend Marina
♦ All existing fueling and ship berthing or construction facilities
♦ All existing marinas except those listed as high ranked
♦ All ferry terminals with the exception of Keystone
LOW-MODERATE RANKINGS:
♦ Lummi
♦ Inner Eagle Harbor (west of former creosote plant)
♦ Port Orchard
♦ Duwamish River upstream of station 257+35
♦ Outer Quartermaster Harbor
♦ Keystone Ferry Terminal
♦ All other unidentified areas
LOW RANKINGS:
♦ Blaine (except marina)
♦ Swinomish Channel
♦ Blair Waterway (Commencement Bay)
♦ Sitcum Waterway (Commencement Bay)
♦ Oak Bay Channel

3.2. DETERMINING THE VOLUME OF MATERIAL TO BE DREDGED

Where possible, the physical geometry and volume of sediments proposed for dredging should be determined from a pre-sampling bathymetric survey. The dredging volume calculation should include side slopes, overdepth and sediments anticipated to slough from under piers and wharves. For dredging projects that occur infrequently, the dredging prism should be divided between a "surface" layer (generally four feet in depth) and a "subsurface" layer consisting of everything below the surface layer. The volumes comprising each of these layers should be calculated. For projects that are dredged more frequently, the entire dredging prism may be considered homogeneous and the volume need not distinguish between surface and subsurface layer.

PSDDA volume estimates are incorporated into the section 10/404 permit, water quality certification and site use authorization. Exceedances of permitted volumes may result in fines or work stoppages. Therefore, it is important to develop an accurate volume estimate for PSDDA characterization. To reduce the incidence of permit violations, the following guidelines should be followed:

1. Pre-sampling surveys should be taken as close in time as possible to the sampling event to get the best possible bathymetric data for volume estimates.

2. Pre-sampling volume estimates must include allowable overdepth for the entire dredging prism, including sideslopes. Technical justification for the selected angle of repose for the sideslopes must be included in the sampling and analysis plan.

3. When a box cut is proposed along a pier face, it is recommended that sloughing from under the pier be anticipated in all cases. Technical justification for the selected angle of repose for sideslopes under piers must be included in the sampling and analysis plan. The dredging proponent should ensure that all necessary geotechnical or under-pier survey data be provided to the contractor estimating the dredged material volume.

4. It is highly recommended that presampling estimates of in-situ volume be increased by an uncertainty factor to account for the error inherent in the estimation process and to include reasonable “non-pay” volume. Sampling and testing requirements will be based on this adjusted volume. The uncertainty factor must be identified in the sampling and analysis plan along with a technical justification for its selection. It should be noted that the uncertainty factor applies only to estimates of in-situ volume and is not meant to address bulking of sediments during dredging.

It is recognized that some areas in Puget Sound, particularly the Swinomish Channel, Duwamish settling basin and Snohomish settling basins, are characterized by rapid shoaling during winter storm events. Since sampling and testing are required to be conducted prior to dredging, not all of the sediments to be dredged will have been deposited at the time of sampling. In such instances, presampling bathymetric surveys, records from previous dredging events and best professional judgement will be used to estimate the volume of sediments likely to be dredged. Sampling and testing requirements will be based on this estimated volume.

3.3. DETERMINING THE NUMBER OF DMMUS AND FIELD SAMPLES

The number of field samples to be taken and the number of laboratory analyses conducted to fully characterize the sediments for any given project must be sufficient to allow for an adequate assessment. The following guidelines specify a maximum volume of dredged material that can be represented by a single field sample and by a single laboratory analysis. They are considered "minimum" requirements in that the dredger may opt, or regulatory agencies may require, additional samples or analyses if warranted.

3.3.1. Dredged Material Management Units

In determining the number of field samples and laboratory analyses that will be required for characterizing project sediments, the concept of "dredged material management units" (DMMUs) is used. A DMMU is the smallest volume of dredged material that is truly dredgeable (i.e., capable of being dredged independently from adjacent sediments) and, consequently, for which a separate disposal decision can be made by the agencies. Thus, a given volume of sediment can only be considered a DMMU if it is capable of being dredged and managed separately from all other sediment in the project. The DMMU is represented by one or more field samples, which are composited for a single laboratory analysis. The decision on the suitability or unsuitability of material for unconfined, open-water disposal is made on individual DMMUs independently of other DMMUs within the project, and based on the results of the laboratory analysis representing that DMMU.

Table 3-3 presents the maximum volume of sediment that may be included in a DMMU based on area ranking and depth. For example, in a moderate-ranked area with 32,000 cubic yards (CY) of surface material (less than a 4-foot cut depth) and 24,000 CY of subsurface material (greater than a 4-foot cut depth), a total of three DMMUs are required (two from the surface volume and one from the subsurface volume). This approach assumes that the surface material is more contaminated than the underlying material. If it is known, or suspected, that this scenario does not hold for a particular dredging project, then best professional judgement must be applied in determining volume limits for DMMUs.

Table 3-3. Maximum Sediment Volume Represented by Each Dredged Material Management Unit.

PROJECT RANK	HETEROGENEOUS SEDIMENT (SURFACE MORE CONTAMINATED THAN SUBSURFACE)		HOMOGENEOUS SEDIMENT
	SURFACE	SUBSURFACE	
Low	48,000 CY	72,000 CY	60,000 CY
Low-moderate	32,000 CY	48,000 CY	40,000 CY
Moderate	16,000 CY	24,000 CY	N/A
High	4,000 CY	12,000 CY	N/A

For projects which are dredged frequently due to rapid or routine shoaling (Swinomish Channel, Duwamish settling basin and Snohomish settling basins), the sediments are expected to be relatively homogeneous and the distinction between surface and subsurface sediments becomes less important. In this case, DMMU volumes may be based on the average of surface and subsurface maximum allowable volumes. The proposed dredging volume may be divided by this average volume to determine the number of DMMUs. Grab samples are considered adequate to characterize homogeneous sediments.

3.3.2. Sampling Intensity

The maximum volume of sediment that may be represented by a single field sample (typically a 4-foot core) varies with project rank and is presented in Table 3-4. A single core (e.g., 12 feet in length) may be divided into several samples (e.g., three samples each 4 feet in length). For projects in areas ranked low or low-moderate, a single sediment sample will be taken for every 8,000 CY of material to be dredged. For projects in areas ranked high or moderate, a single sediment sample will be taken for every 4,000 CY. Unlike the maximum volume represented by each DMMU, the maximum volume represented by each field sample does not vary with sediment depth. Continuing with the example presented in the previous section, a moderate-ranked project with 32,000 CY of surface sediment and 24,000 CY of subsurface sediment would require a total of 14 field samples (eight from the surface volume and six from the subsurface volume).

Table 3-4. Maximum Sediment Volume Represented by Each Field Sample.

PROJECT RANK	SURFACE	SUBSURFACE
Low/Low-moderate	8,000	8,000
Moderate/High	4,000	4,000

3.3.3. Reduced Sampling and Testing for Small Projects.

For small projects, the cost of testing must be balanced against the environmental risks posed by a very small volume of dredged material. Small projects in low, low-moderate and moderate ranked areas represent low potential risk that unacceptable adverse effects will result at the disposal site from the discharge of project material. As a result, with the exception of high-ranked areas, a small volume of sediment to be removed at a dredging site may require no testing or reduced testing.

To clearly define what constitutes a small project, there are two key qualifiers. First, intentional partitioning of a dredging project to reduce or avoid testing requirements is not acceptable. Second, recognizing that multiple small discharges can cumulatively affect the disposal site, "project volumes" are defined in as large a context as possible. One example of this latter qualifier is recurring maintenance dredging of a small marina where "project volume" will be the projected dredging volume over 5 years. Another example is multiple-project dredging contracts where a single dredging contractor conducts dredging for several projects under a single contract or contract effort. Again, the "project volume" will be summed across all projects (as will any sampling and compositing efforts prior to testing).

3.3.3.1. "No-Test" Volumes for Small Projects.

For projects in low, low-moderate, or moderate ranked areas, volumes for which no testing need be conducted are shown in Table 3-5. In the absence of specific, conclusive evidence of unacceptable material, most projects with these or lesser volumes will be categorically considered suitable for unconfined, open-water disposal. For low-ranked areas, the "no test" volume is equal to the maximum volume represented by a single field sample (i.e., 8,000 CY). For low-moderate and moderate rankings, the "no test" volume of 1,000 CY is representative of the capacity of medium-sized barges. For high-ranked areas there is not a "no test" volume; some testing is always required.

Some small dredging projects consist of the removal of sediment discharged from an outfall, or located directly adjacent to an outfall, yet fall within a general geographic area ranked low, low-moderate or moderate. However, it is possible that these sediments contain chemicals at a level of concern far greater than the area in general. Therefore, such dredging projects may be given a “high” rank by the PSDDA agencies regardless of the rank of the general area. This decision will be made on a case-by-case basis, with consideration given to the type and size of the outfall, the shoaling pattern relative to the outfall, and any other relevant information available to the project proponent, such as catch basin and particulate data associated with the outfall.

3.3.3.2. Reduced Testing for Small Projects Exceeding the "No Test" Volume.

For projects of less than 500 CY located in high-ranked areas, some testing will be required. The dredger will have the option to conduct either a single chemical analysis for all chemicals of concern (without the required QA/QC replication), or to conduct bioassays (amphipod and one additional bioassay) on a single sample (without chemistry, but with appropriate bioassay replicates). For the chemistry option, the "maximum levels" will be used as "acceptable/unacceptable" values. The dredger will still have the additional option to conduct standard and Tier IV biological testing if the material exceeded the ML values. (A single ML exceedance of less than 100% will require standard biological testing only).

For low-moderate and moderate-ranked projects between 1,000-4,000 cubic yards and high-ranked projects between 500-4,000 cubic yards, standard chemical testing must be conducted, but if biological testing is needed only two bioassays will be required (Table 3-6). These will include the 10-day amphipod test and one other bioassay from the standard suite. For projects in low-ranked areas that exceed 8,000 CY and require biological testing based on chemical test results, the full biological testing suite will be conducted. This is because low-ranked areas are not expected to exceed the chemical "screening levels," which is one of the reasons why the "no test" volume is set so high relative to other area rankings.

Table 3-5. "No Test" Volumes for Small Projects.

PROJECT RANK	"NO-TEST" VOLUME
Low	Less than 8,000 CY
Low-moderate and Moderate	Less than 1,000 CY
High	Some testing is always required

Table 3-6. Reduced Testing Requirements for Small Projects Above the "No Test" Volume.

PROJECT RANK	VOLUME	REQUIRED BIOLOGICAL TESTS[1]
Low-moderate and Moderate	1,000-4,000 CY	Amphipod and One Other Bioassay
High	0-500 CY	see narrative
High	500-4,000 CY	Amphipod and One Other Bioassay

[1] Chemical tests are required of all such projects, with the exception of high-ranked projects less than 500 cubic yards. Biological tests as listed are required if chemical results indicate that the dredged material contains chemical concentrations above the screening levels.

3.3.4. Reduced Sampling and Testing for Native Material

Projects that involve dredging of native material, which has not been exposed to contaminated groundwater, may require less sampling and testing than the requirements identified in Tables 3-3 and 3-4. The agencies will make this determination on a case-by-case basis using site-specific information.

3.4. DEVELOPING A CONCEPTUAL DREDGING PLAN

Prior to determining a sampling plan, a project-specific conceptual dredging plan needs to be prepared. This plan takes into consideration the depth and physical characteristics of the sediments, side slopes, practicable dredge cut widths and depths, dredging along pier faces, other physical and logistical constraints, available dredging methods and equipment, and conventional construction practices at similar dredging projects.

While construction-level detail is not required at this point in the process, a realistic conceptual dredging plan will aid in the delineation of DMMUs and avoid the situation in which a regulatory determination could negatively impact the ability to dredge the project and properly dispose of the material.

3.5. DEVELOPING A SAMPLING PLAN

Once the required number of DMMUs and field samples have been calculated and a dredging plan conceived, a sampling plan must be developed which delineates the DMMUs, proposes locations for the collection of field samples, and identifies which field samples will be composited to represent each of the DMMUs. The DMMUs and field samples are distributed to the actual dredging prism in a manner consistent with the definition of a DMMU and any project-specific constraints. Ideally, the maximum volumes from Table 3-3 and Table 3-4 will be carried through to the actual field situation but this will not always be possible. It is not necessary or always desirable to restrict the volumes characterized by each individual sample or DMMU in the field to the maximums found in Table 3-3 and Table 3-4. Best professional judgement is necessary in the allocation of DMMUs and the development of a sampling and compositing plan. A case study is presented in PSDDA (1988), page II-50 to II-58.

In dividing the proposed dredging volume into DMMUs, it is important to ensure that the DMMUs be fully reflective of the dredging plan, i.e., *that the management units be truly "dredgeable."* If an individual DMMU (represented by one or more field samples) is found unsuitable for unconfined open water disposal, then that DMMU must be capable of being dredged independently from adjacent sediments. Additional DMMUs, beyond the minimum number, may be required to achieve an appropriate dredging plan (e.g., where different sediment types or physically separated areas warrant separate DMMUs).

It is also important to note that the 4-foot cut (for heterogeneous sediments) need not be carried through to the actual dredging plan. The 4-foot cut is used solely as a guideline to establish the minimum number of required analyses. The actual dredging cuts will depend on the geometry of the dredging prism and project-specific physical, environmental and logistical constraints.

All of the field samples taken from a DMMU are composited to provide a single sediment sample for laboratory analysis that is representative of that DMMU. Therefore, the selection of sampling locations and the development of a compositing scheme must provide an accurate representation of the condition of each DMMU. In general, samples should be uniformly distributed across the dredging prism. However, special circumstances, such as the presence of sources of contamination, may dictate otherwise. The location of point sources in the vicinity of the project must be taken into consideration when locating field samples, but "worst-case" sampling should *not* be the goal of full characterization (it *is* the goal of partial characterization sampling; see Section 3.6). Tier I information, including the location of point sources, should be included in the sampling and analysis plan and should support the sampling locations selected to ensure representative sampling of the proposed dredged sediments.

3.6. PARTIAL CHARACTERIZATION FOR DOWN-RANKING

A dredging proponent may choose to do a partial characterization (PC) of project sediments. A PC is most frequently done on larger projects and is based on the chemical analysis of a limited number of samples. If the PC data indicate that the project has been over-ranked, then down-ranking may be permitted for a subsequent full characterization (FC). Down-ranking may substantially reduce the overall cost of sampling and testing for a large project.

A PC is designed to be simple and economical. A PC is not a substitute for an FC, but is only a means for establishing a "reason to believe" that a lower ranking is appropriate. A PC must provide sufficient information to support a decision to re-rank a project. PC results are used to downrank a project on a one-time basis only. Two cycles of testing are required for longer-term downranking.

3.6.1. Development of a PC Sampling and Analysis Plan.

A sampling and analysis plan must be developed for a PC. The PC plan must be submitted to the DMMO, who in turn will coordinate agency review with EPA, Ecology and DNR representatives.

The following PC guidelines are appropriate for most dredging projects. However, because anomalies may exist for a given project, the agencies reserve the right to depart from these guidelines if conditions so warrant (e.g. complex chemical source environment, ambiguous and/or highly variable characterization data, etc.). As with all aspects of the dredged material evaluation process, professional judgment will be an important factor in the decision-making process. The dredger should coordinate with the DMMO in the development of an adequate PC plan.

3.6.2. Sampling Requirements for a Downranking.

The number of samples required for a downranking is based on a percentage of the number of samples that would be required for an FC. A dredger may elect to downrank up to two levels by increasing the sampling intensity. No compositing of samples is allowed. PC sampling station delineation must be approved in advance by the agencies and should represent "worst-case" sampling relative to the location of local point sources.

For the option of lowering a rank one level, ten percent of the FC minimum surface sample requirement must be analyzed for a PC. A minimum of two samples must be analyzed for this option. For the option of lowering a ranking two levels, 20 percent of the FC minimum surface sample requirement must be analyzed for a PC. At least three samples must be analyzed for this option. A dredger has the option of performing a PC on subareas of a dredging project. Subareas must be selected with the approval of the agencies. A minimum of two samples is required for each subarea. Although a PC is most frequently done on surface sediments, a dredger may be required to perform subsurface sampling and analysis during a PC if there is reason to believe that subsurface sediments are contaminated relative to sediments in the upper 4 feet of the dredging prism.

Partial characterization data for a given sampling station may also be used, in some limited cases, in partial fulfillment of FC requirements. The strategy for doing so must be clearly stated in the PC sampling and analysis plan and approved by the agencies.

3.6.3. Ranking Guidelines Based on PC Data.

The downranking of a project (or subarea) will be based on the results of the sample having the highest level of chemicals of concern. Ranking guidelines based on PC data will be as shown in Table 3-7:

PC samples must be analyzed for the full list of chemicals of concern (see Table 5-1) and sediment conventionals. PC data may also be used as a "reason to believe" test to screen out certain chemicals of concern. If a chemical is not found in the PC and is not available from nearby sources, it may be deleted from the FC.

Table 3-7. Ranking Guidelines Based on Partial Characterization Data.

RANKING	PC GUIDELINE
High	At least one chemical > ML
Moderate	At least one chemical > (SL +ML)/2 and ≤ ML
Low-moderate	At least one chemical > SL and ≤ (SL + ML)/2
Low	All chemicals ≤ SL

3.7. RECENCY GUIDELINES

A key consideration in determining whether available data are adequate for project review is the recency of the information. "Recency" guidelines for existing information refer to the duration of time for which chemical and biological characterization of a given sediment (that might be dredged) remains adequate and valid for decisionmaking without further testing. These guidelines are based on the number and operating status of chemical sources near the area to be dredged, on whether the sediment is close to the sediment-water interface or not, and on how well previous samples describe the current conditions at the project site. With older data there is increased potential for a "changed condition" that could alter its validity. Data must be sufficiently recent to be considered representative of the material to be dredged.

The ranking system for dredging projects takes into consideration both the sources of contamination and historical chemical and biological testing data (which are considered an integrated reflection of the effects of sources on the project area). Therefore, the recency guidelines are based on the project rank. For high-ranked projects, the recency guidelines allow characterization data to be valid for a period of 2 years. The recency guideline for moderate, low-moderate and low-ranked projects is a period of 5 to 7 years.

The recency guidelines do not apply when a known "changed" condition has occurred (e.g., accidental spills or new discharges have occurred since the most recent samples were obtained). For subsurface sediments, the potential for contamination from groundwater sources must be considered.

3.8. FREQUENCY GUIDELINES

Recency guidelines apply only to material that has been sampled and tested for open-water disposal but not yet dredged. Once the sampled and tested material has been dredged, a separate "frequency" guideline applies. The time durations for the frequency guidelines are the same as for the recency guidelines: 2 years for high-ranked areas; and 5 to 7 years for moderate, low-moderate, and low-ranked areas. Sediment dredged within the frequency guidelines will not generally require full PSDDA testing. However, two cycles of sampling and testing for a project are required before the frequency guidelines take effect. A biological testing failure during any testing cycle will negate the applicability of the frequency guidelines and automatically result in a need to conduct testing every dredging cycle.

To avoid the possibility of "surprises" in dredging cycles to which frequency guidelines apply, a minimum of one bulk chemical analysis (project composite) may be required as a "safety net" against unexpected chemical concentrations not indicated by historical data. Chemical data resulting from this analyses will be compared to screening level values and historical data to determine if there is reason to believe that biological testing is warranted. Safety-net testing will be required on a case-by-case basis using best professional judgement.

CHAPTER 4

SAMPLING

4.1. TIMING OF SAMPLING

When required, sampling and testing must be coordinated in advance of dredging to allow time for chemical testing, possible biological testing, and data review. Sampling and analysis prior to dredging prevents a situation in which the testing data show sediments to be unacceptable for open-water disposal after disposal occurs.

Areas that receive large volumes of material due to shoaling during winter storm events (e.g., Swinomish Channel and the settling basins in the Snohomish and Duwamish rivers) also need to be sampled prior to dredging. Because these projects are typically dredged within a short time after deposition by winter storms, insufficient time is available to completely characterize all the material that will eventually be dredged. Instead, material that is already in place prior to the winter storm season is generally sampled and tested. This sampling strategy assumes that sediments deposited by winter storms will have a chemical composition very similar to the sediments that are in place at the time sampling and testing is conducted. This strategy is a compromise that includes consideration of the need to provide representative sampling and the need to provide an evaluation process adaptable to the fast shoaling pattern found in these areas. Accordingly, the number of DMMUs and field samples will be based on pre-sampling bathymetric surveys, records from previous dredging events and best professional judgement.

4.2. SAMPLING APPROACH

If full characterization sampling and analysis are required for a project, the applicant will be required to sample the sediment for chemical and, if necessary, biological analyses. There are three sampling approaches that the dredging proponent may take:

Alternative #1: Collect sufficient sediment for all chemical and biological tests potentially required. Run these tests concurrently.

Alternative #2: Collect sufficient sediment as above, but archive adequate sediment for biological testing pending the results of the chemical analysis.

Alternative #3: Collect only enough sediment to conduct the chemical analyses and, if biological testing is required, re-sample the site.

The sampling approach should be clearly documented in the sampling and analysis plan. The selection of either alternative #1 or #2 is encouraged because they provide chemical and biological data on sub-samples of a single homogenized sediment. These alternatives are also advantageous because they both preclude the cost involved with collection of additional sediment. Alternative #1 is the least time consuming, and is likely the most economical when the need for biological testing is expected. For alternative #2, the biological samples must be stored at 4 degrees C with zero headspace (or with headspace purged with nitrogen) to allow chemical tests to be completed first. For alternative #3, biological analysis can proceed without re-analysis of sediment chemistry (unless bioaccumulation testing will be conducted). Biological samples must be taken from the same stations as the sediment chemistry samples.

In general, a minimum of 6 liters of homogenized sediment will be needed to provide adequate volume for physical, chemical and standard biological analysis. Bioassay analysis requires approximately four (4) liters and chemical analysis requires approximately one (1) liter of sediment. The additional liter should be archived for contingencies such as bioassay retests. Bioaccumulation testing would require a minimum of an additional 15-20 liters of sediment beyond the 6 liters identified here. If there is any reason to suspect that subsurface sediments are contaminated, refer to Section 4.6.

4.3. POSITIONING METHODS

A precision navigation system should be used to record all sediment sampling locations to a geodetic accuracy of $\pm$ 3 meters. In addition, all samples should be obtained as close as possible to the target locations provided in the project sampling plan. Such accuracy can be obtained with a range of positioning hardware, such as microwave trisponders, differential GPS, electronic measuring devices, etc. The exact positioning system to be used and associated QA/QC procedures should be documented in the project sampling plan.

Sampling location data will be entered into the Dredged Analysis Information System (DAIS) in the form of latitudes and longitudes referenced to North American Datum of 1983 (NAD 83) which is considered equivalent to the World Geodetic System 1984 (WGS 84). If sampling locations are referenced to a local coordinate grid, the local grid should be tied to NAD to allow conversion to latitudes and longitudes. Latitudes and longitudes referenced to the North American Datum of 1927 (NAD 27) can easily be transformed to NAD 83.

4.4. SAMPLING METHODS

The goal of sediment sampling for characterization of each individual DMMU is to collect a sample (or a number of composited samples) which will be representative of the DMMU. The accuracy of this representation can be increased vertically by taking core samples from the sediment/water interface down to the maximum proposed depth of dredging and horizontally by increasing the number of samples taken. The agencies have established minimum sampling requirements (see Chapter 3) based on volumetric measurements. The type of sampling required, however, depends on the type of project. The sampling methodology to be used should be presented in the sampling and analysis plan along with the rationale for its use.

4.4.1. Core Sampling

For projects which are dredged infrequently (less than once every 5-7 years) and for new-work dredging, the proponent will be required to take core samples from the sediment/water interface down to the maximum depth of dredging because of the greater stratigraphic heterogeneity expected at a project which has seen sediment deposition over a relatively long timeframe. In high-ranked areas, full length cores will also be required because the possibility exists that more heavily contaminated sediments have been recently buried by cleaner sediments.

There are numerous methods available for obtaining core samples including impact corers, hydraulic push corers, Gus samplers, augers with split spoons or Shelby tubes, jet samplers, etc. The methodology chosen will depend on availability, cost, efficacy, and anticipated sediment recoveries.

4.4.2. Grab Sampling
It is anticipated that sediments in frequently dredged areas will be relatively homogeneous. Therefore, for frequently dredged projects which are not in high-ranked areas, grab samples will be considered adequate to represent the dredged material, even if shoaling results in sediment accumulation greater than four feet. The minimum number of grab samples required will be calculated from the tables in Chapter 3.

4.5. SAMPLE COLLECTION AND HANDLING PROCEDURES

Proper sample collection and handling procedures are vital to maintain the integrity of the sample. If the integrity of the sample is compromised, the analysis results may be skewed or otherwise unacceptable. Sample collection and handling include procedures for decontamination, sampler deployment, sample logging, sample extrusion, compositing, sample transport, chain of custody, archiving and storage, all of which need to be treated in the sampling and analysis plan.

The following paragraphs provide general guidance on sample handling procedures. The reader is urged to consult the *Puget Sound Protocols and Guidelines* (PSEP, 1996b) for more detailed guidance. The *Puget Sound Protocols and Guidelines* is available for download from the internet at http://www.wa.gov/puget_sound/pslibrary/protocols/protocol.html. For assistance with the download or to request diskettes, contact Scott Redman (sredman@psat.wa.gov; 360-407-7315) or Gigi Williams (gwilliams@psat.wa.gov; 360-407-7311). The protocols describe field collection and processing methods, bioassay specific QA/QC, and data reporting procedures. Also, general protocols are provided for field collection of surficial test sediments and for general QA/QC procedures that apply to all sediment bioassays.

4.5.1. Decontamination Procedures
It is recommended that sampling containers be decontaminated by the laboratory or manufacturer prior to use. It is also recommended that all sampling equipment and utensils, such as spoons, mixing bowls, extrusion devices, sampling tubes and cutter heads, etc., be made of non-contaminating materials and be thoroughly cleaned prior to use. The intention is to avoid contaminating the sediments to be tested, since this could possibly result in dredged material, which would otherwise be found acceptable for open-water disposal, being found unacceptable. While not strictly required, an adequate decontamination procedure is highly recommended. The dredging proponent assumes a

higher risk of sample contamination by not following an established protocol. The following procedure has been used successfully for other dredging projects:

1. Wash with brush and Alconox soap.
2. Double rinse with distilled water.
3. Rinse with nitric acid (except when sampling for volatile organics).
4. Rinse with metal-free water.
5. Rinse with methanol (except when sampling for volatile organics).

While methylene chloride has been used extensively in the past as an organic solvent, its use is discouraged by the dredging regulatory agencies because of its status as a potential carcinogen and ozone-depleting chemical.

After decontamination, sampling equipment should be protected from recontamination. Any sampling equipment suspected of contamination should be decontaminated again or rejected. If core sampling is being conducted, extra sampling tubes should be available on-site to prevent interruption of operations should a sampling tube become contaminated. Sampling utensils should be decontaminated again after all sampling has been conducted for a DMMU to prevent cross-contamination. Disposable gloves are typically used and decontaminated or disposed of between DMMUs.

4.5.2. Sample Collection

Sampling procedures and protocols will vary depending on the sampling methodology chosen. Whatever sampling method is used, measures should be taken to prevent contamination from contact with sources of contamination such as the sampling platform, grease from winches, engine exhaust, etc. Core sampling methodology should include the means for determining when the core sampler has penetrated to the required depth. If the core is driven beyond the proposed dredging depth, the core logging must be adequate to allow the proper core section to be taken post-sampling for inclusion in the sample composite. The sampling location must be referenced to the actual deployment location of the sampler, not another part of the sampling platform such as the bridge of a sampling vessel.

4.5.3. Volatiles and Sulfides Sub-sampling

The volatiles and sulfides sub-samples should be taken immediately upon extrusion of cores or immediately after accepting a grab sample for use. For composited samples, one core section or grab sample should be randomly selected for the volatiles and sulfides sampling. Sediments which are directly in contact with core liners or the sides of the grab sampler should not be used.

Two separate 4-ounce containers should be completely filled with sample sediment for volatiles analysis. No headspace should be allowed to remain in either container. Two samples are collected to ensure that an acceptable sample with no headspace is submitted to the laboratory for analysis. The containers, screw caps, and cap septa (silicone vapor barriers) should be washed with detergent, rinsed once with tap water, rinsed at least twice with distilled water, and dried at >105 degrees C. A solvent rinse should not be used because it may interfere with the analysis.

To avoid leaving headspace in the containers, sample containers can be filled in one of two ways. If there is adequate water in the sediment, the vial should be filled to overflowing so that a convex meniscus forms at the top. Once sealed, the bottle should be inverted to verify the seal by demonstrating the absence of air bubbles. If there is little or no water in the sediment, jars should be filled as tightly as possible, eliminating obvious air pockets. With the cap liner's PTFE side down, the cap should be carefully placed on the opening of the vial, displacing any excess material.

For sulfides sampling, 5 mls of 2 Normal zinc acetate per 30-g of sediment should be placed in a 4-ounce sampling jar. The sulfides sample should be placed in the jar, covered, and shaken vigorously to completely expose the sediment to the zinc acetate.

The volatiles and sulfides sampling jars should be clearly labeled with the project name, sample/composite identification, type of analysis to be performed, date and time, and initials of person(s) preparing the sample, and referenced by entry into the log book. The sulfides sampling jars should indicate that zinc acetate has been added as a preservative.

4.5.4. Sampling Logs
As samples are collected, and after the volatiles and sulfides subsamples have been taken, logs and field notes of all samples should be taken and correlated to the sampling location map. The following should be included in this log:

1. Date and time of collection of each sediment sample.
2. Names of field supervisors and person(s) collecting and logging in the sample.
3. Weather conditions.
4. The sample station number and individual designation numbers assigned for individual core sections.
5. Quantitative notation of apparent resistance of sediment column to coring.
6. The water depth at each sampling station. This depth should then be referenced to mean lower low water (MLLW NAD 83) through the use of an on-site tide gage.
7. Length, depth interval (referenced to the sediment/water interface) and percent recovery of core sections.
8. Physical sediment description, including type, density, color, consistency, odor, stratification, vegetation, debris, biological activity, presence of an oil sheen or any other distinguishing characteristics or features.
9. Any deviation from the approved sampling plan.

4.5.5. Extrusion, Compositing and Subsampling
Depending on the sampling methodology and procedure proposed, sample extrusion, compositing and subsampling may take place at different times and locations. If core

sampling is conducted, these activities can either occur at the sampling site (e.g., on board the sampling vessel) or at a remote facility. Grab samples will be processed immediately upon sampling. If cores are to be transported to a remote facility for processing, they should be stored at on ice onboard the sampling vessel and during transport. The cores should be sealed in such a way as to prevent leakage and contamination. If the cores will be sectioned at a later time, thought needs to be given to core integrity during transport and storage to prevent loss of stratification. For cores or split-spoon sampling, the extrusion method should include procedures to prevent contamination.

For composited samples, representative volumes of sediment should be removed from each core section or grab sample comprising a composite. The composited sediment should be mixed until homogenized to a uniform color and consistency, and should occasionally be stirred while individual samples are taken of the homogenate. This will ensure that the mixture remains homogenous and that settling of coarse-grained sediments does not occur.

At least 6 liters of homogenized sample needs to be prepared to provide adequate volume for physical, chemical and biological laboratory analyses. Bioassays require approximately 4 liters while chemical testing requires approximately 1 liter of sediment. Physical, chemistry and bioassay samples should be taken from the same homogenate. Portions of each composite sample will be placed in appropriate containers obtained from the testing laboratories. See Table 4-1 for container and sample size information.

After compositing and subsampling are performed, the sample containers should be refrigerated or stored on ice until delivered to the analytical laboratory. The samples reserved for bioassays should be stored at 4 degrees C in containers with zero headspace, or with headspace purged with nitrogen, for up to 56 days pending initiation of any required biological testing. Each sample container should be clearly labeled with the project name, sample/composite identification, type of analysis to be performed, date and time, and initials of person(s) preparing the sample, and referenced by entry into the log book.

4.5.6. Sample Transport and Chain-of-Custody Procedures

Sample transport and chain-of-custody procedures should follow the PSEP protocols, which include the following guidelines:

1. If sediment cores are taken in the field and transported to a remote site for extrusion and compositing, chain-of-custody procedures should commence in the field for the core sections and should track the compositing and subsequent transfer of composited samples to the analytical laboratory. If compositing occurs in the field, chain-of-custody procedures should commence in the field for the composites and should track transfer of the composited samples to the analytical laboratory.

2. Samples should be packaged and shipped in accordance with U.S. Department of Transportation regulations as specified in 49 CFR 173.6 and 49 CFR 173.24.

3. Individual sample containers should be packed to prevent breakage and transported in a sealed ice chest or other suitable container.

4. Ice should be placed in separate plastic bags and sealed, or blue ice used.

5. Each cooler or container containing sediment samples for analysis should be delivered to the laboratory within 24 hours of being sealed.

6. A sealed envelope containing chain-of-custody forms should be enclosed in a plastic bag and taped to the inside lid of the cooler.

7. Signed and dated chain-of-custody seals should be placed on all coolers prior to shipping.

8. The shipping containers should be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the container and consultant's office name and address) to enable positive identification.

9. Upon transfer of sample possession to the analytical laboratory, the chain-of-custody form should be signed by the persons transferring custody of the sample containers. The shipping container seal should be broken and the condition of the samples should be recorded by the receiver.

10. Chain-of-custody forms should be used internally in the lab to track sample handling and final disposition.

Table 4-1. Sample Storage Criteria

SAMPLE TYPE	HOLDING TIME	SAMPLE SIZE (1)	TEMPERATURE (2)	CONTAINER	ARCHIVE(3)
Particle Size	6 Months	100-200 g (75-150 ml)	4 degrees C	1-liter Glass (combined)	X
Total Solids	14 Days	125 g (100 ml)	4 degrees C		
Total Volatile Solids	14 Days	125 g (100 ml)	4 degrees C		
Total Organic Carbon	14 Days	125 g (100 ml)	4 degrees C		
Ammonia	7 Days	25 g (20 ml)	4 degrees C		
Metals (except Mercury)	6 Months	50 g (40 ml)	4 degrees C		
Semi-volatiles, Pesticides and PCBs	14 Days until extraction 1 Year until extraction 40 Days after extraction	150 g (120 ml)	4 degrees C -18 degrees C		
Total Sulfides	7 Days	50 g (40 ml)	4 degrees C (4)	125 ml Glass or polyethylene	
Mercury	28 Days	50 g (40 ml)	-18 degrees C	125 ml Teflon or polyethylene	
Tribuytytin (porewater)	7 Days	Sediment sufficient to collect 200-500 ml of porewater	4 degrees C (5)	Field: Polycarbonate, glass, or steel Lab (post extraction): Polycarbonate	
Volatile Organics	14 Days	100 g (2-40 ml jars)	4 degrees C	2-40 ml Glass	
Bioassay	8 Weeks	5 liters	4 degrees C (5)	5-1 liter Glass or polyethylene	
Bioaccumulation	8 Weeks	variable (6)	4 degrees C (5)	Glass or polyethylene	

(1) Recommended minimum field sample sizes for one laboratory analysis. Actual volumes to be collected have been increased to provide a margin of error and allow for retests.

(2) During transport to the lab, samples will be stored on ice. The mercury and archived samples will be frozen immediately upon receipt at the lab.

(3) For every DMMU, a 250 ml container is filled and frozen to run any or all of the analyses indicated.

(4) The sulfides sample will be preserved with 5 ml of 2 Normal zinc acetate for every 30 g of sediment.

(5) Headspace purged with nitrogen.

(6) See Table 6-4.

CHAPTER 5

TIER II CHEMICAL TESTING

Consistent with the tiered testing approach, and following an assessment of existing information in Tier 1, chemical testing of the dredged material may be required. Chemical analysis includes both the measurement of "conventional" parameters and the measurement of concentrations of chemicals which have been identified as chemicals of concern for Puget Sound dredged material.

5.1. SEDIMENT CONVENTIONAL PARAMETERS

"Conventional" parameters are required to be measured to further characterize the sediment in the DMMU and to provide information to aid in interpreting chemical and biological tests. Conventionals that will be measured include:

- Total volatile solids (TVS).
- Grain size.
- Total organic carbon (TOC).
- Percent solids (Total solids).
- Total sulfides.
- Ammonia.

5.2. SEDIMENT CONVENTIONALS TESTING PROTOCOLS

Analysis of total solids, TVS and total sulfides under the PSDDA testing program must follow the *Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound* (PSEP, 1986). Ammonia analysis should be conducted according to standard EPA/Corps procedures (Plumb, 1981). Appendix D of *Recommended Guidelines for Measuring Organic Compounds in Puget Sound Water, Sediment and Tissue Samples* (PSEP, 1996c) must be consulted for analysis of TOC.

Particle size may be determined using either PSEP (1986) or ASTM Method D-422, which subdivide the silt-clay fraction by pipette and hydrometer respectively. One of the following sieve series must be used: 1) Modified EPA - sieve numbers 4, 10, 18, 35, 60, 120, 230 or 2) Modified ASTM - sieve numbers 4, 10, 20, 40, 60, 140, 230. The fine-grained fraction must be classified by phi size (+5, +6, +7, +8, >8).

***Revised* Table 5-1. Screening Level (SL), Bioaccumulation Trigger (BT) and Maximum Level (ML) Guideline Chemistry Values** (Dry Weight Normalized) (updated with 2003 guidelines)

CHEMICAL	CAS [1] NUMBER	SCREENING LEVEL	BIOACCUM TRIGGER	MAXIMUM LEVEL
METALS (mg/kg)				
Antimony	7440-36-0	150	150	200
Arsenic	7440-38-2	57	507.1	700
Cadmium[2]	7440-43-9	5.1	---	14
Chromium	7440-47-3	---	267	---
Copper	7440-50-8	390	---	1,300
Lead	7439-92-1	450	---	1,200
Mercury	7439-97-6	0.41	1.5	2.3
Nickel	7440-02-0	140	370	370
Selenium[2]	7782-49-2	---	3	---
Silver	7440-22-4	6.1	6.1	8.4
Zinc	7440-66-6	410	---	3,800
ORGANOMETALLIC COMPOUNDS (ug/L)				
Tributyltin (interstitial water)	56573-85-4	0.15	0.15	---
ORGANICS (ug/kg)				
Total LPAH	**---**	**5,200**	**---**	**29,000**
Naphthalene	91-20-3	2,100	---	2,400
Acenaphthylene	208-96-8	560	---	1,300
Acenaphthene	83-32-9	500	---	2,000
Fluorene	86-73-7	540	---	3,600
Phenanthrene	85-01-8	1,500	---	21,000
Anthracene	120-12-7	960	---	13,000
2-Methylnaphthalene[3]	91-57-6	670	---	1,900
Total HPAH	**---**	**12,000**	**---**	**69,000**
Fluoranthene	206-44-0	1,700	4,600	30,000
Pyrene	129-00-0	2,600	11,980[4]	16,000
Benz(a)anthracene	56-55-3	1,300	---	5,100
Chrysene	218-01-9	1,400	---	21,000
Benzofluoranthenes (b+k)	205-99-2 207-08-9	3,200	---	9,900
Benzo(a)pyrene	50-32-8	1,600	--- [5]	3,600
Indeno(1,2,3-c,d)pyrene	193-39-5	600	---	4,400
Dibenz(a,h)anthracene	53-70-3	230	---	1,900
Benzo(g,h,i)perylene	191-24-2	670	---	3,200
Chlorinated Hydrocarbons				
1,3-Dichlorobenzene	541-73-1	170	--- [5]	---
1,4-Dichlorobenzene	106-46-7	110	--- [5]	120
1,2-Dichlorobenzene	95-50-1	35	--- [5]	110
1,2,4-Trichlorobenzene	120-82-1	31	---	64
Hexachlorobenzene (HCB)	118-74-1	22	168	230

CHEMICAL	CAS [1] NUMBER	SCREENING LEVEL	BIOACCUM TRIGGER	MAXIMUM LEVEL
ORGANICS, cont. (ug/kg)				
Phthalates				
Dimethyl phthalate	131-11-3	1,400	--- [5]	---
Diethyl phthalate	84-66-2	1,200	---	---
Di-n-butyl phthalate	84-74-2	5,100	--- [5]	---
Butyl benzyl phthalate	85-68-7	970	---	---
Bis(2-ethylhexyl) phthalate	117-81-7	8,300	--- [5]	---
Di-n-octyl phthalate	117-84-0	6,200	---	---
Phenols				
Phenol	108-95-2	420	--- [5]	1,200
2-Methylphenol	95-48-7	63	---	77
4-Methylphenol	106-44-5	670	---	3,600
2,4-Dimethylphenol	105-67-9	29	---	210
Pentachlorophenol	87-86-5	400	504	690
Miscellaneous Extractables				
Benzyl alcohol	100-51-6	57	---	870
Benzoic acid	65-85-0	650	---	760
Dibenzofuran	132-64-9	540	---	1,700
Hexachloroethane	67-72-1	1,400	--- [5]	14,000
Hexachlorobutadiene	87-68-3	29	--- [5]	270
N-Nitrosodiphenylamine	86-30-6	28	--- [5]	130
Volatile Organics				
Trichloroethene	79-01-6	160	--- [5]	1,600
Tetrachloroethene	127-18-4	57	--- [5]	210
Ethylbenzene	100-41-4	10	--- [5]	50
Total Xylene (sum of o-, m-, p-)	95-47-6 108-38-3 106-42-3	40	---	160
Pesticides				
Total DDT (sum of 4,4'-DDD, 4,4'-DDE and 4,4'-DDT)	72-54-8 72-55-9 50-29-3	6.9	50	69
Aldrin	309-00-2	10	--- [5]	---
alpha-Chlordane	12789-03-6	10	37	---
Dieldrin	60-57-1	10	--- [5]	---
Heptachlor	76-44-8	10	--- [5]	---
Alpha-BHC	319-84-6	---	10 [2] [6]	---
gamma-BHC (Lindane)	58-89-9	10	---	---
Total PCBs	---	130	38 [6]	3,100

(1) Chemical Abstract Service Registry Number.
(2) As no SL value exits to trigger toxicity testing, this chemical will only be evaluated for its bioaccumulative potential.
(3) 2-Methylnaphthalene is not included in the sum for total LPAHs
(4) New BT added with 2003 guidelines (for Pyrene)
(5) BT deleted with 2003 guidelines (for Benzo(a)pyrene, 1,2-Dichlorobenzene, 1,3-Dichlorobenzene, 1,4-Dichlorobenzene, Dimethyl phthalate, Di-n-butyl phthalate, Bis(2-ethylhexyl) phthalate, Phenol, Hexachloroethane, Hexachlorobutadiene, N-Nitrosodiphenylamine, Trichloroethene, Tetrachloroethene, Ethylbenzene, Aldrin, Dieldrin & Heptachlor)
(6) This value is normalized to total organic carbon, and is expressed in mg/kg (TOC normalized).

5.3. STANDARD LIST OF CHEMICALS OF CONCERN.

Chemical testing, when required, will generally involve analysis for 61 chemicals (or families of chemicals) of concern. Table 5-1 lists these chemicals and presents recently updated (1998) guideline values for each chemical. Use of the guideline values is discussed in the following section. The chemicals-of-concern list was developed using historical data and existing activities information from Puget Sound. The chemicals of concern generally have the following characteristics:

- A demonstrated or suspected effect on ecology or human health (i.e., the focus of chemical concerns is on ultimate biological effects).

- One or more present or historical sources of sufficient magnitude to be of concern (i.e., relatively widespread distribution and high concentration when compared to natural conditions).

- A potential for remaining in a toxic form for long periods in the environment (persistence).

- A potential for entering the food web (bioavailability).

Table 5-2. Toxicity Equivalency Factors (TEFs) for PCDDs and FCDFs.

	CONGENER / ISOMERS	TOXIC EQUIVALENCY FACTOR (TEF)
Dioxins	2,3,7,8-TCDD	1.0
	2,3,7,8-PeCDDs	0.5
	2,3,7,8-HxCDDs	0.1
	2,3,7,8-HpCDDs	0.01
	OCDD	0.001
Furans	2,3,7,8-TCDF	0.1
	1,2,3,7,8-PeCDF	0.05
	2,3,4,7,8-PeCDF	0.5
	2,3,7,8-HxCDFs	0.1
	2,3,7,8-HpCDFs	0.01
	OCDF	0.001

5.4. CHEMICALS OF CONCERN FOR LIMITED AREAS

In addition to the list of standard chemicals of concern, there is a list of chemicals of concern that may need to be measured for dredging projects in limited areas. These chemicals include those from the following list, which are further discussed below.

- Guaiacol (2-methoxyphenol)
- Chlorinated guaiacols (3,4,5-trichloroguaiacol; 4,5,6-trichloroguaiacol; tetrachloroguaiacol)
- Tri-, tetra-, and pentachlorobutadienes
- Polychlorinated dibenzodioxins
- Polychlorinated dibenzofurans
- Butyltins (mono-, di-, tributyltin)

5.4.1. Guaiacol and chlorinated guaiacols

Guaiacol and chlorinated guaiacols are measured in areas where kraft pulp mills are located. Only guaiacol will be measured near sulfite pulp mills (chlorinated guaiacols are not expected in processes that do not involve bleaching).

5.4.2. Tri-, tetra-, and pentachlorobutadienes

Tri-, tetra-, and pentachlorobutadienes are non-priority pollutants that have been detected at highly elevated levels in certain areas of Puget Sound (e.g., Hylebos Waterway in Commencement Bay). They are recommended for analysis only where chlorinated butadienes are suspected to have a major source.

5.4.3. Polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)

PCDDs and PCDFs meet several of the requirements for listing as chemicals of concern in dredged material. These dioxin/furan compounds are documented to be highly toxic, are persistent in the environment, may bioaccumulate in animal tissues, and are listed as human teratogens and carcinogens. Dredging projects proposed for areas in the near vicinity of the Weyerhaeuser (Everett), Simpson (Tacoma) and Georgia-Pacific (Bellingham) pulp mills will be required to test for dioxins and furans.

A bulk sediment 2,3,7,8-tetrachlorodibenzo-p-dioxin concentration of 5 ng/kg, or a total toxic equivalent concentration (TEC) of 15 ng/kg, will trigger the requirement to perform bioaccumulation testing. The TEC for each individual dioxin and furan congener is calculated by multiplying the congener's sediment concentration by its respective toxicity equivalency factor (TEF). Table 5-2 lists the TEFs for the various dioxins and furans. Once the TEC for each congener has been determined, the total TEC is calculated by summing the individual TECs. For undetected congeners, detection limits will be divided by two and used in the calculations. Therefore, it is imperative to achieve sufficiently low detection limits to avoid a situation in which undetected congeners trigger the requirement to conduct bioaccumulation testing.

5.4.4. Butyltins

Butyltin testing is indicated in areas near marinas, boatyards, shipyards, CSOs, treatment plant outfalls and in urban areas, especially Commencement Bay, Elliott Bay, Duwamish River, Lake Washington ship canal, Salmon Bay and Lake Union.

The available evidence indicates that neither sediment chemistry screening levels nor the existing PSDDA bioassays may be as useful in predicting environmental effects as measurement of TBT concentrations in interstitial water and tissues. Therefore, the standard tiered testing approach utilizing bulk sediment chemistry and short-term bioassays is not considered appropriate for evaluating the potential adverse effects of TBT.

Measurement of TBT in interstitial water provides a more direct measure of potential bioavailability, and hence toxicity, than bulk sediment concentrations. Therefore, interstitial water analysis replaces bulk sediment analysis as the initial step in a tiered assessment of TBT toxicity for PSDDA projects. Centrifugation is preferred for collecting sediment interstitial water(for detailed guidance on interstitial water collection and sample handling go to: http://www.nws.usace.army.mil/dmmo/10th_arm/tbt_clar.98.pdf). Alternative interstitial water extraction methods may be used in cases where centrifugation is not an effective technique, (e.g., for very sandy sediments) and will be decided on a case-by-case basis by the DMMP agencies.

Acceptable methods for measuring TBT involve tropolone/methylene chloride extraction, followed by Grignard derivitization and analysis by GC/MS (e.g., Krone *et al.*, 1989), GC/MS SIM (e.g., PSEP, 1997), or GC/FPD (e.g., Unger *et al.*, 1986).

5.4.5. TBT QC Performance Criteria: Sample Collection/Interstitial Water Analysis

The DMMP agencies have decided to recommend QC performance criteria rather than providing a step-by-step protocol for the extraction, derivitization, and analysis of TBT. The criteria presented in Table 1 must be met in order to verify that cleaning, extraction and derivitization methods are being performed correctly. Laboratories will be required to meet these performance criteria as well as take the specified corrective action if performance criteria are not met. Deviations from the specified performance criteria will be considered by the DMMP agencies on a project-specific basis. Justification for alternative performance criteria must be submitted in writing and receive agency approval prior to the initiation of testing. As discussed in earlier guidance (Michelsen, *et al.*, 1996), TBT analytical results and QC information should be reported as the TBT ion.

If the TBT concentration in the interstitial water is quantitated above 0.15 ug TBT/L, bioaccumulation testing of project sediments must be conducted using the PSDDA bioaccumulation guidelines in effect at the time of testing. Acute bioassay testing will not be required (unless other chemicals of concern exceed screening levels). If unacceptable tissue concentrations are measured at the end of the bioaccumulation test, the sediment will be found unsuitable for open-water disposal. Additional information regarding TBT testing can be found at http://www.nws.usace.army.mil/dmmo/8th_arm/tbt_96.htm.

Table 5-3. Summary of Quality Control Procedures for TBT in Interstitial Water.

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action
Laboratory Control Sample (LCS) *	1 per analytical batch (≤ 20 samples)	Recovery 50 – 150%	1. Check calculations 2. Reanalyze (matrix or injection problems?) 3. If still out, re-extract and reanalyze LCS and assoc. samples (if available); If not available flag data.
Matrix spike (MS) and matrix spike duplicate (MSD) *	1 MS/MSD pair per analytical batch (≤ 20 samples)	Recovery 50 – 150% and relative percent difference (RPD) ≤ 30%	1. Evaluate for supportable matrix effect. 2. If no interference, re-extract and reanalyze MS/MSD once (if available). 3. If still out, report both sets of data.
Surrogate spike * (Tripentyltin recommended)	1 per sample	Recovery 50 – 150%	1. Check calculations. 2. Evaluate for supportable matrix effect 3. If no interference is evident, re-extract and reanalyze affected sample(s) (if available) and flag any outliers.
Method blank**	1 per analytical batch (≤ 20 samples)	Target analyte < 3x the reporting limit (RL)	1. Flag if target > 3x RL but less than 0.075 ppb***. 2. Rerun batch and ID contamination source if target >0.075 ppb.

* All QC samples should be run using the same sample handling as is used on the environmental samples.
** Method blank can include centrifugation step or, alternatively a centrifugation blank can be run separately from the analytical method blank.
*** 0.075 ppb TBT is used here as a benchmark for evaluating blank performance because it represents a concentration that is one-half the interstitial water screening level (0.15 ppb) that is being used by the DMMP agencies to determine the need for bioaccumulation testing. Note that a minimum interstitial water volume of 200-500 ml will be needed to attain reporting limits less than 0.075 ppb TBT.

5.5. WOOD-WASTE MANAGEMENT[1]

Wood-waste can range in size from intact logs down to fine bark and sawdust. The DMMP program requires logs and large to be removed prior to disposal. No debris greater than 24" X 24" is allowed at the open-water disposal sites. Sediments with large pieces of wood debris may require debris removal by passing the dredged material through a 24" X 24" steel screen. The quantity of wood debris that would pass through a 24" X 24" screen must be visually assessed during field collection of sediments. If the sediment contains a significant quantity of smaller wood debris, the sediments must be analyzed in the laboratory to quantify the wood fraction as described below.

Wood debris can be quantified in the laboratory on either a volume or a weight-specific basis. While quantifying wood debris in sediments on a volumetric basis may be more ecologically meaningful, it is much more difficult and less accurate than quantifying it on a weight-specific basis. Therefore, dredged material assessment of wood debris will be accomplished on a dry-weight basis, then converted to a volumetric basis by multiplying the weight-based number by two[2] (example: 25% by weight ≅ 50% by volume). The dry-weight fraction of debris is estimated by quantifying the organic fraction[3]. Dredged material containing an organic fraction greater than 25% dry weight will be required to undergo biological testing to assess the suitability of the material for unconfined open-water disposal. Likewise, dredged material containing an organic fraction less than 25% dry weight will be considered suitable for unconfined open-water disposal without further testing unless one or more chemicals of concern exceed chemical screening levels.

Samples with significant quantities of wood debris subjected to biological testing may encounter some toxicity associated with ammonia generated from natural biological processes in the sediments. In these cases, applicants may wish to consider monitoring interstitial ammonia levels before initiating bioassays to ensure that total ammonia levels are equal to or less than 20 mg/l. If ammonia levels exceed 20 mg/l, the EPA/COE protocol for reducing ammonia levels may be followed before initiating bioassays (EPA/COE, 1993).

Sediment grain size is an important consideration when selecting the species to be used in the amphipod test and choosing appropriate reference sediments. Therefore, in addition to conventional grain size analysis, applicants should analyze the residue left from the modified Total Volatile Solids analysis for grain size. This organic-free particle size distribution should be used in conjunction with the conventional particle size distribution in selecting the appropriate amphipod species and reference sediment.

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[1] See Management of wood waste under DMMP and SMS Cleanup Program at http://www.nws.usace.army.mil/dmmo/9th_arm/wood_97.htm

[2] Observed ratio from Port of Everett/South Terminal Dredging Project reported in Floyd & Snider and Pentec (1997).

[3] One method recently applied to a dredging project involved a weight based method: quantification by modified Total Volatile Solids (TVS) analysis (ASTM D-2974C. Method A) protocol, where the sample size was increased to 100-300 grams of sample. Other methods may be proposed by the applicant in lieu of this approach, but must be approved by the agencies with jurisdiction over dredging and disposal.

5.6. CHEMICAL TESTING PROTOCOLS AND LABORATORY ACCREDITATION

Laboratories are required to be accredited for sediment methods used to generate chemical and biological data for PSDDA projects. In March 1990, Ecology proposed that laboratories performing analyses for PSDDA dredging projects become accredited by January 1, 1991. A letter from Ecology for the PSDDA agencies to laboratory managers states, “This was predicated by the PSDDA agencies’ general agreement with the Director of Ecology’s written policy that:

“(Ecology) managers ... will ensure that water quality analyses are performed by laboratories accredited by the Quality Assurance Section. Applicable water quality data includes results of analyses of sediments, dredging, ... Applicable analyses include chemical, physical, biological ... determinations which provide recorded qualitative and/or quantitative results.” (Ecology Executive Policy 1-22, effective January 23, 1990.)

An increase in the availability of performance evaluation samples has made it possible for the Quality Assurance Section to accredit for an expanded range of analysis for chemical and biological parameters. For information on accreditation application and renewal, contact Ecology’s Quality Assurance Section at (360) 895-4649.

5.7. CHEMICAL DISPOSAL GUIDELINES

Chemical concentrations will be compared to two chemical guideline values presented in Table 5-1. First, a lower "screening level" (SL) has been defined for each chemical as a guideline to identify chemical concentrations below which there is no reason to believe that dredged material disposal would result in unacceptable adverse effects. For dredged material with chemical concentrations below the SL values, biological testing is not required to determine material suitability for unconfined, open-water disposal. Second, a higher "maximum level" (ML) has been defined for each chemical which corresponds to the concentration of a chemical in dredged material above which there is reason to believe that the material would be unacceptable for unconfined, open-water disposal. Chemical concentrations present at levels between the SL and ML require additional biological information for decision-making.

For each DMMU, the SL and ML guideline values will be used to determine whether biological testing is needed before a decision is made on the suitability for unconfined, open-water disposal. Four potential scenarios are possible:

1. All chemicals are below their SLs; no biological testing is needed; the DMMU is considered suitable for unconfined, open-water disposal at any PSDDA site and for all open-water beneficial uses.

2. One or more chemicals are present at levels between SL and ML; standard biological testing is needed (see Chapter 6).

3. A single chemical exceeds ML by less than 100 percent (i.e., less than twice the ML value); standard biological testing is needed (see Chapter 6).

4. A single chemical exceeds ML by more than 100 percent (i.e., twice the ML value) or two or more chemicals are above the ML; no biological testing is needed; there is reason to believe the DMMU is unacceptable for unconfined, open-water disposal. However, the dredger has the option described below to accept the indication of the ML or conduct additional biological testing (see Chapter 7).

When chemicals of concern exceed the ML values, the dredger has two options. First, he may elect to accept the indication of the ML and conclude that the material is unsuitable for unconfined, open-water disposal. Biological testing is not required for this decision. The second option is to conduct biological testing rather than rely on the indications of the chemical maximum level. For this option, the dredger must conduct the standard suite of bioassays, bioaccumulation (if necessary), and a Tier IV assessment in order to determine final suitability of the material for unconfined, open-water disposal (see Chapter 7).

5.8. BIOACCUMULATION TRIGGERS

In addition to comparisons to SL and ML and subsequent determinations outlined above, bioaccumulation trigger (BT) values are used as guidelines to determine when bioaccumulation testing is required. These values are found in Table 5-1. If any chemical of concern exceeds the bioaccumulation trigger guideline value, additional information gained via bioaccumulation testing will be required in order to determine whether dredged material is suitable for unconfined, open-water disposal. Discussion on bioaccumulation testing is presented in Section 6-4.

5.9. DETECTION LIMITS

In the case of undetected chemicals of concern, sample-specific detection limits will be used to determine biological testing requirements. The chemical disposal guidelines presented in Section 5.6 for detected chemicals of concern will apply equally to detection limits. The following scenarios are possible and need to be understood and handled appropriately:

1. One or more chemicals-of-concern (COC) have sample detection limits exceeding screening levels while all other COCs are quantitated or have sample detection limits at or below the screening levels: the requirement to conduct biological testing will be triggered solely by sample detection limits. In this case the chemical testing subcontractor should do everything possible to bring sample detection limits down to or below the screening levels, including additional cleanup steps, re-extraction, etc. This is the only way to prevent unnecessary biological testing. If problems or questions arise, the chemical testing subcontractor should be directed to contact the Dredged Material Management Office.

2. One or more COCs have sample detection limits exceeding screening levels for a lab sample, but below respective bioaccumulation triggers (BT) and maximum levels (ML), and other COCs have quantitated concentrations above screening levels: The need to do bioassays is based on the detected exceedances of SLs and the sample detection limits above SL become irrelevant. No further action is necessary.

3. One or more COCs have sample detection limits exceeding SL and exceeding BT or ML, and other COCs have quantitated concentrations above screening levels: the need to do bioassays is based on the detected exceedances of SLs but all other sample detection limits must be brought below BTs and MLs to avoid the requirement to do bioaccumulation testing or Tier IV testing. As in scenario "a" above everything possible should be done to lower the sample detection limits.

4. One COC is quantitated at a level which exceeds ML by more than 100%, or more than one COC concentration exceeds ML: there is reason to believe that the test sediment is unsuited for open-water disposal without additional Tier IV testing data. In the absence of a Tier IV assessment, problems with sample detection limits for other COCs are irrelevant. No further action is necessary.

In all cases, to avoid potential problems and leave open the option for retesting, sediments or extracts should be kept under proper storage conditions until the chemistry data are deemed acceptable by the regulatory agencies.

CHAPTER 6

TIER III BIOLOGICAL TESTING

6.1. BIOLOGICAL TESTING OF DREDGED MATERIAL

Tier III biological testing of dredged material will be required when chemical testing results indicate the potential for unacceptable adverse environmental or human health effects. The interpretation guidelines used to evaluate the test results define what is acceptable and unacceptable relative to unconfined open-water disposal. A standard suite of bioassays will be used to evaluate potential environmental effects, and to make a determination regarding the suitability of the dredged material for unconfined open-water disposal. Additionally, for certain chemicals which bioaccumulate and are known or suspected agents affecting human or ecological health in the marine environment, a bioaccumulation test will be required when these chemicals of concern are detected at concentrations high enough in dredged material to pose a potential risk in the disposal environment.

6.2. SOLID PHASE - ACUTE AND CHRONIC EVALUATION

The standard suite of bioassays in tier III sediment evaluations is triggered by meeting or exceeding one or more screening levels for chemicals of concern in the dredged material (see Table 5-1). Following is the list of standard bioassays used in the PSDDA program. The biological testing suite of three bioassays discussed below addresses solid phase toxicity testing using whole sediment; a fourth solid phase test will be determined in the future. The Annual Review Meeting process will be followed to allow public input and peer review prior to implementing a fourth test for regulatory purposes.

1. 10-day amphipod acute mortality test.

- *Rhepoxynius abronius* – preferred species for coarser-grained sediments (i.e. fines <60%)
- *Ampelisca abdita* - may be used if test sediment contains greater than 60% fines.
- *Eohaustorius estuarius* - may be considered for use over grain size distributions ranging from 100% sand to 0.6% sand, as long as the clay fraction <30%; and in interstitial salinities ranging from 2 ppt to 28 ppt.

2. 20-day juvenile infaunal growth test.

- *Neanthes arenaceodentata* (Los Angeles karyotype)

3. Sediment larval test.

Echinoderm

- *Dendraster excentricus* – recommended species
- *Strongylocentrotus purpuratus* – acceptable species
- *Strongylocentrotus droebachiensis*[4]

Bivalve

- *Mytilus galloprovincialis*[4]
- *Crassostrea gigas*[4]

The protocols for the required bioassays can be found in the *Puget Sound Protocols and Guidelines* (PSEP, 1995). The *Puget Sound Protocols and Guidelines* may be obtained by email at srpswqat@wln.com (put the word *protocols* in the subject line to alert the Puget Sound Action Team staff) or by calling Scott Redman (360-407-7315) or Gigi Williams (360-407-7311). The *Puget Sound Protocols and Guidelines* is also available for download from the internet at http://www.wa.gov/puget_sound. The protocols describe field collection and processing methods, bioassay specific QA/QC, and data reporting procedures. Also, general protocols are provided for field collection of surficial test sediments and for general QA/QC procedures that apply to all sediment bioassays.

As described in Section 5.5, laboratories providing biological effects data for PSDDA projects must be accredited by the Department of Ecology for the analytical methods used to produce the data. Additional information related to biological testing under the PSDDA and SMS programs can be found at http://www.nws.usace.army.mil/dmmo/by_topic.htm .

6.2.1. Amphipod Species Selection

Rhepoxynius abronius has shown sensitivity to high percent fines in sediments, particularly high clay content sediments, and has exhibited mortalities greater than 20 percent in clean, reference area sediments (DeWitt *et al.*, 1988; Fox, 1993). Applicants may wish to consider use of *Ampelisca abdita* or *Eohaustorius estuarius* when when fines exceed 60 percent. *Ampelisca* is relatively grain-size-insensitive to concentrations of fines greater than 60 percent. When testing fine-grained sediments (> 60 percent) where interstitial salinities are substantially below 25 ppt, dredging applicants may prefer to use *Eohaustorius estuarius*. This species is relatively insensitive to salinity changes and effects of grain size, except for high clay (>30%) content. Proposed species must be coordinated through the Dredged Material Management Office, and the rationale for species selection must be documented in the sampling and analysis plan for the proposed dredging project. Appropriate negative control sediment must be used for the test species selected. More information on amphipod species selection can be found in an clarification paper from the 1999 SMARM, at http://www.nws.usace.army.mil/dmmo/11th_arm/amph_99.pdf

6.2.2. Species Selection for the Sediment Larval Test

For the sediment larval test, adults must be collected in spawning condition or must be induced to spawn in the laboratory. Therefore, seasonality plays a role in selecting a test organism for this bioassay. Figures 6-1 through 6-3 show the availability of various

[4] may be substituted if test sediment contains greater than 60% fines

echinoderms and bivalves used in this test. Viable test organisms are most difficult to obtain near the end of the calendar year (November and December) and the probability of performance problems increases during that time. The PSDDA agencies recommend that biological testing be avoided late in the year if at all possible.

6.2.3. Quality Assurance/Quality Control

The following QA/QC guidelines apply to the standard suite of solid phase bioassays:

Negative Control and Reference Samples. For the amphipod and the juvenile infaunal species biological tests, a negative control sediment will be run with each test batch. The negative control sediment for the amphipod test is taken from the test organism collection site (see additional information regarding selection of negative control sediments). The juvenile infaunal growth test, using laboratory-cultured *Neanthes arenaceodentata*, requires collection of negative control sediment from an appropriate area such as West Beach, Whidbey Island. For the sediment larval test, a negative seawater control is required. The negative control provides an estimate of test organism general health during the test exposure period.

In addition to the negative control, a reference sediment must be run with each batch, for all three bioassays. The reference sediment will be collected from one of the reference sediment collection sites in Puget Sound and should be compatible on a physical and grain size basis with the dredged material (see Section 6.5). The primary purpose of the reference sediment is to determine the response of the test organisms to sediments of physical characteristics similar to the proposed dredged material. The reference sediment must be run in-batch. For dredged material with relatively coarse-grained sediments (> 80 % sand), the dredger can opt to rely solely on a control sediment[5] (see guidance below on when it is appropriate to use as both reference and control).

Selection of Negative Control Sediments. An appropriate negative control sediment must be used for the amphipod mortality and *Neanthes* growth tests. PSEP (1995) provides the following description of native habitat for various amphipods: "*Rhepoxynius abronius* and *Eohaustorius estuarius* typically inhabit well-sorted, fine sand while *Ampelisca abdita* is a tube-dwelling amphipod found mainly in protected areas and is often abundant in sediments with a high organic content. It generally inhabits sediments from fine sand to mud and silt without shell, although it can also be found in relatively coarser sediments with a sizable fine component." The best way to ensure a good negative control is to collect the control sediment from the same location at which the test organisms are collected.

Neanthes arenaceodentata is cultured in the lab rather than field-collected. However, PSEP (1995) states that, "For the *Neanthes* bioassay, sand should be used as the control sediment." West Beach of Whidbey Island is most often used as a collection site for clean control sediment. From PSEP (1995), "*Neanthes* maintained in West Beach sand exhibited low mortality and high percentage increases in biomass during the exposure period, indicating that West Beach sand is a suitable material for a control sediment."

[5] for *Rhepoxynius abronius* and *Neanthes arenaceodentata*.

PSEP (1995) also states that, "All bioassays must be conducted using well-established negative (clean) controls. Such controls are clean, nontoxic seawater and/or sediment samples taken from outside each study area." For dredged material management programs in the State of Washington or for comparison to SMS, sediments proposed for use as negative controls must be approved before bioassays commence. If an area without a proven track record is proposed for collection of negative control sediment, sufficient data (such as grainsize, organic carbon content, chemical data, bioassay results) must be submitted before its use can be approved by the regulatory agencies.

Use of Control Sediments as Reference Sediments. When a reference sediment fails to meet its performance standard, and more than one reference has been collected, Michelsen and Shaw (1996) provide procedures for statistical comparisons. If no reference sediments meet performance standards, or if the control sediment is closer in grain size and TOC to one or more stations being evaluated than any of the remaining reference sediments, the control sediment should be evaluated for use as a reference sediment. If the control sediment is similar in grain size and TOC to the site sediments and/or a reference sediment that failed to meet performance standards, it will be considered an acceptable substitute for the reference sediment and the data will be interpreted accordingly.

If a control sediment is substantially dissimilar to the site stations and a failed reference sediment in its physical characteristics (e.g., >25% difference in fines and a difference of 1% TOC), it may still be used as a substitute for the reference station if both the agencies/site manager and the project proponent agree that this is appropriate. Otherwise, the data will be considered uninterpretable and the bioassay(s) in question will need to be rerun.

Quality Control Limits for the Negative Control Treatment. All three bioassays have negative control performance standards that must be met (see Table 6-1). In the amphipod and juvenile infaunal bioassay tests, control mortality over the exposure period should be less than or equal to 10 percent. This represents a generally accepted level of mortality of test organisms under control conditions, where the bioassay (in terms of test organism health) is still considered a valid measure of effects of the test treatments. If control mortality is greater than 10 percent, the bioassay test will generally have to be repeated, although that determination must be made in consultation with the agencies through the Corps' Dredged Material Management Office. For the sediment larval test, the performance standard for the seawater negative control combined endpoint (mortality + abnormality) is 30 percent.

Quality Control Limits for the Reference Sediment. Performance guidelines for reference sediments are listed in Table 6-1. The mean amphipod test mortality for the reference sediment must not exceed 20 percent absolute over the mean control sediment mortality. For the juvenile infaunal growth test, the reference sediment mean mortality must be less than or equal to 20 percent at the end of the exposure period, while the mean growth rate must be greater than or equal to 80 percent of the control sediment's mean growth rate. The seawater-normalized combined endpoint (mortality + abnormality) observed in the reference sediment for the sediment larval test must not exceed 35 percent. Failure to meet the reference sediment performance standard for a bioassay may require that the bioassay be rerun with a new reference sediment. If a performance guideline is not met for a reference sediment, the Corps' Dredged Material Management Office should be contacted as soon as possible to coordinate with the agencies regarding a retest. Additional information regarding reference sediment performance can be found at http://www.nws.usace.army.mil/dmmo/by_topic.htm

Reference Toxicant. An appropriate reference toxicant must be run with each batch of test sediments to assess the test organism sensitivity. The LC_{50} or EC_{50} must be within the 95 percent confidence interval of responses expected for the toxicant used.

Water Quality Monitoring. Temperature, aqueous salinity, pH, and dissolved oxygen should be monitored on a daily basis for the amphipod and sediment larval tests, and every three days for the 20-day *Neanthes* growth test. Total sulfides and ammonia should be measured at test initiation and termination for all three tests. Interstitial salinity should be measured prior to test initiation. The test protocols for each of these bioassays specify acceptable ranges for these parameters. Water quality data can be critical in the interpretation of bioassay results.

6.2.4. Bioassay Interpretive Criteria

The response of bioassay organisms exposed to the tested dredged material representing each DMMU will be compared to the response of these organisms in both control and reference treatments. This comparison will determine whether the material is suitable for unconfined, open-water disposal relative to the Clean Water Act (CWA) Section 404(b)(1) Guidelines (see Table 6-1).

The determination of a "statistically significant" response involves two conditions: first, that the response in the tested DMMU must be greater than 20 percent different from the control response; and, second, that a statistical comparison between mean test and mean reference responses must show a significant difference. For the latter determination, the following guidelines are to be followed:

- Multiple comparison tests (e.g., ANOVA, Dunnett's) are not to be used.
- A null hypothesis shall be selected that reflects the one-tailed t-test approach and the type of endpoint being evaluated.
- Bioassay data expressed in percent should be transformed, if necessary, prior to statistical testing using the arcsine-square root transform to stabilize the variances and improve the normality of the data.
- Bioassay data should then be tested for normality and homogeneity of variances, using the Wilks-Shapiro test (W test) and Cochran's test (F test for variances), respectively.
- Bioassay data passing both tests should be tested for statistical difference using a one-tailed Student's t-test.

- ➢ Amphipod or sediment larval data failing one or both of these tests should be tested for statistical difference using the nonparametric Mann-Whitney test.

- ➢ *Neanthes* growth data failing one or both of these tests may be transformed, as appropriate, and retested. If again the growth data fail one or both of these tests, statistical difference should be tested using the nonparametric Mann-Whitney test.

Note: Seattle District developed statistical analysis software named BIOSTAT to facilitate bioassay statistical comparisons with appropriate reference sediments. Anyone interested in getting a copy of this software can download BioStat from the Seattle District FTP server in any of the following ways:

1. Using your internet explorer, type in the following URL:

   - ftp://ftp.nws.usace.army.mil/
   - Biostat is located under pub/psdda/biostat
   - click on BIOSTAT2.EXE and select "Save to Disk option" when prompted

2. Using a DOS command window, enter the following case-sensitive commands:

   - ftp ftp.nws.usace.army.mil
   - User: anonymous
   - password: [your email address]
   - cd pub/psdda/biostat
   - type binary
   - get BIOSTAT2.EXE
   - quit

3. Using FTP software (such as Vista Exceed):

   - host address: ftp.nws.usace.army.mil
   - User: anonymous
   - password: [your email address]
   - type: binary

   - BIOSTAT2.EXE is located under pub/psdda/biostat

The file size is 4.8MB so be aware that downloading using a 33kb modem might take a little while. A draft users guide and SMARM clarification paper can also be downloaded from the same directory. The 1998 clarification paper describing the capabilities and use of this software to interprete bioassays can be found at http://www.nws.usace.army.mil/dmmo/10th_arm/bio_stat.98.htm. For a more detailed discussion of hypothesis testing and statistical evaluations, see: http://www.nws.usace.army.mil/dmmo/8th_arm/stats_96.htm.

6.2.4.1. Single-Hit Failure.

When **<u>any one</u>** biological test exhibits a test sediment response relative to the negative control and reference sediment which exceeds the bioassay-specific response guidelines, and which is "statistically significant" from the reference, the DMMU is judged to be unsuitable for unconfined open-water disposal (see Table 6-1).

Amphipod Bioassay. For the amphipod bioassay, mean test mortality greater than 20 percent absolute over the mean negative control response, and greater than 10 percent (dispersive) or 30 percent (nondispersive) absolute over the mean reference sediment response, and statistically different from the reference (alpha = 0.05), is considered a "hit" under the “single-hit” guidelines.

Juvenile Infaunal Growth Test. Juvenile *Neanthes* growth test results that show a mean individual growth rate less than 80 percent of the mean negative control growth rate, and less than 70 percent (dispersive) or 50 percent (nondispersive) of the mean reference sediment growth rate, and statistically different from the reference (alpha = 0.05), is a hit under the single-hit rule.

Sediment Larval Bioassay. For the sediment larval bioassay, test and reference sediment responses are normalized to the negative seawater control response. This normalization is performed by dividing the number of normal larvae from the test or reference treatment at the end of the exposure period by the number of normal larvae in the seawater control at the end of the exposure period, and multiplying by 100 to convert to percent. The normalized combined mortality and abnormality (NCMA) is then 100 minus this number. If the mean NCMA for a test sediment is greater than 20 percent, and is 15 percent (dispersive) or 30 percent (nondispersive) absolute over the mean reference sediment NCMA, and statistically different from reference (alpha = 0.10), it is considered a hit under the single-hit rule.

6.2.4.2. Two-Hit Failure.

When **any two** biological tests (amphipod, juvenile infaunal growth or sediment larval) exhibit test sediment responses which are less than the bioassay-specific guidelines noted above for a single-hit failure, but are significantly different from the reference sediment (and less than 70 percent of the mean reference sediment growth rate for the *Neanthes* bioassay for nondispersive sites), the DMMU is judged to be unsuitable for unconfined open-water disposal.

6.3. WATER COLUMN BIOASSAY TESTING.

The Tier III evaluation of dredged material may include an evaluation of potential water column effects using echinoderm or bivalve larvae, when warranted. Water column testing for biological effects is not routinely required for regulated or federal dredging projects evaluated under CWA Section 404 for PSDDA disposal. This test will need to be conducted only when the Washington Department of Ecology requires for water quality certification an assessment of potential water column toxicity effects relative to a particular chemical of concern.

In the event that water column testing is required, the echinoderm/bivalve larval test will be conducted to evaluate water column effects. The appropriate assessment is described in the draft *Inland Testing Manual* (EPA/USACE, 1994). The protocol found in PSEP (1995) may be followed to the extent that it conforms with test specifications described in the *Inland Testing Manual* (Appendix E). The following species may be used for the larval water column bioassay test:

Echinoderm
- *Dendraster excentricus* - recommended species
- *Strongylocentrotus purpuratus* – acceptable species
- *Strongylocentrotus droebachiensis* – acceptable species

Bivalve
- *Crassostrea gigas* – acceptable species
- *Mytilus galloprovincialis* – acceptable species

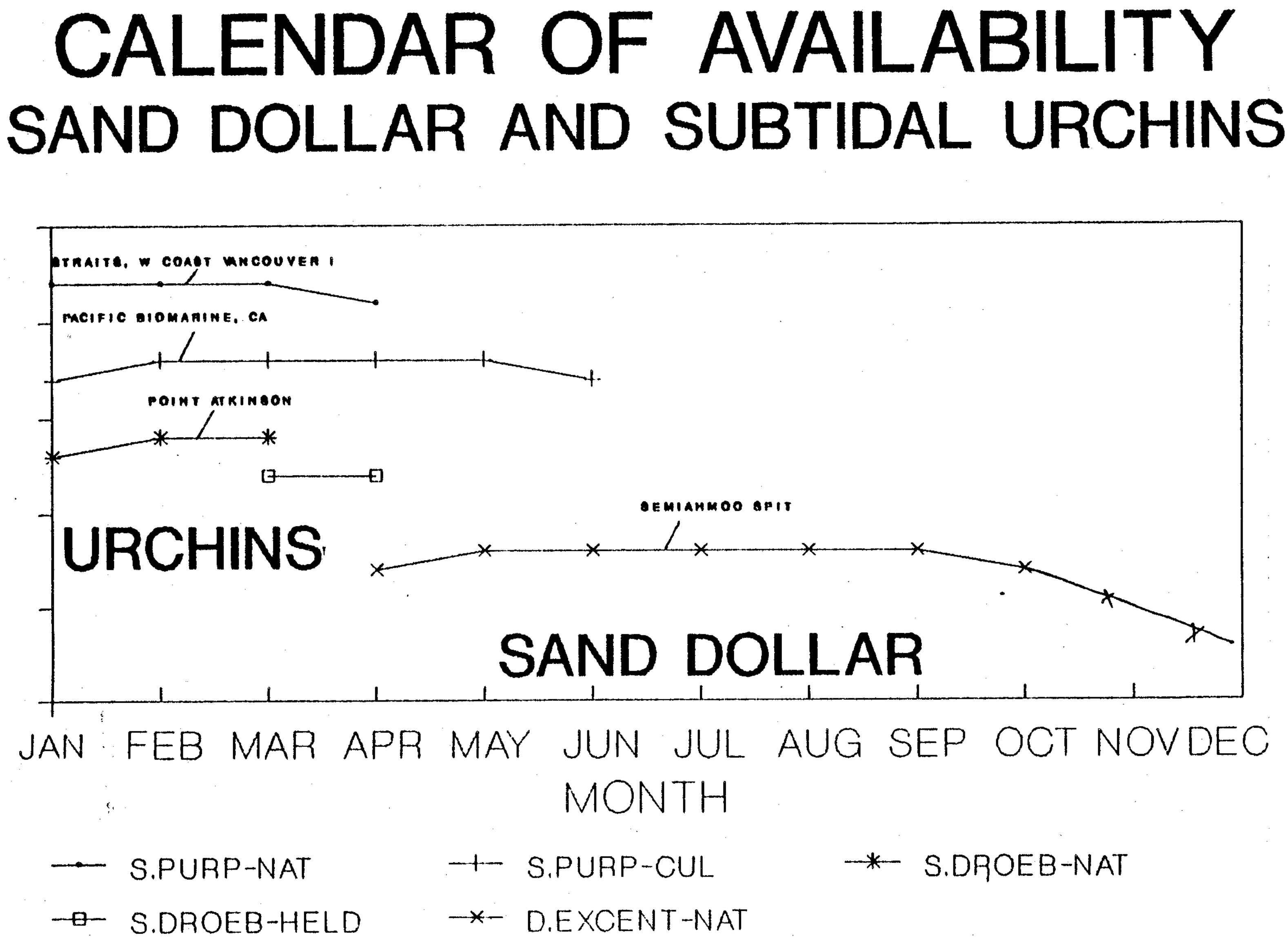


Figure 6-1. Calendar of Availability for Sand Dollar and Subtidal Urchins. From Larval Workshop 6/15/89.

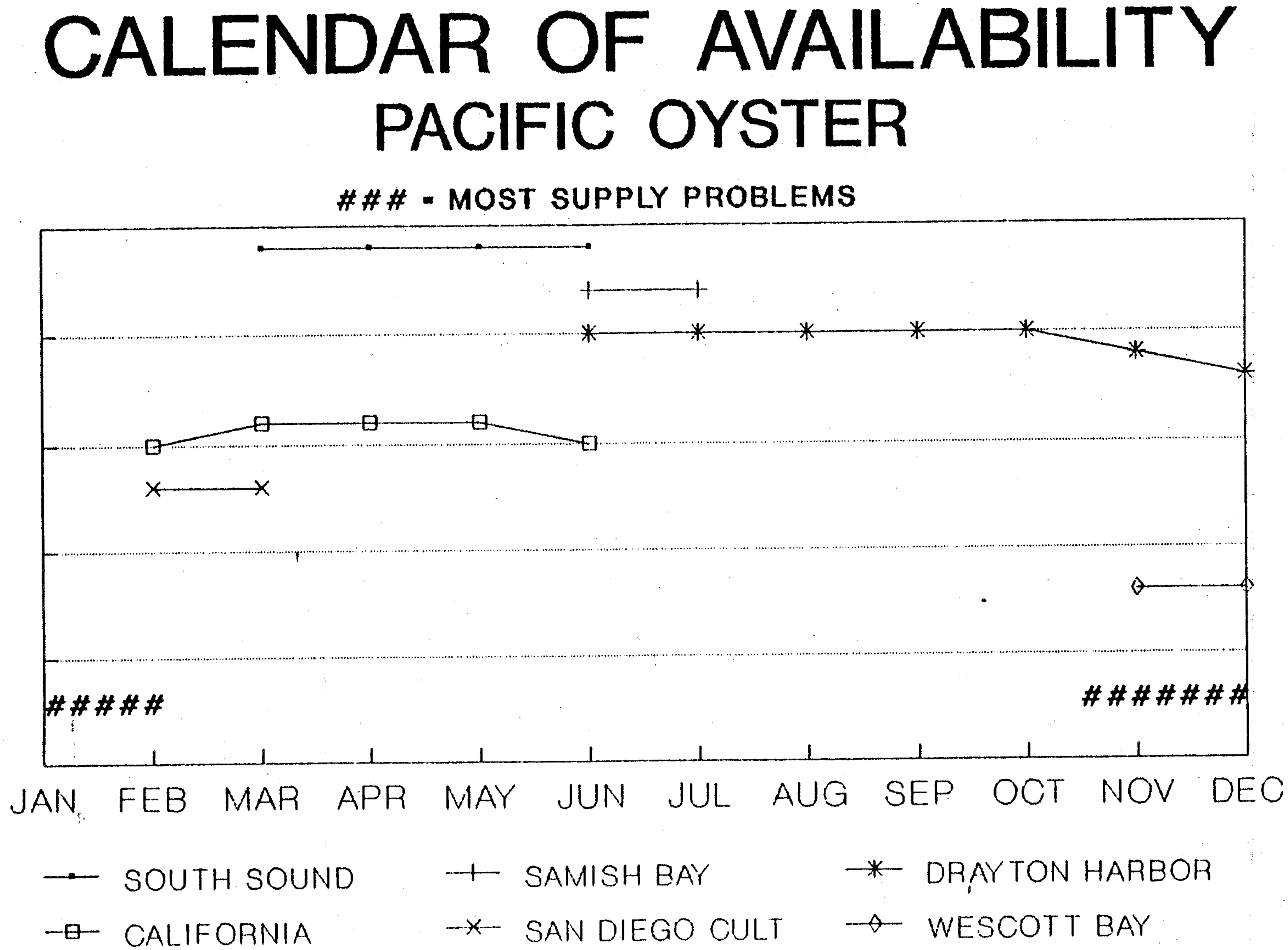


Figure 6-2. Calendar of Availability for Pacific Oysters. From Larval Workshop 6/15/89.

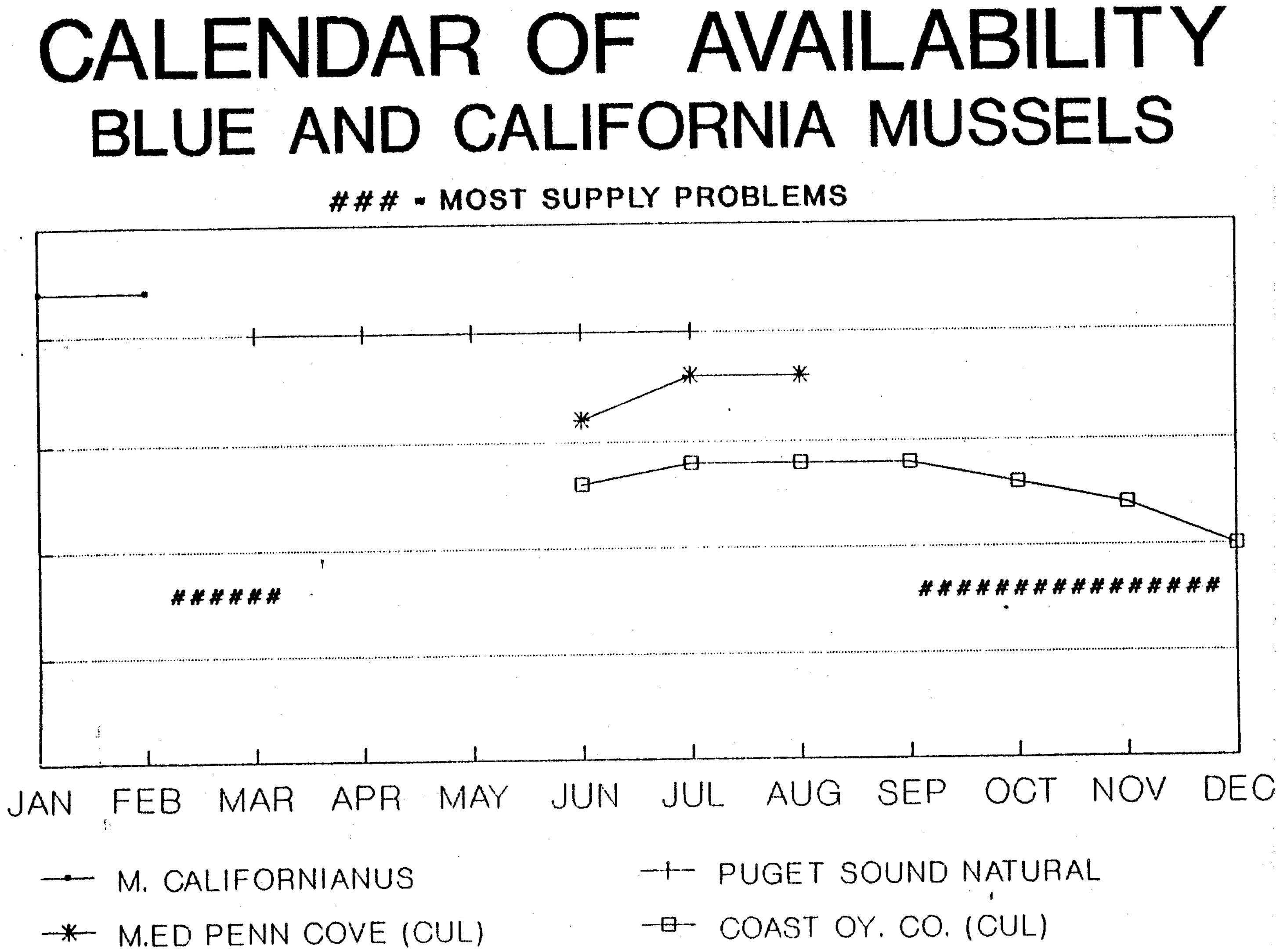


Figure 6-3. Calendar of Availibility for Mussels, *Mytilus galloprovinciallus* and *M. californianus*. From Larval Workshop 6/15/89.

Table 6-1. Solid Phase Bioassay Performance Standards and Evaluation Guidelines.

Bioassay	Negative Control Performance Standard	Reference Sediment Performance Standard	Dispersive Disposal Site Interpretation Guidelines		Nondispersive Disposal Site Interpretation Guidelines	
			1-hit rule	2-hit rule	1-hit rule	2-hit rule
Amphipod	$M_C \leq 10\%$	$M_R - M_C \leq 20\%$	$M_T - M_C > 20\%$ and M_T vs M_R SD (p=.05) and		$M_T - M_C > 20\%$ and M_T vs M_R SD (p=.05) and	
			$M_T - M_R > 10\%$	NOCN	$M_T - M_R > 30\%$	NOCN
Larval	$N_C \div I \geq 0.70$	$N_R \div N_C \geq 0.65$	$N_T \div N_C < 0.80$ and N_T/N_C vs N_R/N_C SD (p=.10) and		$N_T \div N_C < 0.80$ and N_T/N_C vs N_R/N_C SD (p=.10) and	
			$N_R/N_C - N_T/N_C > 0.15$	NOCN	$N_R/N_C - N_T/N_C > 0.30$	NOCN
Neanthes growth	$M_C \leq 10\%$ and $MIG_C \geq 0.38$	$M_R \leq 20\%$ and $MIG_R \div MIG_C \geq 0.80$	$MIG_T \div MIG_C < 0.80$ and MIG_T vs MIG_R SD (p=.05) and		$MIG_T \div MIG_C < 0.80$ and MIG_T vs MIG_R SD (p=.05) and	
			$MIG_T/MIG_R < 0.70$	NOCN	$MIG_T/MIG_R < 0.50$	$MIG_T/MIG_R < 0.70$

M = mortality, N = normals, I = initial count, MIG = mean individual growth rate (mg/individual/day)
SD = statistically different, NOCN = no other conditions necessary, N/A = not applicable
Subscripts: R = reference sediment, C = negative control, T = test sediment

6.4. BIOACCUMULATION TESTING.

During the study phase of the PSDDA program, due to a paucity of research data on the ecological effects of bioaccumulation, the focus of attention shifted to the potential for human health effects. While bioaccumulation from dredged material was not perceived to represent a major risk to human health at PSDDA open-water disposal sites, the PSDDA evaluation procedures work group (EPWG) deemed it necessary to collect additional data to support or refute this view. Therefore, EPWG determined that bioaccumulation testing should be required for dredged material, but only when chemical concentrations were relatively elevated.

Consensus was developed regarding what constituted “elevated chemistry” and bioaccumulation triggers (BTs) were established for chemicals of concern for human health at concentrations in the upper 30th percentile of the concentration allowable for unconfined, open-water disposal (i.e. 70 percent of the difference between the SL and ML). The BTs represent a "reason to believe" that specific chemicals of concern may be accumulated in the tissues of target organisms. Therefore, bioaccumulation testing is required when a BT value is exceeded (see Table 6-2). In 1998, new SL and ML guidelines necessitated some adjustments to BTs for seven chemicals. BTs were adjusted to the new SL for antimony, silver and dimethylphthalate[6]. The BT was adjusted to the new ML for nickel, benzo(a)pyrene, 1,4-dichlorobenzene, and N-nitrosodiphenylamine. The DMMP agencies plan to re-examine the BT approach in the near future and update BTs as necessary.

The standard Tier III bioaccumulation test utilizes the EPA protocol (Lee *et al*. 1989) and a 28-day exposure period, after which a chemical analysis is conducted of the tissue residue to determine the concentration of chemicals of concern. Protocols for tissue digestion and chemical analysis will follow the PSEP-recommended procedures for metals and organic chemicals. For many chemicals in Table 6-2, it can be assumed that a 28-day exposure is sufficient for a steady state tissue concentration to be reached. For other chemicals, particularly those with octanol/water partitioning coefficients (K_{OW}) greater than 5.5, it is unlikely that steady state will have been reached after 28 days. However, even for these highly hydrophobic chemicals, tissue concentrations should be detectable following a 28-day exposure period, providing a measure of bioavailability in the project sediments.

1. The draft Inland Testing Manual requires bioaccumulation testing with species from two different trophic niches, representing a suspension-feeding/filter-feeding and a burrowing deposit-feeding organism. Therefore, the Tier III 28-day bioaccumulation test is conducted with both an adult bivalve (*Macoma nasuta*) and an adult polychaete (*Nereis virens, Arenicola marina* or *Nephtys caecoides*). Recent DMMP bioaccumulation testing since 1997 have extended the test exposure period to 45 days, to insure steady state concentrations of the tested chemicals (primarily total PCBs and TBT). Moreover, to provide additional nutrients and to maintain contaminant doses for the test animals during the longer exposure period, once-weekly additions of 175-mL of test or control/reference sediment should be added to each of the test chambers. Additional bioaccumulation protocol changes may be forthcoming after the bioaccumulation workgroup has completed its review work.

[6] An issue paper presented at the 1998 SMARM proposes updates to the DMMP bioaccumulation chemical-of-concern list, and recommends delisting antimony, nickel, silver and dimethylphthalate.

Selection of appropriate species is an important consideration before undertaking a Tier III bioaccumulation test. Studies have shown that the time required for any given species to achieve a steady-state tissue concentration of a chemical of concern may vary, or are not well substantiated (see Table 6-3) (Windom and Kendall, 1979; Rubenstein, Lores, and Gregory, 1983). As such, for a given chemical triggering a Tier III bioaccumulation test, the agencies should consider selecting a species that will assimilate the target chemical near its steady state concentration (e.g., if known) within the exposure period or consider extending the exposure period.

Another consideration is the volume of sediment required for testing (Table 6-4). As much as 40 liters of sediment may be required to conduct bioaccumulation testing for five replicates and two test species. To reduce laboratory space and sediment volume requirements, applicants may test *Macoma nasuta* and *Nepthtys caecoides* together in the same test chambers. The total sediment requirement for co-testing is 20 liters.

If sediment for bioaccumulation testing was not taken from the same sediment homogenate analyzed for bulk chemistry, it will be necessary to analyze the bioaccumulation sediment for the chemicals of concern being tested for bioaccumulation. If the chemical concentration found in the bioaccumulation sediment is less than that found in the original sediment analysis (which triggered bioaccumulation testing in the first place), the actual tissue concentrations will be adjusted to reflect the chemical concentrations found in the original sediment analysis. Similarly, for chemicals with a high K_{OW}, it may be necessary to extrapolate the actual tissue concentrations to "steady-state" concentrations prior to making comparisons to human health or ecological guideline values.

While ecological effects of bioaccumulation were not addressed during the study phase of PSDDA, the potential for such effects has played an increasingly important role in the interpretation of bioassay results. Current test interpretation guidelines for the assessment of human health and ecological effects are discussed below:

<u>Human Health and Ecological Health</u>. For the bioaccumulation test, results are compared to the PSDDA guidelines for allowable tissue concentrations, which are a combination of risk-based numbers and FDA action levels. The risk-based concentrations were developed during the PSDDA study for deep-water disposal sites, using consumption rates of bottom fish by recreational anglers, the home range of bottom fish and the size of the Elliott Bay disposal site. For those chemicals with FDA action levels lower than the risk-based concentrations, the FDA action levels were adopted. Table 6-5 shows the resulting tissue concentrations of concern for human health. DMMUs resulting in tissue concentrations that are not significantly less than these table values will be considered unsuitable for PSDDA disposal. The DMMP agencies are in the process of re-examining the basis for current target tissue concentrations of concern for human health and ecological health, and will provide updated guidance when completed by the interagency bioaccumulation workgroup and after undergoing the public interest review through the SMARM process. Interim target tissue guidelines for TBT and total PCBs have recently been adopted for use by the DMMP through a project specific application in Elliott Bay.

Table 6-2. Sediment Chemistry Trigger Values for Bioaccumulation Testing (Bioaccumulation Triggers).

CHEMICAL	log K_{OW}[1]	BIOACCUMULATION[2] TRIGGER
METALS (ppm dry weight basis)		
Antimony	N/A	150
Arsenic	N/A	507.1
Mercury	N/A	1.5
Nickel	N/A	370
Silver	N/A	6.1
ORGANIC COMPOUNDS (ppb dry weight basis)		
Fluoranthene	5.5	4,600
Benzo(a)pyrene	6.0	3,600
1,2-Dichlorobenzene	3.4	37
1,3-Dichlorobenzene	3.4	1,241
1,4-Dichlorobenzene	3.5	120
Hexachlorobenzene	5.2	168
Dimethyl phthalate	1.6	1,400
Di-n-butyl phthalate	5.1	10,220
Bis(2-ethylhexyl) phthalate	4.2	13,870
Hexachloroethane	3.9	12,220
Hexachlorobutadiene	4.3	212
Phenol	1.5	876
Pentachlorophenol	5.0	504
N-Nitrosodiphenylamine	3.1	130
Trichloroethene	2.4	1,168
Tetrachloroethene	2.6	102
Ethylbenzene	3.1	27
Tributyltin	--	0.15[4]
Total DDT	(5.7 - 6.0)[6]	50
Aldrin	3.0	37[3]
Chlordane	6.0	37[3]
Dieldrin	5.5	37[3]
Heptachlor	5.4	37[3]
Total PCBs	(4.0 - 6.9)[6]	38[5]

1 Octanol/Water Partitioning Coefficients (log K_{OW}) for organic chemicals of concern for bioaccumulation in Puget Sound.
2 For most chemicals, BT = 0.7(ML-SL) + SL.
3 These chemicals do not have an ML value. Therefore, the concentration = (0.7(10SL-SL)) + SL = 7.3 SL.
4 Units are ug/l in porewater.
5 This value is normalized to total organic carbon and is expressed in ppm oc.
6 Range of individual congeners making up total.

Note: Polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) may also require bioaccumulation testing, although no bioaccumulation trigger has been established for PCDDs and PCDFs. The requirement to conduct bioaccumulation testing will be made by the agencies utilizing best professional judgement after reviewing the Tier II data.

Table 6-3. Percent of Steady-State Tissue Residues of Selected Metals and Neutral Organics from 10 and 28 day Exposures to Bedded Sediment[1].

COMPOUND	% OF STEADY STATE[2] TISSUE RESIDUE		SPECIES	ESTIMATED BY	REFERENCES[3]
	10-DAY	28-DAY			
METALS					
Copper	75	100	*Macoma nasuta*	G[5]	Lee (unpublished)
Lead	81	100	*Macoma nasuta*	G	Lee (unpublished)
Cadmium	17	50	*Callianassa australiensis*	G	Ahsanulla et al., 1984
Mercury	ND[4]	ND[4]	*Neanthes succinea*	G	Kendall, 1978
ORGANICS					
PCBs					
Aroclor 1242	18	87	*Nereis virens*	G	Langston, 1978
Aroclor 1254	12	82	*Macoma balthica*	G	Langston, 1978
Aroclor 1254	25	56	*Nereis virens*	K[6]	McLeese et al., 1980
Aroclor 1260	53	100	*Macoma balthica*	G	Langston, 1978
Total PCBs	21	54	*Nereis virens*	G	Pruell et al., 1986
Total PCBs	48	80	*Macoma nasuta*	G	Pruell et al., 1986
Total PCBs	23	71	*Macoma nasuta*	G	Boese (unpublished)
PAHs					
Benzo(a)pyrene	43	75	*Macoma inquinata*	G	Augenfield et al., 1982
Benzo(b,k)fluoranthene	71	100	*Macoma nasuta*	G	Lee (unpublished)
Chrysene	43	87	*Macoma inquinata*	G	Augenfield et al., 1982
Fluoranthene	100	100	*Macoma nasuta*	G	Lee (unpublished)
Phenanthrene	100	100	*Macoma inquinata*	G	Augenfield et al., 1981
Phenanthrene	100	100	*Macoma nasuta*	G	Lee (unpublished)
Pyrene	84	97	*Macoma nasuta*	G	Lee (unpublished)
TCDD/TCDF					
2,3,7,8-TCDD	6	22	*Nereis virens*	G	Pruell et al., 1990
2,3,7,8-TCDD	63	100	*Macoma nasuta*	G	Pruell et al., 1990
2,3,7,8-TCDF	43	62	*Nereis virens*	G	Pruell et al., 1990
2,3,7,8-TCDF	92	100	*Macoma nasuta*	G	Pruell et al., 1990
MISCELLANEOUS					
4,4-DDE	20	50	*Macoma nasuta*	G	Lee (unpublished)
2,4-DDD	31	56	*Macoma nasuta*	G	Lee (unpublished)
4,4-DDD	32	60	*Macoma nasuta*	G	Lee (unpublished)
4,4-DDT	17	10	*Macoma nasuta*	G	Lee (unpublished)

1 Modified from Inland Testing Manual (Table C), using data updated from Boese and Lee (1992).

2 Steady-state values are estimates, as steady-state is not rigorously documented in these studies.

3 See Boese and Lee (1992) for complete citations.

4 ND = Not Determined. Observed AFs (accumulation factors) for field tissue levels compared with sediment levels (normalized to dry weight) averaged 4 for this species, but ranged from 1.3 to 45 among other benthic macroinvertebrate species. Laboratory 28-day exposures to bedded sediment indicated uptake fit a linear regression model over the exposure period and experimental conditions. Tissue levels observed (*N. succinea)* at 28 days amounted to only 2.5 % of the total sediment-bound Hg potentially available.

5 G = Steady-state residue estimated by visual inspection of graphs of tissue residue versus time.

6 K = Steady-state residue estimated from a 1st-order kinetic uptake model.

Table 6-4. Species-specific Sediment Requirement for Bioaccumulation Testing.

Species	Minimum Sediment Requirement
Macoma nasuta	250-400 ml per beaker x 10 beakers per replicate x 5 replicates = **12.5-20 liters**
Nereis virens	200 ml per worm x 20 worms per replicate x 5 replicates = **20 liters**
Arenicola marina or *Abarenicola sp.*	500 ml per beaker x 4 beakers per replicate x 5 replicates = **10 liters**
Co-testing: Macoma/Nephthys	4 liters per replicate x 5 replicates = **20 liters**

Interpretation of test results requires an evaluation of the statistical significance of the mean tissue concentration of contaminants in animals exposed to dredged material compared to the tissue guideline. If the mean tissue concentration of one or more contaminants of concern is greater than or equal to the applicable action level, then no statistical testing is required. The conclusion is that the dredged material does not meet the guidelines associated with the particular action level. If the mean tissue concentration of a chemical of concern is less than the applicable action level, than a confidence-interval approach is used to determine if the mean is significantly less than the action level. One-tailed t-tests are appropriate since there is concern only if bioaccumulation from the dredged sediment is not significantly less than the action level. The one-sample t-test approach is appropriate to allow independent decisions to be made on each DMMU tested:

$$t = \frac{\bar{x} - actionlevel}{\sqrt{\frac{s^2}{n}}}$$

where "x", "s^2", and "n" refer to the mean, variance, and number of replicates for contaminant bioaccumulation from the proposed dredged material. For undetected chemicals, a concentration equal to one-half the detection limit will be used in the statistical analysis.

Ecological Effects. The results of a Tier III 28-day bioaccumulation test will be compared directly with reference results for statistical significance. Significant bioaccumulation of chemicals of concern in test species relative to reference areas may demonstrate a concern for potential food web effects. For undetected chemicals, a concentration equal to one-half the detection limit will be used in the statistical analysis. If the results of a statistical comparison show that the tissue concentration of the chemical(s) of concern tested in sediments is statistically different (t-test, alpha level of 0.05) from the reference sediment, the dredged material will be evaluated further for the ecological significance of the bioaccumulation.

The five factors summarized below will be reviewed as part of the regulatory assessment process when bioaccumulation of contaminants in dredged material tests shows statistically significant accumulation of one or more chemicals of concern. In reviewing these factors, the best regional guidance will be used to assess the relative importance of each factor to the regulatory decision.

1. How many contaminants demonstrate bioaccumulation from dredged material relative to reference sediments?

2. What is the magnitude of the bioaccumulation from dredged material compared to reference sediments?

3. What is the toxicological importance of the contaminants (e.g., do they biomagnify or have effects at low concentrations?). Examples of contaminants with biomagnification concerns are DDT, PCB, Hg/MeHg, and possibly dioxins and furans. In assessing the toxicological importance, ecological action levels may be set by the regulatory agencies based on a review of the literature. As in the human health assessment, a statistical comparison will be made to the ecological action level using the confidence-interval approach described earlier.

4. What is the potential for the identified contaminants to biomagnify within aquatic food webs? (see Kay, 1984).

5. What is the magnitude by which contaminants found to bioaccumulate in tissues exceed the tissue burdens of comparable species found at or in the vicinity of the disposal site?

If results of the bioaccumulation test in Tier III are found to be equivocal, or there is a concern that steady state body burdens in test organisms were not achieved, further testing may be required in Tier IV before a regulatory decision can be made on the suitability of the dredged material for unconfined open-water disposal. An exposure period of 28 days may be insufficient for the test species selected to achieve a steady state tissue concentration in a normal Tier III bioaccumulation test.

Table 6-5. Target Tissue Concentration Values for Chemicals of Concern to Human Health.

CHEMICAL	TISSUE GUIDELINES (mg/kg wet weight)
METALS	
Arsenic	10.1
Antimony	5,600
Mercury (Methyl Mercury)	1.0[1]
Nickel	20,000
Silver	200
ORGANIC COMPOUNDS	
Fluoranthene	8,400
Benzo(a)pyrene	1.2
1,2-Dichlorobenzene	300
1,3-Dichlorobenzene	300
1,4-Dichlorobenzene	300
Hexachlorobenzene	180
Dimethyl phthalate	300,000
Di-n-butyl phthalate	30,000
Bis(2-ethylhexyl) phthalate	18,000
Hexachloroethane	98
Hexachlorobutadiene	180
Phenol	3,000
Pentachlorophenol	900
Ethylbenzene	600
N-Nitrosodiphenylamine	2,845
Trichloroethene	127
Tetrachloroethene	27
Tributyltin	0.6 (3 ppm dry weight)
Total DDT + DDE	5.0[1]
Chlordane	0.3[1]
Dieldrin + Aldrin	0.3[1]
Heptachlor + Heptachlor Epoxide	0.3[1]
Total PCBs	0.75[2]

[1]FDA Action Level.

[2] December 1999, DMMP Interim Total PCB Human Health Target Tissue Level re-evaluation

Note: Polychlorinated dibenzodioxins, and polychlorinated dibenzofurans are additional compounds for which bioaccumulation testing could be required. Interpretation will utilize most current advisory guidelines and best professional judgement.

6.5. REFERENCE SEDIMENT COLLECTION SITES.

Bioassays must be run with a reference sediment which is well-matched to the test sediments for grain-size and other sediment conventionals (such as total organic carbon). Table 6-6 contains information about each of the sites that are recommended for use. Other reference areas may be utilized if:

- biological tests are initially run using the proposed reference area along with an already recognized reference area

- chemistry (PSDDA contaminants of concern) analysis is performed for the proposed area.

Table 6-6. Reference Sediment Collection Areas.

	Carr Inlet	Samish Bay	Holmes Harbor	Sequim Bay
Fines (%):	5-79	11-96	3-96	19-85
TOC (%):	0.2-1.2	0.4-2.4	0.2-2.6	2.3-2.7
Reference:	PTI, 1991	PTI, 1991	PTI, 1991	DAIS

The sampling protocol used for the collection of a reference sediment can affect its performance during biological testing. The following guidelines should be followed when collecting reference sediments:

- Use experienced personnel.
- Follow PSEP protocols.
- Sample from biologically active zone.
- Avoid anoxic sediment below the Redox Potential Discontinuity (RPD) horizon.
- Use wet-sieving method.
- Fix sulfides sample with zinc acetate.

Wet-sieving is imperative in finding a good grain size match with the test sediment. Wet-sieving is accomplished using a 63-micron (#230) sieve and a graduated cylinder; 100 ml of sediment is placed in the sieve and washed thoroughly until the water runs clear. The volume of sand and gravel remaining in the sieve is then washed into the graduated cylinder and measured. This represents the coarse fraction; the fines content is determined by subtracting this number from 100. Because of the wide heterogeneity of grain size in the reference areas, it may be necessary to perform wet-sieving in several places before a reference sediment with the proper grain size is found.

It should be noted that wet-sieving results will not perfectly match the dry-weight-normalized grain size results from the laboratory analysis, but should be relatively close. It is requested that wet-sieving results be submitted along with the laboratory data so that a regression line for each embayment can be developed which more accurately predicts the dry-weight fines fraction from the wet-sieving results found in the field. Reference station coordinates should also be reported, with an accuracy of $\pm$ 3 meters.

In addition to wet-sieving in the field, reference sediments must be analyzed in the laboratory for total solids, total volatile solids, total organic carbon, grain size, ammonia and sulfides. The methods and QA guidelines used for analysis of sediment conventionals in test sediments should also be used for reference sediments.

CHAPTER 7
TIER IV EVALUATIONS

Tier II evaluations of dredged material may result in a requirement to conduct a Tier IV assessment in order to make a determination of dredged material suitability. If two or more chemicals of concern during a Tier II evaluation exceed the maximum level (ML) guidelines, or any one chemical exceeds the ML by more than 100 percent, the material will be considered unsuitable for unconfined open-water disposal unless a Tier IV assessment is conducted. A Tier IV assessment is considered a special, non-routine evaluation and will require discussions among the agencies and the dredging proponent to determine the specific testing or assessment requirements. Alternative analyses that may be conducted in this tier may include any or all of the following.

7.1. STEADY STATE BIOACCUMULATION TEST

In a Tier IV evaluation, bioaccumulation testing may be necessary to determine, either by time-sequenced laboratory bioaccumulation testing (Lee *et al.*, 1989) or by collection of field samples, the steady state concentrations of contaminants in organisms exposed to the dredged material as compared with organisms exposed to the reference material. Testing options may also include longer time-sequenced laboratory exposures (exposures longer than 28 days may be necessary to reach a steady state concentration). Tier IV evaluations of data collected would follow the interpretation guidance specified in Section 6-4 (also, see Appendix D of the draft Inland Testing Manual).

7.1.1. Time-Sequenced Laboratory Testing

This test is designed to detect differences, if any, between steady-state bioaccumulation in organisms exposed to the dredged sediments and steady-state bioaccumulation in organisms exposed to the reference sediments. If organisms are exposed to biologically available contaminants under constant conditions for a sufficient period of time, bioaccumulation will eventually reach a steady-state in which maximum bioaccumulation has occurred, and the net exchange of contaminant between the sediment and organism is zero.

The necessary species, apparatus and test conditions for laboratory testing are the same as those utilized for the Tier III bioaccumulation test. Tissue sub-samples taken from separate containers during the exposure period provide the basis for determining the rate of uptake and elimination of contaminants. From these rate data, the steady state concentrations of contaminants in the tissues can be calculated, even though the steady state may not have been reached during the actual exposure. For the purposes of conducting this test, steady state is defined as "the concentration of contaminant that would occur in tissue after constant exposure conditions have been achieved."

An initial time-zero sample is collected for each species for tissue analysis. Additional tissue samples are then collected from each of the five replicate reference and dredged-material exposure chambers at intervals of 2, 4, 7, 10, 18, and 28 days. Alternative time intervals may be proposed by the agencies. It is critical that sufficient tissue is available to allow the interval body burden analyses at the specified detection limits for the chemical(s) of concern.

Based on the magnitude of bioaccumulation from the dredged material, a comparison is then made with the FDA action levels (or best professional judgement for chemicals with no FDA action levels) found in Table 6-5 (or future Human Health Guidelines promulgated by the Washington State Department of Ecology and Department of Health), and a statistical comparison of test sediment organisms with reference organisms at steady state body burdens.

Calculating steady-state concentrations following time-sequenced testing should follow data analysis procedures outlined in the Corps/EPA Inland Testing Manual (Appendix D, Paragraph D3.2.1, pages D-47 to D-51). Bioaccumulation data are very expensive to obtain, because of the extensive number of chemical analyses required, and the data should be carefully and correctly analyzed.

7.1.2. Field Assessment of Steady State Bioaccumulation

Measuring concentrations in field-collected organisms may be considered as an alternative to laboratory exposures. A field sampling program designed to compare dredging and reference tissue levels of the same species allows a direct comparison of steady state contaminant tissue levels. The assessment involves measurements of tissue concentrations from individuals of the same species collected within the boundaries of the dredging site and a suitable reference site. Collecting sufficient numbers of individuals of the same relative size ranges and biomass of the same species to enable tissue analyses at the reference and dredging site can make this type of assessment problematic. A determination is made based on a statistical comparison of the magnitude of contaminant tissue levels in organisms collected within the boundaries of the reference site, compared with organisms living within the area to be dredged.

7.2. HUMAN HEALTH/ECOLOGICAL RISK ASSESSMENTS

When deemed appropriate by the agencies, a human health and/or ecological risk assessment may be required to evaluate a particular chemical of concern, such as dioxin, mercury, PCBs, etc. In the case of chemicals like dioxin, national guidance is in a rapid state of flux, and project-specific risks to human health or ecological health should be evaluated using the best available technical information and risk assessment models.

7.3. OTHER CASE-SPECIFIC STUDIES

Biological effects tests in Tier IV should only be used in situations that warrant special investigative procedures. To address unique concerns, special studies not formally approved for use may be recommended to evaluate a specific dredged material issue. The nature and details of these studies would have to be worked out on a case-by-case basis through a consensus process with the agencies and dredging proponent.

Tests considered may include chronic/sublethal tests, field studies such as benthic infaunal studies, experimental studies such as *in situ* toxicity tests or toxicity identification evaluations

(TIE procedure; see Ankley *et al*, 1992), risk assessments and/or no effects levels for aquatic life. In such cases, test procedures have to be tailored for specific situations, and general guidance cannot be offered. Such studies, when conducted, require design and evaluation specific to the need arising, with the assistance of administrative and scientific expertise from the agencies and other sources as appropriate.

Prediction of the movement of contaminants from sediment into and through pelagic food webs is technically challenging and should only be dealt with in a Tier IV evaluation, if deemed necessary. General approaches may be explored which bracket likely concentrations of specific contaminants at different trophic levels based on an empirical model derived from a variety of marine food webs (Young, 1988). Other methods may be recommended, such as bioenergetic based toxicokinetic modeling, if deemed appropriate to address a particular concern.

As part of the annual review process, the agencies will continually evaluate new tests and evaluation procedures that have been peer reviewed and are deemed ready for use in the regulatory evaluation of dredged material. The agencies will subsequently make recommendations about their potential implementation and use in Puget Sound.

CHAPTER 8
SUBMITTAL OF SAMPLING AND TESTING DATA

Upon completion of sampling and testing, data submittal is comprised of four elements:

1. A sediment characterization report.
2. Data in the format required for the Corps' Dredged Analysis Information System (DAIS).
3. Data in the format required for Ecology's Sediment Quality database (SEDQUAL).
4. Sampling and testing cost data (optional).

8.1. SEDIMENT CHARACTERIZATION REPORT

The sediment characterization report should include the following items:

1. Quality assurance report documenting deviations from the sampling and analysis plan and the effects of quality assurance deviations on the testing results.
2. A plan view showing the actual sampling locations.
3. The sampling coordinates in latitude and longitude within an accuracy of $\pm$ 3 m.
4. Methods used to locate the sampling positions.
5. The compositing scheme.
6. The type of sampling equipment used, the protocols used during sampling and compositing and an explanation of any deviations from the sampling plan.
7. Sampling logs with sediment descriptions.
8. Chain-of-custody procedures used, and explanation of any deviations from the sampling plan.
9. Chemical and biological testing results, including quality assurance data (NOTE: QA2 data defined in Section 8.3 should not be included in this report). Chemical testing results shall be presented in the same order as the list of chemicals of concern presented in Table 5-1 to facilitate data entry into DAIS.
10. Explanation of deviations from the analysis plan.
11. Comparison to SMS for beneficial use projects or where “Z” samples have been analyzed.

8.2. DREDGED ANALYSIS INFORMATION SYSTEM (DAIS)

The Dredged Analysis Information System (DAIS) was developed by Seattle District to manage data generated through the implementation of PSDDA. Within DAIS an environmental information module manages physical, chemical and biological testing data associated with both dredged material characterization and post-disposal monitoring. An administrative module tracks permit data, suitability determinations, disposal volumes, and cost data.

DAIS includes a variety of standard reporting options, including summary reports, automated quality assurance flagging, and comparisons of chemical concentrations to regulatory guidelines. An export module allows direct data transfers to the Department of Ecology's sediment quality database system (see paragraph 8.3). DAIS data are GIS-compatible which provides the ability to do spatial data analysis. The Dredged Analysis Information System (DAIS) has been rewritten in Visual Basic 6.0, making it Y2K-compliant and Windows-compatible. Testing will be completed in early 2000.

A checklist of required DAIS data has been compiled and will be furnished to the dredging proponent as part of the sampling and analysis plan approval process. The Corps will perform a quality assurance evaluation of all sediment test data, including checks on completeness, accuracy, precision and laboratory contamination. This level of quality assurance is referred to as QA1.

8.3. SEDIMENT QUALITY DATABASE (SEDQUAL)

The Department of Ecology uses the sediment quality (SEDQUAL) database, among other things, to develop and update the AET values upon which SLs, BTs and MLs are based. Data entered into DAIS will be converted to SEDQUAL format and provided to Ecology for direct import into SEDQUAL. In addition to the DAIS data, Ecology requires additional quality assurance data to fully validate the chemical and biological testing data used to update the AETs. This includes information such as chromatograms, calibration curves, etc., and is referred to as QA2. Hardcopy QA2 data should be submitted to the DMMO. which will then pass this data on to the Sediment Management Unit at Ecology. Alternatively, the QA2 data may be sent directly to Ecology with a copy of the transmittal letter provided to the DMMO. Requirements for QA2 data have also been compiled and will be furnished to the dredging proponent.

8.4. SAMPLING AND TESTING COSTS

The submittal of sampling and testing costs is encouraged for all PSDDA projects. While voluntary, this data is vital in tracking trends in costs and will provide dredging proponents with information useful in planning future dredging. The Corps will report on sampling and testing costs in its biennial report. A cost data form has been created by the DMMO for cost data submittals and will be furnished to the dredging proponent.

CHAPTER 9

DREDGING AND DISPOSAL

9.1. DREDGING AND DISPOSAL QUALITY CONTROL PLAN

Once a Section 10/404 permit has been issued, the permittee must notify the Enforcement Section of the Corps of Engineers Regulatory Branch at (206)764-3495, at least 14 days prior to the permittee's intent to begin the dredging and disposal work. Then, at least 7 days prior to dredging and disposal, the permittee must submit in writing to the Enforcement Section, FAX (206)764-6602, a quality control plan for dredging and disposal which will ensure:

1. the separation of contaminated material from sediments suitable for open-water disposal

2. the removal of all floatable and non-floatable debris

3. the accuracy of disposal within the specified surface disposal zone.

The plan must include details of the dredging and disposal as follows:

- Project description.
- Schedule of dredging and disposal activities.
- Dredging method and procedures, including measures to control or minimize potential water quality impacts.
- Horizontal and vertical controls during dredging.
- Debris removal plan.
- Dredging contractor, personnel and equipment.
- Disposal method and procedures.
- Names and capacities of barges and dump scows.
- Identification of tow boats (by name and call letters).
- Tug operator's name and telephone number.
- Disposal site coordinates.
- Navigation equipment and positioning protocol for disposal.
- Disposal data recording and reporting.

- Water quality monitoring.
- Hydrographic surveys.
- Telephone numbers of contractors and operators.
- Coordination procedures with the regulatory agencies.

The dredging and disposal quality control plan must be approved by the Corps of Engineers and Washington State Department of Natural Resources prior to commencement of open-water disposal.

9.2. DEBRIS MANAGEMENT

In general, debris is not allowed to be disposed at the PSDDA open-water sites. This includes all floatable debris and large non-floatable debris such as logs, piling, rip-rap and concrete. Occasionally it may include smaller non-floatable woody debris such as sawdust, bark or wood chips, where these occur in relatively large homogeneous volumes. Large woody debris is most often segregated from sediment using a clamshell bucket during the dredging operation. In cases where a heterogeneous mix of smaller woody debris and sediment exists, which otherwise meets PSDDA disposal guidelines, open-water disposal may occur as long as none of the debris measures more than two feet in it longest dimension. Occasionally, a relatively small quantity of rip-rap may be approved for open-water disposal. However, a 2-ft by 2-ft steel mesh must be used during the dredging operation to remove larger pieces of rip-rap. Pre- and post-disposal monitoring may be required at the disposal site, on a case-by-case basis, to verify the absence of problem debris.

9.3. PREDISPOSAL CONFERENCE

The permittee, the contractor's representative, and the contractor's site positioning supervisor must attend a predisposal conference with the Corps of Engineers, Department of Natural Resources and Department of Ecology to review the quality control plan and procedures to be used for separation of contaminated materials from sediments suitable for open-water disposal, water quality monitoring, debris removal and disposal positioning.

Modifications to the dredging and disposal quality control plan that are made at the predisposal conference must be incorporated into a final control plan and submitted to the agencies for approval prior to dredging. A predisposal dry run may be required by the Corps. At the discretion of the Corps, an enforcement project manager may ride out to the disposal site during the predisposal dry run or the first disposal run to verify positioning accuracy.

9.4. DREDGED MATERIAL VOLUME ADJUSTMENTS

Exceedances of permitted volumes may result in fines or work stoppages. In addition to the presampling guidance provided in Section 3.2, the following guidelines should be followed to reduce the potential for permit violations:

- Up to two feet of additional shoaling is permitted under the PSDDA guidelines between the time of sampling and dredging without the need for additional characterization. It is the project proponent's responsibility to identify the need for a volume adjustment as a result of post-sampling shoaling. Volume adjustments should be made prior to issuing the public notice if possible. If significant shoaling occurs after the public notice has been issued, written requests for permit revisions must be made to the permitting agencies as early as possible and before dredging commences.

- An estimate of the bulking factor, and a justification for its selection, must be included in the contractor's dredging and disposal plan.

- A description of the barge measurement method must be included in the dredging and disposal plan.

- A description of the procedures to ensure vertical and horizontal dredging control must be included in the dredging and disposal plan. Such procedures prevent dredging of unreasonable non-pay volume, and may reduce the need for confirmatory surveys in areas where suitable and unsuitable dredged materials are in close proximity.

- Once dredging has begun, if the dredging proponent or contractor determines that significant dredging has occurred outside the permitted dredging prism, vertical and horizontal control must be re-established immediately and DNR and the Corps contacted as soon as possible.

- When the daily barge estimates, corrected for bulking, tally to fifty percent of the permitted in-situ volume, the dredging contractor must confer with the Corps, DNR and the dredging proponent. Based on the experience of the dredging contractor during the first half of the project, a correction in the bulking factor will be made if necessary. Dredging progress (based on condition surveys or spatial coverage) will then be compared to the corrected barge measurements (using the revised bulking factor) as a check on the adequacy of the permitted in-situ volume. A decision will be made by the conferees as to whether permit revisions for an increased volume will be necessary. Details of this coordination procedure must be included in the dredging and disposal plan.

- As dredging proceeds, the contractor must closely monitor dredging progress and notify the agencies as soon as possible if an exceedance of the permitted volume appears likely. Revision of the permits will be made as necessary. Dredging must stop when the sum of the daily barge estimates, corrected for bulking using the revised bulking factor, reaches the permitted in-situ volume. DNR and the Corps must be notified at this time. If the dredging has not been completed, a determination will be made as to the cause of the impending volume exceedance and permit volumes revised as appropriate. It must be stressed that, given the contingencies incorporated into the above process, the probability of a dredging contractor being required to stop dredging is small. Good project management and prompt communication with the regulatory agencies will prevent this from occurring.

- Post-dredge surveys will be reviewed by the agencies, as necessary, to ensure that the dredging plan has been followed.

9.5. DREDGING AND DISPOSAL CLOSURES IN PUGET SOUND

9.5.1. WDFW Closures

The Washington Department of Fisheries and Wildlife (WDFW) establishes closure periods in various parts of Puget Sound to protect aquatic resources. In-water work, including dredging and disposal, cannot be conducted during closed periods. WDFW is currently undergoing revisions to specified closure periods. WDFW Habitat Managers should be contacted directly (Table 9-1) to determine the closure periods for dredging and disposal of specific project.

Table 9-1. WDFW Regional Habitat Program Managers.

Region	Location	Regional Habitat Program Manager	Contact Information
Region 1	Eastern Washington	John Andrews	WDFW, Region 1 8702 North Division Street Spokane, WA 99218-1199 (509) 456-4084
Region 2	North Central Washington	Tracy Lloyd	WDFW, Region 2 1550 Aklder Street, NW Ephrata, WA 98823-9561 (509) 754-4624
Region 3	South Central Washington	Ted Clausing	WDFW, Region 3 1701 South 24th Avenue Yakima, WA 98902-5720 (509) 457-9314
Region 4	North Puget Sound	Ted Muller	WDFW, Region 4 16018 Mill Creek Blvd.
Region 5	Southwest Washington	Rich Costello	WDFW, Region 5 2108 SE Grand Blvd. Vancouver, WA 98661 (360) 906-6720
Region 6	Coastal Washington	Steve Keller	WDFW, Region 6 48 Devonshire Road Montesano, WA 98563-9618 (360) 249-1223

9.5.2. Native American Fisheries

The following standard site use conditions will be specified by the Corps and the Washington Department of Natural Resources as part of the Federal/State permitting processes:

1. during periods of tribal fishing in the disposal site area, disposal will only occur during daylight hours; and
2. during daylight hours, "navigation rules of the road" will apply to the dredger in the event Indian treaty fishing is occurring at the disposal site.

The dredger's permit will state that disposal is to occur when there is no treaty fishing occurring at the disposal site. The permittee must coordinate any nighttime disposal with the Enforcement Section, Regulatory Branch. Approval must be received from the District Engineer prior to conducting nighttime disposal.

9.5.3. Endangered Species Act

Due to recent listings of some Puget Sound species under the Endangered Species Act (ESA), all in-water projects are under scrutiny for impacts to listed species. Under Section 7 of ESA, the Seattle District is currently undergoing formal consultation with the National Marine Fisheries Service (NMFS) and U. S. Fish and Wildlife Service (USFWS) to address the potential use effects of the PSDDA disposal sites on three federally listed species: the Puget Sound chinook salmon, Hood Canal summer run chum salmon, and the Steller sea lion. NWS has prepared programmatic biological evaluations for the nondispersive and dispersive PSDDA disposal sites, and this consultation is still ongoing with NMFS and USFWS. **ESA issues may decrease the windows available for dredging and for disposal at PSDDA sites.** Until programmatic guidance is available, dredging and disposal timing must be coordinated on a project-specific basis through the permit application process.

9.6. PSDDA DISPOSAL SITE INFORMATION

Table 9-2 contains descriptive information about the PSDDA disposal sites. Figure 9-1 is a schematic delineating the target area and disposal zone within a generic non-dispersive disposal site. In the nondispersive sites the disposal barges should open within the target area to ensure dredged material is released within the disposal zone. The zone allows for some difficulties in maneuvering. For dispersive sites, the target area and the disposal zone are one and the same. Figures 9-2 through 9-9 show the disposal sites and are suitable drawings for public notices.

9.7. DISPOSAL POSITIONING

9.7.1. VTS SITES

The United States Coast Guard (USCG) must be notified by letter 14 days prior to commencing dredging operations. Notification should be sent to Commander, Thirteenth Coast Guard District, 915 Second Avenue, Seattle, Washington 98174-1067 or faxed to (206) 220-7285, Attention: Commander. Dredging operations from and north of Marrowstone Point Light must monitor VHF-FM Channels 13 and 5A. Dredging operations south of Marrowstone Point Light must monitor VHF-FM Channels 13 and 14. The USCG Vessel Traffic Service (VTS) must be contacted by radio prior to each disposal for positioning and verification of location within the surface target disposal zone. Disposal may not commence until verification is received from the USCG. Information required by the USCG must be provided for recording of the dump.

9.7.2. NON-VTS SITES

The Corps of Engineers and Department of Natural Resources jointly invested in silent-inspector equipment that utilizes differential global positioning and a tracking system to provide a record of disposal events. The permittee and the disposal contractor will be responsible for installation of the equipment on the tug and barges, protection and security of such equipment, and ensuring that equipment is operational. The Corps and DNR must be provided access to the equipment at any time for approval of installation, monitoring of equipment, or any maintenance, adjustment, or replacement needed for operation of such equipment.

Table 9-2. PSDDA Disposal Site Descriptions.

Site	Area (acres)	Depth (feet)	Disposal Zone Diameter (feet)	Target Area Diameter (feet)	Disposal Site Dimensions (feet)	VTS / GPS
Non-dispersive:						
Elliott Bay	415	330	1800	1200	6200 x 4000 (tear drop)	VTS
Commencement Bay	310	550	1800	1200	4600 x 3800 (ellipsoid)	VTS
Port Gardner	318	420	1800	1200	4200 x 4200 (circular)	GPS
Anderson-Ketron	318	440	1800	1200	4400 x 3600 (ellipsoid)	GPS
Bellingham Bay	260	95	1800	1200	3800 x 3800 (circular)	GPS
Dispersive:						
Rosario Strait	650	120	3000	3000	6000 x 6000 (circular)	VTS
Port Angeles	884	435	3000	3000	7000 x 7000 (circular)	VTS
Port Townsend	884	360	3000	3000	7000 x 7000 (circular)	VTS

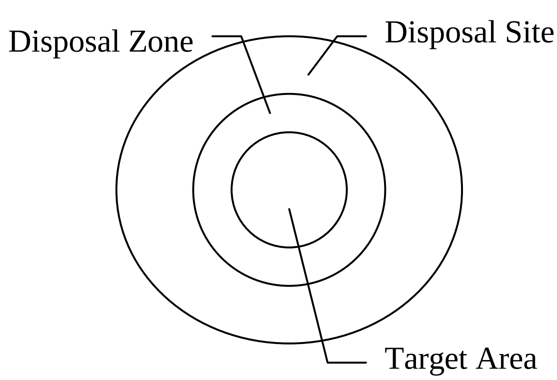
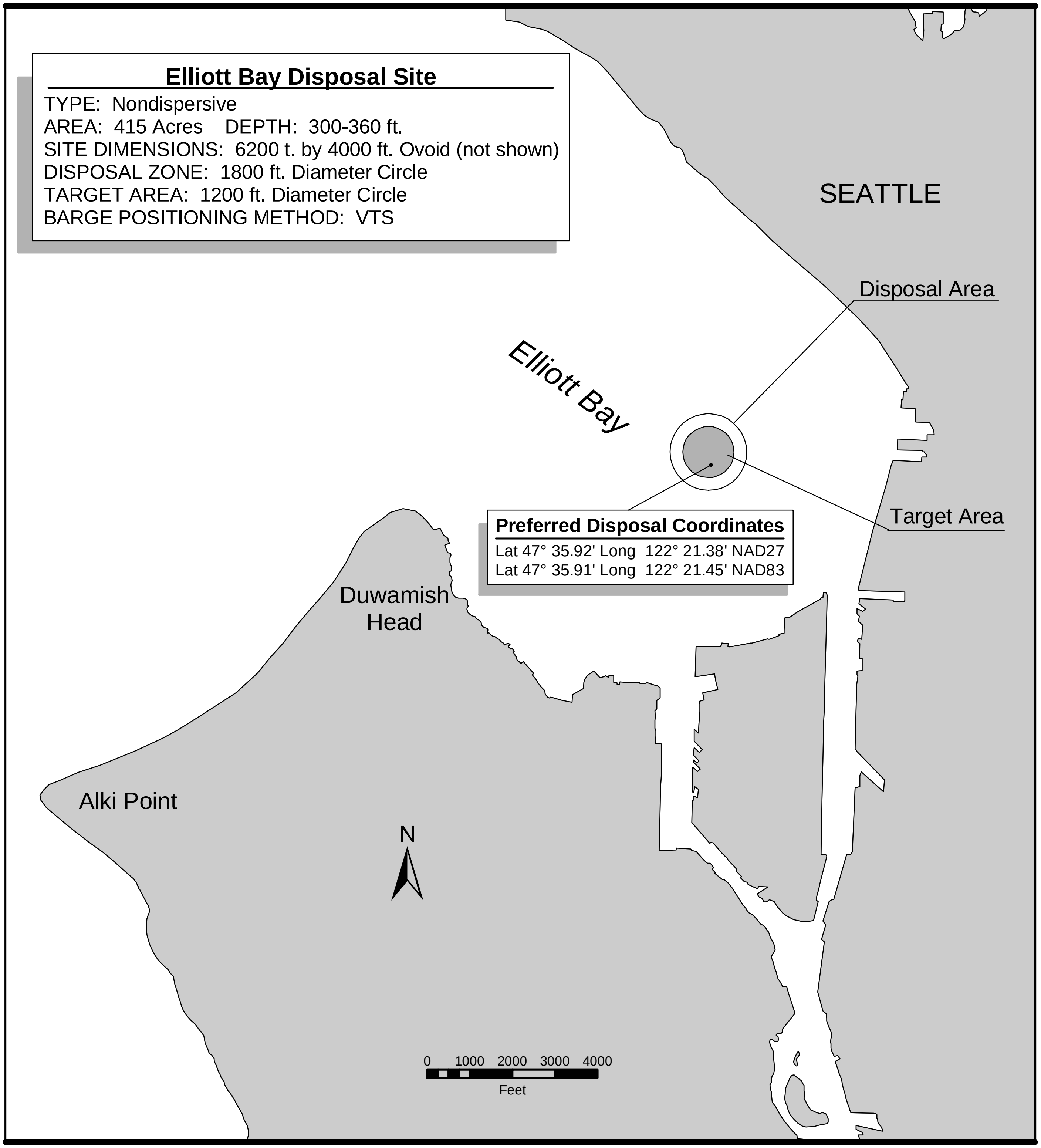


Figure 9-1. Disposal Zone vs. Target Area.



PURPOSE:

DATUM:

ADJACENT PROPERTY OWNERS:

1

2

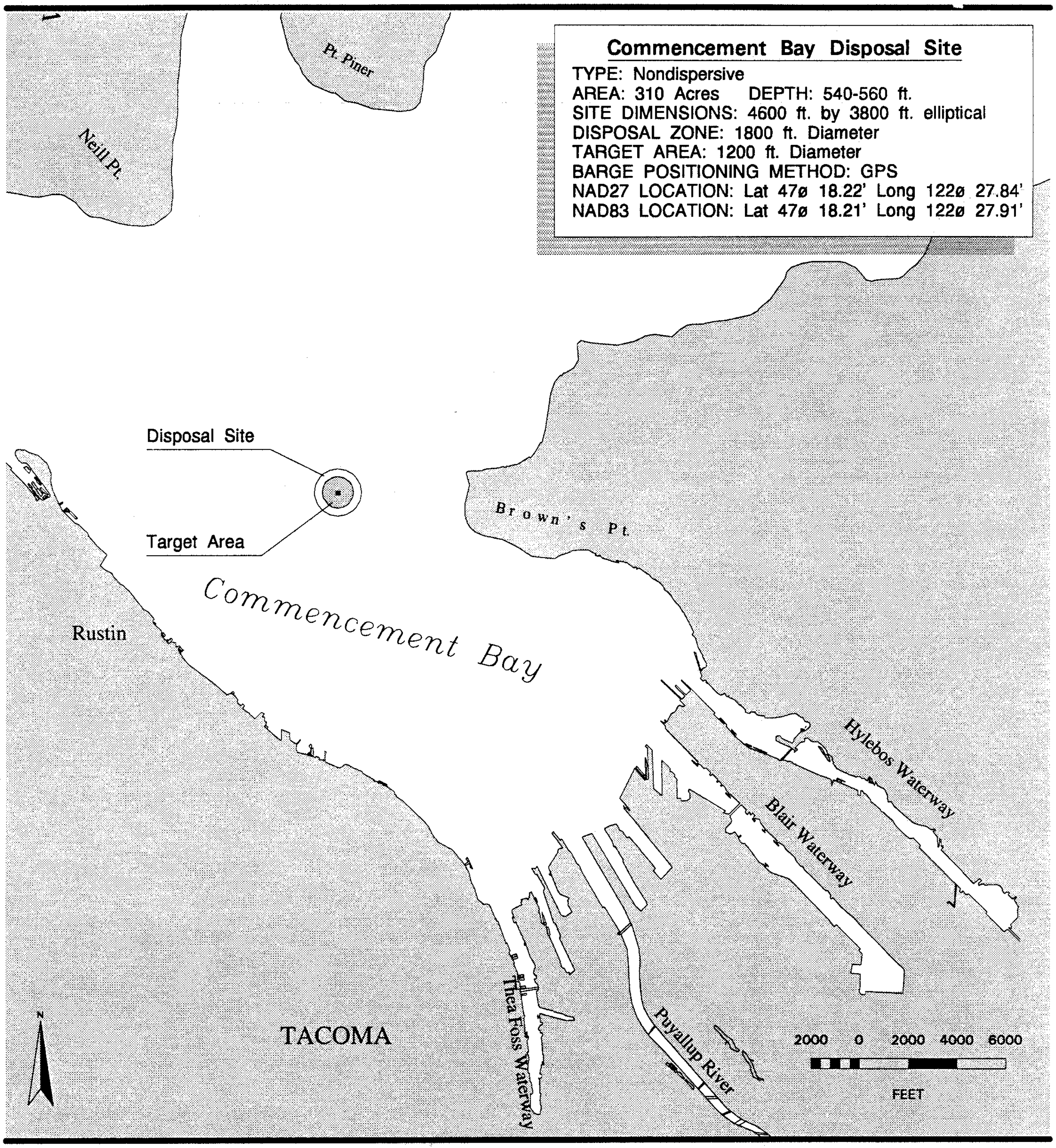
IN

AT

COUNTY OF STATE

APPLICATION BY

SHEET OF DATE



PURPOSE:

DATUM:

ADJACENT PROPERTY OWNERS:

(1)

(2)

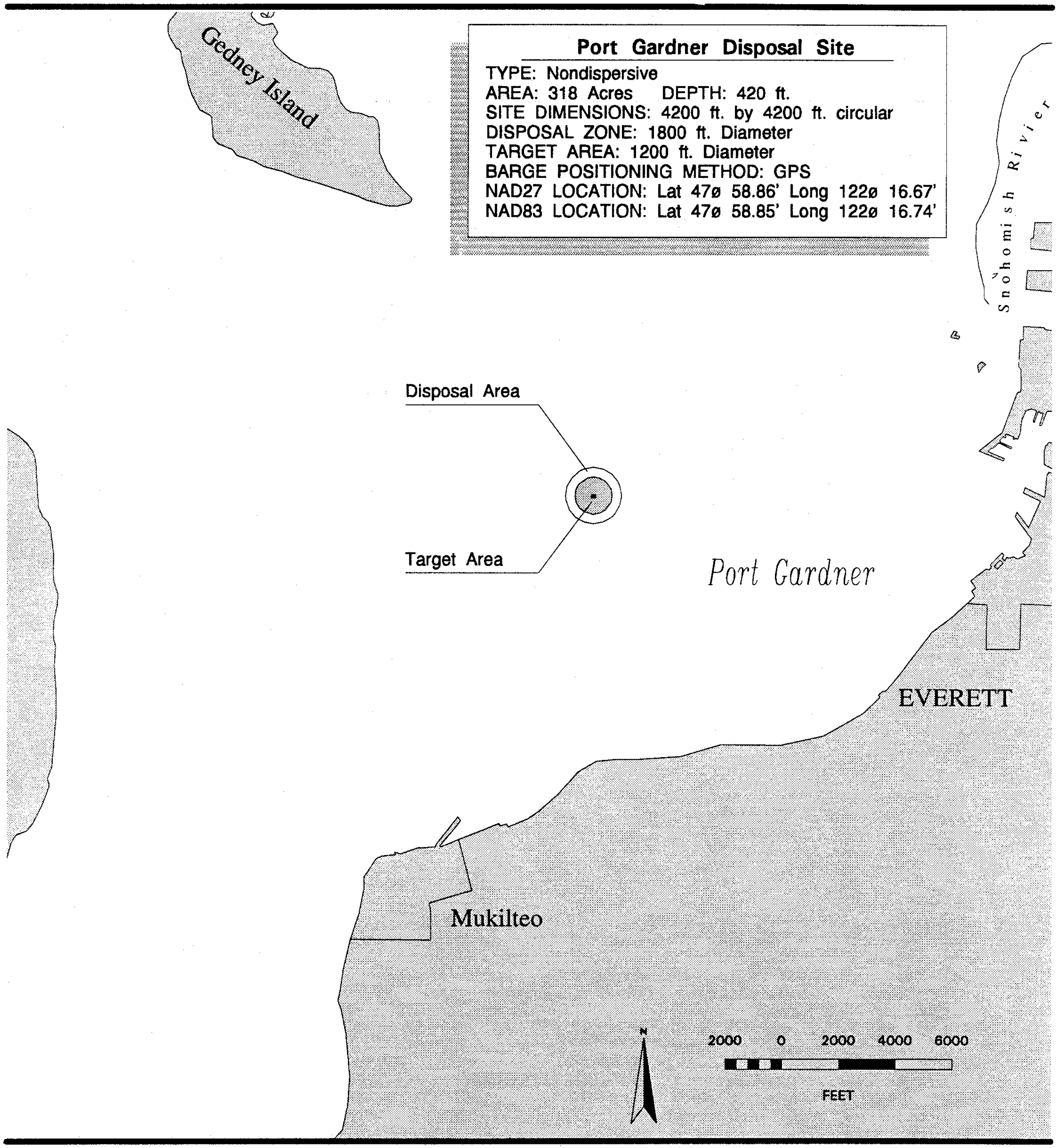
IN

AT

COUNTY OF STATE

APPLICATION BY

SHEET OF DATE



PURPOSE:

DATUM:

ADJACENT PROPERTY OWNERS:

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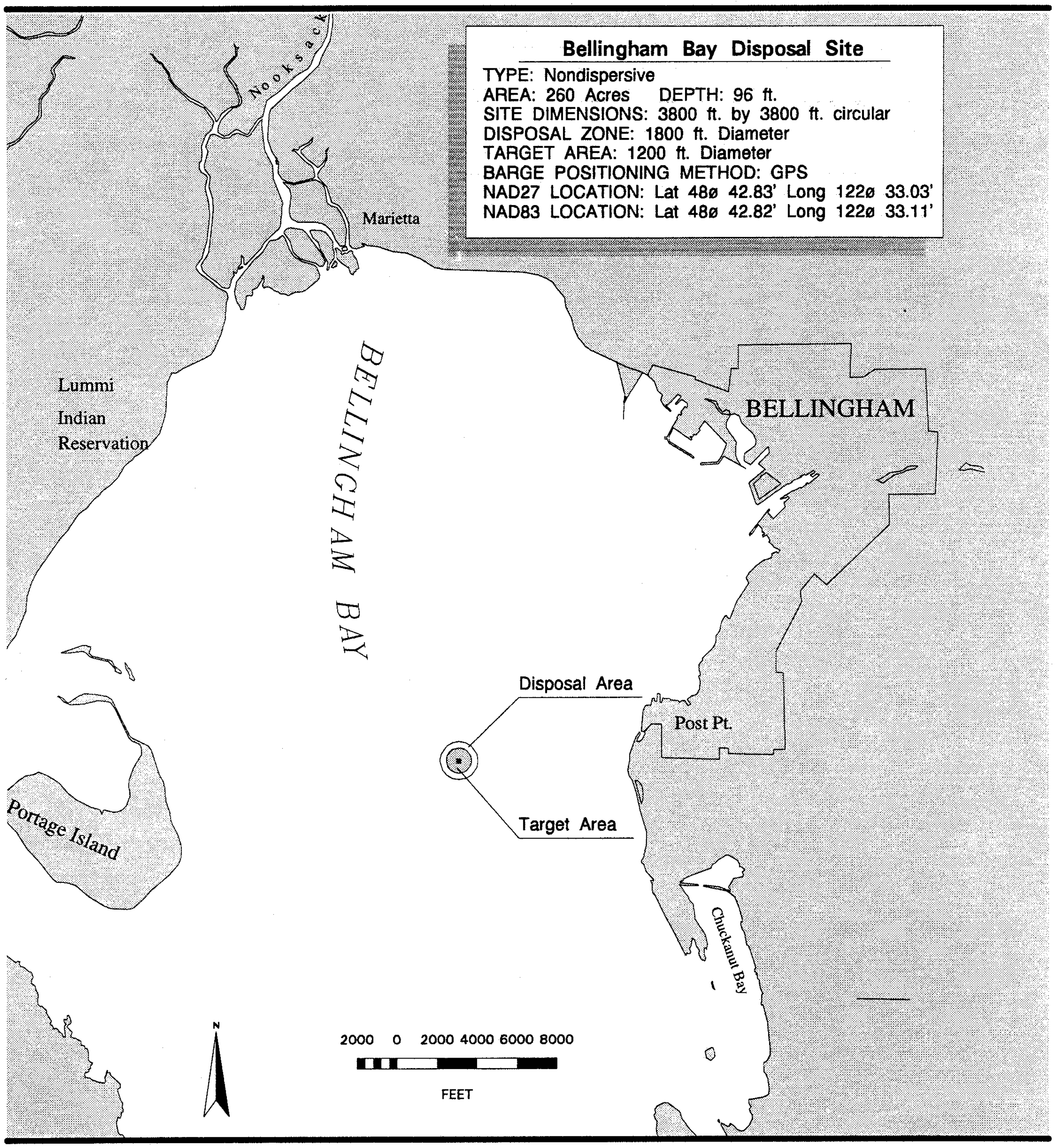
SHEET OF DATE



PURPOSE:

DATUM:

ADJACENT PROPERTY OWNERS:

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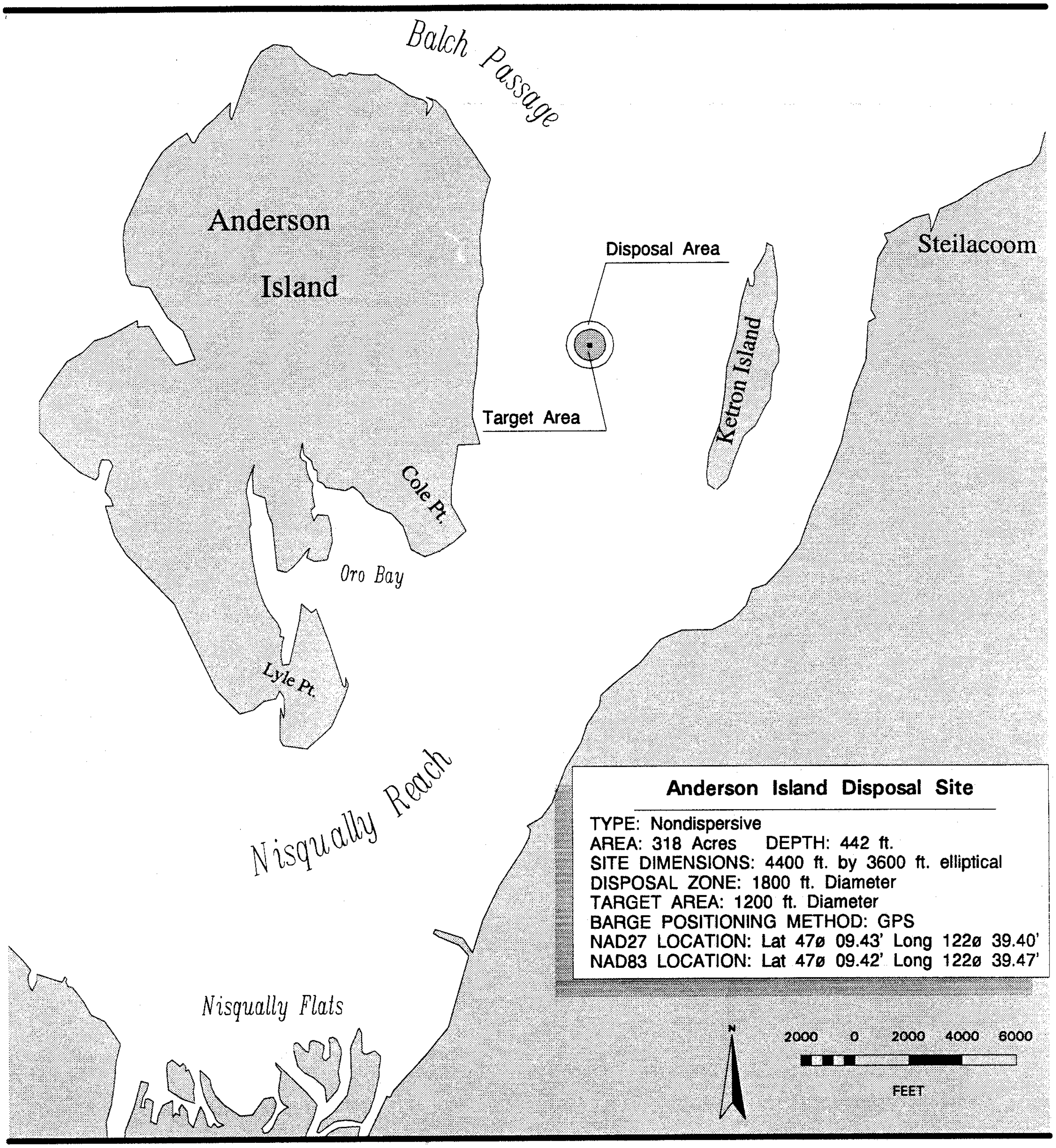
COUNTY OF STATE

APPLICATION BY

SHEET OF DATE



PURPOSE:

DATUM:

ADJACENT PROPERTY OWNERS:

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APPLICATION BY

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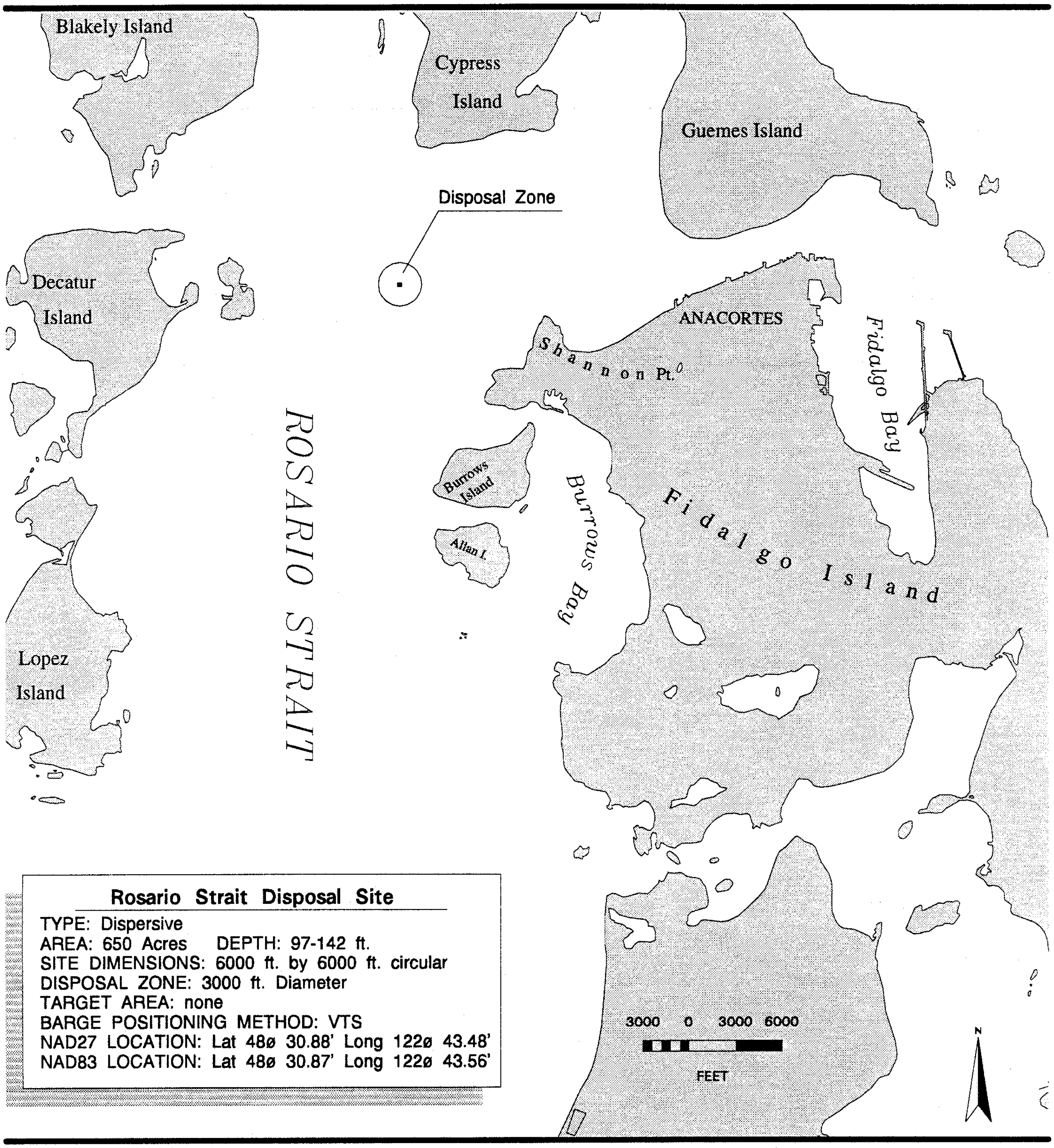

PURPOSE:

DATUM:

ADJACENT PROPERTY OWNERS:

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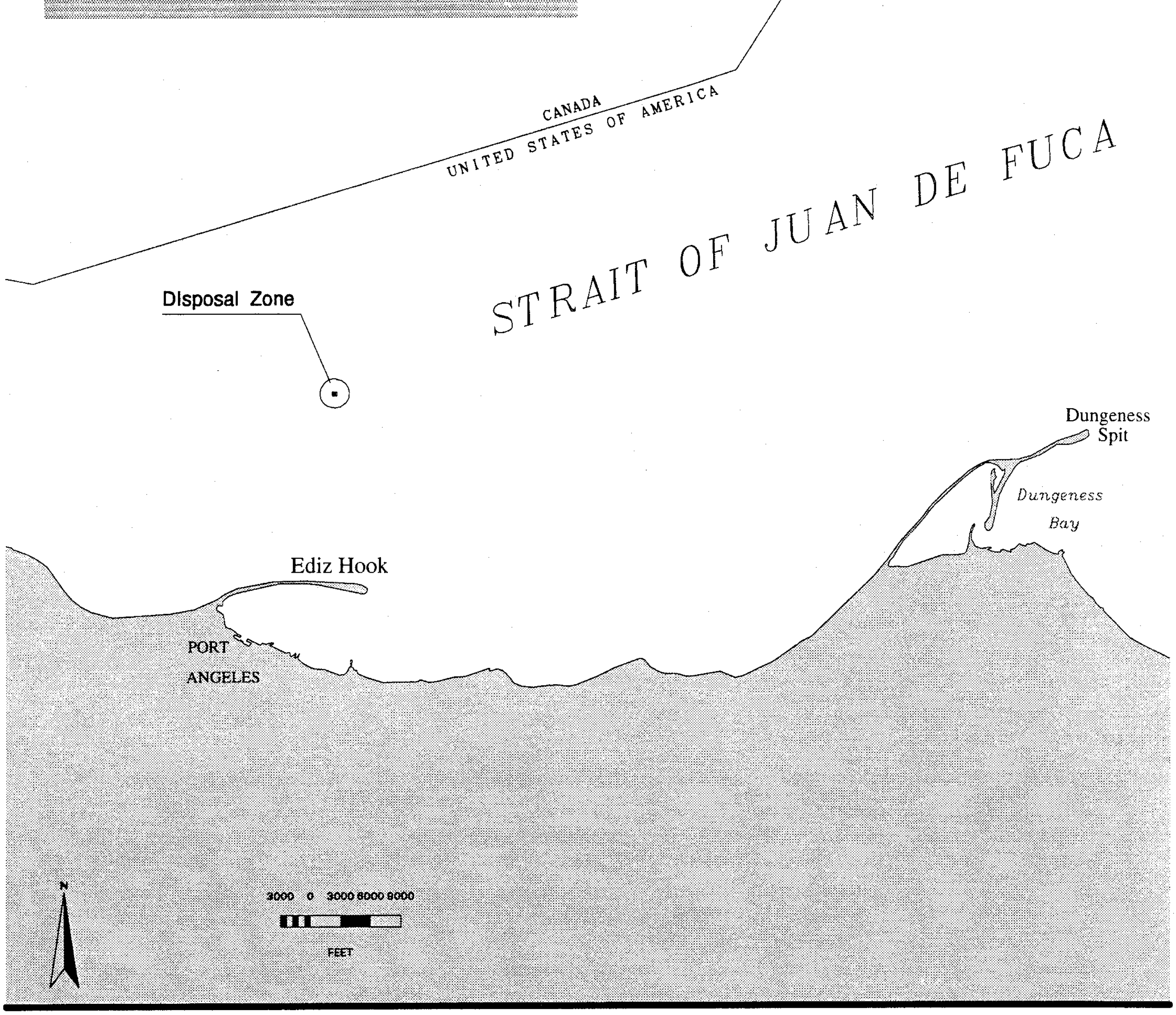
APPLICATION BY

SHEET OF DATE

Port Angeles Disposal Site

TYPE: Dispersive
AREA: 884 Acres   DEPTH: 435 ft.
SITE DIMENSIONS: 7000 ft. by 7000 ft. circular
DISPOSAL ZONE: 3000 ft. Diameter
TARGET AREA: none
BARGE POSITIONING METHOD: VTS
NAD27 LOCATION: Lat 48ø 11.68' Long 123ø 24.86'
NAD83 LOCATION: Lat 48ø 11.67' Long 123ø 24.94'



PURPOSE:

DATUM:

ADJACENT PROPERTY OWNERS:

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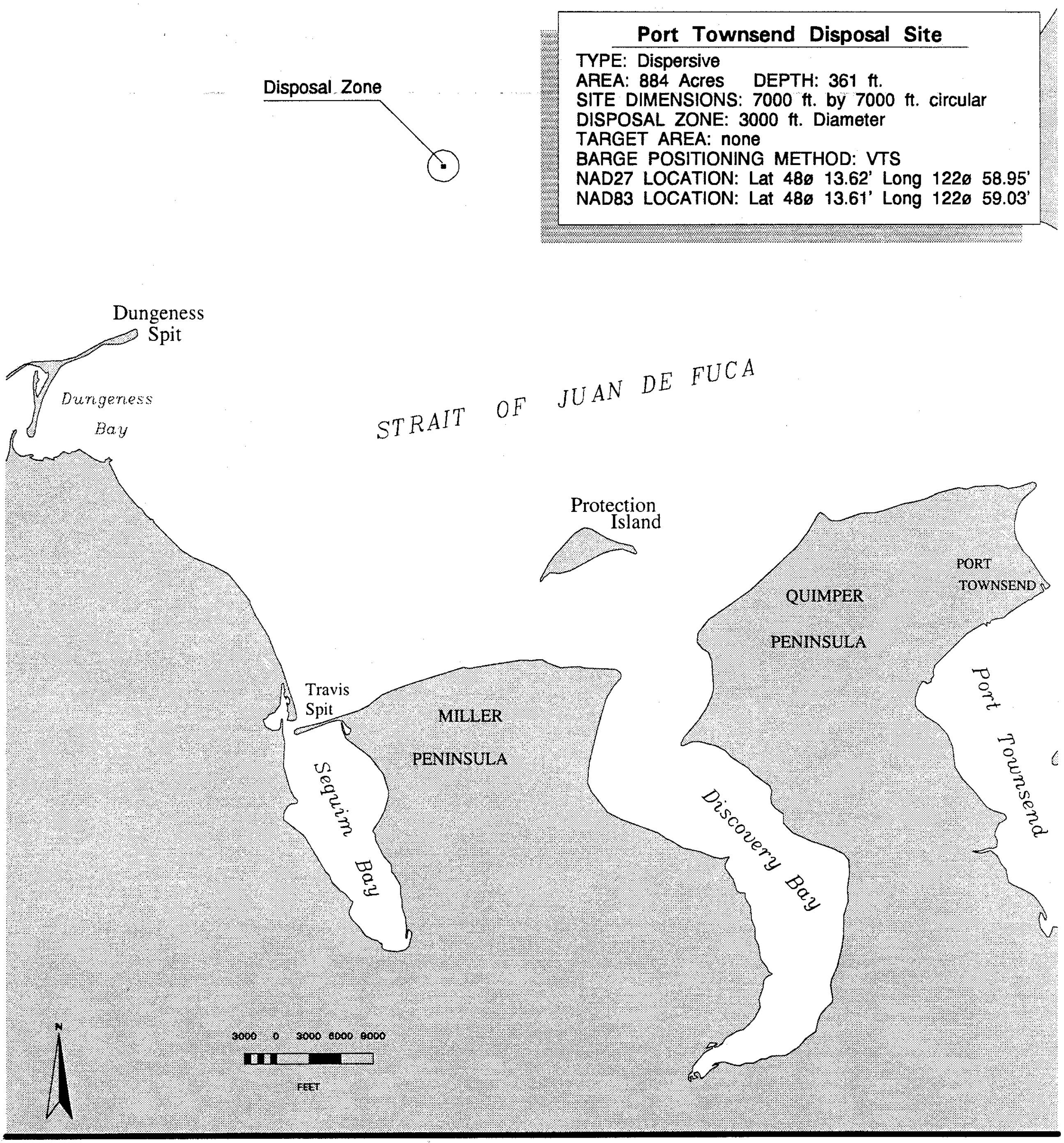
COUNTY OF   STATE

APPLICATION BY

SHEET   OF   DATE

Port Townsend Disposal Site

TYPE: Dispersive
AREA: 884 Acres   DEPTH: 361 ft.
SITE DIMENSIONS: 7000 ft. by 7000 ft. circular
DISPOSAL ZONE: 3000 ft. Diameter
TARGET AREA: none
BARGE POSITIONING METHOD: VTS
NAD27 LOCATION: Lat 48ø 13.62' Long 122ø 58.95'
NAD83 LOCATION: Lat 48ø 13.61' Long 122ø 59.03'



PURPOSE:

DATUM:

ADJACENT PROPERTY OWNERS:

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